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Station

Hydroacoustic Evaluations of Juvenile Salmonid Passage at Bonneville Dam Including Surface-Collection Simulations

by Gene R. Ploskey, Larry R. Lawrence, WES Peter N. Johnson, AScI Corporation William T. Nagy, Portland District Mike G. Burczynski, DynTel Corporation

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Preface

The report herein was prepared for the U.S. Army Engineer District, Portland, by the Fisheries Engineering Team (FET), Water Quality and Contaminant Modeling Branch (WQCMB), Environmental Processes and Effects Division (EPED), Environmental Laboratory (EL), U.S. Army Engineer Waterways Experiment Station (WES), with support from AScI Corporation, Mclean, VA, DynTel Corporation, Vicksburg, MS, and the U.S. Army Engineer District, Portland, Fishery Field Unit (FFU) and Environmental Resources Branch (ERB). The report was prepared by Messrs. Gene R. Ploskey, FET, Peter N. Johnson, AScI, William T. Nagy, FFU, Mike G. Burczynski, DynTel, and Dr. Larry R. Lawrence, FET, and was conducted under the general supervision of Dr. Mark S. Dortch, Chief, WQCMB; Dr. Richard E. Price, Chief, EPED; and Dr. John Harrison, Director, EL.

Many other people made valuable contributions to this study. Mr. Marvin Shutters, ERB, helped man a safety boat for mobile acoustic surveys, and Mr. Larry Beck and Ms. Sally Jones, FFU, assisted when Mr. Shutters was unavailable. Many people helped process data from underwater video cameras including Messrs. Johnson, Burczynski, Scott Bourne, Bruce Sabol, Mike Cariola, and Buddy Sanders and Ms. Elizabeth Lord. Visual tracking of fixed-aspect hydroacoustic data was done by Mr. Burczynski and Mses. Ellen Czaika, Hope Waite, Anila Taylor, and Linda Moss. Ms. Virginia Sutton and Mr. Nagy spent months developing automated fish-tracking algorithms and computer programs. Mr. Gary Weeks and Ms. Deborah Patterson helped process data and create figures. Mr. Rick Martinson, National Marine Fisheries Service, provided 1996 juvenile bypass data. Riggers from the Bonneville Project moved trash racks with a gantry crane and welded shackles and conduits for cable routing during transducer installations at both powerhouses, moved trash racks to facilitate repair of acoustic equipment, and shuffled 9 blocked and 18 unblocked trash racks weekly at Powerhouse 1 to create test treatments. Bonneville rigging crews also provided a crane and man basket to help the WES team install acoustic monitoring equipment at the sluice chute at Powerhouse 2. Mr. Vincent Schlosser provided welding support for attachment of conduits to trash racks when Project riggers were not available.

At the time of publication of this report, Director of WES was Dr. Robert W. Whalin. Commander was COL Robin R. Cababa, EN.

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Conversion Factors, Non-SI to SI Units of Measurement

Non-SI units of measurement used in this report can be converted to SI units as follows:

Multiply	By	To Obtain
degrees (angle)	0.01745329	radians
feet	0.3048	meters

Summary

This Technical Report describes results of studies conducted by the US Army Engineer District, Portland (CENPP) and the US Army Engineer Waterways Experiment Station (CEWES) to resolve critical uncertainties in the implementation of smolt-collector technologies and estimation of fish passage efficiency (FPE) for the Bonneville Project. Available biological information is inadequate to design and locate surface collector prototypes at Bonneville Dam (Giorgi and Stevenson 1995). Information on the vertical and lateral distributions of smolts in forebay areas of both powerhouses and the spillway was limited, no mobile surveys had been conducted, and no manipulative testing had been done to determine likely responses of smolts to surface openings.

The goals of this study were to (1) provide biological information necessary to facilitate the design and placement of a surface-collector prototype and (2) make progress toward the estimation of FPE for the entire Bonneville Project. Objectives were to:

- use mobile hydroacoustics to measure the vertical and horizontal distribution of salmon smolts in forebay areas of both powerhouses and to characterize the day and night variation in distributions in spring and summer;
- estimate smolt passage into two turbines and into the center sluice gate above each turbine, as well as the FPE ratio for paired sluiceway/turbine openings under two test conditions (blocked versus unblocked trash racks and open versus closed sluice gates) in spring and summer at Powerhouse 1;
- 3. evaluate smolt swimming direction in the area immediately upstream of two test units at Powerhouse 1, particularly at the zone of separation between flows entering turbines and flows entering sluice gates.
- 4. estimate guided and unguided smolt passage into eight turbine intakes of Powerhouse 2 and identify effects of an open or closed sluice chute on the fish guidance efficiency (FGE) of adjacent turbine units;

Mobile surveys showed that there were significant longitudinal, lateral, and vertical gradients in smolt density that provide opportunities in optimizing surface collector prototype location and configuration. At Powerhouse 1, mean densities generally were higher in mid-channel areas in spring and were more spread out along the powerhouse face in summer. If this pattern is consistent in 1997 mobile surveys, a good test location for a prototype collector would be near the center of the powerhouse at units 3-5 or 4-6, especially in spring. Lateral densities at Powerhouse 1 in summer suggest that many young-of-year smolts would encounter a centrally located collector, although the highest densities of sub-yearling smolts may be shore oriented. We found a consistent upward shift in the vertical distribution of smolts at transects within 20 m of Powerhouse 1 relative to transects 50-75 m upstream. This shift may be explained by smolts moving up in the water column as they approach the dam, a behavior that a surface collector could exploit. In contrast, we found a downward shift in the vertical distribution of smolts at transects within

30 m of Powerhouse 2 relative to transects located 50-75 m upstream. This downward shift probably is a function of hydrology and rapid increases in depth as smolts approach Powerhouse 2. Lateral distributions of smolts were more consistent for both seasons at Powerhouse 2 than at Powerhouse 1 and, if confirmed by 1997 mobile surveys, we would recommend intakes 11-13 or Unit 18 as good locations for a collector prototype because that is where we usually observed the highest densities of smolts. With modification, the sluice chute near unit 11 also would be a good collector because of its proximity to relatively high densities of smolts holding upstream of Unit 11-13. We usually found lower densities upstream of Unit 11-13 on days when the sluice chute was open than when it was closed suggesting that the chute reduced smolt delays in the south eddy. However, we found no effect of sluice-chute operations on the fish-guidance efficiency of traveling screens in adjacent intakes. Therefore, benefits of the sluice chute would appear to be solely a function of numbers of smolts it passed. Previous research has suggested that a 1/4 gate opening on the sluice chute could pass 25-50% of the numbers passed at a single turbine. We tried several times to sample the sluice chute with fixed-aspect hydroacoustics and found high background noise from entrained air that obscured smolts smaller than about -47 dB or about 100 mm long from reliable detection. Also, surges in turbulent flow moving around the TIE at 11A prevented reliable counting of larger smolts one fourth of the time. We did not continue acoustic sampling of the chute because we doubted that estimates would be accurate given noise that frequently would obscure smolts from detection and the high probability of mistakenly counting bubbles as fish.

Results from 1996 sampling of smolt passage at Powerhouse 1 with fixed-aspect hydroacoustics and underwater video cameras provided promising evidence that surface collection could substantially increase FPE at Bonneville Dam. The 1996 results were not without ambiguities, many of which can be explained by high variation in smolt counts among days and significant differences among test units and intakes that kept us from pooling data to increase sample size and the power of statistical tests.

Several response variables were created to analyze effects of test treatments or locations. We standardized two passage variables to minimize effects of migration timing that might obscure treatment effects which were assigned by day or week. Standardized turbine passage (STP) was the total number of smolts passing into a test turbine per treatment day divided by the number of smolts estimated to have passed through the juvenile bypass during the same time period. Similarly, standardized sluice passage (SSP) was the total number of smolts passing into a center sluice opening per treatment day divided by the number of smolts estimated to have passed through the juvenile bypass during the same time period. Similarly, standardized sluice passage (SSP) was the total number of smolts passing into a center sluice opening per treatment day divided by the number of smolts estimated to have passed through the juvenile bypass during the same time period. Other variables expressed the number of smolts passing by a specific route at a turbine unit to the number passing by all available routes at the same unit. These efficiency variables reflect the relative importance of one route to other routes being considered. For example, fish guidance efficiency (FGE) was the percent of all in-turbine smolts that were guided by traveling screens. Fish passage efficiency (FPE) was the percent of all smolts (screen guided, unguided, and sluice passed) that passed by non-turbine routes (i.e., guided and sluice passed). Sluice passage efficiency (SPE) was the percent of all smolts (guided, unguided, and sluice passed through the center sluice gate.

We found considerable evidence that blocking trash racks (lowering the zone of flow separation) was beneficial. For example, standardized turbine passage (STP) was significantly less for blocked treatments (passage under blocks) than for unblocked treatments at Unit 3 in spring (53% less) and summer (70.3% less). In spring, for example, intakes 3A, 3C, and 5A all had lower mean STP when racks were blocked than when they were unblocked. In summer, intakes 3A, 3C, and 5B all had lower mean STP when racks mean streatments were blocked than when they were unblocked, and the differences at intake 3B was nearly significant (P=0.0553). Standardized sluice passage and sluice passage efficiency (SPE) did not

differ significantly between blocked and unblocked treatments probably because tests lacked sufficient power to reject the null hypothesis of no difference. The mean ratio of blocked to unblocked mean sluice passage was 6.8 for Unit 3 and 2.2 for Unit 5, and differences were nearly significant at the 5B sluice in spring (P = 0.0809). Non-significant increases in SPE during blocked trash-rack treatments were + 14.6 % for Unit 3 and + 12.8 % for Unit 5. The behavior of smolts upstream of trash racks also was informative. At intake 3B and depths of 5-6 m, the mean number of smolt-sized fish moving up in the water column and the ratio of upward- to downward-moving fish were both significantly higher for blocked than for unblocked treatments. At intake 5B, significantly more fish were moving up and down in the water column when trash racks were blocked than when they were unblocked. This milling of smolts upstream of the block cannot occur during unblocked treatments because of flow into the intake. Milling may afford smolts time to discover the surface opening, but it also may make them more vulnerable to predation. In contrast to spring results, sluice passage efficiency at Unit 5 was significantly lower when racks were blocked than when they were not blocked in summer. Apparent differences in effects of trash-rack blocks on sluice passage and SPE in spring and summer may result from differences in swimming ability of yearling and sub-yearlings smolts.

We could not estimate FGE or FPE for blocked-trash-rack treatments and make meaningful comparisons to unblocked treatments because traveling screens were present in one treatment but not the other. Even if screens had been deployed behind trash rack blocks, there was insufficient flow to guide smolts. Fish behind trash-rack blocks were moving slowly in and out of the up-looking acoustic beam and differences in counts for blocked and unblocked treatments likely resulted from multiple counts of milling fish in low velocity flows behind blocks. Consequently, we did not use counts of fish behind blocks to evaluate treatments.

Underwater cameras showed that the lateral distribution of smolts passing into sluice 5B was consistently skewed (two to one) toward the sides of the gate near concrete piers. The skewed distribution was observed both night and day and in spring and summer and has important implications for sampling smolt passage at these sluice openings. For example, acoustic sampling with a single up-looking transducer would underestimate passage by 50%. Adequate sampling would require more up-looking transducers to sample the lateral distribution, or the orientation of a single transducer would need to be changed from vertical to horizontal to integrate counts across the opening.

Provision of a surface opening at sluice gates significantly increased non-turbine smolt passage, although the effect of a 0.5-2 m deep opening on more deeply distributed smolts appeared to be limited. Opening a center sluice gate significantly increased the mean FPE of Unit 5 by 35.5 % (from 27.5 to 63.0 %) in spring and at Unit 3 by 46 % (from 30.3 to 76.9 %) in summer. For Unit 3 in spring and Unit 5 in summer, respective FPE means of 58.6 and 39.1 % for the open sluice treatment were 18.6 and 10.1 % higher than means for the closed sluice treatments (40 and 29 %, respectively), although differences were not significant at $\alpha = 0.05$. In-turbine FGE relative to traveling screens was not significant effect of sluice-gate treatments on vertical movements of smolts, a finding suggesting that open-sluice treatments have a limited range of influence for attracting juvenile salmonids. Flow vectors 6 m upstream of a sluice gate opened 2 m were downward into the intake at depths > 2 m when trash racks were not blocked and downward at depths > 4.0 m when trash racks were blocked. No attraction flow would be discernable at greater depths for the respective treatments.

We found significant differences in total smolt passage among seasons, time of day, and intakes at Powerhouse 2. Smolt passage was higher in summer than in spring, at night than during the day, at Unit 11 than at other intakes in spring, and apparently at units on the south end of the powerhouse (11-14) than at units on the north end in summer. We found a very close correspondence between spring run timing estimated by acoustic samples and trap catches in the bypass. Correspondence also was good in summer after we excluded high passage rates from units 11-14 during the first week of summer from Powerhouse 2 averages. Numbers were inflated at the southern intakes during the first week of summer immediately after river flows peaked for the year and loaded the south eddy with debris. The diel trend in total smolt passage was similar to the trend in juvenile bypass numbers in spring and summer, although it was highly variable among days. Sluice-chute treatments had no effect on standardized turbine passage at any intake in spring or summer.

Tests on mean FGE at Powerhouse 2 revealed significant differences among seasons, time of day, and intakes, but FGE was not affected by sluice-chute treatment. Estimates of FGE were higher in spring than summer and during the day than at night. Mean FGE of individual intakes ranged from about 16 to 66 % in spring and from 10 to 42 % in summer. Sluice chute treatments had no effect on FGE in spring or summer. Average FGE declined during summer from about 55 to about 30 %. Vertical distribution data from mobile surveys suggested that FGE should be 20 % higher in spring than what was measured in-turbine with fixed-aspect transducers and 32 % higher in summer, at least during the day. Either the distribution of smolts changed within 10 m of the structures where we did not sample or smolts were avoiding screens as they entered intakes. Both hypotheses are testable.

The 1996 acoustic FGE estimates were within 3-25 % of estimates by Fyke netting and acoustic sampling in previous years for the same intake and season. The mean difference among 10 paired estimates was $10.7 \pm 5\%$, where 5% is a 95% confidence interval. The 1996 estimates were based upon sampling 24-hours per day for each season, whereas estimates from previous years were based upon daytime or early night samples.

1 Introduction

Construction and evaluation of surface collectors to meet the goal of 80 percent fish passage efficiency (FPE) for salmon smolts passing the Bonneville Project will require extensive research. Project FPE is defined as the percent of all smolts passing the project by non-turbine routes, and its evaluation requires measurement of smolt passage through all significant routes. Estimating FPE and quantifying any enhancement by surface collectors will be difficult because the Bonneville Project is among the most complex on the Columbia River. From the Oregon shore north toward Washington, the project is composed of a navigation lock, a 10-unit Powerhouse 1, Bradford Island, an 18-gate spillway, Cascades Island, and an 8-unit Powerhouse 2. Principal passage routes include the spillway and two powerhouses, but within each powerhouse, passage can be through ice/trash sluiceways, turbines, or the juvenile bypass system (JBS). Smolts enter the JBS after they encounter traveling screens in the upper part of turbine intakes and are diverted to gatewell slots and orifices opening to a bypass channel.

This Technical Report describes results of studies conducted by US Army Engineer District, Portland (CENPP) and the US Army Engineer Waterways Experiment Station (CEWES) to resolve critical uncertainties in the implementation of smolt-collector technologies and measurement of FPE at Bonneville Dam. Studies in FY 1996 addressed questions of immediate concern for installation of prototype surface collectors in FY 98 or FY 99 and some strategies for measuring select components of FPE.

Available biological information is inadequate to design and locate successful surface collector prototypes at Bonneville Dam (Giorgi and Stevenson 1995). Information on the vertical and lateral distributions of smolts in forebay areas of both powerhouses and spillway is very limited. No mobile hydroacoustic sampling has been conducted, and the proportion of smolts approaching Powerhouse 1, the spillway, and Powerhouse 2 has not been estimated.

Diel (24 hour) patterns of smolt passage are not uniform regardless of whether passage is measured in sluiceways (Uremovich et al. 1980; Willis and Uremovich 1981) or the JBS (Hawkes et al. 1991; Wood et al. 1994). Diel passage through the JBS often has a bimodal distribution with a major peak occurring just after dark and a minor peak after sunrise. In contrast, passage through the sluiceway usually is higher during the day than at night (Willis and Uremovich 1981). However, patterns apparently are influenced by the operation of sluice gates (Uremovich et al. 1980), flow, unit outages, and species (Willis and Uremovich 1981). Hydroacoustic and Fyke-net measures of fish-guidance efficiency (FGE) are intensive but usually limited to a few hours per day and therefore do not provide diel information. Diel patterns of passage have important implications for statistical designs to estimate FPE at all three dam structures at Bonneville. Data on vertical distributions of smolts in forebay areas are limited to fixed-aspect hydroacoustic samples taken in front of trash racks of several turbine intakes at both powerhouses. The Fishery Field Unit sampled smolts with up-looking transducers at several units of Powerhouse 2 in 1985 (Nagy and Magne 1986) and of Powerhouse 1 in 1986. Similar vertical data were collected at the north end of Powerhouse 1 in 1995 with a deployment of down-looking transducers (Ploskey et al., In review). A problem with both data sets is that numbers of smolts in the upper water column (< ca. 6 m) were underestimated during the day because densities often were too high to accurately count fish. Nevertheless, these data clearly show a downward shift in the vertical distribution at night and a strong skew toward the surface during the day. Although these data reveal nothing about vertical distributions of smolts > 10 m upstream from structures, they do have implications for selecting depths of collector openings and for explaining day/night differences in FGE.

Available data indicate that the horizontal distribution of smolt passage among intakes is not uniform. Lateral distributions of smolts sampled in gatewells of Powerhouse 1 apparently are influenced by the number and location of operating units and sluice gates as well as the species of smolt (Willis and Uremovich 1981). Interactions among factors may account for a lack of consistency in measures of horizontal patterns by Uremovich et al. (1980), who found concentrations at units 6, 7, and 10, Willis and Uremovich (1981), who found variable patterns depending on operations, and Krcma et al. (1982), who observed most passage at units 4-6. Hydroacoustic sampling in front of intakes 8c-10b of Powerhouse 1 from 2200 through 0100 hours in June 1995 showed a distribution highly and consistently skewed toward Unit 10 (Ploskey et al., In review). Units 3, 4, and 6 were inoperable at the time of sampling. Considerable amounts of FGE data collected at Powerhouse 2 with in-turbine hydroacoustics (e.g., Magne et al. 1989; Stansell et al. 1990) and Fyke nets (Gessel et al. 1988; Muir et al. 1989) are of limited value for evaluating the lateral distribution of passage because they typically focused on one or two units at a time. Hydroacoustic sampling of smolts passing through several spillway gates was attempted in the mid 1980's by the Fishery Field Unit. Transducers were mounted on the bottom of gates and aimed upward in the water column and out from the gate. Apparently, noise generated by sound echoing off of vortices at some gates masked echoes from smolts and prevented a uniform distribution of sampling effort among gates. The assumption of equal sampling volume among transducers is critical for unbiased estimation of FPE.

Hydroacoustics also has been used on limited spatial and temporal scales to evaluate sampling potential or relative passage among a few routes. Thorne and Kuehl (1989) evaluated the effects of noise on hydroacoustic assessment of passage within several turbines of Powerhouse 1. Results showed that acoustic sampling was feasible at the units they tested. Magne et al. (1986, 1987, 1989) and Stansell et al. (1990) compared smolt passage through turbine units 11 and 17 with passage estimates obtained by Fyke netting and found reasonably good correlation for acoustic and Fyke-net FGE.

The goals for the FY 96 studies were to provide biological information necessary to facilitate the design and placement of a surface-collector prototype and to continue progress toward measuring Project FPE. Prioritized objectives included:

1. Use mobile hydroacoustics to measure the vertical and horizontal distribution of salmon smolts in forebay areas of both powerhouses and to characterize the day and night variation in spring and summer. This task was designed to provide guidance on the location and depth of openings of prototype surface collectors under prevailing operations in FY 96.

- 2. Estimate smolt passage into two turbines and the center sluice gate above each turbine, as well as the FPE ratio for the paired sluiceway/turbine openings under two test treatments for spring and summer at Powerhouse 1. Test treatments included alternating trash rack blocks between the two turbine units weekly and opening or closing of center sluice gates above test units according to a treatment schedule. Blocking trash racks served to increase the depth of the zone of separation between flow entering a turbine and flow entering a sluice gate. Opening a center sluice gate provided surface flow above the unit intake.
- 3. Estimate guided and unguided smolt passage into eight turbines of Powerhouse 2 and identify effects of the sluice chute on FGE of adjacent turbine units. The sluice chute was opened or closed for randomly selected 24-hour periods to provide treatments for evaluating its effect on Powerhouse 2 FPE in spring and summer.
- 4. Evaluate smolt behavior in terms of swimming direction in the area immediately upstream of two test units at Powerhouse 1, particularly near the zone of separation between flows entering turbines and flows entering sluice gates.

2 Materials and Methods

Mobile Hydroacoustic Surveys

Each season, we conducted six day and six night mobile hydroacoustic surveys in forebay areas of Bonneville Dam. Day surveys began about 1000 hours and night surveys about 2100 hours. Transects parallel to and located 10, 20, 30, 40, 50, 75, 100, 125, 150 m upstream of each powerhouse were sampled sequentially in opposite directions beginning at the powerhouse and moving upstream. Transect spacing was stratified to focus effort on forebay areas immediately upstream of each powerhouse. Transects were located 10 m apart in areas within 60 m of each powerhouse, 25 m apart in areas 75-150 m upstream, and 150-1000 m apart upstream toward the Bridge of the Gods (Figure 1). A BioSonics ES 2000 echosounder was used to transmit 420 kHz sounds from a 6 x 15 degree dual-beam transducer mounted on a BioSonics Biofin and deployed from a boom off the bow of a 24-ft boat. Target-strength information from the dual-beam transducer theoretically allowed us to count echo traces composed of smolt-sized targets and traces from larger fish. The ping rate during sampling was 10 pings per second in spring and 15 pings per second in summer. February 1996 calibration data for the transceiver and dualbeam transducer was used to set receiver gains (the amount of signal amplification) to avoid echo saturation from the largest targets of interest while amplifying echoes from fish with a target strength as low as -60 dB || 1 µPa. The sounder was controlled with BioSonics Dual-beam Multiplex software running on a 66 MHZ, 486 Austin laptop computer with a BioSonics Echo Signal Processing (ESP) board.

Densities of smolt-sized targets per m^3 were estimated for each 1-m depth interval and associated with a latitude and longitude from a Trimble Pathfinder Pro-XL geographical position system (GPS). Surveys within 150 m of each powerhouse had sub-meter position accuracy as the position dilution of precision (PDOP) was consistently < 4.0. Differential corrections were obtained from a Bureau of Land Management Bulletin Board in Portland, Oregon, and applied to position data after surveys were completed. Occasionally the PDOP exceeded 4.0 near the beginning or end of long transects located upstream of the Boat Restricted Zone (BRZ) and positions either had 1-10 m accuracy or were extrapolated from lines fitted to more reliable positions in the transect.

Dates of mobile surveys were selected to coincide with specific test treatments (Table 1). The goal was to survey three times while Unit 3 trash racks were blocked and three times when Unit 5 trash racks were blocked each season. Similarly, the schedule provided three day and night surveys when the sluice chute at Powerhouse 2 was open and three day and night surveys when it was closed each season.

Table 1							
		SPRING			1	SUMMER	
Day	Unit 3	Unit 5	Mobile	Day	Unit 3	Unit 5	Mobile
			Survey				Survey
26 Apr - Fri	UC	BO		14 Jun - Fri	BO	UC	
27 Apr - Sat	UO	BC		15 Jun - Sat	BO	UC	
28 Apr - Sun	UC	BO		16 Jun - Sun	BO	UC	
29 Apr - Mon	UC	BO		17 Jun - Mon	BC	UO	
30 Apr - Tue	UO	BC	x	18 Jun - Tue	BC	UO	
1 May - Wed	UO	BC		19 Jun - Wed	во	UC	
2 May - Thu	UC	BO		20 Jun - Thu	BO	UC	X'
3 May - Fri	во	UC		21 Jun - Fri	UC	BO	
4 May - Sat	BO	UC	x	22 Jun - Sat	UC	BO	
5 May - Sun	BC	UO		23 Jun - Sun	UO	BC	X'
6 May - Mon	BC	UO		24 Jun - Mon	UC	BO	
7 May - Tue	BO	UC		25 Jun - Tue	UO	BC	
8 May - Wed	во	UC	x	26 Jun - Wed	UO	BC	
9 May - Thu	BC	UO		27 Jun - Thu	UC	BO	x
10 May - Fri	UC	BO		28 Jun - Fri	BC	UO	
11 May - Sat	UO	BC		29 Jun - Sat	BC	UO	x
12 May - Sun	UC	BO	x	30 Jun - Sun	BO	UC	X
13 May - Mon	UC	BO		1 Jul - Mon	BC	UO	
14 May - Tue	UO	BC		2 Jul - Tue	вс	UO	
15 May - Wed	UC	BO	x	3 Jul - Wed	во	UC	x
16 May - Thu	υo	BC		4 Jul - Thu	во	UC	
17 May - Fri	вс	UO		5 Jul - Fri	UO	BC	
18 May - Sat	BC	υo	x	6 Jul - Sat	UO	BC	
19 May - Sun	BC	UO		7 Jul - Sun	UC	BO	x
20 May - Mon	BO	UC		8 Jul - Mon	UO	BC	
21 May - Tue	BO	UC		9 Jul - Tue	UC	BO	x
22 May - Wed	BC	UO		10 Jul - Wed	UO	BC	
23 May - Thu	BO	UC		11 Jul - Thu	UC	BO	
24 May - Fri				12 Jul - Fri			

¹ Surveys with invalid bottom settings that were repeated

Powerhouse 1 Passage at Manipulated Units and Sluice gates

Turbine Passage. At Powerhouse 1, the WES estimated smolt passage into Units 3 and 5 in two manipulative tests in two experimental tests each season. One test evaluated the effect of partially blocked versus unblocked turbine units, and the other evaluated effects of open or closed sluice gates. Trash racks of one unit were blocked to the maximum possible elevation, i.e., 10.1 m mean sea level (MSL), while those of the other unit were left unblocked. Blocked racks were moved weekly between test units, whereas the sluice opening above the center intake of test units was opened or closed according to the test design in Table 1. Fiscal constraints precluded moving the blocks more than three times per season. Units 3 and 5 were selected because they were thought to be far enough apart to minimize interaction effects due to flow. Units 4 and 6 were both inoperable throughout FY 96 sampling. Blocked trash racks were moved on Fridays, and relocation required about 8 hours. Chain-gate and sluice-chute changes were made between 0700 and 0900 hours so that day and night mobile surveys on the same day would have the same treatment.

In-turbine acoustic samples of passing smolts were made with a pair of 6-degree, 420-kHz, single-beam transducers mounted on trash racks inside every intake of turbine units 3 and 5 for four weeks in spring and four weeks in summer. Each turbine intake is protected from debris by six 3.6-m-tall x 6.4-m-wide trash racks that are stacked vertically in the most upstream slot. The first transducer of each pair was mounted on the downstream face and south end of the uppermost trash rack in the intake opening and aimed downward to sample unguided smolts passing below the traveling screen. It was aimed 24 degrees off of the downstream face of the trash rack and about 7 degrees north of vertical so that the distal end of the acoustic beam was centered from north to south on the intake floor. A 0.3- x 0.6-m hole had to be cut in the plywood block of the top trash rack to accommodate the transducer. The second transducer of each pair was mounted on the fifth (always unblocked) trash rack from the surface and aimed upward to sample fish passing above the tip of the screen. It was aimed about 21 degrees off of the downstream face of the trash rack and to the north of vertical 10 degrees to center the distal end of the acoustic beam from north to south on the intake ceiling. A system consisting of one Model 103 echosounder and six transducers made by Precision Acoustic Systems (PAS) Incorporated, Seattle, WA, were deployed to sample Unit 3 and another identical system was used to sample Unit 5. Each system was controlled by a Zeos 100-MHZ Pentium computer and HARP software by Hydroacoustic Assessments, Seattle, WA. We slow multiplexed among the three pairs of transducers per unit (i.e., rotated sampling among intakes) every 5 minutes, and sampled 24 hours per day, except for occasions when a computer locked up and was not restarted until the problem was discovered. Paired transducers per intake were sampled simultaneously by alternating pings at a rate of 30 per second or 15 pings per second per transducer. This ping rate provided essentially uniform detection of juvenile salmonids over the ranges sampled, given maximum in-turbine flows through beams of about 1.4 m/second. Flow estimates were obtained from runs of a 1:25 physical model of a Powerhouse 1 turbine with a traveling screen. Parameters used in detection modeling included ping rate, a circular 8-degree effective beam pattern, beam angle relative to fish trajectory, detection threshold, fish velocity, minimum and maximum range, mean target strength, minimum number of pings required. Criteria for accepting echo traces as guided fish were range = 5.9-13.8 m, 3-10 echoes per trace, linearity > 0.995, and -0.03 < slope < 0.03. Criteria for accepting echo traces as unguided fish were range = 5.9-17.5 m, 3-15 echoes per trace, linearity > 0.995, and slope > 0.01 m/ping.

About 2,500 hours of in-turbine data were processed using an automated tracking program developed during this project. About one fifth of these echograms also were processed by people visually

identifying echo traces as fish and appending trace statistics to a data base. An hour of data requires from 0.75-1.5 hours to process visually but only minutes with the automated tracking program, after the program is properly calibrated to perform like a visual tracker. We checked the quality of performance of the calibrated autotracking program by correlating numbers of fish tracked visually with the numbers tracked automatically. The correlation coefficient was 0.91 ($r^2 = 0.83$) for a sample of 253 paired estimates of fish / hour by both methods. Fish numbers in about 12 five-minute echogram segments were counted separately by both methods and summed for every day of sampling. About 50 percent of the 5-minute data segments came from night hours and the other 50 percent from day hours. Similarly, one half of the numbers was from transducers sampling guided fish, while the other half was from transducers sampling unguided fish. The equation describing the relation of counts based upon the two processing methods was log(visually tracked fish) = 0.910 × log(auto-tracked fish) + 0.095. Correlations between tracking methods were very similar for guided and unguided counts processed separately (guided: r^2 =0.85, N=134; unguided: r^2 =0.81, N=120). All results presented in this report were based upon automated processing to increase consistency and the robustness of data sets.

Cable routing from the echosounders to transducers had to allow for the upper three trash racks of each test unit (one set of racks blocked and the other unblocked) to be swapped weekly. Belden deck cables were routed from a mobile trailer located on the forebay deck (elevation 90 feet mean sea level) at Unit 4B, through a grating and under the crane tracks, and up to the hand railing. Deck cables were tie wrapped along the rail and routed to the pier immediately south of the intake to be sampled. At the pier point, the deck cables were attached to armored cables that were routed through 0.3-m-long, 7.6-cm diameter pipes welded to the downstream side and south end of each trash rack. Pieces of pipe were welded within 1 m of the top and bottom of each rack and permitted the upper three racks to be removed by feeding armored cable through the pipe as the crane lifted each rack until the cable cleared the pipe. Installation of each of the upper three racks required us to feed armored cable up through the pipe as each rack was lowered. Down-looking transducers mounted on the upper three racks were swapped among test units each week. As a result, down-looking transducers were controlled by different echosounders each week and calibration settings and receiver gains had to be changed accordingly in the controlling software before sampling resumed.

Numbers of tracked fish were expanded based upon the ratio of intake width to the diameter of the hydroacoustic beam at given range:

Expanded Numbers = $6.5 / (MID_R \times TAN(B0/2) \times 2)$

where 6.5 is the width of the intake in m, MID_R is the mid-point range of a fish trace in m, TAN is the tangent, and B0 is beam angle in degrees. This expansion was necessary to allow us to estimate passage of juvenile salmonids without bias associated with range-dependent sample volume. Beam angle depends upon the average target strength of fish because larger fish can be detected farther away from the main axis of the acoustic beam than smaller fish. We estimated the target strength and associated beam angle for smolt-sized targets by solving for target strength in an equation relating target strength to fish length (Love 1977) using length-frequency data on smolts sampled in the juvenile bypass each season by the NMFS.

Sluice Passage. Smolt passage into center sluice gates at intakes 3B and 5B was sampled with two separate up-looking 6-degree, 420-kHz, split-beam transducers located 1.5 m upstream of the south

pier at depths of 9 and 13 m, respectively. Split-beam transducers were mounted on a trolley fitted to a 18-m-long 15- x 15-cm wide flange that was attached vertically to the upstream edge of the adjacent pier. Transducer trolleys were lowered to depths of 13 m at Unit 5 and about 9 m at Unit 3. Depths were limited by warp in the 15- x 15-cm wide flange that prevented trolleys from moving past certain points. The warp was caused when divers tightened bolts securing the flange to the pier. Split-beam sampling was continuous (24 hours / day) at open center sluice gates after the 14 May 1996 installation, except on occasions when data acquisition inadvertently stopped due to computer-interrupts until the problem was discovered and corrected.

Passage of smolts over the center sluice gate at Intake 5B also was monitored using video cameras and infrared lights during spring and summer 1996. Four black and white cameras (Sony SSC-M350) and eight sets of lights (American Dynamics 30 watt, 50 degree LED banks) were mounted to the upstream side of the 6.4-m-wide chain gate and aimed upward toward the water's surface. Two infrared lights were placed on either side of every camera lens and aimed upward. Cameras and lights were powered by a Sony camera adapter YS-W230 and Tripp-Lite 110 VAC to 13.8 VDC PR-15 power converters, respectively. Video images were recorded using either a Sony HI8 EV-C200 Real Time recorder or a Sony EVT-820 Time Lapse recorder. Real time video was sampled at a rate of 30 frames/sec, allowing for three hours of real time video data to be captured on 180 minute metal evaporate tapes. Time lapse video was sampled at a rate of 4 frames/sec, allowing for 16 hours of time lapse video data to be captured on 120 minute tapes. Sequential sampling across all four cameras at one minute intervals was performed using a Sony YS-S100 intelligent sequential switcher. Video images were viewed with Sony SSM-171 black and white image monitors.

According to the treatment schedule (Table 1), the chain gate was lowered via the Gantry crane to the elevation at which the bottom of the camera mount rested on the sill of the intake, leaving the face of the cameras at elevation 21.3 m MSL. Video recording was continuous as long as Sluice Gate 5B was open. Generally and whenever feasible, real-time video data were collected during the day and time lapse video data were collected during the night. Infrared lights were turned on approximately at 1700 hr during each day of video recording.

Video counts of smolt passage were expanded both spatially and temporally. The cross-sectional area of a single camera's field of view based on a viewing distance of 0.61 m was calculated and multiplied by a factor of four to account for total coverage of all cameras. Cross-sectional area of water passing over the gate was calculated for each treatment day (variable due to fluctuating forebay levels) and divided by the cross-sectional area of camera coverage resulting in a factor used to expand counts to accommodate total coverage. Finally, counts were multiplied by a factor of five to account for our sub-sampling of 12 minutes for every hour of video data.

Correlation analysis was used to determine whether acoustic and video methods of estimating sluice passage of smolts provided concordant results. Passage estimates from both methods were used to estimate smolt passage into the center sluice opening and FPE for test units when the sluice gate was open. Days were the experimental unit for evaluating effects of trash-rack blocks and center sluice-gate openings on five measures of smolt passage (Table 2).

Table 2		
Variable Name	Abbreviatio	Definition
		Smolt Passage Variables
Standardized Turbine Passage into	STP	Standardized turbine passage (STP) is the number of smolts passing into
Fish Guidance Efficiency	FGE	Fish-guidance efficiency (FGE) of in-turbine screens is the percent of all
Fish Passage Efficiency	FPE	Fish passage efficiency (FPE) is percent of smolts passed by non-turbine
Standardized Sluice Passage	SSP	Standardized sluice passage (SSP) is the number of smolts passing into
Sluice Passage Efficiency	SPE	Sluice-passage efficiency (SPE) per turbine unit is the percent of all
		Treatment or Location Variables
Block and Sluice Treatment	TREAT	Blocked and open = BO; Blocked and closed = BC; Unblocked and open
Block Treatment	BTRT	Upper three trash racks blocked or unblocked without regard to sluice
Sluice Gate Treatment	GTRT	Center sluice gate open or closed without regard to block treatments at
Sluice-chute Treatment	CTREAT	Sluice chute at Powerhouse 2 open or closed for 24 hours
Turbine Unit	UNIT	Turbine Unit 3 or 5
Turbine Intake	INTAKE	Turbine Intake 3A, 3B, 3C, 5A, 5B, and 5C

Smolt Behavior Upstream of Test Units and Sluice Gates. The WES used split-beam hydroacoustics to evaluate smolt swimming direction relative to flows in the area upstream of Unit 5 at Powerhouse 1. Near-field measurements of flow were obtained with an acoustic Doppler current profiler and a Gurley flow meter by the WES Hydraulics Lab under several treatment conditions. Acoustic sampling of smolts focused upon the zone of separation between flows entering turbines and those entering sluice gates at night and during the day under different test conditions. The null hypothesis for trash-rack blocks was that smolts would not cross the zone of flow separation or strong velocity gradients. A 6-degree, 420 kHz, PAS split-beam transducer was attached to a dual axis rotator (Remote Ocean Systems Model PT-10). The rotator was mounted on a trolley that rolled up or down on a 15- x 15-cm wide flange attached to the pier just south of Intake 5B. By raising or lowering the trolley and rotating the transducer aiming angle, we were able to sample from a down-looking deployment, the transducer was aimed 7 degrees north of the east-west vertical plane and downward to intersect the trash rack at a range of 15 m. This maximum range was 2.5 m below the bottom of the trash-rack block. Both the uplooking and down-looking deployments were sampled for two 24-hour periods each season.

Powerhouse 2 Passage

The WES estimated guided and unguided smolt passage in eight turbines, the horizontal distribution of passage through the Powerhouse 2, and effects of the sluice chute on the FGE of adjacent units in spring and summer 1996. The sluice chute was opened or closed for 24-hour periods according to a stratified random design (Table 3).

Table 3					
	Spring			Summer	
Day	Sluice	Mobile Survey	Day	Sluice Chute	Mobile Survey
26 Apr - Fri	0		1 (14 Jun - Fri)	С	
27 Apr - Sat	C		2 (15 Jun - Sat)	0	
28 Apr - Sun	0		3 (16 Jun - Sun)	0	
29 Apr - Mon	0		4 (17 Jun - Mon)	С	
30 Apr - Tue	c	x	5 (18 Jun - Tue)	0	
1 May - Wed	С		6 (19 Jun - Wed)	С	
2 May - Thu	0		7 (20 Jun - Thu)	0	X'
3 May - Fri	С	x	8 (21 Jun - Fri)	С	
4 May - Sat	С		9 (22 Jun - Sat)	0	
5 May - Sun	0		10 (23 Jun - Sun)	c	X ¹
6 May - Mon	0		11 (24 Jun - Mon)	C	
7 May - Tue	C		12 (25 Jun - Tue)	0	
8 May - Wed	0	X	13 (26 Jun - Wed)	0	
9 May - Thu	С		14 (27 Jun - Thu)	C	X
10 May - Fri	0		15 (28 Jun - Fri)	C	
11 May - Sat	C		16 (29 Jun - Sat)	. 0	X
12 May - Sun	0	x	17 (30 Jun - Sun)	0	X
13 May - Mon	0		18 (1 Jul - Mon)	С	
14 May - Tuə	C		19 (2 Jul - Tue)	С	
15 May - Wed	C	X	20 (3 Jul - Wed)	0	X
16 May - Thu	0		21 (4 Jul - Thu)	C	
17 May - Fri	С		22 (5 Jul - Fri)	0	
18 May - Sat	0	X	23 (6 Jul - Sat)	0	
19 May - Sun	С		24 (7 Jul - Sun)	C	X
20 May - Mon	0		25 (8 Jul - Mon)	0	
21 May - Tue	С		26 (9 Jul - Tue)	c	x
22 May - Wed	C		27 (10 Jul - Wed)	0	
23 May - Thu	0		28 (11 Jul - Thu)	c	
24 May - Fri			29 (12 Jul - Fri)		

¹ Surveys with invalid bottom setting that were repeated.

Days were the experimental unit for evaluating effects of sluice-chute opening, and the test parameter was the FGE of adjacent turbine units (i.e., units 11 and 12). Unlike estimates of sluice-chute or turbine passage, FGE should be relatively independent of the number of smolts passing Powerhouse 2 on a given day.

In-turbine acoustic counts of smolts passing above and below traveling screens were made with paired, 6-degree, 420-kHz, single-beam transducers inside of eight intakes, each selected randomly from the three intakes composing every turbine unit. One transducer of each pair was mounted in the top of the second trash rack below the water surface and aimed downward to sample smolts passing below the screen. Initially, all down-looking transducers were mounted 0.5 m to the right of the vertical center of the trash rack and in the uppermost compartment. They were aimed 30 degrees off of the downstream face of the rack and along the east-west vertical plane. A second transducer of each pair was initially mounted near the vertical center of the fourth trash rack from the surface and aimed upward and downstream off of the face of the trash rack 25 degrees to sample fish passing above the tip of the screen. Armored cables were routed up the centerline of trash racks and through shackles welded to cross members near the top and bottom of each rack. All turbine units were running during spring and the first week of summer, but Unit 11 broke down and was out of commission thereafter.

Strong lateral flow toward the south end of Powerhouse 2 and turbulence created by flows passing TIES caused armored cables at Units 11 and 12 to vibrate wildly. Vibration either broke stainless steel Kellum grips near the transducer or on the 90 deck or rubbed the shackle pins through the armor causing an electrical short. After several failures of armored cable at intakes 11A and 12A, both down- and up-looking-transducers were moved from near the centerline to the sides of trash racks and aimed 7-10 degrees to the north or south of vertical to place the distal end of the acoustic beam near the center of the intake floor and ceiling, respectively.

One PAS-103 echosounder and eight transducers were deployed to sample intakes 11A, 12A, 13C, and 14B, and another identical system was used to sample intakes 15B, 16C, 17B, and 18A. Each system was controlled by a Zeos 100-MHZ Pentium computer and HARP software. We slow multiplexed among four pairs of transducers (i.e., rotated sampling sequentially among intakes) every 5 minutes, and sampled 24 hours per day, except when cables failed or on occasions when a computer locked up and was not restarted until the problem was discovered. Paired transducers per intake were sampled simultaneously by alternating pings at a rate of 30 per second or 15 pings per second for each transducer. This ping rate provided essentially uniform detection of juvenile salmonids over the ranges sampled, given maximum in-turbine flows through beams of about 1.4 m/second. Parameters used in detection modeling were the same as those used for Powerhouse 1 turbines. Criteria for accepting echo traces as guided fish were range = 4.6-10.8 m, 3-10 echoes per trace, linearity > 0.999, and -0.03 < slope < 0.03. Criteria for accepting echo traces as unguided fish were range = 4.8-17.5 m, 3-15 echoes per trace, linearity > 0.999, and -0.03 < slope < 0.03. Criteria for accepting echo traces as unguided fish were range = 4.8-17.5 m, 3-15 echoes per trace, linearity > 0.999, and -0.03 < slope < 0.01 m/ping. Numbers of tracked fish were expanded based upon the ratio of intake width to the diameter of the hydroacoustic beam at given range as described earlier under Powerhouse 1 Passage at Manipulated Unit and Sluice Gates.

On three dates in spring and two in summer, we unsuccessfully attempted to acoustically sample smolts passing into the sluice chute at Powerhouse 2 using either a 7-degree, 120-kHz transducer and echosounder made by PAS, Incorporated, or 6-degree, 420-kHz, single- or split-beam transducers and echosounders made by BioSonics Incorporated, Seattle, WA. Initial attempts involved mounting a transducer 1 m deep on a pole attached to the middle of the south side of the turbine intake extension

(TIE) on Intake 11A (5 m from the face of the powerhouse). The transducer was aimed horizontally south across the sluice opening. A dual axis rotator (Remote Ocean Systems Model PT-10) was programmed to repeatedly aim the single transducer 4, 7, and 14 degrees below the horizontal every 5 minutes to sample different depths. A second deployment involved mounting a transducer or a rotator and transducer on a pole extending out 3 m horizontally from upstream side of the sluice gate. The pole was mounted 1 m below the top of the gate so that opening the sluice gate lowered the transducer about 4.5 m below the water's surface. The transducer was aimed downstream 10 degrees from the vertical plane.

3 Results

Mobile Hydroacoustic Surveys

Overview

Locations of mobile hydroacoustic transects in forebay areas of Bonneville Dam are illustrated in Figures 1-3. Mobile samples could not be taken behind log booms and cables at Powerhouse 1 (Figure 2) or closer than about 20 m upstream of the face of Powerhouse 2 because of the presence of TIES. Within 30 m upstream of Powerhouse 1, 45 percent of the length of the dam could not be sampled because of the log booms and wire cable. From 40 to 75 m upstream, log-booms on the north and south side of the forebay prevented us from sampling the 5-19 percent of transects near shore. Sometimes transects at Powerhouse 2 had to be truncated because of floating logs and debris in the eddy at the north end of the forebay.

Plots of average densities of smolt-sized fish interpolated from transect data (Figures 4-19) or from densities in 1-m depth strata (Figures 20-27) do not account for variation among surveys and therefore must be tempered with results of statistical tests. For example, a plot showing high fish densities in a particular location may result from consistently high densities in most surveys or from very high densities in one or two of the six surveys per season.

Densities of smolt-sized fish usually were lower in upriver areas from the Bridge of the Gods down to the three-way split in the channel than they were near the powerhouses in spring (Figures 4 and 5) and particularly in summer (Figures 6 and 7). Highest densities of smolt-sized targets usually were in immediate forebay areas within 200 m of the dam (Figures 4-11), except for small areas downstream of islands upstream of the spillway in spring (Figures 8 and 9) or a larger area downstream (west) of the mouth of Eagle Creek in both seasons (Figures 8-11). In general, average fish densities were higher in summer than in spring, and average fish density patterns were similar for day and night surveys.

Powerhouse 1

In spring, average densities in the Powerhouse 1 forebay were higher in mid-channel areas than near shore (Figures 12 and 13) and lowest upstream of units 8-10. There were no significant differences in smolt density (number/ m^3) among springtime transects upstream and within 75 m of Powerhouse 1, but there were differences in density among turbine units, and depth strata. There also was a significant interaction effect by at least two of the three dimensions. There were significant differences in springtime smolt density (number / m^3) among turbine units (lateral distribution) and among 6-m depth strata (vertical distribution), but there was no effect of lateral position on vertical distribution (i.e., the interaction term was not significant). Mean densities were significantly higher upstream of turbine units 4-5 and 1-2 than they were upstream of units 8-9 and 10 north to Bradford Island. Mean density was higher upstream of units 4-5 than at all other units except Unit 1 south to the navigation lock wall. There were no significant differences in springtime smolt density among transects 1-5 (10-50 m upstream of Powerhouse 1) nor among transects 2-6 (20-75 m upstream).

In summer, average densities were more spread out along Powerhouse 1 and the north-shore of Bradford Island (Figures 14 and 15) than they were in spring. There were significant differences in summertime smolt density (number / m^2) among turbine units (lateral distribution) and a slight effect on transect distance upstream from the dam on that distribution (i.e., the interaction term was significant). There were no significant differences in smolt density (number/m³) among transects upstream and within 75 m of Powerhouse 1 at $\alpha = 0.05$. There were significant differences in summertime smolt density (number / m³) among turbine units (lateral distribution) and among 6-m depth strata (vertical distribution), but there was no effect of lateral position (UNIT) on vertical distribution (i.e., the interaction term was not significant).

Powerhouse 2

In both spring and summer, the average of six day or six night surveys usually showed the highest densities upstream of units 11-13 (Figures 16-19) and smaller patches of high densities upstream of Unit 18 or just north of Unit 18. In spring, we detected no significant differences in smolt densities among transects within 75 m of the dam, but there were differences among turbine units and 6-m depth strata. There was a significant interaction between effects of transects and turbine units on mean density, i.e., the lateral distribution changed as smolts approached the dam. Average springtime densities of smolt-sized fish upstream of Unit 18 were higher at night than during the day (compare Figures 16 and 17), and densities in the north corner of Powerhouse 2 were higher during the day than at night (compare Figures 18 and 19). In summer, a two-way ANOVA showed significant differences in mean numbers per m² among transects upstream and within 75 m of Powerhouse 2 and among turbine units, but there was no significant interaction between effects of transects and units, i.e., the lateral distribution apparently does not change as smolts approach within 75 m of the dam. In summer, mean densities were significantly higher upstream of turbine units 11, 12-13 and 18 than they were at units 14-15 and 16-17. No significant differences in means were detected among units 11, 12-13, and 18 nor among units 14-15 and 16-17.

At Powerhouse 2, vertical interpolations for transects 1 and 2 showed the highest concentrations of fish in the upper one third of the water column regardless of sluice- chute treatment or time of day in both spring (Figures 20-23) and summer (Figures 24-27). However, smolt-sized fish often were observed in low densities at depths > 15 m. Although variability among surveys was high, densities of fish at transects 1 and 2 tended to be higher during surveys when sluice chute was closed than when it was open (Figures 20-27), particularly in summer (Figures 24-27).

Changes in Vertical Distributions near Powerhouses

Average vertical distributions of smolt-sized fish at transects 50-70 m upstream of powerhouses usually differed from distributions at transects just 20 m upstream, but differences were not the same for both powerhouses. The vertical distribution of smolt-sized fish within 20 m of Powerhouse 1 was

consistently shallower than the distribution of fish 50-75 m upstream, regardless of time of day or season (Figures 28-31). In contrast, the vertical distribution within 20 m of Powerhouse 2 usually was deeper than the distribution of fish 50-75 m upstream (Figures 32-35).

Powerhouse 1 Passage at Manipulated Units and Sluice gates

Background

Variable names, abbreviations, and definitions used in the following description of effects are presented in Table 2. Results are presented by season and response variable, usually with two-way analysis of variance (ANOVA) tests described first followed by results of one-way-ANOVA and multiple-range tests. Variable names often are capitalized to make them easy to identify and reference to Table 2. Most ANOVA tables and multiple range tests are included as appendices to this report.

We found no significant correlation of sluice passage estimates from split-beam sampling with estimates from four underwater video cameras mounted on the sluice gate (Figure 36). Therefore, we relied upon camera counts in which we had a high degree of confidence for estimating smolt passage into the 5B sluice. We were forced to use split-beam estimates of the flux of smolts toward the sluice opening at 3B because cameras were not deployed there. Data from split beams at 3B and 5B were process in the same way. We used the net movement or flux of fish toward the sluice gate as a measure of passage because many fish also were tracked moving upstream through the beam and away from the open gate. Estimates required many assumptions about which fish were most likely to enter the sluice opening based upon their depth and direction of travel. We assumed that smolt-sized fish at depths from 2-4 m that were moving up in the water column and all smolts < 2 m deep were likely to pass into the sluice opening if they were moving downstream toward the center of the gate (± 45 horizontal degrees). However, we subtracted the number that were moving upstream away from the sluice gate from the number moving toward the gate because smolt-sized fish moved through the acoustic beam in all directions. Unfortunately, smolts were not committed to passing into the sluice when they were 3-4 m upstream of the gate, and up-looking split beams could not be aimed closer than 3-4 m upstream of the gate opening because a trash rack was placed there for boat safety. Normally, this top trash rack would not be present so that logs and debris would pass into the sluiceway. The only redeeming feature of the split-beam estimate of fish flux toward the gate was that it was always positive, i.e., the number moving downstream always exceeded the number moving upstream.

Spring

Standardized turbine passage (STP). The STP into turbines differed significantly among block treatments (BTRT) and turbine units (UNIT), but the interaction effect of BTRT and UNIT was not significant at $\alpha = 0.05$. The STP did not differ among combination block and sluice treatments (TREAT), probably because sluice-gate treatments (GTRT) had no significant effect. We also found no significant effect of the interaction term GTRT x UNIT. A two way ANOVA looking at the effect of BTRT and GTRT showed a significant effect of BTRT and no effect of GTRT or the interaction of BTRT and GTRT. Pooling data for units 3 and 5 despite differences among units showed that blocking upper racks significantly reduced STP from a mean of 0.32 to 0.19. At Unit 3, STP was lower when the upper three trash racks were blocked (mean = 0.014) than when they were unblocked (mean = 0.029) and STP did not differ among open and closed sluice gate treatments (GTRT). In contrast, we found no significant effect

of TREAT, BTRT or GTRT for Unit 5, so the significant BTRT effect for pooled data for both units was entirely due to effects at Unit 3.

Effects of treatments on STP also were examined by turbine intake and treatment. We found a highly significant effect of INTAKE, BTRT, and the interaction term INTAKE*BTRT. Intakes 3A, 3C, and 5A all had significantly lower mean STP when blocked than when unblocked. Blocking had no effect at intakes 3B or 5B, and Intake 5C showed the opposite effect (i.e., blocking doubled turbine passage). Pooled data for Unit 3 and 5 indicated lower STP during blocked than during unblocked treatments. The STP was higher at all unit 3 intakes and Intake 5A, which did not differ, than it was at intakes 5B and 5C.

Fish passage efficiency (FPE). The FPE for pooled data for units 3 and 5 was unaffected by combined block and sluice treatments (TREAT), units (UNIT), and the interaction thereof. It also was unaffected by block treatment (BTRT), sluice gate treatment (GTRT), and their interaction. The change in mean FPE among sluice-gate treatments (GTRT) was significant at Unit 5 but not at Unit 3, although the direction of change was similar for both units. At Unit 3, the mean for the open-gate-treatment was 58.6 percent relative to 40 percent for the closed gate treatment. At Unit 5, opening a center sluice gate significantly increased mean FPE from 27.5 to 63.0 percent.

Fish guidance efficiency (FGE). The FGE, which could only be estimated for unblocked treatments, was significantly affected by UNIT and INTAKE, but not by the sluice-gate treatment (GTRT) or the interaction of the INTAKE and GTRT. Mean FGE was higher at Unit 3 (49%) than at Unit 5 (29%), and within both units, FGE was consistently higher in the A intake than in the B and C intakes, which did not differ significantly (Figure 37). We found no significant difference in the mean FGE for closed- and open-sluice treatments at either unit (Figure 38 and 39). Mean FGE for unblocked treatments nearly differed significantly between day and night at Unit 3 (day = 74; night = 69; P = 0.1140; N = 25) and at Unit 5 (day = 45; night = 33%; P = 0.1922; N = 19).

Standardized sluice passage (SSP). The SSP was not significantly affected by block treatments, unit, nor the interaction effect of blocking treatments and unit. This result was consistent for pooled data for both units and for individual units. However, the ratio of blocked to unblocked means were consistently > 1, as follows: 4.8 (units pooled), 6.8 (Unit 3), and 2.2 (Unit 5), although variability in SSP was high in all cases. The probability associated with the statistical test on underwater video counts at sluice gate 5B was nearly significant at a 5 percent level (P = 0.0809), indicating higher sluice passage in spring during blocked treatments than during unblocked treatments.

Sluice passage over the diel cycle for selected spring days (Figure 40) shows that the majority of passage occurred during the early morning hours, with a peak at approximately 0300 hours. Passage was reduced during daytime hours and appeared to increase shortly after sunset. Hourly sluice passage over the spring migration season (Figure 41) shows a similar pattern, with peak passage occurring in the early morning hours then declining steadily to a much reduced daytime passage rate. A secondary peak is apparent shortly after sunset.

The horizontal distribution of smolt passage over sluice gate 5B (Table 4) was not uniform for spring migrants. A disproportionate number of smolts passed near the ends of the gate (especially the north end) than near the middle. This trend even more noticeable during the day than at night. An analysis of variance comparing mean proportional counts of end cameras (cameras 1 and 4 pooled) with

means for middle cameras (cameras 2 and 3 pooled) was significant. Passage events captured with real time sampling rates (30 frames per second) in the spring resulted in a mean of 2.7 and a maximum of 15 frames per event. Passage events captured with time-lapse sampling rates (4 frames per second) in the spring resulted in a mean and maximum of 1 frame per event.

Sluice passage efficiency (SPE). The SPE was significantly affected by unit, but not by block treatment, or the interaction of block treatment and unit. The ratio of blocked : unblocked means was as follows: 62.8 : 51.0 (units pooled), 40.4 : 25.8 (Unit 3), and 89.0 : 76.2 (Unit 5), respectively.

Summer

Standardized turbine passage (STP). The STP into test turbines differed significantly among block treatments (BTRT) and turbine units, and the interaction effect of BTRT x UNIT was significant. There was no significant effect of sluice gate treatment or the interaction of BTRT x GTRT. We processed data for the two units separately because of the strong effect of unit upon results. For Unit 3, blocked treatments with open or closed center sluice gates (TREAT) resulted in significantly lower mean STP (0.07 for open sluice and 0.09 for closed sluice) than did unblocked treatments (0.27). Mean STP did not differ between open and closed sluice treatments at Unit 3. At Unit 5, mean STP was significantly higher for blocked treatments with an open or closed center sluice gate (open mean = 0.92; closed mean = 0.97) than it was for unblocked treatments (closed mean = 0.33; open mean = 0.34), just the opposite of what was observed at Unit 3. At Unit 5 like at Unit 3, mean STP did not differ between open and closed sluice 3, mean STP did not differ between open and closed sluice 3, mean STP did not differ between open and closed treatments (closed mean = 0.33; open mean = 0.34), just the opposite of sluice gate treatments.

Effects of treatments on STP also were examined by turbine intake and treatment. We found highly significant effects of intake, block treatment, and the interaction term INTAKE*BTRT in a two-way ANOVA. Intakes 3A, 3C, and 5B all had significantly lower mean STP when trash racks were blocked than when they were not blocked. Blocking had no significant effect on mean STP at intakes 3B or 5C at $\alpha = 0.05$, although the difference at 3B was nearly significant (P = 0.0553). Mean STP at intake 5A was higher under the blocked treatment than it was under the unblocked treatment. Intake 5A had a higher mean STP than all other intakes, which did not differ significantly.

Fish passage efficiency (FPE). The FPE for pooled data for units 3 and 5 was significantly affected by combined sluice treatments, units, and the interaction thereof. The highest mean was for the unblocked, open-sluice treatment (77.8%) which was significantly greater than the unblocked, closed sluice treatment (53.9%). For Unit 3, the mean FPE for the unblocked, open sluice treatment (87.0%) was significantly higher than mean for the unblocked closed treatments (56.3%), which did not differ. At Unit 5, means for the unblocked open (67.0%) and unblocked closed treatments (52.5%) did not differ.

Effects of sluice-gate treatment (GTRT) for data pooled for both units was not significant as it was confounded by a significant among-unit effect (P = 0.0026) and the interaction of GTRT x UNIT (P = 0.0136). For Unit 3, the mean FPE for the open sluice treatment (76.9%) was significantly higher than the mean for the closed sluice treatment (30.3%). Means for the same treatments at Unit 5, i.e., open sluice = 39.1% and closed sluice = 29.0%, did not differ at $\alpha = 0.05$.

Fish guidance efficiency (FGE). The FGE relative to in-turbine traveling screens was significantly affected by intake but not by sluice-gate treatment (GTRT), or the interaction of GTRT and intake. Mean FGE was higher for Unit 3 (57%) than for Unit 5 (49%) at $\alpha = 0.15$ (P = 0.1378). Estimates of FGE did not differ significantly among open- and closed-sluice treatments at either unit (Figures 42 and 43). Mean FGE was similar for intakes 3A, 3C, 5B, and 5C and ranged from 62 to 64%, and it was lower for intakes 5A and 3B, which did not differ significantly (Figure 44). Mean FGE did not differ between day and night periods at Unit 3 (day = 57%; night = 55%) or at Unit 5 (day = 50%; night = 44%).

Standardized sluice passage (SSP). The SSP was affected by block treatments, unit, and the interaction effect of TREAT and UNIT. For Unit 3, mean SSP was significantly higher for the unblocked, open-sluice treatment than it was for the blocked, open-sluice treatment. Blocked trash racks did not have a significant effect (alpha = 0.05) on video-monitored sluice passage at Intake 5B.

Sluice passage over the diel cycle for 18 June (Figure 40) shows that, as in the spring, the majority of passage occurred during the early morning hours, with a peak at approximately 3 a.m. Passage was reduced during daytime hours for 18 and 27 June, and increased sharply just after sunset. As in the spring, hourly sluice passage in summer peaked in the early morning hours and then declined steadily to a much reduced daytime passage rate (Figure 41). A secondary peak of higher magnitude than the secondary peak in spring was apparent shortly after sunset.

Analysis of variance on proportional counts for corner cameras (cameras 1 and 4 pooled) relative to middle cameras (cameras 2 and 3 pooled) showed that differences were significant. Passage events captured with real time sampling rates (30 frames per second) in the summer resulted in a mean of 2.9 and a maximum of 11 video frames per smolt. Passage events captured with time-lapse sampling rates at night (4 frames per second) in the summer resulted in a mean and maximum of 1 frame per smolt. However, trends in the horizontal distribution of passage were observed for both time-lapse and real-time sampling. Horizontal distribution of passage at Intake 5B in summer was similar to that observed in spring (Table 4). In both seasons disproportionate number of smolts passed near the ends of the sluice gate than passed over the middle. This trend was more noticeable at night than during the day in summer, just the opposite of the pattern observed in spring.

Sluice passage efficiency (SPE). (TREAT x UNIT). Means nearly differed among unblocked (46.0%) and blocked treatments (22.5%) for Unit 5 but not for Unit 3 (unblocked = 69.5%; blocked = 68.1%). Unit-three estimates were based solely on split-beam counts, whereas Unit 5 counts were based upon video counts.

Diel Trends in Spring and Summer

Mean hourly smolt passage into turbines generally was higher during night hours than during day hours in both seasons. Data were more variable in spring than in summer (Figure 45). The pattern of increased passage just after sunset is consistent with what has been observed for the juvenile bypass channel at Bonneville. However, passage though the bypass peaks just after sunset and then falls off during the night not unlike the pattern for spring. In summer, mean total passage into the turbine did not appear to decrease during the night.

Table 4						
Treatmen	Camera	Camera 2	Camera	Camera	N	
Spring	22.00	19.30	20.80	38.00	524	
Day	28.10	16.70	16.70	38.50	96	
Night	20.60	20.00	21.70	37.90	428	I †
						•
Blocked	21.60	18.20	21.00	39.20	362	
Unblocked	22.80	21.60	20.40	35.20	162	
						F
Summer	31.50	18.70	15.60	34.10	577	L
						0
Day	31.10	13.50	20.30	35.10	74	W
Night	31.60	19.50	14.90	34.00	503	
Blocked	26.70	19.80	11.60	41.80	232	
Unblocked	34.80	18.00	18.30	29.00	345	

Smolt Behavior Upstream of Test Units and Sluice Gates

Split-beam acoustics were better suited for qualitative sampling of smolt behavior upstream of sluice gates than for making quantitative estimates of number of smolts passing into the 0.5-2-m deep surface sluice openings. Smolt-sized fish moved through the acoustic beam in all directions, although the number moving in a downstream direction always exceeded the number moving in an upstream direction. Clearly smolts in the acoustic beam were not committed to passage in the center intakes or sluice opening. We examined the number of smolts moving up and down in the water column relative to depth of fish and test treatments, including blocked or unblocked trash racks and open or closed center sluice gates. Most tests were on the ratio of fish moving up to the number moving down in the water column 3-4 m upstream of the intake 3B or 5B. At Intake 3B the ratio of upward-to downward-moving fish differed significantly between treatments. Means were 4.0 for the blocked, open-sluice treatment and 1.7 for the unblocked, open-sluice treatment at Intake 3B when all depth intervals were pooled. The mean number of fish moving up in the water column per treatment day was significantly higher during blocked, open-sluice treatments for fish at depths of 5-6 m for Unit 3 and at all depths for Unit 5 than it was for unblocked, open-sluice treatments (Figure 54). However, we found no significant effect of fish depth, test treatment, nor the treatment x depth interaction on the up:down ratio for Intake 5B (Figure 54) as nearly equivalent numbers of fish were detected moving up and down. At Intake 5B, numbers of upward and downward moving fish at all depths were higher during the blocked, open-sluice treatment than during the unblocked, open-sluice treatment, just the opposite of results for downward moving fish at 3-4 m of depth upstream of Intake 3B. Treatment means for all depths at Intake 5B were 1.3 for the blocked, open-sluice treatments and 1.1 for the unblocked, open-sluice treatment. Numbers of fish moving deeper in the 3-4 m

depth strata upstream of Unit 3 were higher during the unblocked, open-sluice treatment than during the blocked, open-sluice treatment (Figure 54). Differences at other depths were not significant.

Powerhouse 2 Passage

Spring

Two-way analysis of variance indicated that there were highly significant differences in standardized turbine passage (STP) among intakes, but effects of sluice-chute treatments (CTREAT) and the interaction of INTAKE x CTREAT were not significant at $\alpha = 0.05$ (P < 0.1). At Intake 11A, STP was 1.5 times higher on days when the sluice chute was closed than when it was open at $\alpha = 0.1$. Nothing approaching a significant effect of sluice-chute operations was detected for other intakes at Powerhouse 2. Analysis of total smolt passage into turbines intakes revealed that Intake 11A passed significantly more fish per unit of trackable time than all other monitored intakes.

Examples of diel cycles of turbine passage (Figure 46) showed a nighttime peak for a couple of treatment days, but the majority of days had no consistent pattern, as data were highly variable in spring. Expanded counts of smolts in the juvenile bypass (screen guided fish) from NMFS showed the springtime daily passage peak at 2200 hours (Figure 47). Total smolt passage by treatment day for the spring migration (Figure 48) shows a fairly consistent rate of passage for most of the first half of the season before peaking towards the end of the third and into the fourth week. This pattern also occurred in the plot of NMFS bypass data from the same period.

Analysis of fish guidance efficiency (FGE) showed significant differences among intakes (Figure 49), but no effect of sluice-chute treatment or an interaction term. Intake 12A that had no TIE had the highest mean FGE and differed significantly from all other intakes except 15B. Sampled intakes on either side of 12A with TIES both had lower FGE than 12A. Intake 11A had the lowest mean FGE and did not differ significantly from intakes 14B, 16C and 18A. Intakes 13C, 14B, 16C, 17B, and 18A also did not differ.

The spatial pattern of variable FGE estimates across the powerhouse was consistent for day and night periods of time (Figure 50). Sluice chute treatments had no significant effect on FGE by intake. Guidance efficiency by treatment day for the spring migration (Figure 48) shows a tri-modal pattern of equal amplitudes, with a substantial trough occurring towards the end of the third and into the fourth week. This temporal reduction in FGE coincides with the peak in total turbine passage for the spring migration (Figure 48). Mean FGE for the powerhouse was 37% in spring. Mean FGE for all intakes was significantly higher (P = 0.0004; N = 350) during the day (45%) than it was at night (27%).

Summer

A two way analysis of variance showed a strong effect of intake on standardized turbine passage (STP) but no effect of sluice-chute treatment or the interaction term INTAKE x CTREAT. Analysis of total smolt passage by intake for the summer migration showed that Intake 11A passed significantly more fish per unit of trackable time than all other monitored intakes, as it did in spring. However, turbine unit 11 was inoperable for most of the summer migration season, so the sample size for Intake 11A was small

(N = 5 treatment days) relative to the other intakes (sample sizes ranged from 21 to 28 treatment days). There was no effect of sluice chute treatment on standardized turbine passage at any intake.

The diel pattern of total smolt passage in summer had a pronounced peak during nighttime hours for the majority of days (Figure 51). The summer diel peak for TSP occurs either during the evening at 2200 to 2300 or the early morning hours of 0200 to 0400. Bypass data on screen-guided smolts from NMFS for 1996 shows daily peak passage during the summer migration at 2300 hours (Figure 47). The summer run pattern (Figure 52) was initially high during the first week (based on a couple of sharp spikes) then leveled out for two weeks before moderately increasing during the last week. Bypass data from NMFS depicts a general increase in the run through the summer season before peaking towards the beginning of the last week.

Analysis of guidance efficiency for the summer migration showed considerable differences among intakes (Figure 53) but no significant effect of the sluice-chute treatment or an interaction between CTREAT and INTAKE on FGE. Intake 12A had the highest mean FGE during the summer, and it differed significantly from Intakes 16C, 18A and 11A. Intake 11A had the lowest mean FGE and differed significantly from Intakes 12A and 14B. The spatial pattern of FGE estimates across the powerhouse depicts higher guidance efficiency among a group of adjacent units starting with Intake 12A and spanning to 15B. This pattern was consistent for day and night hours (Figure 53). The only difference was a shift of higher FGE among this group of intakes towards Intake 14B at night. Unlike patterns of FGE and turbine passage in spring, the summer pattern (Figure 52) shows highest turbine passage and guidance during the first week of the season, a decrease and leveling off through summer. Mean FGE across the powerhouse during summer was 26%. The mean for all intakes was significantly higher (P = 0.0001; N = 417) during the day (38%) than it was at night (25%).

4 Discussion

Inferences about Desirable Locations and Depths for Collectors

Low FGE of traveling screens in turbines of both powerhouses and a desire to increase Project FPE have been driving forces behind proposals to evaluate prototype surface collectors at Bonneville Dam. Results from 1996 sampling of smolt passage with hydroacoustics and cameras provide evidence that surface collection has promise to increase FPE at Bonneville Dam. The 1996 test results were not without ambiguities, many of which can be explained by high variability among days, turbine units, and intakes. Also sample sizes were limited by the duration of spring and summer runs and by significant differences in measures of smolt passage among units and intakes that kept us from pooling data to increase sample size and the power of statistical tests.

Mobile surveys showed significant longitudinal, lateral, and vertical gradients in smolt density that provide opportunities to optimize prototype location and configuration. High densities of fish estimated by mobile acoustics show where fish are holding, whereas areas with low densities suggest that fish either do not use an area or are moving more rapidly through it. For example, we consistently found low densities in the riverine area upstream of the boat restricted zone to the Bridge of the Gods and high densities in certain areas near both powerhouses.

At Powerhouse 1, mean densities generally were higher in mid-channel areas in spring and were more spread out along the powerhouse in summer. If this pattern is consistent in 1997 mobile surveys, a good test location for a prototype collector would be near the center of the powerhouse at units 3-5 or 4-6, especially in spring. Lateral densities at Powerhouse 1 in summer also suggest that many young-of-year smolts would encounter a centrally located collector, although smolts may be more dense along the north shore than at the center of the powerhouse. The highest densities of smolts in forebay areas in summer were 2.6 times higher than the highest densities in spring. Unfortunately, we could not be certain of the horizontal distribution near Powerhouse 1 because we could not survey the area immediately upstream of units 7 - 10 or along the north shore of Bradford Island because of a steel cable and log boom. However, we know from fixed-aspect sampling in June 1995 that the area north of Unit 7 had a high density of smolts in summer (Ploskey et al. In Review).

We found a consistent upward shift in the vertical distribution of smolts when comparing samples 50-75 m upstream of Powerhouse 1 to distributions 10-20 m upstream of the dam. This shift may be explained by smolts moving up in the water column as they approach the dam, a behavior that a surface collector could exploit. This distribution shift also might be caused by entrainment and removal of smolts

from depths greater than 8 m near turbine intakes, but we find it hard to believe that smolts 10-20 m upstream of turbines would be susceptible to entrainment or that they would mill around an area 1-20 m from the intakes in 1.2 m / sec flows. Radio tracking of smolts suggests that there is little horizontal movement along the powerhouse or milling (Rip Shively, Personal Communication). Nevertheless, both hypotheses for explaining the shift in vertical distribution should be tested by tracking smolts with depth sensitive radio tags or by passive split-beam tracking of smolts with ultrasonic tags.

Lateral distributions of smolts were more consistent for both seasons at Powerhouse 2 than at Powerhouse 1 and, if confirmed by 1997 mobile surveys, we would recommend intakes 11-13 or Unit 18 as good locations for a collector prototype because that is where we almost always observed the highest densities of smolts. With modification, the sluice chute near unit 11 also would be a good collector because of its proximity to relatively high densities of smolts holding upstream of Unit 11-13. In-turbine acoustic sampling also identified these units as having high passage rates. We usually found lower densities upstream of Unit 11-13 on days when the sluice chute was open than when it was closed suggesting that the chute reduced holding in the south eddy. However, we found no effect of sluice-chute operations on the fish-guidance efficiency of screens in adjacent intakes. Therefore, benefits of the sluice chute would appear to be solely a function of numbers of smolts it passed rather than altering depth distributions of smolts and increasing FGE of traveling screens. Laminar flows toward the chute opening likely could be increased by removing TIES on the south end of the powerhouse. In fixed-aspect sampling, we found that intakes with TIES passed significantly more fish but with a lower FGE than intakes without TIES. A potential problem with this interpretation is that sampled intakes with TIES were clustered in the south half of the powerhouse (i.e., 11A, 13C, and 14B) and differences in passage and FGE might be a function of location as much as intake shape. It is interesting that the highest FGE in spring and summer was observed at Intake 12A which was between low-FGE intakes with TIES. Mobile surveys in summer detected no significant interaction between effects of transects and units, i.e., the lateral distribution apparently does not change as smolts approach within 75 m of the dam. This result is consistent with observations by the NBS researchers tracking smolts (Rip Shively, Personal Communication). Gessel et al. (1988) observed higher FGE at intake 12A without a TIE (> 70%) than at intake 12B with a TIE (60%) and recommended alternating TIES on every other intake at Powerhouse 2...

We tried several times to sample the sluice chute with fixed-aspect hydroacoustics and failed each time because of high background noise from entrained air associated with a fully opened gate and turbulent flows moving around the end of the TIE on Intake 11A and up-welling flow upstream of the gate. Two cabled logs deployed upstream of the sluice-chute opening as a safety measure to prevent survey boats from being passed down the sluice way also may have contributed to background noise levels. However, some acoustic sampling was possible in 1988 when the gate was opened to elevation 21 m MSL or 1.5 m deep (Stansell et al. 1990) below normal pool elevation. Sluice passage, even with such a small opening, was about 60-63% of total passage through Unit 11 or 18 in spring and about 28 and 45% of total passage through Unit 11 and 18, respectively, in summer. Perhaps a larger opening would pass even more smolts and modification of the chute could turn the sluice into a valuable surface collector.

The sluice gate was fully open (elevation 18.6 m MSL or 3.96 m of depth below normal pool elevation 22.55 m MSL) during all of our attempts at monitoring. Our first attempt was with a 120 kHz split-beam transducer mounted on the TIE at 11A and aimed horizontally across the sluice opening. Sampling revealed a signal to noise ratio of about 1 even when the threshold was set to see fish > -44 dB

(about 150 mm long). This means that most yearling and all sub-yearling smolts could not be counted. We also sampled with BioSonics digital, 420-kHz, single- and split-beam transducers. Transducers were mounted 1-m below the top of the sluice gate on the end of a 3-m-long pole extending out into the forebay perpendicular to gate. Transducers were aimed upward and about 45 degrees downstream of vertical and provided a maximum range of about 4 m to the water's surface. Maximum beam diameter at 4 m is about 0.42 m, so the small sample volume should have greatly reduced volume reverberation. Nevertheless, noise from entrained air obscured smolts smaller than about -47 dB or about 100 mm long from reliable detection. Also, surges in turbulent flow moving around the TIE at 11A prevented reliable counting of larger smolts one fourth of the time.

The vertical distribution of smolts in the forebay upstream of Powerhouse 2 was strongly skewed toward the surface during most surveys but it was different within 20 m of TIES than it was 50-75 m upstream. The downward shift in the vertical distribution as smolts approached the dam was the opposite of what we observed at Powerhouse 1. The shift may be a function of approach hydraulics caused by the rapid increase in depth as smolts approach Powerhouse 2. Flows moving over the relatively shallow area (13.4 m deep) between transects 9 and 5 (Figure 3) probably decelerate and mix vertically as depths increased rapidly to 30 m over a horizontal distance of about 40 m. This possibility should be evaluated using physical models of the Powerhouse 2 forebay.

Inferences about Blocked Trash-Rack Effects

Blocking and unblocking the upper three trash racks down to a depth of about 13.4 m was designed to test the hypothesis that total smolt passage into a turbine or intake would decrease when racks were blocked. Biologists have hypothesized that smolts either would avoid rapidly accelerating flow or move up in the water column upstream of trash rack blocks. Another hypothesis was that sluice passage and the efficiency of the sluice relative to total passage (SPE) would be higher when racks were blocked than when they were not blocked. Estimates of FGE could not be made during blocked trash rack treatments because traveling screens were not installed behind blocks. Even if they had been installed, there was insufficient flow behind blocks to guide fish. Counts of smolts behind blocked trash racks were over five times higher than counts in the same intake area when racks were not blocked. Fish behind blocks were wallowing in and out of the up-looking acoustic beam and differences in blocked and unblocked counts likely resulted from multiple counts of milling fish in low velocity flows behind blocks. Consequently, we did not use counts of fish behind blocks to evaluate any treatment effects.

Although results were not consistently significant, there was considerable evidence that blocking trash racks (lowering the zone of flow separation) was beneficial. For example, total standardized passage was significantly less for blocked treatments (passage under blocks) than for unblocked treatments at Unit 3 in spring (53% less) and summer (70.3% less). Several individual intakes also showed significant differences. In spring, for example, intakes 3A, 3C, and 5A all had lower mean STP when racks were blocked than when they were unblocked. In summer, intakes 3A, 3C, and 5B all had lower mean STP when racks were blocked than when they were unblocked and differences at intake 3B was nearly significant (P = 0.0553). The only intakes with contrary effects, i.e., higher turbine passage when blocked than when unblocked, were intake 5C in spring and 5A in summer. Blocked trash-rack tests were based on relatively small sample sizes for each treatment (i.e., about N = 14) because differences among units and intakes made us cautious about pooling data to increase the power of tests.
The behavior of smolts upstream of trash racks also was informative. At intake 3B and depths of 5-6 m, the mean number of smolt-sized fish moving up in the water column and the ratio of upward- to downward-moving fish were both significantly higher for blocked than for unblocked treatments. At intake 5B, significantly more fish were moving up and down in the water column when trash racks were blocked than when they were unblocked (Figure 54). Milling of smolts upstream of the block does not and perhaps cannot occur during unblocked treatments because of flows into the intake. Milling may afford smolts time to discover the surface opening, but it also may make them more vulnerable to predation.

In spring, standardized sluice passage and sluice passage efficiency (SPE) did not differ significantly between blocked and unblocked treatments, but likely only because tests lacked sufficient power to reject the null hypothesis of no difference. The mean ratio of blocked to unblocked sluice passage was 6.8 for Unit 3 and 2.2 for Unit 5 (P = 0.0809; N=6). Non-significant increases in mean SPE resulting from blocking trash racks were +14.6% at Unit 3 and +12.8% for Unit 5.

In summer, blocking trash racks did not significantly increase standardized sluice passage or sluice passage efficiency. We found no effect of blocking on passage at 5B, which was monitored with confidence using underwater video cameras. In fact, mean SPE at Unit 5 declined when racks were blocked. Standardized passage into Sluice 3B also declined when racks were blocked, but we have little confidence in the accuracy of these split-beam estimates.

Apparent spring and summer differences in effects of blocks on sluice passage and SPE might result from differences in swimming ability of spring yearling and summer sub-yearlings smolts. Yearling fish may be able to navigate up along blocks and into surface flows whereas sub-yearlings are entrained in downward accelerating flows from 4-13.5 m of depth along trash-rack blocks. Sluice passage may be a function of the number of smolts in the 1-3 m of the water column (which is highly variable), regardless of the block treatment.

Inferences about Sluice Gate Treatments

Opening a center sluice gate significantly increased the mean FPE of Unit 5 by 35.5% (from 27.5 to 63.0%) in spring and at Unit 3 by 46% (from 30.3 to 76.9%) in summer. For Unit 3 in spring and Unit 5 in summer, respective means of 58.6 and 39.1% for the open sluice treatment were 18.6 and 10.1% higher than means for the closed sluice treatments (40 and 29%, respectively), although differences were not significant at $\alpha = 0.05$ because of high variability. Obviously, provision of a surface opening is better for smolt passage than not providing an opening, although the effect of a 0.5-2 m deep opening on more deeply distributed smolts appeared to be limited. For example, we found no significant effect of sluice-gate treatments on vertical movements of smolts sampled with split-beam acoustics. Flow vectors 6 m upstream of a sluice gate opened 2 m were downward into intake at depths > 2 m when trash racks were not blocked and downward at depths > 4.0 m when trash racks were blocked. No attraction flow would be discernable at greater depths than these for the respective treatments.

In-turbine FGE relative to traveling screens was not significantly affected by the opening or closing the sluice gate in the center intake of either unit in spring or in summer. Among intakes of both units in spring, FGE was highest for the A intake that never had an opened sluice above it. Intakes B and

C did not differ in spring. For in-turbine FGE to be affected by a sluice gate treatment, smolts would have to sense the surface flow from depths > 4 m, which is unlikely. Another explanation of how a sluice-gate treatment might affect FGE is that smolts in the upper 2-3 m of the water that might pass into an open sluice wind up passing into the turbine below as guided fish when the sluice gate is closed. However, a cursory examination of behavioral data from up-looking acoustics suggests that this explanation also is unlikely. Smolts 3 m upstream of open or closed sluice gates were moving in all directions including upstream, laterally, downstream, and up and down in the water column. A smolt unable to pass a closed sluice gate above the B intake was just as likely to move with the lateral flow toward the A intake as it was to pass into the B intake below. Lateral flow from Unit 5 toward Unit 3 also may explain higher passage at more southern intakes in spring (Figure 37), although we failed to detect such a skewed distribution of passage in summer. Perhaps sub-yearling smolts in summer were less able to avoid entrainment at the first intake they encountered than yearling smolts in spring.

The lateral distribution of smolts passing into sluice 5B was consistently skewed (two to one) toward the sides of the gate near concrete piers. Smolts may attempt to hold upstream of piers where flow into intakes is disrupted and then end up concentrated near the sides of sluice gates, or lower velocities adjacent to piers may be preferred by smolts for passage. The skewed lateral distribution into the sluice above the B intake also may have resulted from recruitment of smolts that first encountered sluice gates A and C, which were always closed. Whatever the reason, the lateral distribution within sluice gates has important implications for sampling sluice passage. For example, hydroacoustic sampling with a single up-looking transducer would underestimate passage by 50%. Adequate sampling would require more up-looking transducers to sample the lateral distribution, or the orientation of a single transducer would need to be changed from vertical to horizontal to integrate counts laterally. In 1997, the WES will examine the lateral distribution of passage into the center intake of Unit 8 to determine whether similar implications might apply to acoustic sampling of turbine passage.

Smolt Passage at Powerhouse 2

We found significant differences in total smolt passage among seasons, time of day, and intakes at Powerhouse 2. Smolt passage was higher in summer than in spring, at night than during the day, at Unit 11 than at other intakes in spring, and apparently at units on the south end of the powerhouse (11-14) than at units on the north end in summer. We found a very close correspondence between spring run timing estimated by acoustic samples and trap catches in the bypass. Correspondence also was good in summer after we excluded high passage rates from units 11-14 during the first week of summer from Powerhouse 2 averages (Figure 52). Most of the high acoustic rates at southern intakes occurred during the first week of summer immediately after river flows peaked for the year and loaded the south eddy with debris. The diel trend in total smolt passage was similar to the trend in juvenile bypass numbers of the NMFS in spring and summer, although it was highly variable among days. Sluice-chute treatments had no effect on standardized turbine passage at any intake in spring or summer.

Tests on mean fish guidance efficiency revealed significant differences among seasons, time of day, and intakes, but FGE was not affected by sluice-chute treatment. Estimates of mean FGE were higher in spring than summer and during the day than at night. Mean FGE of individual intakes ranged from about 16 to 66% in spring and from 10 to 42% in summer. In spring, mean FGE was highest at units 12 and 15 (52-65%) and lowest at Unit 11 (16%), which passed the most fish. In summer, unlike in the spring, the four units that passed the most fish also had the highest mean FGE (about 32- 42%). Sluice

chute treatments had no effect on FGE in spring or summer. Average FGE declined during summer from about 55 to about 30%. Such a decrease in FGE has been observed by other researchers (Gessel et al. 1989; Stansell et al. 1990).

Vertical Distributions and FGE

Vertical distribution data from mobile surveys often suggest that FGE should be higher than what was measured in turbine with fixed-aspect transducers. For example, the cumulative percent of smolts above 10 m of depth immediately upstream of trash racks was 73.1-76.6 in spring and 84.8-94.2 in summer at Powerhouse 1, while FGE at units 3 and 5 averaged about 55% in spring and 50% summer. At Powerhouse 2, the cumulative percent of smolts above 10 m of depth along transects 1 and 2 during the day was 93% in spring and summer whereas daytime FGE averaged 46% in spring and 32% in summer. The only time the vertical distribution data provided a reasonable explanation of FGE for Powerhouse 2 was at night in summer, when only 36% of the fish were above 10 m of depth and FGE averaged 28%. If nothing but the vertical distribution of smolts entering an intake influenced FGE, we would expect higher estimates of FGE than we measured in 1996. Either the distribution of smolts changes within 10 m of the structures where we did not sample or smolts must be avoiding screens as they enter intakes. The basis of this behavior was described in Nestler and Davidson (1995). This avoidance hypothesis could be tested by continuously sampling vertical distributions upstream of trash racks and inturbine FGE with fixed-aspect acoustics while applying daily screen and no-screen treatments. If acoustic FGE based upon relative numbers above and below the elevation of the tip of the screen was higher for treatments without screens than for treatments with screens, avoidance would be confirmed.

Comparisons of FGE Estimates

Acoustic FGE estimates in 1996 were within 3-25% of previous FGE estimates in other years by hydroacoustics and Fyke netting for the same intake and seasons. The mean difference in 10 estimates was $10.7 \pm 5\%$ (± 95 -% confidence interval), which is low considering that previous estimates were based upon daytime or early night samples as opposed to 24-hour samples. Acoustic FGE depends upon many factors including bias in the detection of fish by transducers sampling guided and unguided fish. Without intensive sampling of a single intake, it is difficult to determine the extent of bias, if any, in the 1996 estimates. Therefore, we compared 1996 estimates of FGE for the same intakes in other years by other researchers. We still need to identify biases in acoustic FGE estimates and define standards for deploying transducers, sampling, and processing to minimize them. The 1996 estimates of acoustic FGE in spring for Intake 3B averaged 66%, considerably higher than a Fyke net estimate of 41% but close to a theoretical FGE estimate of 74.3% (Gessel et al. 1989). Our average FGE estimate for Intake 3B in summer was about 46% compared to an average acoustic estimate of 32% (20-68%) by Thorne and Kuehl (1989). They sampled 7-9 hours per day for two days in late June whereas our estimate was based upon 14 days of sampling most hours each day. Fyke net sampling of Intake 3B in summer ranged from 33 to 61 percent with a mean of 41% (Gessel et al. 1989), which was reasonably close to our estimate of 46%. Our estimate of 65% FGE for Intake 12A without a TIE was close to an estimate of 70% by Gessel et al. (1988) and was higher than FGE of nearby intakes with TIES (i.e., 11A and 13C) much like Fyke-net results (Gessel et al. 1989). Acoustic and Fyke net estimates of FGE for Intake 17B in spring 1988 averaged 34 and 25%, respectively (Magne et al. 1989), compared to our estimate of 39% in 1996. Our estimates of FGE for intake 11A during the day in spring (17%) and summer (8%) were low compared to acoustic

estimates of 33 and 20% for the same intake and season in 1988 (Stansell et al. 1990). Our estimates included samples after 2300 hours and through the night when FGE usually is lower than during the day whereas the 1988 samples were taken from 0900-2300 hours only. For intake 18A, our estimates for spring and summer (31 and 15%, respectively) probably do not differ significantly from estimates of 22 and 13% taken in 1988 (Stansell et al. 1990).

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Figure 2. Transect locations in Bonneville Powerhouse 1 Forebay for mobile surveys in 1996.



Figure 3. Transect locations in Bonneville Powerhouse 2 Forebay for mobile surveys in 1996.



Figure 4. Mean horizontal interpolation of fish densities between transects from Bonneville Dam to Bridge of the Gods surveyed during the day in spring 1996.



Figure 6. Mean horizontal interpolation of fish densities between transects from Bonneville Dam to Bridge of the Gods surveyed during the day in summer 1996.

0

BRUDGE OF

0

WASHINGTON

PH2



Figure 7. Mean horizontal interpolation of fish densities between transects from Bonneville Dam to Bridge of the Gods surveyed at night in summer 1996.

MEAN# FISH/M^{r2}

OREGON

•

WAY

SPIL

PHA

EAGLE CREEK





Bonneville Powerhouse 1 Forebay surveyed during the day in spring 1996.





"igure 14. Mean horizontal interpolation of fish densities between transects in Bonneville Powerhouse 1 Forebay surveyed during the day in summer 1996.



Mean horizontal interpolation of fish densities between transects in Figure 15. Mean horizontal interpolation of fish densities between tran Bonneville Powerhouse 1 Forebay surveyed at night in summer 1996.











Bonneville Powerhouse 2 Forebay surveyed at night in summer 1996.

Figure 20. Spring daytime vertical interpolation of fish densities for transects 1 and 2 at Bonneville Powerhouse 2; sluice chute open. Column 1 = Transect 1; Column 2 = Transect 2. Row 1 = 05/08/96; Row 2 = 05/12/96; Row 3 = 05/18/96.

Orientation is facing dam from forebay. Vertical lines represent turbine unit locations and portion of transect sampled.



Figure 21. Spring daytime vertical interpolation of fish densities for transects 1 and 2 at Bonneville Powerhouse 2; sluice chute closed.

Column 1 = Transect 1; Column 2 = Transect 2. Row 1 = 04/30/96; Row 2 = 05/04/96; Row 3 = 05/15/96. Orientation is facing the dam from forebay. Vertical lines represent turbine unit locations and portion of transect sampled.



Figure 22. Spring nighttime vertical interpolation of fish densities for transects 1 and 2 at Bonneville Powerhouse 2; sluice chute open. Column 1 = Transect 1; Column 2 = Transect2. Row 1 = 05/08/96; Row 2 = 05/12/96; Row 3 = 05/18/96.

Orientation is facing dam from forebay. Vertical lines represent turbine unit locations and portion of transect sampled.



Figure 23. Spring nighttime vertical interpolation of fish densities for transects 1 and 2 at Bonneville Powerhouse 2; sluice chute closed. Column 1 = Transect 1; Column 2 = Transect 2.



Orientation is facing dam from forebay. Vertical lines represent turbine unit locations and portion of transect sampled.



Figure 24. Summer daytime vertical interpolation of fish densities for transects 1 and 2 at Bonneville Powerhouse 2; sluice chute open.

Column 1 = Transect 1; Column 2 = Transect 2. Row 1 = 06/29/96; Row 2 = 06/30/96; Row 3 = 07/03/96. Orientation is facing dam from forebay. Vertical lines represent turbine unit locations and portion of transect sampled.



Figure 25. Summer daytime vertical interpolation of fish densities for transects 1 and 2 at Bonneville Powerhouse 2; sluice shute closed. Column 1 = Transect 1; Column 2 = Transect 2.

Row 1 = 07/07/96; Row 2 = 07/09/96*first survey; Row 3 = 07/09/96*second survey.

Orientation is facing dam from forebay. Vertical lines represent turbine unit locations and portion of transect sampled.



Figure 26. Summer nighttime vertical interpolation of fish densities for transects 1 and 2 at Bonneville Powerhouse 2; sluice chute open.

Column 1 = Transect 1; Column 2 = Transect 2. Row 1 = 06/29/96; Row 2 = 06/30/96; Row 3 = 07/03/96; Orientation is facing dam from forebay. Vertical lines represent turbine unit locations and portion of transect sampled.



Figure 27. Summer nighttime vertical interpolation of fish densities for transects 1 and 2 at Bonneville Powerhouse 2; sluice chute closed.

Column 1 = Transect 1; Column 2 = Transect 2. Row 1 = 06/27/96; Row 2 = 07/07/96; Row 3 = 07/09/96. Orientation is facing dam from forebay. Vertical lines represent turbine unit locations and portion of transect sampled.





Figure 28. Average vertical distributions of smolt-sized fish 50-75 m upstream of Powerhouse 1 (left graph) and within 20-30 m of the powerhouse (right graph) during the day in spring.

25.9 32.42 45.44 660.35 66.86 69.61 73.66 74.38 82.2 88.13 82.2 88.13 88.13 88.13 88.13 89.87 91.9 91.9 98.41 91.0 98.41 91.0 100 100 100



Figure 29. Average vertical distributions of smolt-sized fish 50-75 m upstream of Powerhouse 1 (left graph) and within 20-30 m of the powerhouse (right graph) at night in spring.

9.09 27.56 27.56 36.65 55.97 65.48 65.48 76.14 80.11 89.2 90.2 91.9 93.75 99.29 100 100 100 100



Average vertical distributions of smolt-sized fish 50-75 m upstream of Powerhouse 1 (left graph) and within 20-30 m of the powerhouse (right graph) during the day in summer. Figure 30.



Average vertical distributions of smolt-sized fish 50-75 m upstream of Powerhouse 1 (left graph) and within 20-30 m of the powerhouse (right graph) at night in summer. Figure 31.



Figure 32. Average vertical distributions of smolt-sized fish 50-75 m upstream of Powerhouse 2 (left graph) and within 20-30 m of the powerhouse (right graph) during the day in spring.



Average vertical distributions of smolt-sized fish 50-75 m upstream of Powerhouse 2 (left graph) and within 20-30 m of the powerhouse (right graph) dat night in spring. Figure 33.



Average vertical distributions of smolt-sized fish 50-75 m upstream of Powerhouse 2 (left graph) and within 20-30 m of the powerhouse (right graph) during the day in summer. Figure 34.

3.37 8.55 8.55 37.99 55.06 55.06 55.06 73.25 83.73 89.84 98.84 98.41 98.47 98.47 98.47 98.47 98.47 98.47 98.47 98.84 99.96 99.96 99.96 99.96 99.96



Average vertical distributions of smolt-sized fish 50-75 m upstream of Powerhouse 2 (left graph) and within 20-30 m of the powerhouse (right graph) at night in summer. Figure 35.











Figure 38. Mean fish guidance efficiency (FGE) during unblocked trash-rack treatments at Unit 3 in spring 1996. The sluice gate over the center intake was either opened (white bars) or closed (grey bars). The line shows the total smolt passage normalized to a maximum of 1.



Figure 39. Mean fish guidance efficiency (FGE) during unblocked trash-rack treatments at Unit 5 in spring 1996. The sluice gate over the center intake was either opened (white bars) or closed (grey bars). The line shows the total smolt passage normalized to a maximum of 1.



Figure 40. Diel smolt passage patterns at sluice opening 5B based upon expanded video counts for selected days in spring and summer.





Figure 41. Estimates of sluice passage by hour based on expanded video counts at Bonneville Powerhouse 1 Sluice 5B for spring and summer, 1996. Tables to the right of the plots list the number of hours (N) used to calculate the mean for each hour of the day.



Figure 42. Mean fish guidance efficiency (FGE) during unblocked trash-rack treatments at Unit 3 in summer 1996. The sluice gate over the center intake was either opened (white bars) or closed (grey bars). The line shows the total smolt passage normalized to a maximum of 1.



Figure 43. Mean fish guidance efficiency (FGE) during unblocked trash-rack treatments at Unit 5 in summer 1996. The sluice gate over the center intake was either opened (white bars) or closed (grey bars). The line shows the total smolt passage normalized to a maximum of 1.



Figure 44. Fish guidance efficiency (FGE) among intakes of test turbines at Bonneville Powerhouse 1 in summer 1996. Numbers above bars indicate total counts of guided and unguided fish per intake.



Figure 45. Mean diel patterns of smolt passage into turbines (guided and unguided fish) at Powerhouse 1 in spring and summer with error bars representing the standard error of the mea


Figure 46. Average diel pattern of total smolt passage into intakes at Powerhouse 2 in spring.









Figure 48. Plot of fish guidance efficiency (FGE) and normalized total passage by treatment day in spring at Powerhouse 2 (upper plot) and National Marine Fisheries Service juvenile bypass data by spring date in 1996 (lower plot). Bars represent mean FGE across the powerhouse for each treatment day. The horizontal line is the grand mean for spring. Total passage values were normalized to a maximum of 1. Mean FGE for the season is shown in the upper left corner. Bypass counts reflect sub-samples expanded to full hours. Dates along the abscissa coincide with spring treatment days.



Figure 49. Plot of fish guidance efficiency (FGE) by turbine intake in spring and summer at Powerhouse 2. Bars represent mean FGE based on all hours for each intake through the seasons. Values above the bars indicate total smolt passage for each intake. A "T" at the base of some of the bars indicates that a turbine intake extension was present.



Figure 50. Plots of fish guidance efficiency (FGE) by turbine intake for day and night hours in spring at Powerhouse 2. Bars represent mean FGE based on day or night hours for each intake through the season. Values above the bars indicate total smolt passage for each intake during those hours. A "T" at the base of some of the bars indicates that a turbine intake extension was present.



Figure 51. Average diel pattern of total smolt passage into intakes at Powerhouse 2 in summer.



Figure 52. Plot of fish guidance efficiency (FGE) and normalized total passage by treatment day in summer at Powerhouse 2. Bars represent mean FGE across the powerhouse for each treatment day. Acoustic estimates of turbine passage were normalized to a maximum of 1 and excluded high estimates from units 11-14 for the first week of sampling after the highest forebay inflows for the year (see inset) loaded the eddy on the south end of the powerhouse with debris. Mean FGE for the season is shown in the upper left corner. Also shown is a plot of NMFS bypass data by summer date, 1996. Smolt counts reflect sub-samples expanded to full hours. Dates along the x axis of the bottom plot coincide with summer treatment days in the upper plot.



Figure 53. Plots of fish guidance efficiency (FGE) by turbine intake for day and night hours in summer at Powerhouse 2. Bars represent mean FGE based on day or night hours for each intake through the season. Values above the bars indicate total smolt passage for each intake during those hours. A "T" at the base of some of the bars indicates that a turbine intake extension was present.



Figure 54. Plots showing the number of smolt-sized fish moving up or down in the water column 3-4 m upstream of trash racks of center intakes of Unit 3 and 5 when the sluice gate was open. Trash rack treatments are indicated by the color of bars (black = blocked; white = unblocked). Positive and negative vectors indicate upward and downward movement, respectively.

TWO-WAY ANOVA ON STANDARDIZED SMOLT PASSAGE [(GUIDED + UNGUIDED)/BYPASSED] AMONG BLK TREATMENTS AND UNITS FOR SUMMED DATA SETS SPRING 96

General Linear Models Procedure Class Level Information

Class	Levels	Values
BTRT	2	BLKED UNBLKED
UNIT	2	35

Number of observations in data set = 56 NOTE: Due to missing values, only 53 observations can be used in this analysis.

General Linear Models Procedure

Dependent Variable: STP

Source	DF	Sum of Squares	F Value	Pr > F
Model	3	0.71148245	6.61	0.0008
Error	49	1.75825564		
Corrected Total	52	2.46973809		
	R-Square	c.v.	STP	Mean
	0.288080	74.03376		0.25586635
Source	DF	Type I SS	F Value	Pr > F
BTRT UNIT BTRT*UNIT	1 1 1	0.25034378 0.32242414 0.13871453	6.98 8.99 3.87	0.0111 0.0043 0.0550
Source	DF	Type III SS	F Value	Pr > F
BTRT UNIT BTRT*UNIT	1 1 1	0.23947485 0.31339910 0.13871453	6.67 8.73 3.87	0.0128 0.0048 0.0550

TWO-WAY ANOVA ON STANDARDIZED SMOLT PASSAGE [(GUIDED + UNGUIDED)/BYPASSED] AMONG TREATMENTS AND UNITS FOR SUMMED DATA SETS SPRING 96

General Linear Models Procedure Class Level Information

Class	Levels	Values
TREAT	4	BC BO UC UO
UNIT	2	3 5

Number of observations in data set = 56 NOTE: Due to missing values, only 53 observations can be used in this analysis.

General Linear Models Procedure

Dependent Variable: STP

Source	DF	Sum of Squares	F Value	Pr > F
Model	7	0.73092031	2.70	0.0200
Error	45	1.73881778		
Corrected Total	52	2.46973809		
	R-Square	c.v.	STP N	fean
	0.295951	76.82589	0.	25586635
Source	DF	Type I SS	F Value	Pr > F
TREAT UNIT TREAT*UNIT	3 1 3	0.27046776 0.31185404 0.14859851	2.33 8.07 1.28	0.0867 0.0067 0.2921
Source	DF	Type III SS	F Value	Pr > F
TREAT UNIT TREAT*UNIT	3 1 3	0.23703759 0.29486578 0.14859851	2.04 7.63 1.28	0.1210 0.0083 0.2921

ONE-WAY ANOVA ON STANDARDIZED SMOLT PASSAGE [(GUIDED + UNGUIDED)/BYPASSED] AMONG TREATMENTS (Unit 3 & 5 Pooled) FOR SUMMED DATA SETS SPRING 96					
	General L: Class	inear Models Proced Level Information	lure		
	Class	Levels Values			
	TREAT	4 BC BO UC	: UO		
Nu	mber of obse	ervations in data s	set = 56		
NOTE: Due to missing values, only 53 observations can be used in this analysis.					
Dependent Variabl	e: STP				
Source	DF	Sum of Squares	F Value	Pr > F	
Model	3	0.27046776	2.01	0.1250	
Error	49	2.19927033			
Corrected Total	52	2.46973809			
	R-Square	c.v.	STP	Mean	
	0.109513	82.79957		0.25586635	
Source	DF	Type I SS	F Value	Pr > F	
TREAT	3	0.27046776	2.01	0.1250	
Source	DF	Type III SS	F Value	Pr > F	
TREAT	3	0.27046776	2.01	0.1250	

Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: STP NOTE: This test controls the type I experimentwise error rate.

> Alpha= 0.05 df= 49 MSE= 0.044883 WARNING: Cell sizes are not equal.

 Number of Means
 2
 3
 4

 Critical F
 5.3223725
 3.1865824
 2.7939489

Means with the same letter are not significantly different.

REGWF Grouping	Mean	N	TREAT	
A	0.34942	14	UC	
AA	0.29519	13	UO	
AA	0.18948	12	BC	
A	0.18270	14	во	

TWO-WAY ANOVA ON STANDARDIZED SMOLT PASSAGE [(GUIDED + UNGUIDED)/BYPASSED] AMONG GATE TREATMENTS AND UNITS FOR SUMMED DATA SETS SPRING 96

General Linear Models Procedure Class Level Information

Class	Levels	Values	
GTRT	2	OPEN CLOSEI)
UNIT	2	35	

Number of observations in data set = 56 NOTE: Due to missing values, only 53 observations can be used in this analysis.

General Linear Models Procedure

DF	Sum of Squares	F Value	Pr > F
3	0.32419732	2.47	0.0730
49	2.14554077		
52	2.46973809		
are	c.v.	STP	Mean
268	81.78189		0.25586635
កទ	Type I SS	F Value	Pr > F
21	Tibe T pp	i vuitue	** * *
1	0.01988339	0.45	0.5036
1	0.29892890	6.83	0.0119
1	0.00538502	0.12	0.7273
DF	Type III SS	F Value	Pr > F
1	0.00854475	0.20	0.6606
1	0.29624371	6.77	0.0123
1	0.00538502	0.12	0.7273
	DF 3 49 52 are 268 DF 1 1 1 DF 1 1 1	DF Sum of Squares 3 0.32419732 49 2.14554077 52 2.46973809 are C.V. 268 81.78189 DF Type I SS 1 0.01988339 1 0.29892890 1 0.00538502 DF Type III SS 1 0.00854475 1 0.29624371 1 0.00538502	DF Sum of Squares F Value 3 0.32419732 2.47 49 2.14554077 2 52 2.46973809 3 are C.V. STP 268 81.78189 3 DF Type I SS F Value 1 0.01988339 0.45 1 0.29892890 6.83 1 0.00538502 0.12 DF Type III SS F Value 1 0.00854475 0.20 1 0.29624371 6.77 1 0.00538502 0.12

TWO-WAY ANOVA ON STANDARDIZED SMOLT PASSAGE [(GUIDED + UNGUIDED)/BYPASSED] AMONG GATE TREATMENTS AND BLOCK TREATMENTS FOR SUMMED DATA SETS SPRING 96

General Linear Models Procedure Class Level Information

Class	Levels	Values
BTRT	2	BLKED UNBLKED
GTRT	2	OPEN CLOSED

Number of observations in data set = 56 NOTE: Due to missing values, only 53 observations can be used in this analysis.

General Linear Models Procedure

Dependent Variab	ole: STP			
Source	DF	Sum of Squares	F Value	Pr > F
Model	3	0.27046776	2.01	0.1250
Error	49	2.19927033		
Corrected Total	52	2.46973809		
	R-Square 0.109513	C.V. 82.79957	STP O	Mean .25586635
Source	DF	Type I SS	F Value	Pr > F
BTRT GTRT BTRT*GTRT	1 1 1	0.25034378 0.01269722 0.00742676	5.58 0.28 0.17	0.0222 0.5972 0.6859
Source	DF	Type III SS	F Value	Pr > F
BTRT GTRT BTRT*GTRT	1 1 1	0.24484917 0.01228423 0.00742676	5.46 0.27 0.17	0.0236 0.6032 0.6859

Appendix A Statistical Tests on Powerhouse 1 Data from Spring 1996

ONE-WAY ANOVA ON STANDARDIZED SMOLT PASSAGE [(GUIDED + UNGUIDED)/BYPASSED] AMONG TREATMENTS (Unit 3 & 5 Pooled) FOR SUMMED DATA SETS SPRING 96

> General Linear Models Procedure Class Level Information

Class	Levels	Values	3
BTRT	2	BLKED	UNBLKED

Number of observations in data set = 56 NOTE: Due to missing values, only 53 observations can be used in this analysis.

General Linear Models Procedure

Dependent Variable: STP

Source	DF	Sum of Squares	F Value	Pr > F
Model	1	0.25034378	5.75	0.0202
Error	51	2.21939431		
Corrected Total	52	2.46973809		
	R-Square	c.v.	STP 1	Mean
	0.101365	81.53029	0	.25586635
Source	DF	Type I SS	F Value	Pr > F
BTRT Source BTRT	1 DF 1	0.25034378 Type III SS 0.25034378	5.75 F Value 5.75	0.0202 Pr > F 0.0202

Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: STP

NOTE: This test controls the type I experimentwise error rate.

Alpha= 0.05 df= 51 MSE= 0.043518 WARNING: Cell sizes are not equal. Harmonic Mean of cell sizes= 26.49057

> Number of Means 2 Critical F 4.0303926

Means with the same letter are not significantly different.
REGWF GroupingMeanNBTRTA0.3233127UNBLKED

B 0.18583 26 BLKED

ONE-WAY ANOVA ON STANDARDIZED SMOLT PASSAGE [(GUIDED + UNGUIDED)/BYPASSED] AMONG TREATMENTS (Unit 3 & 5 Pooled) FOR SUMMED DATA SETS SPRING 96

> General Linear Models Procedure Class Level Information

Class	Levels	Values
GTRT	2	OPEN CLOSED

Number of observations in data set = 56

NOTE: Due to missing values, only 53 observations can be used in this analysis.

General Linear Models Procedure

Dependent Variable: STP

Source	DF	Sum of Squares	F Value	Pr > F
Model	1	0.01988339	0.41	0.5229
Error	51	2.44985470		
Corrected Total	52	2.46973809		
	R-Square	c.v.	STP :	Mean
	0.008051	85.65878	0	.25586635
Source	DF	Type I SS	F Value	Pr > F
GTRT	1	0.01988339	0.41	0.5229
Source	DF	Type III SS	F Value	Pr > F
GTRT	1	0.01988339	0.41	0.5229

Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: STP NOTE: This test controls the type I experimentwise error rate.

> Alpha= 0.05 df= 51 MSE= 0.048036 WARNING: Cell sizes are not equal. Harmonic Mean of cell sizes= 26.49057

> > Number of Means 2 Critical F 4.0303926

Means with the same letter are not significantly different. REGWF Grouping Mean N GTRT A 0.27560 26 CLOSED A A 0.23686 27 OPEN

ONE-WAY J UNGU	ANOVA ON STA IDED)/BYPASS I	NDARDIZED SMOLT PAS SED] AMONG TREATMENT FOR SUMMED DATA SPRING 96	SAGE [(GUII S (Unit 3))ED +	
	General I Class	Linear Models Proced 5 Level Information	ure		
	Class Levels Values TREAT 4 BC BO UC UO				
N	umber of obs	servations in data s	et = 28		
Dependent Variab	le: STP				
Source	DF	Sum of Squares	F Value	Pr > F	
Model	3	0.00172135	2.03	0.1367	
Error	24	0.00678936			
Corrected Total	27	0.00851071			
	R-Square	c.v.	STP	Mean	
	0.202257	78.17918		0.02151383	
Source	DF	Type I SS	F Value	Pr > F	
TREAT	3	0.00172135	2.03	0.1367	
Source	DF	Type III SS	F Value	Pr > F	
TREAT	3	0.00172135	2.03	0.1367	

Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: STP

NOTE: This test controls the type I experimentwise error rate.

Alpha= 0.05 df= 24 MSE= 0.000283 WARNING: Cell sizes are not equal. Harmonic Mean of cell sizes= 6.927835

 Number of Means
 2
 3
 4

 Critical F
 5.6887853
 3.4028261
 3.0087866

Means with the same letter are not significantly different. REGWF Grouping Mean N TREAT

0.029777	8	UC
0.028636	6	υo
0.015065	7	во
0.012414	7	BC

Appendix A Statistical Tests on Powerhouse 1 Data from Spring 1996

A A A A A A A

ONE-WAY ANOVA ON STANDARDIZED SMOLT PASSAGE [(GUIDED + UNGUIDED)/BYPASSED] AMONG BLK TREATMENTS (Unit 3) FOR SUMMED DATA SPRING 96

General Linear Models Procedure Class Level Information

Class	Levels	Values	
BTRT	2	BLKED UNBLKE	D

Number of observations in data set = 28

General Linear Models Procedure

Dependent Variable: STP

Source	DF	Sum of Squares	F Value	Pr > F
Model	1	0.00169229	6.45	0.0174
Error	26	0.00681842		
Corrected Total	27	0.00851071		
	R-Square	c.v.	STP	Mean
	0.198843	75.27268		0.02151383
Source	DF	Type I SS	F Value	Pr > F
BTRT	1	0.00169229	6.45	0.0174
Source	DF	Type III SS	F Value	Pr > F
BTRT	1	0.00169229	6.45	0.0174

Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: STP NOTE: This test controls the type I experimentwise error rate.

Alpha= 0.05 df= 26 MSE= 0.000262

Number of Means 2 Critical F 4.2252013

Means with the same letter are not significantly different. REGWF Grouping Mean N BTRT

A	0.029288	14	UNBLKED
в	0.013740	14	BLKED

10	NE-WAY ANOVA ON S' UNGUIDED)/BYPASSI	FANDARDIZED SMOLT ED] AMONG GATE TRE FOR SUMMED DATA SPRING 96	PASSAGE [(GUID) ATMENTS (Unit)	ED + 3)
	General Cla:	Linear Models Prod ss Level Informatio	cedure on	
Class Levels Values GTRT 2 OPEN CLOSED				
	Number of of	oservations in data	a set = 28	
Dependent	Variable: STP			
Source	DF	Sum of Squares	F Value	Pr > F
Model	1	0.0000083	0.00	0.9602
Error	26	0.00850988		
Corrected	Total 27	0.00851071		
	R-Square	c.v.	STP	Mean
	0.000098	84.09251	(0.02151383
Source	DF	Type I SS	F Value	Pr > F
GTRT	1	0.0000083	0.00	0.9602
Source	DF	Type III SS	F Value	Pr > F

Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: STP

1

GTRT

NOTE: This test controls the type I experimentwise error rate.

0.0000083

Alpha= 0.05 df= 26 MSE= 0.000327 WARNING: Cell sizes are not equal. Harmonic Mean of cell sizes= 13.92857

> Number of Means 2 Critical F 4.2252013

Means with the same letter are not significantly different.

REGWF Grouping	Mean	N	GTRT
A	0.021674	15	CLOSED
A A	0.021329	13	OPEN

Appendix A Statistical Tests on Powerhouse 1 Data from Spring 1996

A11

0.9602

01	NE-WAY ANOVA ON S UNGUIDED)/BYPA	TANDARDIZED SMO SSED] AMONG TRE FOR SUMMED DAT SPRING 96	LT PASSAGE [(GU ATMENTS (Unit ! A	JIDED + 5)	
	General Cla	Linear Models H ss Level Informa	rocedure ation		
	Class Levels Values TREAT 4 BC BO UC UO				
	Number of ol	oservations in c	lata set = 28		
Dependent	Variable: STP				
Source	DF	Sum of Squar	es F Value	e Pr > F	
Model	3	0.000082	21 0.85	0.4839	
Error	21	0.000679	73		
Corrected	Total 24	0.000761	94		
	R-Square	c.	v. s	TP Mean	
	0.107889	49.662	95	0.01145585	
Source	DF	Type I	SS F Value	Pr > F	
TREAT	3	0.000082	21 0.85	0.4839	
Source	DF	Type III	SS F Value	Pr > F	
TREAT	3	0.000082	21 0.85	0.4839	

Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: STP

NOTE: This test controls the type I experimentwise error rate.

Alpha= 0.05 df= 21 MSE= 0.000032 WARNING: Cell sizes are not equal. Harmonic Mean of cell sizes= 6.131387

 Number of Means
 2
 3
 4

 Critical F
 5.7978344
 3.4668001
 3.072467

Means with the same letter are not significantly different. REGWF Grouping Mean N TREAT

A	0.013734	6	UC
A	0.012425	5	BC
A A	0.011384	7	υo
A A	0.008883	7	во

ONE-WAY ANOVA ON STANDARDIZED SMOLT PASSAGE [(GUIDED + UNGUIDED)/BYPASSED] AMONG BLK TREATMENTS (Unit 5) FOR SUMMED DATA SPRING 96

> General Linear Models Procedure Class Level Information

Class	Levels	Values
BTRT	2	BLKED UNBLKED

Number of observations in data set = 28

General Linear Models Procedure

Dependent Variable: STP

Source	DF	Sum of Squares	F Value	Pr > F
Model	1	0.00002777	0.87	0.3607
Error	23	0.00073417		
Corrected Total	24	0.00076194		
	R-Square	c.v.	STP	Mean
	0.036440	49.31831	0	.01145585
Source	DF	Type I SS	F Value	Pr > F
BTRT	1	0.00002777	0.87	0.3607
Source	DF	Type III SS	F Value	Pr > F
BTRT	1	0.00002777	0.87	0.3607

Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: STP

NOTE: This test controls the type I experimentwise error rate.

Alpha= 0.05 df= 23 MSE= 0.000032 WARNING: Cell sizes are not equal. Harmonic Mean of cell sizes= 12.48

> Number of Means 2 Critical F 4.2793443

Means with the same letter are not significantly different. REGWF Grouping Mean N BTRT A 0.012468 13 UNBLKED A A 0.010359 12 BLKED

ONE-WAY ANOVA ON STANDARDIZED SMOLT PASSAGE [(GUIDED + UNGUIDED)/BYPASSED] AMONG GATE TREATMENTS (Unit 5) FOR SUMMED DATA SPRING 96

General Linear Models Procedure Class Level Information

Class	Levels	Values
GTRT	2	OPEN CLOSED

Number of observations in data set = 28 NOTE: Due to missing values, only 25 observations can be used in this analysis.

General Linear Models Procedure

. . .

Dependent	Variable: STP			
Source	DF	Sum of Squares	F Value	Pr > F
Model	1	0.00005565	1.81	0.1914
Error	23	0.00070629		
Corrected	Total 24	0.00076194		
	R-Square	c.v.	STP	9 Mean
	0.073031	48.37282		0.01145585
Source	DF	Type I SS	F Value	Pr > F
GTRT	1	0.00005565	1.81	0.1914
Source	DF	Type III SS	F Value	Pr > F
GTRT	1	0.00005565	1.81	0.1914

Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: STP NOTE: This test controls the type I experimentwise error rate.

> Alpha= 0.05 df= 23 MSE= 0.000031 WARNING: Cell sizes are not equal. Harmonic Mean of cell sizes= 12.32

Number of Means2Critical F4.2793443

Means with the same letter are not significantly different. REGWF Grouping Mean N GTRT A 0.013139 11 CLOSED A A 0.010133 14 OPEN

TWO-WAY ANOVA ON STANDARDIZED SMOLT PASSAGE (GUIDED + UNGUIDED/BYPASSED) AT TEST TURBINES AMONG BLK TREATMENTS AND INTAKES SPRING 96

General Linear Models Procedure Class Level Information

Class	Levels	Values
INTAKE	6	03A 03B 03C TU5A TU5B TU5C
BTRT	2	BLKED UNBLKED

Number of observations in data set = 163

General Linear Models Procedure

Dependent Variable: STP

Source	DF	Sum of Squares	F Value	Pr > F
Model	11	1.16582107	6.31	0.0001
Error	151	2.53463205		
Corrected Total	162	3.70045312		
	R-Square	c.v.	STP 1	Mean
	0.315048	85.42632	0	.15166218
Source	DF	Type I SS	F Value	Pr > F
INTAKE BTRT INTAKE*BTRT	5 1 5	0.53117924 0.30419458 0.33044725	6.33 18.12 3.94	0.0001 0.0001 0.0022
Source	DF	Type III SS	F Value	Pr > F
INTAKE BTRT INTAKE*BTRT	5 1 5	0.52151976 0.27477541 0.33044725	6.21 16.37 3.94	0.0001 0.0001 0.0022

ONE-WAY ANOVA ON STANDARDIZED SMOLT PASSAGE (GUIDED + UNGUIDED/BYPASSED) AT TEST TURBINES AMONG BLK TREATMENTS BY INTAKE SPRING 96 ----- INTAKE=03A -----General Linear Models Procedure Class Level Information Class Levels Values BLKED UNBLKED BTRT 2 Number of observations in by group = 28 _____ INTAKE=03A ______ Dependent Variable: STP Sum of Squares F Value Pr > FSource DF 0.17980409 14.15 0.0009 1 Model 0.33027749 26 Error 27 0.51008158 Corrected Total c.v. STP Mean R-Square 69.23050 0.16280036 0.352501 F Value Pr > FType I SS DF Source 0.17980409 14.15 Type III SS F Value 17080409 14.15 0.0009 Pr > F 0.0009 BTRT 1 DF Source BTRT 1 ------ INTAKE=03A -----Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: STP NOTE: This test controls the type I experimentwise error rate. Alpha= 0.05 df= 26 MSE= 0.012703 Number of Means 2 Critical F 4.2252013 Means with the same letter are not significantly different. REGWF Grouping Mean N BTRT 0.24294 14 UNBLKED Α 0.08267 14 BLKED в

ON UNGUIDED	IE-WAY AN)/BYPASSE	OVA ON STA D) AT TEST	NDARDIZED SMOLT PAS: TURBINES AMONG BLK SPRING 96	SAGE (GUIDED TREATMENTS	+ BY INTAKE
			- INTAKE=03B		
		General L Class	inear Models Procedu Level Information	ıre	
		Class BTRT	Levels Values 2 BLKED UNBI	LKED	
	Num	ber of obs	ervations in by grou	up = 28	
			- INTAKE=03B		
Dependent	Variable	: STP			
Source		DF	Sum of Squares	F Value	Pr > F
Model		1	0.12371866	2.92	0.0996
Error		26	1.10299556		
Corrected	Total	27	1.22671422		
	1	R-Square	c.v.	STP 1	lean
	I	0.100854	87.90817	0	.23429929
Source		DF	Type I SS	F Value	Pr > F
BTRT		1	0.12371866	2.92	0.0996
BTRT		DF 1	0.12371866	2.92	0.0996
			- INTAKE=03B		
Ryan-Ei	not-Gabr:	iel-Welsch	Multiple F Test for	variable: S	STP
NOTE:	This te:	st control:	s the type I experim	entwise erro	or rate.
	2	Alpha= 0.0	5 df= 26 MSE= 0.04	2423	
		Number Critica	of Means 2 al F 4.2252013		
Means	with the REGWF (e same let Grouping	ter are not signific Mean	antly diffe N BTRT	rent.
		A	0.30077	14 UNBLKEI)
		A A	0.16783	14 BLKED	

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A17

OI UNGUIDEI	NE-WAY AL D/BYPASSI	NOVA ON STAN ED) AT TEST	IDARDIZEI TURBINES SPRING) SMOLT P 3 AMONG B 96	ASSAG	e (guii Eatmeni	DED + IS BY I	NTAKE
			· INTAKE=	=03C				
		General Li Class	near Mod Level Ir	lels Proc formatio	edure n			
		Class I BTRT	evels. 2	Values BLKED U	NBLKE	D		
	Nur	mber of obse	rvations	; in by g	roup =	= 28		
			INTAKE=	:03C				
Dependent	Variable	e: STP						
Source		DF	Sum of	Squares	F	Value	P	r > F
Model		1	0.1	2789704		4.73	0	.0390
Error		26	0.7	0362819				
Corrected	Total	27	0.8	3152523				
		R-Square 0.153810	8	C.V. 4.08805		ST	P Mean 0.195	63686
Source		DF	Ту	pe I SS	F	Value	P.	r > F
BTRT Source BTRT		1 DF 1	0.1 Type 0.1 INTAKE=	2789704 III SS 2789704 03C	F	4.73 Value 4.73	0 P: 0	.0390 r > F .0390

Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: STP NOTE: This test controls the type I experimentwise error rate.

Alpha= 0.05 df= 26 MSE= 0.027063

Number of Means 2 Critical F 4.2252013

Means with the same letter are not significantly different. REGWF Grouping Mean N BTRT A 0.26322 14 UNBLKED B 0.12805 14 BLKED

ONE UNGUIDED/	-WAY ANC BYPASSEI	OVA ON STA D) AT TESI	ANDARDIZED TURBINES SPRING	SMOLT PA AMONG BL 96	SSAGE K TREA	(GUIDED TMENTS P	+ BY INTAKE
			- INTAKE=T	U5A			
		General I Class	Linear Mod 3 Level In	els Proced formation	dure		
		Class BTRT	Levels 2	Values BLKED UNI	BLKED		
	Numb	er of obs	ervations	in by gro	oup =	28	
			INTAKE=T	U5A			
Dependent V	ariable:	STP					
Source		DF	Sum of	Squares	FV	alue	Pr > F
Model		1	0.1	7159312	2	6.64	0.0001
Error		26	0.1	6744275			
Corrected T	otal	27	0.3	3903586			
	R	-Square		c.v.		STP M	ean
	0	.506121	5	3.74893		0.	14930578
Source		DF	Ту	pe I SS	FV	alue	Pr > F
BTRT		1	0.1	7159312	2	6.64	0.0001
Source BTRT		DF 1	Type 0.1	III SS 7159312	F V 2	alue 6.64	Pr > F 0.0001
		-			_		
			INTAKE=T	U5A			
Ryan-Eine	ot-Gabri	el-Welsch	Multiple	F Test fo	or var	iable: S	TP
NOTE: 2	This tes	t control	s the type	e I experi	mentw	ise erro	r rate.
	A	lpha= 0.0	5 df= 26	MSE= 0.0	0644		
		Number Critic	of Means al F	2 4.2252013			
Means w	with the REGWF G	same let rouping	ter are no	ot signifi Mean	cantly N	y differ BTRT	ent.
		A	(0.22759	14	UNBLKED	
		В	(0.07102	14	BLKED	

A19

ONE-WAY I UNGUIDED/BYPAS	ANOVA ON STAN SED) AT TEST	DARDIZED SMOLT PAS TURBINES AMONG BLF SPRING 96	SSAGE (GUIDED (TREATMENTS	+ BY INTAKE
		INTAKE=TU5B		
	General Li Class	near Models Proced Level Information	lure	
	Class L BTRT	evels Values 2 BLKED UNE	BLKED	
Nu	mber of obse	rvations in by gro	oup = 26	
		INTAKE=TU5B		
Dependent Variabl	.e: STP			
Source	DF	Sum of Squares	F Value	Pr > F
Model	1	0.00399856	0.66	0.4246
Error	24	0.14540791		
Corrected Total	25	0.14940647		
	R-Square	c.v.	STP 1	Mean
	0.026763	97.22733	0	.08005713
Source	DF	Type I SS	F Value	Pr > F
BTRT	1	0.00399856	0.66	0.4246
Source	DF	Type III SS	F Value	Pr > F
BTRT	1	0.00399856	0.66	0.4246
]	INTAKE=TU5B		
Ryan-Einot-Gab	riel-Welsch M	Aultiple F Test fo	r variable: S	STP
NOTE: This t	est controls	the type I experim	mentwise erro	or rate.
н	Alpha= 0.05 WARNING: Cel armonic Mean	df= 24 MSE= 0.0 l sizes are not e of cell sizes= 12	06059 qual. .92308	
	Number o Critical	of Means 2 . F 4.2596773		
Means with t REGWF	he same lette Grouping	er are not signific Mean	cantly differ N BTRT	cent.

A	0.09345	12	BLKED
A A	0.06858	14	UNBLKED

ONE-WAY UNGUIDED/BYPAS	ANOVA ON STAI SED) AT TEST	NDARDIZED SMOLT PA: TURBINES AMONG BLI SPRING 96	SSAGE (GUIDED K TREATMENTS	+ BY INTAKE
		INTAKE=TU5C		
	General L: Class	inear Models Proced Level Information	lure	
	Class 1 BTRT	Levels Values 2 BLKED UNI	BLKED	
N	Number of obse	ervations in by gro	oup = 25	
		INTAKE=TU5C		
Dependent Variab	le: STP	w.		
Source	DF	Sum of Squares	F Value	Pr > F
Model	1	0.02763036	7.49	0.0118
Error	23	0.08488015		
Corrected Total	24	0.11251051		
	R-Square 0.245580	C.V. 81.55253	STP 1 0	Mean .07449064
Source	DF	Type I SS	F Value	Pr'> F
STRT Source STRT	1 DF 1	0.02763036 Type III SS 0.02763036	7.49 F Value 7.49	0.0118 Pr > F 0.0118
		INTAKE=TU5C		
Ryan-Einot-Ga	briel-Welsch	Multiple F Test fo	or variable: S	STP
- NOTE: This	test controls	the type I experi	mentwise erro	or rate.
	Alpha= 0.05 WARNING: Ce Harmonic Me	df= 23 MSE= 0.0 ell sizes are not e ean of cell sizes=	0369 qual. 12.48	
	Number Critica	of Means 2 1 F 4.2793443		
Means with REGW	the same lett F Grouping	er are not signifi Mean	cantly diffe N BTRT	rent.
	A	0.10909	12 BLKED	
	В	0.04255	13 UNBLKEI)

A21

ONE-WAY ANOVA ON STANDARDIZED SMOLT PASSAGE [(GUIDED + UNGUIDED)/BYPASSED] AMONG TREATMENTS (Unit 3 & 5 Pooled) SPRING 96

General Linear Models Procedure Class Level Information

Class	Levels	Values
BTRT	2	BLKED UNBLKED

Number of observations in data set = 163 General Linear Models Procedure

Dependent Variable: STP

Source	DF	Sum of Squares	F Value	Pr > F
Model	1	0.28519783	13.44	0.0003
Error	161	3.41525529		
Corrected Total	162	3.70045312		
	R-Square 0.077071	c.v. 96.03319	STP 3 0	Mean .15166218
Source	DF	Type I SS	F Value	Pr > F
BTRT	1	0.28519783	13.44	0.0003
Source	DF	Type III SS	F Value	Pr > F
BTRT	1	0.28519783	13.44	0.0003

Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: STP

NOTE: This test controls the type I experimentwise error rate.

Alpha= 0.05 df= 161 MSE= 0.021213 WARNING: Cell sizes are not equal. Harmonic Mean of cell sizes= 81.47239

Number of Means2Critical F3.899867

Means with the same letter are not significantly different. REGWF Grouping Mean N BTRT A 0.19273 83 UNBLKED

B 0.10906 80 BLKED

ONE-WAY ANOVA ON STANDARDIZED SMOLT PASSAGE [(GUIDED + UNGUIDED)/BYPASSED] AMONG INTAKES (Unit 3 & 5 Pooled) SPRING 96					
Class INTAK	E Levels E 6	Values 03A 03B 03C TU5A	A TU5B TU5C		
Nu	mber of obse	rvations in data s	set = 163		
Dependent Variabl	e: STP				
Source	DF	Sum of Squares	F Value	Pr > F	
Model	5	0.53117924	5.26	0.0002	
Error	157	3.16927388			
Corrected Total	162	3.70045312			
	R-Square 0.143544	C.V. 93.68127	STP N O.	fean 15166218	
Source	DF	Type I SS	F Value	Pr > F	
INTAKE	5	0.53117924	5.26	0.0002	
Source	DF	Type III SS	F Value	Pr > F	
INTAKE	5	0.53117924	5.26	0.0002	
Ryan-Einot-Gab	riel-Welsch M	Aultiple F Test fo	or variable: S	STP	
NOTE: This t	est controls	the type I experi	mentwise erro	or rate.	
н	Alpha= 0.05 WARNING: Cel armonic Mean	df= 157 MSE= 0.0 ll sizes are not e of cell sizes= 27	20186 qual. .11023		
Number of Means Critical F	2 5.8248769 3.	3 4 .7635743 2.9708048	5 2.4292527 2.	6 2717627	
Means with t REGWF	he same lette Grouping	er are not signifi Mean	cantly differ N INTAKE	ent.	
	А	0.23430	28 03B		
	AA	0.19564	28 03C		
В	AA	0.16280	28 03A		
B	A	0.14931	28 TU5A		
B		0.08006	26 TU5B		
B		0.07449	25 TU5C		

A23

TWO-WAY ANOVA ON FPE [(GUIDED + SLUICE) / (GUIDED + SLUICE + UNGUIDED) AMONG TREATMENTS AND UNITS FOR SUMMED DATA SETS SPRING 96

General Linear Models Procedure Class Level Information

Class	Levels	Values
TREAT	3	BO UC UO
UNIT	2	35

Number of observations in data set = 43

NOTE: Due to missing values, only 41 observations can be used in this analysis.

General Linear Models Procedure

Dependent Variabl	e: FPE		X = = =		
Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	7409.9813664	1481.9962733	1.54	0.2035
Error	35	33731.4282653	963.7550933		
Corrected Total	40	41141.4096317			
	R-Square	c.v.	Root MSE		FPE Mean
	0.180110	49.97340	31.044405		62.121858
Source	DF	Type I SS	Mean Square	F Value	Pr > F
TREAT UNIT TREAT*UNIT	2 1 2	3141.6154043 349.4703006 3918.8956615	1570.8077022 349.4703006 1959.4478307	1.63 0.36 2.03	0.2105 0.5509 0.1461
Source	DF	Type III SS	Mean Square	F Value	Pr > F
TREAT UNIT TREAT*UNIT	2 1 2	3202.5658946 392.9294956 3918.8956615	1601.2829473 392.9294956 1959.4478307	1.66 0.41 2.03	0.2045 0.5273 0.1461

TWO-WAY ANOVA ON FPE [(GUIDED + SLUICE) / (GUIDED + SLUICE + UNGUIDED) FOR Unit 3 & 5 Pooled FOR SUMMED DATA SETS SPRING 96

General Linear Models Procedure Class Level Information

Class	Levels	Values
TREAT	. 3	BO UC UO

Number of observations in data set = 43NOTE: Due to missing values, only 41 observations can be used in this analysis.

Dependent Variable: FPE

Dependent varia		Sum of	Mean		
Source	DF	Squares	Square	F Value	Pr > F
Model	2	3141.6154043	1570.8077022	1.57	0.2211
Error	38	37999.7942274	999.9945849		
Corrected Total	40	41141.4096317			
	R-Square 0.076361	C.V. 50.90429	Root MSE 31.622691		FPE Mean 62.121858
Source	DF	Type I SS	Mean Square	F Value	Pr > F
TREAT	2	3141.6154043	1570.8077022	1.57	0.2211
Source	DF	Type III SS	Mean Square	F Value	Pr > F
TREAT	2	3141.6154043	1570.8077022	1.57	0.2211

Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: FPE

NOTE: This test controls the type I experimentwise error rate.

Alpha= 0.05 df= 38 MSE= 999.9946 WARNING: Cell sizes are not equal. Harmonic Mean of cell sizes= 13.65

Number of Means 2 3 Critical F 4.0981717 3.2448184

Means with the same letter are not significantly different. REGWF Grouping Mean N TREAT A 71.89 13 UO

A A	64.47	14	υc
A A	50.71	14	во

Appendix A Statistical Tests on Powerhouse 1 Data from Spring 1996

TWO-WAY ANOVA ON FPE [(GUIDED + SLUICE) / (GUIDED + SLUICE + UNGUIDED) AMONG BLK TREATMENTS AND UNITS FOR SUMMED DATA SETS SPRING 96

General Linear Models Procedure Class Level Information

Class	Levels	Values
BTRT	2	BLKED UNBLKED
UNIT	2	3 5

Number of observations in data set = 43 NOTE: Due to missing values, only 41 observations can be used in this analysis.

General Linear Models Procedure

Dependent	Variable: FPE				
Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	6643.1109597	2214.3703199	2.37	0.0857
Error	37	34498.2986720	932.3864506		
Corrected	Total 40	41141.4096317			
	R-Square 0.161470	C.V. 49.15340	Root MSE 30.535004		FPE Mean 62.121858
Source	DF	Type I SS	Mean Square	F Value	Pr > F
BTRT UNIT BTRT*UNIT	1 1 1	2770.8518206 285.7106173 3586.5485219	2770.8518206 285.7106173 3586.5485219	2.97 0.31 3.85	0.0931 0.5832 0.0574
Source	DF	Type III SS	Mean Square	F Value	Pr > F
BTRT UNIT BTRT*UNIT	1 1 1	2659.6233256 8.5120889 3586.5485219	2659.6233256 8.5120889 3586.5485219	2.85 0.01 3.85	0.0996 0.9244 0.0574

ONE-WAY ANOVA ON FPE [(GUIDED + SLUICE) / (GUIDED + SLUICE + UNGUIDED) AMONG BLOCK TREATMENTS (Unit 3 & 5 Pool FOR SUMMED DATA SETS SPRING 96

General Linear Models Procedure Class Level Information

Class	Levels	Values	5
BTRT	2	BLKED	UNBLKED

Number of observations in data set = 43 NOTE: Due to missing values, only 41 observations can be used in this analysis.

Dependent Variable: FPE

Doponiaonio valizana		Sum of	Mean		
Source	DF	Squares	Square	F Value	Pr > F
Model	1	2770.8518206	2770.8518206	2.82	0.1013
Error	39	38370.5578111	983.8604567		
Corrected Total	40	41141.4096317			
	R-Square	c.v.	Root MSE		FPE Mean
	0.067349	50.49197	31.366550		62.121858
Source	DF	Type I SS	Mean Square	F Value	Pr > F
BTRT	1	2770.8518206	2770.8518206	2.82	0.1013
Source	DF	Type III SS	Mean Square	F Value	Pr > F
BTRT	1	2770.8518206	2770.8518206	2.82	0.1013

Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: FPE

NOTE: This test controls the type I experimentwise error rate.

Alpha= 0.05 df= 39 MSE= 983.8605 WARNING: Cell sizes are not equal. Harmonic Mean of cell sizes= 18.43902

> Number of Means 2 Critical F 4.0912786

Means with the same letter are not significantly different. REGWF Grouping Mean N BTRT

A	68.04	27	UNBLKED
A A	50.71	14	BLKED
TWO-WAY ANOVA ON FPE [(GUIDED + SLUICE) / (GUIDED + SLUICE + UNGUIDED) AMONG GATE TREATMENTS AND UNITS FOR SUMMED DATA SETS SPRING 96

General Linear Models Procedure Class Level Information

Class	Levels	Values
GTRT	2	OPEN CLOSED
UNIT	2	35

Number of observations in data set = 43 NOTE: Due to missing values, only 41 observations can be used in this analysis.

General Linear Models Procedure

Dependent	Variable: FPE	Cum of	Maan		
Source	DF	Sum of Squares	Square	F Value	Pr > F
Model	3	2305.3928207	768.4642736	0.73	0.5395
Error	37	38836.0168110	1049.6220760		
Corrected	Total 40	41141.4096317			
	R-Square	c.v.	Root MSE		FPE Mean
	0.056036	52.15213	32.397871		62.121858
Source	DF	Type I SS	Mean Square	F Value	Pr > F
GTRT UNIT GTRT*UNIT	1 1 1	117.2832942 287.7397307 1900.3697958	117.2832942 287.7397307 1900.3697958	0.11 0.27 1.81	0.7401 0.6037 0.1866
Source	DF	Type III SS	Mean Square	F Value	Pr > F
GTRT UNIT GTRT*UNIT	1 1 1	32.8045628 914.2378078 1900.3697958	32.8045628 914.2378078 1900.3697958	0.03 0.87 1.81	0.8606 0.3567 0.1866

ONE-WAY ANOVA ON FPE [(GUIDED + SLUICE) / (GUIDED + SLUICE + UNGUIDED) AMONG GATE TREATMENTS (Unit 3 & 5 Poole FOR SUMMED DATA SETS SPRING 96

General Linear Models Procedure Class Level Information

Class	Levels	Values
GTRT	2	OPEN CLOSED

Number of observations in data set = 43 NOTE: Due to missing values, only 41 observations can be used in this analysis.

General Linear Models Procedure

Dependent	Variable:	FPE				
Source		DF	Sum of Squares	Mean Square	F Value	Pr > F
Model		1	117.28329423	117.28329423	0.11	0.7402
Error		39	41024.12633748	1051.90067532		
Corrected	Total	40	41141.40963171			
	R- 0.	-Square .002851	c.V. 52.20871	Root MSE 32.433018		FPE Mean 62.121858
Source		DF	Type I SS	Mean Square	F Value	Pr > F
GTRT		1	117.28329423	117.28329423	0.11	0.7402
Source		DF	Type III SS	Mean Square	F Value	Pr > F
GTRT		1	117.28329423	117.28329423	0.11	0.7402

Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: FPE NOTE: This test controls the type I experimentwise error rate.

> Alpha= 0.05 df= 39 MSE= 1051.901 WARNING: Cell sizes are not equal. Harmonic Mean of cell sizes= 18.43902

> > Number of Means 2 Critical F 4.0912786

Means with the same letter are not significantly different. REGWF Grouping Mean N GTRT

A	64.47	14	CLOSED
A			
A	60.90	27	OPEN

Appendix A Statistical Tests on Powerhouse 1 Data from Spring 1996

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ONE-WAY ANOVA ON FPE [(GUIDED + SLUICE) / (GUIDED + SLUICE + UNGUIDED) AMONG GATE TREATMENTS (Unit 3) FOR SUMMED DATA SPRING 96

General Linear Models Procedure Class Level Information

Class	Levels	Values
GTRT	2	OPEN CLOSED

Number of observations in data set = 28

General Linear Models Procedure

Dependent Variabl	e: FPE				
		Sum of	Mean	1	
Source	DF	Squares	Square	F Value	Pr > F
Model	1	2415.9803790	2415.9803790	1.48	0.2348
Error	26	42453.0320186	1632.8089238		
Corrected Total	27	44869.0123976			
	R-Square	c.v.	Root MSE		FPE Mean
	0.053845	83.09461	40.408030		48.628941
Source	DF	Type I SS	Mean Square	F Value	Pr > F
GTRT	1	2415.9803790	2415.9803790	1.48	0.2348
Source	DF	Type III SS	Mean Square	F Value	Pr > F
GTRT	1	2415.9803790	2415.9803790	1.48	0.2348

Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: FPE NOTE: This test controls the type I experimentwise error rate.

> Alpha= 0.05 df= 26 MSE= 1632.809 WARNING: Cell sizes are not equal. Harmonic Mean of cell sizes= 13.92857

> > Number of Means 2 Critical F 4.2252013

Means with the same letter are not significantly different. REGWF Grouping Mean N GTRT A 58.61 13 OPEN A A 39.98 15 CLOSED

ONE-WAY ANOVA ON FPE [(GUIDED + SLUICE) / (GUIDED + SLUICE + UNGUIDED) AMONG GATE TREATMENTS (Unit 5) FOR SUMMED DATA SPRING 96

General Linear Models Procedure Class Level Information

Class	Levels	Values
GTRT	2	OPEN CLOSED

Number of observations in data set = 28 NOTE: Due to missing values, only 25 observations can be used in this analysis.

Dependent Variable: FPE

		Sum of	Mean		
Source	DF	Squares	Square	F Value	Pr > F
Model	1	7764.6578869	7764.6578869	7.35	0.0125
Error	23	24312.6227923	1057.0705562		
Corrected Total	24	32077.2806792			
	R-Square 0.242061	C.V. 68.56970	Root MSE 32.512621		FPE Mean 47.415434
Source	DF	Type I SS	Mean Square	F Value	Pr > F
GTRT	1	7764.6578869	7764.6578869	7.35	0.0125
Source	DF	Type III SS	Mean Square	F Value	Pr > F
GTRT	1	7764.6578869	7764.6578869	7.35	0.0125

Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: FPE

NOTE: This test controls the type I experimentwise error rate.

Alpha= 0.05 df= 23 MSE= 1057.071 WARNING: Cell sizes are not equal. Harmonic Mean of cell sizes= 12.32

Number of Means 2 Critical F 4.2793443

Means with the same letter are not significantly different. REGWF Grouping Mean N GTRT

A	63.04	14	OPEN
В	27.53	11	CLOSED

ONE-WAY ANOVA ON FGE [(GUIDED / (GUIDED + UNGUIDED) AMONG UNITS FOR SUMMED DATA SETS SPRING 96

General Linear Models Procedure Class Level Information

Class Levels Values UNIT 2 3 5

Number of observations in data set = 28 NOTE: Due to missing values, only 27 observations can be used in this analysis.

General Linear Models Procedure

Dependent	Variable:	FGE	_			
Source		DF	Sum of Squares	Mean Square	F Value	Pr > F
Model		1	5672.5172027	5672.5172027	40.30	0.0001
Error		25	3518.9653743	140.7586150		
Corrected	Total	26	9191.4825770			
	R- 0.	Square 617149	C.V. 19.82755	Root MSE 11.864174	FGE	Mean 59.836822
Source		DF	Type I SS	Mean Square	F Value	Pr > F
UNIT		1	5672.5172027	5672.5172027	40.30	0.0001
Source		DF	Type III SS	Mean Square	F Value	Pr > F
UNIT		1	5672.5172027	5672.5172027	40.30	0.0001

Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: FGE

NOTE: This test controls the type I experimentwise error rate.

Alpha= 0.05 df= 25 MSE= 140.7586 WARNING: Cell sizes are not equal. Harmonic Mean of cell sizes= 13.48148

> Number of Means 2 Critical F 4.2416991

Means with the same letter are not significantly different. REGWF Grouping Mean N UNIT

A	73.804	14	3
В	44.795	13	5

Appendix A Statistical Tests on Powerhouse 1 Data from Spring 1996

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TWO-WAY ANOVA ON IN-TURBINE FGE AMONG GATE TREATMENTS (Unit 3 & 5 Pooled) SPRING 96

General Linear Models Procedure Class Level Information

Class	Levels	Values
GTRT	2	OPEN CLOSED
INTAKE	6	03A 03B 03C TU5A TU5B TU5C

Number of observations in data set = 83

Dependent Variabl	e: FGE				
Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	11	40163.553770	3651.232161	11.64	0.0001
Error	71	22264.232746	313.580743		
Corrected Total	82	62427.786516			
	R-Square	c.v.	Root MSE		FGE Mean
	0.643360	32.63593	17.708211		54.259865
Source	DF	Type I SS	Mean Square	F Value	Pr > F
GTRT	1	744.586440	744.586440	2.37	0.1278
INTAKE	5	38356.120072	7671.224014	24.46	0.0001
GTRT*INTAKE	5	1062.847258	212.569452	0.68	0.6416
Source	DF	Type III SS	Mean Square	F Value	Pr > F
GTRT	1	171.473562	171.473562	0.55	0.4621
INTAKE	5	38148.229102	7629.645820	24.33	0.0001
GTRT*INTAKE	5	1062.847258	212.569452	0.68	0.6416

ONE-WAY ANOVA ON IN-TURBINE FGE AMONG INTAKES (Unit 3 & 5 Pooled) SPRING 96

General Linear Models Procedure Class Level Information

	Class Leve INTAKE	ls Values 6 03A 03B	03C TU5A TU5B	TU5C		
Dependent Variabl	le: FGE					
Source	DF	Sum of Squares	Mea Squa:	an re FValue	Pr > F	
Model	5	38916.491812	7783.2983	62 25.49	0.0001	
Error	77	23511.294704	305.34149	90		
Corrected Total	82	62427.786516				
	R-Square 0.623384	C.V. 32.20433	Root M 17.47402	5E 23	FGE Mean 54.259865	
Source	DF	Type I SS	Mean Squar	re F Value	Pr > F	
INTAKE	5	38916.491812	7783.29836	52 25.49	0.0001	
Source	DF	Type III SS	Mean Squar	ce F Value	Pr > F	
INTAKE	5	38916.491812	7783.29836	52 25.49	0.0001	
Ryan-Ei	not-Gabriel-W	elsch Multiple	F Test for va	ariable: FGE		
NOTE: T	his test cont	rols the type	I experimentwi	se error rate	è.	
Alpha= 0.05 df= 77 MSE= 305.3415 WARNING: Cell sizes are not equal. Harmonic Mean of cell sizes= 13.82278						
Number of Critical F Means w R	Means 5.95742 ith the same EGWF Grouping	2 3 31 3.8573667 3 Letter are not	4 3.0480784 2.490 5 significantly Mean N I	5 94465 2.333307 different. NTAKE	6 79	
	A	86	5.444 14 0	3A		
	B	65	.860 14 0	3B		
	B	63	.296 14 0	30		

в

С

С

С

14 TU5A

13 TU5C

14 TU5B

53.836

34.710

20.016

ONE-WAY ANOVA ON IN-TURBINE FGE AMONG GATE TREATMENTS (Unit 3 & 5 Pooled) SPRING 96

General Linear Models Procedure Class Level Information

Class	Levels	Values
GTRT	2	OPEN CLOSED

Number of observations in data set = 83

Dependent Variable: FGE

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	744.58644023	744.58644023	0.98	0.3257
Error	81	61683.20007601	761.52098859		
Corrected Total	82	62427.78651623			
	R-Square 0.011927	C.V. 50.85835	Root MSE 27.595670		FGE Mean 54.259865
Source	DF	Type I SS	Mean Square	F Value	Pr > F
GTRT	1	744.58644023	744.58644023	0.98	0.3257
Source	DF	Type III SS	Mean Square	F Value	Pr > F
GTRT	1	744.58644023	744.58644023	0.98	0.3257

Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: FGE

NOTE: This test controls the type I experimentwise error rate.

Alpha= 0.05 df= 81 MSE= 761.521 WARNING: Cell sizes are not equal. Harmonic Mean of cell sizes= 41.3494

Number of Means 2 Critical F 3.9588517

Means with the same letter are not significantly different. REGWF Grouping Mean N GTRT

А	57.080	44	CLOSED
A			
A	51.079	39	OPEN

Appendix A Statistical Tests on Powerhouse 1 Data from Spring 1996

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	one-way a Among g	NOVA ON IN-TUR ATE TREATMENTS SPRING 9	BINE FGE BY UNI (SUMMED DATA) 6	Т		
		UNIT=3				
	Gener C	al Linear Mode lass Level Inf	ls Procedure ormation			
	Clas GTRT Number of	s Levels 2 observations	Values OPEN CLOSED in by group = 1	4		
		UNIT=3				
Dependent Variable:	: FGE		Nr			
Source	DF	Sum OI Squares	Mea Squar	n e FValue	Pr > F	
Model	1	25.15779747	25.1577974	7 0.43	0.5236	
Error	12	699.32919792	58.2774331	6		
Corrected Total	13	724.48699539				
I (R-Square 0.034725	C.V. 10.34354	Root MS 7.633965	E F(8	E Mean 73.804161	
Source	DF	Type I SS	Mean Square	e F Value	Pr > F	
GTRT	1	25.15779747	25.1577974	7 0.43	0.5236	
Source	DF	Type III SS	Mean Square	e F Value	Pr > F	
GTRT	1	25.15779747	25.1577974	7 0.43	0.5236	
		UNIT=3				
Ryan-Einot-	Gabriel-Wel	lsch Multiple I	F Test for varia	able: FGE		
NOTE: Thi	s test cont	trols the type	I experimentwis	se error rat	æ.	
Alpha= 0.05 df= 12 MSE= 58.27743 WARNING: Cell sizes are not equal. Harmonic Mean of cell sizes= 6.857143						
Number of Means 2 Critical F 4.7472253						
Means wit RE	h the same GWF Groupir	letter are not ng	t significantly Mean N C	different. FTRT		

A	74.965	8	CLOSED
A A	72.256	6	OPEN

Appendix A Statistical Tests on Powerhouse 1 Data from Spring 1996

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ONE-WAY ANOVA ON IN-TURBINE FGE BY UNIT AMONG GATE TREATMENTS (SUMMED DATA) SPRING 96

----- UNIT=5 -----

Class Level Information

Class Levels Values GTRT 2 OPEN CLOSED Number of observations in by group = 14 NOTE: Due to missing values, only 13 observations can be used in this analysis.

Dependent Variable: FGE

Dependente varrab.		Sum of	Mean		
Source	DF	Squares	Square	F Value	Pr > F
Model	1	359.87447253	359.87447253	1.63	0.2285
Error	11	2434.60390642	221.32762786		
Corrected Total	12	2794.47837895			
	R-Square 0.128781	C.V. 33.21143	Root MSE 14.877084	FGE	Mean 44.795072
Source	DF	Type I SS	Mean Square	F Value	Pr > F
GTRT	1	359.87447253	359.87447253	1.63	0.2285
Source	DF	Type III SS	Mean Square	F Value	Pr > F
GTRT	1	359.87447253	359.87447253	1.63	0.2285
		UNIT=5 -			

Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: FGE

NOTE: This test controls the type I experimentwise error rate.

Alpha= 0.05 df= 11 MSE= 221.3276 WARNING: Cell sizes are not equal. Harmonic Mean of cell sizes= 6.461538

> Number of Means 2 Critical F 4.8443357

Means with the same letter are not significantly different. REGWF Grouping Mean N GTRT

А	50.478	6	CLOSED
A A	39.924	7	OPEN

TWO-WAY ANOVA ON STANDARDIZED SLUICE PASSAGE [(SLUICE / BYPASSED] AMONG TREATMENTS AND UNITS FOR SUMMED DATA SETS SPRING 96

General Linear Models Procedure Class Level Information

Class	Levels	Values
TREAT	2	BO UO
UNIT	2	35

Number of observations in data set = 26

NOTE: Due	to missi	ing values,	only 25 observa	tions can be used	in this	analysis.
Dependent	Variable	e: SSP				
Source		DF	Sum of Squares	Mean Square	F Value	Pr > F
Model		3	0.10641856	0.03547285	0.90	0.4572
Error		21	0.82665376	0.03936446		
Corrected	Total	24	0.93307232			
		R-Square	c.v.	Root MSE	SSP	Mean
		0.114052	279.3589	0.1984048		0.0710215
Source		DF	Type I SS	Mean Square	F Value	Pr > F
TREAT UNIT TREAT*UNIT		1 1 1	0.05212343 0.03030355 0.02399158	0.05212343 0.03030355 0.02399158	1.32 0.77 0.61	0.2628 0.3902 0.4437
Source		DF	Type III SS	Mean Square	F Value	Pr > F
TREAT UNIT TREAT*UNIT		1 1 1	0.04646293 0.02829897 0.02399158	0.04646293 0.02829897 0.02399158	1.18 0.72 0.61	0.2896 0.4061 0.4437

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ONE-WAY ANOVA ON STANDARDIZED SLUICE PASSAGE [(SLUICE / BYPASSED] AMONG TREATMENTS (Unit 3 & 5 Pooled) FOR SUMMED DATA SETS SPRING 96

General Linear Models Procedure Class Level Information

Class Levels Values TREAT 2 BO UO

Number of observations in data set = 26

NOTE: Due to missing values, only 25 observations can be used in this analysis.

General Linear Models Procedure

Dependent	Variable: SSP				
Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	0.05212343	0.05212343	1.36	0.2553
Error	23	0.88094889	0.03830213		
Corrected	Total 24	0.93307232			
	R-Square	c.v.	Root MSE	SSP	Mean
	0.055862	275.5636	0.1957093		0.0710215
Source	DF	Type I SS	Mean Square	F Value	Pr > F
TREAT	1	0.05212343	0.05212343	1.36	0.2553
Source	DF	Type III SS	Mean Square	F Value	Pr > F
TREAT	1	0.05212343	0.05212343	1.36	0.2553

Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: SSP

NOTE: This test controls the type I experimentwise error rate.

Alpha= 0.05 df= 23 MSE= 0.038302 WARNING: Cell sizes are not equal. Harmonic Mean of cell sizes= 12.48

Number of Means 2 Critical F 4.2793443

Means with the same letter are not significantly different.

REGWF	Grouping	Mean	N	TREAT
	A	0.11489	13	во
	A A	0.02350	12	UO

ONE-WAY ANOVA ON STANDARDIZED SLUICE PASSAGE [(SLUICE /BYPASSED] AMONG TREATMENTS (Unit 3) FOR SUMMED DATA SPRING 96

General Linear Models Procedure Class Level Information

Class	Levels	Values
TREAT	2	BO UO

Number of observations in data set = 13

General Linear Models Procedure

Dependent Variab	le: SSP				
Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	0.07125369	0.07125369	0.95	0.3498
Error	11	0.82194852	0.07472259		
Corrected Total	12	0.89320221			
	R-Square 0.079773	c.v. 257.5559	Root MSE 0.2733543	SSP	Mean 0.1061340
Source	DF	Type I SS	Mean Square	F Value	Pr > F
TREAT	1	0.07125369	0.07125369	0.95	0.3498
Source	DF	Type III SS	Mean Square	F Value	Pr > F
TREAT	1	0.07125369	0.07125369	0.95	0.3498

Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: SSP

NOTE: This test controls the type I experimentwise error rate.

Alpha= 0.05 df= 11 MSE= 0.074723 WARNING: Cell sizes are not equal. Harmonic Mean of cell sizes= 6.461538

> Number of Means 2 Critical F 4.8443357

Means with the same letter are not significantly different. REGWF Grouping Mean N TREAT A 0.1747 7 BO A A 0.0262 6 UO

ONE-WAY ANOVA ON STANDARDIZED SLUICE PASSAGE [(SLUICE /BYPASSED] AMONG TREATMENTS (Unit 5) FOR SUMMED DATA SPRING 96

General Linear Models Procedure Class Level Information

Class Levels Values TREAT 2 BO UO

Number of observations in data set = 13

NOTE: Due to missing values, only 12 observations can be used in this analysis.

General Linear Models Procedure

Dependent	Variable: SSP				
Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	0.00177414	0.00177414	3.77	0.0808
Error	10	0.00470524	0.00047052		
Corrected	Total 11	0.00647937			
	R-Square	c.v.	Root MSE	SSP	Mean
	0.273813	65.76606	0.0216916		0.0329829
Source	DF	Type I SS	Mean Square	F Value	Pr > F
TREAT	1	0.00177414	0.00177414	3.77	0.0808
Source	DF	Type III SS	Mean Square	F Value	Pr > F
TREAT	1	0.00177414	0.00177414	3.77	0.0808

Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: SSP

NOTE: This test controls the type I experimentwise error rate.

Alpha= 0.05 df= 10 MSE= 0.000471

Number of Means2Critical F4.9646027

Means	with REGW	the F Gr	same coupin	letter ng	are	not	signific Mean	antly N	y different. TREAT
				A		0.0	04514	6	во
				A A		0.0	02082	6	UO

TWO-WAY ANOVA ON SLUICE FPE [(SLUICE / SLUICE + TURBINE] AMONG TREATMENTS AND UNITS IN SPRING 1996

General Linear Models Procedure Class Level Information

Class	Levels	Values
TREAT	2	BO UO
UNIT	2	35

Number of observations in data set = 26

NOTE: Due	to missi	ing values,	only 25 observa	ations can be used	in this	analysis.
Dependent	Variable	e: SPE				
Source		DF	Sum of Squares	Mean Square	F Value	Pr > F
Model		3	16154.995255	5384.998418	4.65	0.0121
Error		21	24333.055793	1158.716943		
Corrected	Total	24	40488.051048			
		R-Square	c.v.	Root MSE	SI	PE Mean
		0.399006	59.56435	34.039932		57.148165
Source		DF	Type I SS	Mean Square	F Value	Pr > F
TREAT UNIT TREAT*UNIT		1 1 1	866.833432 15282.783954 5.377868	866.833432 15282.783954 5.377868	0.75 13.19 0.00	0.3969 0.0016 0.9463
Source		DF	Type III SS	Mean Square	F Value	Pr > F
TREAT UNIT TREAT*UNIT	,	1 1 1	1160.469545 15283.048715 5.377868	1160.469545 15283.048715 5.377868	1.00 13.19 0.00	0.3283 0.0016 0.9463

ONE-WAY ANOVA ON SLUICE FPE [(SLUICE / SLUICE + TURBINE] AMONG TREATMENTS IN SPRING 1996 (Unit 3)

General Linear Models Procedure Class Level Information

Class	Levels	Values
TREAT	2	BO UO

Number of observations in data set = 13

General Linear Models Procedure

Dependent	Variable:	SLU_FGE	_			
Source		DF	Sum of Squares	Mean Square	F Value	Pr > F
Model		1	687.38134112	687.38134112	0.33	0.5798
Error		11	23228.88658053	2111.71696187		
Corrected	Total	12	23916.26792166			
	R	-Square	c.v.	Root MSE	SLU	_FGE Mean
	0	.028741	136.6498	45.953422		33.628600
Source		DF	Type I SS	Mean Square	F Value	Pr > F
TREAT		1	687.38134112	687.38134112	0.33	0.5798
Source		DF	Type III SS	Mean Square	F Value	Pr > F
TREAT		1	687.38134112	687.38134112	0.33	0.5798

Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: SLU_FGE

NOTE: This test controls the type I experimentwise error rate.

Alpha= 0.05 df= 11 MSE= 2111.717 WARNING: Cell sizes are not equal. Harmonic Mean of cell sizes= 6.461538

> Number of Means 2 Critical F 4.8443357

Means with the same letter are not significantly different. REGWF Grouping Mean N TREAT A 40.36 7 BO A A 25.77 6 UO

ONE-WAY ANOVA ON SLUICE FPE [(SLUICE / SLUICE + TURBINE] AMONG TREATMENTS IN SPRING 96 (Unit 5)

General Linear Models Procedure Class Level Information

Class	Levels	Values
TREAT	2	BO UO

Number of observations in data set = 13

NOTE: Due to missing values, only 12 observations can be used in this analysis.

General Linear Models Procedure

Dependent	Variable:	SLU_FGE				
Source		DF	Sum of Squares	Mean Square	F Value	Pr > F
Model		1	485.92733155	485.92733155	4.40	0.0623
Error		10	1104.16921255	110.41692125		
Corrected	Total	11	1590.09654410			
	R· 0	-Square .305596	c.v. 12.71722	Root MSE 10.507946	SL	U_FGE Mean 82.627695
Source		DF	Type I SS	Mean Square	F Value	Pr > F
TREAT		1	485.92733155	485.92733155	4.40	0.0623
Source		DF	Type III SS	Mean Square	F Value	Pr > F
TREAT		1	485.92733155	485.92733155	4.40	0.0623

Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: SLU_FGE NOTE: This test controls the type I experimentwise error rate.

Alpha= 0.05 df= 10 MSE= 110.4169

Number of Means 2 Critical F 4.9646027

Means with the same letter are not significantly different. REGWF Grouping Mean N TREAT

A	88.991	6	BO
A			
A	76.264	6	UO

TWO-WAY ANOVA ON STANDARDIZED SMOLT PASSAGE [(GUIDED + UNGUIDED)/BYPASSED] AMONG BLK TREATMENTS AND UNITS FOR SUMMED DATA SETS SUMMER 96

General Linear Models Procedure Class Level Information

Class	Levels	Values
BTRT	2	BLKED UNBLKED
UNIT	2	35

Number of observations in data set = 60

NOTE: Due to missing values, only 59 observations can be used in this analysis.

Dependent Variable: STP

Source	DF	Sum of Squares	F Value	Pr > F
Model	3	2.15497507	26.98	0.0001
Error	55	1.46438928		
Corrected Total	58	3.61936435		
	R-Square	c.v.	STP 1	lean
	0.595402	66.35877	0	.24589438
Source	DF	Type I SS	F Value	Pr > F
BTRT UNIT BTRT*UNIT	1 1 1	0.27815169 1.08534616 0.79147723	10.45 40.76 29.73	0.0021 0.0001 0.0001
Source	DF	Type III SS	F Value	Pr > F
BTRT UNIT BTRT*UNIT	1 1 1	0.21634315 1.05688729 0.79147723	8.13 39.69 29.73	0.0061 0.0001 0.0001

TWO-WAY ANOVA ON STANDARDIZED SMOLT PASSAGE [(GUIDED + UNGUIDED)/BYPASSED] AMONG GATE TREATMENTS AND UNITS FOR SUMMED DATA SETS SUMMER 96

General Linear Models Procedure Class Level Information

Class	Levels	Values
GTRT UNIT	2	OPEN CLOSED 3 5

Number of observations in data set = 60

NOTE: Due to missing values, only 59 observations can be used in this analysis.

Dependent Variable: STP

Source	DF	Sum of Squares	F Value	Pr > F
Model	3	1.12535298	8.27	0.0001
Error	55	2.49401137		
Corrected Total	58	3.61936435		
	R-Square 0.310926	C.V. 86.60027	STP 1 0	Mean .24589438
Source	DF	Type I SS	F Value	Pr > F
GTRT UNIT GTRT*UNIT	1 1 1	0.00010222 1.10888007 0.01637070	0.00 24.45 0.36	0.9623 0.0001 0.5504
Source	DF	Type III SS	F Value	Pr > F
GTRT UNIT GTRT*UNIT	1 1 1	0.00519271 1.11111073 0.01637070	0.11 24.50 0.36	0.7364 0.0001 0.5504

ONE-WAY ANOVA ON STANDARDIZED SMOLT PASSAGE [(GUIDED TWO-WAY ANOVA ON STANDARDIZED SMOLT PASSAGE [(GUIDED + UNGUIDED)/BYPASSED] AMONG GATE TREATMENTS AND BLOCK TREATMENTS FOR SUMMED DATA SETS SUMMER 96

General Linear Models Procedure Class Level Information

Class	Levels	Values
BTRT	2	BLKED UNBLKED
GTRT	2	OPEN CLOSED

Number of observations in data set = 60 NOTE: Due to missing values, only 59 observations can be used in this analysis.

General Linear Models Procedure

Dependent Variable: STP

Source	DF	Sum of Squares	F Value	Pr > F
Model	3	0.28338749	1.56	0.2101
Error	55	3.33597686		
Corrected Total	58	3.61936435		
	R-Square	c.v.	STP 1	lean
	0.078298	100.1571	0.	.24589438
Source	DF	Type I SS	F Value	Pr > F
BTRT GTRT BTRT*GTRT	1 1 1	0.27815169 0.00304368 0.00219212	4.59 0.05 0.04	0.0367 0.8236 0.8499
Source	DF	Type III SS	F Value	Pr > F
BTRT GTRT BTRT*GTRT	1 1 1	0.27998275 0.00293951 0.00219212	4.62 0.05 0.04	0.0361 0.8266 0.8499

ONE-WAY ANOVA ON STANDARDIZED SMOLT PASSAGE [(GUIDED + UNGUIDED)/BYPASSED] AMONG TREATMENTS (Unit 3) FOR SUMMED DATA SUMMER 96

General Linear Models Procedure Class Level Information

Class	Levels	Values
TREAT	4	BC BO UC UO

Number of observations in data set = 28

General Linear Models Procedure

Dependent	Variable:	STP
-----------	-----------	-----

Source	DF	Sum of Squares	F Value	Pr > F
Model	3	0.25686969	6.54	0.0022
Error	24	0.31423866		
Corrected Total	27	0.57110834		
	R-Square 0.449774	C.V. 64.96691	STP 0	Mean .17612945
Source	DF	Type I SS	F Value	Pr > F
TREAT	3	0.25686969	6.54	0.0022
Source	DF	Type III SS	F Value	Pr > F
TREAT	3	0.25686969	6.54	0.0022

Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: STP

NOTE: This test controls the type I experimentwise error rate.

Alpha= 0.05 df= 24 MSE= 0.013093 WARNING: Cell sizes are not equal. Harmonic Mean of cell sizes= 6.927835

 Number of Means
 2
 3
 4

 Critical F
 5.6887853
 3.4028261
 3.0087866

Means with the same letter are not significantly different. N TREAT REGWF Grouping Mean Α 0.27410 7 UC Α 0.26925 7 UO Α 0.09113 6 BC В в в 0.07267 8 BO

ONE-WAY ANOVA ON STANDARDIZED SMOLT PASSAGE [(GUIDED + UNGUIDED)/BYPASSED] AMONG BLK TREATMENTS (Unit 3) FOR SUMMED DATA SUMMER 96

General Linear Models Procedure Class Level Information

Class	Levels	Values
BTRT	2	BLKED UNBLKED

Number of observations in data set = 28

General Linear Models Procedure

Dependent	Variable:	STP
Dependence		

Source	DF	Sum of Squares	F Value	Pr > F
Model	1	0.25561998	21.07	0.0001
Error	26	0.31548836		
Corrected Total	27	0.57110834		
	R-Square 0.447586	C.V. 62.54218	STP N O.	1ean 17612945
Source	DF	Type I SS	F Value	Pr > F
BTRT	1	0.25561998	21.07	0.0001
Source	DF	Type III SS	F Value	Pr > F
BTRT	1	0.25561998	21.07	0.0001

Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: STP

NOTE: This test controls the type I experimentwise error rate.

Alpha= 0.05 df= 26 MSE= 0.012134

Number of Means2Critical F4.2252013

Means with the same letter are not significantly different. REGWF Grouping Mean N BTRT

A	0.27168	14	UNBLKED
в	0.08058	14	BLKED

ONE-WAY ANOVA ON STANDARDIZED SMOLT PASSAGE [(GUIDED + UNGUIDED)/BYPASSED] AMONG GATE TREATMENTS (Unit 3) FOR SUMMED DATA SUMMER 96

> General Linear Models Procedure Class Level Information

Class	Levels	Values
GTRT	2	OPEN CLOSED

Number of observations in data set = 28

General Linear Models Procedure

Dependent Variable: STP

Source	DF	Sum of Squares	F Value	Pr > F
Model	1	0.00443705	0.20	0.6556
Error	26	0.56667129		
Corrected Total	27	0.57110834		
	R-Square	c.v.	STP	Mean
	0.007769	83.81986		0.17612945
Source	DF	Type I SS	F Value	Pr > F
GTRT	1	0.00443705	0.20	0.6556
Source	DF	Type III SS	F Value	Pr > F
GTRT	1	0.00443705	0.20	0.6556

Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: STP

NOTE: This test controls the type I experimentwise error rate.

Alpha= 0.05 df= 26 MSE= 0.021795 WARNING: Cell sizes are not equal. Harmonic Mean of cell sizes= 13.92857

Number of Means2Critical F4.2252013

Means with the same letter are not significantly different. REGWF Grouping Mean N GTRT A 0.18965 13 CLOSED A A 0.16441 15 OPEN

ONE-WAY A UNGUI	NOVA ON STAN DED)/BYPASSE FO	DARDIZED SMOLT PAS D] AMONG TREATMENT R SUMMED DATA SUMMER 96	SAGE [(GUIDE: S (Unit 5)	D +
	General Li Class	near Models Proced Level Information	ure	
	Class TREAT	Levels Values 4 BC BO UC	υο	
Nu NOTE: Due to miss analysis.	mber of obse ing values,	rvations in data s only 31 observatio	et = 32 ns can be us	ed in this
Dependent Variabl	e: STP			
Source	DF	Sum of Squares	F Value	Pr > F
Model	3	2.88804882	6.44	0.0020
Error	27	4.03890072		
Corrected Total	30	6.92694953		
	R-Square 0.416929	c.v. 59.61900	STP 1 0.	Mean .64873157
Source	DF	Type I SS	F Value	Pr > F
TREAT	3	2.88804882	6.44	0.0020
Source	DF	Type III SS	F Value	Pr > F
TREAT	3	2.88804882	6.44	0.0020

Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: STP

NOTE: This test controls the type I experimentwise error rate.

Alpha= 0.05 df= 27 MSE= 0.149589 WARNING: Cell sizes are not equal. Harmonic Mean of cell sizes= 7.578947

 Number of Means
 2
 3
 4

 Critical F
 5.6059779
 3.3541308
 2.9603513

Means with the same letter are not significantly different. N TREAT REGWF Grouping Mean 8 BO А 0.9667 Α 0.9209 8 BC Α 6 UO 0.3403 в в 9 UC 0.3297 в

ONE-WAY ANOVA ON STANDARDIZED SMOLT PASSAGE [(GUIDED + UNGUIDED)/BYPASSED] AMONG BLK TREATMENTS (Unit 5) FOR SUMMED DATA SUMMER 96

General Linear Models Procedure Class Level Information

Class	Levels	Values	
BTRT	2	BLKED UNBLKED	

Number of observations in data set = 32 NOTE: Due to missing values, only 31 observations can be used in this analysis.

Dependent Variable: STP

Source	DF	Sum of Squares	F Value	Pr > F
Model	1	2.87925063	20.63	0.0001
Error	29	4.04769890		
Corrected Total	30	6.92694953		
	R-Square 0.415659	C.V. 57.58907	STP O	Mean .64873157
Source	DF	Type I SS	F Value	Pr > F
BTRT	1	2.87925063	20.63	0.0001
Source	DF	Type III SS	F Value	Pr > F
BTRT	1	2.87925063	20.63	0.0001

Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: STP

NOTE: This test controls the type I experimentwise error rate.

Alpha= 0.05 df= 29 MSE= 0.139576 WARNING: Cell sizes are not equal. Harmonic Mean of cell sizes= 15.48387

Number of Means2Critical F4.1829643

Means with the same letter are not significantly different. REGWF Grouping Mean N BTRT A 0.9438 16 BLKED

в	0.3340	15	UNBLKED

ONE-WAY AN UNGUIDEI	IOVA ON STAN))/BYPASSED] FO	DARDIZED SMOLT PAS AMONG GATE TREAT R SUMMED DATA SUMMER 96	SAGE [(GUIDE MENTS (Unit 5	D +)
	General Li Class	near Models Proced Level Information	lure	
	Class GTRT	Levels Values 2 OPEN CLC	SED	
Num NOTE: Due to missi analysis	ber of obse ng values,	rvations in data s only 31 observatio	set = 32 ons can be us	ed in this
Dependent Variable	: STP			
Source	DF	Sum of Squares	F Value	Pr > F
Model	1	0.06264684	0.26	0.6108
Error	29	6.86430270		
Corrected Total	30	6.92694953		
	R-Square	c.v.	STP 1	lean
	0.009044	74.99532	0	.64873157
Source	DF	Type I SS	F Value	Pr > F
GTRT	1	0.06264684	0.26	0.6108
Source	DF	Type III SS	F Value	Pr > F
GTRT	1	0.06264684	0.26	0.6108

Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: STP

NOTE: This test controls the type I experimentwise error rate.

Alpha= 0.05 df= 29 MSE= 0.2367 WARNING: Cell sizes are not equal. Harmonic Mean of cell sizes= 15.35484

Number of Means 2 Critical F 4.1829643

Means with the same letter are not significantly different. REGWF Grouping Mean N GTRT A 0.6983 14 OPEN A A 0.6079 17 CLOSED

TWO-WAY ANOVA ON STANDARDIZED SMOLT PASSAGE (GUIDED + UNGUIDED/BYPASSED) AT TEST TURBINES AMONG BLK TREATMENTS AND INTAKES SUMMER 96

General Linear Models Procedure Class Level Information

Class	Levels	Values
INTAKE	6	03A 03B 03C TU5A TU5B TU5C BLKED UNBLKED

Number of observations in data set = 176 NOTE: Due to missing values, only 173 observations can be used in this analysis.

General Linear Models Procedure

Dependent Variable: STP

Source	DF	Sum of Squares	F Value	Pr > F
Model	11	3.89685304	38.00	0.0001
Error	161	1.50076038		
Corrected Total	172	5.39761342		
	R-Square	c.v.	STP 1	Mean
	0.721959	105.1542	0	.09181549
Source	DF	Type I SS	F Value	Pr > F
INTAKE BTRT INTAKE*BTRT	5 1 5	2.22394931 0.11979232 1.55311141	47.72 12.85 33.32	0.0001 0.0004 0.0001
Source	DF	Type III SS	F Value	Pr > F
INTAKE BTRT INTAKE*BTRT	5 1 5	2.10988551 0.09306534 1.55311141	45.27 9.98 33.32	0.0001 0.0019 0.0001

Appendix B Statistical Tests on Powerhouse 1 Data from Summer 1996

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ONE-WAY ANOVA ON STANDARDIZED SMOLT PASSAGE (GUIDED + UNGUIDED/BYPASSED) AT TEST TURBINES AMONG BLK TREATMENTS BY INTAKE SUMMER 96							
		- INTAKE=0)3A				
General Linear Models Procedure Class Level Information							
Class Levels Values BTRT 2 BLKED UNBLKED							
Nu	mber of obs	ervations	in by ç	group =	28		
		- INTAKE=0	3A				
Dependent Variabl	e: STP						
Source	DF	Sum of S	quares	F١	Value	Pr > F	
Model	1	0.01	162329	2	22.05	0.0001	
Error	26	0.01	370725				
Corrected Total	27	0.02	533053				
	R-Square		c.v.		STP 1	Mean	
	0.458865	62	.62149		0	.03666613	
Source	DF	Тур	e I SS	FV	Value	Pr > F	
BTRT	1	0.01	162329	2	2.05	0.0001	
Source	DF	Type	III SS	FV	Value	Pr > F	
BTRT	1	0.01	162329	2	2.05	0.0001	
		INTAKE=0	3A				
Ryan-Einot-Gab	riel-Welsch	Multiple	F Test	for var	iable: S	STP	
NOTE: This te:	st controls	the type	I exper	imentwi	se erro	r rate.	
	Alpha= 0.05	df= 26	MSE= 0	.000527	,		
	Number Critica	of Means l F	4.22520	2 13			
Means with th REGWF	ne same lett Grouping	er are no	t signi: Mean	ficantl N	y diffe: BTRT	cent.	
	А	0.0	057041	14	UNBLKEI	þ	
	в	0.0	016292	14	BLKED		

ONE-WAY ANOVA ON STANDARDIZED SMOLT PASSAGE (GUIDED + UNGUIDED/BYPASSED) AT TEST TURBINES AMONG BLK TREATMENTS BY INTAKE SUMMER 96 General Linear Models Procedure Class Level Information Class Levels Values 2 BLKED UNBLKED BTRT Number of observations in by group = 28 ----- INTAKE=03B ------General Linear Models Procedure Dependent Variable: STP DF Sum of Squares F Value Pr > F Source 0.00263597 4.03 0.0553 Model 1 26 0.01702510 Error 27 Corrected Total 0.01966106 STP Mean c.v. R-Square 87.37143 0.134070 0.02928793 Source DF Type I SS F Value Pr > F 0.00263597 4.03 BTRT 1 0.0553 Type III SS F Value Source DF Pr > F1 0.00263597 4.03 BTRT 0.0553

Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: STP

NOTE: This test controls the type I experimentwise error rate.

Alpha= 0.05 df= 26 MSE= 0.000655

Number of Means2Critical F4.2252013

Means with the same letter are not significantly different. REGWF Grouping Mean N BTRT A 0.038991 14 UNBLKED A A 0.019585 14 BLKED

ONE-WAY ANOVA ON STANDARDIZED SMOLT PASSAGE (GUIDED + UNGUIDED/BYPASSED) AT TEST TURBINES AMONG BLK TREATMENTS BY INTAKE SUMMER 96 _____ INTAKE=03C _____ General Linear Models Procedure Class Level Information Levels Values 2 BLKED UNBLKED Class Levels BTRT Number of observations in by group = 28----- INTAKE=03C ------General Linear Models Procedure Dependent Variable: STP DF Sum of Squares F Value Pr > F Source 0.02773204 26.87 0.0001 1 Model 26 0.02683632 Error

Corrected Total	27	0.05456837		
	R-Square 0.508207	c.v. 67.63320	STI	Mean 0.04750233
Source	DF	Type I SS	F Value	Pr > F
BTRT	1	0.02773204	26.87	0.0001
Source	DF	Type III SS	F Value	Pr > F
BTRT	1	0.02773204	26.87	0.0001

----- INTAKE=03C ------

General Linear Models Procedure

Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: STP

NOTE: This test controls the type I experimentwise error rate.

Alpha= 0.05 df= 26 MSE= 0.001032

Number of Means 2 Critical F 4.2252013

Means with the same letter are not significantly different.

REGWF Grouping	Mean	N	BTRT
A	0.07897	14	UNBLKED
В	0.01603	14	BLKED

ONE-WAY ANOVA ON STANDARDIZED SMOLT PASSAGE (GUIDED + UNGUIDED/BYPASSED) AT TEST TURBINES AMONG BLK TREATMENTS BY INTAKE SUMMER 96 ----- INTAKE=TU5A -----General Linear Models Procedure Class Level Information Class Levels Values BTRT 2 BLKED UNBLKED Number of observations in by group = 32NOTE: Due to missing values, only 31 observations can be used in this analysis. ----- INTAKE=TU5A ------General Linear Models Procedure Dependent Variable: STP Source DF Sum of Squares F Value Pr > F 33.60 0.0001 Model 1 1.61278409 1.39197824 Error 29 30 3.00476233 Corrected Total R-Square c.v. STP Mean 0.536743 65.55953 0.33418073 F Value Source DF Type I SS Pr > F33.60 BTRT 1 1.61278409 0.0001 F Value Source DF Type III SS Pr > F1.61278409 33.60 0.0001 BTRT 1 Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: STP NOTE: This test controls the type I experimentwise error rate. Alpha= 0.05 df= 29 MSE= 0.047999 WARNING: Cell sizes are not equal. Harmonic Mean of cell sizes= 15.48387 Number of Means 2 Critical F 4.1829643 Means with the same letter are not significantly different. REGWF Grouping N BTRT Mean 0.55503 16 BLKED Α

15 UNBLKED

0.09861

Appendix B Statistical Tests on Powerhouse 1 Data from Summer 1996

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ONE-WAY ANOVA ON STANDARDIZED SMOLT PASSAGE (GUIDED + UNGUIDED/BYPASSED) AT TEST TURBINES AMONG BLK TREATMENTS BY INTAKE SUMMER 96 ----- INTAKE=TU5B -----General Linear Models Procedure Class Level Information Class Levels Values 2 BLKED UNBLKED BTRT Number of observations in by group = 30 NOTE: Due to missing values, only 29 observations can be used in this analysis. ----- INTAKE=TU5B -----General Linear Models Procedure Dependent Variable: STP Sum of Squares F Value Pr > F DF Source 0.01795108 14.08 0.0008 1 Model 0.03441554 27 Error 0.05236662 28 Corrected Total c.v. STP Mean R-Square 95.12209 0.03753307 0.342796 Source DF 0.0008 0.01795108 14.08 1 BTRT Type III SS F Value Pr > FDF Source 0.0008 0.01795108 14.08 1 BTRT ----- INTAKE=TU5B -----Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: STP NOTE: This test controls the type I experimentwise error rate. Alpha= 0.05 df= 27 MSE= 0.001275 WARNING: Cell sizes are not equal. Harmonic Mean of cell sizes= 14.48276 Number of Means 2 Critical F 4.2100085

Means with the same letter are not significantly different. REGWF Grouping in Mean N BTRT A 0.06329 14 UNBLKED B 0.01350 15 BLKED

Appendix B Statistical Tests on Powerhouse 1 Data from Summer 1996

B16

ONE-WAY ANOVA ON STANDARDIZED SMOLT PASSAGE (GUIDED + UNGUIDED/BYPASSED) AT TEST TURBINES AMONG BLK TREATMENTS BY INTAKE SUMMER 96 General Linear Models Procedure Class Level Information Levels Values Class BTRT 2 BLKED UNBLKED Number of observations in by group = 30NOTE: Due to missing values, only 29 observations can be used in this analysis. General Linear Models Procedure Dependent Variable: STP Sum of Squares F Value Pr > F Source DF 0.00017726 0.28 0.5979 1 Model 27 0.01679793 Error 28 0.01697520 Corrected Total c.v. STP Mean R-Square 0.010442 57.44278 0.04342208 DF Type I SS F Value Pr > FSource 0.00017726 1 0.28 0.5979 BTRT Pr > FDF Type III SS F Value Source 1 0.00017726 0.28 0.5979 BTRT Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: STP NOTE: This test controls the type I experimentwise error rate. Alpha= 0.05 df= 27 MSE= 0.000622 WARNING: Cell sizes are not equal. Harmonic Mean of cell sizes= 14.48276 Number of Means 2 Critical F 4.2100085 Means with the same letter are not significantly different.

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REGWF Grouping Mean N BTRT A 0.045981 14 UNBLKED A A 0.041034 15 BLKED

Appendix B Statistical Tests on Powerhouse 1 Data from Summer 1996

B17

ONE-WAY ANOVA ON STANDARDIZED SMOLT PASSAGE [(GUIDED + UNGUIDED)/BYPASSED] AMONG INTAKES (Unit 3 & 5 Pooled) SUMMER 96					
General Linear Models Procedure Class Level Information					
Class Levels Values INTAKE 6 03A 03B 03C TU5A TU5B TU5C					
Number of observations in data set = 176 NOTE: Due to missing values, only 173 observations can be used in this analysis.					
Dependent Variabl	e: STP				
Source	DF	Sum of Squares	F Value	Pr > F	
Model	5	2.22394931	23.41	0.0001	
Error	167	3.17366411			
Corrected Total	172	5.39761342			
	R-Square 0.412025	C.V. 150.1434	STI	9 Mean 0.09181549	
Source	DF	Type I SS	F Value	Pr > F	
INTAKE	5	2.22394931	23.41	0.0001	
Source	DF	Type III SS	F Value	Pr > F	
INTAKE	5	2.22394931	23.41	0.0001	

Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: STP

NOTE: This test controls the type I experimentwise error rate.

Alpha= 0.05 df= 167 MSE= 0.019004 WARNING: Cell sizes are not equal. Harmonic Mean of cell sizes= 28.79542

Number of Means23456Critical F5.81736793.75826122.96642462.42577722.2682669

Means with the same letter are not significantly different. REGWF Grouping Mean N INTAKE

A	0.33418	31	TU5A
В	0.04750	28	03C
B	0.04342	29	TU5C
B	0.03753	29	TU5B
B	0.03667	28	03A
в B	0.02929	28	03B

TWO-WAY ANOVA ON FPE [(GUIDED + SLUICE) / (GUIDED + SLUICE + UNGUIDED) AMONG TREATMENTS AND UNITS FOR SUMMED DATA SETS SUMMER 96

General Linear Models Procedure Class Level Information

Class	Levels	Values		
TREAT	3	BO UC UO		
UNIT	2	35		

Number of observations in data set = 46

General Linear Models Procedure

Dependent Variab	le: FPE				
		Sum of	Mean		
Source	DF	Squares	Square	F Value	Pr > F
Model	5	20224.331535	4044.866307	17.34	0.0001
Error	40	9329.938037	233.248451		
Corrected Total	45	29554.269572			
	R-Square 0.684312	c.v. 26.85461	Root MSE 15.272474		FPE Mean 56.870951
Source	DF	Type I SS	Mean Square	F Value	Pr > F
TREAT	2	8865.9011219	4432.9505610	19.01	0.0001
UNIT	1	6982.1622772	6982.1622772	29.93	0.0001
TREAT*UNIT	2	4376.2681358	2188.1340679	9.38	0.0005
Source	DF	Type III SS	Mean Square	F Value	Pr > F
TREAT	2	8386.2872024	4193.1436012	17.98	0.0001
UNIT	1	6840.9850317	6840.9850317	29.33	0.0001
TREAT*UNIT	2	4376.2681358	2188.1340679	9.38	0.0005
TWO-WAY ANOVA ON FPE [(GUIDED + SLUICE) / (GUIDED + SLUICE + UNGUIDED) FOR Unit 3 & 5 Pooled FOR SUMMED DATA SETS SUMMER 96

General Linear Models Procedure Class Level Information

Class	Levels	Valu	les	
TREAT	3	BO U	C	υo

Number of observations in data set = 46

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	2	8865.9011219	4432.9505610	9.21	0.0005
Error	43	20688.3684502	481.1248477		
Corrected Total	45	29554.2695721			
	R-Square 0.299987	C.V. 38.56900	Root MSE 21.934558		FPE Mean 56.870951
Source	DF	Type I SS	Mean Square	F Value	Pr > F
TREAT	2	8865.9011219	4432.9505610	9.21	0.0005
Source	DF	Type III SS	Mean Square	F Value	Pr > F
TREAT	2	8865.9011219	4432.9505610	9.21	0.0005

Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: FPE

NOTE: This test controls the type I experimentwise error rate.

Alpha= 0.05 df= 43 MSE= 481.1248 WARNING: Cell sizes are not equal. Harmonic Mean of cell sizes= 15.13267

Number of Means 2 3 Critical F 4.0670474 3.2144803

Means with the same letter are not significantly different.

REGWF Grouping	Mean	N	TREAT
А	77.766	13	UO
В	53.856	17	UC
B	43.097	16	во

ONE-WAY ANOVA ON FPE [(GUIDED + SLUICE) / (GUIDED + SLUICE + UNGUIDED) AMONG TREATMENTS (Unit 3) FOR SUMMED DATA SUMMER 96

General Linear Models Procedure Class Level Information

Class	Levels	Values
TREAT	4	BC BO UC UO

Number of observations in data set = 28

Dependent Variable: FPE

		Sum of	Mean		
Source	DF	Squares	Square	F Value	Pr > F
Model	3	26689.461394	8896.487131	61.08	0.0001
Error	24	3495.953905	145.664746		
Corrected Total	27	30185.415300			
	R-Square	c.v.	Root MSE		FPE Mean
	0.884184	21.83587	12.069165		55.272195
Source	DF	Type I SS	Mean Square	F Value	Pr > F
TREAT	3	26689.461394	- 8896.487131	61.08	0.0001
Source	DF	Type III SS	Mean Square	F Value	Pr > F
TREAT	3	26689.461394	8896.487131	61.08	0.0001

Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: FPE

NOTE: This test controls the type I experimentwise error rate.

Alpha= 0.05 df= 24 MSE= 145.6647 WARNING: Cell sizes are not equal. Harmonic Mean of cell sizes= 6.927835

 Number of Means
 2
 3
 4

 Critical F
 5.6887853
 3.4028261
 3.0087866

Means with the same letter are not significantly different. REGWF Grouping Mean N TREAT

A	86.976	7	υo
В	68.100	8	во
B	56.285	7	UC
с	0.000	6	BC

Appendix B Statistical Tests on Powerhouse I Data from Summer 1996

ONE-WAY ANOVA ON FPE [(GUIDED + SLUICE) / (GUIDED + SLUICE + UNGUIDED) AMONG TREATMENTS (Unit 5) FOR SUMMED DATA SUMMER 96

General Linear Models Procedure Class Level Information

Class	Levels	Values	
TREAT	4	BC BO UC UO	

Number of observations in data set = 32

General Linear Models Procedure

Dependent	Variable:	FPE				
Source		DF	Sum of Squares	Mean Square	F Value	Pr > F
Model		3	21098.439850	7032.813283	33.75	0.0001
Error		28	5833.984132	208.356576		
Corrected	Total	31	26932.423982			
	R-	Square	c.v.	Root MSE		FPE Mean
	0.	783384	43.23172	14.434562		33.388822
Source		DF	Type I SS	Mean Square	F Value	Pr > F
TREAT		3	21098.439850	7032.813283	33.75	0.0001
Source		DF	Type III SS	Mean Square	F Value	Pr > F
TREAT		3	21098.439850	7032.813283	33.75	0.0001

Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: FPE

NOTE: This test controls the type I experimentwise error rate.

Alpha= 0.05 df= 28 MSE= 208.3566 WARNING: Cell sizes are not equal. Harmonic Mean of cell sizes= 7.741935

 Number of Means
 2
 3
 4

 Critical F
 5.5826347
 3.3403856
 2.9466853

Means with the same letter are not significantly different. REGWF Grouping Mean N TREAT A 67.022 6 UO A A 52.155 10 UC B 18.095 8 BO C 0.000 8 BC

TWO-WAY ANOVA ON FPE [(GUIDED + SLUICE) / (GUIDED + SLUICE + UNGUIDED) AMONG GATE TREATMENTS AND UNITS FOR SUMMED DATA SETS SUMMER 96

General Linear Models Procedure Class Level Information

Class	Levels	Values
GTRT	2	OPEN CLOSED
UNIT	2	35

Number of observations in data set = 46

General Linear Models Procedure

Dependent	Variable: FPE				
		Sum of	Mean		
Source	DF	Squares	Square	F Value	Pr > F
Model	3	10686.767375	3562.255792	7.93	0.0003
Error	42	18867.502197	449.226243		
Corrected	Total 45	29554.269572			
	R-Square	c.v.	Root MSE		FPE Mean
	0.361598	37.26851	21.194958		56.870951
Source	DF	Type I SS	Mean Square	F Value	Pr > F
GTRT	1	245.1920176	245.1920176	0.55	0.4641
UNIT	1	7457.6971106	7457.6971106	16.60	0.0002
GTRT*UNIT	1	2983.8782467	2983.8782467	6.64	0.0136
Source	DF	Type III SS	Mean Square	F Value	Pr > F
GTRT	1	148.9356325	148.9356325	0.33	0.5678
UNIT	1	4624.8864057	4624.8864057	10.30	0.0026
GTRT*UNIT	1	2983.8782467	2983.8782467	6.64	0.0136

Appendix B Statistical Tests on Powerhouse I Data from Summer 1996

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ONE-WAY ANOVA ON FPE [(GUIDED + SLUICE) / (GUIDED + SLUICE + UNGUIDED) AMONG GATE TREATMENTS (Unit 3 & 5 Poole FOR SUMMED DATA SETS SUMMER 96

General Linear Models Procedure Class Level Information

Class	Levels	Values
GTRT	2	OPEN CLOSED

Number of observations in data set = 46

General Linear Models Procedure

Dependent Variabl	e: FPE				
Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	245.19201756	245.19201756	0.37	0.5472
Error	44	29309.07755457	666.11539897		
Corrected Total	45	29554.26957214			
	R-Square 0.008296	C.V. 45.38206	Root MSE 25.809212		FPE Mean 56.870951
Source	DF	Type I SS	Mean Square	F Value	Pr > F
GTRT	1	245.19201756	245.19201756	0.37	0.5472
Source	DF	Type III SS	Mean Square	F Value	Pr > F
GTRT	1	245.19201756	245.19201756	0.37	0.5472

Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: FPE

NOTE: This test controls the type I experimentwise error rate.

Alpha= 0.05 df= 44 MSE= 666.1154 WARNING: Cell sizes are not equal. Harmonic Mean of cell sizes= 21.43478

> Number of Means 2 Critical F 4.0617065

Means with the same letter are not significantly different. REGWF Grouping Mean N GTRT A 58.639 29 OPEN A A 53.856 17 CLOSED

ONE-WAY ANOVA ON FPE [(GUIDED + SLUICE) / (GUIDED + SLUICE + UNGUIDED) AMONG GATE TREATMENTS (Unit 3) FOR SUMMED DATA SUMMER 96

General Linear Models Procedure Class Level Information

Class	Levels	Values
GTRT	2	OPEN CLOSED

Number of observations in data set = 28

General Linear Models Procedure

Dependent Variable: FDF

Dependent Variabi	e. rrb	Sum of	Mean		
Source	DF	Squares	Square	F Value	Pr > F
Model	1	15124.265188	15124.265188	26.11	0.0001
Error	26	15061.150112	579.275004		
Corrected Total	27	30185.415300			
	R-Square	c.v.	Root MSE		FPE Mean
	0.501045	43.54474	24.068133		55.272195
Source	DF	Type I SS	Mean Square	F Value	Pr > F
GTRT	1	15124.265188	15124.265188	26.11	0.0001
Source	DF	Type III SS	Mean Square	F Value	Pr > F
GTRT	1	15124.265188	15124.265188	26.11	0.0001

Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: FPE NOTE: This test controls the type I experimentwise error rate.

> Alpha= 0.05 df= 26 MSE= 579.275 WARNING: Cell sizes are not equal. Harmonic Mean of cell sizes= 13.92857

> > Number of Means2Critical F4.2252013

Means with the same letter are not significantly different. REGWF Grouping Mean N GTRT A 76.909 15 OPEN B 30.307 13 CLOSED

Appendix B Statistical Tests on Powerhouse I Data from Summer 1996

ONE-WAY ANOVA ON FPE [(GUIDED + SLUICE) / (GUIDED + SLUICE + UNGUIDED) AMONG GATE TREATMENTS (Unit 5) FOR SUMMED DATA SUMMER 96

General Linear Models Procedure Class Level Information -

Class	Levels	Values
GTRT	2	OPEN CLOSED

Number of observations in data set = 32

Dependent	Variable:	FPE				
Source		DF	Sum of Squares	Mean Square	F Value	Pr > F
Model		1	801.52248980	801.52248980	0.92	0.3451
Error		30	26130.90149200	871.03004973		
Corrected	Total	31	26932.42398180			
	R- 0	-Square .029761	c.v. 88.39251	Root MSE 29.513218		FPE Mean 33.388822
Source		DF	Type I SS	Mean Square	F Value	Pr > F
GTRT		1	801.52248980	801.52248980	0.92	0.3451
Source		DF	Type III SS	Mean Square	F Value	Pr > F
GTRT		1	801.52248980	801.52248980	0.92	0.3451

Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: FPE

NOTE: This test controls the type I experimentwise error rate.

Alpha= 0.05 df= 30 MSE= 871.03 WARNING: Cell sizes are not equal. Harmonic Mean of cell sizes= 15.75

> Number of Means 2 4.1708768 Critical F

Means with the same letter are not significantly different. Mean N GTRT REGWF Grouping

A	39.06	14	OPEN
A	28 98	18	CLOSED
A	20.50	10	

Appendix B Statistical Tests on Powerhouse 1 Data from Summer 1996

1

TWO-WAY ANOVA ON IN-TURBINE FGE AMONG GATE TREATMENTS (Unit 3 & 5 Pooled) SUMMER 96

General Linear Models Procedure Class Level Information

Class	Levels	Values
GTRT	2	OPEN CLOSED
INTAKE	6	03A 03B 03C TU5A TU5B TU5C
Numbe	r of obsei	rvations in data set = 87

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Dependent Variable: FGE

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	11	7198.4900552	654.4081868	3.29	0.0010
Error	75	14924.9286779	198.9990490		
Corrected Total	86	22123.4187331			
	R-Square	c.v.	Root MSE		FGE Mean
	0.325379	25.45225	14.106702		55.424192
Source	DF	Type I SS	Mean Square	F Value	Pr > F
GTRT INTAKE GTRT*INTAKE	1 5 5	58.1935314 6675.5442475 464.7522762	58.1935314 1335.1088495 92.9504552	0.29 6.71 0.47	0.5903 0.0001 0.7996
Source	DF	Type III SS	Mean Square	F Value	Pr > F
GTRT INTAKE GTRT*INTAKE	1 5 5	57.5634755 7024.1252302 464.7522762	57.5634755 1404.8250460 92.9504552	0.29 7.06 0.47	0.5923 0.0001 0.7996

ONE-WAY ANOVA ON FGE [(GUIDED / (GUIDED + UNGUIDED) AMONG UNITS FOR SUMMED DATA SETS SUMMER 96

General Linear Models Procedure Class Level Information

Class Levels Values UNIT 2 35

Number of observations in data set = 29

Dependent Variable: FGE

Dependent Variabi	e. ren	Sum of	Mean		
Source	DF	Squares	Square	F Value	Pr > F
Model	1	443.18281802	443.18281802	2.34	0.1378
Error	27	5116.73023161	189.50852710		
Corrected Total	28	5559.91304963			
	R-Square	c.v.	Root MSE	FGE	Mean
	0.079710	25.93301	13.766210	:	53.083734
Source	DF	Type I SS	Mean Square	F Value	Pr > F
UNIT	1	443.18281802	443.18281802	2.34	0.1378
Source	DF	Type III SS	Mean Square	F Value	Pr > F
UNIT	1	443.18281802	443.18281802	2.34	0.1378

Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: FGE

NOTE: This test controls the type I experimentwise error rate.

Alpha= 0.05 df= 27 MSE= 189.5085 WARNING: Cell sizes are not equal. Harmonic Mean of cell sizes= 14.48276

> Number of Means 2 Critical F 4.2100085

Means with the same letter are not significantly different. REGWF Grouping Mean N UNIT

A	57.130	14	3
A A	49.307	15	5

ONE-WAY ANOVA ON IN-TURBINE FGE AMONG GATE TREATMENTS (Unit 3 & 5 Pooled) SUMMER 96

General Linear Models Procedure Class Level Information

Class	Levels	Values
GTRT	2	OPEN CLOSED

Number of observations in data set = 87

Dependent Variable: FGE

		Sum of	Mean		
Source	DF	Squares	Square	F Value	Pr > F
Model	1	58.19353145	58.19353145	0.22	0.6371
Error	85	22065.22520162	259.59088472		
Corrected Total	86	22123.41873307			
	R-Square	c.v.	Root MSE		FGE Mean
	0.002630	29.07002	16.111824		55.424192
Source	זר	Type I SS	Mean Square	F Value	Pr > F
GTRT	1	58.19353145	58.19353145	0.22	0.6371
Source	DF	Type III SS	Mean Square	F Value	Pr > F
GTRT	1	58.19353145	58.19353145	0.22	0.6371

Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: FGE NOTE: This test controls the type I experimentwise error rate.

Alpha= 0.05 df= 85 MSE= 259.5909 WARNING: Cell sizes are not equal. Harmonic Mean of cell sizes= 43.03448

Number of Means 2 Critical F 3.9532093

Means with the same letter are not significantly different. REGWF Grouping Mean N GTRT

A	56.161	48	CLOSED
A A	54.517	39	OPEN

Appendix B Statistical Tests on Powerhouse I Data from Summer 1996

ONE-WAY ANOVA ON IN-TURBINE FGE BY UNIT AMONG GATE TREATMENTS (SUMMED DATA) SUMMER 96

UNIT=3 -----

General Linear Models Procedure Class Level Information

Class Levels Values GTRT 2 OPEN CLOSED Number of observations in by group = 14

_____ UNIT=3 ______

General Linear Models Procedure

Dependent	Variable:	FGE				
			Sum of	Mean		
Source		DF	Squares	Square	F Value	Pr > F
Model		1	10.00691863	10.00691863	0.86	0.3718
Error		12	139,47591774	11.62299315		
Corrected	Total	13	149.48283637			
	R	-Square	c.v.	Root MSE	FG	E Mean
	0	.066944	5.967513	3.4092511		57.130183
		52		Moon Sellaro	E Value	Dr \ F
GTRT		DF 1	10.00691863	10.00691863	0.86	0.3718
Source		DF	Type III SS	Mean Square	F Value	Pr > F
GTRT		1	10.00691863	10.00691863	0.86	0.3718
			UNIT=3			

Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: FGE NOTE: This test controls the type I experimentwise error rate.

Alpha= 0.05 df= 12 MSE= 11.62299

Number of Means 2 Critical F 4.7472253

Means with the same letter are not significantly different. REGWF Grouping Mean N GTRT

A	57.976	7	OPEN
A A	56.285	7	CLOSED

ONE-WAY ANOVA ON IN-TURBINE FGE BY UNIT AMONG GATE TREATMENTS (SUMMED DATA) SUMMER 96

General Linear Models Procedure Class Level Information

Class Levels Values GTRT 2 OPEN CLOSED Number of observations in by group = 15

Dependent	Variable:	FGE				
-			Sum of	Mean		
Source		DF	Squares	Square	F Value	Pr > F
Model		1	167.150 ² 8550	167.15028550	0.45	0.5128
Error		13	4800.09710974	369.23823921		
Corrected	Total	14	4967.24739525			
	F	-Square	c.v.	Root MSE	FGI	E Mean
	C	.033650	38.97125	19.215573		49.307049
Source		DF	Type I SS	Mean Square	F Value	Pr > F
GTRT		1	167.15028550	167.15028550	0.45	0.5128
Source		DF	Type III SS	Mean Square	F Value	Pr > F
GTRT		1	167.15028550	167.15028550	0.45	0.5128
			UNIT=5 -			

Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: FGE NOTE: This test controls the type I experimentwise error rate.

> Alpha= 0.05 df= 13 MSE= 369.2382 WARNING: Cell sizes are not equal. Harmonic Mean of cell sizes= 7.2

Number of Means 2 Critical F 4.6671927

Means with the same letter are not significantly different.

REGWF Grouping	Mean	N	GTRT
A	52.03	9	CLOSED
A	45.22	6	OPEN

Appendix B Statistical Tests on Powerhouse I Data from Summer 1996

ONE-W7	łΥ	ANOVA	ON	IN-	-Tl	JRI	BII	NE	FGE	
AMONG	II	NTAKES	(Ur	nit	3	æ	5	Pc	oole	d)
		SU	лмн	ER 9	96					

General Linear Models Procedure Class Level Information

Class	Levels	val [.]	ues		
INTAKE	6	03A	03B ()3C TU5A	TU5B TU5C
Number	r of ob	servati	ons ir	n data se	et = 87

Dependent	Variable: FG	Æ				
-			Sum of	Mean		
Source		DF	Squares	Square	F Value	Pr > F
Model		5	6674.4989628	1334.8997926	7.00	0.0001
Error		81	15448.9197703	190.7274046		
Corrected	Total	86	22123.4187331			
	R-Sa	uare	c.v.	Root MSE		FGE Mean
	0.30	1694	24.91766	13.810409		55.424192
Source		DF	Type I SS	Mean Square	F Value	Pr > F
INTAKE		5	6674.4989628	1334.8997926	7.00	0.0001
Source		DF	Type III SS	Mean Square	F Value	Pr > F
INTAKE		5	6674.4989628	1334.8997926	7.00	0.0001

Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: FGE NOTE: This test controls the type I experimentwise error rate.

> Alpha= 0.05 df= 81 MSE= 190.7274 WARNING: Cell sizes are not equal. Harmonic Mean of cell sizes= 14.48276

Number of Means	2	3 4		5 6
Critical F 5	5.9443883 3.848	31424 3.040483	\$ 2.4	844414 2.32/2689
Means with the REGWF GI	e same letter a couping	are not signifi Mean	.cant N	ly different. INTAKE
	A	64.364	14	03C
	A A	62.875	15	TU5C
	A A	61.702	15	TU5B
в	A	56 073	14	032
B	A	00.075	11	0011
В	C C	45.933	14	03B
	c	41.605	15	TU5A

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TWO-WAY ANOVA ON STANDARDIZED SLUICE PASSAGE [(SLUICE / BYPASSED] AMONG TREATMENTS AND UNITS FOR SUMMED DATA SETS SUMMER 96

General Linear Models Procedure

Dependent Variab	le: SSP				
-		Sum of	Mean		
Source	DF	Squares	Square	F Value	Pr > F
Model	3	1.15896115	0.38632038	7.78	0.0008
Error	24	1.19181393	0.04965891		
Corrected Total	27	2.35077508			
	R-Square	c.v.	Root MSE	SSP	Mean
	0.493012	86.18065	0.2228428		0.2585764
Source	DF	Type I SS	Mean Square	F Value	Pr > F
TREAT	1	0.52305568	0.52305568	10.53	0.0034
UNIT	1	0.32610192	0.32610192	6.57	0.0171
TREAT*UNIT	1	0.30980354	0.30980354	6.24	0.0198
Source	DF	Type III SS	Mean Square	F Value	Pr > F
TREAT	1	0.46001342	0.46001342	9.26	0.0056
UNIT	1	0.37177245	0.37177245	7.49	0.0115
TREAT*UNIT	1	0.30980354	0.30980354	6.24	0.0198

Appendix B Statistical Tests on Powerhouse I Data from Summer 1996

ONE-WAY ANOVA ON STANDARDIZED SLUICE PASSAGE [(SLUICE /BYPASSED] AMONG TREATMENTS (Unit 3) FOR SUMMED DATA SUMMER 96

General Linear Models Procedure Class Level Information

Class	Levels	Values
TREAT	2	BO UO

Number of observations in data set = 15

General Linear Models Procedure

Dependent	Variable	e: SSP				
-			Sum of	Mean		
Source		DF	Squares	Square	F Value	Pr > F
Model		1	0.82171767	0.82171767	9.92	0.0077
Error		13	1.07656176	0.08281244		
Corrected	Total	14	1.89827943			
		R-Square	c.v.	Root MSE	SSP	Mean
		0.432875	80.00440	0.2877715		0.3596946
Source		DF	Type I SS	Mean Square	F Value	Pr > F
TREAT		1	0.82171767	0.82171767	9.92	0.0077
Source		DF	Type III SS	Mean Square	F Value	Pr > F
TREAT		1	0.82171767	0.82171767	9.92	0.0077

Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: SSP NOTE: This test controls the type I experimentwise error rate.

> Alpha= 0.05 df= 13 MSE= 0.082812 WARNING: Cell sizes are not equal. Harmonic Mean of cell sizes= 7.466667

Number of Means 2 Critical F 4.6671927

Means with the same letter are not significantly different. REGWF Grouping Mean N TREAT

A	0.6099	7	UO
в	0.1408	8	во

ONE-WAY ANOVA ON STANDARDIZED SLUICE PASSAGE [(SLUICE /BYPASSED] AMONG TREATMENTS (Unit 5) FOR SUMMED DATA SUMMER 96

General Linear Models Procedure Class Level Information

Class	Levels	Values
TREAT	2	BO UO

Number of observations in data set = 13

_

Dependent Variable: SSP

		Sum of	Mean		
Source	DF	Squares	Square	F Value	Pr > F
Model	1	0.00690052	0.00690052	0.66	0.4343
Error	11	0.11525218	0.01047747		
Corrected Total	12	0.12215270			
	R-Square	c.v.	Root MSE	SSP	Mean
	0.056491	72.13422	0.1023595		0.1419015
Source	DF	Type I SS	Mean Square	F Value	Pr > F
TREAT	1	0.00690052	0.00690052	0.66	0.4343
Source	DF	Type III SS	Mean Square	F Value	Pr > F
TREAT	1	0.00690052	0.00690052	0.66	0.4343

Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: SSP NOTE: This test controls the type I experimentwise error rate.

> Alpha= 0.05 df= 11 MSE= 0.010477 WARNING: Cell sizes are not equal. Harmonic Mean of cell sizes= 6.461538

Number of Means 2 Critical F 4.8443357

Means with thesame letter are not significantly different.

REGWF	Grouping	Mean	N	TREAT
	A	0.16679	6	UO
	A	0.12057	7	во

Appendix B Statistical Tests on Powerhouse I Data from Summer 1996

TWO-WAY ANOVA ON SLUICE FPE [(SLUICE / SLUICE + TURBINE] AMONG TREATMENTS AND UNITS IN SUMMER 1996

General Linear Models Procedure Class Level Information

Class	Levels	Values
TREAT	2	BO UO
UNIT	2	3 5

Number of observations in data set = 28

TWO-WAY ANOVA ON SLUICE FPE [(SLUICE / SLUICE + TURBINE] AMONG TREATMENTS AND UNITS IN SUMMER 1996

General Linear Models Procedure

Dependent variabi	C. DID	Sum of	Mean		
Source	DF	Squares	Square	F Value	Pr > F
Model	3	10529.400802	3509.800267	7.64	0.0009
Error	24	11027.723729	459.488489		
Corrected Total	27	21557.124531			
	R-Square	c.v.	Root MSE	SPE	Mean
	0.488442	40.98355	21.435683	• •	52.303143
Source	DF	Type I SS	Mean Square	F Value	Pr > F
TREAT UNIT TREAT*UNIT	1 1 1	973.8402087 8710.2800939 845.2804994	973.8402087 8710.2800939 845.2804994	2.12 18.96 1.84	0.1584 0.0002 0.1876
Source	DF	Type III SS	Mean Square	F Value	Pr > F
TREAT UNIT TREAT*UNIT	1 1 1	1072.2599378 8278.7148479 845.2804994	1072.2599378 8278.7148479 845.2804994	2.33 18.02 1.84	0.1397 0.0003 0.1876

ONE-WAY	ANOVA	ON	SLUICE	FPE	[(SLUIC	CE /	SLUICE	+	TURBINE]
	AMONG	TRE	LATMENTS	IN	SUMMER	1996	(Unit	3)	1

General Linear Models Procedure Class Level Information

Class	Levels	Values
TREAT	2	BO UO

Number of observations in data set = 15

Dependent V	ariable: SPE				
Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	7.26485699	7.26485699	0.01	0.9165
Error	13	8256.33596985	635.10276691		
Corrected T	otal 14	8263.60082683			
	R-Square	c.v.	Root MSE	SP	E Mean
	0.000879	36.65598	25.201245		68.750701
G	75		Noon Cruche	TI 17-1	
Source	DF	Type 1 55	mean Square	r value	
TREAT	1	7.26485699	7.26485699	0.01	0.9165
Source	DF	Type III SS	Mean Square	F Value	Pr > F
TREAT	1	7.26485699	7.26485699	0.01	0.9165

Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: SPE

NOTE: This test controls the type I experimentwise error rate.

Alpha= 0.05 df= 13 MSE= 635.1028 WARNING: Cell sizes are not equal. Harmonic Mean of cell sizes= 7.466667

> Number of Means 2 Critical F 4.6671927

Means with the same letter are not significantly different. REGWF Grouping Mean N TREAT

A	69.49	7	UO
A			
A	68.10	8	BO

Appendix B Statistical Tests on Powerhouse I Data from Summer 1996

ONE-WAY ANOVA ON SLUICE FPE [(SLUICE / SLUICE + TURBINE] AMONG TREATMENTS IN SUMMER 96 (Unit 5)

General Linear Models Procedure Class Level Information

Class	Levels	Values
TREAT	2	BO UO

Number of observations in data set = 13

Dependent	Variable:	SPE	6	Maan		
Source		DF	Sum of Squares	Square	F Value	Pr > F
Model		1	1782.1883200	1782.1883200	7.07	0.0222
Error		11	2771.3877588	251.9443417		
Corrected	Total	12	4553.5760788			
	R-	-Square	c.v.	Root MSE	SPI	E Mean
	0	.391382	47.62990	15.872755		33.325190
Source		DF	Type I SS	Mean Square	F Value	Pr > F
TREAT		1	1782.1883200	1782.1883200	7.07	0.0222
Source		DF	Type III SS	Mean Square	F Value	Pr > F
TREAT		1	1782.1883200	1782.1883200	7.07	0.0222

Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: SPE

NOTE: This test controls the type I experimentwise error rate.

Alpha= 0.05 df= 11 MSE= 251.9443 WARNING: Cell sizes are not equal. Harmonic Mean of cell sizes= 6.461538

Number of Means 2 Critical F 4.8443357

Means with the same letter are not significantly different.

REGWF	Grouping	Mean	N	TREAT
	A	45.972	6	UO
	В	22.485	7	во

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UNGUII	TWO-WAY DED & SLUI	ANOVA ON S CED/BYPASSE	TANDARDIZED SMOLT D) AT TEST TURBINE PH2 SPRING 96	PASSAGE (GUIDED S AMONG INTAKES	& AND TREATMENTS	
		General Cla	Linear Models Pro ss Level Informati	cedure on		
	Class	Levels Va	alues			
	INTAKE	8 TI	J11 TU12 TU13 TU14	TU15 TU16 TU17	TU18	
	CTREAT	2 C	0			
	Number of observations in data set = 216					
		General	Linear Models Prod	cedure		
Depend	lent Varia	ble: STP				
Source	2	DF	Sum of Squares	F Value	Pr > F	
Model		15	0.00602145	14.29	0.0001	
Error		200	0.00561934			
Correc	ted Total	215	0.01164079			
		R-Square	c.v.	STP 1	lean	
		0.517272	91.41359	0	.00579852	
Source	•	DF	Type I SS	F Value	Pr > F	
INTAKE	2	7	0.00559390	28.44	0.0001	
CTREAT		1	0.00007054	2.51	0.1147	
INTAKE	*CTREAT	7	0.00035701	1.82	0.0801	
Source	:	DF	Type III SS	F Value	Pr > F	
INTAKE		7	0.00569883	28.98	0.0001	
CTREAT	I	1	0.00008069	2.87	0.0917	
INTAKE	*CTREAT	7	0.00035701	1.82	0.0861	

ONE-WAY ANOVA ON STANDARDIZED SMOLT PASSAGE [(GUIDED & UNGUIDED)/BYPASSED] AMONG SLUICE CHUTE TREATMENTS PH2 SPRING 96

General Linear Models Procedure Class Level Information

Class	Levels	Values	
CTREAT	2	со	

Number of observations in data set = 216

General Linear Models Procedure

Dependent Variable: STP

Source	DF	Sum of Squares	F Value	Pr > F
Model	1	0.00004953	0.91	0.3400
Error	214	0.01159127		
Corrected Total	215	0.01164079		
	R-Square	c.v.	STP 1	Mean
	0.004255	126.9234	0	.00579852
	55	B arra T 00	T 17-1	
Source	DF	Type I SS	F value	Pr > F
CTREAT	1	0.00004953	0.91	0.3400
Source	DF	Type III SS	F Value	Pr > F
CTREAT	1	0.00004953	0.91	0.3400

Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: STP

NOTE: This test controls the type I experimentwise error rate.

Alpha= 0.05 df= 214 MSE= 0.000054 WARNING: Cell sizes are not equal. Harmonic Mean of cell sizes= 107.9907

> Number of Means 2 Critical F 3.8852796

Means with the same letter are not significantly different.

REGWF	Grouping	Mean	N	CTREAT	
	A	0.006273	109	с	
	A	0.005315	107	0	

Appendix C Statistical Tests on Powerhouse 2 Data from Spring 1996

ONE-WAY ANOVA ON STANDARDIZED SMOLT PASSAGE [(GUIDED & UNGUIDED)/BYPASSED] AMONG SLUICE CHUTE TREATMENTS BY INTAKE AT PH2 SPRING 96					
		INTAKE=TU11			
	General Li Class	near Models Proce Level Information	dure		
	Class	Levels Value:	5		
	CTREAT	2 C O			
N	umber of obse	ervations in by gro	oup = 25		
		INTAKE=TU11			
	General Li	near Models Proced	dure		
Dependent Variab	le: STP				
Source	DF	Sum of Squares	F Value	Pr > F	
Model	1	0.00040944	2.92	0.1009	
Error	23	0.00322331			
Corrected Total	24	0.00363275			
	R-Square	c.v.	STP 1	Mean	
	0.112708	60.77298	0	.01947943	
Source	DF	Type I SS	F Value	Pr > F	
CTREAT	1	0.00040944	2.92	0.1009	
Source	DF	Type III SS	F Value	Pr > F	
CTREAT	1	0.00040944	2.92	0.1009	
		INTAKE=TU11			
Ryan-Einot-Ga	briel-Welsch	Multiple F Test fo	or variable: S	STP	
NOTE: This	test controls	the type I experi	mentwise erro	or rate.	
Alpha= 0.05 df= 23 MSE= 0.00014 WARNING: Cell sizes are not equal. Harmonic Mean of cell sizes= 12.48					
	Number Critica	of Means 2 1 F 4.2793443			
Means with	the same lett	er are not signifi	cantly differ	cent.	
REGW	F Grouping	Mean	N CTREAT		
	A	0.023692	12 C		
	A A	0.015591	13 0		

ONE-WAY ANOVA ON STANDARDIZED SMOLT PASSAGE [(GUIDED & UNGUIDED)/BYPASSED] AMONG SLUICE CHUTE TREATMENTS BY INTAKE AT PH2 SPRING 96					
		INTAKE=TU12			
	General L: Class	near Models Proced Level Information	ure		
	Class	Levels Values			
	CTREAT	2 C O			
Ν	umber of obse	ervations in by gro	up = 24		
		INTAKE=TU12			
	General Li	near Models Proced	ure		
Dependent Variab	le: STP				
Source	DF	Sum of Squares	F Value	Pr > F	
Model	1	0.00000144	0.16	0.6906	
Error	22	0.00019514			
Corrected Total	23	0.00019659			
	R-Square	c.v.	STP 1	Mean	
	0.007342	117.6895	0	.00253063	
Source	DF	Type I SS	F Value	Pr > F	
CTREAT	1	0.00000144	0.16	0.6906	
Source	DF	Type III SS	F Value	Pr > F	
CTREAT	1	0.00000144	0.16	0.6906	
		INTAKE=TU12			
Ryan-Einot-Ga	briel-Welsch	Multiple F Test fo	r variable: S	STP	
NOTE: This	test controls	the type I experiment	mentwise erro	or rate.	
· ·	Alpha= 0.05 df= 22 MSE= 8.87E-6 WARNING: Cell sizes are not equal. Harmonic Mean of cell sizes= 11.91667				
	Number Critica	of Means 2 1 F 4.3009495			
Means with	the same lett	er are not signifi	cantly diffe	rent.	
REGW	F Grouping	Mean	N CTREAT		

WF	Grouping	Mean	N	СТ	RE/
	А	0.002756	13	с	
	A A	0.002264	11	0	

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ONE-WAY ANOVA ON STANDARDIZED SMOLT PASSAGE [(GUIDED & UNGUIDED)/BYPASSED] AMONG SLUICE CHUTE TREATMENTS BY INTAKE AT PH2 SPRING 96				
		INTAKE=TU13		
	General L Class	inear Models Proced Level Information	lure	
	Class	Levels Values	3	
	CTREAT	2 C O		
נ	Number of obs	ervations in by gro	oup = 28	
		INTAKE=TU13		
	General L	inear Models Proced	lure	
Dependent Variab	ole: STP			
Source	DF	Sum of Squares	F Value	Pr > F
Model	1	0.00000395	0.22	0.6451
Error	26	0.00047342		
Corrected Total	27	0.00047737		
R-Squar		c.v.	STP N	iean
	0.008283	124.9818	0.	00341419
Source	DF	Type I SS	F Value	Pr > F
CTREAT	1	0.00000395	0.22	0.6451
Source	DF	Type III SS	F Value	Pr > F
CTREAT	1	0.00000395	0.22	0.6451
		INTAKE=TU13		
Ryan-Einot-Ga	briel-Welsch	Multiple F Test fo	r variable: S	TP
NOTE: This	test controls	the type I experi	mentwise erro	or rate.
	Alpha= 0.05	df= 26 MSE= 0.0	00018	
	Number Critica	of Means 2 1 F 4.2252013		
Means with	the same lett	er are not signifi	cantly differ	ent.
REGW	F Grouping	Mean	N CTREAT	
	A A	0.003790	14 C	
	A	0.003038	14 0	

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ONE-WAY ANOVA ON STANDARDIZED SMOLT PASSAGE [(GUIDED & UNGUIDED)/BYPASSED] AMONG SLUICE CHUTE TREATMENTS BY INTAKE AT PH2 SPRING 96					
	;	INTAKE=TU14			
	General Lin Class :	near Models Proced Level Information	lure		
	Class	Levels Values	1		
	CTREAT	2 C O			
Number of observations in by group = 27					
		INTAKE=TU14			
	General Lin	near Models Proced	ure		
Dependent Variab	le: STP				
Source	DF	Sum of Squares	F Value	Pr > F	
Model	1	0.00000672	0.17	0.6796	
Error	25	0.00096190			
Corrected Total	26	0.00096862			
	R-Square	c.v.	STP	Mean	
	0.006936	102.1838	0	.00607034	
Source	DF	Type I SS	F Value	Pr > F	
CTREAT	1	0.00000672	0.17	0.6796	
Source	DF	Type III SS	F Value	Pr > F	
CTREAT	1	0.00000672	0.17	0.6796	
]	INTAKE=TU14			
Ryan-Einot-Gab	oriel-Welsch M	fultiple F Test fo	r variable:	STP	
NOTE: This t	est controls	the type I experi	mentwise err	or rate.	
Alpha= 0.05 df= 25 MSE= 0.000038 WARNING: Cell sizes are not equal. Harmonic Mean of cell sizes= 13.48148					
Number of Means 2					

Number of Means 2 Critical F 4.2416991

Means with the same letter are not significantly different.

REGWF	Grouping	Mean	N	TREAT
	A	0.006551	14	с
AA	0.005553	13	0	

Appendix C Statistical Tests on Powerhouse 2 Data from Spring 1996

ONE-WAY ANOVA ON STANDARDIZED SMOLT PASSAGE [(GUIDED & UNGUIDED)/BYPASSED] AMONG SLUICE CHUTE TREATMENTS BY INTAKE AT PH2 SPRING 96						
INTAKE=TU15						
General Linear Models Procedure Class Level Information						
	Class	Levels Values				
	CTREAT	2 C O				
Nu	umber of obsei	rvations in by gro	up = 28			
	3	INTAKE=TU15				
	General Lir	near Models Proced	ure			
Dependent Variabl	.e: STP					
Source	DF	Sum of Squares	F Value	Pr > F		
Model	1	0.0000097	0.33	0.5722		
Error	26	0.00007736				
Corrected Total	27	0.00007833				
R-Square C.V. STP Mean						
	0.012431	72.81023	0.	00236905		
Source	DF	Type I SS	F Value	Pr > F		
CTREAT	1	0.0000097	0.33	0.5722		
Source	DF	Type III SS	F Value	Pr > F		
CTREAT	1	0.0000097	0.33	0.5722		
	I	NTAKE=TU15				
Ryan-Einot-Gab	riel-Welsch M	ultiple F Test fo:	r variable: S	TP		
NOTE: This t	est controls	the type I experin	nentwise erro	or rate.		
	Alpha= 0.05	df= 26 MSE= 2.9	75E-6			
	Number o Critical	f Means 2 F 4.2252013				
Means with t	he same lette	r are not signific	cantly differ	ent.		
REGWF	Grouping	Mean	N CTREAT			
	A a	0.0025555	14 O			
	Â	0.0021826	14 C			

ONE-WAY & UNGUI	ANOVA ON STAN DED)/BYPASSED BY INTA	DARDIZED SMOLT PA:] AMONG SLUICE CHI KE AT PH2 SPRING S	SSAGE [(GUIDE JTE TREATMENT 96	D S
		INTAKE=TU16		
	General Lin Class 1	near Models Proced Level Information	lure	
	Class	Levels Value:	5	
	CTREAT	2 C O		
N	umber of obse	rvations in by gro	oup = 28	
		INTAKE=TU16		
	General Lin	near Models Proced	lure	
Dependent Variab	le: STP			
Source	DF	Sum of Squares	F Value	Pr > F
Model	1	0.0000064	0.06	0.8159
Error	26	0.00030077		
Corrected Total	27	0.00030141		
	R-Square	c.v.	STP	Mean
	0.002123	66.57986	0	.00510841
Source	DF	Type I SS	F Value	Pr > F
CTREAT	1	0.0000064	0.06	0.8159
Source	DF	Type III SS	F Value	Pr > F
CTREAT	1	0.0000064	0.06	0.8159
]	INTAKE=TU16		
Ryan-Einot-Gal	briel-Welsch M	Multiple F Test fo	or variable:	STP
NOTE: This	test controls	the type I experi	mentwise err	or rate.
	Alpha= 0.05	df= 26 MSE= 0.0	000012	
	Number c Critical	of Means 2 F 4.2252013	2	
Means with	the same lette	er are not signifi	cantly diffe.	rent.
REGW	F Grouping	Mean	N CTREAT	
	A	0.005260	14 0	
	A A	0.004957	14 C	

ONE-WAY A	NOVA ON STANI	ARDIZED SMOLT PAS	SAGE [(GUIDE	D
2 0NG011	BY INTAP	E AT PH2 SPRING S	96	
]	NTAKE=TU17		
	General Lir Class I	near Models Proced Level Information	lure	
	Class	Levels Values	5	
	CTREAT	2 C O		
Nu	mber of obser	vations in by gro	oup = 28	
	I	NTAKE=TU17		
	General Lin	ear Models Proced	lure	
Dependent Variabl	e: STP			
Source	DF	Sum of Squares	F Value	Pr > F
Model	1	0.00000167	0.23	0.6373
Error	26	0.00019039		
Corrected Total	27	0.00019205		
	R-Square	c.v.	STP 1	Mean
	0.008675	57.48777	0	.00470715
Source	DF	Type I SS	F Value	Pr > F
CTREAT	1	0.00000167	0.23	0.6373
Source	DF	Type III SS	F Value	Pr > F
CTREAT	1	0.00000167	0.23	0.6373
	I	NTAKE=TU17		
Ryan-Einot-Gab:	riel-Welsch M	ultiple F Test fo	r variable:	STP
NOTE: This to	est controls	the type I experi	mentwise erro	or rate.
	Alpha= 0.05	df= 26 MSE= 7.3	23E-6	
	Number o Critical	f Means 2 F 4.2252013		
Means with th	ne same lette	r are not signifi	cantly differ	rent.
REGWF	Grouping	Mean	N CTREAT	
	A	0.004951	14 0	
	A A	0.004463	14 C	

	ONE-WAY A & UNGUID	NOVA ON STAN ED)/BYPASSED BY INTA	DARDIZED SMOLT PAS] AMONG SLUICE CHU KE AT PH2 SPRING S	SAGE [(GUIDE TE TREATMENT 96	D S			
INTAKE=TU18								
		General Li Class	near Models Proced Level Information	lure				
	Class Levels Values							
		CTREAT	2 C O					
	Nu	mber of obse	rvations in by gro	oup = 28				
			INTAKE=TU18					
		General Li	near Models Proced	ure				
Dependen	t Variabl	e: STP						
Source		DF	Sum of Squares	F Value	Pr > F			
Model		1	0.00000271	0.36	0.5548			
Error		26	0.00019706					
Correcte	d Total	27	0.00019977					
		R-Square	c.v.	STP	Mean			
		0.013585	74.05418	0	.00371760			
Source		DF	Type I SS	F Value	Pr > F			
CTREAT		1	0.00000271	0.36	0.5548			
Source		DF	Type III SS	F Value	Pr > F			
CTREAT		1	0.00000271	0.36	0.5548			
			INTAKE=TU18					
Ryan-	Einot-Gab	riel-Welsch (Multiple F Test fo	r variable:	STP			
NOT	E: This t	est controls	the type I experi	mentwise err	or rate.			
		Alpha= 0.05	df= 26 MSE= 7.5	79E-6				
		Number Critica	of Means 2 1 F 4.2252013					
Mea	ns with t	he same lett	er are not signifi	cantly diffe	rent.			
	REGWF	Grouping	Mean	N CTREAT				
		A	0.004029	14 C				
		A A	0.003406	14 O				

ONE-WAY ANOVA ON STANDARDIZED SMOLT PASSAGE [(GUIDED & UNGUIDED)/BYPASSED] AMONG INTAKES PH2 SPRING 96

General Linear Models Procedure Class Level Information

Class Levels Values

INTAKE 8 TU11 TU12 TU13 TU14 TU15 TU16 TU17 TU18

Number of observations in data set = 216

General Linear Models Procedure

Dependent Variable: STP

Source Model Error Corrected Total	DF 7 208 215	Sum of Squares 0.00559390 0.00604689 0.01164079	F Value 27.49	Pr > F 0.0001
	R-Square	c.v.	STP	Mean
	0.480543	92.98598	0	.00579852
Source INTAKE	DF 7	Type I SS 0.00559390	F Value 27.49	Pr > F 0.0001
Source INTAKE	DF 7	Type III SS 0.00559390	F Value 27.49	Pr > F 0.0001

Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: STP NOTE: This test controls the type I experimentwise error rate.

> Alpha= 0.05 df= 208 MSE= 0.000029 WARNING: Cell sizes are not equal. Harmonic Mean of cell sizes= 26.9111

 Number of Means
 2
 3
 4
 5

 Critical F
 6.3134752
 4.0370093
 3.1697188
 2.703401

 Number of Means
 6
 7
 8

 Critical F
 2.4089733
 2.1423641
 2.0538082

Means with the same letter are not significantly different.

REGWF Grouping	Mean	N	INTAKE
A	0.019479	25	TU11 TU14
B	0.000070	21	1014
В	0.005108	28	TU16
B B	0.004707	28	TU17
B B	0.003718	28	TU18
B B	0.003414	28	тU13
В	0 002521	24	m11 2
В	0.002531	24	1012
В	0.002369	28	TU15

Appendix C Statistical Tests on Powerhouse 2 Data from Spring 1996

TWO-WAY	ANOVA ON F	GE AMONG INTAKES A PH2 SPRING 96	ND TREATMENT	S
	General Clas	Linear Models Proc s Level Informatio	edure m	
Class L	evels Va	lues		
INTAKE	8 TU	11 TU12 TU13 TU14	TU15 TU16 TU	17 TU18
CTREAT	2 C	0		
N	umber of ob	servations in data	set = 216	
	General	Linear Models Proc	edure	
Dependent Variab	le: FGE			
Source	DF	Sum of Squares	F Value	Pr > F
Model	15	51153.8078772	4.78	0.0001
Error	200	142574.4676714		
Corrected Total	215	193728.2755486		
	R-Square	c.v.		FGE Mean
	0.264049	71.90404		37.1323641
Source	DF	Type I SS	F Value	Pr > F
INTAKE	7	45084.2501986	9.03	0.0001
CTREAT INTAKE*CTREAT	1 7	5931.4554086	1.19	0.3108
Source	DF	Type III SS	F Value	Pr > F
INTAKE CTREAT INTAKE*CTREAT	7 1 7	44943.2237990 125.3752390 5931.4554086	9.01 0.18 1.19	0.0001 0.6754 0.3108

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ONE-WAY ANOVA ON FGE AMONG INTAKES PH2 SPRING 96

General Linear Models Procedure Class Level Information

Class	Levels	Values		
INTAKE	8	TU11 TU12 TU13	TU14 TU15	TU16 TU17 TU18

Number of observations in data set = 216

General Linear Models Procedure

Dependent	Variable: FGE			
Source	DF	Sum of Squares	F Value	Pr > F
Model	7	45084.2501986	9.01	0.0001
Error	208	148644.0253500		
Corrected	Total 215	193728.2755486		
	R-Square	c.v.		FGE Mean
	0.232719	71.99287		37.1323641
Source	DF	Type I SS	F Value	Pr > F
INTAKE	7	45084.2501986	9.01	0.0001
Source	DF	Type III SS	F Value	Pr > F
INTAKE	7	45084.2501986	9.01	0.0001

Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: FGE NOTE: This test controls the type I experimentwise error rate.

> Alpha= 0.05 df= 208 MSE= 714.6347 WARNING: Cell sizes are not equal. Harmonic Mean of cell sizes= 26.9111

Number of Means2345Critical F6.31347524.03700933.16971882.703401

 Number of Means
 6
 7
 8

 Critical F
 2.4089733
 2.1423641
 2.0538082

Means with the same letter are not significantly different. REGWF Grouping Mean N INTAKE

	А		66.054	24	TU12	
В	A A		52.141	28	TU15	
B	С		40.375	28	TU13	
B	с с		39.331	28	TU17	
B B	C C	D	30.376	28	TU18	
	C C	D D	28.473	27	TU14	
	с с	D D	26.301	28	TU16	
		ם ם	15.514	25	TU11	

Appendix D Statistical Tests on Powerhouse 2 Data from Summer 1996

TWO-WAY ANOVA ON STANDARDIZED SMOLT PASSAGE (GUIDED & UNGUIDED & SLUICED/BYPASSED) AT TEST TURBINES AMONG INTAKES AND TREATMENTS PH2 SUMMER 96						
	General Linear Models Procedure Class Level Information					
	Class	Levels V	alues			
	INTAKE	8 T	J 11 TU12 TU	13 TU14	TU15 TU16 TU	17 TU18
	CTREAT	2 C	0			
		Number of ol	oservations	in data	a set = 188	
		General	Linear Mode	els Proc	edure	
Depend	ent Varia	ble: STP				
Source		DF	Sum of S	Squares	F Value	Pr > F
Model		15	0.16	5730069	6.20	0.0001
Error		172	0.30)951473		
Correc	ted Total	187	0.47	7681543		
		R-Square		c.v.	STI	P Mean
		0.350871	12	21.3089		0.03496904
Source		DF	Ťyp	e I SS	F Value	Pr > F
INTAKE		7	0.14	569558	11.57	0.0001
CTREAT	*CTREAT	17	0.00	945807	1.19 1.54	0.2762 0.1552
Source		DF	Type	III SS	F Value	Pr > F
DUALCE		21	-150			
INTAKE		7	0.12	988529	10.31	0.0001
CTREAT		1	0.00	0/5007	U.14 1 EA	0.7078
TNIAKE	CTREAT	/	0.01	.943007	1.34	0.1002

ONE-WAY ANOVA ON STANDARDIZED SMOLT PASSAGE [(GUIDED & UNGUIDED)/BYPASSED] AMONG INTAKES PH2 SUMMER 96

General Linear Models Procedure Class Level Information

Class Levels Values

INTAKE 8 TU11 TU12 TU13 TU14 TU15 TU16 TU17 TU18

Number of observations in data set = 188

General Linear Models Procedure

Dependent	Variable: STP			
Source Model Error Corrected	DF 7 180 Total 187	Sum of Squares 0.14569558 0.33111985 0.47681543	F Value 11.31	Pr > F 0.0001
	R-Square	c.v.	STP	Mean
	0.305560	122.6514		0.03496904
Source	DF	Type I SS	F Value	Pr > F
INTAKE	7	0.14569558	11.31	0.0001
Source	DF	Type III SS	F Value	Pr > F
INTAKE	7	0.14569558	11.31	0.0001

Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: STP NOTE: This test controls the type I experimentwise error rate.

> Alpha= 0.05 df= 180 MSE= 0.00184 WARNING: Cell sizes are not equal. Harmonic Mean of cell sizes= 17.00309

 Number of Means
 2
 3
 4
 5

 Critical F
 6.3306494
 4.0490667
 3.1796455
 2.7121273

 Number of Means
 6
 7
 8

 Critical F
 2.416915
 2.1492492
 2.0607618

Means with the same letter are not significantly different.

REGWF Grouping	Mean	N	INTAKE
A	0.18032	5	TU11
В	0.04987	27	TU14
B B	0.04841	27	TU12
B	0.03780	24	TU13
B B	0.03217	21	TU18
B B	0.02119	28	TU16
В			

Appendix D Statistical Tests on Powerhouse 2 Data from Summer 1996
0.01987 28 TU17 в в 28 TU15 0.01023 В ONE-WAY ANOVA ON STANDARDIZED SMOLT PASSAGE [(GUIDED & UNGUIDED) / BYPASSED] AMONG SLUICE CHUTE TREATMENTS PH2 SUMMER 96 ----- INTAKE=TU11 ------General Linear Models Procedure Class Level Information Class Levels Values 2 C O CTREAT Number of observations in by group = 5_____ INTAKE=TU11 ------General Linear Models Procedure Dependent Variable: STP F Value Pr > FSum of Squares Source DF Model 0.00985866 0.69 0.4662 1 0.04266489 Error 3 4 0.05252356 Corrected Total c.v. STP Mean R-Square 0.18031854 0.187700 66.13545 DF Type I SS F Value Pr > FSource 0.00985866 CTREAT 0.69 0.4662 1 Type III SS F Value DF Pr > FSource 0.00985866 0.69 0.4662 CTREAT 1 Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: STP NOTE: This test controls the type I experimentwise error rate. Alpha= 0.05 df= 3 MSE= 0.014222 WARNING: Cell sizes are not equal. Harmonic Mean of cell sizes= 2.4 Number of Means 2 Critical F 10.127964 Means with the same letter are not significantly different. N TREAT **REGWF** Grouping Mean 0.2166 3 C А Α 0.1259 2 0 А

ONE-WAY ANOVA ON STANDARDIZED SMOLT PASSAGE [(GUIDED & UNGUIDED)/BYPASSED] AMONG SLUICE CHUTE TREATMENTS

PH2 SUMMER 96						
	INT	AKE=TU12				
General Linear Models Procedure Class Level Information						
	Class L	evels Values				
	CTREAT 2 C O					
Mumbor	of observe	tions in hy grou	n = 27			
	OI ODSEIVA	AKE=TII12	up - 27			
	neral Linea	r Models Proced	ure			
Domondont Variable: S	TTD	r houers rroced	ur.			
Source	חד פוו	m of Squares	F Value	Pr > F		
Nedel	1	0 00032211	0 13	0 7248		
Model	1 25	0.06354451	0.15	0.7240		
	25	0.06386662				
Corrected Total	20	0.00300002	677D M	~~~~		
K-5	quare		SIP M	ean		
0.0	05043	104.1387	0.	04841241		
Source	DF	Type I SS	F Value	Pr > F		
CTREAT	1	0.00032211	0.13	0.7248		
Source	DF	Type III SS	F Value	Pr > F		
CTREAT	1	0.00032211	0.13	0.7248		
	INT.	AKE=TU12				
Ryan-Einot-Gabriel	-Welsch Mul	tiple F Test fo	r variable: S	TP		
NOTE: This test	controls th	e type I experia	mentwise erro:	r rate.		
Alpha= 0.05 df= 25 MSE= 0.002542 WARNING: Cell sizes are not equal. Harmonic Mean of cell sizes= 13.48148						
	Number of E Critical F	Means 2 4.2416991				
Means with the s	ame letter	are not signific	cantly differ	ent.		
REGWF Gro	uping	Mean	N TREAT			
	A A	0.05200	13 0			
	Ä	0.04508	14 C			

ONE-WAY ANOVA ON STANDARDIZED SMOLT PASSAGE [(GUIDED

Appendix D Statistical Tests on Powerhouse 2 Data from Summer 1996

& UNGUI	IDED) /BYPASSE	D] AMONG SLUICE CHU PH2 SUMMER 96	UTE TREATMENI	S
		INTAKE=TU13		
	General L Class	inear Models Proced Level Information	dure	
	Class	Levels Values	5	
	CTREAT	2 C O		
N	umber of obse	ervations in by gro	oup = 24	
	General Li	inear Models Proced	lure	
Dependent Variab	le: STP			
Source	DF	Sum of Squares	F Value	Pr > F
Model	1	0.00749238	1.78	0.1954
Error	22	0.09244546		
Corrected Total	23	0.09993784		
	R-Square	c.v.	STP 1	Mean
	0.074970	171.4855	0	.03780107
Source	DF	Type I SS	F Value	Pr > F
CTREAT	1	0.00749238	1.78	0.1954
Source	DF	Type III SS	F Value	Pr > F
CTREAT	1	0.00749238	1.78	0.1954
		INTAKE=TU13		
Ryan-Einot-Gal	briel-Welsch	Multiple F Test fo	r variable: S	STP
NOTE: This	test controls	the type I experin	mentwise erro	or rate.
I	Alpha= 0.05 WARNING: Ce Harmonic Mean	df= 22 MSE= 0.0 ll sizes are not e of cell sizes= 11	04202 qual. .91667	
	Number Critica	of Means 2 1 F 4.3009495		
Means with t	the same lett	er are not signific	cantly differ	rent.
REGWI	f Grouping	Mean	N TREAT	
	A a	0.05701	11 0	
	Â	0.02155	13 C	
ONE-WAY A	NOVA ON STAN	DARDIZED SMOLT PASS	SAGE [(GUIDEI)

& UNGUIDED)/BYPASSED] AMONG SLUICE CHUTE TREATMENTS PH2 SUMMER 96					
		INTAKE=TU14			
	General Li Class	inear Models Proced Level Information	dure		
	Class	Levels Value:	5		
	CTREAT	2 C O			
N	umber of obse	ervations in by gro	oup = 27		
		INTAKE=TU14			
	General Li	near Models Proced	dure		
Dependent Variab	le: STP				
Source	DF	Sum of Squares	F Value	Pr > F	
Model	1	0.00376078	0.96	0.3354	
Error	25	0.09746009			
Corrected Total	26	0.10122087			
	R-Square	c.v.	STP 1	Mean	
	0.037154	125.1990	0	.04987037	
Source	DF	Type I SS	F Value	Pr > F	
CTREAT	1	0.00376078	0.96	0.3354	
Source	DF	Type III SS	F Value	Pr > F	
CTREAT	1	0.00376078	0.96	0.3354	
		INTAKE=TU14			
Ryan-Einot-Ga	briel-Welsch	Multiple F Test fo	or variable:	STP	
NOTE: This	test controls	the type I experi	mentwise err	or rate.	
:	Alpha= 0.05 WARNING: Ce Harmonic Mean	df= 25 MSE= 0.0 df sizes are not e of cell sizes= 13	003898 equal. 3.48148		
	Number of Means 2 Critical F 4.2416991				
Means with	the same lett	er are not signifi	cantly diffe:	rent.	
REGW	F Grouping	Mean	N TREAT		
	A	0.06212	13 0		
	A	0.03850	14 C		
ONE-WAY	ONE-WAY ANOVA ON STANDARDIZED SMOLT PASSAGE [(GUIDED				
Appendix D Statistical Tests on Powerhouse 2 Data from Summer 1996					

& UNGUIDED) / BYPASSED] AMONG SLUICE CHUTE TREATMENTS PH2 SUMMER 96 General Linear Models Procedure Class Level Information Class Levels Values CTREAT 2 C O Number of observations in by group = 28 General Linear Models Procedure Dependent Variable: STP DF Sum of Squares F Value Pr > F Source 1 0.00001142 0.31 0.5845 Model 26 0.00096860 Error 0.00098003 Corrected Total 27 STP Mean c.v. R-Square 0.01023357 59.64290 0.011657 Type I SS F Value Pr > F DF Source 0.00001142 0.31 0.5845 1 CTREAT DF Type III SS F Value Pr > FSource 0.00001142 0.31 0.5845 1 CTREAT Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: STP NOTE: This test controls the type I experimentwise error rate. Alpha= 0.05 df= 26 MSE= 0.000037 Number of Means 4.2252013 Critical F Means with the same letter are not significantly different. N TREAT Mean REGWF Grouping 0.010872 14 C А Α 0.009595 14 0 Ά

ONE-WAY ANOVA ON STANDARDIZED SMOLT PASSAGE [(GUIDED

Appendix D Statistical Tests on Powerhouse 2 Data from Summer 1996

& UNGUIDED) / BYPASSED] AMONG SLUICE CHUTE TREATMENTS PH2 SUMMER 96 _____I INTAKE=TU16 ------General Linear Models Procedure Class Level Information Class Levels Values 2 C O CTREAT Number of observations in by group = 28 General Linear Models Procedure Dependent Variable: STP DF Sum of Squares F Value Pr > F Source 1 0.00001613 0.16 0.6882 Model 26 0.00254787 Error 27 0.00256400 Corrected Total c.v. STP Mean R-Square 0.02119437 46.70693 0.006292 Type I SS F Value Pr > FDF Source 0.16 0.6882 0.00001613 1 CTREAT DF Type III SS F Value Pr > FSource 0.00001613 0.16 0.6882 1 CTREAT ----- INTAKE=TU16 ------Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: STP NOTE: This test controls the type I experimentwise error rate. Alpha= 0.05 df= 26 MSE= 0.000098 Number of Means 2 Critical F 4.2252013 Means with the same letter are not significantly different. N TREAT REGWF Grouping Mean 0.021953 14 C Α А 0.020435 14 0 Ά

ONE-WAY ANOVA ON STANDARDIZED SMOLT PASSAGE [(GUIDED

Appendix D Statistical Tests on Powerhouse 2 Data from Summer 1996

& UNGUI	DED)/BYPASSED PI] AMONG SLUICE CHU H2 SUMMER 96	JTE T	REATMENT	S
		INTAKE=TU17			
	General Lin Class 1	near Models Proced Level Information	lure		
	Class	Levels Values	5		
	CTREAT	2 C O			
Nı	umber of obsei	rvations in by gro	oup =	28	
	J	INTAKE=TU17			
	General Lir	hear Models Proced	lure		
Dependent Variabl	le: STP				
Source	DF	Sum of Squares	FV	Value	Pr > F
Model	1	0.0000017		0.00	0.9641
Error	26	0.00207341			
Corrected Total	27	0.00207357			
	R-Square	c.v.		STP N	lean
	0.000080	44.95043		0.	.01986652
Source	DF	Type I SS	F٦	/alue	Pr > F
CTREAT	1	0.00000017		0.00	0.9641
Source	DF	Type III SS	FΛ	Value	Pr > F
CTREAT	1	0.0000017		0.00	0.9641
	I	NTAKE=TU17			
Ryan-Einot-Gab	riel-Welsch M	ultiple F Test fo	r var	iable: S	TP
NOTE: This t	est controls	the type I experi	mentw	vise erro	or rate.
	Alpha= 0.05	df= 26 MSE= 0.0	8000		
	Number o Critical	f Means 2 F 4.2252013			
Means with t	he same lette	r are not signific	cantl	y differ	ent.
REGWF	Grouping	Mean	N	TREAT	
	A	0.019943	14	0	
	A A	0.019790	14	с	

ONE-WAY ANOVA ON STANDARDIZED SMOLT PASSAGE [(GUIDED

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Appendix D Statistical Tests on Powerhouse 2 Data from Summer 1996

& UNGUIDED) / BYPASSED] AMONG SLUICE CHUTE TREATMENTS PH2 SUMMER 96 ----- INTAKE=TU18 -----General Linear Models Procedure Class Level Information Class Levels Values 2 C O CTREAT Number of observations in by group = 21 _____I ______ INTAKE=TU18 _____ General Linear Models Procedure Dependent Variable: STP Sum of Squares F Value Pr > F DF Source 0.35 0.5616 1 0.00014345 Model 0.00780991 19 Error 20 0.00795336 Corrected Total c.v. STP Mean **R-Square** 63.03077 0.03216574 0.018037 Type I SS F Value DF Pr > FSource 0.35 0.5616 0.00014345 1 CTREAT DF Type III SS F Value Pr > FSource 0.35 0.00014345 0.5616 1 CTREAT ----- INTAKE=TU18 ------Rvan-Einot-Gabriel-Welsch Multiple F Test for variable: STP NOTE: This test controls the type I experimentwise error rate.

> Alpha= 0.05 df= 19 MSE= 0.000411 WARNING: Cell sizes are not equal. Harmonic Mean of cell sizes= 10.47619

> > Number of Means 2 Critical F 4.3807497

Means with the same letter are not significantly different.

REGWF	Grouping	Mean	N	TREAT
	A	0.034907	10	0
	A A	0.029674	11	с

TWO-WAY ANOVA ON FGE AMONG INTAKES AND TREATMENTS

Appendix D Statistical Tests on Powerhouse 2 Data from Summer 1996

PH2 SUMMER 96

General Linear Models Procedure Class Level Information				
Class	Levels	Values		
INTAK	E 8	TU11 TU12 TU13 TU14 TU15 TU16 TU17 TU18		
CTREA	T 2	со		
	Number of	observations in data set = 188		
	Genera	l Linear Models Procedure		
Dependent V	ariable: FGE			
Source	D	F Sum of Squares F Value Pr > F		
Model	1	5 25082.4209644 2.36 0.0041		
Error	17	2 121725.9101061		
Corrected T	otal 18	7 146808.3310705		
	R-Squar	e C.V. FGE Mean		
	0.17085	1 93.91434 28.3266607		
Source	ום	F Type ISS FValue Pr > F		
INTAKE	-	7 20733.9214680 4.19 0.0003		
CTREAT INTAKE*CTREA	AT :	$\begin{array}{cccccccccccccccccccccccccccccccccccc$		
Source	DI	F Type III SS F Value Pr > F		
INTAKE CTREAT INTAKE*CTRE4	AT -	721126.04413334.260.00021915.73018581.290.256972427.54160100.490.8410		

Appendix D Statistical Tests on Powerhouse 2 Data from Summer 1996

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ONE-WAY ANOVA ON FGE AMONG SLUICE CHUTE TREATMENTS PH2 SUMMER 96
INTAKE=TU11
General Linear Models Procedure Class Level Information
Class Levels Values
CTREAT 2 C O
Number of observations in by group = 5
General Linear Models Procedure
Dependent Variable: FGE

Source	DF	Sum of Squares	F Value	Pr > F
Model	1	28.13225113	0.87	0.4193
Error	3	96.79985580		
Corrected Total	4	124.93210694		
	R-Square	c.v.		FGE Mean
	0.225180	55.69851		10.1984260
Source	DF	Type I SS	F Value	Pr > F
CTREAT	1	28.13225113	0.87	0.4193
Source	DF	Type III SS	F Value	Pr > F
CTREAT	1	28.13225113	0.87	0.4193
		INTAKE=TU11		

Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: FGE NOTE: This test controls the type I experimentwise error rate.

> Alpha= 0.05 df= 3 MSE= 32.26662 WARNING: Cell sizes are not equal. Harmonic Mean of cell sizes= 2.4

Number of Means 2 Critical F 10.127964

Means with the same letter are not significantly different.

REGWF Grouping	Mean	N	TREAT
A	12.135	3	С
A A	7.293	2	0

Appendix D Statistical Tests on Powerhouse 2 Data from Summer 1996

ONE-WAY ANOVA ON FGE AMONG SLUICE CHUTE TREATMENTS PH2 SUMMER 96					
		INTAKE=TU12 -			
	General Li Class	near Models P Level Informa	rocedure tion		
	Class	Levels V	alues		
	CTREAT	2 C	0		
Nı	umber of obse	rvations in b	y group	= 27	
		INTAKE=TU12 -			
	General Li	near Models P.	rocedure		
Dependent Variabl	.e: FGE				
Source	DF	Sum of Square	es F	Value	Pr > F
Model	1	1325.463618	09	1.27	0.2702
Error	25	26059.850316	86		
Corrected Total	26	27385.313934	95		
	R-Square	c.7	v.		FGE Mean
	0.048401	77.075	74		41.8888332
6		Mumo T (7 0 17	Value	
Source	DF	Type I 2		1 07	PI > I
CTREAT	1	1325.4636180		1.27	0.2702
Source	DF	Type III S	SS F	Value	Pr > F
CTREAT	1	1325.4636180	9	1.27	0.2702
		INTAKE=TU12			
Ryan-Einot-G	abriel-Welscl	n Multiple F 1	est for	variabl	e: FGE
NOTE: This t	est controls	the type I ex	periment	wise er	ror rate.
Alpha= 0.05 df= 25 MSE= 1042.394 WARNING: Cell sizes are not equal. Harmonic Mean of cell sizes= 13.48148					
	Number o Critica]	of Means F 4.241	2 .6991		
Means with t	he same lette	er are not sig	mificant	ly diff	erent.
REGWF	Grouping	Mea	in N	I TREAT	
	A	49.1	.6 13	; O	,
	A A	35.1	4 14	с	

ONE-WAY ANOVA ON FGE AMONG SLUICE CHUTE TREATMENTS PH2 SUMMER 96					
		INTAKE=TU13			
	General L Class	inear Models Proce Level Information	dure		
	Class	Levels Value	S		
	CTREAT	2 C O			
Nu	mber of obs	ervations in by gr	oup = 24		
		INTAKE=TU13			
	General L	inear Models Proce	dure		
Dependent Variabl	e: FGE				
Source	DF	Sum of Squares	F Value	Pr > F	
Model	1	939.84986529	0.70	0.4114	
Error	22	29484.96744560			
Corrected Total	23	30424.81731089			
	R-Square	c.v.		FGE Mean	
	0.030891	116.9760		31.2962430	
Source	DF	Type I SS	F Value	Pr > F	
CTREAT	1	939.84986529	0.70	0.4114	
Source	DF	Type III SS	F Value	Pr > F	
CTREAT	1	939.84986529	0.70	0.4114	
		INTAKE=TU13			
Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: FGE					

NOTE: This test controls the type I experimentwise error rate.

Alpha= 0.05 df= 22 MSE= 1340.226 WARNING: Cell sizes are not equal. Harmonic Mean of cell sizes= 11.91667

Number of Means 2 Critical F 4.3009495

Means with the same letter are not significantly different.

REGWF Grouping	Mean	N	TREAT
A	38.10	11	0
A	25.54	13	с

Appendix D Statistical Tests on Powerhouse 2 Data from Summer 1996

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ONE-WAY ANOVA ON FGE AMONG SLUICE CHUTE TREATMENTS PH2 SUMMER 96							
		INTAKE=TU14					
	General I Class	inear Models Proce Level Information	dure				
	Class Levels Values						
	CTREAT	2 C O					
N 	umber of obs	ervations in by gr INTAKE=TU14	oup = 27				
	General L	inear Models Proce	dure				
Dependent Variab	le: FGE						
Source	DF	Sum of Squares	F Value	Pr > F			
Model	1	961.70814964	0.90	0.3508			
Error	25	26592.46737688					
Corrected Total	26	27554.17552653					
	R-Square	c.v.		FGE Mean			
	0.034902	82.22140		39.6665529			
Source	DF	Type I SS	F Value	Pr > F			
CTREAT	1	961.70814964	0.90	0.3508			
Source	DF	Type III SS	F Value	Pr > F			
CTREAT	1	961.70814964	0.90	0.3508			
		INTAKE=TU14					
Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: FGE NOTE: This test controls the type I experimentwise error rate.							

Alpha= 0.05 df= 25 MSE= 1063.699 WARNING: Cell sizes are not equal. Harmonic Mean of cell sizes= 13.48148

Number of Means 2 Critical F 4.2416991

Means with the same letter are not significantly different.

REGWF Grouping	Mean	N	TREAT	
A	45.86	13	0	
A	33.92	14	с	

Appendix D Statistical Tests on Powerhouse 2 Data from Summer 1996

ONE-WAY ANOVA ON FGE AMONG SLUICE CHUTE TREATMENTS PH2 SUMMER 96						
		INTAKE=TU15				
	General Li Class	near Models Pro Level Informati	ocedure .on			
	Class	Levels Val	ues			
	CTREAT	2 C C)			
Num	per of obse	rvations in by	group = 28			
	General Li	near Models Pro	cedure			
Dependent Variable	FGE	neur nouerb rre				
Source	DF	Sum of Squares	F Value	Pr > F		
Model	1	163.55214576	0.27	0.6096		
Error	26	15918.19449912				
Corrected Total	27	16081.74664488				
1	R-Square	c.v.		FGE Mean		
	0.010170	71.04504		34.8278331		
Source	DF	Type I SS	F Value	Pr > F		
CTREAT	1	 163.55214576	0.27	0.6096		
Source	DF	Type III SS	F Value	Pr > F		
CTREAT	1	163.55214576	0.27	0.6096		
		INTAKE=TU15				
Ryan-Einot-Gal	oriel-Welsc	h Multiple F Te	st for variab	ole: FGE		
NOTE: This te:	st controls	the type I exp	erimentwise e	error rate.		
1	Alpha= 0.05	df= 26 MSE=	612.2382			
	Number Critica	of Means 1 F 4.2252	2 013			
Means with the	e same lett	er are not sign	ificantly dif	ferent.		
REGWF (Grouping	Mean	N TREA	T		
	A	37.245	14 C			
	A A	32.411	14 0			

ONE-WAY ANOVA ON FGE AMONG SLUICE CHUTE TREATMENTS PH2 SUMMER 96						
INTAKE=TU16						
General Linear Models Procedure Class Level Information						
Class Levels Values						
CTREAT 2 C O						
Number of observations in by group = 28						
INTAKE=TU16						
General Linear Models Procedure						
Dependent Variable: FGE						
Source DF Sum of Squares F Value	Pr > F					
Model 1 922.35878352 2.23	0.1477					
Error 26 10772.82990629						
Corrected Total 27 11695.18868981						
R-Square C.V.	FGE Mean					
0.078867 114.9811 1	7.7032063					
Source DF Type I SS F Value	Pr > F					
CTREAT 1 922.35878352 2.23	0.1477					
Source DF Type III SS F Value	Pr > F					
CTREAT 1 922.35878352 2.23	0.1477					
INTAKE=TU16						
Ryan-Einot-Gabriel-Welsch Multiple F Test for variable:	: FGE					
NOTE: This test controls the type I experimentwise erro	or rate.					
Alpha= 0.05 df= 26 MSE= 414.3396						
Number of Means 2 Critical F 4.2252013						
Means with the same letter are not significantly differ	cent.					
REGWF Grouping Mean N TREAT						
A 23.443 14 O						
A 11.964 14 C						

ONE-WAY ANOVA ON FGE AMONG SLUICE CHUTE TREATMENTS PH2 SUMMER 96						
		INTAKE=TU17				
General Linear Models Procedure Class Level Information						
	Class	Levels	Values			
CTREAT 2 C O						
Nun	ber of obse	rvations in	by group	= 28		
		INTAKE=TU17				
	General Li	near Models	Procedure	1		
Dependent Variable	: FGE					
Source	DF	Sum of Squ	ares F	' Value	Pr > F	
Model	1	3.6508	0460	0.01	0.9254	
Error	26	10618.8852	7217			
Corrected Total	27	10622.5360	7678			
	R-Square		c.v.		FGE Mean	
	0.000344	105.	7744	:	19.1061090	
Source	DF	Туре	ISS F	' Value	Pr > F	
CTREAT	1	3.6508	0460	0.01	0.9254	
Source	DF	Type II	ISS F	' Value	Pr > F	
CTREAT	1	3.6508	0460	0.01	0.9254	
		INTAKE=TU17				
Ryan-Einot-Ga	briel-Welsc	h Multiple	F Test for	variable	: FGE	
NOTE: This te	st controls	the type I	experimen	twise er	for rate.	
	Alpha= 0.05	df= 26 M	SE= 408.41	87		
	Number Critica	of Means lF 4.	2 2252013			
Means with th	e same lett	er are not	significan	tly diffe	erent.	
REGWF	Grouping	:	Mean	N TREAT		
	A	19	.467 1	4 O		
	A A	18	.745 1	4 C		

ONE-WAY ANOVA ON FGE AMONG SLUICE CHUTE TREATMENTS PH2 SUMMER 96						
		INTAKE=TU18				
	General L Class	inear Models Proce Level Information	dure			
Class Levels Values						
	CTREAT	2 C O				
N	umber of obs	ervations in by gro	oup = 21			
		INTAKE=TU18				
	General L	inear Models Proce	iure			
Dependent Variab	le: FGE					
Source	DF	Sum of Squares	F Value	Pr > F		
Model	1	3.78387841	0.03	0.8579		
Error	19	2181.91543334				
Corrected Total	20	2185.69931175				
	R-Square	c.v.		FGE Mean		
	0.001731	71.33406		15.0226031		
Source	DF	Type I SS	F Value	Pr > F		
CTREAT	1	3.78387841	0.03	0.8579		
Source	DF	Type III SS	F Value	Pr > F		
CTREAT	1	3.78387841	0.03	0.8579		
		INTAKE=TU18				
Ryan-Einot-G	Gabriel-Welso	ch Multiple F Test	for variab	le: FGE		
NOTE: This t	est controls	s the type I experi	mentwise e	rror rate.		

Alpha= 0.05 df= 19 MSE= 114.8377 WARNING: Cell sizes are not equal. Harmonic Mean of cell sizes= 10.47619

Number of Means 2 Critical F 4.3807497

Means with the same letter are not significantly different.

REGWF	Grouping	Mean	N	TREAT	
	A	15.468	10	0	
	A	14.618	11	с	

Appendix D Statistical Tests on Powerhouse 2 Data from Summer 1996

ONE-WAY ANOVA ON FGE AMONG INTAKES PH2 SUMMER 96

General Linear Models Procedure Class Level Information

Class Levels Values

INTAKE 8 TU11 TU12 TU13 TU14 TU15 TU16 TU17 TU18

Number of observations in data set = 188

General Linear Models Procedure

Dependent Source Model Error Corrected	Variable: FGE DF 7 180 Total 187	Sum of Squares 20733.9214680 126074.4096025 146808.3310705	F Value 4.23	Pr > F 0.0002
	R-Square	c.v.		FGE Mean
	0.141231	93.42903		28.3266607
Source INTAKE Source INTAKE	DF 7 DF 7	Type I SS 20733.9214680 Type III SS 20733.9214680	F Value 4.23 F Value 4.23	Pr > F 0.0002 Pr > F 0.0002

Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: FGE NOTE: This test controls the type I experimentwise error rate.

Alpha= 0.05 df= 180 MSE= 700.4134 WARNING: Cell sizes are not equal. Harmonic Mean of cell sizes= 17.00309

 Number of Means
 2
 3
 4
 5

 Critical F
 6.3306494
 4.0490667
 3.1796455
 2.7121273

 Number of Means
 6
 7
 8

 Critical F
 2.416915
 2.1492492
 2.0607618

Means with the same letter are not significantly different.

REGWF G	rouping		Mean	N	INTAKE
	А		41.889	27	TU12
В	AA		39.667	27	TU14
B	AA	C	34.828	28	TU15
B	AA	C	31.296	24	TU13
B	A A		19.106	28	TU17
B		C	17.703	28	TU16
		c	15.023	21	TU18
		c	10.198	5	TU11

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13.ABSTRACT (Maximum 200 work This technical report desc U.S. Army Engineer Waterw surface-collector technologie Project. The goals of this stu a surface-collector prototype Objectives were as follow a. Use mobile hydroacour powerhouses and to characte b. Estimate smolt passage paired sluiceway/turbine ope sluice gates) in spring and su	ds) ribes results of studies conducted ays Experiment Station to resolve s and the estimation of fish passag dy were to (a) provide biological and (b) make progress toward the s: stics to measure the vertical and he rize the day and night variation in e into two turbines and into the cen nings under two test conditions (b mmer at Powerhouse 1.	by the U.S. Army Engine critical uncertainties in ge efficiency (FPE) for ju- information necessary to e estimation of FPE for the orizontal distribution of distributions in spring a nter sluice gate above ea- olocked versus unblocked	eer District, Portland, and the the implementation of avenile salmon at the Bonneville of facilitate the design and placement of the entire project. salmon smolts in forebay areas of both and summer. th turbine, as well as the FPE ratio for it trash racks and open versus closed
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13. (Concluded).

c. Evaluate smolt swimming direction in the area immediately upstream of two test units at Powerhouse 1, particularly at the zone of separation between flows entering turbines and flows entering sluice gates.

d. Estimate guided and unguided smolt passage into eight turbine intakes of Powerhouse 2 and identify effects of an open or closed sluice chute on the fish guidance efficiency of adjacent turbine units. The enclosed Summary presents highlights of study results, discussions, and conclusions.