BUELL & ASSOCIATES, Inc.

Consulting Biologists

Aquatic Resource Management • Estuarine Ecology • Salmonid Enhancement • Bioengineering

MEMORANDUM

To: John Buckley, General Manager
East Fork Irrigation District

cc: Mick Jennings, CTWS
Jim Newton, ODFW
Mark Wharry, SJO
Rich Fitterer, SJO

From: J. W. Buell, Ph.D.

Date: 24 January 2000

Subject: CIWS comments on the Phase I Biological Performance Report.

I spoke with Mick Jennings today and he gave me the Warm Springs Tribe's comments on the Phase I Biological Performance Tests for your East Fork Hood River sand separation and fish screen facility. Their comments are:

- Add a discussion of the injuries for which we were inspecting the fish, in addition to scale loss (*e.g.* split fins, bruises, eye injuries, etc.);
- Provide a copy of the data collection sheet used;
- Provide more detail on what various scale loss rates might mean (*i.e.* to NMFS);
- Provide a photo appendix – especially provide a photo of the catch net arrangement;
- Discuss the condition of the steelhead smolts used for these tests (*i.e.* these fish were "non-migrants"; these fish were seined, crowded, handled in a "sandy" environment and not fed prior to being used) and the idea that these fish might have been pre-disposed to poor performance.

We discussed these helpful comments and agreed on the following:

- I will add the discussion of the injuries we looked for;
- We used two kinds of data sheets and used them in various ways; this would not add anything substantive to the report, so it will not be included;

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BIOLOGICAL PERFORMANCE TESTS

of

EAST FORK IRRIGATION DISTRICT'S

SAND TRAP AND FISH SCREEN FACILITY

PHASE I – 1999

conducted for

EAST FORK IRRIGATION DISTRICT

J. W. Buell, Ph.D.

BUELL & ASSOCIATES, Inc.

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Portland OR 97225
(503) 203-1248

January 2000

BIOLOGICAL PERFORMANCE TESTS OF EAST FORK IRRIGATION DISTRICT'S SAND TRAP AND FISH SCREEN FACILITY

PHASE I - 1999

BACKGROUND

East Fork Irrigation District operates an irrigation diversion on the East Fork Hood River near Parkdale OR. This diversion is operated pursuant to a Water Right issued by Oregon Water Resources Department, which permits withdrawal of up to 127 cfs. Since the East Fork Hood River is primarily of glacial origin and carries a prodigious sand load, a sand trap has been operated approximately 1/2 mi from the diversion point, with sand sluiced back to the main river. In recent years it had become apparent that the aging sand trap structure was in need of replacement. SJO Consulting Engineers Inc. (SJO) was retained by the District to design a replacement sand trap facility and to investigate passive fish screening facility options in order to comply with Oregon Department of Fish and Wildlife (ODFW) requirements for a suitable protective screen on this sediment-laden diversion. Final design and construction of the sand trap and screening facility was fast-tracked as a result of complete distruction of the old sand trap by the 1996 flood.

Diversion of water from the East Fork Hood River presents some relatively unusual and difficult problems. The glacial origin of this stream results in an unusual hydrology, with relatively high discharge occurring during the warmer summer months, especially during sunny periods, and with large daily fluctuations due to higher altitude temperature cycles. In addition, a large proportion of the sand load is delivered during the irrigation season, when water is being diverted. One design specification which affects selection of a screening approach is the need to separate, retain and eventually dispose of at least 1,000 yards of sand within an 8-hour period. This need and the direct experience of the District with excessive wear caused by suspended fine sand particles on moving parts associated with conventional fish screen designs, along with certain site limitations, led the District and SJO to explore "unconventional" designs for fish screens. After review of several alternative passive approaches, SJO recommended a system incorporating a horizontal profile bar screen surface fitted into the face of an overflow weir, sometimes called a "Coanda" type screening system. This static, overflow weir, horizontal profile bar screen was conceptually developed and presented to ODFW and the Confederated Tribes of the Warm Springs Reservation of Oregon (CTWS) as the preferred solution to fish screening requirements. This design was then incorporated into a "sectionalized" sand trap facility designed to accommodate capture and slurry of silt and sand during periods of high suspended load concentration.

Although several systems of this type had been installed in the West, notably in Montana and California and usually across entire natural stream channels, biological performance tests to ascertain the safety of these facilities for fish passing over them had not been conducted. Regulatory agencies and other interested parties, such as CTWS, were therefore reluctant to endorse application of the overflow weir face screen concept, especially for systems supporting anadromous fish.

Due to the lack of biological performance data for Coanda-type screening facilities, it was agreed among the District, ODFW and CTWS that biological performance tests would be conducted on a small prototype version of a full-height section of the proposed screening system. The purpose of these tests was to address the lack of knowledge regarding the biological performance of overflow weir profile bar ("Coanda") screens. Biological performance tests were conducted by Buell and Associates, Inc. with the participation of Mick Jennings and Mike Lambert, CTWS, and Jim Newton, ODFW. Tests were conducted in late June and early July, 1996 at the powerhouse of the Middle Fork Hydroelectric Project on the Middle Fork Hood River. Results of these tests are included in a report "Biological Performance Evaluation of an Overflow Weir Profile Bar Fish Screen for East Fork Irrigation District" (Buell & Associates, Inc. 1996). Test results demonstrated no adverse consequences for juvenile chinook salmon and steelhead passing over the screen section, and it was concluded that there was no reason based on the potential for fish injury due to passage over the overflow screen to delay installation of this type of screen in the new sand trap facility. It was agreed among the parties, however, that a similar test of the fully constructed and operational facility would be appropriate, in order to confirm the results of prototype tests.

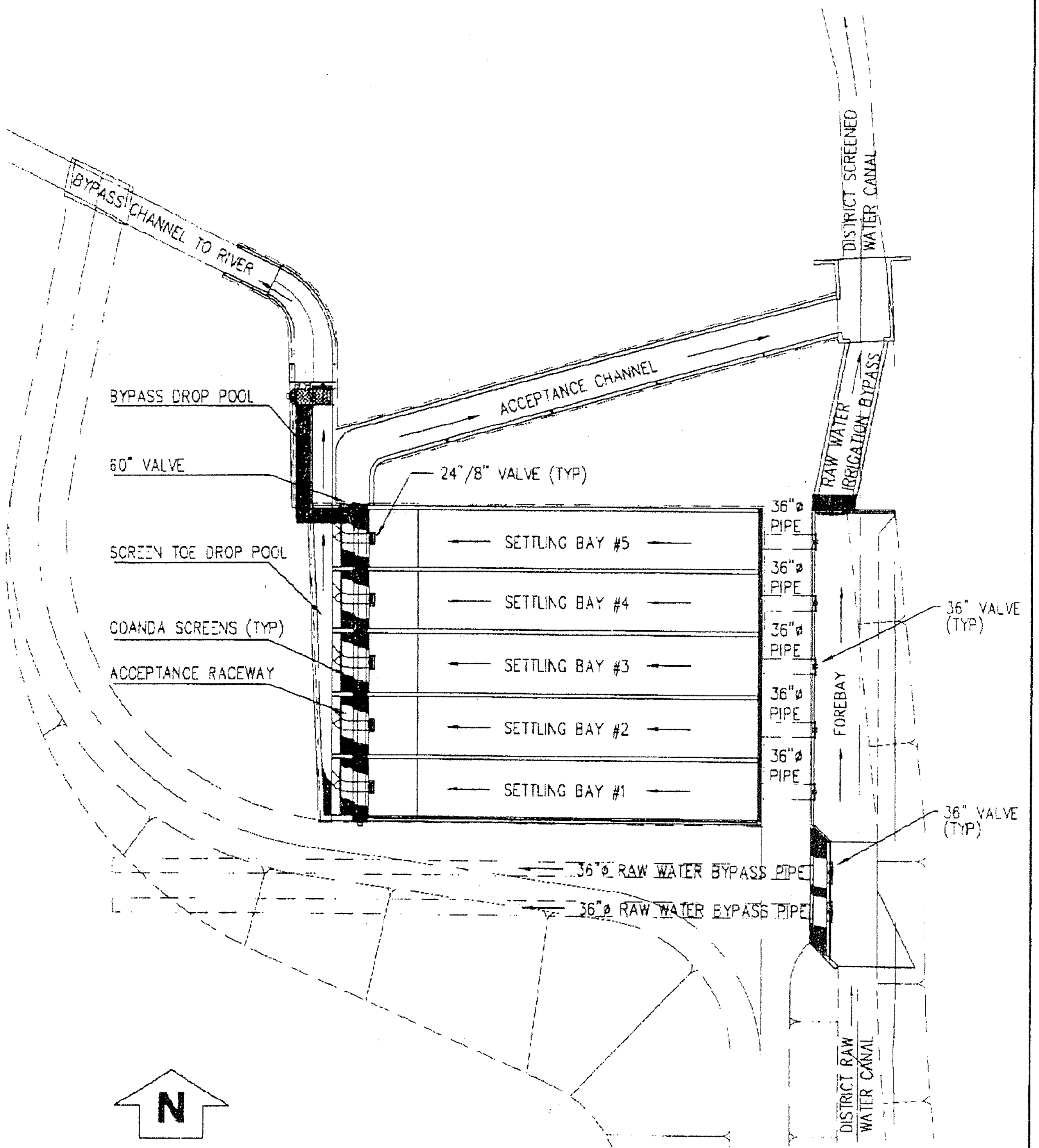
Following approval by ODFW and concurrence on the part of CTWS, SJO commenced with fast-track final design for the new facility. Construction commenced in the Spring of 1996 and the new facility was operational by the start of the irrigation season of 1997. Modifications to correct certain hydraulic problems were implemented after the first season, and the modified, fully operational facility was completed by the spring of 1998. A plan view of the completed facility is shown in Figure 1.

National Marine Fisheries (NMFS) was re-engaged in discussions surrounding the East Fork Irrigation District sand trap and screen facility in the spring of 1998. Draft study plans for the biological performance evaluation of the completed facility were submitted to ODFW, CTWS and NMFS for review and comment at that time. Following incorporation of changes suggested by review by these parties, the first phase of testing, focusing on the overflow screens themselves, was scheduled for the spring of 1999.

METHODS

During the week of 17 May 1999, biological evaluation tests were conducted at the new fish screens at the EFID Sand Trap adjacent to the East Fork Hood River. Cooperating in these tests were the Confederated Tribes of the Warm Springs (CTWS) and the Oregon Department of Fish and Wildlife (ODFW). Several groups each of newly emergent fry and smolt life stages of winter steelhead and the newly emergent fry life stage of spring chinook were subjected to passage over the fish screens in order to determine if any injury or other adverse effects would result.

FIGURE 1



FACILITY DIAGRAM

EAST FORK IRRIGATION SAND TRAP / HEAD GATE

O-OVERHEAD\CAD\BUELL\PLAN.DWG

PLOTTED: 01/06/2000 09:00

Appropriate control groups were subjected to handling and inspection procedures, but were not passed over the screens. Water levels in the sand trap and fish screen facility were adjusted to reflect normal operating conditions, with the lower portion of the fish screen submerged and the upper portion continuously wetted (see Figure 2).

Prior to introduction into the system, all experimental and control fish were anaesthetized (MS-222) and individually inspected for prior injuries, including any scale loss, and data were recorded for comparison to comparable data taken after testing. For fry, only fish in "perfect" condition (no injuries or anomalies of any kind observed) were used. For steelhead smolts, all fish exhibited some scattered scale loss; the percent scattered scale loss on each side of the fish was recorded prior to use.

Following recovery from the anaesthetic, experimental fish were introduced to the system at the crest of the overflow weir in Bay No. 1. Figure 2 shows the arrangement of elements for individual settling bays and associated screens. Care was taken to assure that experimental fish were immersed fully into the water column prior to passage over the screen below. After passage over the weir and screen face, fish were retained in a specially constructed "catch net" deployed in the bypass channel below the screen (Figure 3). Normal operation of the facility calls for submersion of the lower one-third of the screen surface; this condition was maintained throughout testing. After all fish in each group had passed down the screen face into the catch net, the net was hoisted and fish were concentrated in a 5-gal bucket fastened to the bottom of the net. The bucket and its contents were then removed, the fish re-anaesthetized and inspected for injuries, and data were recorded. Control fish were handled identically to experimental fish, except these groups were introduced directly into the catch net without passing over the screen face.

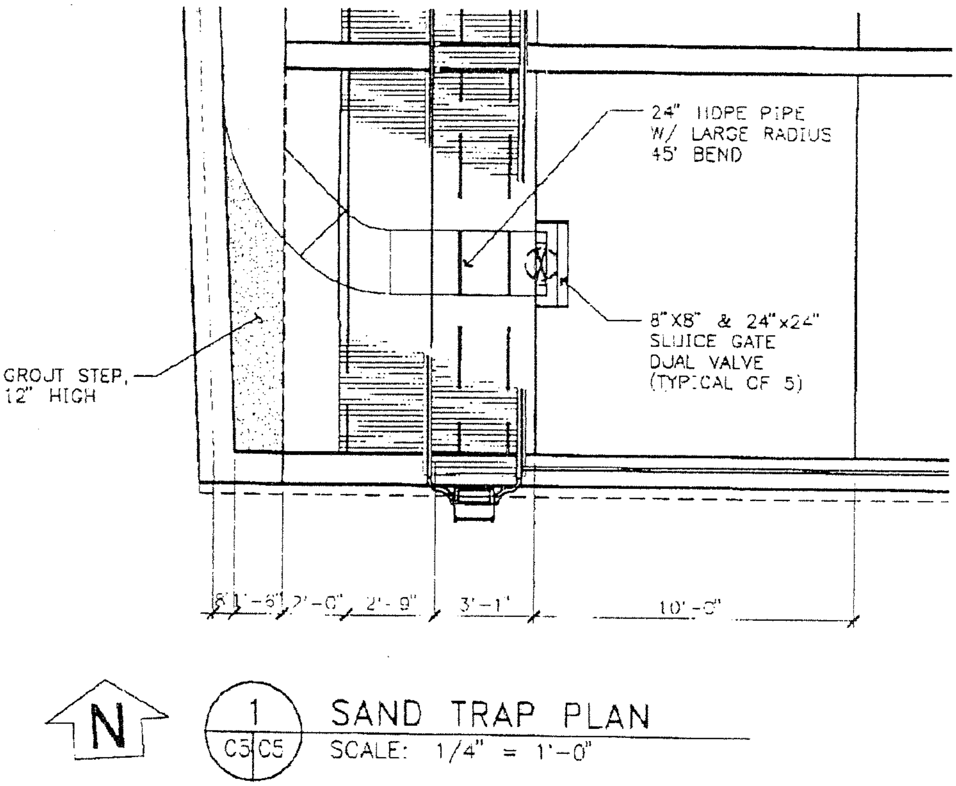
All experimental and control fish were held in net pens in Settling Bay No. 1 for 96 hours after testing to see if latent mortality would occur and could be attributable to exposure to the screen. These fish were checked daily for latent mortalities and anomalous behavior.

STEELHEAD FRY TESTS

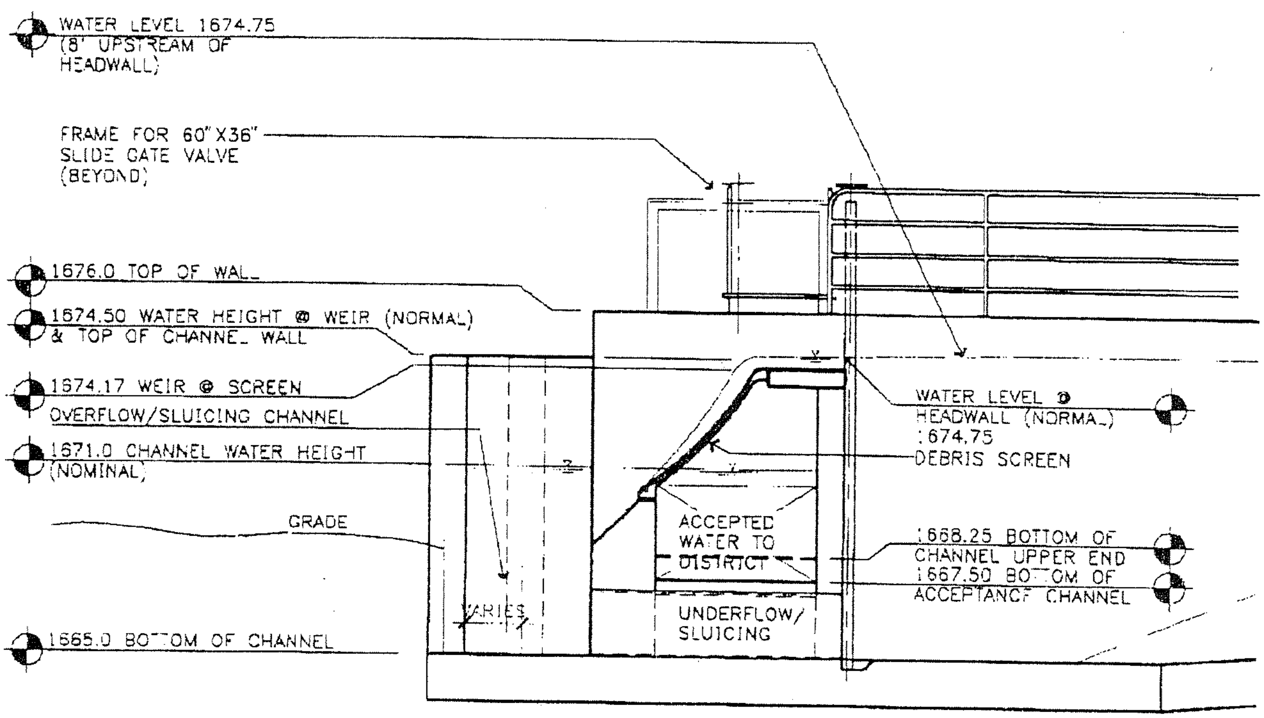
Winter steelhead fry were obtained from ODFW's Oak Springs Hatchery. These fish averaged 36.4 mm in fork length (FL) (n=58; S.D.=5.80). A length-frequency histogram for a sub-sample of these fish (n=58) is given in Figure 4. Test fish were held in 64 ft^3 net pens in the sand trap section of the facility until use, and thereafter for a 96-hr latent mortality observation.

Five experimental groups of approximately 50 winter steelhead fry were carefully inspected for physical condition and released at the crest of the screen weir and allowed to pass naturally over the screen to the bypass pool below. Following recovery, fish were again carefully inspected for physical condition and behavior, and any change in condition was noted. Five control groups of approximately 50 fish each were inspected, released directly into the net at the toe of the screen and subjected to the same recovery and inspection procedures as experimental fish. Since it was impossible to render the recovery net completely "fish-tight", especially for fry, fewer fish were sometimes recovered than were released. This does not invalidate the tests, however, since

FIGURE 2



SAND TRAP PLAN
SCALE: 1/4" = 1'-0"

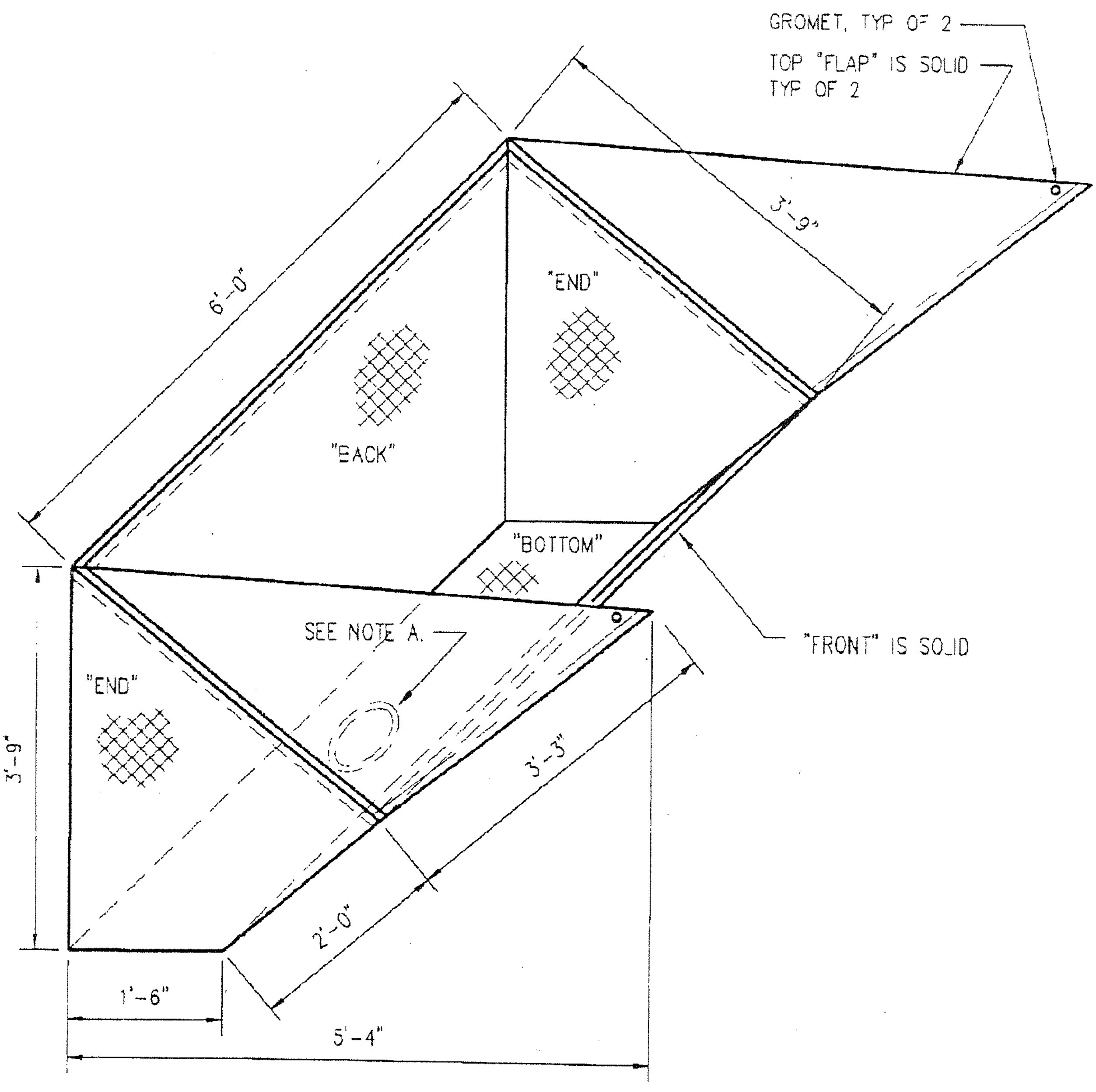


SAND TRAP ELEVATION
SCALE: 1/4" = 1'-0"

O-OVERHEAD\CAD\BUELL\BAYSECT.DWG

PLOT: 01/14/2000-16:33

FIGURE 3



LEGEND

SOLID – PLASTIC COATED CANVAS

(net pattern) – NET

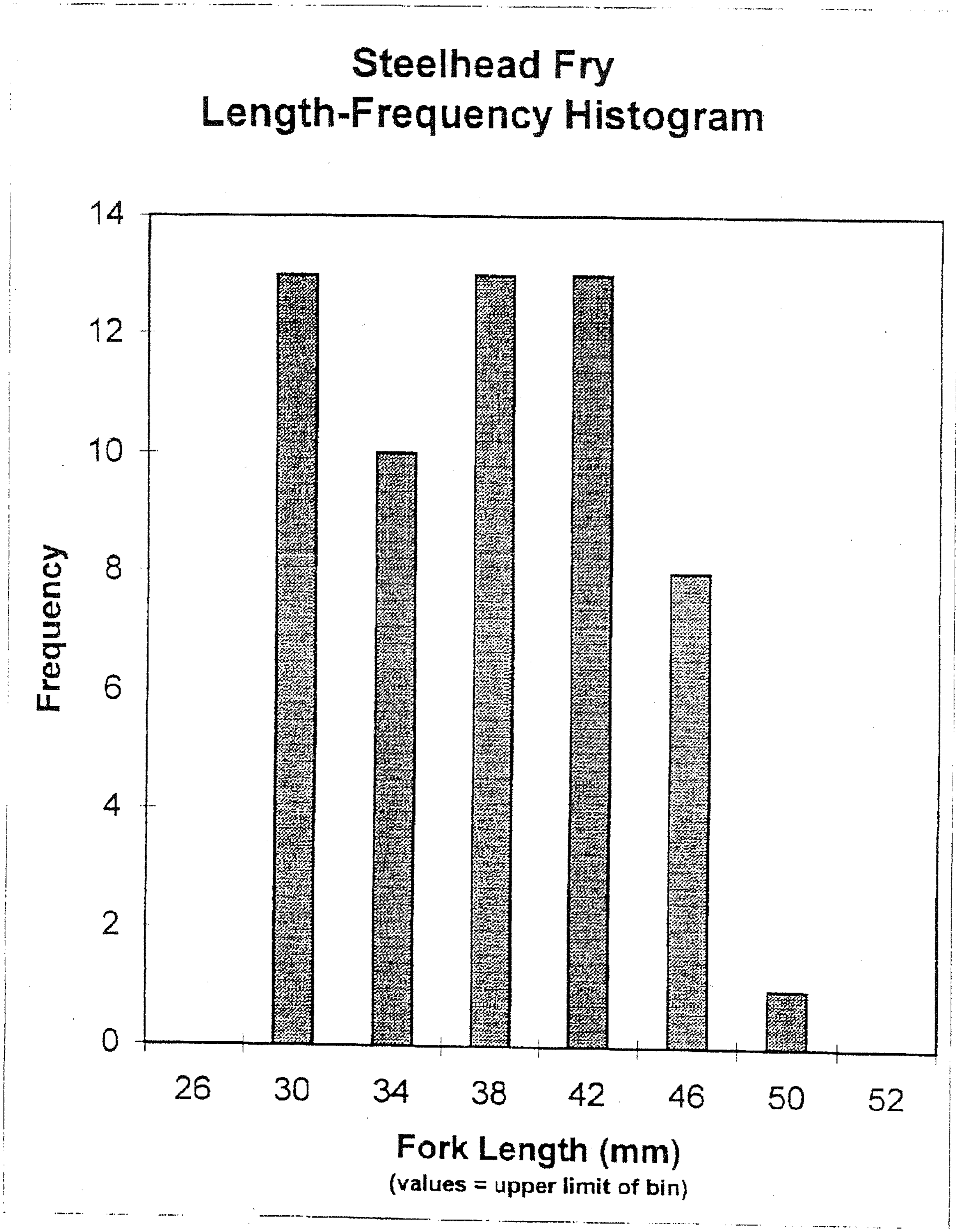
NOTES:

A. 11 3/4" DIA HOLE WITH DRAWSTRING IN BOTTOM.

0-OVERHEAD\CAD\BUELL\FISHNET-A.DWG

PLOTTED: 01/06/2000-09:01

FIGURE 4


Steelhead Fry
Length-Frequency Histogram
Frequency
0
2
4
6
8
10
12
14
26
30
34
38
42
46
50
52
Fork Length (mm)
(values = upper limit of bin)

sufficient fish were recaptured to evaluate the groups for injury or other effects of passage and handling. All fish were held for a 96-hr latent mortality test.

SPRING CHINOOK FRY TESTS

Newly emergent spring chinook fry were obtained from ODFW's Parkdale facility for use in these tests. These fish averaged 36.8 mm FL (n=25; S.D.=0.85). A length-frequency histogram of a sub-sample of these fish (n=25) is given in Figure 5. Five experimental groups and three control groups of approximately 50 spring chinook fry each were carefully inspected for physical condition and released at the crest of the screen weir and allowed to pass naturally over the screen to the bypass pool below. In some cases, chinook fry were not completely "buttoned up" (the ventral slit through which the yolk sac had protruded during embryonic and "sac fry" development, was not yet closed); these fish, although otherwise in good condition, were rejected for use in these tests. Fish were recaptured and inspected using the same procedures as for steelhead fry. As with steelhead fry, the recapture net proved not to be completely "fish-tight", and not all released fish were recaptured; as with winter steelhead fry, this does not invalidate these tests since sufficient fish were recaptured to evaluate the groups for injury and other effects of passage and handling. All fish were held for a 96-hr latent mortality test.

STEELHEAD SMOLT TESTS

Steelhead smolts for these tests were obtained from the CTWS hatchery in the Hood River basin. These fish averaged 189 mm FL (n=150; S.D.=23.7) and 725 gm in weight (n=150; S.D.=296). A length-frequency histogram of these fish is given in Figure 6; the length-weight relationship is depicted in Figure 7. Twelve experimental groups and eleven control groups of approximately 20 winter steelhead smolts were carefully inspected for physical condition and released into a specially constructed holding net immediately upstream of the crest of the screen weir. This net was then slowly tipped toward the weir crest to "encourage" the fish to pass over the screen to the bypass pool below. At the request of NMFS, some of these fish were placed in this net enclosure, which was open to the crest of the weir, to observe how long it would take before these fish would voluntarily move over the weir crest, and whether there would be behavioral or injury rate differences between "volunteers" and fish "encouraged" to pass. As in the fry tests, recaptured fish were carefully inspected for physical condition and data were recorded. All fish were held for a 96-hr latent mortality test.

Particular attention was given to the degree of scale loss for steelhead smolts, since these fish have "deciduous" scales which are easily shed, and since the degree of scale loss for this life stage has been traditionally used in fish screen biological performance tests as a measure of fish injury or stress. It was noted that virtually all fish in the lot from which both experimental and control fish were drawn showed some scattered scale loss. Since it is virtually impossible to estimate the percent of missing scales with this loss pattern with great precision, estimates were made to the nearest 5%. A level of scale loss of 40% is considered by NMFS to be a surrogate for "mortality". Scale loss data for the left and right sides of each fish were recorded separately to increase statistical power and to determine if any discernable scale loss patterns (*e.g.* one side

FIGURE 5

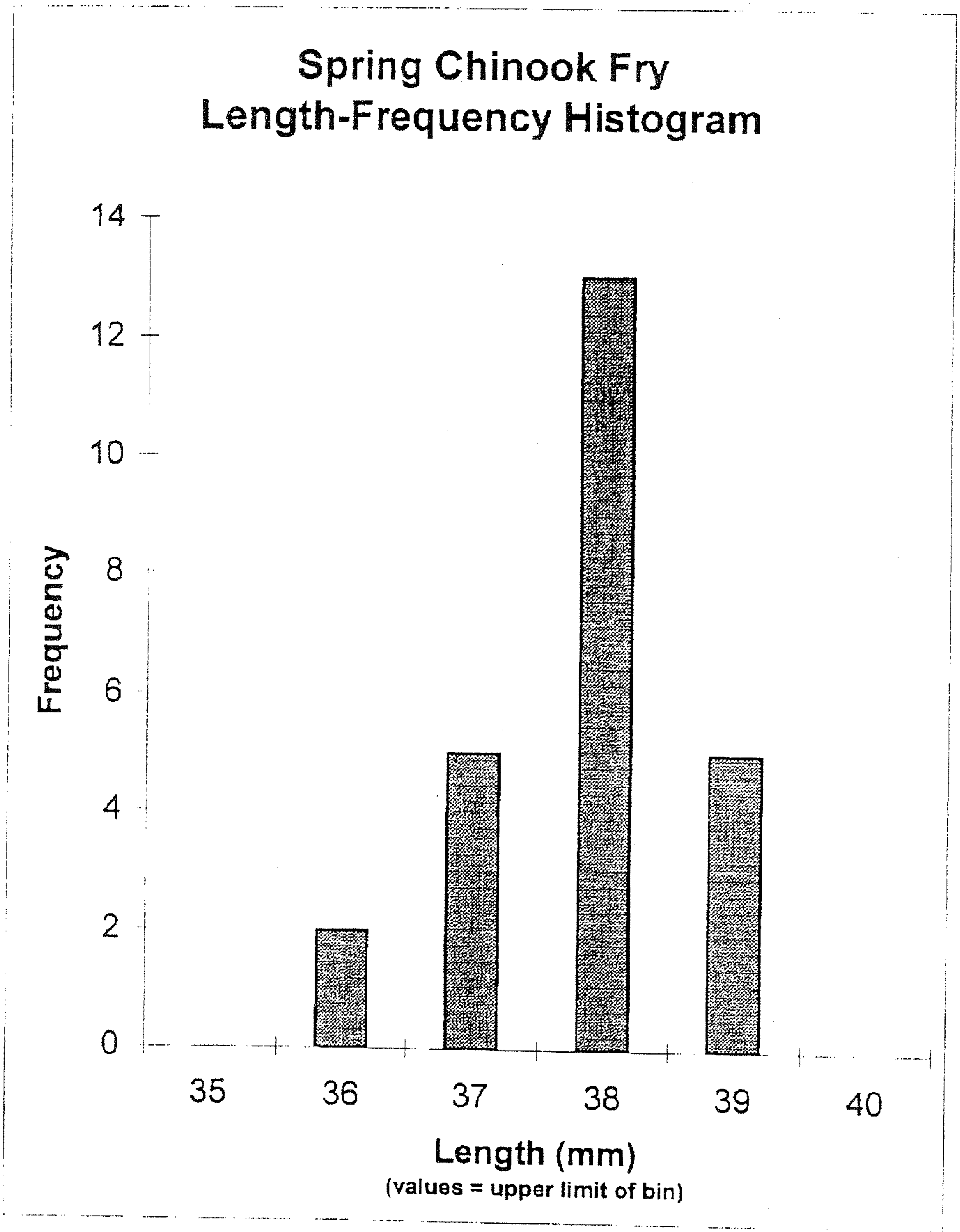

Spring Chinook Fry
Length-Frequency Histogram
Frequency
14
12
10
8
6
4
2
0
35
36
37
38
39
40
Length (mm)
(values = upper limit of bin)

FIGURE 6

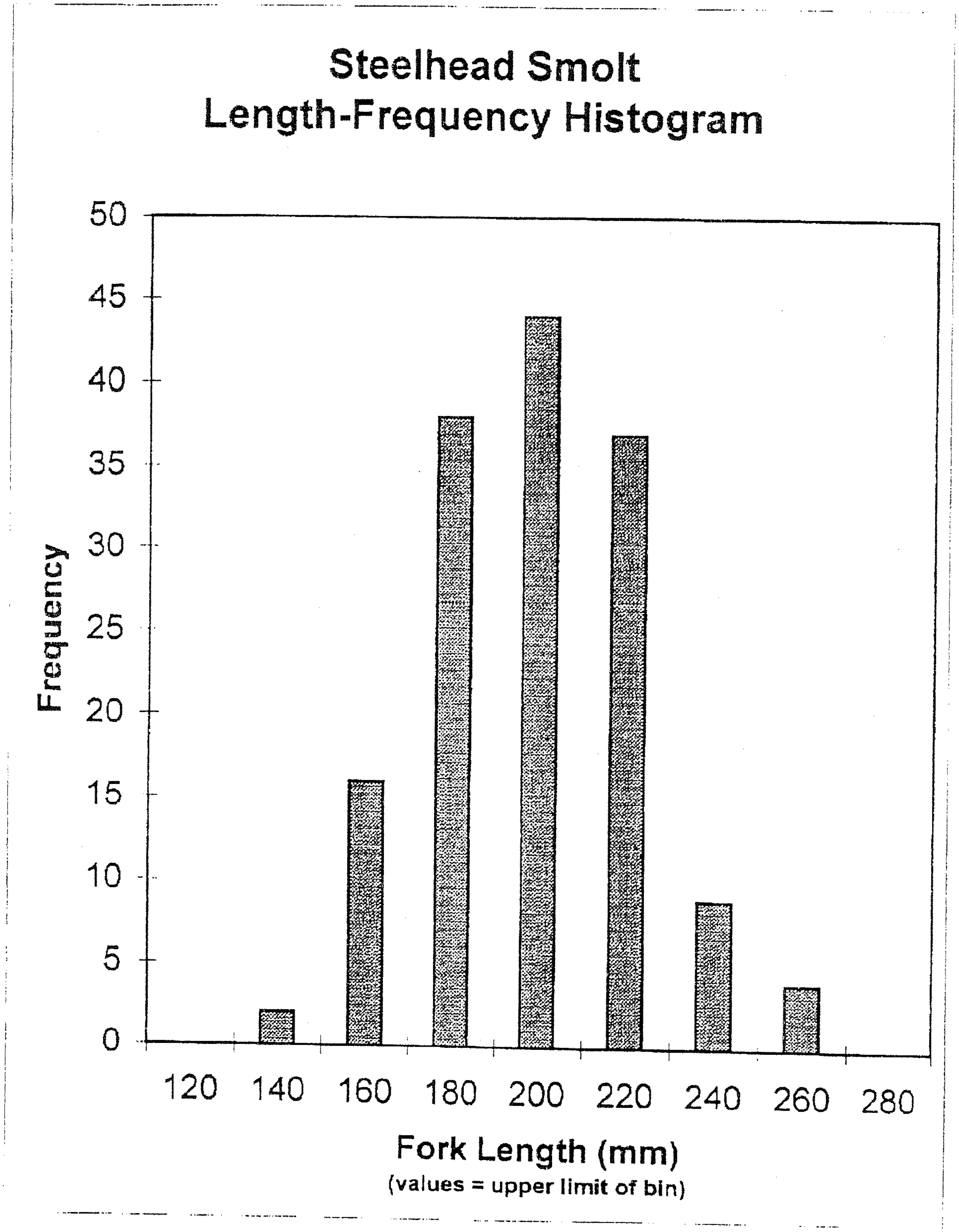
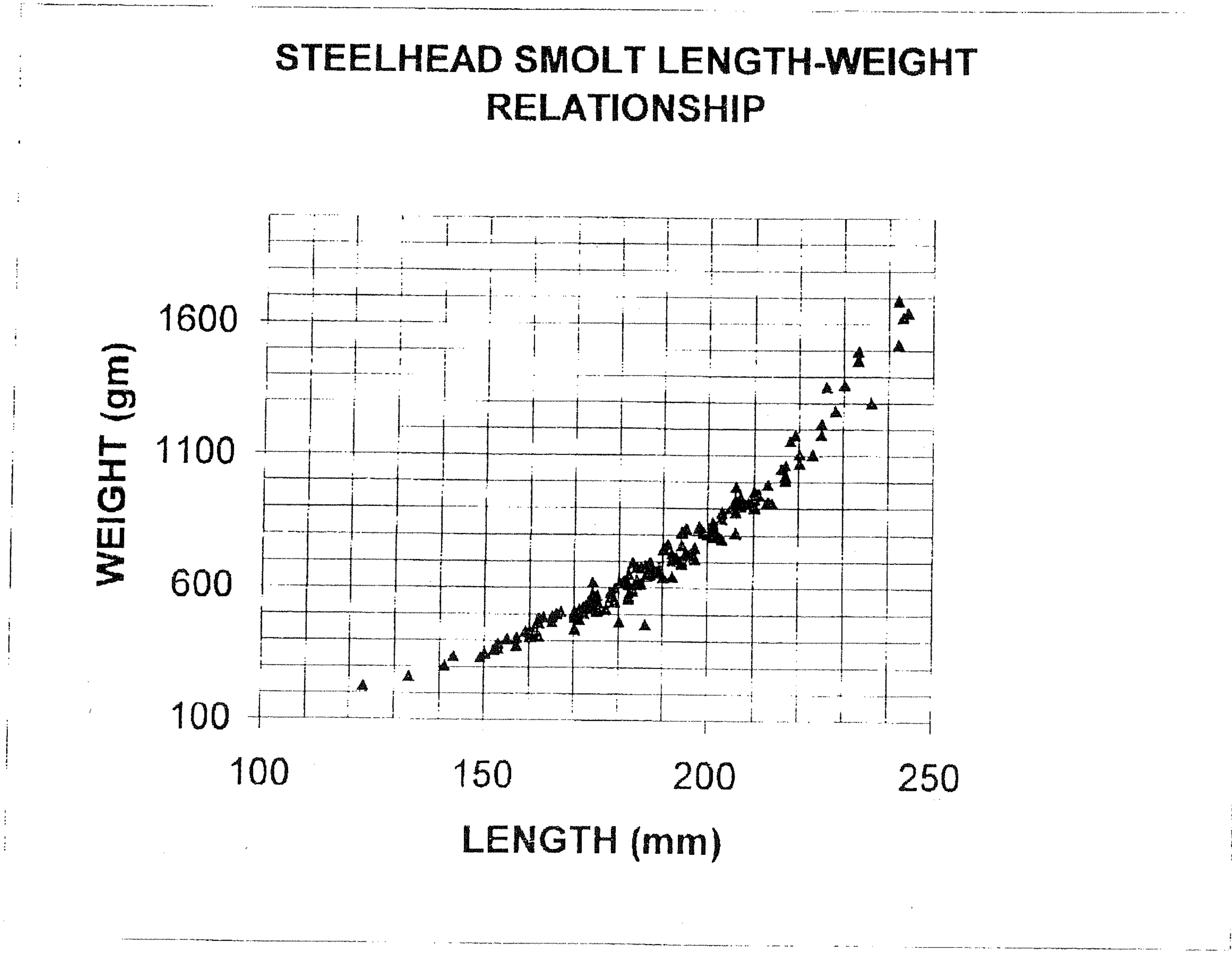

Steelhead Smolt
Length-Frequency Histogram
Frequency
0
5
10
15
20
25
30
35
40
45
50
120
140
160
180
200
220
240
260
280
Fork Length (mm)
(values = upper limit of bin)

FIGURE 7


STEELHEAD SMOLT LENGTH-WEIGHT RELATIONSHIP
WEIGHT (gm)
1600
1100
600
100
100
150
200
250
LENGTH (mm)

only) would be produced by passage over the fish screens. Only fish with scattered scale loss of less than 10% on any one side were selected for use either as experimental or control fish. No fish was encountered with less than 5% scattered scale loss on any one side. As with the fry tests, the recapture net proved not to be completely "fish-tight", and not all released fish were recaptured. In addition, steelhead smolts are powerful enough swimmers that a few individuals left the release net and were able to swim against the rather strong current at the weir crest and escape into the sand trap bay, accounting for most of the incomplete recapture. These differences did not invalidate the statistical tests, however.

RESULTS

STEELHEAD FRY TESTS

Of the 260 experimental fish released in five groups, 202 were recaptured and inspected for any injuries or other anomalies. No injuries or behavioral or other anomalies of any kind were observed. Of the 260 control fish released, 250 were recovered and inspected. No injuries or behavioral or other anomalies of any kind were observed. Data are summarized in Table 1.

Both experimental and control fish were held for 96 hours in net pens to determine if any latent mortalities attributable to passage over the fish screens would result. No mortalities or behavioral anomalies were observed for any fish in either group during this period.

SPRING CHINOOK FRY TESTS

Of the 260 experimental fish released in five groups, 244 were recovered and inspected. No injuries or behavioral or other anomalies of any kind were observed. Of the 156 control fish released in three groups, 134 were recovered and inspected. No injuries or behavioral or other anomalies of any kind were observed. Data are summarized in Table 1. The reason that only three control groups were used is because it was apparent from observations of experimental fish that neither passage over the screen nor handling/inspection was causing any injuries or behavioral anomalies, and there would be little or no utility in proceeding with all five control groups.

Both experimental and control fish were held for at least 96 hours in net pens to determine if any latent mortalities attributable to passage over the fish screens would result. No mortalities or behavioral or other anomalies were observed for any fish in either group during this period.

STEELHEAD SMOLT TESTS

Of the 240 experimental fish released (in 12 groups), 232 were recovered and inspected. A slight increase in the amount of scattered scale loss was generally detected (Table 2). Scattered scale loss for experimental fish increased from about 7.5% to about 8.1 % of the body surface, an increase of 0.5 - 0.6%. Beyond this slight but rather consistent increase in scattered scale loss, no injuries or behavioral anomalies of any kind were observed. No pattern of scale loss (*e.g.* one side only; "scrapes" or "patches") was detected.

TABLE 1

EAST FORK IRRIGATION DISTRICT
FISH SCREEN BIOLOGICAL PERFORMANCE TESTS
1999

DATA SUMMARY

STEELHEAD FRY TESTS

	Trial	# released	# recovered (n)	Observations
Test fish:	1	52	45	
	2	52	54	
	3	52	42	
	4	52	29	
	5	52	32	
		260	202	No injuries of any kind
Control fish:	1	52	52	
	2	52	52	
	3	52	51	
	4	52	44	
	5	52	51	
		260	250	No injuries of any kind

SPRING CHINOOK FRY TESTS

	Trial	# released	# recovered (n)	
Test fish:	1	52	50	
	2	52	49	
	3	52	48	
	4	52	51	
	5	52	46	
		260	244	No injuries of any kind
Control fish:	1	52	49	
	2	52	35	
	3	52	50	
		156	134	No injuries of any kind

TABLE 2

EAST FORK IRRIGATION DISTRICT
FISH SCREEN BIOLOGICAL PERFORMANCE TESTS
1999

DATA SUMMARY – STEELHEAD SMOLT TESTS

	Trial	# released	# recovered (n)	Observations
Test fish:				
	1	20	20	Average scattered scale loss
	2	20	16	*before* release/recovery:
	3	20	20	
	4	20	20	Left side: 7.58 %
	5	20	21 *	Right side: 7.50 %
	6	20	19	
	7	20	19	Average scattered scale loss
	8	20	20	*after* release/recovery:
	9	20	19	
	10	20	18	Left side: 8.18 %
	11	20	20	Right side: 8.03 %
	12	20	20	
		240	232	Difference:
				Left side: + 0.60 %
				Right side: + 0.53 %
Control fish:				
	1	20	20	Average scattered scale loss
	2	20	20	*before* release/recovery:
	3	20	20	
	4	20	20	Left side: 6.70 %
	5	20	20	Right side: 6.73 %
	6	20	20	
	7	20	20	Average scattered scale loss
	8	20	20	*after* release/recovery:
	9	20	20	
	10	20	20	Left side: 7.20 %
	11	24	19	Right side: 7.35 %
		224	219	Difference:
				Left side: + 0.50 %
				Right side: + 0.62 %

Of the 224 control fish released (in 11 groups), 219 were recovered and inspected. As with the experimental fish, a slight increase in the amount of scale loss was generally detected (Table 2). Scattered scale loss for experimental fish increased from about 6.7% to about 7.2 - 7.3% of the body surface, an increase of 0.5 - 0.6%. Beyond this slight but rather consistent increase in scattered scale loss, no injuries or behavioral anomalies of any kind were observed. No pattern of scale loss was detected. The slight increase in scattered scale loss for control fish is almost exactly the same as that for experimental fish.

Statistical tests (Mann-Whitney Rank Sum Test; data were non-normal) were performed to determine if any of the differences between pre-treatment and post-treatment scattered scale loss within experimental groups and control groups were significant. Each side of the fish was treated as an individual observation to increase the power of the statistical tests (*e.g.* 40 observations per 20 fish). For control fish, only two of the 11 groups exhibited significant differences in scattered scale loss before and after handling ($P<0.05$). For experimental fish, only one of the 12 groups exhibited significant differences in scattered scale loss before and after exposure to the screen. When all data were pooled, however, pre-treatment and post-treatment differences were found to be significant for both experimental and control groups ($P<0.004$ and $P<0.001$ respectively).

Although slight increases in scattered scale loss before and after treatments were observed for both experimental and control fish, this is not in itself a measure of any effect of exposure to the fish screen. Such a measure is the difference between experimental and control results, and answers the question: "Is the increase in scattered scale loss for experimental fish greater than the increase in scattered scale loss for control fish?" Since the average scattered scale loss for experimental fish prior to release was noted to be greater than that for control fish, a Mann-Whitney Rank Sum Test (data distribution was non-normal) was performed to determine the significance of the difference in starting fish condition. This test showed that the starting condition of experimental fish was significantly different from that of control fish ($P<0.001$).

The significant difference in starting condition of the fish, with experimental fish exhibiting greater starting scattered scale loss than control fish, means that the ending condition of experimental and control fish cannot be directly compared. For this reason, experimental and control *groups* were treated as observations, and mean differences in scattered scale loss before and after treatments were compared for each group. The average scattered scale loss for each experimental and control group, and differences before and after treatment, are given in Table 3. These differences were subjected to a Mann-Whitney Rank Sum Difference Test (data distribution is non-normal) to determine if pre-treatment / post-treatment differences for experimental fish were significantly different from those for control fish. The results of that test are also given in Table 3. These results show that scattered scale loss following exposure to the fish screen is not significantly different from control fish handling ($P>0.90$). This is a very powerful result, given the P-value which was produced by the test.

VOLUNTARY PASSAGE TEST (Steelhead smolts)

The first experimental group of 20 steelhead smolts was placed in a special holding net immediately upstream of the crest of the screen weir and allowed to pass voluntarily over the screen. These fish

TABLE 3

EAST FORK IRRIGATION DISTRICT
FISH SCREEN BIOLOGICAL PERFORMANCE TESTS
1999

STEELHEAD SMOLT SCATTERED MEAN PERCENT SCALE LOSS AND DIFFERENCES BEFORE AND AFTER TREATMENT

CONTROL GROUPS				EXPERIMENTAL GROUPS			
Group	**Pre**	**Post**	**Difference**	**Group**	**Pre**	**Post**	**Difference**
1	6.875	6.375	-0.500	1	7.000	7.375	0.375
2	6.500	6.875	0.375	2	6.375	6.719	0.344
3	5.875	8.125	2.250	3	6.750	8.500	1.750
4	6.250	6.250	0.000	4	7.625	7.750	0.125
5	6.125	6.667	0.542	5	7.125	7.738	0.613
6	7.750	7.750	0.000	6	7.525	8.421	0.896
7	6.750	7.875	1.125	7	8.375	8.553	0.178
8	7.625	8.125	0.500	8	8.250	8.625	0.375
9	6.375	7.375	1.000	9	8.375	8.947	0.572
10	7.250	7.375	0.125	10	8.000	8.472	0.472
11	6.458	8.026	1.568	11	7.750	8.000	0.250
				12	7.375	8.000	0.625
Means	6.712	7.348	**0.635**		7.541	8.092	**0.548**

MANN-WHITNEY RANK SUM DIFFERENCE TEST RESULTS

Group	**Median**	**25%**	**75%**
Control	0.4520	0.03125	1.094
Experimental	0.4235	0.2970	0.6190

T = 129.500 **P=0.902**

Conclusion: There is no statistical difference between differences in group means (P=0.902) were observed for over an hour and data were recorded on elapsed time before passage and behavior, including orientation of the fish as they passed down the screen face. These data are summarized in Table 4. The first few fish moved out of the holding net soon after having been placed there, and had exhibited "nervous" or "agitated" behavior prior to passing over the weir. Once the remaining fish had settled down, movement was much less frequent. Although difficult to test, crowding probably played a role in stimulating movement of individual fish over the weir. As the group thinned out, the urge to move appeared to decrease. The voluntary behavior test was terminated after a little more than an hour, since to prolong it would have been impractical.

When fish moved voluntarily, they nearly always moved up into the faster current immediately upstream of the weir crest, held there for a moment, and then let the current move them backward over the crest. Occasionally, fish would move into the current and then out again, appearing uncertain of what they would do. Once "captured" by the current, the general response was to begin to turn and continue head first. However, the passage down the screen face is so fast, most fish did not have an opportunity to complete the rotation into a downstream-facing attitude. These results indicate that "voluntary" movement by steelhead smolts is strongly affected by the recent "history" of the fish, and that once individuals become accustomed to their environment, movement will be in "due time", which can be a long time.

When fish were "encouraged" over the face of the weir, movement was often resisted and fish orientation was generally random. Occasionally, vigorous swimming occurred as fish tried to "fight" the current. Behavior was obviously different from voluntary passage, with some fish thrashing wildly as they passed down the screen face into the catch net.

Data on scattered scale loss for "volunteers" and "encouraged" fish were recorded separately so that they could be analyzed to see if the more "active" behavior associated with being "encouraged" over the weir crest would result in more scale loss. A Mann-Whitney Rank Sum Test (data distribution was non-normal) was applied to the data, and the results indicate that there was no significant difference in scattered scale loss between fish which engaged in "volunteer" passage and those which were "encouraged" over the weir ($P=0.750$).

LATENT MORTALITY TESTS

Steelhead Fry

Both experimental and control fish were held for at least 96 hours in net pens to determine if any latent mortalities attributable to passage over the fish screens would result. No mortalities or behavioral anomalies were observed for any fish in either group during this period.

Spring Chinook Fry

Both experimental and control fish were held for at least 96 hours in net pens to determine if any latent mortalities attributable to passage over the fish screens would result. No mortalities or behavioral anomalies were observed for any fish in either group during this period.

TABLE 4

EAST FORK IRRIGATION DISTRICT
FISH SCREEN BIOLOGICAL PERFORMANCE TESTS
1999

STEELHEAD SMOLT VOLUNTARY PASSAGE TEST

Fish #	Elapsed Time (min.)	Orientation	Notes
1	1	Tail first	Did not fight the current; no rotation
2	2	No obs.	
3	3	No obs.	
4	7	Rotated	Started tail first; rotated to head first half way down
5	13	Rotated	Started tail first, then rotated to head first
6	13	Rotated	Started tail first, then rotated to head first
7	55	Sideways	Rotated to sideways at weir crest, continued
8	60	Tail first	Started to rotate to head first near screen toe
End test	65		

Some human movement occurred from time to time near the release net. At these times, fish generally responded by moving deeper in the net and schooling more "tightly".

Steelhead Smolts

Both experimental and control fish were held for at least 96 hours in net pens to determine if any latent mortalities attributable to passage over the fish screens would result. In addition, the lot of fish from which both experimental and control fish were taken was held for the same 96-hour period. Of the 232 experimental fish, two died within the first 24 hours, and three died thereafter for a total of five fish or 2.16%. The first two mortalities were attributed by Mike Lambert (CTWS biologist performing the pre-test and post-test inspections) as "possibly" due to a "dry skin" condition (lack of the normal mucous coat) noted *prior* to release of these fish over the screens; fish with such condition were rejected for use in subsequent experimental and control groups. If these fish are considered "outliers", the percent latent mortality for the experimental fish would be 1.29%. Of the 219 control fish, two died during the 96-hr holding period yielding a 0.91% mortality rate. Several hundred fish remained in the lot from which both experimental and control fish were taken. Of these, a little over 6% died during the 96-hour post-test holding period, a considerably higher mortality than that for either the experimental or control groups. This higher rate might be attributable to a more crowded holding pen or the presence of some fish in "inferior" condition (rejected for use in tests), or both. In any case, this higher mortality suggests presence of factors other than the tests or control handling which caused mortality in these fish.

A statistical test was performed to determine if the mortality rate observed for experimental fish was higher than that observed for control fish, including the two fish in the experimental group which may have died due to a "dry skin" condition noted prior to release (one-tailed "Z" test):

Experimental mortality rate = 0.0216 (n=232);
Control mortality rate = 0.0091 (n=219).

$Z = 1.174 \quad (Z < 1.645;\ \text{n.s.},\ \alpha = 0.05)$

The mortality rate for the experimental group is not statistically greater than that for the control group at the $\alpha=0.05$ level of significance.

INTERPRETATION

The biological performance tests performed at the East Fork Irrigation District's new sand separation and fish screen facility proceeded with few problems, none of which compromised the test procedures or the results. For the winter steelhead and spring chinook newly emergent fry tests, no effect of any kind of exposure to the screen was detected. All fish appeared to be in the same condition after exposure to the screen and handling/inspection procedures as prior to exposure, and no mortalities or behavioral anomalies were detected either in association with the tests or with the 96-hr post-test holding period.

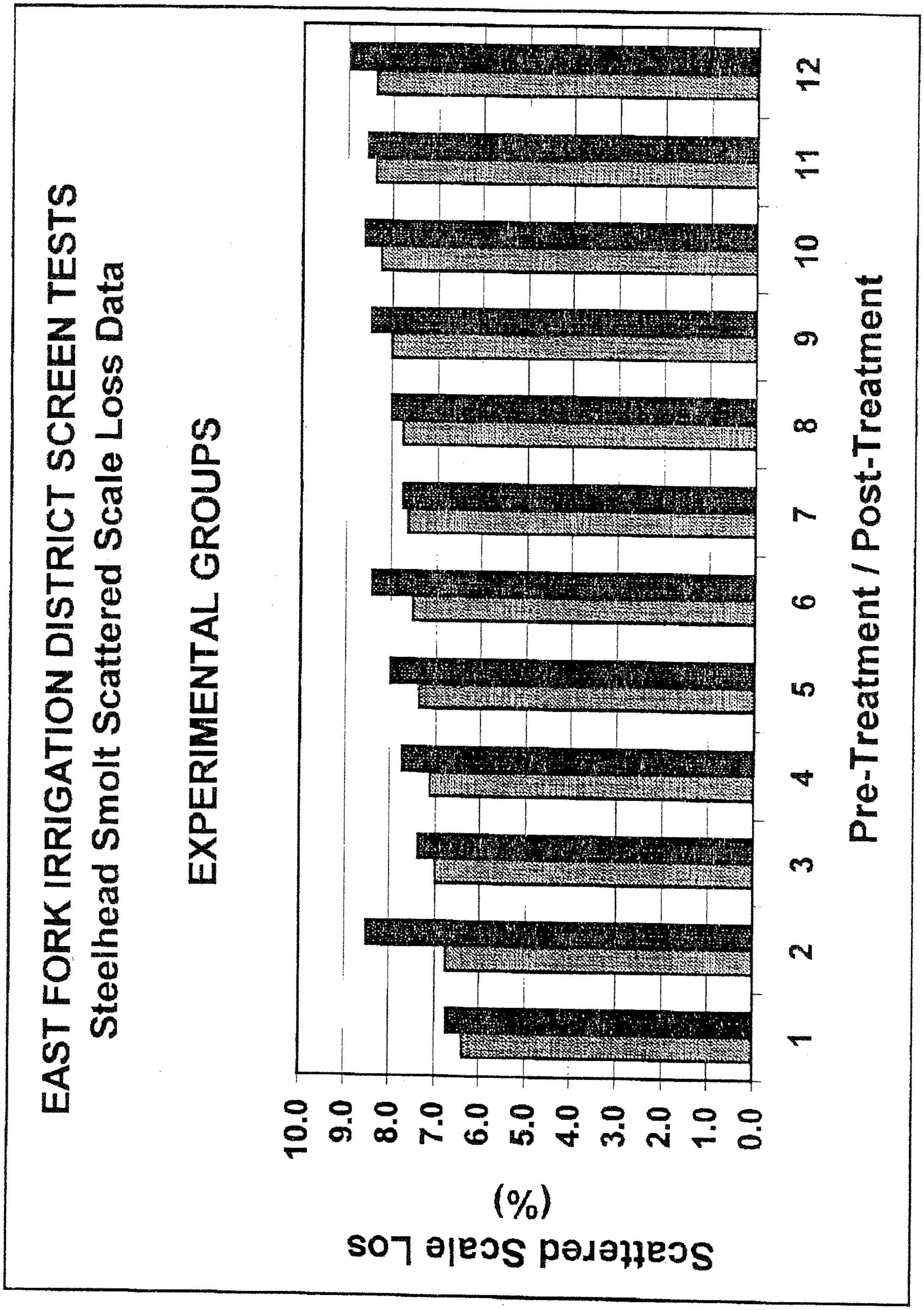
For the winter steelhead smolt tests, a slight increase in scattered scale loss was observed for both experimental and control fish, with the increase being almost identical in the two groups. None of this scale loss approached that which is generally considered debilitating for these fish. No scale loss patterns suggestive of injury-inducing contact with the screen or recovery net were observed. These results very strongly suggest no adverse consequences for steelhead smolt passage over these fish screens. The P-value obtained from the Mann-Whitney Rank Sum test of the differences between experimental and control group means ($P > 0.90$) indicates that there is a probability of over 90% that there is no effect on steelhead smolts due to passage over the weir crest and screen face at the EFID facility. This is a considerably more positive result than is normally required when scientifically rejecting the idea of an effect ($P > 0.05$).

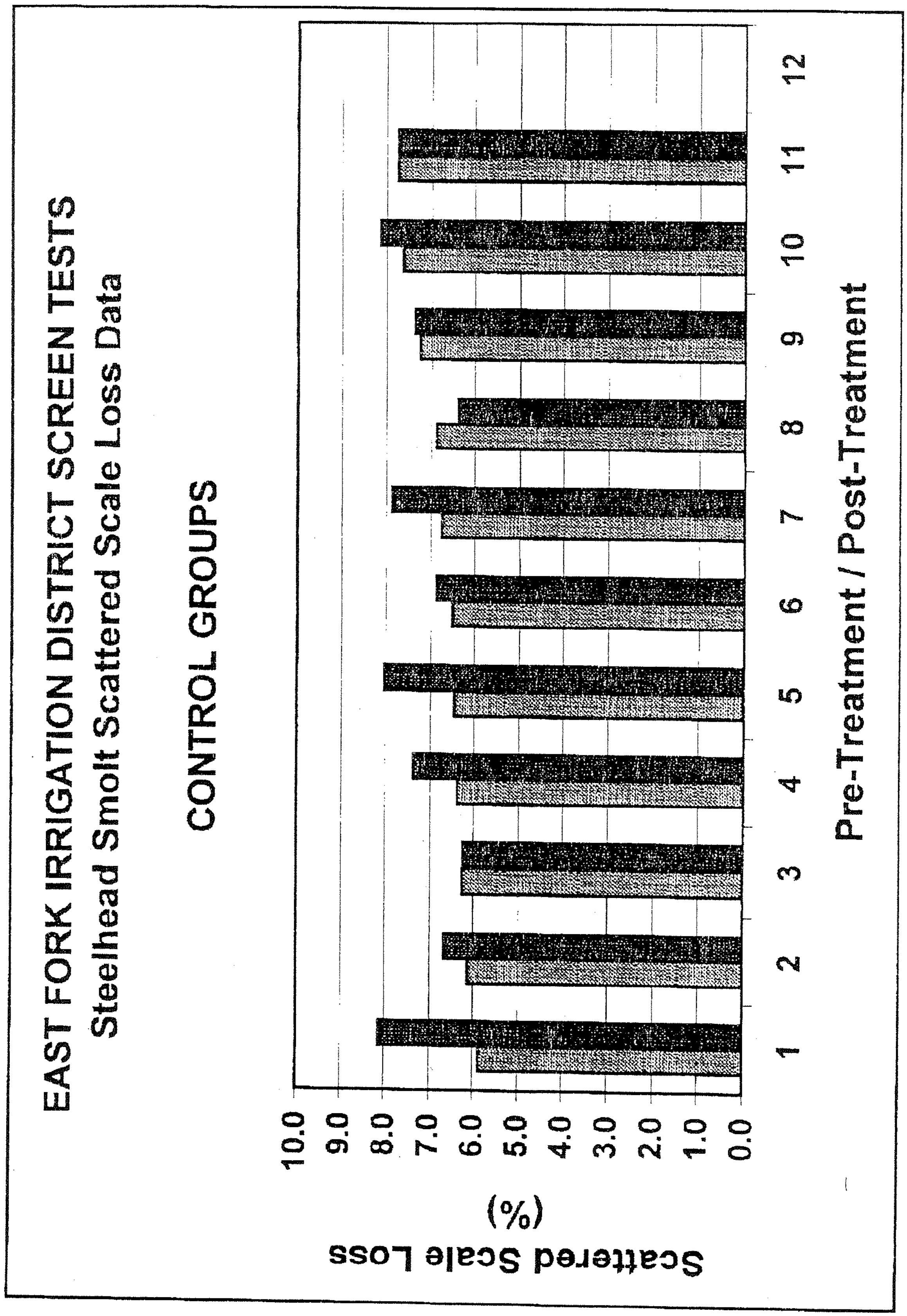
Observations of fish behavior during voluntary passage tests indicate a relatively consistent pattern of starting over the weir crest tail-first followed by a rotation toward a head-first orientation. Very little "fighting" of the current at the crest of the weir or "agitated" behavior was noted for voluntary passage. This was in stark contrast to behavior patterns observed when fish were "encouraged" over the weir crest. In these cases, most fish resisted passage, often swimming vigorously against the current and sometimes thrashing as they passed down the screen face. It was felt by the observers that the potential for detectable scattered scale loss or other injury or stress would be much greater for "encouraged" fish than for "volunteers". In this sense, encouraging fish over the weir crest constitutes a "worst case" test more likely to result in an observable effect of passage over the EFID fish screen than would be expected during normal facility operation. This adds strength to the conclusion of "no effect" which can be drawn from the scattered scale loss data.

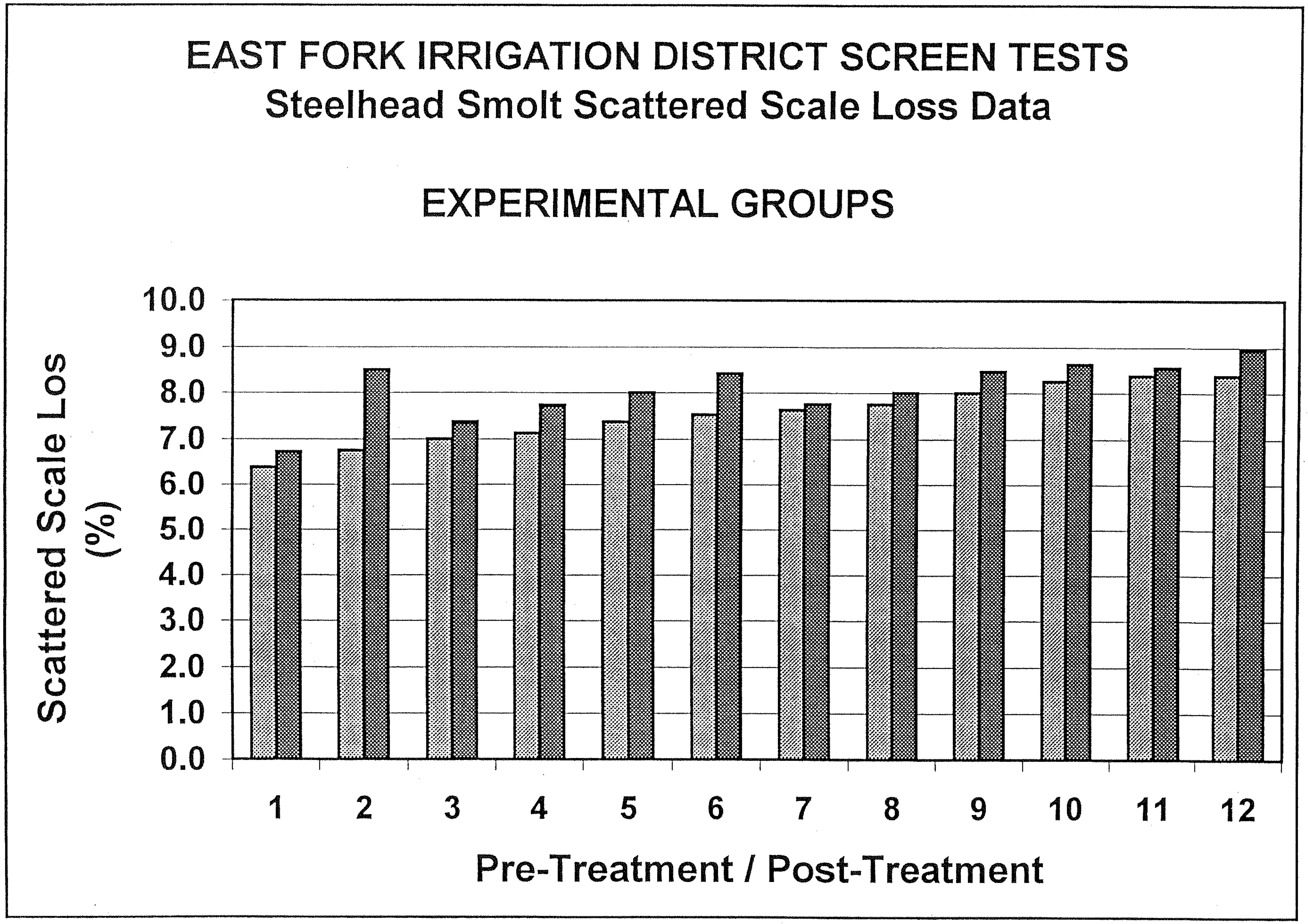
A few mortalities were observed for both experimental and control groups of steelhead smolts during the 96-hr post-test holding period. Mortality rates for both groups are quite low, even though that for the experimental group was about twice that for the control group. Nevertheless, it was determined that the mortality rate for the experimental group was not significantly greater than that for the control group, even when two of the five experimental mortalities included in the analysis could be attributed to their poor condition prior to the test. Finally, it was noted by CTWS biologists (Jennings and Lambert) that the steelhead smolts used for these tests had been held without food for several weeks for acclimation to East Fork Hood River water, netted and sorted prior to the initiation of fish screen tests, and subjected to netting and sorting to select individual fish for use in the tests. Taken in the context of the relatively much higher mortality rate of over 6% for the lot of fish from which both experimental and control fish were taken, differences in holding density notwithstanding, it is not likely that any of the mortalities observed in the experimental or control groups were due to either exposure to the fish screen or to handling/inspection procedures conducted as part of these tests.

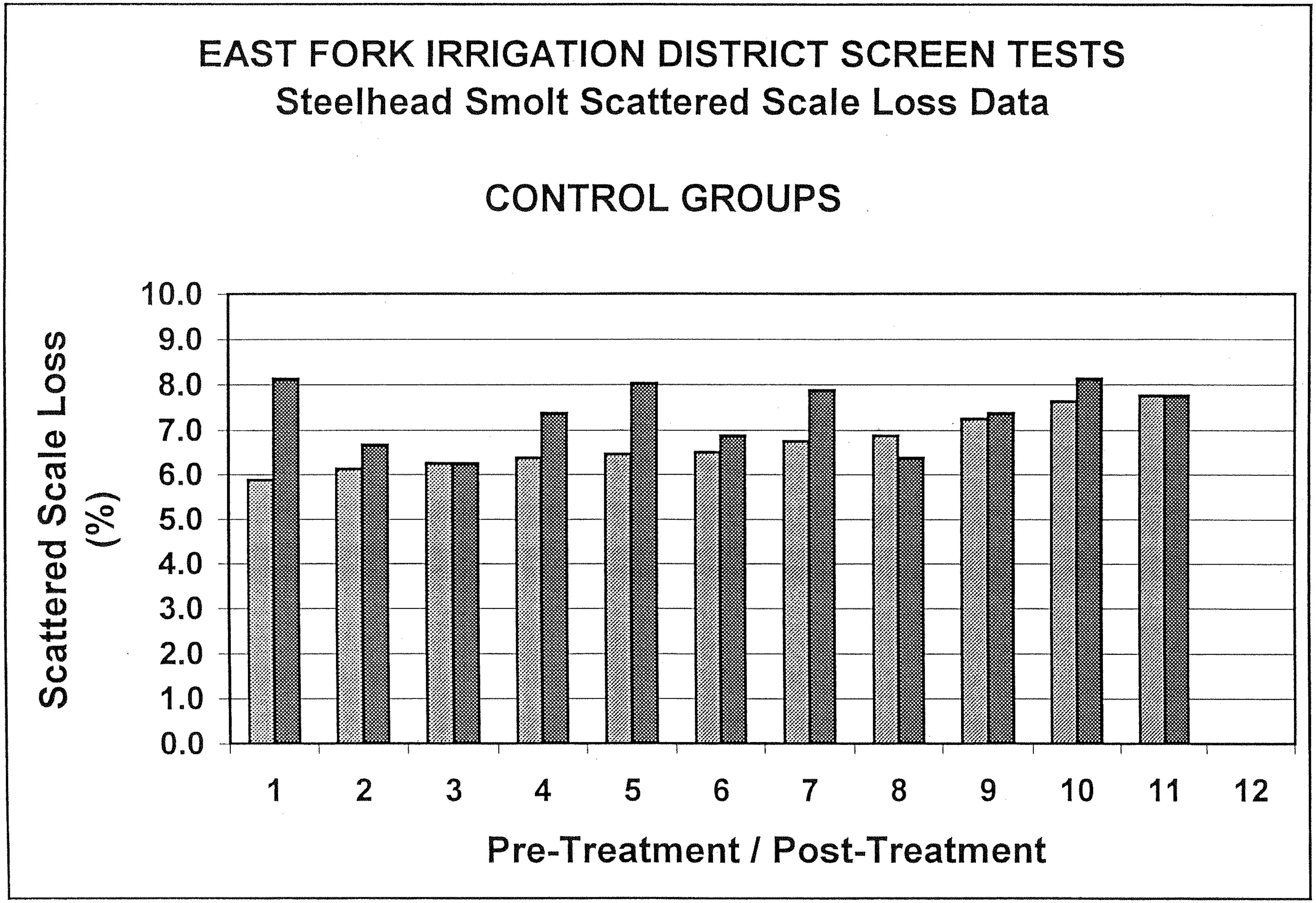
APPENDIX

Statistical Test Results


EAST FORK IRRIGATION DISTRICT SCREEN TESTS
Steelhead Smolt Scattered Scale Loss Data
EXPERIMENTAL GROUPS
Scattered Scale Los
(%)
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
1
2
3
4
5
6
7
8
9
10
11
12
Pre-Treatment / Post-Treatment


EAST FORK IRRIGATION DISTRICT SCREEN TESTS
Steelhead Smolt Scattered Scale Loss Data
CONTROL GROUPS
Scattered Scale Loss (%)
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
1
2
3
4
5
6
7
8
9
10
11
12
Pre-Treatment / Post-Treatment


EAST FORK IRRIGATION DISTRICT SCREEN TESTS
Steelhead Smolt Scattered Scale Loss Data
EXPERIMENTAL GROUPS
Scattered Scale Los (%)
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
1 2 3 4 5 6 7 8 9 10 11 12
Pre-Treatment / Post-Treatment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Steelhead Smolt Scattered Scale Loss Data
CONTROL GROUPS
Scattered Scale Loss
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7.0
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3.0
2.0
1.0
0.0
1
2
3
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5
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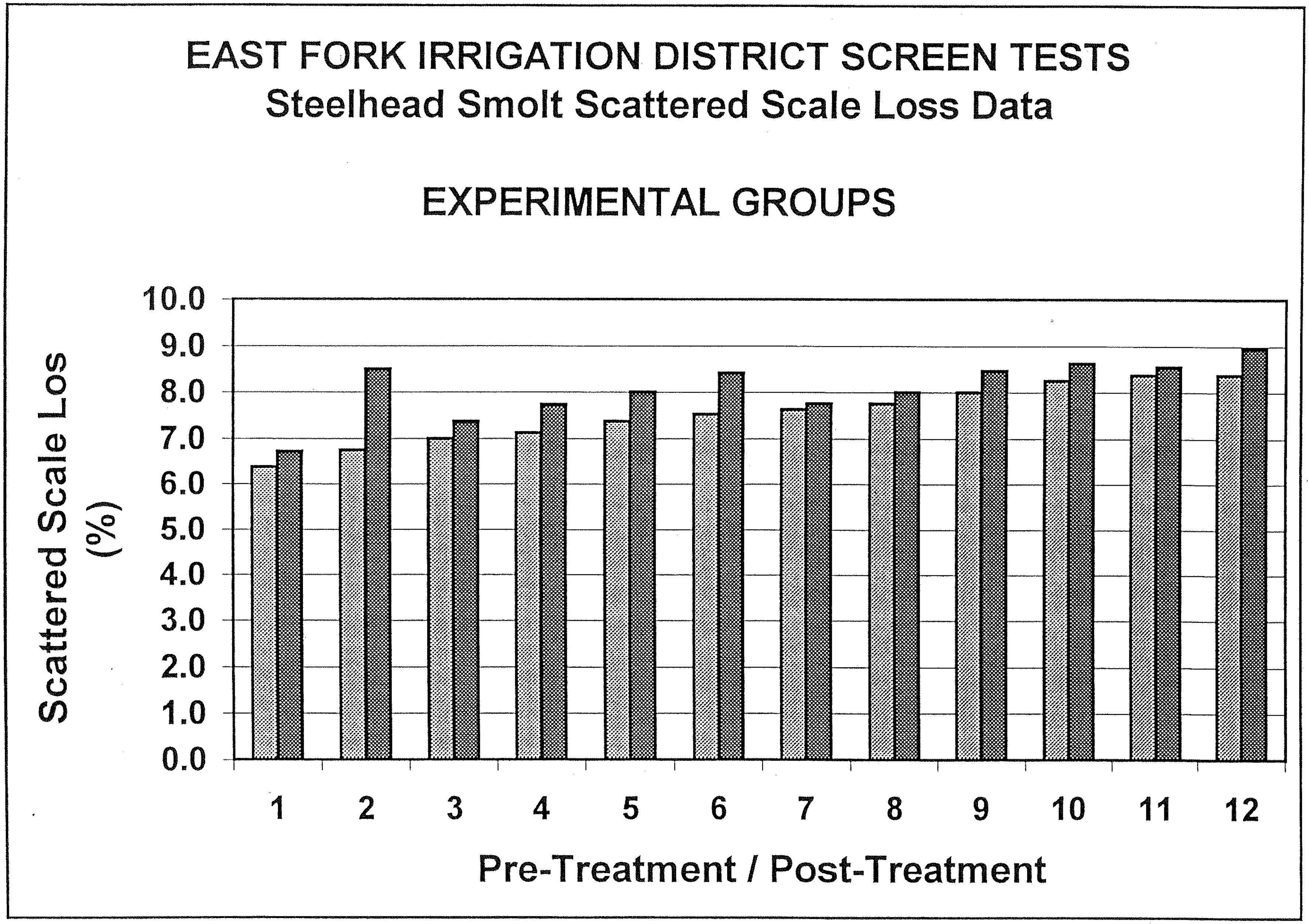
11
12
Pre-Treatment / Post-Treatment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Steelhead Smolt Scattered Scale Loss Data
EXPERIMENTAL GROUPS
Scattered Scale Los (%)
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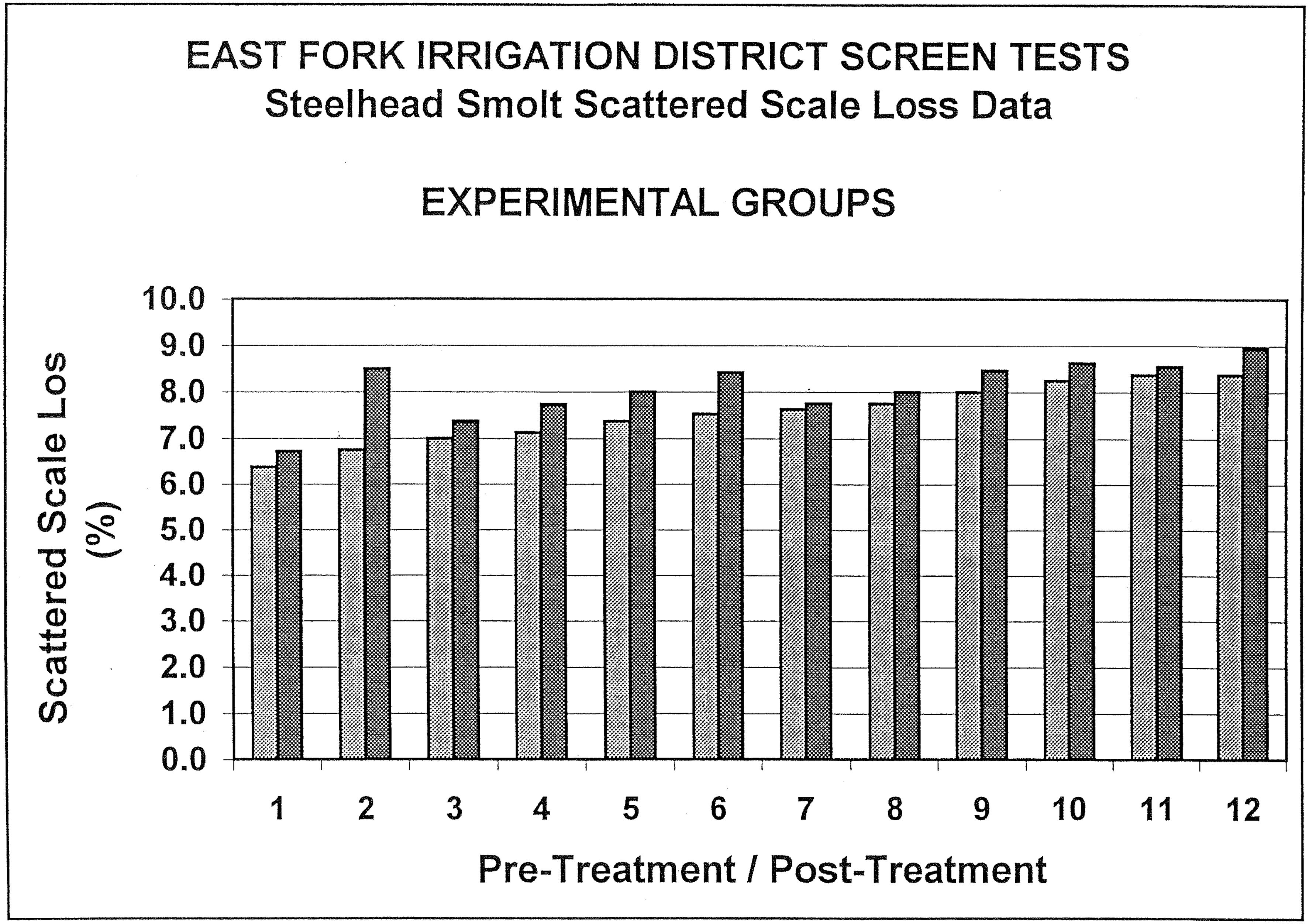
Pre-Treatment / Post-Treatment


EAST FORK IRRIGATION DISTRICT SCREEN TESTS
Steelhead Smolt Scattered Scale Loss Data
EXPERIMENTAL GROUPS
Scattered Scale Los (%)
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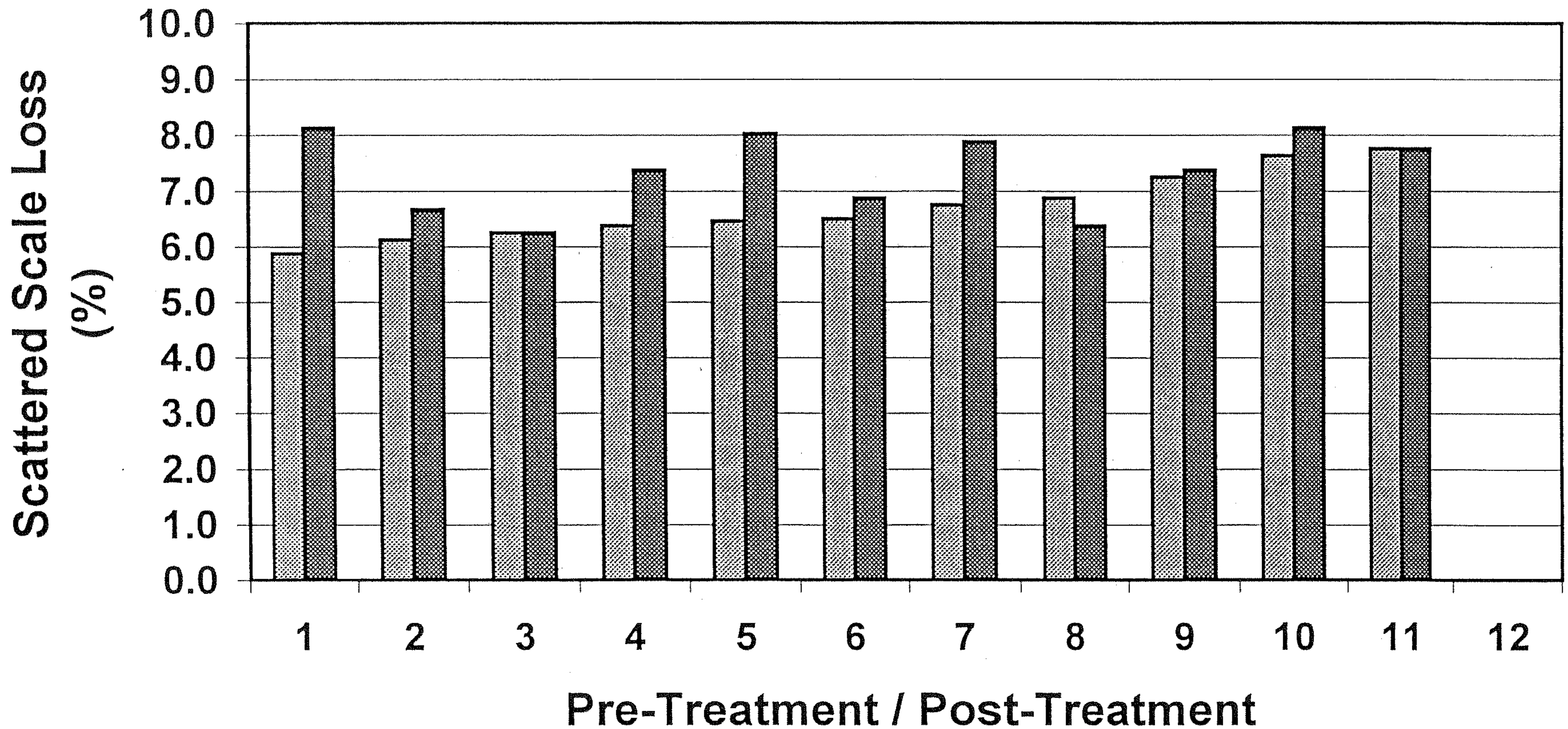
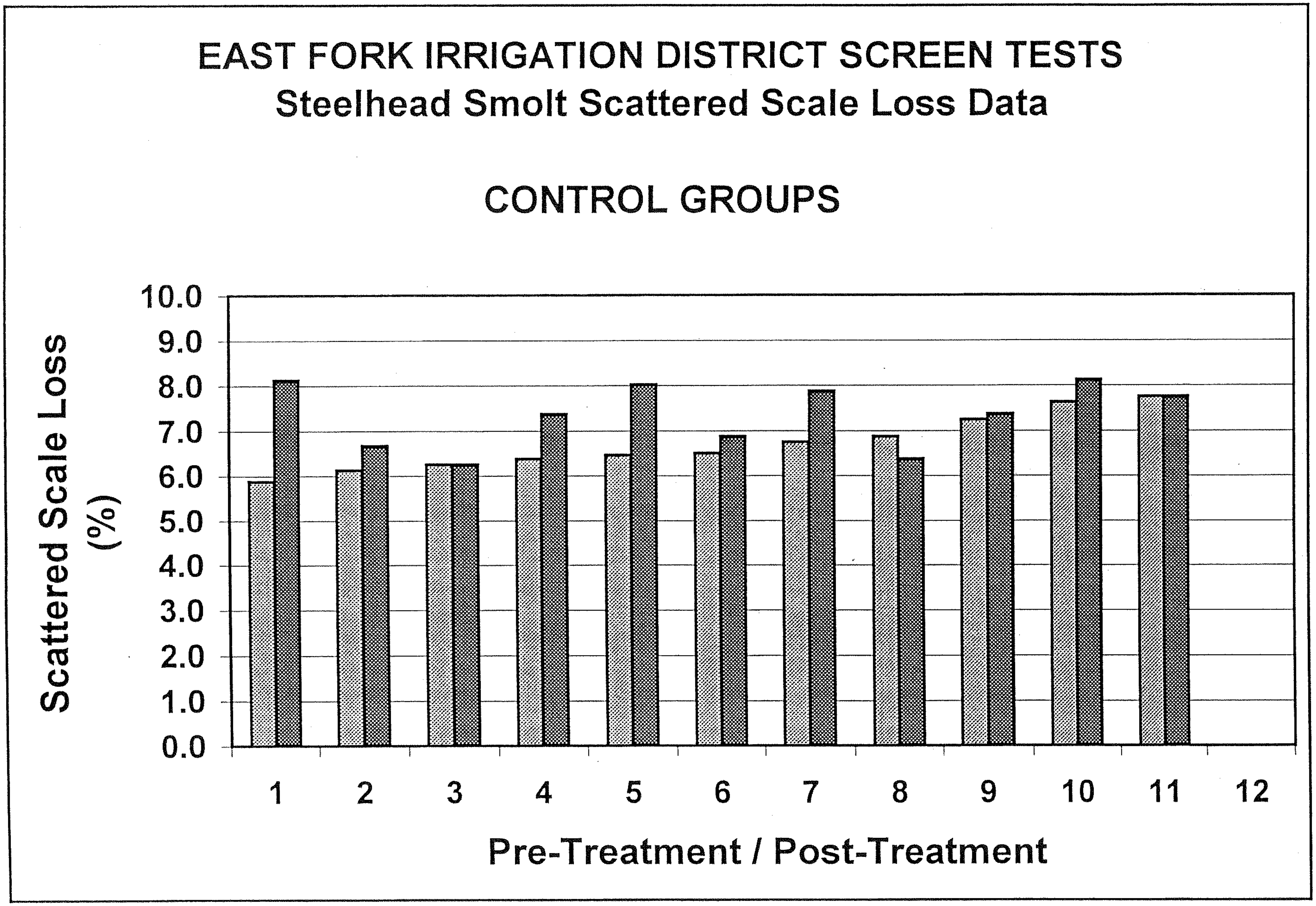
Pre-Treatment / Post-Treatment

EAST FORK IRRIGATION DISTRICT SCREEN TESTS
Steelhead Smolt Scattered Scale Loss Data

CONTROL GROUPS

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Steelhead Smolt Scattered Scale Loss Data
CONTROL GROUPS
Scattered Scale Loss (%)
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Pre-Treatment / Post-Treatment