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A REPORT ON THE TOXIC EFFECTS OF A PULP MILL EFFLUENT ENTERING CAMAS SLOUGH

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ABSTRACT

Flow-through bioassays were conducted on Crown Zellerbach bleach plant effluent, Camas, Washington. The data produced 24-hour and 48-hour TLm values of 9.4% and 6.5%, respectively. Live-box studies were conducted in Camas Slough above and below the bleach plant discharge. Live-box test fish appeared to be adversely affected by the bleach plant effluent, however, nitrogen supersaturation levels reaching 146% tended to mask the effects produced by the effluent.

INTRODUCTION

Data compiled by the Washington Department of Fisheries (WDF) during stream survey programs and hatchery return enumerations have shown that similar fall chinook salmon releases in Columbia River tributaries have resulted in significantly lower adult returns to the Washougal River than to the other streams in the system. To determine whether or not a real difference in survival rate could be demonstrated, marked chinook of the 1966 brood were released above and below Camas Slough by the Washington Department of Fisheries (WDF) and Bureau of Commercial Fisheries (BCF) in 1967. The results of this study indicated that the groups of marked fish passing through Camas Slough experienced approximately 50% higher losses than those released in the Columbia River (Table 1). These data suggest that the groups of fish that passed through Camas Slough and the Washougal estuary experienced significantly higher losses than those that bypassed the slough in the Columbia River. The present study was conducted during June, 1969, using 1968 brood fall chinook to determine if similar results to the 1967 study could be obtained by repeating the experiment.

MATERIALS AND METHODS

The 1969 program was a joint effort conducted by the WWPCC, WDF and the BCF. WDF performed the rearing, fish marking and releasing, BCF did the beach-sein recovery work in the Columbia River and the enumerations, while WWPCC conducted bioassays on Crown Zellerbach Blue Creek sewer effluent, did the live box studies in Camas Slough, and financed the WDF fish marking effort.

Table 1. Mark and recovery data for hatchery-produced fall chinook salmon (1966 brood) released at four selected sites near Camas, Washington, during 1967.

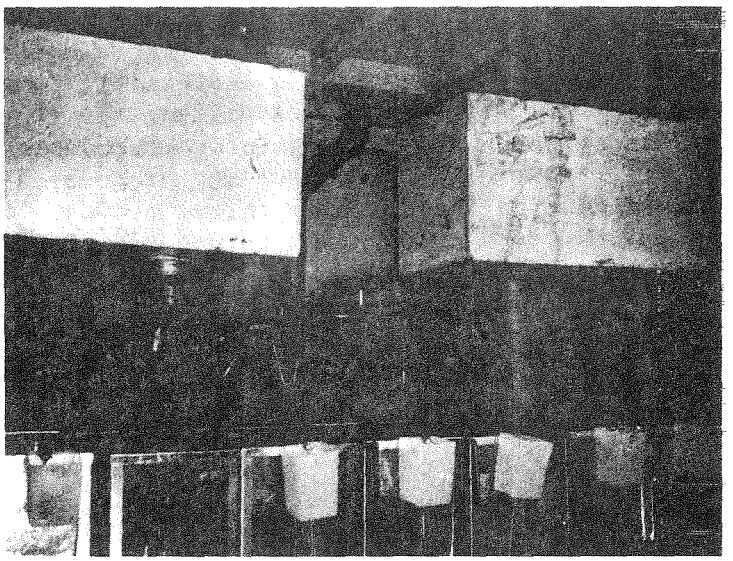
Group	Number	Release Point	No. Recaptured
1	77,924	Washougal hatchery	103
2	78,694	Washougal hatchery (trucked 2 hrs.)	103
3	76,538	Camas Slough(2 miles from Columbia River)	145
4	77,693	Columbia River 1 1/2 miles from confluence with Camas Slough	236

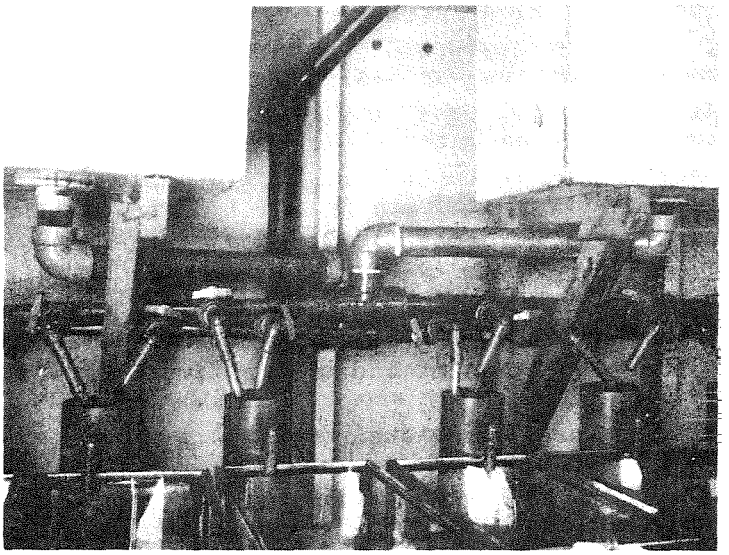
Mark and Recovery Study. Individual groups of 100,000 thermally marked fish were released at four sites in the Columbia River, one site in the Washougal River, and one site at the mouth of Camas Slough (Appendix I). One control group of marked fish was held at the Washougal River Salmon Hatchery. Each group of fish was marked differently to correspond to its release site. Random beach and purse seining procedures used to recover marked fish were conducted in the Woody Island vicinity of the Columbia River.

Bioassays. Flow-through bioassays were conducted on the Crown Zellerbach Blue Creek sewer effluent using juvenile fall chinook salmon from the Washougal River Salmon Hatchery as the test organism. Approximately five hundred fish were acclimated at least four days in the Washougal River estuary prior to their use in the experiment. An additional three hundred fish were held in a 50 gal. aquaria and acclimated for a period of four days to Washougal River estuary water.

The bioassay apparatus was designed to provide a controlled flow of the mill effluent-dilution water concentration to eight test vessels (10-gallon glass aquaria) each containing ten juvenile fall chinook salmon. Dilution water drawn from Camas Slough above the mill discharge, and effluent pumped from the Blue Creek sewer were introduced into separate wooden constant-head boxes. The water and mill effluent flowed from the head boxes by gravity through individual nontoxic pvc pipe systems to pvc ball valves which were adjusted manually to control the flow rates. From the ball valves, each system provided a flow into a baffled mixing chamber which supplied two test vessels providing a duplicate test for each effluent concentration (Figure 1). Desired test concentrations were obtained by

Figure 1. The flow-through bioassay apparatus used to evaluate the acute toxicity of Blue Creek sewer effluent to juvenile fall chinook salmon.





adjusting the diluent-to-effluent flow ratio at the ball valves. Overflow water was removed from the test and control aquaria using a constant-head siphon system.

Preliminary screening tests were conducted to determine the toxic range of the test substance toward juvenile chinook salmon. From these screening tests three effluent concentrations (3.2%, 5.6% and 10%) and a control were selected to permit determination of a 48-hour and 96-hour TL_{50}. All experiments were conducted in duplicate.

At the start of each experiment, the flow rates of effluent and dilution water were adjusted to provide the desired effluent-diluent concentration. Ten acclimated fish were then placed in each test vessel. During the course of each experiment, flow rates were checked periodically; adjustments were made as necessary. Mortalities were enumerated at 24-hour intervals during the 48-hour and 96-hour tests.

Live Box Studies. Three separate live box studies were conducted to evaluate the effects of Camas Slough water on downstream migrating fall chinook. One study was designed to show how fish were affected by passively drifting through Camas Slough with the current. The live boxes used to retain the test fish were tubular fiberglass units which measured 18 inches long and 12 inches in diameter. Both ends were enclosed with 3/16-inch mesh nylon bobbinet held in position with rubber straps. At the beginning of each drift experiment, ten previously acclimated chinook salmon were placed in each live box. Two live boxes were attached to each wooden float at depths of one and five feet and allowed to drift freely in the current. After completion of the drift, surviving fish were held in Camas Slough upstream from the mill effluent for 96 hours; mortalities were enumerated each day.

Three drifts were conducted, one in mid-channel (Drift No. 1) and two through the mill-effluent affected area against the north shore of Camas Slough (Drift Nos. 2 and 3). A control drift was conducted in the Columbia River along the south side of Lady Island simultaneously with each drift through the slough.

Two separate stationary live-box experiments were conducted; the first study employed a single live-box, placed near the water surface, at each station. For the second stationary live-box experiment, fiber glass tubes were assembled in pairs; the superior and inferior boxes were positioned at one and five foot depths, respectively, from the water surface. With each live box containing 10 chinook juveniles, 11 of these units were placed at selected sites along the north and south shore of the slough (Figure 2). Similarly arranged control boxes were placed in the Washougal River estuary and in the Columbia River off the western tip of Lady Island. The 24 and 48-hour tests were conducted using the stationary live boxes; mortalities were recorded at 24-hour intervals.

Water samples were collected at various stations in Camas Slough previous to and during the study (Figure 3). From these samples determinations for nitrogen and oxygen saturation, PBI, conductivity, pH, turbidity, and total coliform were made. Background data were obtained while the Crown Zellerbach mill was not in operation during a labor dispute on 4/15/69 (Table 2). After mill operations returned, frequent sampling sorties were again conducted for comparison (Table 3,4,5, and 6).

RESULTS

The 24-hour and 48-hour bioassay data gave TL_{50}'s of 9.4% and 6.5%, respectively, in Test 1, and 6.6% and 6.8%, respectively, in Test II (Tables 7 & 8).

Figure 2. A schematic drawing showing the location of stationary live boxes placed in Camas Slough.

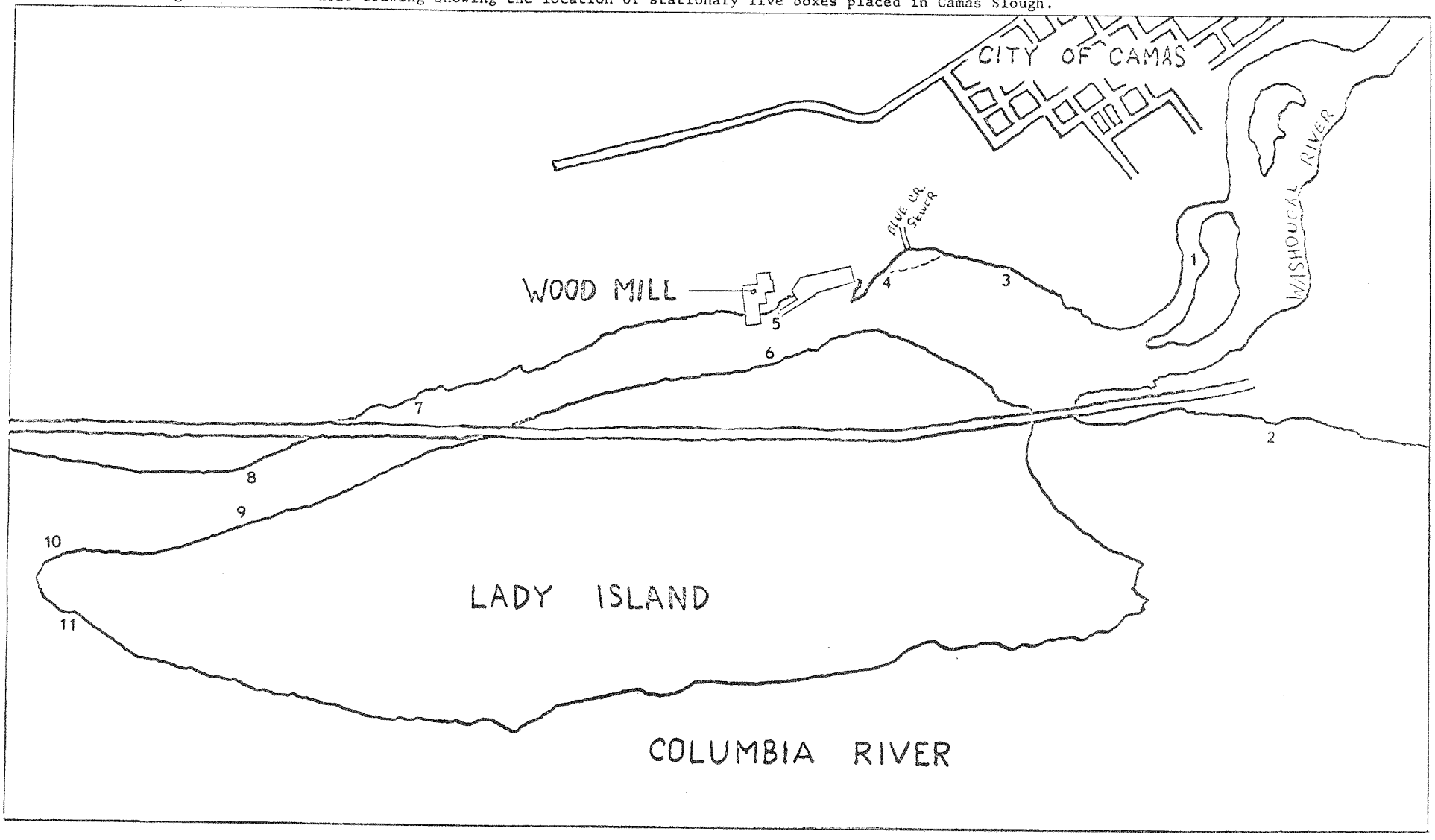


Figure 3. A schematic drawing showing the location of ten water quality sampling stations in Camas Slough.

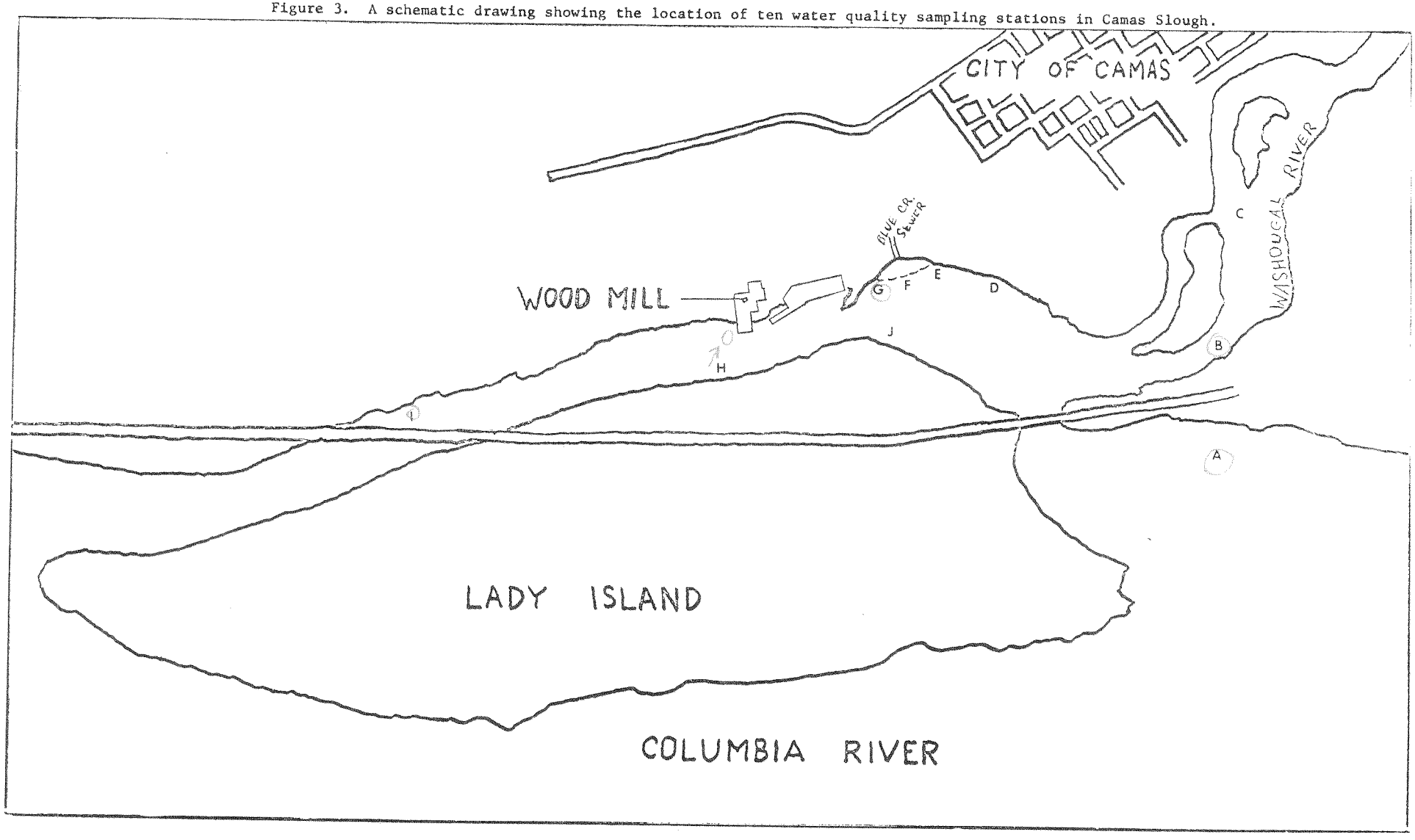


Table 2. Water quality data collected on 4/15/69 while the Crown Zellerbach mill was not in operation.

Station (Figure 3)	Depth (in ft.)	Conductivity (μmhos/cm^2)	Turbidity (JTU)	PBI	pH	Total Coliform 1/
A	1	181	25	12	7.5	146
B	1	24	4	6	6.9	58
B	10	24	8	2	6.8	----
C	1	26	3	1	6.9	46
C	10	22	6	2	6.7	----
D	1	160	15	3	7.5	1500
D	10	165	20	2	7.6	----
E	1	163	20	3	7.7	1400
E	10	162	20	4	7.8	----
F	1	172	25	3	7.7	900
G	1	170	25	3	7.7	1000
G	10	169	20	2	7.8	----
H	1	178	25	2	7.9	900
H	20	179	25	1	7.7	----
I	1	177	25	3	7.6	170
I	40	175	25	4	7.7	----
J	1	181	25	3	7.8	1000
J	15	180	20	4	7.8	----

1/ As sheen colonies per 100 ml

Tables 3, 4, 5, and 6. Water quality data for the Camas Slough study during mill operation. Samples were collected one foot below the surface at each station.

Table 3. Date: 4/17/69

Station	Conductivity (μmhos/cm^2)	Turbidity (JTU)	PBI	pH	Total Coliform 1/
A	104	30	5	7.8	3800
B	38	10	2	7.4	570
C	36	10	2	7.2	320
D	110	30	3	7.8	2400
E	108	30	3	7.6	4000
F	---	--	--	---	5000
G	153	30	77	6.8	2800
H	128	30	31	7.3	3400
I	114	30	9	7.7	5000
J	110	30	3	7.8	2200

1/ As sheen colonies per 100 ml

Table 4. Date: 6/5/69

Station	Conductivity (μmhos/cm^2)	Turbidity (JTU)	PBI	pH	N_2 (ppm)	N_2 (%)
A	106	15	4	8.0	23.3	145.3
B	26	3	4	7.3		
C	28	3	16	7.2	17.4	111.7
D	107	20	3	8.0	23.6	146.9
E	110	20	5	8.0		
F	115	20	10	8.1		
G	150	20	191	7.6		
H	110	20	16	7.9		
I	112	20	9	7.9		
J	113	20	5	8.0		

Table 5. Date: 6/19/69

Station	Conductivity (μmhos/cm2)	Turbidity (JTU)	PBI	pH	N_2 (ppm)	N_2 (%)
A	104	20	3	7.8	21.9	140.9
B	37	15	4	7.2		
C	36	15	4	6.9	15.8	109.6
D	108	15	4	7.6	21.8	140.6
E	109	15	4	7.5		
F	109	20	5	7.6		
G	213	35	100	6.5		
H	123	20	40	7.1		

Table 6. Date: 6/23/69

Station	Conductivity (μmhos/cm^2)	Turbidity (JTU)	PBI	pH
A	112	30	5	7.9
B	36	6	4	7.3
C	40	6	5	7.2
D	111	20	4	7.8
F	112	30	3	7.9
G	185	20	150	7.3
H	143	20	75	7.4
I	127	20	30	7.6

Table 7. (Test I) Acute toxicity bioassay results for fall chinook salmon exposed to Blue Creek sewer effluent for 48 hours during the period 6/18/69 to 6/20/69, WWPCC, 1969.

Test Vessel No.	% Concentration of effluent during test period			% Survival in hours	
	Low	High	Mean	24	48
1, 2 (Control)	0	0	0	100	100
3, 4	2.6	3.8	3.1	100	100
5, 6	2.8	5.8	4.8	100	85
7, 8	9.5	10.6	10.0	45	0

Table 8. (Test II) Acute toxicity bioassay results for fall chinook salmon exposed to Blue Creek sewer effluent for 96 hours during the period 6/21/69 to 6/25/69, WWPCC, 1969.

Test Vessel No.	% Concentration of effluent during test period			% Survival in hours			
	Low	High	Mean	24	48	72	96
1, 2 (Control)	0	0	0	100	100	100	100
3, 4	2.4	4.0	3.3	100	100	100	85
5, 6	4.8	6.5	5.6	80	55	55	40
7, 8	3.4	10.6	8.6	0	0	0	0

A 96-hour TL_{50} of 5.0% was obtained in Test II, where the test fish in high effluent concentration tanks (3.4% - 10%) died within 18 hours.

All of the test fish in live boxes which were drifted mid-channel through Camas Slough survived, whereas those which were drifted near the north bank of the slough suffered mortality rates ranging from 10 to 50 percent (Table 9). Control fish in Drifts 1 and 2 all survived, but a 30% mortality was experienced in Drift 3.

Test fish survival rates at stations below the Blue Creek effluent discharge were lower than upstream stations during the first stationary live-box study (Table 10). Ten percent of the fish held in the Washougal River (Station 1, control) died during the test period compared to a 50% mortality of fish held in the Columbia River (Station 2). Heavy mortalities ranging from 40% to 100% occurred at stations below the mill effluent. The five-day tests using the dual live-boxes placed at depths of one and five feet indicate that significantly greater test fish mortalities were experienced in the surface live-boxes than in the subsurface boxes at all stations except Station 1, where 100% survival occurred at the surface (Table 11). Fish placed in the influence of the mill effluent downstream from the discharge did not experience significantly greater rates of mortality than did those placed upstream from the effluent.

Table 9. Survival data for fall chinook salmon retained in live boxes and allowed to drift through Camas Slough and a selected control area of the Columbia River. 1/

Drift No.	Location	Date	Depth in Feet	% Survival in Hours 24	48	96
1	Control	6/17/69	1	100	100	100
	Camas Slough		1	100	100	100
2	Control		1	100	100	100
	Camas Slough	6/18/69	1	90	70	60
	Camas Slough		4	No Data 2/		
3	Control		1	70	70	70
	Camas Slough	6/19/69	1	50	50	50
	Camas Slough		4	100	100	90

1/ The control drift was conducted in a section of the Columbia River extending from the eastern tip of Lady Island to the confluence of the Columbia River Camas Slough.

2/ The test fish escaped from the live box during the drift.

Table 10. Survival data for fall chinook salmon retained in live boxes and placed at a depth of one foot in selected areas above and below the influence of the Blue Creek sewer effluent discharge into Camas Slough

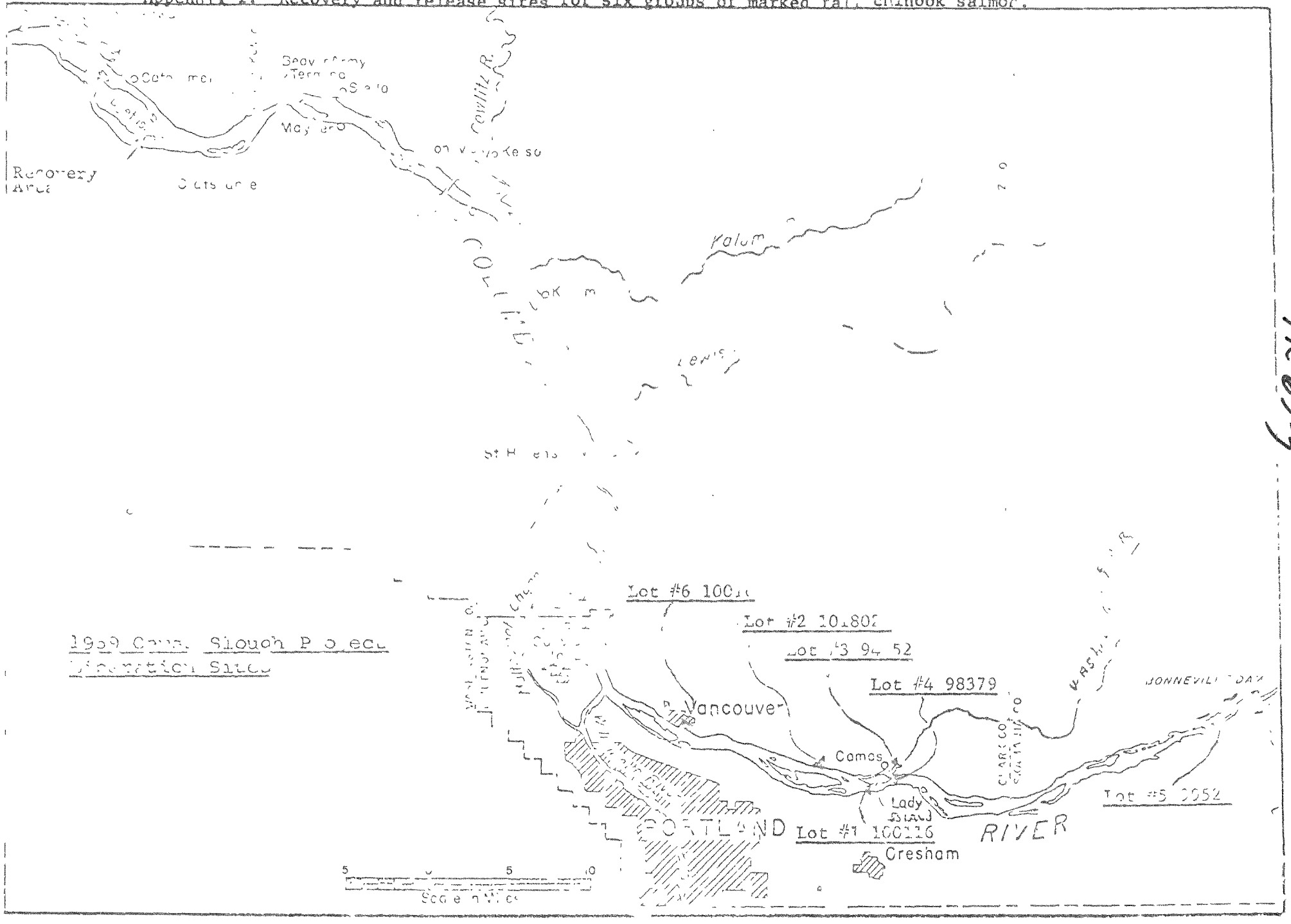
Date of Placement	Station No.	% Survival in Hours	
		24	48
	1	90	90
	2	60	50
6/17/69	4	0	0
	5	50	0
	7	30	10
	8	60	20
	2	70	60
6/18/69	4	30	0
	6	30	30

Table 11. Survival data for fall chinook salmon retained in live boxes in selected areas above and below the influence of the Blue Creek sewer effluent discharge into Camas Slough.

Station No.	Date of Placement	Depth in Feet	% Survival in Days				
			1	2	3	4	5
1	6/20/69	1	100	100	100	100	100
2	"	1	90	80	70	60	50
2	"	5	100	100	100	90	90
3	"	1	100	90	80	80	60
3	"	5	100	100	100	100	100
5	"	1	100	100	90	90	80
5	"	5	100	100	100	100	100
6	"	1	100	80	60	50	30
6	"	5	100	100	100	90	90
8	"	1	90	90	80	80	80
8	"	5	100	100	100	100	100
9	"	1	80	70	70	60	50
9	"	5	100	100	100	100	100
10	6/21/69	1	100	80	70	70	---
10	"	5	100	100	100	100	---
11	6/22/69	1	90	90	90	---	---
11	"	5	90	90	90	---	---

APPENDIX

Appendix I. Recovery and release sites for six groups of marked fall chinook salmon.



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