76-21

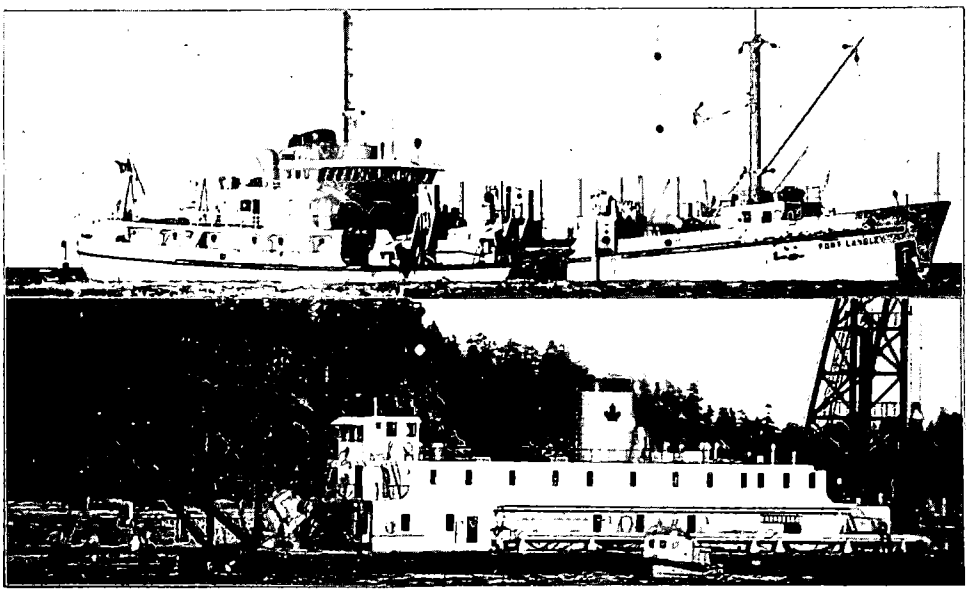
Environment Canada | Environnement Canada
Fisheries and Marine Service | Service des pêches et des sciences de la mer
GREAT LAKES BIOLIMNOLOGY LABORATORY
CANADA CENTRE FOR INLAND WATERS
867 LAKESHORE ROAD
P.O. BOX 5050
BURLINGTON, ONTARIO L7R 4A6

DREDGE MONITORING CAPTURE DATA AND ENTRAINMENT ESTIMATES DURING THE 1976 JUVENILE SALMONID MIGRATION IN THE LOWER FRASER RIVER.

By
B.D. Tutty
J.A. Morrison

Technical Report Series No. PAC/T-76-21

HABITAT PROTECTION DIRECTORATE
PACIFIC REGION



Cover Illustration,

Upper. DPW #312 (Fort Langley) mobile hopper dredge in operation on the Fraser River between Steveston and Sand Heads.

Cover Illustration,

Lower. DPW #322 stationary pipeline dredge in operation on the Fraser River at Point Grey.

TABLE OF CONTENTS

	Page
LIST of FIGURES	ii
LIST of TABLES	iii
ABSTRACT	1
1. INTRODUCTION	2
2. DPW #312 (FORT LANGLEY) HOPPER DREDGE.	3
2.1 Dredge Outfall Monitoring Data.	4
2.1.1 Explanation of Entrainment Calculations.	7
2.1.2 Explanation of Superscripts to Monitoring Data Within Table 1.	24
2.2 Hopper Dredge Pump Discharge Monitoring Data.	31
2.3 DPW #312 (Fort Langley) Hopper Dredge Monitoring, Discussion and Recommendations.	34
3. DPW #322 STATIONARY PIPELINE DREDGE.	38
3.1 100% Outflow Monitoring Data, Richmond Landfill and Byrne Road Sites.	39
3.2 Stationary Pipeline Diversion Monitoring Data, DPW #322, Point Grey Site.	42
3.2.1 Explanation of Superscripts for Tables 6 and 7.	46
3.3 DPW #322 Stationary Pipeline Dredge Monitoring, Discussion and Recommendations.	47
ACKNOWLEDGEMENTS	48
BIBLIOGRAPHY	49
APPENDIX	
DPW #312 Hopper Dredge Schematic Drawings	51
DPW #312, Potential for Increased Data Acquisition	56

LIST OF FIGURES

Figure		Page
1.	Dredge outfall monitoring, DPW #312.	5
2.	Shaded portion indicates DPW #312 dredging areas for March 15 to June 4, 1976.	6
3.	Salmonid hourly entrainment rates by date, DPW #312.	28
4.	Sand lance and eulachon hourly entrainment rates by date, DPW #312.	29
5.	Pump discharge monitoring, DPW #312.	31
6.	100% spoil site outflow monitoring, DPW #322 pipeline dredge.	39
7.	Shaded portion indicates DPW #322 dredging areas for March 15 to May 21, 1976.	40
8.	DPW #322 partial pipeline diversion monitoring with pipeline discharge onto intertidal beach zone.	43
9.	Pipeline discharge onto beach zone.	43
]0.	Partial pipeline diversion monitoring facility. Note the unmanageable flow and heavy debris obscuring any specimens.	44

LIST OF TABLES

Table		Page
1.	Dip net captures and calculated entrainment by date, DPW #312.	9
2.	Calculated total entrainment of each species for the DPW #312, March 15 to June 4, 1976.	26
3.	Indexing estimates for total entrainment of juvenile salmonids, DPW #312.	30
4.	Sand lance captures near Sand Heads, (selected dates only).	30
5.	Pump discharge monitor captures and calculated entrainment by date, DPW #312.	32
6.	DPW #322 calculated entrainments from March 15 to April 16, 1976.	41
7.	Diversion monitoring catch data, DPW #322, April 19 to May 21, 1976, Point Grey site.	

ABSTRACT

Suction dredging operations to maintain navigable channel depths in the lower Fraser River were undertaken by the Department of Public Works from March 15 to June 4, 1976 during the annual downstream juvenile salmonid migration. These operations were monitored for salmonid entrainment in accordance with Department of Fisheries and Environment guidelines. Capture data for the hopper dredge DPW #312 and pipeline dredge DPW #322 is presented. Indexing techniques to assess total hopper dredge salmonid entrainment are reviewed. Partial discharge outfall monitoring with dipnets is the most successful method to date for continued assessments of juvenile salmonid entrainment by hopper dredges. Pipeline dredge monitoring with 100% screening of the spoil outfall provided adequate juvenile salmonid entrainment assessments, however, partial pipeline diversion flow monitoring was an ineffective technique.

1. INTRODUCTION

Monitoring of suction dredges was initiated in 1971 by the Department of Fisheries and the Environment, Fisheries and Marine Service, to assess the impact of dredging activities in the Lower Fraser River on the juvenile salmonid downstream migration. Continuing investigations have resulted in awareness of the potential damage unregulated dredging may have on the fisheries resource. Available data to 1975 and quantification of total entrainment for a pipeline dredge was summarized by Dutta and Sookachoff (1975 A and 1975 B).

The "Fraser River Dredging Guide" (Boyd, 1975), was developed to reduce the impacts of dredging on the fisheries resource. In accordance with that guide, under section 3(d) of General Dredging Restrictions, only essential dredging is permitted during March 15 - June 1 of each year. Dredging operations necessary to maintain a navigable channel in the Fraser River, conducted by the Department of Public Works mobile hopper dredge DPW #312 (Fort Langley) and the stationary pipeline dredge DPW #322 were permitted subject to monitoring during the 1976 restricted dredging period. It was agreed that a monitoring capture rate in excess of 10 salmonids per hour would require cessation of dredging operations for the remainder of that day.

Section 2. DPW #312 (FORT LANGLEY) HOPPER DREDGE.

2.1 Hopper Dredge Outfall Monitoring Data

A standard procedure of monitoring the DPW #312 mobile hopper dredge is described by Tutty (1976). The recommended method incorporates two technicians sampling with two dip nets each in the port and starboard outfall discharges, (Fig. 1). The number of dip nets in daily use changed due to variable dredge operation, lack of lighting at the starboard outfall for night monitoring, loss of dip nets due to operational damage, use of the inboard pump discharge monitoring method and personnel absences. In addition, there were some areas, notably channel 33 and 34 of the North Arm (Fig. 2), where one man could only control one dip net due to the high volume of entrapped filtrate. The hopper discharge monitoring data for the period March 15 to June 4, 1976 is presented in Table 1 and summarized in Table 2. Superscripts in Table 1 refer to explanatory notes detailed on page 24.

Strict comparison of daily fish sampling data proved impractical considering the variations within the sampling format. However, the relationship between dip net captures and total entrainment established by Tutty (1976) permitted extrapolation of the daily catch data to total estimated entrainments and hourly entrainment rates.

Figure 1. Dredge outfall monitoring DPW #312.

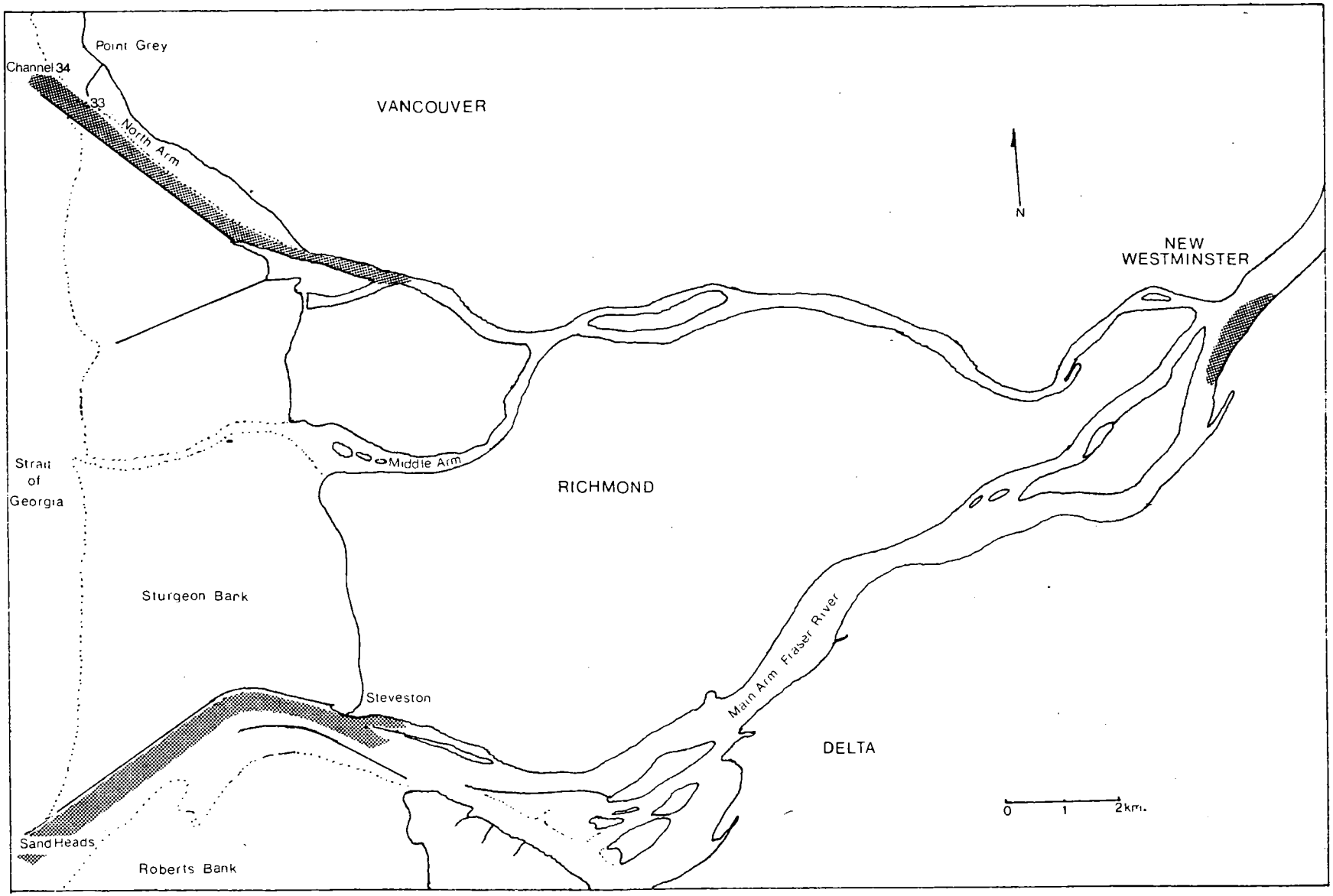


Figure 2. Shaded Portion Indicates DPW #312 Dredging Areas for March 15 to June 4, 1976.

2.1.1 Explanation of Entrainment Calculations

Tutty (1976) established that one juvenile salmonid captured with 1 dip net during a standard monitoring procedure represented 84 juvenile salmonids entrained by the dredge. Extension of the indexing assessment and relative coefficients are reproduced in Table 3.

As an example, catch data for March 16, 1976 indicates 419 sand lance *Ammodytes hexapterus*, 3 starry flounder *Platichthys stellatus*, and 3 staghorn sculpin *Leptocottus armatus* were captured in two outfall monitoring dip nets during 151 minutes of sampling. With reference to Table 3, a capture of 419 sand lance with two dip nets represents (419 x 42) = 17,598 total estimated sand lance entrainment. Starry flounder and staghorn sculpin entrainments are similarly calculated, (3 x 42) = 126 individuals entrained for each species. This yields a standardized hourly entrainment rate for sand lance of (17,598 x 60/151) = 6993 fish per hour. Starry flounder and staghorn sculpin rates were calculated (126 x 60/151) = 50 fish per hour for each species. Estimated entrainments indicate total numbers of organisms entrained by the dredge, whereas an hourly entrainment rate permits day to day comparisons independant of variations due to differences in total daily sampling time and number of sampling nets used.

These entrainment calculations are based on values established for juvenile salmonids. Differences in species' behaviour may alter these projections. Sand lance exhibit a burrowing response when stressed and total capture estimates may therefore be conservative due to the inability to assess the population that burrow and are subsequently buried in the dredge hopper load.

Entrainment estimates and hourly entrainment rates are included in Tables 1 and 2. The hourly entrainment rate for juvenile salmonids is displayed in Figure 3, and Figure 4 for sand lance and eulachon.

TABLE 1. DIP NET CAPTURES and CALCULATED ENTRAINMENT by DATE, DPW #312.

Main Arm, Steveston to Sand Heads

DATE	SAMPLING TIME, SPECIES	1 DIP NET	2 DIP NETS	3 DIP NETS	4 DIP NETS	TOTAL TIME	TOTAL DIP NET CAPTURE	CALCULATED ENTRAINMENT	HOURLY ENTRAINMENT RATE
March 15[a,b]	time/min.					0			
March 16[c]	time		151			151			
	Sand lance		419				419	17598	6993
	Starry flounder		3				3	126	50
	Staghorn sculpin		3				3	126	50
March 17	time		256			256			
	Sand lance		31				31	1302	305
	Starry flounder		17				17	714	167
	Sand sole		1				1	42	10
	Speckled sanddab		1				1	42	10
	Crescent gunnel		1				1	42	10
	Staghorn sculpin		3				3	126	30
March 18	time	67	255			322			
	Sand lance	7	31				38	1890	352
	Starry flounder	4	14				18	924	172
	Staghorn sculpin	0	7				7	294	55
	3 spine stickle-back	0	1				1	42	8
March 19[a]	time		199			199			
	Sand lance		545				545	22890	6902
	Starry flounder		3				3	126	38
	Sand sole		1				1	42	13
	Staghorn sculpin		3				3	126	38

TABLE 1. DIP NET CAPTURES and CALCULATED ENTRAINMENT by DATE, DPW #312.
(cont'd.)

DATE	SAMPLING TIME, SPECIES	1 DIP NET	2 DIP NETS	3 DIP NETS	4 DIP NETS	TOTAL TIME	TOTAL DIP NET CAPTURE	CALCULATED ENTRAINMENT	HOURLY ENTRAINMENT RATE
Main Arm, Steveston to Sand Heads									
March 22[a]	time/min.	92	95			187			
	Sand lance	69	0				69	5796	1860
	Starry flounder	0	4				4	168	54
	Unid. sole[d]	1	0				1	84	27
March 23[a]	time	143				143			
	Sand lance	5					5	420	176
	Starry flounder	3					3	252	106
	Staghorn sculpin	2					2	168	70
March 24	time		228	45		333			
	Sand lance		47	6			53	3142	566
	Starry flounder		7	4			11	406	75
	Unid. sole[d]		1	0			1	42	8
	Staghorn sculpin		6	2			8	308	55
March 25	time	115	185	31		331			
	Sand lance	6	26	3			35	1680	305
	Starry flounder	3	9	1			13	658	119
	Speckled sanddab	0	1	0			1	42	8
	Sand sole	0	1	0			1	42	8
	Butter sole	0	1	0			1	42	8
	Staghorn sculpin	1	6	0			7	336	61

TABLE 1. DIP NET CAPTURES and CALCULATED ENTRAINMENT by DATE, DPW #312.
(cont'd.)

DATE	SAMPLING TIME SPECIES	1 DIP NET	2 DIP NETS	3 DIP NETS	4 DIP NETS	TOTAL TIME	TOTAL DIP NET CAPTURE	CALCULATED ENTRAINMENT	HOURLY ENTRAINMENT RATE	
March 26[a]	time /min.		145			145				Main Arm
	Sand lance		39				39	1638	678	
	Starry flounder		16				16	672	278	
	Sand sole		1				1	42	17	
	Unid. sole		2				2	84	35	
	Staghorn sculpin		19				19	798	330	
	Crescent gunnel		1				1	42	17	
	Sturgeon poacher		1				1	42	17	
March 29[ae]	time		288	47		335				North Arm, Point Grey
	Sand lance		52	58			110	3808	682	
	Starry flounder		0	10			10	280	50	
	Staghorn sculpin		0	4			4	112	20	
	Crescent gunnel		0	1			1	28	5	
	Unid. larval fish		0	1			1	28	5	
March 30[a]	time					0				
March 31[a]	time					0				
April 1[a]	time					0				
April 2[a]	time					0				
April 5[a]	time					0				
April 6[a]	time					0				
April 7[a]	time					0				

TABLE 1. DIP NET CAPTURES and CALCULATED ENTRAINMENT by DATE, DPW #312.
(cont'd.)

DATE	SAMPLING TIME, SPECIES	1 DIP NET	2 DIP NETS	3 DIP NETS	4 DIP NETS	TOTAL TIME	TOTAL DIP NET CAPTURE	CALCULATED ENTRAINMENT	HOURLY ENTRAINMENT RATE
North Arm, Point Grey									
April 8[a]	time/min.					0			
April 9[a]	time					0			
April 12	time		426	42		468			
	Sand lance		85	3			88	3654	468
	Starry flounder		3	10			13	406	52
	English sole		1	0			1	42	5
	Staghorn sculpin		0	8			8	224	29
April 13[a]	time		210			210			
	Sand lance		5				5	210	60
	Starry flounder		1				1	42	12
	Staghorn sculpin		1				1	42	12
	3 spine stickle-back		1				1	42	12
April 14[a]	time	56	278			334			
	Sand lance	3	36				39	1764	317
April 15[a]	time	94	39			133			
	Chum salmon	0	1				1	42	19
	Sand lance	5	0				5	420	189
	Starry flounder	0	2				2	84	38

TABLE 1. DIP NET CAPTURES and CALCULATED ENTRAINMENT by DATE, (cont'd.) DPW #312.

DATE	SAMPLING TIME, SPECIES	1 DIP NET	2 DIP NETS	3 DIP NETS	4 DIP NETS	TOTAL TIME	TOTAL DIP NET CAPTURE	CALCULATED ENTRAINMENT	HOURLY ENTRAINMENT RATE
Main Arm, Steveston to Sand Heads									
April 16[a]	time/min.					0			
April 19[a]	time					0			
April 20	time		267	40		307			
	Pink salmon		3	1			4	154	30
	Coho salmon[d]		6	0			6	252	49
	Sand lance		47	406			453	13342	2608
	Staghorn sculpin		4	0			4	168	33
	Eulachon		2	1			3	112	22
	Pacific tomcod		4	0			4	168	33
	3 spine stickle-back		3	5			8	266	52
April 21	time		253	90		343			
	Chum salmon		1	0			1	42	7
	Pink salmon		6	1			7	280	49
	Sand lance		614	6			620	25956	4540
	Starry flounder		3	0			3	126	22
	Staghorn sculpin		1	0			1	42	7
	Longfin gunnel		1	0			1	42	7
	Eulachon		4	5			9	308	54
	Pacific tomcod		2	6			8	252	44
	3 spine stickle-back		3	0			3	126	22

TABLE 1. DIP NET CAPTURES and CALCULATED ENTRAINMENT by DATE, (cont'd.) DPW #312.

Main Arm, Steveston to Sand Heads

DATE	SAMPLING TIME, SPECIES	1 DIP NET	2 DIP NETS	3 DIP NETS	4 DIP NETS	TOTAL TIME	TOTAL DIP NET CAPTURE	CALCULATED ENTRAINMENT	HOURLY ENTRAINMENT RATE
April 22[f]	time/min.				175	175			
	Pink salmon				6		6	126	43
	Sand lance				868		868	18228	6250
	Staghorn sculpin				1		1	21	7
	Juvenile gunnel				6		6	126	43
April 23	time		25		281	306			
	Chum salmon		0		3		3	63	12
	Pink salmon		0		13		13	273	54
	Sand lance		103		483		586	14469	2837
	Starry flounder		0		6		6	126	25
	English sole		0		1		1	21	4
	Unid. sole[d]		0		2		2	42	8
	Staghorn sculpin		0		4		4	84	16
	Crescent gunnel		0		2		2	42	8
	Pacific snake prickle back		1		1		2	63	12
	Eulachon		0		34		34	735	144
	Pacific tomcod		0		2		2	42	8
	Spiny dogfish		0		5		5	105	21
	Unid. larval fish[d]		0		1		1	21	4

TABLE 1. DIP NET CAPTURES and CALCULATED ENTRAINMENT by DATE, (cont'd.) DPW #312.

North Arm, Point Grey

DATE	SAMPLING TIME, SPECIES	1 DIP NET	2 DIP NETS	3 DIP NETS	4 DIP NETS	TOTAL TIME	TOTAL DIP NET CAPTURE	CALCULATED ENTRAINMENT	HOURLY ENTRAINMENT RATE
April 26[a]	time/min.		76		344	420			
	Pink salmon		0		2		2	42	12
	Sand lance		3		290		293	6216	1776
	Starry flounder		0		3		3	63	9
	Sand sole		0		1		1	21	3
	English sole		0		1		1	21	3
	Staghorn sculpin		0		2		2	42	6
	Crescent gunnel		0		1		1	21	3
	Pacific snake prickle-back		0		5		5	105	15
	Juvenile gunnel		0		1		1	21	3
	Shiner seaperch		0		2		2	42	6
	Pacific tomcod		0		1		1	21	3
	3 spine stickle-back		0		2		2	42	6
April 27	time		157		294	451			
	Pink salmon		0		3		3	63	8
	Sand lance		7		61		68	1575	210
	Starry flounder		1		6		7	168	22
	Staghorn sculpin		0		1		1	21	3
	Unid. sculpin[d]		0		1		1	21	3
	Crescent gunnel		0		1		1	21	3
	Juvenile gunnel		0		1		1	21	3
	Sturgeon poacher		0		2		2	42	6

TABLE 1. DIP NET CAPTURES and CALCULATED ENTRAINMENT by DATE, (cont'd.) DPW #312.

North Arm, Point Grey

DATE	SAMPLING TIME, SPECIES	1 DIP NET	2 DIP NETS	3 DIP NETS	4 DIP NETS	TOTAL TIME	TOTAL DIP NET CAPTURE	CALCULATED ENTRAINMENT	HOURLY ENTRAINMENT RATE
April 28	time/min.		58		390	448			
	Sand lance		0		334		334	7014	939
	Starry flounder		0		4		4	84	11
	English sole		0		1		1	21	3
	Pacific snake prickleback		0		1		1	21	3
April 29	time		74		480	482			
	Chum salmon		0		2		2	42	5
	Sand lance		1		104		105	2226	277
	English sole		0		1		1	21	3
	Juvenile sculpin		0		1		1	21	3
	Pacific snake prickleback		0		1		1	21	3
	Juvenile gunnel		0		1		1	21	3
	Unid. smelt[d]		0		1		1	21	3
	3 spine stickle-back		0		1		1	21	3
April 30	time		289		165	454			
	Pink salmon		0		1		1	21	3
	Sand lance		54		103		157	4431	586
	Staghorn sculpin		0		1		1	21	3

TABLE 1. DIP NET CAPTURES and CALCULATED ENTRAINMENT by DATE, DPW #312.
(cont'd.)

North Arm, Point Grey

DATE	SAMPLING TIME, SPECIES	1 DIP NET	2 DIP NETS	3 DIP NETS	4 DIP NETS	TOTAL TIME	TOTAL DIP NET CAPTURE	CALCULATED ENTRAINMENT	HOURLY ENTRAINMENT RATE
May 3	time/min.		230		126	356			
	Chum salmon		0		2		2	42	7
	Pink salmon		1		1		2	63	11
	Sand lance		1		92		93	1974	333
	Starry flounder		3		0		3	126	21
	Pacific snake prickleback		0		1		1	21	4
	Eulachon		1		0		1	42	7
	3 spine stickle-back		2		1		3	105	18
	Unid. larval fish		3		0		3	126	21
May 4	time		39		327	366			
	Sand lance		27		31		58	1785	293
	Staghorn sculpin		0		1		1	21	3
	Pacific snake prickleback		0		1		1	21	3
	Juvenile gunnel		0		1		1	21	3
	Eulachon		0		1		1	21	3
	Unid. larval fish		0		1		1	21	3
May 5[a]	time				296	296			
	Sand lance				14		14	294	60
	Eulachon				3		3	63	13

TABLE 1. DIP NET CAPTURES and CALCULATED ENTRAINMENT by DATE, DPW #312. (cont'd.)

Main Arm, Steveston to Sand Heads

DATE	SAMPLING TIME. SPECIES	1 DIP NET	2 DIP NETS	3 DIP NETS	4 DIP NETS	TOTAL TIME	TOTAL DIP NET CAPTURE	CALCULATED ENTRAINMENT	HOURLY ENTRAINMENT RATE
May 6	time/min.		34		216	250			
	Pink salmon		1		11		12	273	66
	Sockeye salmon		0		1		1	21	5
	Sand lance		0		1		1	21	5
	Starry flounder		0		4		4	84	20
	Eulachon[g]		4		20		24	488	141
May 7	time				286	286			
	Chum salmon				1		1	21	4
	Pink salmon				5		5	105	22
	Starry flounder				4		4	84	18
	Smoothhead sculpin				1		1	21	4
	Eulachon				34		34	714	150
	Unid. smelt[d]				1		1	21	4
	Shiner seaperch				1		1	21	4
	Pacific tomcod				3		3	63	13
	Pacific lamprey				1		1	21	4
	Unid. juv. fish				1		1	21	4
May 10[a]	time		86			86			
	Sand lance		33				33	1386	967
	Juv. gunnel		1				1	42	29
	Spiny dogfish		3				3	126	88

TABLE 1. DIP NET CAPTURES and CALCULATED ENTRAINMENT by DATE, DPW #312.
(cont'd.)

Main Arm, Steveston to Sand Heads

DATE	SAMPLING TIME SPECIES	1 DIP NET	2 DIP NETS	3 DIP NETS	4 DIP NETS	TOTAL TIME	TOTAL DIP NET CAPTURE	CALCULATED ENTRAINMENT	HOURLY ENTRAINMENT RATE
May 11	time/min.		124		116	240			
	Chum salmon		0		1		1	21	5
	Sockeye salmon		0		2		2	42	11
	Sand lance		0		1		1	21	5
	Starry flounder		3		0		3	126	32
	Eulachon		18		0		18	756	189
	Spiny dogfish		0		1		1	21	5
May 12	time		166		168	334			
	Pink salmon		2		6		8	210	38
	Sand lance		2		0		2	84	15
	Starry flounder		2		1		3	105	19
	Crescent gunnel		2		1		3	105	19
	Eulachon		3		4		7	210	38
	3 spine stickle-back		1		0		1	42	8
May 13	time		39		209	248			
	Sockeye salmon		0		1		1	21	5
	Sand lance		0		1		1	21	5
	Starry flounder		0		9		0	189	46
	Eulachon		0		10		10	210	51
May 14	time		39		199	238			
	Pink salmon		0		1		1	21	5
	Starry flounder		1		3		4	105	26
	Eulachon		0		5		5	105	26
	Unid. juv. fish		1		0		1	42	11

TABLE 1. DIP NET CAPTURES and CALCULATED ENTRAINMENT by DATE, DPW #312.
(cont'd.)

DATE	SAMPLING TIME, SPECIES	1 DIP NET	2 DIP NETS	3 DIP NETS	4 DIP NETS	TOTAL TIME	TOTAL DIP NET CAPTURE	CALCULATED ENTRAINMENT	HOURLY ENTRAINMENT RATE
Main Arm, Steveston to Sand Heads									
May 17[a]	time/min.				227	227			
	Sockeye salmon				1		1	21	6
	Starry flounder				14		14	294	78
	Staghorn sculpin				2		2	42	11
May 18	time				348	348			
	Sockeye salmon				6		6	126	22
	Sand lance				4		4	84	14
	Starry flounder				19		19	399	69
	Staghorn sculpin				2		2	42	7
	Pacific snake prickleback				8		8	168	29
	Spiny dogfish				1		1	21	4
May 19[a]	time				29	29			
	Starry flounder				2		2	42	87
	Pacific tomcod				1		1	21	43
New Westminster									
May 19[a]	time				55	55			
	Chum salmon				1		1	21	23
	Sockeye salmon				1		1	21	23

TABLE 1. DIP NET CAPTURES and CALCULATED ENTRAINMENT by DATE, DPW #312.
(cont'd.)

Main Arm, New Westminster									
DATE	SAMPLING TIME SPECIES	1 DIP NET	2 DIP NETS	3 DIP NETS	4 DIP NETS	TOTAL TIME	TOTAL DIP NET CAPTURE	CALCULATED ENTRAINMENT	HOURLY ENTRAINMENT RATE
May 20	time/min.		20		228	248			
	Pink salmon		0		1		1	21	5
	Sockeye salmon		0		2		2	42	10
	Chinook salmon		0		1		1	21	5
May 21	time		145		176	321			
	Pink salmon		0		2		2	42	8
	Sockeye salmon		0		1		1	21	4
	Pacific lamprey		0		1		1	21	4
May 24[a]	time					0			
May 25[h]	time		139		106	235			
	Chum salmon		0		1		1	21	5
	Pink salmon		1		0		1	42	10
	Sockeye salmon		2		9		11	273	67
	3 spine stickle-back		0		1		1	21	5
	Sturgeon		2		0		2	84	21
	Pacific lamprey		22		0		22	924	226
May 26	time		272		98	370			
	Sockeye salmon		4		0		4	168	27
	Sturgeon		2		0		2	84	14
	Pacific lamprey		40		0		40	1680	272

TABLE 1. DIP NET CAPTURES and CALCULATED ENTRAINMENT by DATE, DPW #312. (cont'd.)

Main Arm, New Westminster									
DATE	SAMPLING TIME, SPECIES	1 DIP NET	2 DIP NETS	3 DIP NETS	4 DIP NETS	TOTAL TIME	TOTAL DIP NET CAPTURE	CALCULATED ENTRAINMENT	HOURLY ENTRAINMENT RATE
May 27[h]	time/min.		402			402			
	Sockeye salmon		13				13	546	81
	Sucker		1				1	42	6
	Pacific lamprey		179				179	7518	1122
May 28	time		335		110	445			
	Chum salmon		0		1		1	21	2
	Sockeye salmon		3		2		5	168	23
	Sturgeon		2		2		4	126	17
	Pacific lamprey		67		11		78	3045	411
May 31[a]	time		20			20	0	0	0
June 1	time	199				199			
	Sockeye salmon	1					1	84	25
	Chinook salmon	1					1	84	25
June 2	time		110		334	444			
	Pink salmon		1		0		1	42	6
	Pacific lamprey		2		12		14	336	45
June 3	time		486			486			
	Chum salmon		1				1	42	5
	Pink salmon		2				2	84	10
	Sockeye salmon		1				1	42	5
	Pacific lamprey		2				2	84	10

TABLE 1. DIP NET CAPTURES and CALCULATED ENTRAINMENT by DATE, (cont'd.) DPW #312.

Main Arm, New Westminster									
DATE	SAMPLING TIME. SPECIES	1 DIP NET	2 DIP NETS	3 DIP NETS	4 DIP NETS	TOTAL TIME	TOTAL DIP NET CAPTURE	CALCULATED ENTRAINMENT	HOURLY ENTRAINMENT RATE
June 4	time/min.		302	234		536			
	Pacific lamprey		0	8			8	224	25

2.1.2 Explanation of Superscripts to Monitoring Data Within Table 1.

a.

A reduction in normal dredging operations occurred due to dockside repairs to vessel equipment, lack of ship personnel, transfer of the vessel to a new location, or statutory holidays.

b.

Shrimp were captured from the beginning of the monitoring program, the majority being entrained between Sand Heads and Steveston. Records for dip net captures of shrimp are intermittent, but personnel have indicated that extremely large numbers (100's of thousands) of shrimp were caught in March and April. Shrimp greater than one inch in length were gravid.

c.

The majority of the sand lance captured were entrained near buoy 0 at Sand Heads at the entrance to the Main Arm of the Fraser River (Table 4). Upon examination, approximately 25% of these specimens displayed obvious damage as a direct result of dredging including reversed operculii, missing operculii, decapitation, lacerations and abrasions.

d.

In some cases, specie identification of organisms could not be completed on board the dredge.

e. The North Arm receives approximately 5% of the flow of the mainstem of the Fraser River (Goldie, 1967) and is presumed to transport a similar proportion of the migrating juvenile salmonid population. Operation of the Fort Langley dredge in the North Arm of the Fraser River reduces the potential impact dredging operations have on the downstream juvenile salmonid migration.

f. The monitor indexing test was conducted on April 22, 1976, and described by Tutty, (1976).

g. Hopper outfall sampling indicated that more than 50% of the eulachons entrained after May 6, 1976 had suffered post spawning mortality.

h. Increased sockeye smolt entrainment occurred near the end of the monitoring period (June) and appeared to be correlated to the dredge's close proximity to the river bank.

Table 2. Calculated Total Entrainment of Each Species for the DPW #312, March 15 to June 4, 1976.

Pink salmon	*Oncorhynchus gorbuscha*	1862
Sockeye salmon	*Oncorhynchus nerka*	1596
Chum salmon	*Oncorhynchus keta*	378
Coho salmon	*Oncorhynchus kisutch*	252
Chinook salmon	*Oncorhynchus tshawytscha*	105
Sand lance	*Ammodytes hexapterus*	165339
Pacific lamprey	*Entosphenus tridentatus*	13853
Starry flounder	*Platichthys stellatus*	6979
Unidentified soles	-	252
Sand sole	*Psettichthys melanostictus*	189
English sole	*Paraphrys vetulus*	126
Speckled sanddab	*Citharichthys stigmaeus*	84
Butter sole	*Isopsetta isolepis*	42
Eulachon	*Thaleichthys pacificus*	3764
Unidentified smelt	-	42
Staghorn sculpin	*Leptocottus armatus*	3164
Smoothhead sculpin	*Artedius lateralis*	21
Juvenile sculpin	-	21
Unidentified sculpin	-	21
Crescent gunnel	*Pholis laeta*	301
Juvenile gunnel	-	252
Longfin gunnel	*Pholis clemensi*	42
Three spine stickleback	*Gasterosteus aculeatus*	707

(Cont'd. ...)

Table 2 (cont'd.)

Pacific tomcod	*Microgadus proximus*	567
Pacific snake prickleback	*Lumpenus sagitta*	301
Sturgeon	*Acipenser transmontanus*	294
Spiny dogfish	*Squalus acanthius*	273
Unidentified larval fish	-	259
Sturgeon poacher	*Agonus acipenserinus*	84
Shiner seaperch	*Cymatogaster aggregata*	63
Sucker	*Catastomus sp.*	42

Figure 3. Salmonid Hourly Entrainment Rates by Date, DPW #312.

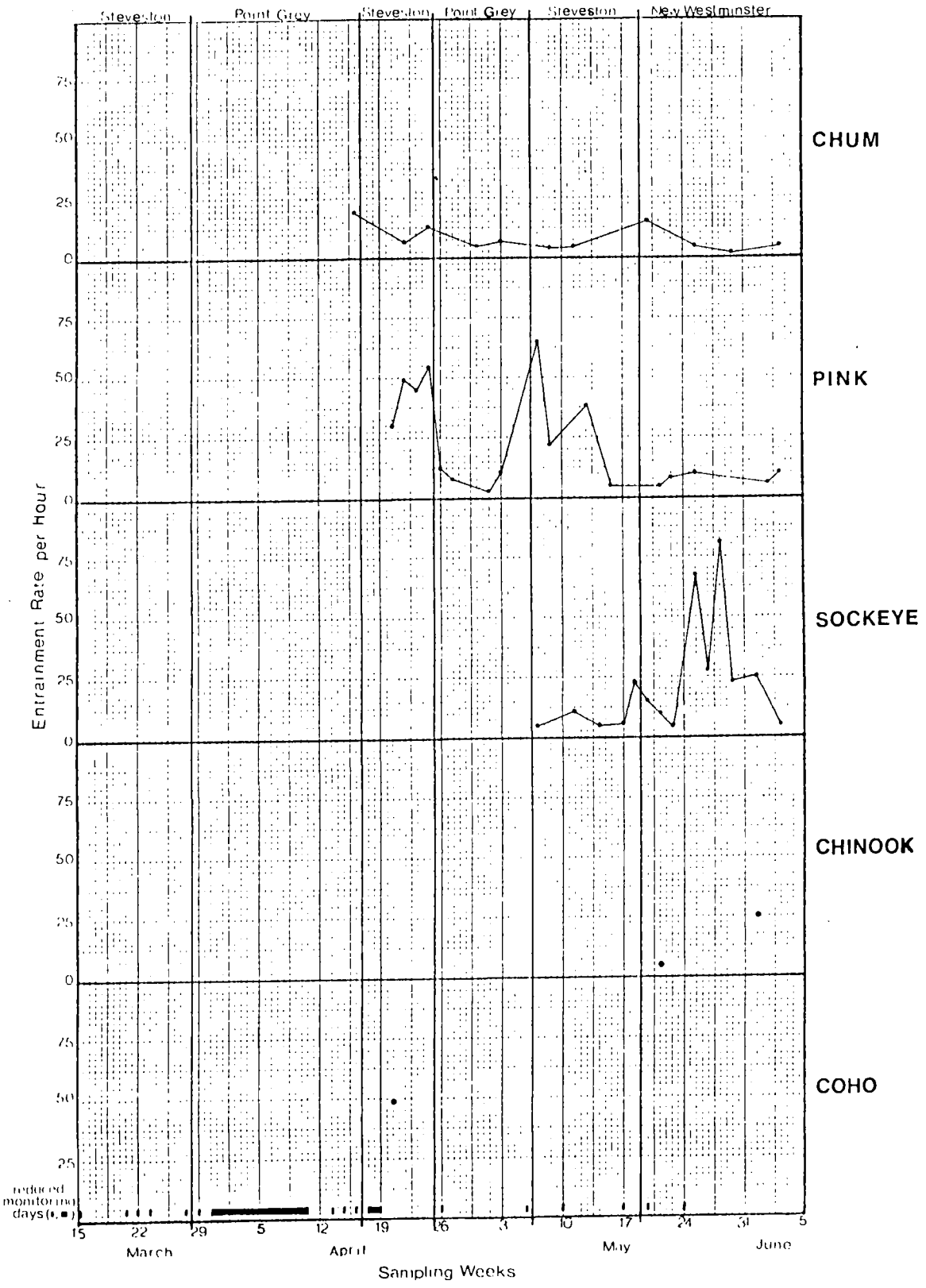


Figure 4. Sand Lance and Eulachon Hourly Entrainment Rates by Date, DPW #312.

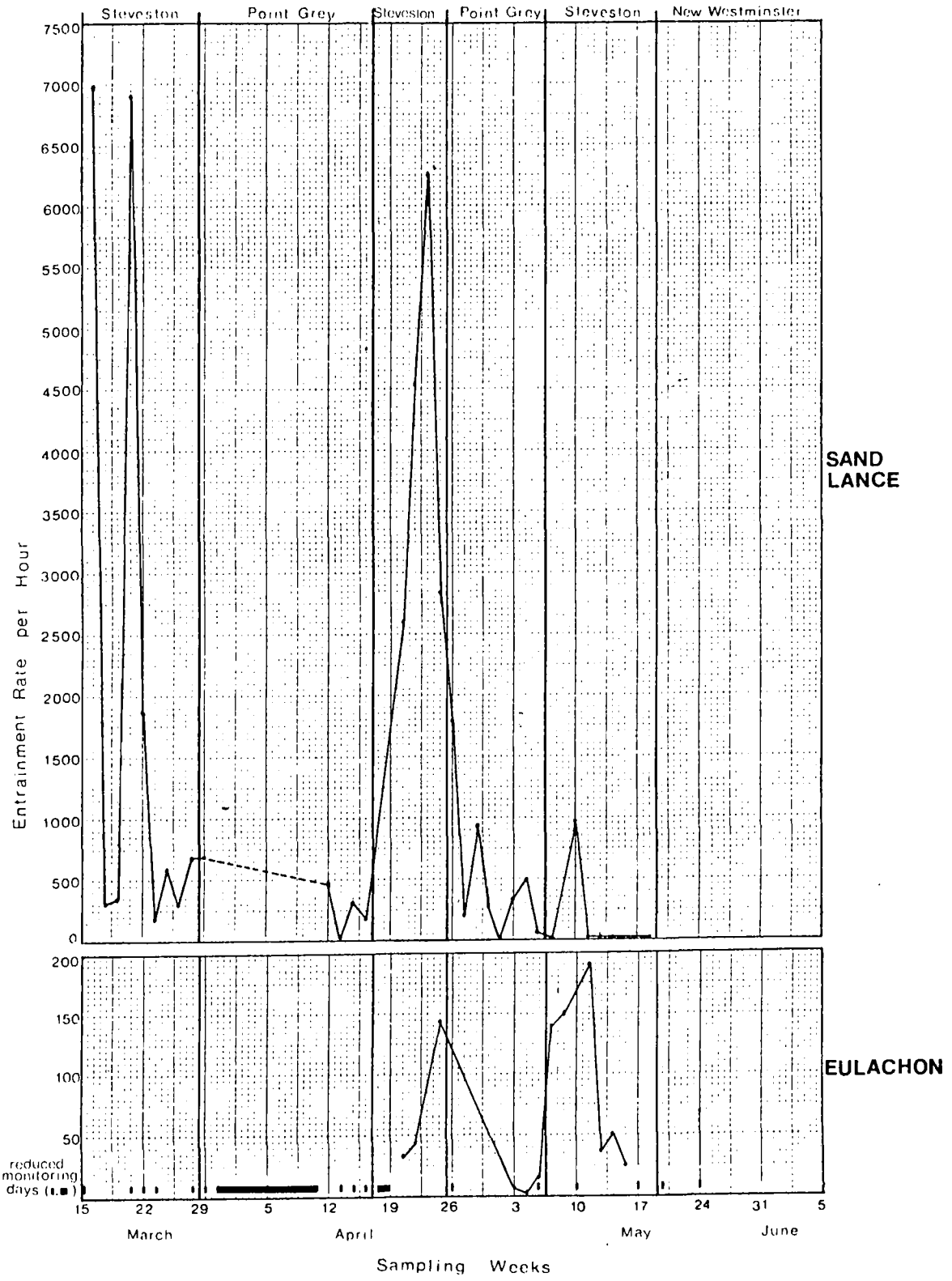


Table 3. Indexing Estimates For Total Entrainment Of Juvenile Salmonids, DPW #312.

Number of Salmonids Captured Using Dipnets

Number of Dipnets (46 cm. diameter)	1	2	3	4	5	6	7	8	9	10
1	84	168	252	336	420	504	588	672	756	840
2	42	84	126	168	210	252	294	336	378	420
3	28	56	84	112	140	168	196	224	252	280
4	21	42	63	84	105	126	147	168	189	210

Table 4. Sand Lance Captures Near Sand Heads, (Selected Dates Only.)

DATE	NO. OF DIP NETS	SAMPLING TIME (min)	NO.'s CAUGHT	CALCULATED ENTRAINMENT	HOURLY ENTRAINMENT RATE
March 16	2	26	400	16,800	38,769
March 19	2	30	532	22,344	44,688
April 20	3	40	406	11,368	17,052
April 22	4	80	812	17,052	12,789
April 23	4	34	477	10,017	17,677

2.2 Hopper Dredge Pump Discharge Monitoring Data

The pump discharge monitor installed aboard the DPW #312 hopper dredge was designed to divert approximately 10% of the incoming dredge spoil from the port discharge flume into a wire mesh screened trap and brailer net (Figure 5 and Appendix). A description of the pump discharge monitor and estimates of total entrainment are based on values established by Tutty, (1976). The capture data is presented in Table 5. The pump discharge monitor sampled 3.15% of the entrained juvenile salmon under optimum test conditions. Tests indicated for each specimen captured by the pump discharge monitor, 32 were entrained by the dredge. Estimates of hourly entrainment rates for this monitoring procedure could not be calculated due to uncontrolled variation of diversion flows.

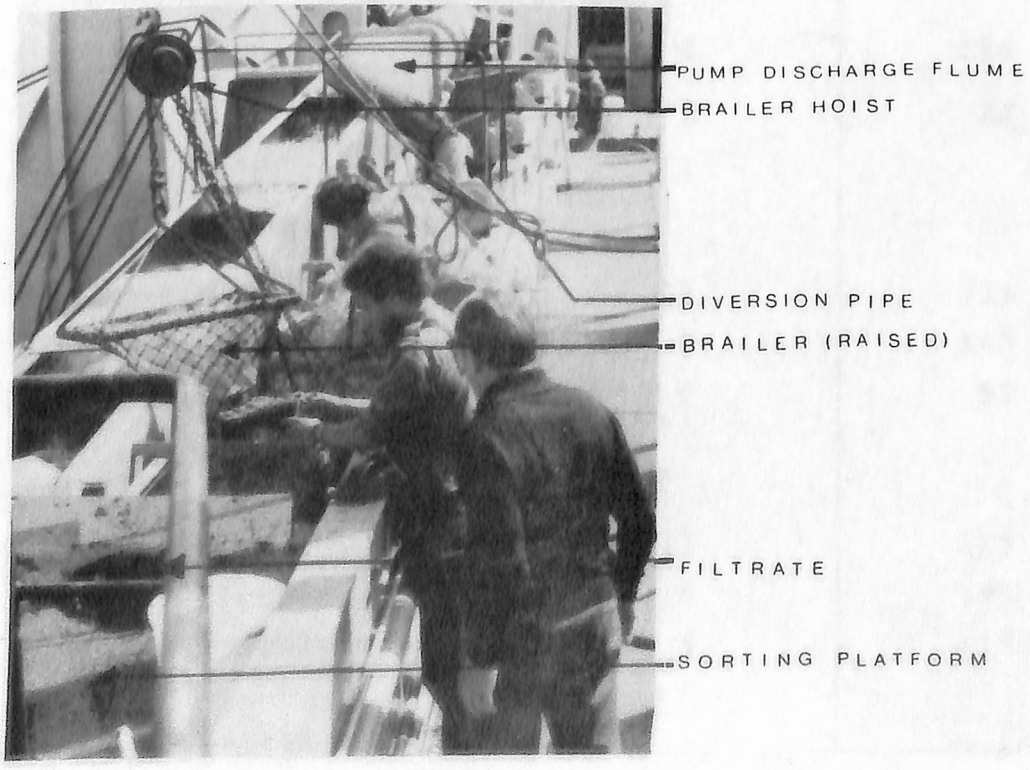


Figure 5. Pump discharge monitoring DPW #312.

Table 5. Pump Discharge Monitor Captures and Calculated Entrainment by Date, DPW 312

	Date/Sampling Time/ Species	Number Captured	Estimated Entrainment
Main Arm, Fraser River, Steveston to Sand Heads	March 16, 2 min.	0	0
	March 18, 72 min.		
	Sand lance	3	86
	Staghorn sculpin	1	29
	March 19, 45 min.		
	Sand lance	4	114
	Staghorn sculpin	1	29
	March 22, 67 min.		
	Sand lance	11	315
	Staghorn	1	29
	March 23, 120 min.		
	Sand lance	4	114
	Staghorn sculpin	1	29
	March 24, 306 min.		
	Sand lance	25	715
	Starry flounder	5	143
	Staghorn sculpin	2	57
	March 25, 125 min.		
	Sand lance	11	315
	Starry flounder	5	143
	Staghorn sculpin	4	114

Table 5 cont'd. Pump Discharge Monitor Captures and Calculated Entrainment by Date, DPW 312

	Date/Sampling Time/ Species	Number Captured	Estimated Entrainment
North Arm, Point Grey	April 12, 83 min.		
	Sand lance	24	686
	Staghorn sculpin	1	29
Main Arm Sand Heads	April 22, 130 min.		
	Sand lance	392	11211
	Starry flounder	2	57
	Unid. sole	3	86
Main Arm, New Westminster	May 19, 44 min.	0	0
	May 20, 182 min.		
	Eulachon	609	17417
	Sturgeon	2	57
	Pacific lamprey	21	601
	May 31, 132 min.		
	Sockeye salmon	1	29
	Sturgeon	5	143
	Sucker	1	29
	Pacific lamprey	43	1230

2.3 DPW #312 (Fort Langley) Hopper Dredge Monitoring, Discussion and Recommendations.

Two dredge monitoring techniques were used during the 1976 restricted dredging season. The installation of the pump discharge monitor facility aboard the DPW #312 permitted examination of the spoil for organisms prior to potential burial within the hopper. However, this diversion system fluctuated between no flow due to debris blockage at the entrance of the diversion pipe and full flow which delivered excessive quantities of debris. This system was therefore considered unmanageable for assessing total juvenile salmonid entrainment.

The alternate hopper discharge outfall monitoring method with dipnets was the most satisfactory sampling procedure. This method was predisposed to sampling variations but could be standardized (Tutty, 1976), permitting extrapolation of dip net captures to estimates of total entrainment and hourly entrainment rates.

Prior to the restricted dredging period, the Department of Public Works in co-operation with the Fisheries and Marine Service agreed to curtail the day's dredging of either the #312 or #322 operation should monitoring captures exceed ten juvenile salmonids per hour. The indexing test conducted on April 22, 1976 revealed that one dip net sampling ten salmonids per hour would represent

an estimated entrainment of 840 juvenile salmonids per hour. A normal two shift (16 hour) daily dredge operation could provide approximately 10 hours of dredging. Should the maximum allowable captures occur for one day's operation, approximately 8,400 juvenile salmonids could be entrained by the dredge. Further review of allowable captures may be necessary in the light of these findings.

The downstream juvenile salmonid migration commenced at the Fisheries and Marine Service sampling station at Mission on March 8, 1976, however, entrainment of salmonids by the DPW #312 was not registered prior to April 15. In explanation, only 6 complete days of normal dredging, 3 days of reduced dredging and 15 days of suspended operation occurred between March 15 and April 15. Also, from March 29 to April 15 the Fort Langley operated in the North Arm which transports approximately 5% of the mainstem flow of the Fraser river and roughly similar proportion of the juvenile salmonid migration.

The North Arm was the most difficult area to monitor and many juvenile salmonids captured in dip nets could have been overlooked due to the high fibre and silt content within the net filtrate. The lowest organism entrainments were recorded for channel 33-34 in the North Arm where 160 minutes of sampling with 2 dip nets resulted in no fish captures. The greatest number of fish captures

were recorded at Sand Heads on the Main Arm, on March 19, 1976, when 532 sand lance were captured using 2 dip nets in 30 minutes, representing an entrainment rate of 44,688 per hour.

Goodman (1975, vol. II, page 159) has found that fish larvae comprise approximately 36% of the stomach contents by weight for juvenile coho, 36% for chinook, 47% for chum, 63% for sockeye and 26% for herring on Sturgeon Bank between Steveston jetty and the Middle Arm. Hart (1973) indicates that juvenile and adult sand lance in the Fraser River estuary serve as food items for migrating coho, chinook and sockeye salmon, steelhead trout and herring. Sand lance spawn in early spring and rearing larvae probably provide an important food resource for transient and rearing juvenile salmonids on Roberts and Sturgeon Banks. The presence of juvenile and adult sand lance may also serve as food items for migratory adult salmon. Further investigations would be required to indicate what extent of the sand lance population is adversely affected by dredging activities, however, the extremely large numbers congregating near Sand Heads would indicate that this area is of particularly high biological importance within the estuarine food web.

The DPW #312 hopper dredge operated in close proximity to the mainstem riverbank opposite New Westminster on May 25, 1976. Nine sockeye and one chum smolt were captured in 47 minutes using two dip nets representing a total

entrainment of 378 sockeye and 42 chum juvenile salmon. On May 27, 1976 a total of 13 sockeye were captured in the same area representing an estimated entrainment of 546. Eighty percent of all sockeye smolt captures occurred in the New Westminster area between May 19 and June 4, 1976. Evidence indicates that the river margins are utilized by schools of migrating smolts to a greater extent than mid-stream areas and are primary rearing areas even after the June 1 expiry of the restricted dredge period. It is recommended that mainstem central channel areas be scheduled for maintenance dredging by the hopper dredge during the restricted period. Furthermore, since the North Arm represents the least potential damaging area for dredge entrainment of juvenile salmon due to the reduced (5%) total discharge capacity, it is recommended that hopper dredge operations during the restricted period be scheduled for the North Arm whenever possible.

Section 3. DPW #322 Stationary Pipeline Dredge

3.1 100% Outflow Monitoring Data, Richmond Landfill and Byrne Road Dredge Sites.

Dutta and Sookachoff (1975 B) described monitoring procedures for pipeline dredges sampling 100% of the spoil site outfall with a large screening facility, (Fig. 6). This method of monitoring was undertaken from March 15 to March 26, 1976 at the Richmond Landfill site and from April 2 to April 14, 1976 at Byrne Road site, (Fig. 7).

Estimates of total entrainment are presented in Table 6 and are based on the total entrainment to sample capture ratio of 22:1 established by Dutta and Sookachoff (1975 B). Superscripts within Table 5 refer to explanatory notes listed on page 46.

Figure 6. 100% spoil site outflow monitoring, DPW #322 pipeline dredge.

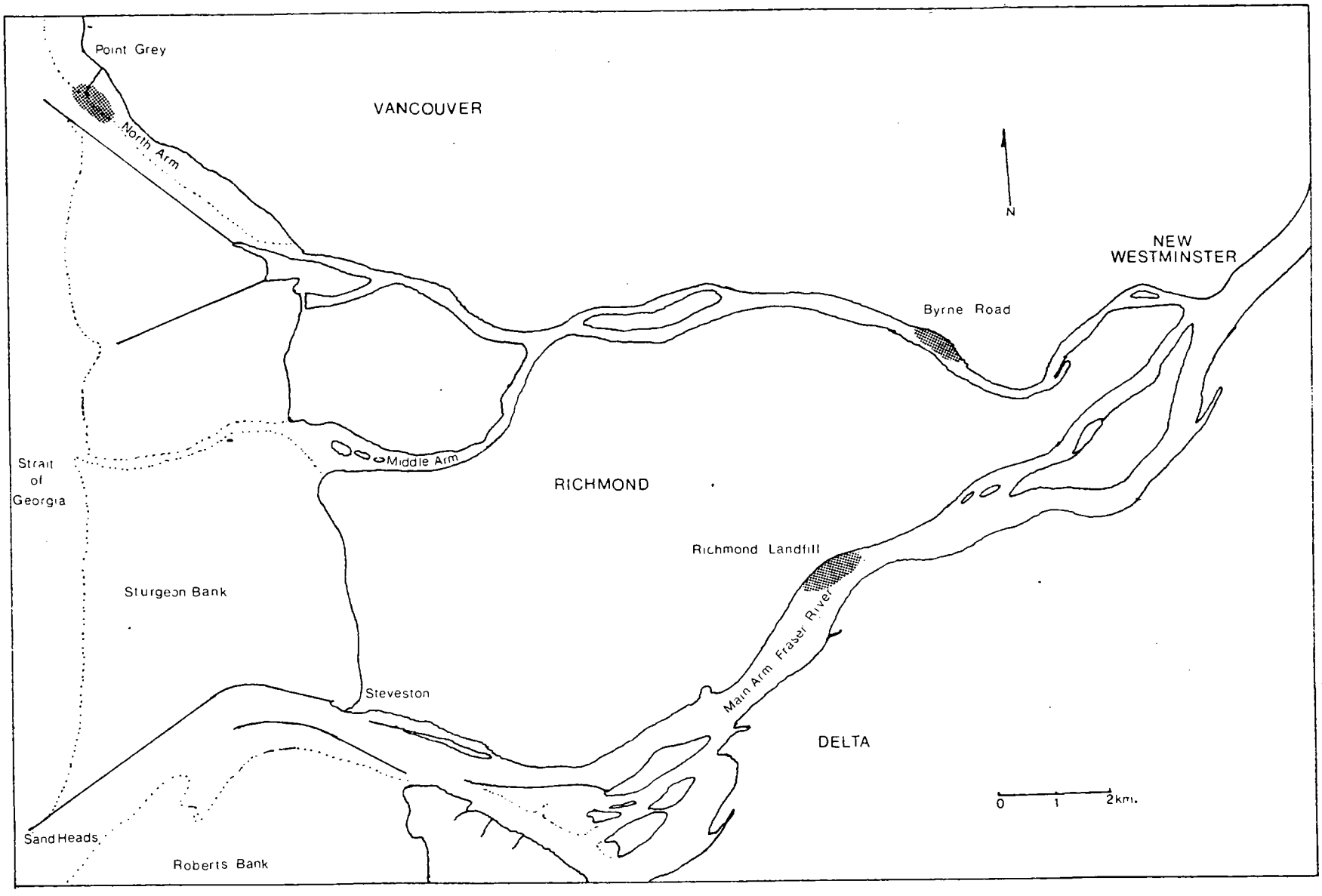


Figure 7. Shaded Portion Indicates DPW #322 Dredging Areas for March 15 to May 21, 1976.

Table 6.DPW #322, Calculated Entrainments from March 15 to April 16, 1976.

	Location	Pink Salmon	Chum Salmon	Sculpin	Starry Flounder	Lamprey	Sturgeon	3 spine Stickleback	Herring	TOTAL
March 15[a]										0
16[b]				44		22				66
17				1232						1232
18				88						88
19				22	66	22				110
22				44		44				88
23				44		44				88
24				22	44	22				88
25		22		110	132	66				330
26				44	44					88
29[a]										0
30[a]										0
31[a]										0
April 1[a]										0
2		44			528	286	22			880
5[c]		264		176	704	1320	22	66		2552
6[a,c,d]		44		352	1012	880				2288
7[a]						22				22
8[a]										0
9[a]		264	22	132		418		22		858
12		352		572	220	264		22		1430
13		418	22	44	88	154		66	22	814
14[a,c]		858	44	154	66	484		132		1738
15[a]										0
16[a]										0
TOTAL		2266	88	3080	2904	4048	44	308	22	12760

3.2 Stationary Pipeline Diversion Monitoring Data, DPW #322, Point Grey Site.

Material dredged from the Point Grey Boat Basin, April 19 to May 21, 1976 was not contained within a dyked spoil ground, but dispersed onto the intertidal zone with the intention of supplementing beach sand (Figure 8, 9 and 10). Consequently, the 100% spoil ground outflow monitoring method could not be applied and a pipeline diversion, similar in principal to the hopper dredge diversion facility (section 2.2 of this report, also Tutty, 1976), was designed to divert 10% of the dredge spoil to a rectangular screening device. This monitoring method was subject to highly variable diversion flow, due to blockages of the diversion pipe and inadequate screening area. Unmanageable quantities of debris accumulated when the diversion flow operated favourably. Monitoring catch data is presented in Table 7. Estimates of entrainment are not possible as an entrainment to catch ratio could not be established. Superscripts within Table 7 refer to explanatory notes on page 46 . The project monitoring was not viewed as a success and any projected repetitions of the project will be subject to close re-evaluation.

Figure 8. DPW #322 Partial pipeline diversion monitoring with pipeline discharge onto intertidal beach zone.

Figure 9. Pipeline discharge onto beach zone.

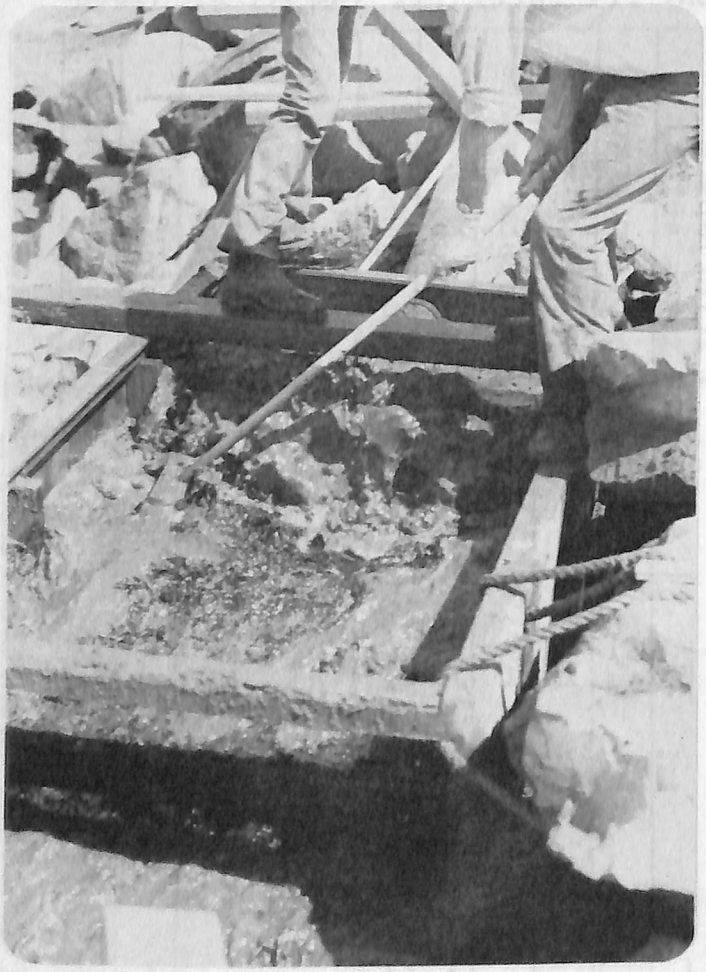


Figure 10. Partial pipeline diversion monitoring facility. Note the unmanageable flow and heavy debris obscuring any specimens.

TABLE 7. DIVERSION MONITORING CATCH DATA, DPW #322, APRIL 19 to MAY 21, 1976, PT. GREY SITE.

	Chinook Salmon	Sculpin	Flounder	Prickleback	Gunnel	Sand lance	Eulachon	Eulachon larvae	Perch	Pacific tomcod	Three spine stickleback	Smelt	Larval fish	Lamprey
APRIL 19[a,b]														
20[a]														
21[a]														
22[a]														
23[a]														
26				1		2								
27		1			1									
28[c]			1			1	3	1	1					1
29[c]		1		1		1							3	
30													1	
MAY 3			1			3								
4[a,c]														
5[c]	1	1		1										1
6[a]				1						1	3			
7[c]								1						1
10[c]		1				1	3			1	1			1
11[c]			1	1	2		13				1	1		1
12[c]			1		2						1			1
13[c]			2				3				1			
14[a]														
17[a]														
18[a]														
19[a]														
20[a]				1								1		
21[c]		1					2							
TOTAL	1	5	6	6	5	8	24	2	1	2	7	2	4	6

3.2.1 Explanation of Superscripts for Tables 6 and 7.

a.
A reduction in normal dredging operations occurred due to dredge repairs, transfer to new dredge location, or statutory holidays.

b.
Shrimp were entrained by the dredge at the Richmond Landfill and Point Grey sites.

c.
A reduction in normal monitoring operations occurred due to equipment failure, or accumulation of debris. At Point Grey these problems were compounded by inadequate screening, screen blockage and intermittent flows.

d.
Crayfish were entrained by the dredge on April 6 and April 12, at the Byrne Road site.

e.
Crabs (cancer sp.) were entrained by the dredge at the Point Grey site.

3.3 DPW #322 Stationary Pipeline Dredge Monitoring Discussion and Recommendations

During the 1976 restricted dredging season, the DPW #322 was monitored for juvenile salmonid captures by 100% spoil ground outflow screening and partial pipeline diversion. Spoil ground outflow sampling data was extrapolated to yield estimates of total entrainment by the dredge for the Richmond Landfill and Byrne Road sites, based on indexing coefficients reported by Dutta and Sookachoff (1975 B). These estimates are considered satisfactory.

Partial pipeline diversion monitoring at the Point Grey site was prone to variable sample flows, accumulation of excessive debris and inadequate screening capabilities. Therefore, this technique could not be indexed for total entrainment ratios. It is doubtful that this diversion system could be modified to provide satisfactory entrainment estimates. The determination of impacts of dredging on juvenile migrating salmon cannot be assessed for the Point Grey Beach fill site.

It is recommended only 100% spoil ground outflow monitoring be continued for assessment of impact of stationary dredge operations on downstream juvenile salmonid migrations. Dredge areas having unacceptable dredge spoil impoundment sites and where 100% spoil ground outflow monitoring is impractical should not be scheduled during the March 15 - June 1 restricted dredging period.

ACKNOWLEDGEMENTS

The dredge monitoring program is directed by F.C. Boyd, Acting Director, Habitat Protection Directorate. Collection and analysis of the data presented was made possible through efforts of permanent and casual employees of the Department of Fisheries and the Environment, Fisheries and Marine Service, Pacific Region, and Public Works Canada. The author expresses sincere appreciation to Mr. P. Van Der Graaf, Public Works Supervisor of dredge monitoring and to Mr. R. Elvidge, Senior Fisheries Technician, and all those who participated in the 1976 programme.

BIBLIOGRAPHY

Boyd, F. C. 1975. Fraser River Dredging Guide. Environment Canada, Fisheries and Marine Service, Southern Operations Branch, Pacific Region. Technical Report No. PAC/T-75-2.

Dutta, L. K. and Sookachoff, P. 1975 A. A Review of Suction Dredge Monitoring in the Lower Fraser River, 1971-1975. Environment Canada, Fisheries and Marine Service, Southern Operations Branch, Pacific Region. Technical Report No. PAC/T-75-27. 136 pages.

Dutta, L. K. and Sookachoff P. 1975 B. Assessing the Impact of a 24-inch Suction Pipeline Dredge on Chum Salmon Fry in the Fraser River. Environment Canada, Fisheries and Marine Service, Southern Operations Branch, Pacific Region. Technical Report No. PAC/T-75-26. 24 pages.

Goldie, C. A. 1967. Pollution and the Fraser: Report I Dealing with Preliminary Investigations of Waste Disposal to the Lower Fraser River. Prepared for the Pollution Control Board, Victoria, British Columbia.

Goodman, D. 1975. Appendices 1 - 5. A Synthesis of the Impacts of Proposed Expansion of Vancouver International Airport and Other Developments on the Fisheries Resources of the Fraser River Estuary. Vol. II of II. Department of the Environment, Fisheries and Marine Service, Habitat Protection Unit. 321 pages.

Hart, J. L. 1973. Pacific Fishes of Canada, Fisheries Research Board of Canada, Bulletin 180. 740 pages.

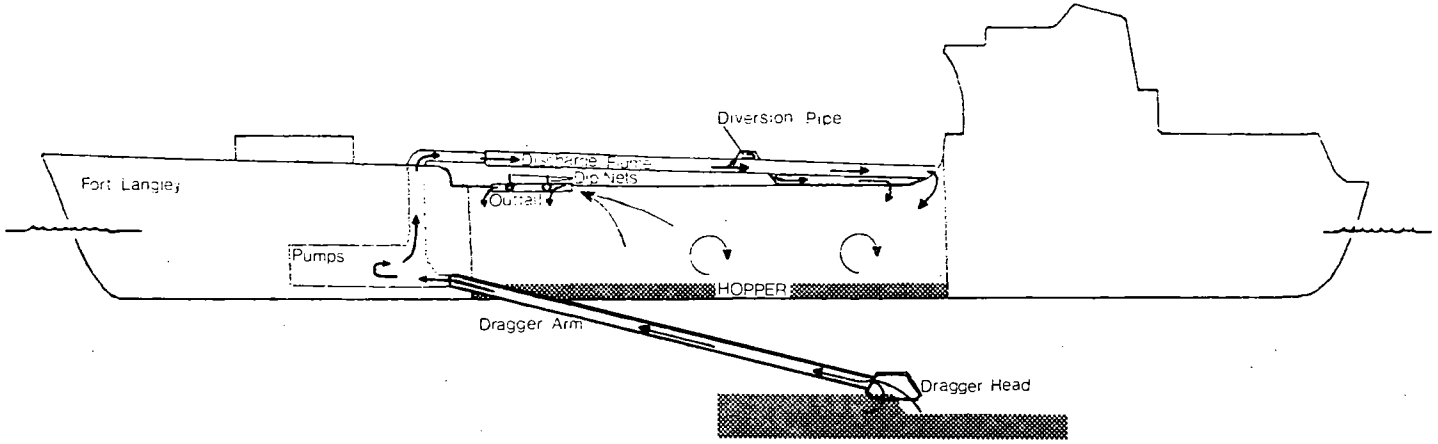
Tutty, B. C. 1976. Assessment of Techniques Used to Quantify Salmon Smolt Entrainment by a Hydraulic Suction Hopper Dredge in the Fraser River Estuary. Environment Canada, Fisheries and Marine Service, Habitat Protection Directorate, Pacific Region. Technical Report No. PAC/T-76-16. 34 pages.

Tutty, B. C. and McBride, 1976. Histopathology of Chum (Onchorynchus keta) and Sockeye (Onchorynchus nerka) Smolts Subjected to Entrainment During Hydraulic Dredging in the Fraser River Estuary. Environment Canada, Fisheries and Marine Service, Pacific Region. Technical Report No. PAC/T-76-15. 24 pages.

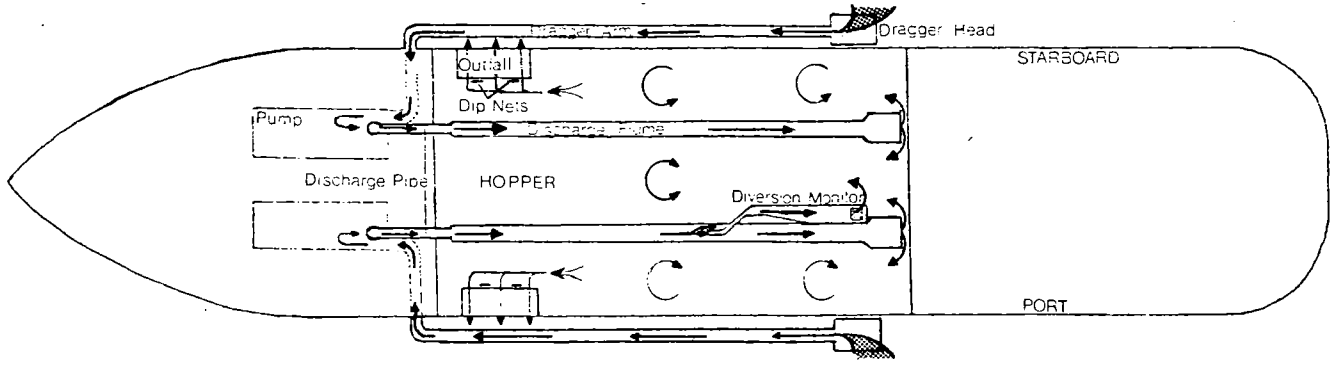
APPENDIX

DPW #312 Hopper Dredge Drawings.

1. Hopper Dredge Schematic Illustrating Dredge Slurry Movements.
2. Pump Discharge Monitor.
3. Pump Discharge Diversion Structure.
4. Pump Discharge Sampling Screen.



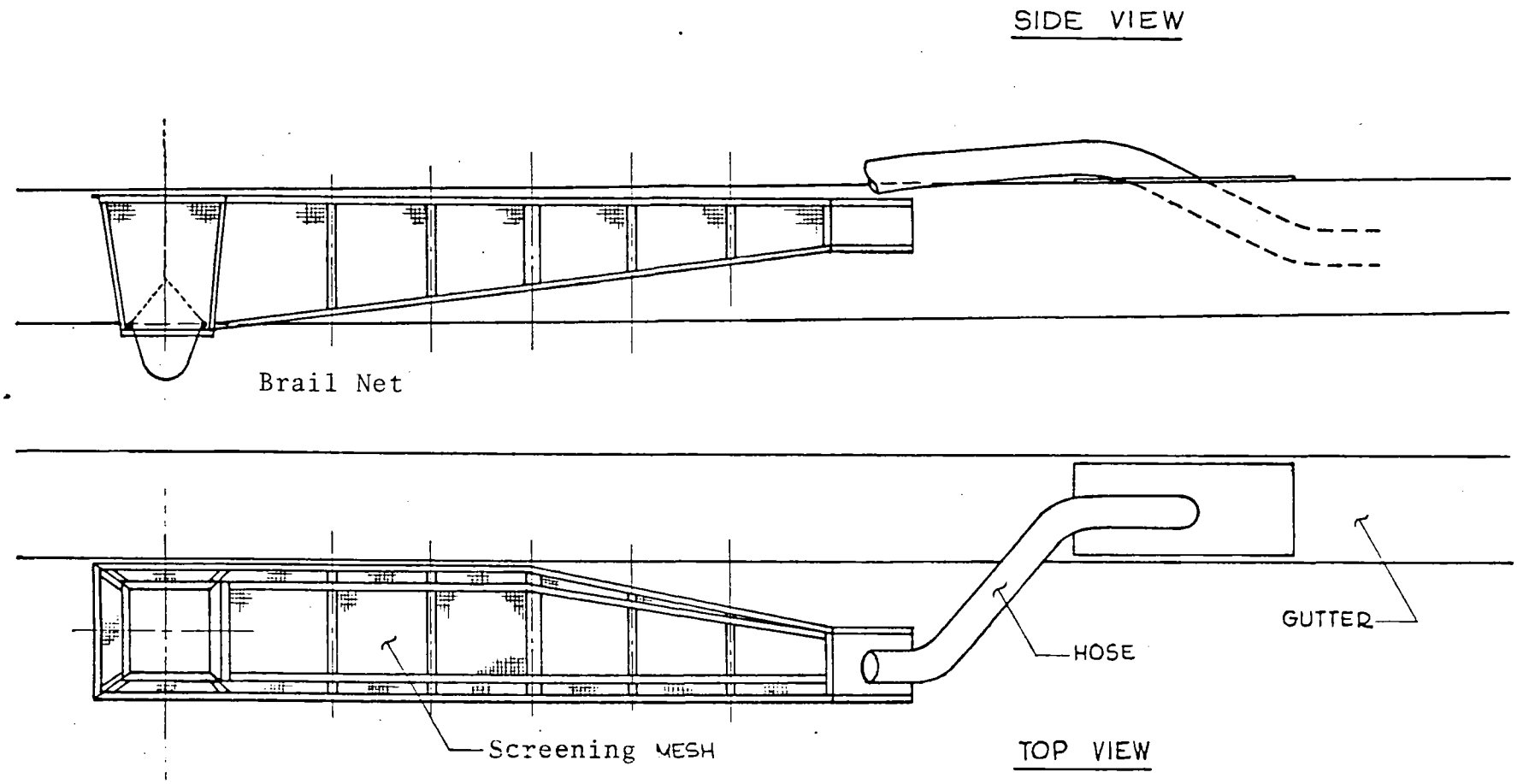
Arrows indicate slurry movement through hopper dredge.



Hopper Dredge Schematic Illustrating Dredge Slurry Movements.

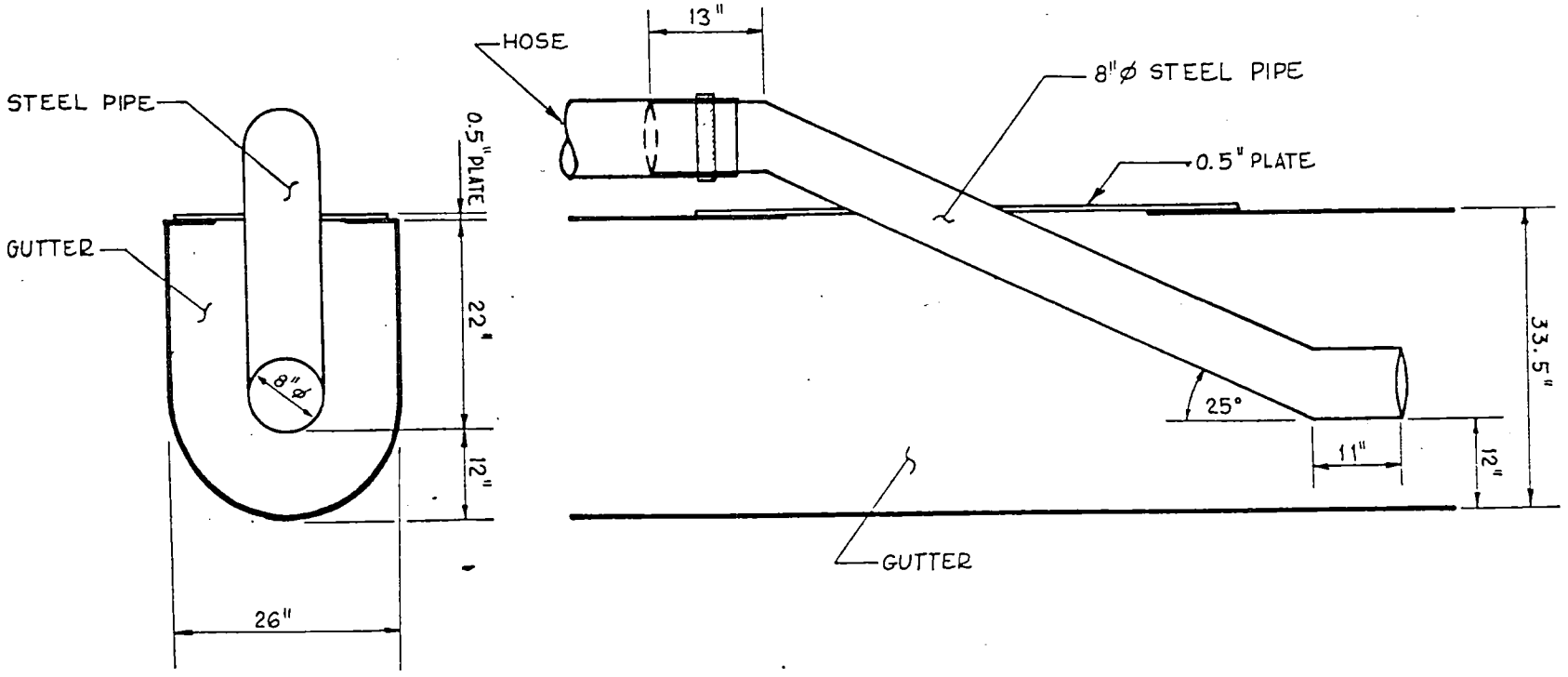
Pump Discharge Moniter

HOPPER DREDGE
FORT - LANGLEY



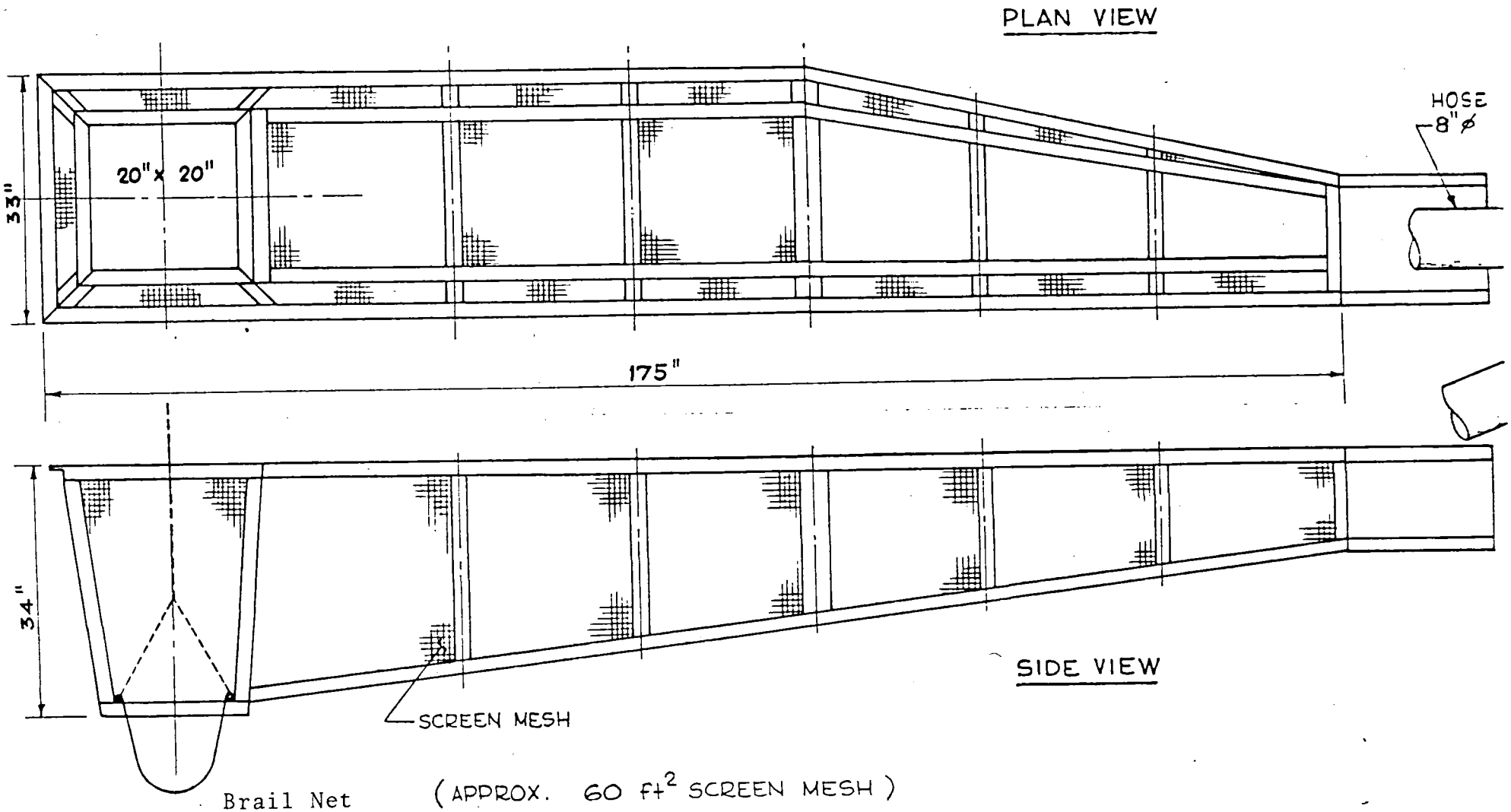
HOPPER DREDGE
FORT - LANGLEY

Pump Discharge Diversion Structure



Pump Discharge Sampling Screen

HOPPER DREDGE FORT-LANGLEY



D.P.W. #312, Potential for Increased Data Acquisition

The Department of Public Works mobile hopper dredge #312 (Fort Langley) is an effective mid-channel epibenthic sampler and offers a unique opportunity to extend information concerning the biology of the lower Fraser River. Dredge monitoring operations within the North and Main Arm navigation channels has provided some data on temporal and spatial distributions of fish species. Other areas of high biological significance may be determined through extension and co-ordination of present dredge monitoring efforts. Benthic invertebrate distribution, sediment, and water quality are some parameters which could be amplified.