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L.K. Dutta
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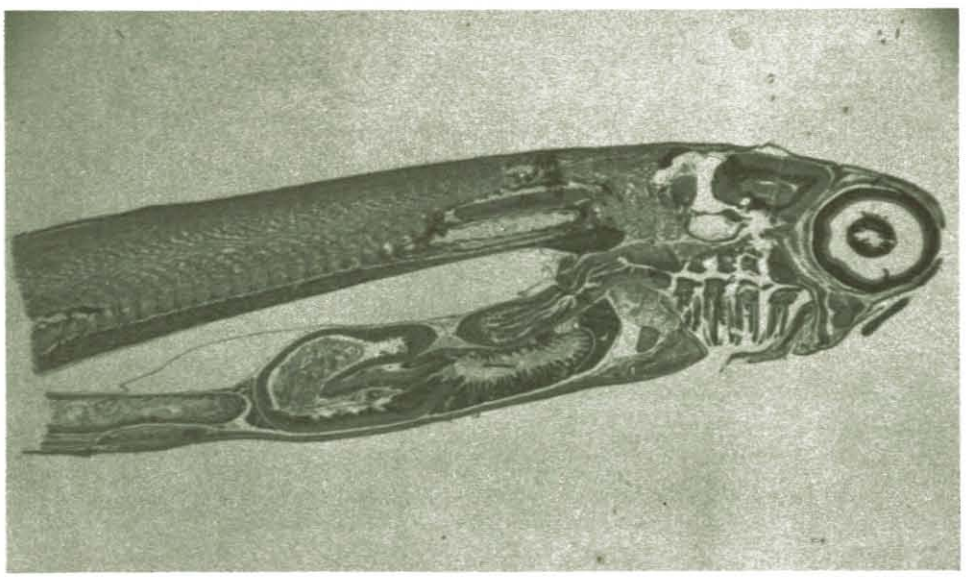
Technical Report Series No. PAC/T-75-27

Southern Operations Branch
Pacific Region



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ABSTRACT

The Fraser River is a major migratory route for chum, coho, sockeye, pink and chinook salmon. Each spring, salmon fry utilize the Fraser River during their seaward migration. An estimated 6.25 billion eulachon larvae; 413 million chum, pink and chinook salmon fry; 1 million steelhead, 2.1 million coho, 1.6 million chinook, and 45 million sockeye juveniles travelled through the lower Fraser River during March 15 to May 31, 1974. Peak daily totals of 9.6 million chum fry and 10.4 million pink fry occurred on April 5, 1974 and May 1st, 1974, respectively.

The lower 25 miles of the river, from the mouth to the trifurcation walls, is being used more extensively for navigation and sandborrow purposes. The resulting suction dredging activity during downstream fry migration, March 15 to May 31, is causing serious concern to fishery resource managers.

Since 1971, the Fisheries & Marine Service has been assessing the impact of anchored suction pipeline and mobile hopper suction dredges on the salmon fisheries resource of the Fraser River. Monitoring techniques ranging from the initial partial flow dip net screening to that of the present 100% screening of the spoil runoff have been developed.

In conjunction with monitoring, a test was performed on May 10th, 1974, to assess the effects of an operating hydraulic suction dredge on chum salmon fry. The test results showed that for every fry recovered at the spoil drain, 22 fry were buried in the spoil mass, and that the over-all mortality rate of fry passing through an operating dredge was 98.8%.

In 1975, histological tests were performed on live fry, recovered at the spoil drain. Analysis confirmed that these

fry, after passing through an operating suction dredge, suffered substantial internal and external injuries sufficient to kill a large proportion of the 4.5% of the entrained population emerging from the spoil site.

The monitoring program and test results described in this report prove conclusively that suction dredging operations during downstream juvenile salmon migration cause a partial destruction of the anadromous salmon fishery resource of the Fraser River. To safeguard this important British Columbia resource, it will be necessary to control the amount and scheduling of suction-dredging activity in relation to the downstream juvenile migration, particularly so until future dredging technology provides a method of preventing juvenile salmon from encountering the dredge's cutterhead and suction pumps.

SUMMARY

Prior to 1971, Fishery Officers had become concerned about the conflict of suction dredge operations and damage to migrating salmon fry. In the spring of 1971, Fishery Officers J. Bentley and V. Knoop documented observations of stranded chum salmon fry in the dredge spoil pile drain during construction of the south bank approach fill of the Mission Bridge across the Fraser River.

In the spring of 1972, the Environmental Quality Unit of the Fisheries & Marine Service initiated a monitoring program of the suction dredging operations in the lower Fraser River during the period of downstream fry migration. Monitoring techniques ranged from visual observation to the hand-held 18-in. diameter marquisette dip nets. Operations monitored included the dredge, "Sceptre Fraser", located in the vicinity of the Mission Bridge from April 10 to April 20, and at the foot of Tillicum Street (North Arm) from May 8 to May 13; Centennial's dredge operating at Trimac in the vicinity of Deas Island on May 24 and May 26; and Dillingham's "King Edward" in the vicinity of the Deas Island Tunnel.

Although these monitoring activities were executed in difficult conditions, they produced some startling and significant results. Monitoring of the "Sceptre Fraser", operating at the foot of Tillicum Street from May 9 to May 13, for a fraction of the total dredging time and sampling 10% of the total runoff water from the spoil pile, resulted in the recovery of 173 salmon fry. Extrapolated to 100% of the dredge operating time and 100% of the spoil runoff, the daily total number of salmon fry captured by the dredge would be of the order of 5,000, excluding those fry buried in the spoil mass. The numbers of buried fry were considered significant in relation to the numbers found floating.

Subsequently in 1973, the Fisheries & Marine Service prepared the Preliminary Fraser River Dredging Guide. The Guide outlined the fishery industry's problems associated with dredge operations, background data, the timing of adult and juvenile anadromous fish migrations and identified the need for scheduling suction dredging activities in the Fraser River to avoid the salmon fry migration period. Suction dredging during fry migration was approved only when operations were subjected to monitoring for fry capture. Copies of the Dredging Guide were distributed to dredging companies, development companies, Harbour Commissions and related federal and provincial agencies in the Greater Vancouver Region for review and comment.

In 1973, Public Works Canada's (DPW) hopper dredge "Fort Langley" operating in the vicinity of Steveston Island at the confluence of Ladner Reach and the Main Arm of the Fraser, was monitored on April 26, May 13 and June4; the DPW dredge "322" operating in the North Arm of the Fraser and at Fraser Surrey Docks was monitored on May 13 and June 4; Centennial Dredging & Sand operating in the Main Arm of the Fraser was monitored on July 4, using an 18-in. diameter hand-operated marquisette dip net. The results of these monitoring activities are reported on pages 25 to 31.

Monitoring operations during the spring of 1974 were carried out at all dredging sites using 18-in. diameter marquisette dip nets, sampling approximately 10% of the flow over 50% of the dredge operating time. Dredging operations monitored were: Sceptre Dredging at the North Arm of the Fraser River from March 20 to April 16; DPW "322" at the Fraser-Surrey Docks from April 10 to May 5, and at Annacis Sandspit from May 6 to May 27; Sceptre Dredging in the Annacis Channel from April 23 to May 1; Centennial Dredging at Barnston Island from May 2 to May 6; Island Sand Sales in the Morey Channel at the west foot of Bridgeport Road from May 6 to June 6. The results of these monitoring activities are reported on pages 32 to 54.

1974 was the most eventful year in the history of the dredge monitoring program. Centennial Dredging & Sand Ltd. was requested to shut down their dredging operations in the Fraser River near Barnston Island on May 6, because a large number of pink salmon fry, eulachon and clusters of eulachon eggs were retrieved from the spoil pile drain. The Company complied with the request and immediately suspended their operations.

Sceptre Dredging Ltd. was requested to close down their dredging operations in the Annacis Channel on April 29, because 11 pink salmon fry and 1 chum salmon fry were retrieved from their spoil site between 09:55 hr and 14:20 hr, while monitoring for only 176 minutes and sampling only 8.25% of the total spoil runoff. Extrapolation to 100% of the dredging time, while sampling 100% of the flow and allowing for a burial factor of 22:1 (number of fry buried to number of fry recovered), would have resulted in a daily total of 26,400 fry being captured by the dredge. By applying the mortality rate of 98.8%, a daily total of 26,083 salmon fry per day were estimated to be killed by this dredging operation. The company refused to comply with the request to shut down operations and was subsequently charged under Section 12 of the "Fisheries Act" on May 1, 1974.

The highlight of the 1974 dredge monitoring was a test performed on May 10 in collaboration with Public Works Canada at Annacis Sandspit. The test was conducted to establish:

a) The relationship between the total number of salmon fry buried in the spoil mass in the settling pond to the total number of salmon fry escaping back into the river from the spoil site.

b) The mortality rate of salmon fry from the time they entered the suction pipe to a time lapse of 96 hrs. after their escape into the river.

It was determined that for each fry which escaped into the river from the spoil area, 22 fry were buried in the spoil mass in the settling pond. A 96-hr. viability test revealed that 70.6% of the salmon fry that escaped into the river alive, died within the first 96-hr. period, thereby indicating an overall salmon fry mortality rate of 98.8%.

Based on the test results of May 10, 1974 (see Appendix I); the monitoring activities during March to June, 1974; the results from the Mission downstream fry monitoring program, conducted jointly by the Fisheries & Marine Service and the International Pacific Salmon Fisheries Commission; an updating of the Preliminary Fraser River Dredging Guide was completed and revised editions were distributed to all dredging companies in the Greater Vancouver Region prior to March 15, 1975. As a result, only emergency dredging was approved during the critical fry migration period in the spring of 1975. Emergency dredging for navigation purposes was carried out by Public Works Canada subject to monitoring by the Fisheries & Marine Service, with the stipulation that if significant fry capture became evident, then the dredging activities would be terminated. Screens were fabricated and installed at the spillway to sample 100% of the outflow from the dredge spoil settling pond over 100% of the time. Public Works Canada voluntarily suspended dredging operations at critical periods to comply with instructions from the Fisheries Service. During the entire period of downstream salmon fry migration, a daily liaison was maintained between the monitoring crew and persons responsible for the Mission downstream migration sampling program. This information was made available to dredging companies upon request.

Histological examination of fry retrieved from the spoil drain was made to determine the extent of internal injury inflicted on the fry while they were passing through the operating suction dredge. Analysis confirmed that those fry which, on superficial visual examination appeared undamaged, had, in fact, suffered

internal hemorrhage and had silt-clogged intestinal tracts. Identical analysis was done on control fry obtained from the Mission sampling site; the latter showed no evidence of damage.

Monitoring activities up to 1975 confirmed that salmon fry migrate not only through the Main Arm of the Fraser River, but that large numbers also move through the North Arm and the Annacis Channel. It is of interest to note that at the trifurcation walls, 77% of the total Fraser River flow passes through the Main Arm, 10% through the Annacis Channel and 13% through the North Arm. North Arm flow is further subdivided below the Oak Street Bridge, 50% flowing through the North Arm and 50% through the Middle Arm. It is assumed that fry distribution is probably directly related to the volume of flow in each channel.

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ACKNOWLEDGEMENTS

The authors wish to acknowledge the invaluable technical direction, advice and assistance given by all those who participated in the monitoring program.

The planning and design of sampling techniques and field observations were directed by Mr. F. C. Boyd, Chief, Habitat Protection Unit. Monitoring, initially supervised by Mr. A. F. Lill, was completed under Mr. J. W. C. McNally. Data collection and analysis was made possible through the efforts of a number of permanent and casual employees of the Fisheries & Marine Service and the Department of Public Works.

1. INTRODUCTION

1.1 THE FRASER RIVER

Throughout the history of British Columbia the Fraser River has played an important role in the development of the province. From the early native populations to those of the present day, the river has provided sustenance to life, transportation access and commercial opportunities along its length and its tributaries. Its prominence as a transportation route to the interior became evident in the 1850's when gold was discovered in the headwaters. From this early transportation beginning it now accommodates over 400 deepsea vessels annually. These ships berth in the lower reach of the river from Annacis Sandspit to Pattullo Bridge. Imported cargoes include automobiles; mine concentrates; creosote oil; canned, dried and fresh fruit; general cargo; gypsum rock; meat; nickel briquettes; rice; steel and wine. Exports are dominated by asbestos, mineral concentrates, fertilizers, flour, lead, lumber, paper products, plywood, seed, wheat, zinc, sawdust and salmon.

From its origin in the mountains of east-central British Columbia, the river traverses over a thousand miles before reaching a 100-mile long delta. The watershed drains an area of approximately 90,000 square miles of predominantly mountainous terrain, releasing in its lower reaches a sediment load ranging from 20 to 25 million tons annually. The typical annual hydrograph of the Fraser River at Hope is shown in Figure 1. (Quick, M.C., 1965). The River discharge falls to a minimum of approximately 50,000 c.f.s. by mid-March and from then on begins to rise, largely due to snowmelt, to reach a peak flow of approximately 300,000 c.f.s. by early June.

Tables 1 to 4 show the average daily discharge of the Fraser River at Mission for the months of March, April, May and June for the years 1971 to 1974, respectively. (Data collected by the Water Survey of Canada).

Figure 2 depicts the average daily discharge of the Fraser River at Mission for the months of March to June for the years 1971 to 1974.

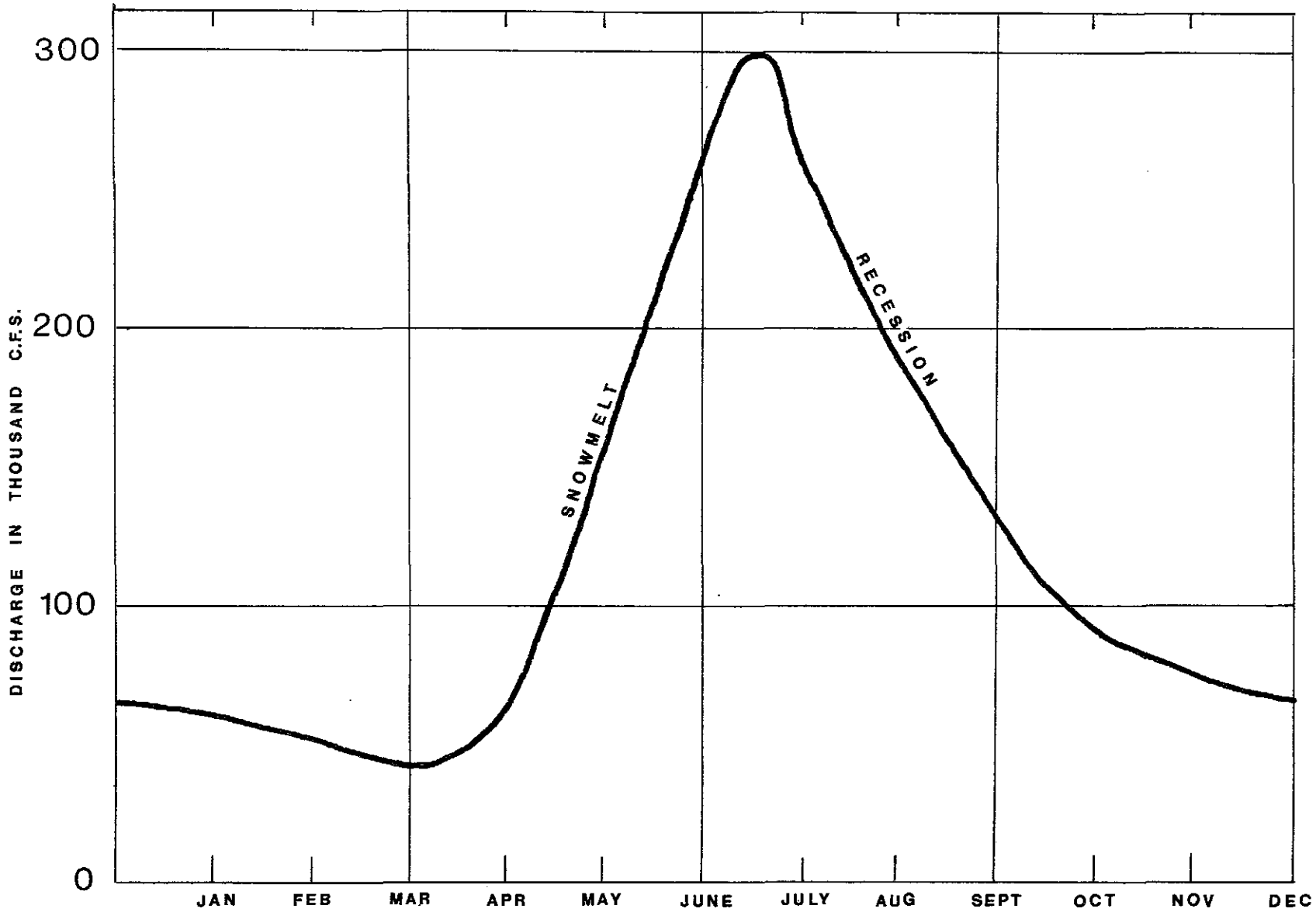

FIGURE 1. Fraser River at Hope: Typical Annual Hydrograph

TABLE 1

MEAN DAILY DISCHARGE OF THE

FRASER RIVER AT MISSION, 1971

(Station No. 08MH024)

DAY	MARCH (c.f.s)	APRIL (c.f.s)	MAY (c.f.s)	JUNE (c.f.s)
1	45,600	41,700	166,000	293,000
2	44,200	41,100	170,000	293,000
3	43,900	40,400	175,000	292,000
4	43,500	39,000	183,000	295,000
5	42,500	36,500	194,000	299,000
6	41,400	36,000	191,000	307,000
7	40,300	38,000	197,000	325,000
8	40,600	38,000	213,000	338,000
9	38,700	39,000	226,000	335,000
10	37,600	41,700	232,000	333,000
11	39,600	42,300	241,000	338,000
12	39,500	43,700	255,000	338,000
13	39,600	45,000	273,000	335,000
14	38,300	47,300	274,000	329,000
15	38,800	50,100	272,000	316,000
16	38,400	51,500	286,000	303,000
17	38,500	52,600	293,000	300,000
18	37,600	53,600	286,000	314,000
19	36,900	53,600	271,000	323,000
20	36,700	54,900	252,000	315,000
21	35,900	57,700	235,000	302,000
22	34,400	59,700	228,000	301,000
23	33,600	64,000	234,000	306,000
24	35,400	71,300	247,000	308,000
25	36,000	81,400	261,000	310,000
26	34,600	96,600	271,000	307,000
27	36,600	117,000	282,000	300,000
28	36,300	139,000	297,000	292,000
29	36,500	154,000	303,000	282,000
30	41,400	161,000	304,000	268,000
31	43,600	-	299,000	-

Summary for the year 1971

Maximum daily discharge, 338,000 c.f.s. on June 8.

Minimum daily discharge, 28,200 c.f.s. on January 7.

TABLE 2

MEAN DAILY DISCHARGE OF THE

FRASER RIVER AT MISSION, 1972

(Station No. 08MH024)

DAY	MARCH (c.f.s)	APRIL (c.f.s)	MAY (c.f.s)	JUNE (c.f.s)
1	44,500	91,000	114,000	416,000
2	42,900	93,300	122,000	429,000
3	42,600	93,500	126,000	443,000
4	41,600	93,900	128,000	459,000
5	38,600	95,600	133,000	462,000
6	49,800	105,000	142,000	455,000
7	51,100	110,000	152,000	440,000
8	47,700	110,000	158,000	432,000
9	44,400	110,000	165,000	447,000
10	44,300	107,000	170,000	469,000
11	50,300	104,000	175,000	470,000
12	52,600	100,000	184,000	463,000
13	57,500	96,500	205,000	466,000
14	65,000	91,600	234,000	471,000
15	66,500	89,200	261,000	485,000
16	68,000	86,600	289,000	502,000
17	77,900	84,600	307,000	507,000
18	85,100	84,000	317,000	490,000
19	89,800	83,500	311,000	469,000
20	91,500	82,000	303,000	456,000
21	92,700	81,500	308,000	436,000
22	107,000	82,200	315,000	410,000
23	132,000	81,200	319,000	392,000
24	132,000	80,700	324,000	386,000
25	117,000	81,800	332,000	382,000
26	113,000	82,900	341,000	380,000
27	106,000	84,400	343,000	374,000
28	102,000	89,800	345,000	370,000
29	97,900	97,300	355,000	367,000
30	94,600	105,000	375,000	366,000
31	91,900	-	400,000	-

Summary for the year 1972

Maximum daily discharge, 507,000 c.f.s. on June 17.

Minimum daily discharge, 25,600 c.f.s. on December 10.

TABLE 3

MEAN DAILY DISCHARGE OF THE

FRASER RIVER AT MISSION, 1973

(Station No. 08MH024)

DAY	MARCH (c.f.s)	APRIL (c.f.s)	MAY (c.f.s)	JUNE (c.f.s)
1	39,400	41,200	96,100	248,000
2	40,000	41,100	98,100	225,000
3	39,800	41,900	99,000	219,000
4	40,200	41,900	103,000	214,000
5	39,800	42,800	108,000	209,000
6	40,200	46,800	118,000	209,000
7	39,600	48,200	130,000	217,000
8	39,500	48,500	138,000	225,000
9	40,800	48,800	146,000	235,000
10	40,500	50,100	155,000	255,000
11	41,300	51,300	156,000	273,000
12	38,900	54,100	149,000	278,000
13	39,400	58,400	143,000	270,000
14	39,400	61,600	144,000	256,000
15	38,800	63,100	154,000	237,000
16	38,000	64,700	168,000	228,000
17	38,900	67,900	187,000	227,000
18	38,100	70,000	200,000	226,000
19	39,600	71,200	227,000	221,000
20	39,600	71,400	248,000	217,000
21	39,900	71,300	258,000	220,000
22	39,600	72,300	262,000	224,000
23	39,500	73,900	260,000	234,000
24	39,700	74,500	263,000	238,000
25	40,100	77,800	266,000	246,000
26	40,900	81,200	261,000	265,000
27	40,100	84,400	259,000	287,000
28	40,000	86,800	264,000	308,000
29	41,100	88,800	266,000	317,000
30	41,100	92,000	260,000	311,000
31	41,400		251,000	

Summary for the year 1973

Maximum daily discharge, 317,000 c.f.s. on June 29.

Minimum daily discharge, 34,800 c.f.s. on February 16.

TABLE 4

MEAN DAILY DISCHARGE OF THE

FRASER RIVER AT MISSION, 1974

(Station No. 08MH024)

DAY	MARCH (c.f.s)	APRIL (c.f.s)	MAY (c.f.s)	JUNE (c.f.s)
1	43,700	57,300	188,000	263,000
2	42,100	58,500	199,000	263,000
3	41,000	59,700	209,000	270,000
4	40,600	61,100	220,000	281,000
5	40,100	62,000	221,000	285,000
6	40,300	65,900	222,000	292,000
7	39,600	68,700	233,000	294,000
8	39,000	69,200	250,000	283,000
9	37,700	70,900	253,000	274,000
10	39,800	72,600	261,000	266,000
11	42,800	73,200	266,000	268,000
12	44,600	77,900	262,000	279,000
13	46,000	79,800	251,000	293,000
14	45,600	81,700	238,000	308,000
15	43,700	84,700	224,000	326,000
16	44,400	88,400	210,000	344,000
17	56,200	93,500	198,000	362,000
18	58,200	98,500	190,000	384,000
19	55,700	101,000	198,000	418,000
20	53,300	106,000	193,000	448,000
21	51,100	111,000	191,000	461,000
22	48,900	115,000	190,000	458,000
23	47,600	120,000	188,000	454,000
24	46,300	123,000	199,000	444,000
25	44,200	133,000	218,000	435,000
26	45,900	144,000	247,000	429,000
27	49,200	150,000	258,000	423,000
28	52,300	159,000	259,000	407,000
29	56,300	171,000	267,000	385,000
30	57,300	185,000	274,000	368,000
31	57,000	-	272,000	-

Summary for the year 1974

Maximum daily discharge, 461,000 c.f.s. on June 21.

Minimum daily discharge, 33,100 c.f.s. on January 7.

Maximum instantaneous discharge, 472,000 c.f.s. at 08:24 PST on June 21.

Drainage Area 88,100 $mile^2$

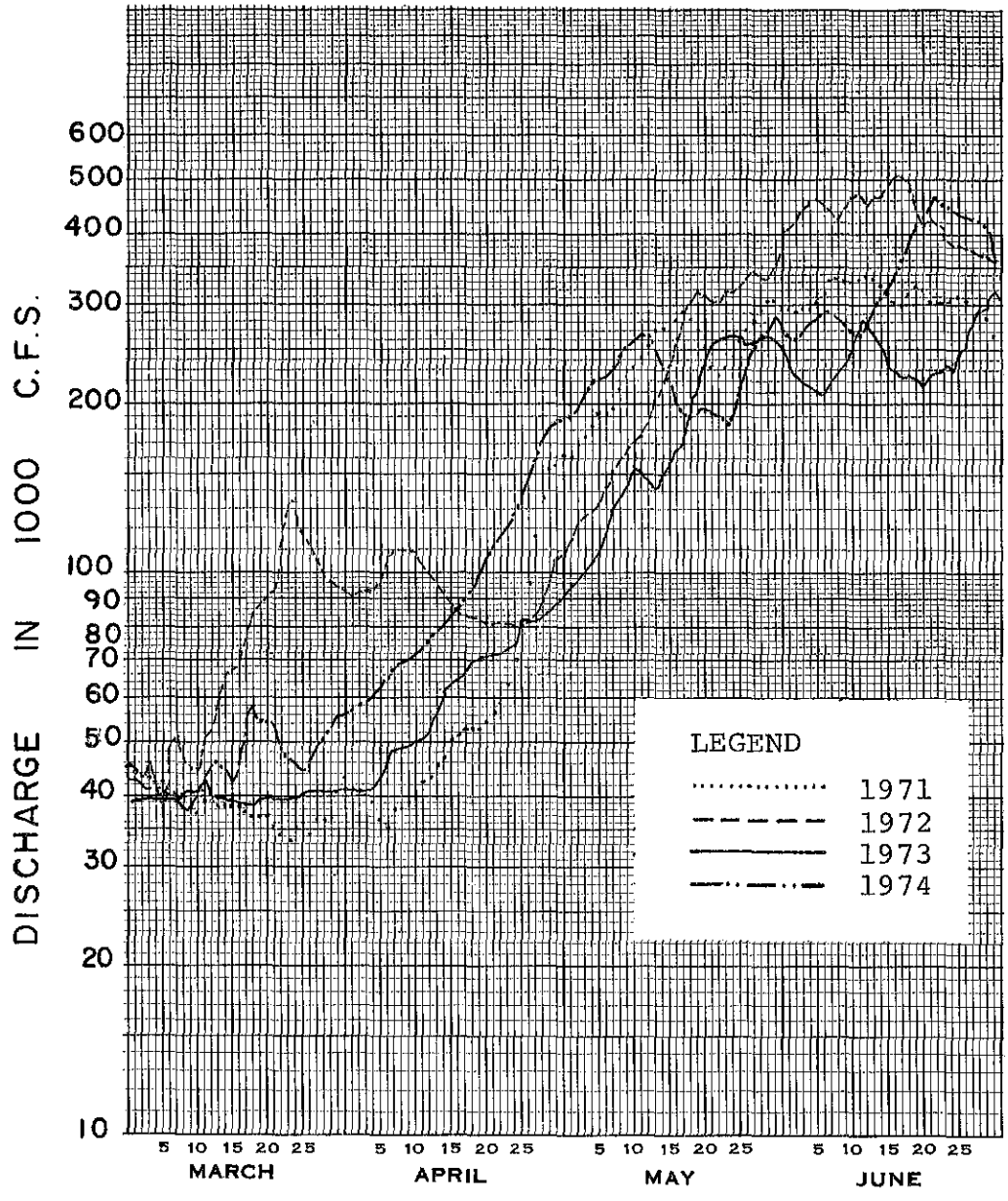

FIGURE 2

AVERAGE DAILY DISCHARGE OF THE FRASER RIVER AT MISSION, DURING CRITICAL FRY MIGRATION (MARCH TO JUNE), FOR THE YEARS 1971 TO 1974

1.2 NAVIGATION AND DREDGING

Taking into consideration the data presented on Figure 1, and the annual sediment load of 20 x 10^6 tons which is carried to an estuary subjected to tidal influences resulting in flow reversal, it becomes apparent that deepsea vessels may encounter draught restrictions during the period September to May of the following year, unless navigable channels are dredged to the necessary depth. The principal contingency controlling depth is the George Massey Tunnel, where the top of the concrete structure is 48 ft. below the local low water level. There is a 6-ft. thick rock blanket over the concrete surface. Allowing for a pilot safety clearance of 5 ft., the maximum attainable draught over the tunnel is 37 ft. The Fraser River Harbour Commission reports that their draught requirement increased from 28 ft. to 33 ft. between 1963 and 1970; and now they are projecting a 40-ft. draught requirement in the near future. The width of the channel over which this draught requirement applies, ranges from 650 ft. to 800 ft., depending on the degree of curvature of the reach under consideration.

Dredging on the lower Fraser River localized in the vicinity of New Westminster has been substantially reduced, due to a government-financed trifurcation project centred at the Annacis Sandspit. A series of dykes, pilings and rock training walls help to accelerate the flow at ebb tide and to carry the fines in suspension down to Sandheads. Investigations are currently underway to strengthen the river training works at Albion Dyke.

Public Works Canada has retained the services of the Western Canada Hydraulics Laboratory to conduct a model study of the lower Fraser River to establish the location and orientation of river training walls which would confine the

river and hence accelerate the flow at low tides. This more efficient transport of bedload and suspended sediment seaward will result in an annual reduction in maintainance dredging.

Annual maintenance dredging is normally carried out by Public Works Canada using their own dredges. The DPW "322" is an anchored suction pipeline dredge, employing a crew of 48, including those in the attending vessels "Keluk" and "Hussis", levee crews, welders and carpenters. The DPW "312", "Fort Langley", is a mobile hopper dredge which has a crew of 31.

Approximately 4×10^6 tons of sediment (most of which is sand), is dredged annually from the river channels in order to maintain the required navigation depth. Approximately 30% of this sediment is removed from the area adjacent to and downstream from Steveston. Much of the main channel from Annacis Sandspit to Deas Island is naturally self-scouring to depths required for navigation purposes. Dredge spoil picked up by DPW "312" from the river bed near St. Mungo Bend, Tilbury Reach and Steveston cut is dumped near the Sandheads at depths exceeding 40 ft.

1.3 In addition to annual dredging activities associated with the maintenance of the navigation channel by the Department of Public Works, there is an increasing amount of suction dredging activity by a number of private concerns such as Sceptre Dredging Ltd., Centennial Dredging & Sand Ltd., Dillingham Corporation, Island Sand Sales, Riparian Dredging, and others. Their dredging work involves sandborrow for the purposes of landfill and preloading; providing new facilities on the banks of the river for transport, storage and docks; and excavating trenches across the river bed for laying pipelines, etc.

1.4 DOWNSTREAM MIGRATION OF SALMON FRY AND SMOLTS

The Fraser River is British Columbia's most important salmon-producing river. The importance of the lower Fraser River as a passageway for migrant fish is well documented in existing Fisheries & Marine Service publications and most recently in a newsletter published by the Westwater Research Centre at U.B.C. (Northcote, T.G. 1974). The juvenile salmon begin their seaward migration coincident with the commencement of the annual spring freshet discharge about mid-March (Figure 1).

The age of the downstream migrants varies according to specie. Pink and chum fry begin their seaward migration immediately after they emerge from the gravel; the pink fry only in even-numbered years. When these fry arrive at the lower reaches of the river, they are between three to four cm in length and are generally carried by the river current. Eighty-five percent of the juvenile chinooks rear in fresh water for 60-90 days and the remaining 15% up to a year before migrating to the sea. Coho and sockeye juveniles rear in fresh water up to a year and migrate to sea as smolts. A very small percentage of the total population of coho and sockeye remain in fresh water up to two years before migrating to the sea.

Factors that influence the timing of fry migration include time of adult migration, temperature of air and water during incubation in the gravel, variation in water supply and the onset of spring freshet.

Although the migration period extends from the beginning of March through to the end of July, the bulk of the migrating population pass through the lower reach of the Fraser River between March 15 and June 1. The peak of migration occurs about mid-April. Peak migration during a 24-hr.

period for chum fry in 1974 was 10.4 million (May 1), while for pink salmon fry in the same year the migration was 9.6 million (April 5). Tables 5, 6 and 7 show the numbers of migrating chum, pink and chinook fry, timing of migration and peak daily total of migrant population. (Bailey, M. and Fraser, F.J., manuscript).

TABLE 5

ESTIMATES OF THE TOTAL CHUM, PINK AND CHINOOK SALMON FRY MIGRATING POPULATIONS IN THE FRASER RIVER, 1965-1975 (Based on Data Gathered at the Mission Sampling Site)

Year	Chum Fry	Pink Fry	Chinook Fry
1965	53,634,448	-	5,634,180
1966	23,435,824	125,562,336	20,561,456
1967	75,195,248	-	5,005,590
1968	69,006,464	218,229,328	17,521,936
1969	72,448,832	-	15,928,793
1970	107,435,520	263,037,088	40,749,392
1971	48,702,113	-	19,661,776
1972	58,156,928	94,823,808	13,446,810
1973	109,477,344	-	13,500,390
1974	130,777,696	265,789,456	16,427,324
1975	114,362,976	-	77,211,984

In addition to the downstream migration of chum, pink and chinook fry during the March-July period, an estimated 6.25 billion eulachon larvae, 1 million steelhead, 1.6 million chinook, 2.1 million coho and an estimated 45 million sockeye juveniles passed seaward through the lower Fraser River in 1974.

TABLE 6

MIGRATION TIMING OF CHUM, PINK AND CHINOOK FRY ON THE FRASER RIVER, 1965-1975

Salmon Fry	Year	Median of Population	Peak	Median of Duration
CHUM	1965	April 17	April 21	April 12
	1966	April 11	March 28	April 14
	1967	April 20	April 14	April 15
	1968	April 17	April 22	April 15
	1969	April 18	April 14	April 18
	1970	April 15	May 5	April 10
	1971	April 21	April 27	May 1
	1972	May 3	May 3	April 17
	1973	April 24	May 4	April 21
	1974	April 19	May 1	April 11
	1975	April 20	March 31	April 24
	Average	April 20	April 21	-
PINK	1966	May 2	May 4	April 18
	1968	April 24	April 27	April 14
	1970	April 24	March 25	April 10
	1972	May 5	May 3	April 17
	1974	April 16	April 5	April 10
	Average	April 26	April 19	-
CHINOOK	1965	April 10	April 5	April 14
	1966	March 31	March 14	April 11
	1967	April 12	April 14	April 25
	1968	April 5	April 15	April 14
	1969	April 19	May 5	April 20
	1970	April 8	April 2	April 15
	1971	May 4	April 28	April 30
	1972	May 7	May 5	April 28
	1973	April 29	May 4	April 25
	1974	April 15	May 3	April 16
	1975	April 17	April 4	April 20
	Average	April 17	April 17	-

TABLE 7

PEAK DAILY TOTALS OF CHUM, PINK, AND CHINOOK SALMON FRY AND FINGERLINGS MIGRATING PAST MISSION, 1965-1975

Year	Species		
	Chum Fry	Pink Fry	Chinook Fry
1965	4,486,619 (April 21)	-	455,389 (April 22)
1966	2,958,784 (March 28)	24,883,648 (May 4)	2,340,882 (April 6)
1967	5,090,325 (April 14	-	1,285,127 (April 14)
1968	5,978,844 (April 22)	43,238,464 (April 27)	1,079,340 (April 13)
1969	3,095,678 (April 12)	-	1,916,569 (May 5)
1970	5,327,303 (May 5)	25,767,760 (May 5)	3,043,706 (April 2)
1971	3,546,246 (April 27)	-	1,742,552 (April 28)
1972	5,655,698 (May 3)	6,791,965 (May 3)	2,155,682 (May 5)
1973	4,395,728 (April 13)	-	1,320,988 (April 12)
1974	10,400,000 (May 1)	9,600,000 (April 5)	-
1975	5,550,000 (March 31)	-	-

It should be noted that the preceding data represents only an estimate of the numbers of juvenile salmon migrating past Mission. Recent studies have documented that significant numbers of these migrants spend considerable time rearing and feeding in the lower reaches of the river, particularly those water areas characterized by reduced velocity, fine substrate and foreshore vegetation (Department of the Environment, Fisheries and Marine Service, 1975).

1.5 SUCTION DREDGING AND ITS IMPACT ON FISHERIES RESOURCE OF THE FRASER RIVER

The impact of suction dredging operations in the lower Fraser River on the salmon fisheries resource during downstream fry migration, may be categorized as follows:

(a) Alienation and/or destruction of rearing habitat due to:
   - (i) Physical removal of river bed material;
   - (ii) Deposition of dredged material in a
     - a. settling pond
     - b. perimeter dykes
   - (iii) Associated pollution problems leading to degradation of water quality;
   - (iv) Annihilation of benthic organisms which form a vital part of the food chain for rearing salmonids.

(b) The destruction of migrating salmon fry.

Excluding eulachon, pink and chum fry, because of their small size, are potentially the most vulnerable to the suction influence of a dredge pump. Juvenile coho, chinook, sockeye, trout, steelhead and eulachon must also be considered highly vulnerable. It is believed that when these fry are within the zone of influence of the cutter-

head, they are attracted into the suction pipe, passed through the pump and finally discharged over the spoil ground.

In 1971, observations by fishery officers, J. Bentley and V. Knoop, confirmed the presence of chum salmon fry in the suction dredge spoil pile drain during construction of the south bank approach fill of the Mission bridge across the Fraser River. Since this documented report, the Fisheries & Marine Service has implemented a dredge monitoring program to assess the degree of impact that suction dredges impart on the fisheries resource. To determine the probable magnitude of the problem, a controlled test involving fry captured by suction dredges was jointly undertaken by Public Works Canada and the Fisheries & Marine Service on May 10, 1974. Results indicated that for the site and operating conditions examined, a significant number of fry were buried in the spoil mass and did not reach the overflow pipes. A buried/recovered ratio of 22:1 was established from this test. These test results were applied during subsequent monitoring activities when assessing the impact of dredging on the fisheries resource.

Data presented in Sections 2, 3, 4, 5 and 6 of this report summarize the dredge monitoring activities from 1971 to 1975. A map of the program area is given in Figure 3.

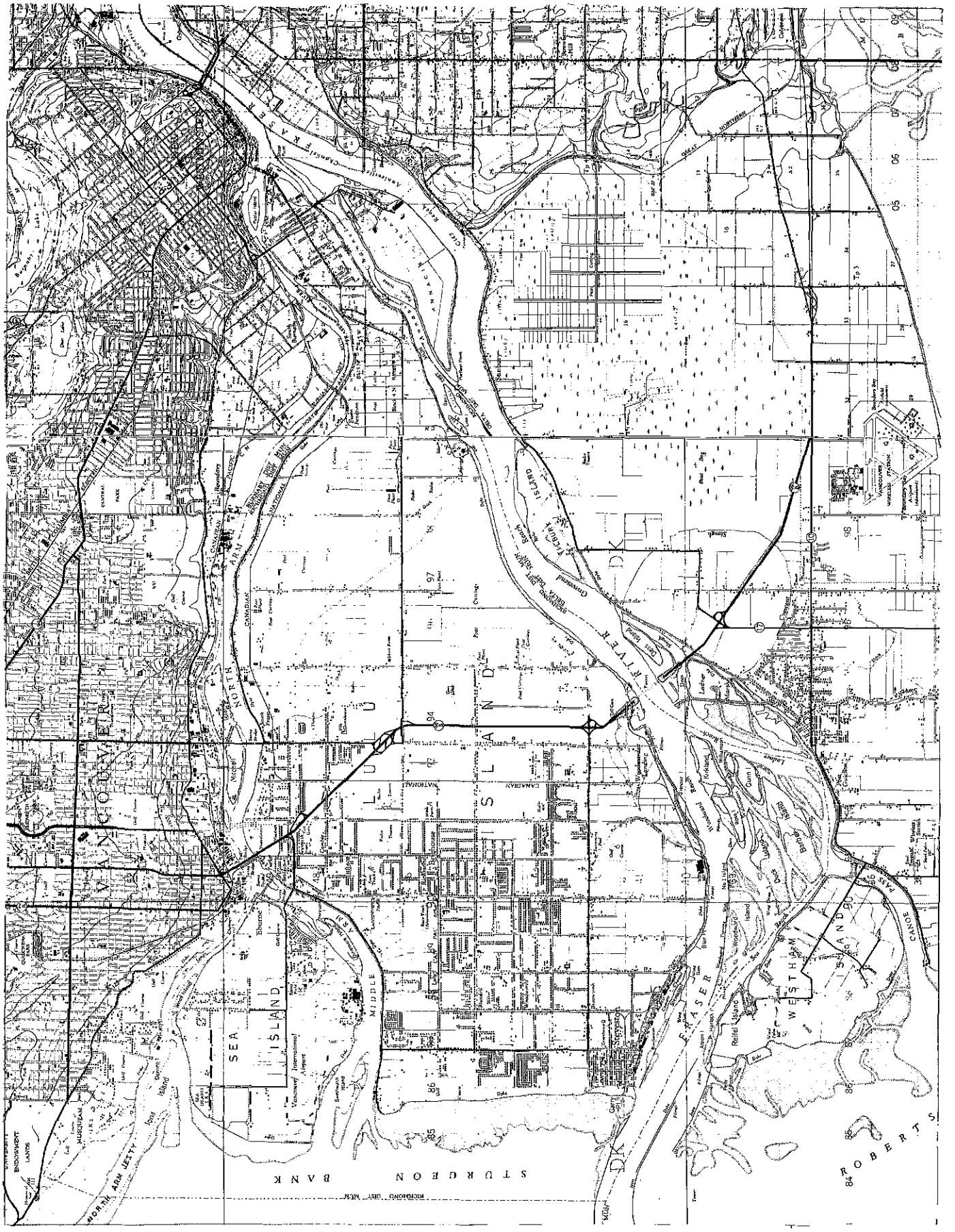

FIGURE 3: LOWER FRASER RIVER FROM PATTULLO BRIDGE TO ITS MOUTH

2. DREDGE MONITORING - 1971

2.1 SCEPTRE DREDGING AT MISSION

(a) Location

Mission, B.C., Fraser River, Bridge Project No. 528, Mission Bridge Contract No. 15, construction of South Bank approach fill for the bridge.

(b) Owner of Dredge

Sceptre Dredging Ltd.,
1443 River Road, Richmond, B.C.
Telephone 273-5521

(c) Description of Dredge

"Sceptre Fraser" - Hydraulic Cutter Suction Dredge.
Discharge Dia.: 26 in.
Hull Size: 161 ft x 34½ ft x 7 ft.
Power on Pump: 3,200 hp Diesel.
Aux. Power: 1,400 hp.
Max. Digging Depth (present): 115 ft.
Max. Production/hr: 1,500 yd^3.
Max. Pumping Distance: 8,000 ft (average material).
Max. Pumping Distance: 12,000 ft (light materials).
Year Built: 1966.

(d) Dredging Period

Not available.

(e) Monitoring Results

Visual observations of the runoff water and area between the fill site and the flood control dyke revealed the presence of salmon fry.

(f) Observers

J. Bentley, Fishery Officer, Fisheries Service
V. Knoop, Fishery Officer, Fisheries Service

3. DREDGE MONITORING - 1972

3.1 SCEPTRE DREDGING AT MISSION

(a) Location

Mission, B.C., Fraser River, Bridge structure No. 2439, an approach and exit ramp for the new Mission Bridge. The dredge worked in an area approximately 300 ft x 1,000 ft long for each structure. Spoil water was returned to the Fraser River via Lane Creek.

(b) Owner of Dredge

Sceptre Dredging Ltd.,
1443 River Road, Richmond, B.C.
Telephone 273-5521

(c) Description of Dredge

"Sceptre Fraser" - Hydraulic Cutter Suction Dredge.
Discharge: 26 in. Diameter.
Hull Size: 161 ft. x 34½ ft. x 7 ft.
Power on Pump: 3,200 hp Diesel
Aux. Power: 1,600 hp Diesel/Electric
Cutter Power: 1,400 hp.
Max. Digging Depth (present): 115 in.
Max. Production/hr: 1,500 yd^3.
Max. Pumping Distance: 8,000 ft. (average material).
Max. Pumping Distance: 12,000 ft. (light materials).
Year Built: 1966
Discharge: 30-in. diameter.
Velocity: 16 ft/sec.
Percent Solids: Varied - 5% to 20%, depending on the type of fill being pumped.
Depth of Cut: Operating at an average depth of 25 ft. below local low water.

(d) Dredging Period

The dredge worked three 8-hr. shifts per day during April 10 to April 20, 1972.

(e) Monitoring Method

Monitoring of the operation began on Tuesday, April 11, 1972. After initial observations the monitoring program was conducted in three phases:

(i) Visual observations of spoil outflow

(ii) Visual observations of the slough area, the fill area, and the flood control dyke.

(iii) Monitoring of at least one of the two discharge overflow pipes using an 18-in. diameter marquisette dip net. Sampling times were varied to include all shifts of operation.

(f) Observers

R. Elvidge, Technician, Habitat Protection Unit
B. Leishman, Casual employee, " " "
D. Derkson, Technician, " " ".

3.1.1 Observations

Due to the amount of debris passing through the outflow pipe, continuous sampling was impossible. The net was removed and emptied of debris for two minutes out of every five-minute period. In an 8-hr. period, actual fishing time using nets was three hours.

Wednesday, April 12, 1972

a. Sampling with net - no observations
b. Spillout area - 2 crayfish

Thursday, April 13, 1972

No fish observed or caught. Total sampling time using net - 60 min.

Friday, April 14, 1972

Three lamprey. Total sampling time using net - 103 min.

Saturday, April 15, 1972

No sampling.

Sunday, April 16, 1972

No dredging - no monitoring.

Monday, April 17, 1972

Eleven lamprey, 4 sculpin, 1 catfish, 1 sturgeon, 3 pink fry, 1 chum fry.
(Night sampling was attempted between 23:00 and 24:00 hr. Insufficient light resulted in the loss of one net and made it impossible to obtain reliable observations of possible fry content.)

Total sampling time using net - 15 min.

On the basis of the monitoring observations, Sceptre Dredging was asked to shut down operations until the fry migration period had been completed.

3.2 SCEPTRE DREDGING AT TILLICUM STREET

(a) Location

The dredging operation was situated in the North Arm of the Fraser River at the foot of Tillicum Street. Pumping depth was to 25 ft. below local low water level. The spoil water drained into and flooded several acres of field on the western edge of the fill area. From there, it was re-introduced into the Fraser River via two ditches and a number of drainage pipes installed in a flood control dyke.

(b) Owner of Dredge

Sceptre Dredging Ltd.,
1443 River Road, Richmond, B.C.
Telephone 273-5521

(c) Description of Dredge

Type: Hydraulic Suction Pipeline.
Intake: 26-in diameter.
Discharge: 30-in. diameter.
Velocity: 16 ft/sec.

Percent Solids: 15% to 20% depending on the type of material being pumped.

Depth of Cut: Operating at a depth 25 ft. below local low water level.

(d) Dredging Period

The dredge worked three 8-hr. shifts per day for six days, May 8 to May 13, 1972.

(e) Monitoring Results

Date	Actual Sampling Time	No. of Salmon Fry Caught	Estimated Fry Capture (Total Flow & Time + Burial)
May 9	-	0	-
May 10	4 hr. 5 min	13	16,800
May 11	8 hr. 5 min	30	19,600
May 12	8 hr. 15 min	67	43,000
May 13	7 hr. 20 min	63	45,400
	TOTAL	173	124,800

(f) Observer

R. Elvidge, Technician, Habitat Protection Unit.

3.2.1 Observations

A total of 120 hrs. of pumping time was logged between May 9, 1972 and May 13, 1972. Of this total, 27 hrs. and 45 minutes were monitored at 10% of the total volume of dredge material pumped between those periods.

Several hundred eulachon and one pink salmon fry were observed in the fill site. The majority of the eulachons were seen at the spill site, and their number decreased as dredging progressed. The eulachons were

determined as being spawned out, the majority already being dead when observed. To ensure that only spawned eulachons were in the dredging area, on May 9 a 50-ft gillnet was set approximately 100 yards upstream from the dredge. Over a 1½-hr period, three sets were made and a total of eight spawned eulachons were taken, several of which were dead.

It should be noted that only one pink salmon fry was found on the spoil site on May 12, 1972. It had been decapitated and was floating in a swath of debris in the north-west extreme of the fill site. This indicates that a number of unobserved salmon fry were buried in the spoil area.

3.3 CENTENNIAL DREDGING AT TRIMAC - DEAS ISLAND

(a) Location

The dredging operation was situated on the main arm of the Fraser River in the vicinity of Deas Island.

(b) Owner of Dredge

Centennial Dredging & Sand Ltd.,
1240 No. 5 Road, Richmond, B.C.
Telephone 277-3131

(c) Description of Dredge

Type: Hydraulic Suction Pipeline.
Intake: 16-in. Diameter
Discharge: 18-in. Diameter
Discharge: Approximately 100 yd^3 of sand per hr.

(d) Description of Monitoring

The operation consisted of two shifts per day from 06:00 to 22:00 hr.

(e) Observations

May 24, 1972

A total of six observations were made with each observation lasting 10 minutes. One hundred percent of the flow was monitored during these observations using an 18 inch diameter marquisette net. Monitoring began at 13:00 hrs. No specimens were obtained from all of the six observations.

May 26, 1972

Monitoring began at 12:00 hrs. and lasted until 14:00 hrs. No specimens were obtained.

3.3.1 OBSERVATIONS DURING CENTENNIAL DREDGING AT TRIMAC - DEAS ISLAND

The operation consisted of a large reservoir with no direct flow to the spoil drain. This may have enabled the fry to remain in the reservoir without being observed at the monitoring station.

3.4 DEPARTMENT OF PUBLIC WORKS DREDGING - ANNACIS CHANNEL

(a) Location

Annacis Channel in the Fraser River.

(b) Owner of Dredge

Public Works Canada (D.P.W.)

(c) Description of Dredge

Type: Dredge Pump - DPW "322"

Pump Size: Centrifugal type, 62-in. impeller.

Diameter of Suction: 24 in.

Diameter of Discharge: 20 in.

Power: 1,550 B.H.P.

Cutterhead R.P.M.: Maximum 375

Depth: Maximum 45 ft.

Suction Distance from Cutterhead to Pump: 103 ft.

Velocity of Fluid within Pipeline: 14.3 ft/sec. with 5,000 ft. Pipeline & 30-ft. Static Head.

Quantity: 13,500 U.S. gal/min. at S.G. 1.2 with 5,000-ft. Pipeline at 375 R.P.M.

N.B. The velocity and quantity of fluid within the pipeline was subject to change dependent upon alteration to pipeline length and pump speed.

(d) Description of Monitoring

May 25, 1972

Two 18-in. diameter marquisette dip nets were used to monitor the outflow pipes at the spoil drain. Six observations were made, each of 10 min. duration from 15:00 hrs. Approximately 30% of the flow was screened.

3.4.1 Observations

Observation	Results
#1	2 Sticklebacks
#2	1 Stickleback
#3	1 Stickleback
#4	nil
#5	nil
#6	nil

There was no evidence of salmon fry being entrained by the dredge.

4. DREDGE MONITORING - 1973

Nineteen seventy-three was an off year for the pink salmon fry migration. For this reason, only spot checks were made on operating dredges to determine the presence of chum fry.

4.1 DEPARTMENT OF PUBLIC WORKS DREDGE "FORT LANGLEY"

(a) Location

Steveston Cut, Main Arm of the Fraser River.

(b) Owner of Dredge

Public Works Canada (D.P.W.)

(c) Description of Dredge

Name: "312" (Fort Langley).
Built: 1961.
Reg. Tonnage: 717.08 tons.
Gross Tonnage: 1,787.94 tons.
Length: 226.5 ft.
Beam: 45.1 ft.
Depth: 19.1 ft.
Power: 3,600 h.p.
Suction Pipe: 25 inches.
Discharge Pipe: 21 5/8 inches.
Hopper Capacity: 1,330 yds^3.
Type: Mobile, Hopper, Hydraulic Suction.
Discharge: Two rectangular openings on the side of the ship.

(d) Description of Monitoring

April 26, 1973

The following is a resume of R. Elvidge's observations while monitoring on board the "Fort Langley". Monitoring commenced at 09:00 hrs. and continued until 15:00 hrs. During dredging the hopper overflow was monitored intermittently using an 18-inch diameter marquisette net. The number of commercially valuable fish that passed through the dredge over a five-hour operating period was extrapolated to 120 chum fry and 240 eulachons. In conjunction with the monitoring, visual inspection accrued a count of 29 eulachons.

The monitoring was performed on the port and starboard hopper spillways, which consisted of two 12-foot openings. These openings maintained a mean depth at the spill crest of 1 foot during normal operations.

(e) Observations

Based on a cross-sectional area at the above point, 1 ft^2 of flow was screened with a No. 281 marquisette net, for a total of 50 min. out of a total of five operating hours. The extrapolated catch from 1 ft^2 of the 24 ft^2 cross-section, including a time factor, is shown below:

a. Eulachons:

2 eulachons were captured in the monitor net during a 60 minute period.

$$2 \text{ eulachons} \times \frac{5 \text{ hr}}{1 \text{ hr}} \times \frac{24 \text{ ft}^2}{1 \text{ ft}^2} = 240 \text{ eulachon}$$

Therefore, 240 eulachon would have been caught in a 5-hour period.

b. Chum salmon fry:

One chum salmon fry was caught in the net during a 60-minute period.

$$1 \text{ chum} \times \frac{5 \text{ hr}}{1 \text{ hr}} \times \frac{24 \text{ ft}^2}{1 \text{ ft}^2} = 120 \text{ chums}$$

Therefore, 120 chum fry would have been caught by the dredge in a 5-hour period.

In addition to this assessment, the number of fish lost in the dredgeate should be considered. Although no satisfactory method of monitoring this segment of the operation was derived, it should be noted that a further 29 eulachons were observed. The majority of the eulachons were recovered from the punched grills located between the intake troughs and the hoppers. These eulachons were removed whenever possible during shutdowns. During pumping an undetermined number of eulachons were observed impinged on various portions of the structure within the hoppers. These eulachons were not included in the total as they could have remained impinged and thereby been recounted erroneously. See Table 8 for data breakdown of eulachon recovered.

TABLE 8

EULACHON RECOVERED DURING
"FORT LANGLEY" DREDGING, APRIL 1973

Location	No. of Fish	No. Dead	No. Alive	Remarks
Monitor Net	2	0	2	Unspawned females damaged.
Grill	19	19	0	Six unspawned.
Hopper	5	5	0	Damaged
Dragger Heads	5	5	0	Damaged

Several thousand lamprey ammocoete were passed through the dredging system along with an undetermined amount of sculpins. One 24-in. dead sturgeon was observed being ejected through the spillway.

4.2 DEPARTMENT OF PUBLIC WORKS DREDGING
- NORTH ARM OF THE FRASER RIVER

(a) Description of Monitoring

The DPW "322" suction hydraulic pipeline dredging operation was monitored on May 13, 1973. The dredge was in operation 500 yds. downstream from the Oak Street Bridge. Only one sample was taken using an 18-inch diameter marquisette net. Crago shrimp were observed.

4.3 DEPARTMENT OF PUBLIC WORKS DREDGING
AT STEVESTON

The DPW hopper dredge was monitored on May 13, 1973. The dredge was in operation at the Steveston Cut in the main arm of the Fraser River. Only one sample was taken at the spoil overflow using an 18-inch diameter marquisette net. Crago shrimp were observed.

4.4 DEPARTMENT OF PUBLIC WORKS DREDGE
"FORT LANGLEY" AT LADNER REACH CONFLUENCE

(a) Location

Fraser River, confluence of Ladner Reach and the Main arm at Buoy #27.

(b) Owner of Dredge

Public Works Canada,

(c) Description of Dredge

Name: "Fort Langley"

Type: Mobile, Hopper, Hydraulic Suction.

Intake: Hopper, two rectangular dragger heads.

Discharge: Two, 12 ft^2 openings on each side of the vessel.

(d) Description of Monitoring

The "Fort Langley" was boarded at 10:30 hrs., June 4, 1973. Three samples of 3-minutes duration each were taken. No aquatic life was observed.

4.5 DEPARTMENT OF PUBLIC WORKS DREDGER "322" AT FRASER - SURREY DOCKS

(a) Location

Fraser River, left bank at the Fraser - Surrey docks.

(b) Owner of Dredge

Public Works Canada

(c) Description of Dredge

Name: "322"

Type: Hydraulic Suction Pipeline

Intake: 24-inch diameter

Discharge: 20-inch diameter.

(d) Description of Monitoring

Two samples were taken at the spoil drain using an 18-inch diameter marquisette dip net on June 4, 1973. No aquatic life was evident. The spoil area was traversed by foot for a closer examination, but no samples were obtained. The spoil area was approximately 200 feet wide by 1,000 feet long.

4.6 CENTENNIAL DREDGING AND SAND LTD. AT THE MAIN ARM OF THE FRASER RIVER

(a) Location

Fraser River, Main Arm, 500 yards downstream from the B.C. Ferry repair yard.

(b) Owner of Dredge

Centennial Dredging & Sand Ltd.,
1250 No. 5 Road,
Richmond, B. C.

Telephone 277-3131.

(c) Description of Dredge

Name: Centennial No. 2

Type: Hydraulic Suction Pipeline

Intake: 20-inch diameter

Discharge: 16-inch diameter.

(d) Description of Monitoring

Three observations were made at the spoil drain on June 8, 1973. Observations were made using an 18-inch diameter marquisette dip net. No visible traces of aquatic life were observed.

Two samples were carried out at the spoil drain on June 15, 1973, but no aquatic life was observed. The spoil area was also traversed by foot to complete a visual inspection.

Several samples were taken at the spoil drain on June 21, 1973, but again no aquatic life was evident.

4.7 SCEPTRE DREDGING LTD., DREDGE "SCEPTRE FRASER" AT THE MAIN ARM OF THE FRASER RIVER

(a) Location

Buoy 32, Main Arm of the Fraser River.

(b) Owner of Dredge

Sceptre Dredging Ltd.,
1443 River Road, Richmond, B.C.

Telephone 273-5521.

(c) Description of Dredge

Name: "Sceptre Fraser"

Type: Hydraulic Suction Pipeline

Intake: 26-inch diameter

Discharge: 30-inch diameter

Velocity: 16 ft./sec.

(d) Dredging Period

July 3 to July 18, 1973.

(e) Description of Monitoring

Several observations were made at the spoil drain on July 4, 1973 using an 18-inch diameter marquisette dip net. No evidence of aquatic life was observed.

4.8 CENTENNIAL DREDGING AND SAND LTD., AT NICOMEN SLOUGH ON THE FRASER RIVER

(a) Location

Nicomen Slough, western end of the slough, approximately 300 yards upstream from the confluence of the Fraser River.

(b) Owner of Dredge

Centennial Dredging & Sand Ltd.,
1250 No. 5 Road,
Richmond, B. C.

Telephone 277-3131.

(c) Description of Dredge

Name: Centennial No. 2

Type: Hydraulic Suction Pipeline

Intake: 16-inch diameter

Discharge: 18-inch diameter

Discharge: Approximately 100 yd^3 of sand per hour.

(d) Monitoring Results

On August 29, 1973 three observations were made at the spoil drain using an 18-inch diameter marquisette dip net. All observations failed to show any evidence of aquatic life.

5. DREDGE MONITORING - 1974

1974 was a pink salmon fry migration year. For this reason emphasis was placed on sustained monitoring rather than infrequent spot checks. During this fry monitoring period, Fisheries & Marine Service began to work in closer co-operation with Public Works Canada to determine the effects of suction dredging on salmon fry.

5.1 SCEPTRE DREDGING LTD., IN THE NORTH ARM OF THE FRASER RIVER

5.1.1 Monitoring Using Experimental Dredge Spoil Holding Tanks

(a) Location

North Arm of the Fraser River in Channels 9, 10, 11, 12 and 13. (See Figure 3).

(b) Owner of Dredge

Sceptre Dredging Ltd.,
1443 River Road,
Richmond, B. C.

Telephone 273-5521.

(c) Description of Dredge

Intake: 26-inch diameter

Discharge: 26-inch diameter

Power on Pump: 3,200 hp diesel

Aux. Power: 1,600 hp diesel/electric

Cutter Power: 1,400 hp.

Max. Digging Depth: 115 feet.

Max. Production per Hour: 1,500 yd^3.

Max. Pumping Distance: 8,000 ft. (average materials).

Max. Pumping Distance: 12,000 ft. (light material).

(d) Monitoring Method

An experimental technique developed by Mr. F. Braun was used by Public Works Canada and Sceptre Dredging Ltd., during monitoring observations between March 20

and April 16, 1974 in the North Arm of Fraser River at the foot of No. 6 Road.

Since a method had not yet been developed to permit sampling of the true discharge mass, i.e., solids and water, the cutterhead was lifted approximately four to five feet from the river bottom so that clear water could be pumped and held in a separately contained area located on shore. This separately contained area consisted of two cylindrical tanks, each 13 feet high, with a combined holding capacity of about 16 thousand gallons. The holding tanks were placed side by side, about 7 feet apart.

The tanks were connected by a trough to accommodate the overflow from one holding tank to the other. The first tank received the initial discharge from the discharge pipe which then ultimately flowed into the second via the tank trough.

Sampling of the discharge (water only) was achieved by installing an 8-inch diameter valve-controlled drain at the bottom of the second tank. Attached to the valve outlet was a 6-inch diameter manifold 6 feet in length. Six 3-inch diameter drain holes were cut into the manifold, thus the flow could be released at a regulated rate over a horizontal screen covered with marquisette netting. Approximately one minute's volume of clear dredgeate could be screened in this manner.

Between March 27 and March 31, 1974 nine tests were conducted. In all of these tests no evidence of salmon fry was observed on the screen.

On April 16, four consecutive tests were conducted using the tanks - no fry were seen.

(f) Comments on Experimental Tests

The test was considered inadequate for the following reasons:

(i) Assuming a dredge plant efficiency of 66.6%, which equals a total of over 19 million gals. per 16-hour day, each tank test represents only 0.08% of the total volume of pumped water.

(ii) Only clear water was pumped, which was not representative of the actual composition of the dredgeate.

(iii) The water was pumped at pump-idle speed. This reduced water velocity may have decreased the zone of influence around the cutterhead which, under non-experimental conditions, would have engulfed the fish.

5.2 DEPARTMENT OF PUBLIC WORKS, DREDGE "322" AT FRASER-SURREY DOCKS

5.2.1 Monitoring Using Commercial Eulachon Fishing Equipment

(a) Location

Fraser River, Fraser-Surrey Docks.

(b) Owner of Dredge

Public Works Canada

(c) Description of Dredge

Name: DPW "322

Type: Hydraulic Suction Pipeline

Intake: 24-inch diameter

Discharge: 20-inch diameter

(d) Monitoring Results

On April 10, 1974 an inspection was made of the DPW dredge at the Fraser-Surrey docks. The dredge was operating behind the trifurcation walls, and had a submerged spoil pipe discharging directly into the Fraser River.

One chum salmon fry was netted in the immediate proximity of the discharge pipe; however, it was impossible to determine if the chum fry had passed through the dredge. A further observation was made upstream from the trifurcation wall but in line with

the dredge, where two salmon fry were netted. Three more salmon fry were netted in the immediate proximity of the cutterhead, to bring the total capture to six salmon fry. This indicated that the fish were possibly schooling behind the trifurcation wall; but it was impossible to detect, at this time, whether the fish were being engulfed by the dredge.

On April 22, 1974, an experienced commercial fisherman was hired to fish for eulachon in the immediate vicinity of the operating dredge. During a 5-minute set just upstream of the dredge, 800 eulachon were caught. A further test set was made on April 23, 1974, in the vicinity of the spoil discharge. Three bruised eulachon were recovered. Also, on April 23, 1974, an attempt was made to monitor the spoil outflow using a tow net. This proved unsuccessful because the net, caught by the strong discharge current, was ripped after several tests. The results of the tests done on April 23, 1974, are as follows:

TABLE 9

FISH SPECIMENS CAPTURED DURING DPW "322" DREDGING AT FRASER-SURREY DOCKS (April 22 and 23, 1974)

Sample Number	Time	Specimens Captured	Eulachon Adult	Damaged Eulachon	Pink Fry	Lamprey Ammocoete
1	17:58-18:00	100	97	3	-	-
2	18:00	3	-	-	1	2
	TOTALS	103	97	3	1	2

Method of Sampling

Sample No. 1 (April 22, 1974) The sample was taken in a commercial gillnet approximately 100 feet long.

The net was located 10 feet upstream from the discharge pipe, which was terminated 10 feet

below water surface. The tide was full and backing slightly.

Duration of test: Five minutes.

Sampling time: Two minutes.

Sample No. 2 (April 23, 1974)

The sample was taken by lowering a 4-foot diameter hoop tow net under the discharge outlet. The sampling period was instantaneous.

The discharge line terminated 100 feet below the surface in the main channel.

Further monitoring was conducted at this site from May 6, 1974 to May 9, 1974, when the spoil discharge was relocated to the easterly tip of Annacis Island. The monitoring results are shown in Table 10.

TABLE 10
(page 1 of 2)

RESULTS OF FRY MONITORING IN THE VICINITY OF THE FRASER-SURREY DOCKS
(May 6 to May 9, 1974)

Date	Sample Number	Time	Number of Fish Netted	Sample Site	SPECIES					
					Pink Fry	Chum Fry	Sockeye Fry	Spring Fry	Eulachon	Others
May 6	1	14:55-14:60	3	Walked spoil		None	None	None	3	
	8	15:50-15:55	2	Walked spoil					2	
May 7	4	08:25-04:45	2	Walked spoil					2	
	5	08:45-03:00	2	Walked spoil					2	
	8	09:15-09:30	1	Drain	Alive					
	10	09:40-10:35	2	Drain		None	None	None	2	
	11	10:35-10:45	1	Drain					1	
	16	12:01-10:16	1	Drain					1	
	17	12:15-12:50	15	Walked spoil					15	
	19	13:03-13:23	1	Drain					1	
	20	12:45-12:50	2	Drain					2	
	22	14:45-14:52	3	Drain	Alive				2	
	52	13:35-13:43	43	Mini-pile					43(8 min)	
May 8	29	10:55-11:05	1	Drain					1	
	31	11:20-11:30	1	Drain	Alive					
	40	13:30-13:45	11	Spoil area		None	None	None	11	
	46	14:50-15:00	24	Spoil area					24	
	49	15:45-16:00	2	Drain					2	
	50	10:55-11:10	25	Spoil area					25	
	51	10:35-10:50		Spoil area					5	
	53	09:41-09:49	12	Mini-pile	1 Dead				10	1 Sturgeon.

1 Net Area = 1.8 ft^2
% of Net Fishing = 80% (1.4 ft^2)
No. of Drains = 3
Dia. of Drains = 2.2 ft^2 x 3 = 6.6 ft^2

% Flowing Full 100%
% of Flow Monitored 21.1%
% of Time Flow Monitored 80%

(Continued overleaf)

TABLE 10
(page 2 of 2)

Date	Sample Number	Time	Number of Fish Netted	Sample Site	SPECIES					
					Pink Fry	Chum Fry	Sockeye Fry	Spring Fry	Eulachon	Others
May 9	2	08:25-08:45	3	Drain	1					2 Sturgeon
	4	08:50-09:00	5	Spoil					5	
	5	09:13-09:33	1	Drain	1					
	6	09:37-09:57	2	Drain	1					1 Flounder
	7	10:00-10:20	1	Drain	1					
	8	10:23-10:43	1	Drain					1	
	10	11:07-11:27	1	Drain		N	N	N	1	
	11	11:29-11:50	1	Drain		o	o	o	1	
	14	12:34-12:54	1	Drain		n	n	n	1	
	15	12:55-13:15	1	Drain	1	e	e	e		
	19	14:20-14:40	3	Drain					2	1 Flounder
	22	15:20-15:40	1	Drain	1					
	24	16:00	5	Spoil					5	
	30	16:00-16:20	1	Drain	1					
	27	09:50-10:00	6	Spoil					6	
	28	11:40-11:50	6	Spoil					6	
	29	14:50-15:00	16	Spoil					16	
	26	- -	3	Mini-spoil	1				2	

3 Nets @ 1.8 ft^2 each (5.4 ft^2 total)

% of Net Fishing = 80% (4.32 ft^2

No. of Drains = 3 Area of Drains = 2.2 ft^2 x 3 = 6.6 ft^2

% Flowing Full = 100%

% of Flow Monitored = 65.4%

% of Time Flow = 93%

5.2.2 Monitoring Combined with Fry Burial Test

A fry monitoring test was conducted on May 10, 1974, at the Fraser-Surrey Dock site. A recorded number of fry were introduced into the dredge and an attempt was made to recover them at the spoil area drain. Three separate tests were conducted, two on a miniature spoil site and one on the normal spoil site. Results obtained indicated that for every fry caught at the spoil drain, 22 were buried in the spoil mass. In addition, of the total number of fry introduced into the dredge, 98.8% were killed, (Dutta, L.K., Sookachoff, P., 1975).

Due to the freshet condition of the Fraser River, the discharge pipeline could not be maintained in its correct position in the swift current. For this reason, dredging operations were interrupted while a new spoil site was located on the Surrey side of the river. Monitoring at this site resumed on May 16, 1974. Table 11 summarizes the daily results.

TABLE 11

MONITORING RESULTS DURING FRY
BURIAL TEST - MAY 16 TO MAY 27, 1974

Date (1974)	Monitoring Time	% Flow Monitored	Remarks
May 16	165 min.	10%	1 lamprey, 1 live flounder
May 17	210 min.	20%	3 lamprey, 3 live flounders
May 21	120 min.	10%	3 lamprey, 1 live flounder
May 22	325 min.	10%	13 lamprey
May 23	120 min.	10%	No catch
May 24	300 min.	10%	No catch
May 27	220 min.	10%	No catch

5.3 SCEPTRE DREDGING LTD., AT FOOT OF NO. 10 ROAD, ANNACIS CHANNEL

(a) Location

Foot of No. 10 Road, Annacis Channel. (See Figure 4).

(b) Owner of Dredge

Sceptre Dredging Ltd.,
1443 River Road, Richmond, B.C.

Telephone 273-5521.

(c) Description of Dredge

Name: "Sceptre Fraser".

Type: Hydraulic Suction Pipeline.

Intake: 26-inch diameter.

Discharge: 26-inch diameter.

Power on Pump: 3,200 hp diesel.

Aux. Power: 1,600 hp diesel/electric

Cutter Power: 1,400 horse power.

Max. Digging Depth: 115 feet.

Max. Production/hour: 1,500 yd^3.

Max. Pumping Distance: 8,000 feet (average materials)

Max. Pumping Distance: 12,000 feet. (light materials)

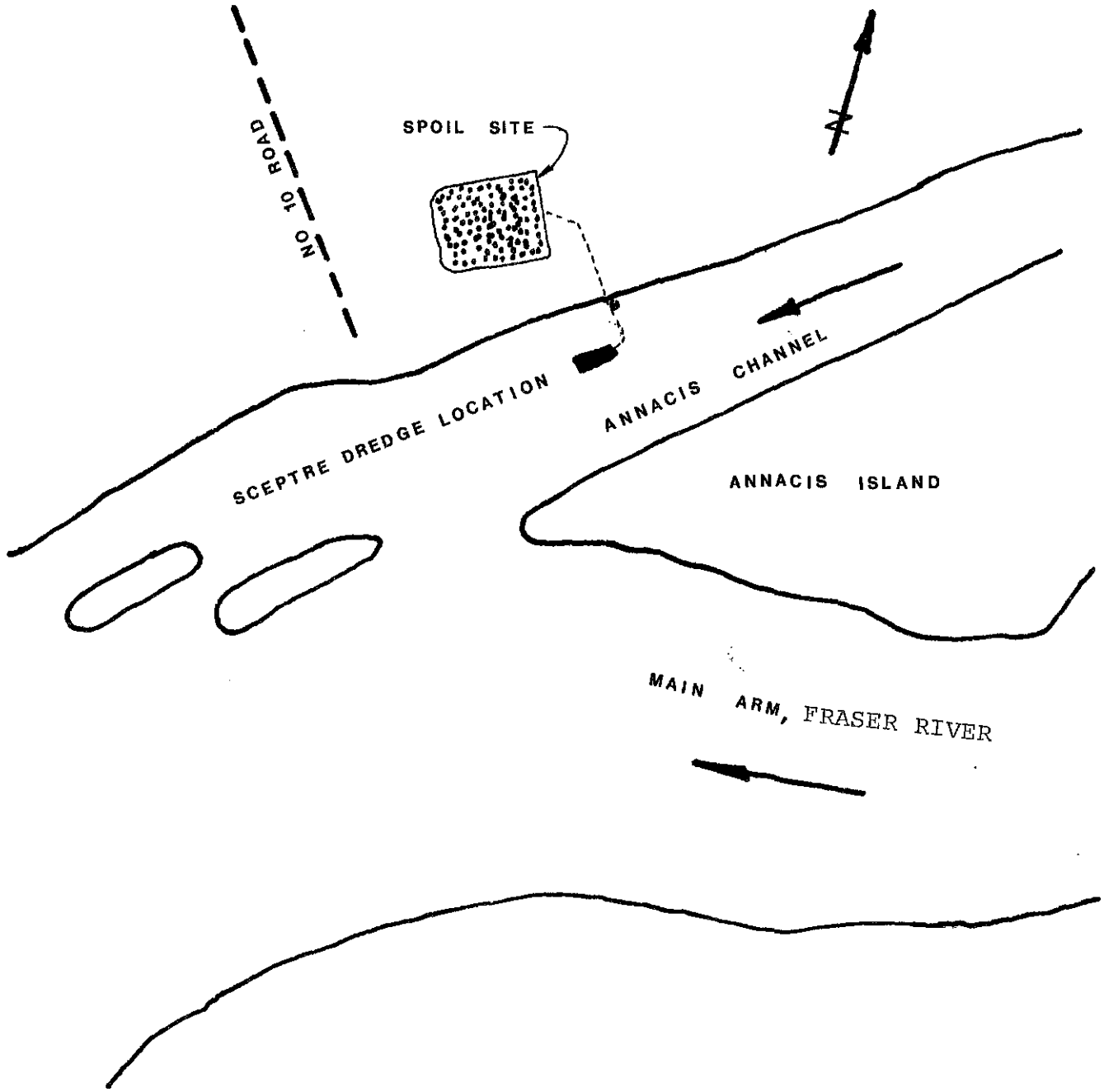

FIGURE 4

LOCATION OF SCEPTRE DREDGING
IN ANNACIS CHANNEL

(d) Monitoring Results

Monitoring commenced on April 24, 1974 using an 18-inch diameter marquisette dip net at the spoil overflow drain. Of the total outflow, 8.25% was screened as is shown in the following calculation:

(i) Area of the Net: $\frac{3.14\ D^2}{4}$

$$= \frac{3.14 \times 1.5^2}{4}$$

$$= 1.8\ ft^2.$$

where D represents the diameter of the net.

Screening Area: 75% of the net was screening water:

Effective area of net = $0.75 \times 1.8\ ft^2$.

$$= 1.32\ ft^2.$$

(ii) Area of Discharge: 8 ft. wide x 2 ft. deep

$$= 16\ ft^2$$

Percentage of total area sampled $= \frac{1.32\ ft^2}{16\ ft^2} \times 100$

$$= 8.25\%$$

The monitoring results are presented in Table 12.

TABLE 12 (Page 1 of 2)

MONITORING RESULTS DURING SCEPTRE DREDGING AT ANNACIS CHANNEL

Date	Sample Number	Observation Time	Fish Netted	Pink Fry	Chum Fry	Eulachon Adult	Extrapolated Number	Remarks
April 24	1	13:05-13:35	1			1	266	
April 26		13:00-13:05						No catch
		13:10-13:15						No catch
		13:20-13:35						No catch
		13:35-14:35						Walked spoil area
	2	14:45-14:50	1	1			266	
		14:50-15:00						No catch
		15:00-15:10						No catch
		15:10-15:20						No catch
		15:20-15:30						No catch
	3	15:30-15:35	1	1			266	
		15:45-16:00						No catch
April 29	1	09:55-10:00	1	1			266	
	2	10:40-10:42	1		1		266	
	3	11:08-11:10	3	1			266	2 fish, other species
	4	11:28-11:30	1	1			266	
	5	11:45-11:47	2	1		1 piece	266	
	6	12:25-12:27	1	1			266	
	7	12:35-12:37	1	1			266	
	8	12:46-12:48	1	1			266	
	9	13:45-13:47	1	1			266	
	10	14:00-14:05	2	2			533	
	11	14:15-14:20	1	1			266	
	Random		2					2 fish, other species

Table continued on next page.

TABLE 12 (Page 2 of 2)

Date	Sample Number	Observation Time	Fish Netted	Pink Fry	Chum Fry	Eulachon Adult	Extrapolated Number	Remarks
April 30	15	13:30-13:32	1	1			266	
	16	15:45-16:00	1	1			266	Observation made at overflow ditch from 30-in. sump pump.
		16:00-20:30						No catch in overflow ditch.
		20:30-20:40						No catch.
May 1		07:00-09:00						No catch.
	17	08:20-08:22	1	1			266	
		02:13-14:10						Looking for eulachon on spoil ground.
May 2			2			2	532	From 30-in. sump pump screen.
May 3			2					From 30-in. pump sump. Cray fish
TOTALS OF ALL OBSERVATIONS			26	16	1	4	5,320	

Total Observation Time: 4 hr 30 min.

Total Sampling Time: 176 min.

8.25% of Outflow Sampled.

5.3.1 Salmon Fry Capture Represented by Sampling on April 29, 1974

A total of 12 salmon fry were netted during 176 minutes of sampling, when 8.25% of the total discharge area was utilized. Extrapolated to 100% of the discharge area, the calculation is as follows:

$$12 \text{ fry} \times \frac{60 \text{ min.}}{176 \text{ min.}} \times \frac{100\% \text{ flow}}{8.25\%} = 50 \text{ fry/hr.}$$

By applying the 22:1 burial factor, this becomes:

50 fry/hour x 22
= 1,100 fry/hour, or
= 1,100 fry/hour x 24 hr/day
= 26,400 fry/day.

5.3.2 Comments Concerning Sceptre Dredging in Annacis Channel

The purpose of the suction dredging operation at the Annacis Channel location was to borrow 200,000 yd^3 of sand for a landfill operation. The spoil site covered an area approximately 700 ft. x 1500 ft. The dredge discharge was at the average rate of 17,000 U.S. gallons per minute and comprised a mixture of 80% water and 20% solids.

Sampling of the spoil site outlet pipes was rendered periodically ineffective when the rate of dredge discharge was increased and shooting flow through the outlet structure was experienced. Under the high flow conditions, it was difficult to hold the dip net in position and removal of the net with contents intact for examination was almost impossible. The nets were ripped and a complete dip net was lost in the discharge pipe due to the excessive volume of water discharging from the spoil site outlet.

Following the study of the fry capture data, the dredging company was requested by the Fisheries and Marine

Service on April 29, 1974, to shut down their operations until the peak of the fry migration had passed the dredge site. The company temporarily complied with the request, but started up again for the evening shift. The Fisheries and Marine Service then sought legal advice which led to the issuance of closure orders, but the company refused to comply, so the dredge was seized. Subsequently, the dredge was released on a $10,000 bond subject to compliance with the Fisheries and Marine Service's instructions.

After operations had ceased and the water had been drained off, the spoil site was examined for buried specimens. The 700 ft. x 1500 ft. area was subdivided into a grid with rectangular co-ordinates; and 20 holes, each 16-inches diameter and 36-inches deep, were dug at the grid intersection points. The excavated fill was examined for buried fry. No buried specimens were recovered. The analogy of hunting for a flesh needle in a sand haystack is applicable.

On May 2, 1974, the debris from the snow fence screen upstream from the outlet structure (see Figure 5), was cleaned and examined. No specimens were recovered. The debris from the wire screen upstream of the sump pump was examined. Three dead eulachon and one flounder were recovered.

On May 3, 1974, the sump downstream from the spillway was drained by pumps and by deepening the bypass ditch. With the assistance of the field personnel of Sceptre Dredging Ltd., the debris from the wire screen in front of the sump pump was cleared and then examined. Eleven crayfish (two alive and nine dead) were recovered.

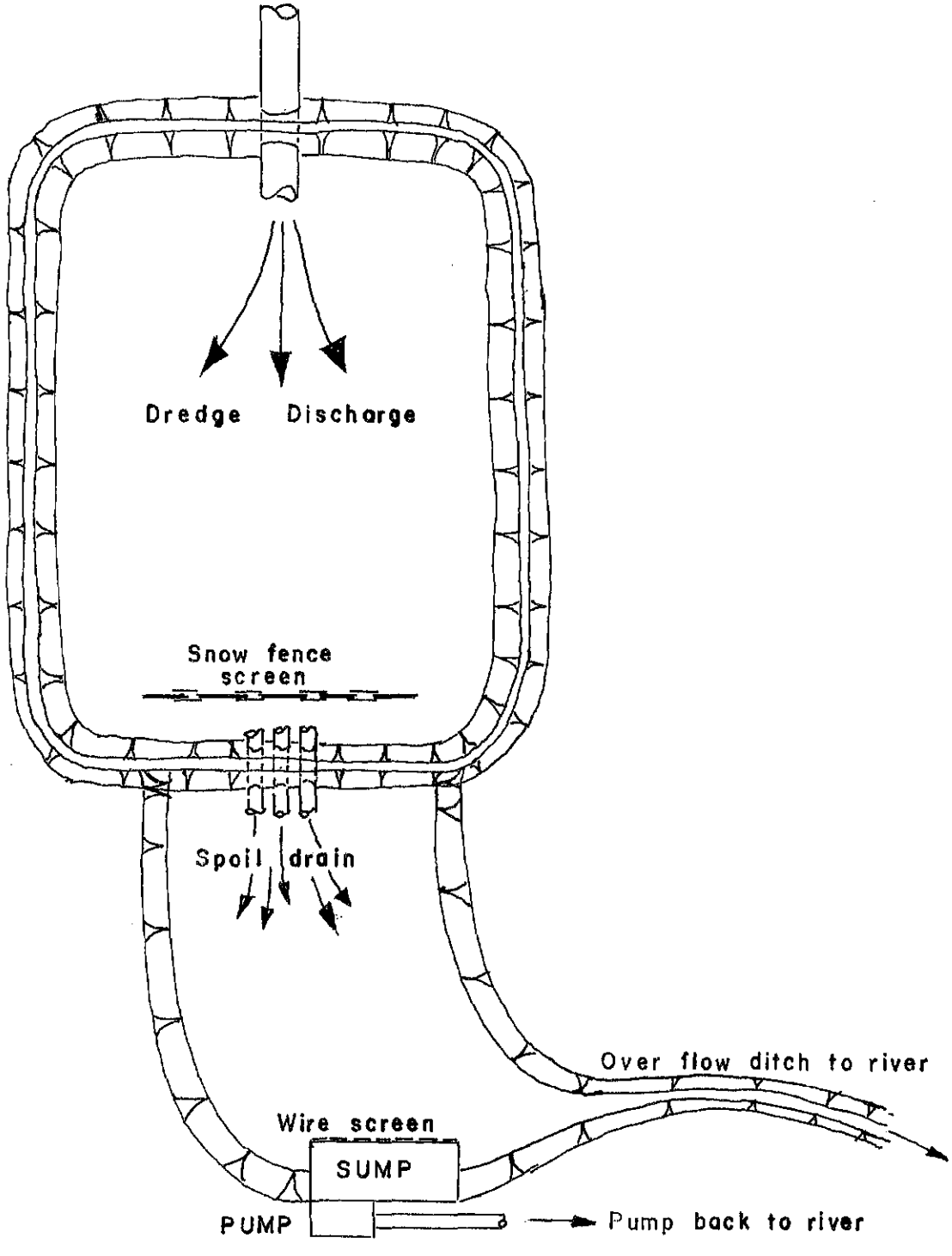

FIGURE 5

SCEPTRE DREDGING SPOIL SITE
FOR THE ANNACIS CHANNEL
DREDGE PROJECT

The legal proceedings relating to Sceptre Ltd.'s refusal to shut down their operations convened on December 3, 1974, and was later adjourned until October 14, 1975, and is still pending.

5.4 CENTENNIAL DREDGING AND SAND LTD., DREDGING IN THE FRASER RIVER OFF BARNSTON ISLAND

(a) Location

Barnston Island, Foot of 192 Street, Surrey, B.C.

(b) Owner of Dredge

Centennial Dredging and Sand Ltd.,
1250 No. 5 Road,
Richmond, B. C.

Telephone 277-3131.

(c) Description of Dredge

Name: "Centennial No. 2"

Type: Hydraulic Suction Pipeline.

Intake: 16-inch diameter.

Discharge: 18-inch diameter.

Discharge Capacity: 10,700 gal./min.

Dredging Capacity: 500 yd^3 of sand/hour.

(d) Monitoring Results

Monitoring commenced at the Barnston Island site on May 2, 1974. An 18-inch diameter marquisette dip net was inserted at the spoil overflow drain at periodic intervals. The spoil area itself was continually examined and large numbers of eulachon were observed. Based on the observations, the dredging company was requested to stop operations on May 6, 1974. Centennial suspended operations immediately. Tables 13, 14 and 15 show the results of monitoring carried out on May 2, May 3 and May 6, respectively.

5.4.1 Centennial Dredge Monitoring Results (May 2, 1974).

Owner: Centennial Dredging & Sand Ltd.,
1250 No. 5 Road, Richmond, B.C.
Telephone 277-3131.

Type of Dredge: 16-inch Hydraulic Pipeline, Centennial No. 2

Capacity: 500 yd^3/hr. @ 10,708 US gals/minute.

Location: Barnston Island - Fraser River, 96th Avenue & 192nd Street.

Operation: 24 hr/day - 70,000 yd^3 (total project).

Table 13 summarizes the monitoring data obtained at this site.

TABLE 13

CENTENNIAL DREDGE MONITORING DATA - MAY 2, 1974

Sample Number		Specimens Recovered	Pink Fry	Chum Fry	Eulachon Adult	Eulachon Eggs	Extra-polated Number
11	09:20-09:22	1					
27	12:08-12:10	1	1				150
47	13:44-13:46	1			(piece)		
50	14:02-14:40	1				cluster	
55	14:39-14:40	1				cluster	
61	15:10-15:11	1			piece		
62	15:45-15:46	1			head		
TOTALS		7	1	0	-	-	150

Area of Sampling

(a) 1.5 ft. diameter dip net:

$$\text{Area of dip net} = \frac{3.14D^2}{4} = \frac{3.14 \times 2.25}{4}$$

$$= 1.766 \text{ ft}^2$$

where D represents diameter of dip net.

Using the value 1.8 ft^2 for area of dip net,

Percentage of dip net open to water = 50% x 1.8 = 0.9 ft^2

Area of discharge 4 ft lin. x 1 ft. 6 in. = 6.12 ft^2

$$\text{Percentage of total area sampled} = \frac{0.9 \text{ ft}^2}{6.12 \text{ ft}^2} \times 100 = 14.6\%$$

(b) Stick net 4 ft^2 placed in front of outflow (20 ft. from N.W. corner), percentage of total area sampled: Approximately 15%.

5.4.2 Centennial Dredge Monitoring Results (May 3, 1974)

Owner of Dredge: Centennial Dredge & Sand Ltd., 1250 No. 5 Road, Richmond, B. C.

Type of Dredge: 16-inch hydraulic pipeline, Centennial No. 2

Capacity: 500 yd^3/hr.

Location: Barnston Island - Fraser River - Foot of 192nd Street.

Operation: 24 hr/day - 70,000 yd^3.

Total project 8,000 US gals/min.

Table 14 summarizes the monitoring data obtained at this site.

TABLE 14

CENTENNIAL DREDGE MONITORING DATA - MAY 3, 1974

Sample No.	Time	Fish Netted	Sample Site	Pink Fry	Chum Fry	Sockeye Fry	Sptg Fry	Eulachon	Extrapolated Number
14	11:07-11:10	1	Spoil Drain					1-	150
21	11:50-11:52	eggs-1	Spoil Drain					1-	150
22	12:00-12:15	1	Reservoir	ω	ω	ω	ω	1-	150
32	13:45-13:50	1	Reservoir	⊆	⊆	⊆	⊆	1-	150
33	13:50-13:55	2	Reservoir	o	o	o	o	2	300
34	13:55-13:59	1	Reservoir	⊆	⊆	⊆	⊆	1	150
35	13:59-14:02	1	Reservoir					1	150
36	14:02-14:10	1	Reservoir					1	150
37	14:20-14:40	5	Reservoir					5	750
TOTALS		14		-	-	-	-	14	2,100

5.4.3 Centennial Dredge Monitoring Results (May 6, 1974)

Owner of Dredge: Centennial Dredge & Sand Ltd., 1250 No. 5 Road, Richmond, B.C.

Type of Dredge: 16-inch hydraulic pipeline, Centennial No. 2

Capacity: 500 yd^3/hr

Location: Barnston Island - Fraser River - Foot of 192nd Street.

Operation: 24 hr/day - 70,000 yd^3.

Total project 8,000 US Gals/minute.

Table 15 summarizes the monitoring data obtained at this site.

TABLE 15

CENTENNIAL DREDGE MONITORING DATA - MAY 6, 1974

Sample No.	Time	Fish Netted	Sample Site	Pink Fry	Chum Fry	Sockeye Fry	Sptg Fry	Eula-chon	Extra-polated Number
1-A	10:10-10:20	8	Reservoir					8	1,200
1-B	10:10-10:20	6	Reservoir					6	900
2	10:35-10:40	33	Reservoir		〃	〃	〃	33	4,950
8	11:45-11:50	2	Net Spill		〃	〃	〃	2	300
99	12:30-12:35	2	Reservoir		〃	〃	〃	2	300
10	12:45-12:50	2	Reservoir		〃	〃	〃	2	300
11	13:05-13:10	1	Reservoir	1				9	1,350
12	13:00-13:10	9	Reservoir						
15	13:40-13:50	3	Reservoir					3	450
TOTALS		66		1	-	-	-	65	9,750

Area of Sampling

(a) Area of dip net: Diameter - 1.5 ft. Area = 1.8 ft^2.
50% of net open to water = 0.9 ft^2.

Area of Spoil Discharge = 4 ft. 1 in. x 1 ft. 6 in. = 6.12 ft^2.

Percentage of total area sampled = $\frac{0.9}{6.12}$ x 100 = 14.6%.

Percentage of total flow sampled, approx. 15%.

5.5 ISLAND SAND SALES LTD., DREDGING AT MIDDLE ARM - MOREY CHANNEL

(a) Location

North Arm, Fraser River - Morey Channel - 150 ft. upstream from the Sea Island Bridge.

(b) Owner of Dredge

Island Sand Sales Ltd.,
1595 River Road, Richmond, B. C.
Telephone 277-4966.

(c) Description of Dredge

Name: "Sandpiper 6"
Type: Hydraulic Suction Pipeline.
Intake: 12-inch diameter
Discharge: 10-inch diameter
Capacity: 150 yd^3/hr.

(d) Monitoring Results

Monitoring at this site commenced on May 6, 1974. An 18-inch diameter marquisette dip net located at the spoil overflow drain was used for monitoring. Due to the amount of debris and silt in the waste water, samples could only be taken for a maximum of one-minute duration. In order to search for fish specimens in the 150 ft. x 340 ft. spoil area, a visual inspection was carried out on foot.

Approximately fifty dead adult eulachon were observed floating on the periphery of the spoil site. Visual examination revealed that these eulachon were spawned out. Monitoring with dip nets was extremely difficult due to the large percentage of fine silt and debris in the spoil mass. Table 16 summarizes the monitoring data at this site.

TABLE 16

ISLAND SAND SALES LTD., MONITORING DATA
FOR MORAY CHANNEL DREDGING PROJECT
(May 6 to June 10, 1974)

Date 1974	Observations	Comments
May 6	No salmonids caught or observed	
May 7	No salmonids caught or observed	
May 8	No salmonids caught or observed	
May 9	Dredge did not operate	
May 14	No salmonids caught or observed	
May 16	Approximately 50 dead eulachon	Walked spoil area
May 17	No salmonids caught or observed	
May 21	No salmonids caught or observed	Dip nets plug up in less than 5 sec.
May 23	No salmonids caught or observed	
May 24	No salmonids caught or observed	
May 27	No operation	
May 31	No operation	
June 4	No salmonids caught or observed	
June 5	No salmonids caught or observed	
June 6	No operation	
June 7	No salmonids caught or observed	
June 10	No operation	
Observers:	John Patterson, Habitat Protection Unit, Doug Moir, Habitat Protection Unit.	

6. DREDGE MONITORING - 1975

During the 1975 fry migration period, only emergency channel navigation dredging was allowed on the Fraser River under close scrutiny of the Fisheries and Marine Service. This essential dredging was carried out by the Department of Public Works utilizing their hydraulic pipeline dredge, the DPW "322" and their hopper dredge, the "Fort Langley".

Observation personnel maintained a close liaison with the Mission downstream fry sampling operation. Daily counts of fry passing the Mission station were obtained to better assess the volume of fry in the lower reaches of the Fraser River. From the information received it appeared that the migration pattern consisted of an average fish population.

6.1 DEPARTMENT OF PUBLIC WORKS DREDGE "322", DREDGING IN THE MAIN ARM AT TILBURY REACH AND NORTH ARM JETTY

(a) Owner of Dredge

Public Works Canada

(b) Description of Dredge

Name: "322".

Type: Hydraulic suction pipeline.

Intake Size: 24-inch diameter.

Discharge Size: 20-inch diameter.

Power: 1,550 b.h.p.

R.P.M.: Maximum 375

Depth of Cut: Maximum 45 feet.

Distance from Cutter Head to Pump: 103 feet.

Velocity of Water in Pipe: 14.3 ft/sec.

6.1.1 Location No. 1: Main Arm, Tilbury Reach, North Side, Foot of No. 8 Road

The proposed cut at Tilbury Reach was 250 feet wide by 6,500 feet long. The total yardage involved was 250,000 yds^3. The work was curtailed on April 5, 1975, when only 110,000 yds^3 of the proposed total had been removed.

(a) Monitoring Results

Monitoring at this site commenced on March 17, 1974. Both 8-hour shifts were monitored. An 18-inch diameter marquisette dip net was used at the spoil drain and subsequently at the spoil drainage ditch

for monitoring. At the spoil drain, 20.6% of the flow was screened. A total of 312 observations were made at this site with no observation of any salmonids. A summary of daily observations is shown in Table 17.

TABLE 17

DPW "322" DREDGE AT TILBURY REACH (FRASER RIVER) -
SYNOPSIS OF FISH CAPTURED, MARCH 15 TO MARCH 27, 1975

Date	First Shift			Second Shift			Total (daily) of Salmon Fry	Location of Dredge	Remarks
	Salmon Fry	Stickle-back	Others	Salmon Fry	Stickle-back	Others			
Mar 17	0	0	0	0	0	0	0	RICHMOND LANDFILL	100% spill water, monitoring screens were not installed.
Mar 18	0	0	0	0	0	1	0	RICHMOND LANDFILL	Sampling was done by using dip nets only.
Mar 19	-	-	-	-	-	-	-		
Mar 20	-	-	-	-	-	-	-		
Mar 21	0	0	0	0	0	0	0	RICHMOND LANDFILL	
Mar 24	0	0	0	0	0	0	0	RICHMOND LANDFILL	
Mar 25	0	0	0	0	0	0	0	RICHMOND LANDFILL	
Mar 26	0	0	0	0	0	0	0	RICHMOND LANDFILL	
Mar 27	0	0	0	0	0	0	0		Dredge shut down and preparations underway to relocate to Iona Island.

6.1.2 Location No. 2: North Arm, Adjacent to North Arm Jetty

Figure 6 shows the dredging location, which includes a river area used for the North Arm Log Transit route.

Figures 7 and 8 illustrate the operating dredge on location, and the dredge cutterhead, respectively.

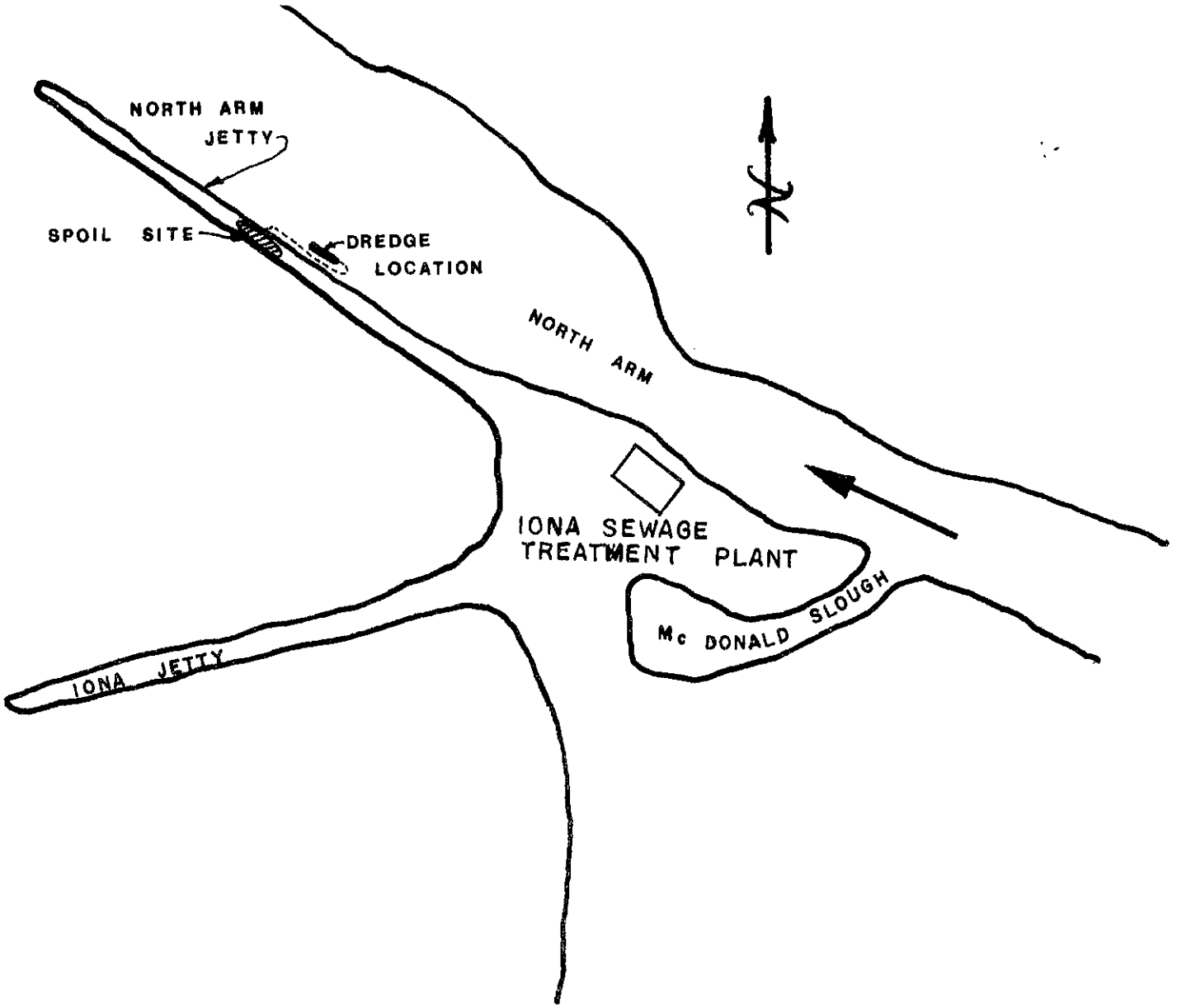

FIGURE 6

LOCATION OF DPW DREDGING PROJECT
IN NORTH ARM OF FRASER RIVER

FIGURE 7

D.P.W. "322" OPERATING IN THE NORTH ARM OF THE FRASER RIVER NEAR THE NORTH ARM JETTY (May 15, 1975)

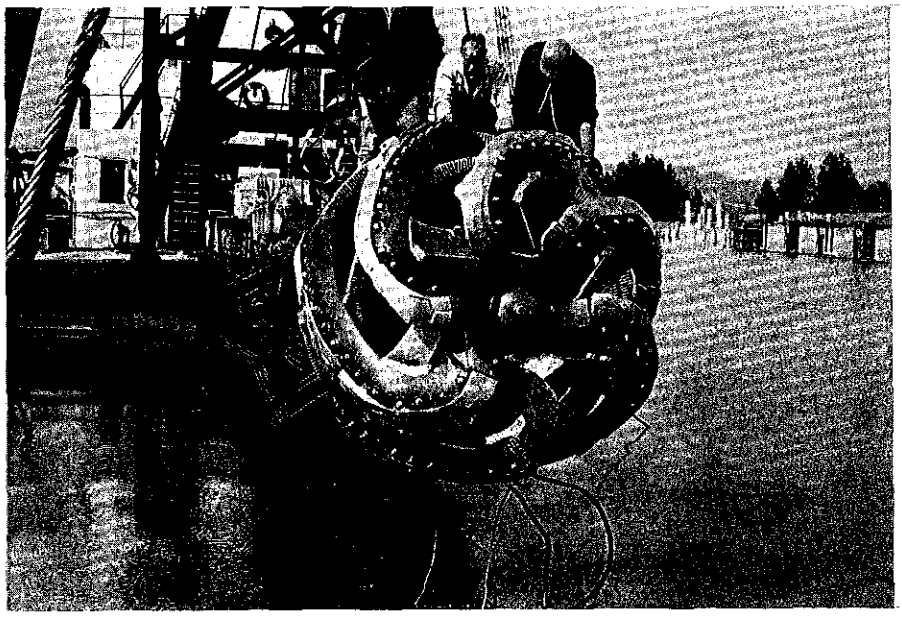

FIGURE 8

D.P.W. "322" - CUTTERHEAD RAISED ABOVE WATER LEVEL

6.1.3 Design of Monitoring Screen at North Arm Jetty Site

One hundred percent monitoring of screened flow was instituted at the North Arm Jetty site. Initially the spoil drainage was split with two-thirds of the flow spilling over a stationary screen 8 feet wide x 16 feet long. Screening material of 3/16 inch mesh was used, which proved very successful for screening the spoil runoff. A report on the effects of suction dredging may be obtained from the Department of Public Works, (Braun, F., 1974, "Monitoring the Effects of Hydraulic Suction Dredging on Migrating Fish in the Fraser River").

A baffled-box fry trap was installed to screen the other third of the flow. Due to excessive amounts of debris in the water, this trap proved unsatisfactory.

After one week of monitoring, the spoil drain was relocated to the west side of the spoil basin. A flow was passed through the large horizontal screen, (see Figures 9, 10 and 11). Monitoring at this location was inhibited by a large amount of suspended debris which necessitated continuous and tedious manual cleaning of the screen. This problem was partially remedied by providing a method of flow control at the spoil drain structure. However, this created another problem in that the dykes were not high enough to accommodate the stored spoil water. This resulted in the need to periodically close the dredge to drain the spoil basin. The daily monitoring observations are summarized in Table 18, pages 65 to 72 inclusive, and Table 19.

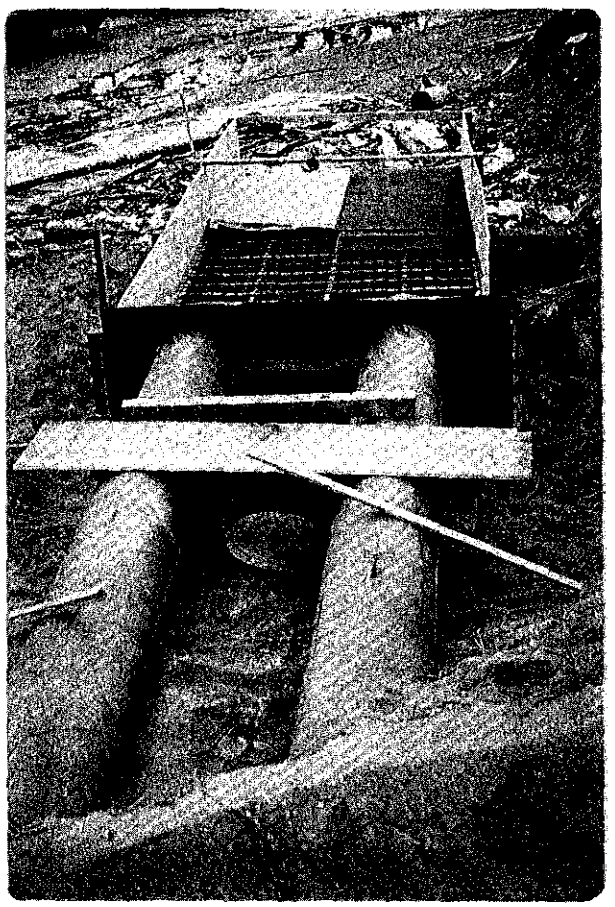

FIGURE 9

CONSTRUCTION OF MONITORING SCREEN AT DPW "322" DREDGING SITE, FOR MONITORING 100% OF THE SPOILPILE RUNOFF

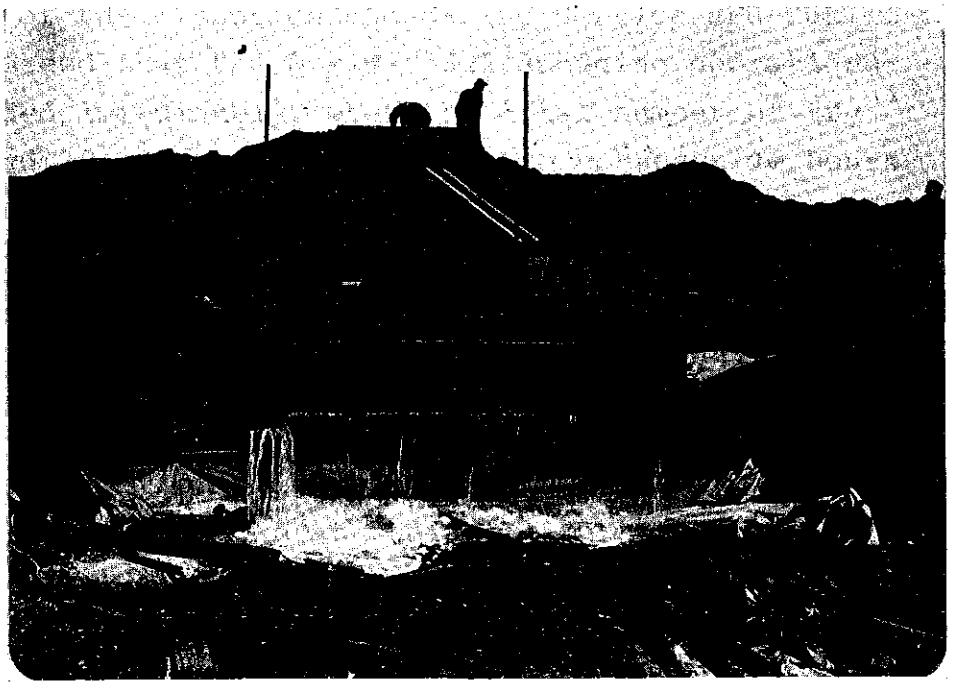

FIGURE 10

COMPLETED SCREEN INSTALLATION FOR
MONITORING 100% OF THE SPOIL RUNOFF
AT THE DPW "322" NORTH ARM DREDGING SITE

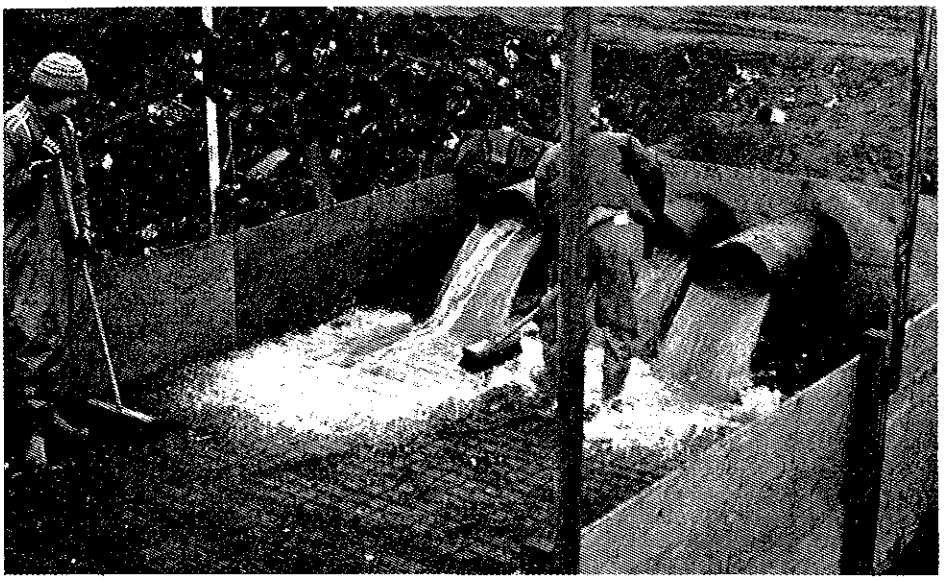

FIGURE 11

MONITORING IN PROGRESS AT THE
DPW "322" NORTH ARM DREDGING SITE

Representatives of the Fisheries and Marine Service and Public Works Canada, agreed that the D.P.W. "322" dredging operations would be suspended immediately, when the total number of fry captured exceeded 10 per hour during any two consecutive hours. This figure, extrapolated to include the burial factor, would result in a total fry capture of 220/hour. The decision to establish an operation cut-off point was based on the understanding that 100% of the runoff from the spoil ground was being monitored 100% of the spoil runoff time.

The following illustration (Figure 12) shows the construction and subsequent erosion of the dyke at the settling basin at the North Arm Jetty site. Problems created by the breaching of the containment dyke and spoil discharge onto the beach focused attention on the need for regular departmental review of spoil site and discharge line location in conjunction with the basic review of the borrow site.

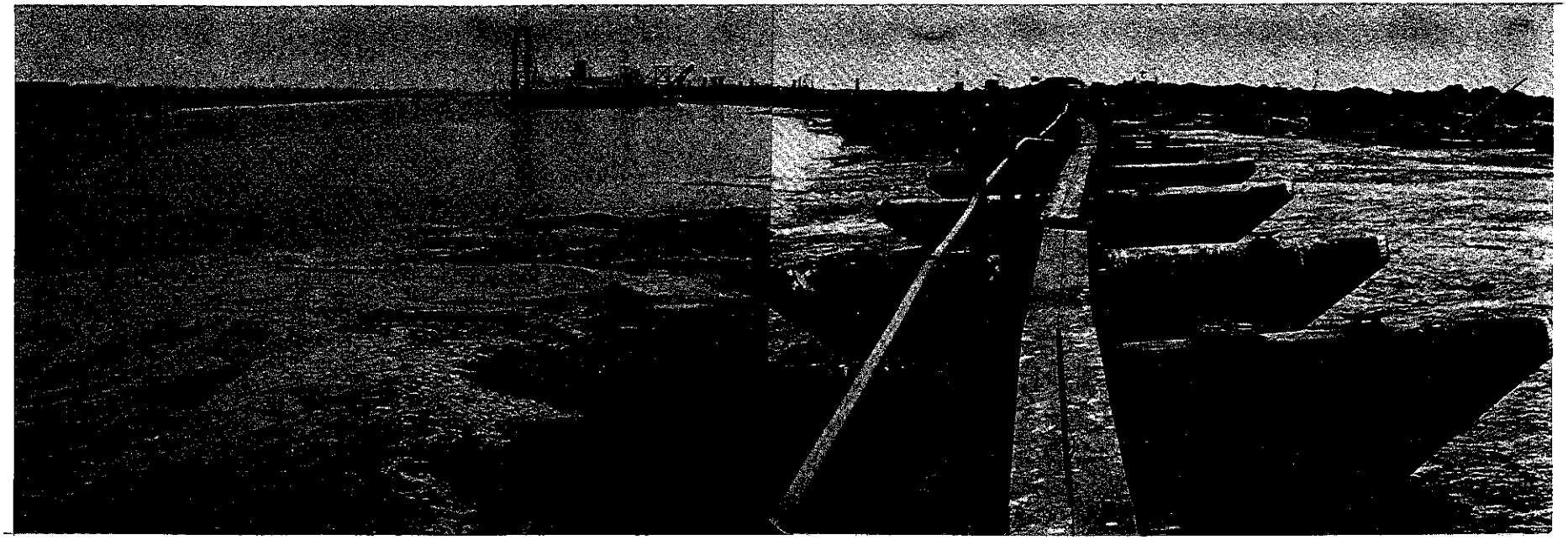

FIGURE 12

DREDGE DPW "322" IN OPERATION, PERIMETER DYKE IN PLACE, AND EROSION OF THE DYKE IN PROGRESS
(Photographed at 13:00 hr, April 16, 1975)

TABLE 18 (Page 1 of 8)

DAILY FRY CAPTURE DURING DPW "322"
DREDGING AT NORTH ARM JETTY
(April 18 to May 29, 1975)

Date 1975	Time	Location (Screen)	No. of Salmon Fry	Estimated Capture	Comments
April 18	14:00-22:00	Discharge Outlet	0	0	Dredge started approx. 12:00. Water at spillway - 14:30. Dyke broke 19:00. Water flow ceased 19:15.
April 21	10:00-13:15		0	0	Started pumping at 07:30. water reached discharge 10:00. Shutdown at 13:15.
	14:00-22:00		0	0	Dredge started - 14:15.
April 22	06:00-13:00		0	0	06:10 - water still flowing from previous night. Dredge started 06:50. Muddy water - 07:45. Dredge shutdown - 13:30. Sluice Box washing out.
	14:00-15:15		0	0	Box removed from spillway 15:15.
April 23	06:00-14:00		0	0	Sluice Box reset 06:30-09:30. Dredge pumping 09:45. Turbid water running 10:15. Green box system not in use.
	14:00-22:00		0	0	Green box system not in use.

(continued overleaf)

TABLE 18 (Page 2 of 8)

Date 1975	Time	Location (Screen)	No. of Salmon Fry	Estimated Capture	Comments
April 24	11:00	Discharge outlet	1	22	Runoff ramp put on Sluice Box 06:30-10:30.
	13:00		2	44	Dredging started 10:00. Water unclear 11:00. Green box system removed.
	14:45		2	44	One of the three pipes not monitored as green boxes were unsuitable.
	15:20		1	22	
	15:50		1	22	
	16:30		2	44	
	16:50		1	22	
	17:05		1	22	
	17:15		2	44	
	17:20		1	22	
	17:55		1	22	
	19:10		3	66	
	19:40		1	22	
April 25	09:30		1	22	06:00 - Much debris in sluice box.
	09:50		2	44	
	10:35		2	44	Dredging started 07:45.
	10:45		1	22	
	10:55		1	22	Dredge shutdown by D.P.W. at 11:35
	11:03-11:07		3	66	at request of Fisheries & Marine
	11:20		5	110	Service.
	11:25-11:28		3	66	
	11:30-11:32		2	44	
	11:36		1	22	
	11:47		1	22	
	12:22		1	22	
	12:45		1	22	
	12:55		1	22	
	13:17		1	22	
	13:37		1	22	
	14:00-15:20		0	0	15:20 - Dismantled spillway and sampling setup.

TABLE 18 (Page 3 of 8)

Date 1975	Time	Location (Screen)	No. of Salmon Fry	Estimated Capture	Comments
April 30	16:35	Discharge outlet	1	22	
	17:56		2	44	
	18:00		1	22	
	18:05-18:10		3	66	
	18:40		1	22	
	18:45		1	22	
	18:48		1	22	
	19:00-19:02		2	44	
	19:10		1	22	
	19:20		1	22	
	19:40		1	22	
	19:45		1	22	
	19:47		1	22	
	20:10		1	22	
	20:31		1	22	
	21:15		1	22	
	22:00		1	22	
	22:10		1	22	
	22:25		1	22	
	23:00		1	22	
	23:10		1	22	
	23:12		1	22	
	23:30		1	22	
	23:35		1	22	
	23:40		1	22	
	23:42		1	22	
	24:25		1	22	
May 1	06:30		2	44	Dredging began 11:30. Water running 12:15. Heavy debris 12:30-14:00.
	15:15		1	22	
	16:00		1	22	
	18:10-18:15		3	66	
	18:20		1	22	
	18:30		1	22	

(Continued overleaf)

TABLE 18 (Page 4 of 8)

Date 1975	Time	Location (Screen)	No. of Salmon Fry	Estimated Capture	Comments
May 1 (cont'd)	19:35	Discharge outlet	1	22	
	19:40		1	22	
	19:45		1	22	
	19:50		1	22	
	20:30		1	22	
May 2	06:00-14:00		0	0	Screens torn and damaged by debris, heavy current - monitoring very poor. Dredge broke down 09:30. Flow stopped at 12:30.
	17:10		1	22	
	17:15		1	22	
	17:40		1	22	
	17:45		1	22	
	19:00		1	22	
May 5	06:00-14:00		0	0	Late start due to screen being clogged by silt deposited by a very high tide 11:00. Screen silted-in; unable to monitor.
	15:45		1	22	
May 6	08:25		1	22	
	09:15		1	22	
	14:00-22:00		0	0	
May 7	11:45		1	22	Spillway opened fully at 10:00-10:35 by D.P.W. Monitoring impossible.
	14:00-22:00		0	0	
May 8	09:00		1	22	
	13:15		1	22	
	13:20		1	22	
	13:30		1	22	
	14:05		1	22	

(continued overleaf)

TABLE 18 (Page 5 of 8)

Date 1975	Time	Location (Screen)	No. of Salmon Fry	Estimated Capture	Comments
May 8 (cont'd)	14:10	Discharge outlet	1	22	
	14:20		1	22	
	14:35		1	22	
	14:45		1 (dead)	22	
	14:50		1	22	
May 9	11:10		1	22	
	11:30		1	22	
	11:40		1	22	
	11:50-12:00		4	88	
	12:15		1	22	
	12:20		2	44	
	12:29		1	22	
	13:00-13:04		2	44	
	13:30		1	22	
	15:30		1	22	
	15:45		1	22	
	17:20		1	22	
	17:30		1	22	
May 12	12:15		1	22	
	13:20		1	22	
	13:40		1	22	
	14:04		1	22	19:25-19:50 - Unable to monitor properly due to high tide and dirty water.
	14:15		1	22	
	14:17		2	44	
	14:58		1	22	
	16:03		1	22	
	18:21		1	22	

(continued overleaf)

TABLE 18 (Page 6 of 8)

Date 1975	Time	Location (Screen)	No. of Salmon Fry	Estimated Capture	Comments
May 13	13:50	Discharge outlet	1	22	Dredge started 08:00. Water dirty and full of debris - Monitoring virtually impossible.
	14:08		1	22	
	15:54		1	22	
	18:12		1	22	
	18:25		1	22	
May 14	06:00-14:00		0	0	11:00 water sample taken to show that water is extremely dirty.
	14:02		1	22	
	14:09		1	22	
	14:16		1	22	
	14:27		1	22	
	14:35		3	66	
	15:11		1	22	
	15:19		1	22	
	15:20		2	44	
	15:25		1	22	
	15:28		1	22	
	16:09		1	22	
	16:20		1	22	
	18:27		1	22	
May 15	08:00		1	22	
	12:10		1	22	
	13:40		1	22	
	13:45		1	22	
	14:20		2	44	
	14:32		1	22	
	15:14		1	22	
	15:16		1	22	
	15:18		1	22	
	15:28		1	22	
	16:00		1	22	
	16:14		1	22	

(continued overleaf)

TABLE 18 (Page 7 of 8)

Date 1975	Time	Location (Screen)	No. of Salmon Fry	Estimated Capture	Comments
May 15 (Cont'd)	16:22	Discharge outlet	1	22	
	17:00		1	22	
	17:17		1	22	
	17:29		1	22	
	17:48		1	22	
	18:36		1	22	
	19:45		2	44	
May 16	11:15		1	22	Water reached spillway - 10:45.
	15:06		1	22	
	15:48		3	66	
	16:18		2	44	
	17:48		1	22	
	18:18		1	22	
May 20	07:42		1	22	
	07:46		1	22	
	08:25		1	22	
	08:30		1	22	
	09:35		1	22	
	09:50		1	22	
	09:56		1	22	
	10:28		1	22	
	10:50		1	22	
	11:09		1	22	
	14:00-22:00		0	0	17:10-18:15. Screens impossible to keep clean. 19:35- Stopped sampling
May 21	09:35				
	10:00				
	10:24				
	10:32				
	11:28				
	11:40				
	15:15		1	22	

(continued overleaf)

TABLE 18 (Page 8 of 8)

Date 1975	Time	Location (Screen)	No. of Salmon Fry	Estimated Capture	Comments
May 22	08:15	Discharge outlet	1	22	
	14:00-18:00		0	0	15:00 - Pipes opened wide to wash out mud.
May 23	12:34		1	22	07:30-08:50 - Water very muddy; monitoring impossible. 08:50-09:30 - Valves opened to flush mud from pond.
	14:00-22:00		0	0	
May 26	06:00-14:00		0	0	Too much mud and debris to monitor properly.
May 27	14:00-22:00		0	0	Box impossible to clean except when dredge is shut down. 20:05 - Tide as high as screens.
May 28	14:00-22:00		0	0	
May 29	14:00-22:00		0	0	Dredge shut down 17:40-20:45.
			Grand Total	4,620	

Note: Public Works Canada dredges, D.P.W. "322" and D.P.W. "312" were operating on two shifts per day basis (first shift 06:00-14:00; second shift 14:00-22:00) from Monday to Friday only. Dredges were not operating during weekends and statutory holidays.

TABLE 19

TOTAL NUMBER OF ALL MARINE SPECIES SAMPLED AND DETERMINED ENTRAINMENT FOR D.P.W. DREDGE No.322 AT NORTH ARM SITE (April 18 to May 29, 1975)

Marine Species	DPW "322" DREDGE	
	Total Sampled	Total Determined
Chum salmon fry	210	4,620
Sockeye smolt	6	132
Crago shrimp	1×10^6	22×10^6
Stickleback	714	15,708
Flounders	222	4,884
Sturgeon	-	-
Dogfish	-	-
Eulachon	26	572
Sandlance	-	-
Sculpin	208	4,576
Hake	-	-
Crab	7	154
Eel	53	1,166
Perch	3	66
Pipefish	3	66
Possible pink salmon fry	-	-

NOTE: Estimated fry capture by DPW "322" = 22 x Sample.

6.1.4 Comments and Observations Related to Monitoring at the DPW "322" Dredging at North Arm Jetty Site

(a) Large numbers of shrimp and other invertebrates were observed in the spoil and drainage area of the North Arm Jetty. The continuous elimination of the organisms from the estuarine food web which supports rearing salmonids could reduce fry survival during downstream migration and transition to their ocean habitat.

(b) A substantial number of fry were sampled at this North Arm Jetty site. The estimated fry capture is shown below:

Actual Capture: 210
Burial Recovery Ratio: 22:1
Estimated Capture: 210 x 22 = 4,620 salmon fry

The fry capture was of such extent that on several occasions, closure of dredging operations was warranted.

Fish specimens (see Figure 14) recovered from the monitoring screen were preserved in a Bouin solution (see Figure 13) and were sent to the Fisheries and Marine Service Laboratory at 6640 Northwest Marine Drive, Vancouver, B.C. for histological analysis. A histopathological examination was conducted on apparently healthy fry retrieved from the spoil drain to determine if the fry had suffered internal injury during their passage through the operating suction dredge. Identical analyses were carried out on control fry obtained from the Fisheries and Marine Service sampling site at Mission. The results obtained during the histological analysis are presented in the memorandums of B. Tutty (Appendix A) and J. McBride (Appendix B) appended to this report.

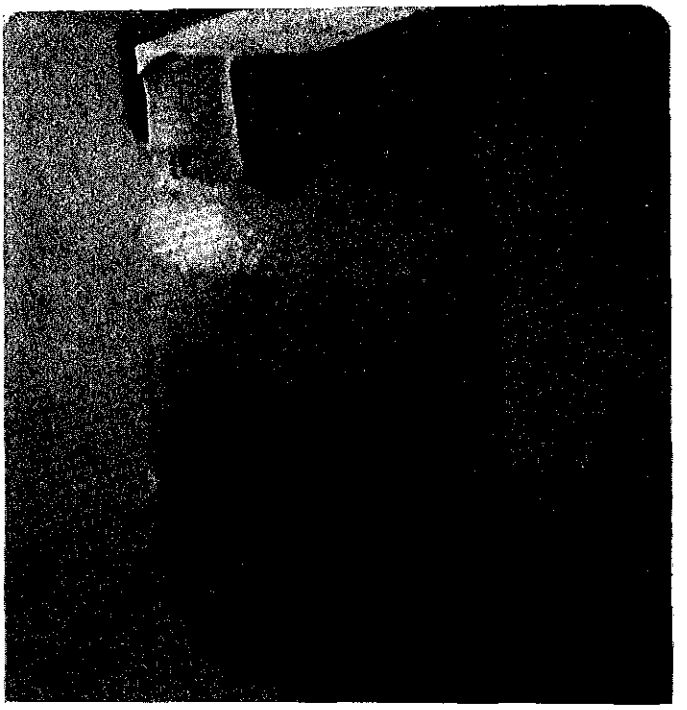

FIGURE 13

SALMON FRY RETRIEVED FROM THE SPOIL DRAIN DURING MONITORING AT THE NORTH ARM JETTY SITE

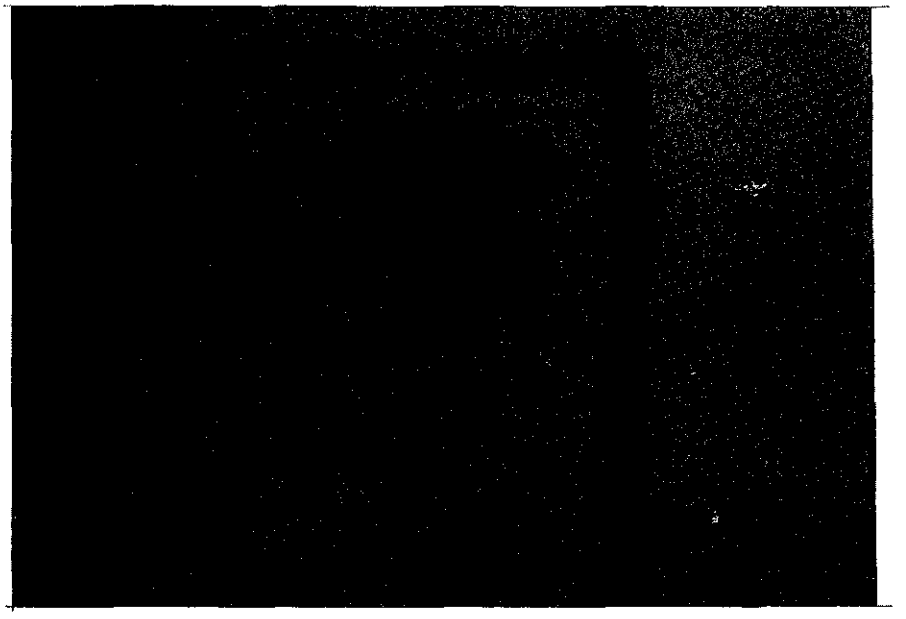

FIGURE 14

JUVENILE SALMON RECOVERED FROM THE SPOIL DRAIN AT THE NORTH ARM JETTY SITE, BOTTLED AND SEALED FOR TRANSPORT TO THE FISHERIES AND MARINE SERVICE LABORATORY

6.2 WATER QUALITY EVALUATION IN THE NORTH ARM OF THE FRASER RIVER

Grab water samples were collected to evaluate the water quality parameters in the vicinity of the DPW "322" operations between March 31 and June 10, 1975. The water quality evaluations are presented in Appendix C (prepared by B.C. Pearce) and Appendix D (prepared by B.C. Research), appended to this report.

6.3 RELATIONSHIP BETWEEN THE FLUCTUATION OF TIDAL HEIGHTS AND CAPTURE OF SALMON FRY

It has been observed (Figure 15, page 78) that the number of salmon fry retrieved at the spoil site tends to increase with the decreasing height of tides. This trend may be due to the following:

(a) As the tidal height decreases, the velocity of the river flow approaching the estuary increases. This increased velocity carries the fry more forcibly rendering them less capable of swimming freely.

(b) The wetted perimeter and the cross-sectional area of the river decreases with the falling tide, thereby concentrating and increasing the density of fry both vertically and horizontally in any given cross-section in the river reach.

(c) As the velocity of the river flow increases, the sediment load (wash load, suspended load, bedload and saltating load) increases, and this phenomenon may have the effect of decreasing the orientation and avoidance capabilities of the fry.

(d) At high tides, the velocity of flow slackens. In fact, at certain times, actual flow reversal takes place. During these periods, fry would have a tendency to appear near the surface and in the

vicinity of the shore zone. This distribution would minimize the possibility of the fry entering the dredge system at high tides.

Figure 15 shows that the capture of salmon fry was at its peak 20 minutes after the tidal height had reached its lowest elevation. This 20-minute period may be attributed to the time lapse from when a fry entered the cutterhead to the moment when the same fry could be recovered at the spoil runoff outlet.

In order to substantiate this tentative conclusion, future work is required, because the graphical determination in Figure 15 represents a trend only. The continuous collection of data at this site was difficult due to the large amount of fines in the spoil mass and the presence of fibrous materials. These materials frequently tend to plug the outlet screens.

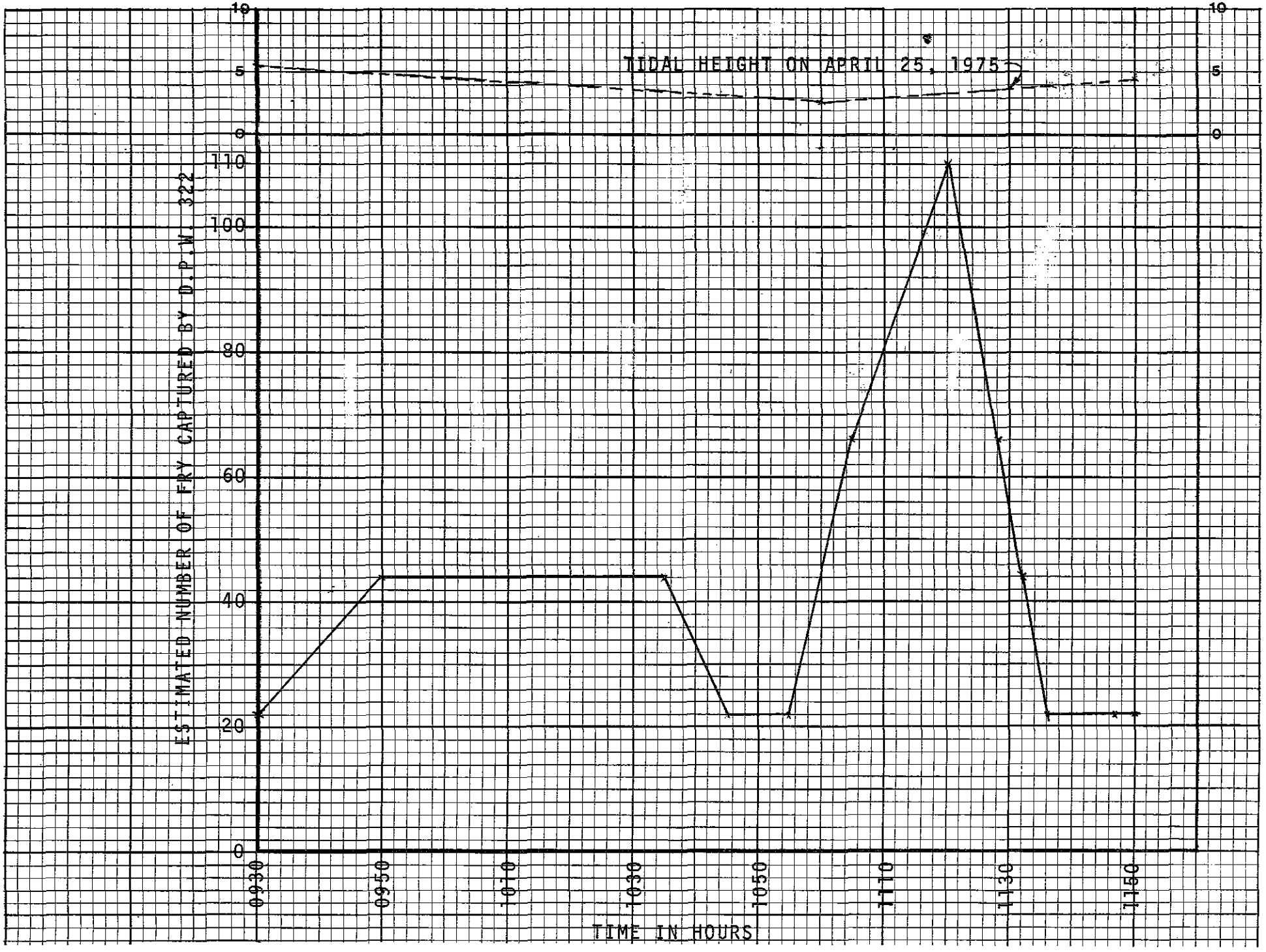

FIGURE 15: CAPTURE OF FRY VERSUS FLUCTUATION OF TIDAL HEIGHT AT THE MOUTH OF FRASER RIVER

6.3.1 Limitation of This Relationship Between Fry Capture and Tidal Fluctuations

The tentative conclusions referred to previously are valid only at, or near, the mouth of the river where the flow patterns vary widely with respect to time. Tidal influences decrease upstream from the mouth of the river.

6.4 MOBILE HOPPER DREDGE DPW "FORT LANGLEY" ("312")

(a) Owner

Public Works Canada

(b) Description of Dredge

Name: "Fort Langley" ("312").

Type: Hopper, Mobile, Hydraulic Suction.

No. of Sumps: Two.

Diameter of Suction: 25 inches.

Power: 3,600 h.p.

Quantity per Pump: 17,000-18,000 US gal/min.

Hopper Capacity: 1,330 yds^3.

(c) Location

(i) March 17 to April 1, 1975 - Steveston Bend.
(ii) April 2 to April 20, 1975 - Sandheads.
(iii) April 21 to April 23, 1975 - Tilbury Reach.
(iv) April 24 to May 6, 1975 - Sandheads.
(v) May 7 to May 30, 1975 - Steveston Cut.
(vi) June 2 to June 4, 1975 - St. Mungo Bend.

(d) Monitoring Results

A total of 1,649 observations were made on board the "Fort Langley" from April 1, 1975 to June 4, 1975. Of this total, 894 observations were made on day shift and 755 during night shift. Observation times varied from 5 minutes to 15 minutes.

Observations were made at two separate monitoring stations. Initially, from April 1 to May 8, 1975, an 18-inch diameter dip net (1/10 inch diameter openings in the net) was secured to a winch amidship of the port hopper. The net screen approximately 0.46% of the flow at 15-minute intervals. The monitoring station was changed to the port spoil water overflow on May 9, 1975 and 11.5% of the combined flow from the two draggerheads was screened. At this latter location, the net was pulled out at 5-minute intervals for inspection.

Table 20 (pages 82 to 86 , inclusive) presents the monitoring results for the period April 1 to June 4, 1975 during DPW "Fort Langley" ("312") dredging at the Sandheads, Tilbury Reach, Steveston Cut and St. Mungo Bend sites.

Table 21 tabulates the total numbers of all fish sampled and the estimated entrainment for the DPW "Fort Langley" ("312") dredging operations.

Representatives of the Fisheries and Marine Service and Public Works Canada, agreed that dredge operations during critical downstream fry migration would be monitored by Fisheries and Marine Service personnel, and that dredge operation would be suspended immediately when the number of fry or smolt captured appeared to be significant. The exact number of fry or smolt captured to establish a cutoff point was not practical due to variables experienced during the daily monitoring process; for example, sampling methods (hand operation of dip net to winch operation), location of sampling (spillway to sump), sampling time, and percentage of discharge sampled.

TABLE 20 (Page 1 of 5)

SYNOPSIS OF FISH CAPTURED DURING DPW DREDGING USING DREDGE "FORT LANGLEY" ("312") (April 1 to June 4, 1975)

Date 1975	First Shift (06:00-14:00 hr)			Second Shift (14:00-22:00 hr)			Total (Daily) of Salmon Fry	Location of Dredge	Estimated Capture of Salmon Fry
	Salmon Fry	Sockeye Smolts	Others	Salmon Fry	Sockeye Smolts	Others			
April 1	0	0	0	0	0	1	0	SANDHEADS	0
Apr 2	0	0	8	0	0	0	0	SANDHEADS	0
Apr 3	-	-	-	0	0	2	0	SANDHEADS	0
Apr 4	0	0	4	0	0	3	0	SANDHEADS	0
Apr 7	0	0	11	0	0	12	0	SANDHEADS	0
Apr 8	0	0	8	0	0	19	0	SANDHEADS	0
Apr 9	0	0	10	0	0	2	0	SANDHEADS	0
Apr 10	0	0	1	0	0	12	0	SANDHEADS	0
Apr 11	0	0	11	0	0	6	0	SANDHEADS	0
Apr 14	0	0	6	0	0	5	0	SANDHEADS	0

(Continued overleaf)

TABLE 20 (Page 2 of 5)

Date 1975	First Shift (06:00-14:00 hr)			Second Shift (14:00=22:00 hr)			Total (Daily) of Salmon Fry	Location of Dredge	Estimated Capture of Salmon Fry
	Salmon Fry	Sockeye Smolts	Others	Salmon Fry	Sockeye Smolts	Others			
April 15	0	0	6	0	0	5	0	SANDHEADS	0
Apr 16	0	0	7	0	0	1	0	SANDHEADS	0
Apr 17	0	0	1	0	0	30	0	SANDHEADS	0
Apr 18	0	0	0	0	0	2	0	SANDHEADS	0
Apr 21	1	0	0	-	-	-	1	TILBURY	286
Apr 23	15	0	1	10	0	0	25	TILBURY	7,150
Apr 24	0	0	5	-	-	-	0	SANDHEADS	0
Apr 25	0	0	24	-	-	-	0	SANDHEADS	0
Apr 28	0	0	2	1	0	2	1	SANDHEADS	286
Apr 30	0	0	6	0	0	6	0	SANDHEADS	0
May 1	0	0	9	0	0	10	0	SANDHEADS	0

(Continued overleaf)

TABLE 20 (Page 3 of 5)

Date 1975	First Shift (06:00-14:00 hr			Second Shift (14:00-22:00 hr)			Total (Daily) of Salmon Fry	Location of Dredge	Estimated Capture of Salmon Fry
	Salmon Fry	Sockeye Smolts	Others	Salmon Fry	Sockeye Smolts	Others			
May 2	0	0	8	0	0	4	0	SANDHEADS	0
May 5	0	0	0	0	0	3	0	SANDHEADS	0
May 6	0	0	4	0	0	2	0	SANDHEADS	0
May 7	0	0	2	0	0	6	0	STEVESTON CUT	0
May 8	1	0	0	0	0	1	1	STEVESTON CUT	286
May 9	0	0	0	0	0	0	0	STEVESTON CUT	0
May 12	-	-	-	1	0	9	1	STEVESTON CUT	286
May 13	2	18	19	1	6	33	3	STEVESTON CUT	858
May 14	1	6	5	-	-	-	1	STEVESTON CUT	286
May 16	0	1	29	0	1	5	0	STEVESTON CUT	0

(Continued overleaf)

TABLE 20 (Page 4 of 5)

Date 1975	First Shift (06:00-14:00 hr)			Second Shift (14:00-22:00 hr			Total (Daily) of Salmon Fry	Location of Dredge	Estimated Capture of Salmon Fry
	Salmon Fry	Sockeye Smolts	Others	Salmon Fry	Sockeye Smolts	Others			
May 20	0	0	15	0	0	130	0	STEVESTON CUT	0
May 21	0	0	1	0	0	0	0	STEVESTON CUT	0
May 22	0	0		0	0	1	0	STEVESTON CUT	0
May 23	0	0	1	0	0	0	0	STEVESTON CUT	0
May 26	0	0	13	-	-	-	0	STEVESTON CUT	0
May 27	0	0	4	0	0	2	0	STEVESTON CUT	0
May 28	0	0	0	0	0	1	0	STEVESTON CUT	0
May 29	0	0	1	-	-	-	0	STEVESTON CUT	0
May 30	0	0	0	-	-	-	0	STEVESTON CUT	0

(Continued overleaf)

TABLE 20 (Page 5 of 5)

DPW "312"

SYNOPSIS OF FISH CAPTURED FROM APRIL 1/75 - JUNE 4/75

Date 1975	First Shift (06:00-14:00 hr)			Second Shift (14:00-22:00 hr)			Total (Daily) of Salmon Fry	Location of Dredge	Estimated Capture of Salmon Fry
	Salmon Fry	Sockeye Smolts	Others	Salmon Fry	Sockeye Smolts	Others			
June 2	-	-	-	0	0	1	0	ST. MONGO BEND	0
June 3	0	0	0	1	0	1	1	ST. MONGO BEND	286
June 4	0	0	0	-	-	-	0	ST. MONGO BEND	0
TOTALS	20	25	222	14	7	317	34		

TABLE 21

TOTAL NUMBERS OF ALL FISH SAMPLED
AND THE ESTIMATED ENTRAINMENT DURING
DPW "FORT LANGLEY" ("312") DREDGING

Sample Species	Numbers of Fish	
	Sampled	Estimated (N)
Chum salmon fry	34	9,724
Sockeye smolt	32	9,152
Crago shrimp	93	26,598
Stickleback	-	-
Flounders	33	9,438
Sturgeon	2	572
Dogfish	21	6,006
Eulachon	344	98,384
Sandlance	259	74,074
Sculpin	7	2,002
Hake	1	286
Crab	10	2,860
Eel	-	-
Perch	-	-
Pipefish	-	-
Pink salmon fry	1	(?)

"312" Fort Langley Dredge Estimated (Factor N)

$$\frac{\text{Total area}}{\text{Area sampled}} \times \frac{\text{Dredging time}}{\text{Time sampled}} \times 22 \times \text{sample} = N$$

$$\frac{100}{11.5} \times \frac{45}{30} \times 22 \times \text{sample} = N$$

$$286 \times \text{sample} = N$$

Note: Only 11.5% of the total spill area was sampled.

Salmon Fry Downstream Migration:

Began March 4/75.
Peaked May 9/75 @ 5 million per day.
Finished May 29/75.

Total downstream salmon fry migration for 1975 was approximately 75 million.

6.4.1 Dredge Monitoring - DPW "Fort Langley" ("312") - Steveston

Monitoring of the "Fort Langley" dredge commenced on March 31, 1975, with four observers monitoring the day and night shifts. An 18-inch diameter dip net was used for monitoring at the aft half of the spoil hold. Due to a high concentration of suspended sediments at this location (location of net), monitoring was executed with considerable difficulty. The monitoring station was relocated towards the bow of the ship and monitoring conditions improved. Monitoring continued until April 20, 1975, with no fry capture recorded.

6.4.2 DPW "Fort Langley" ("312") - Tilbury Reach

On April 20, 1975, the "Fort Langley" commenced dredging at Tilbury Reach in the South Arm of the Fraser River. The effective screening area of the net was:

$$\frac{\text{Area of net}}{\text{Area of hold}} \times 100 = \frac{3.14\ D^2}{4 \times 438} \times 100 = \frac{1.8}{438} \times 100 = 0.46\%.$$

In the absence of data indicating the relationship between numbers of fry escaping into the river via the spoil outlet and numbers of fry that were buried, the ratio of 22:1 obtained from the May 10, 1974 test was applied to estimate the total number of fry captured by the dredge.

Fry capture was encountered on April 21, 22 and 23, 1975. The total numbers of fry caught by the dredge are shown below:

April 21 - (06:00 - 14:00 hrs) Day shift.

$$1 \text{ fry} \times \frac{100\% \text{ net screen}}{0.46 \text{ net screen}} \times \frac{7 \text{ min.}}{5 \text{ min.}} \times 22$$

fry caught = 6,696 fry/8 hr. shift.

April 22 - (06:00-14:00 hrs) Day shift.

$$11 \text{ fry in net} \times \frac{100\% \text{ net screen}}{0.46 \text{ net screen}} \times \frac{7 \text{ min.}}{5 \text{ min.}} \times 22$$

fry caught = 73,656 fry/8 hr. shift.

April 22 - (14:00-22:00 hrs) Night shift.

$$11 \text{ fry caught in net} \times \frac{100\% \text{ net screen}}{0.46 \text{ net screen}} \times \frac{7 \text{ min.}}{5 \text{ min.}} \times 22$$

fry caught = 73,656 fry/8 hr. shift.

April 23 - (06:00-14:00 hrs) Day shift.

$$14 \text{ fry caught in net} \times \frac{100\% \text{ net screen}}{0.46 \text{ net screen}} \times \frac{7 \text{ min.}}{5 \text{ min.}} \times 22$$

fry caught = 93,744 fry/8 hr. shift.

April 23 - (14:00-22:00 hrs) Night shift.

$$10 \text{ fry caught in net} \times \frac{100\% \text{ net screen}}{0.46 \text{ net screen}} \times \frac{7 \text{ min.}}{5 \text{ min.}} \times 22$$

fry caught = 66,960 fry/8 hr. shift.

On April 24, 1975, at the Fisheries Service's request, the "Fort Langley" was relocated to the mouth of the Fraser River.

6.4.3 Comments and Observations Concerning Monitoring of DPW "Fort Langley" ("312") Dredging at Steveston and Tilbury Reach Sites

(a) Nineteen Seventy-five was the first year that intensive fry monitoring had been conducted on board the "Fort Langley" hopper dredge. Results from the 1975 monitoring indicate the following:

(i) In certain areas of the Fraser River, closure of dredging operations was warranted because of the substantial numbers of salmon fry being pumped on board the dredge.

(ii) During peak migration, closure of dredging operations was warranted because of the large numbers of Sockeye smolts being captured on board the dredge.

(iii) The histological analyses reported in Appendices A and B indicate that survival of fry or smolts passing through the dredge is very low.

(iv) Further testing on board the "Fort Langley" is required to establish a burial/escapement ratio.

(v) An improved standardized monitoring method is required on board the Fort Langley to ensure that a larger volume of the flow is screened.

Figures 16, 17, 18 and 19 on the following three pages illustrate some of the on-site monitoring procedures used during the DPW "Fort Langley" ("312") dredging operations.

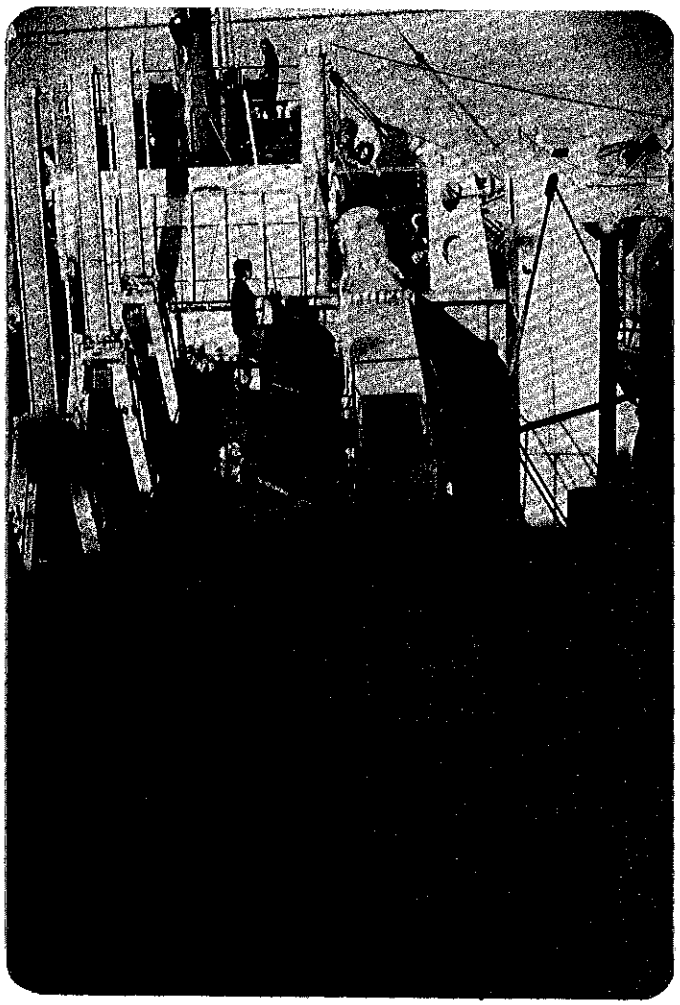

FIGURE 16

MONITORING IN PROGRESS IN
THE HOPPER DURING DPW ("312")
"FORT LANGLEY" OPERATIONS.

Photograph taken at the Steveston Cut
site on May 13, 1975.

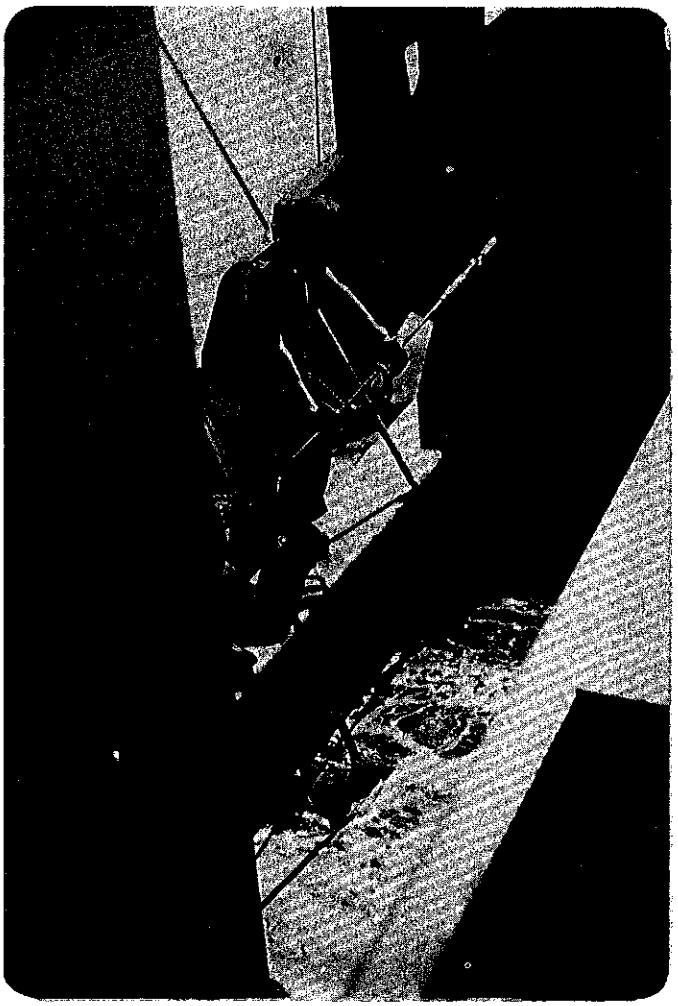

FIGURE 17

MONITORING IN PROGRESS IMMEDIATELY UPSTREAM OF THE SPILLWAY, DURING DPW "FORT LANGLEY" DREDGING OPERATIONS.

Photograph taken at the Steveston Cut site on May 22, 1975.

FIGURE 18

MONITORING WITH DIP NETS AT THE SPOIL DRAIN OUTLET, DURING DPW "FORT LANGLEY" DREDGING OPERATIONS

Photograph taken at the Steveston Cut site on May 27, 1975.

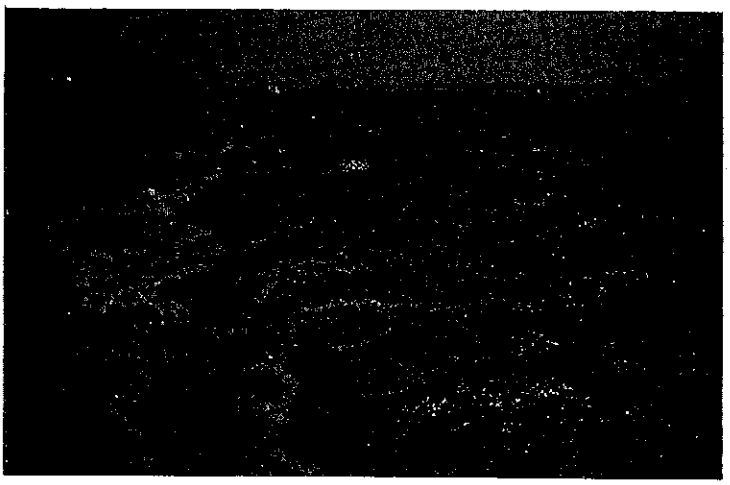

FIGURE 19

VIEW OF THE FRASER RIVER FROM THE STERN OF DPW "FORT LANGLEY" DREDGE DURING ITS RETURN TO STEVESTON CUT AFTER UNLOADING NEAR SANDHEADS.

7. RECOMMENDATIONS FOR FUTURE DREDGING OPERATIONS IN THE FRASER RIVER

7.1 DREDGE SCHEDULING

All Suction Dredging Operations (Hopper Dredges or Suction Dredges) in the Fraser River carried out in connection with projects such as sandborrow for the purposes of landfill and preloading, land reclamation, excavation of berthing facilities or for excavation of pipe-laying trench should not be permitted during the critical fry migration period.

Emergency maintenance dredging required for navigation should be preplanned and scheduled, such that, in river sections where the possibility of large-scale salmon juvenile capture is high, those sections are dredged at times other than the closed period stipulated in the "Fraser River Dredge Guidelines". See Appendix E appended to this report. Other documents related to fish destruction which affect dredging operations are as follows:

(a) The Fisheries Act, see Appendix F.

(b) The Public Works Act, see Appendix G.

(c) The Navigable Waters Protection Act, see Appendix H.

7.2 ALTERNATIVES TO DREDGING

In order to avoid dredging operations in the Fraser River during the downstream fry migration period, the Department of Public Works should be requested to explore alternatives such as:

(a) Dredging the anticipated emergency sites prior to the fry migration period.

(b) Detaining inbound ships at Sandheads for periods which would permit vessels to take advantage of depths afforded by rising tides.

7.3 MONITORING ACTIVITIES

In future monitoring programs associated with dredging operations using a pipe line or hopper dredge, an attempt should be made to fabricate and install screens to sample the entire outflow from the spoil drain.

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APPENDICES

APPENDIX A

MEMORANDUM NOTE DE SERVICE DATE June 23, 1975

Our file Notre référence

FROM: B. Tutty - Biologist
DE: Habitat Protection Unit

Your file Votre référence

TO: T.D. Bird - Senior Biologist
A: Habitat Protection Unit

SUBJECT: Department of Public Works Hydraulic Dredging (Fraser River) -
SUJET: Histopathological Examination of Entrained Salmon Fry

Enclosed is a letter from Mr. Jack McBride, histologist, Fisheries and Marine Service Laboratory, U.B.C., Vancouver, summarizing the results of the histopathological examination of 94 Oncorhynchus keta fry and 16 Oncorhynchus nerka smolts entrained by Dept. of Public Works dredges #312 and #322 operating in the lower Fraser River during the 1975 downstream salmon migration between March 15 and June 1, 1975.

The pathological conditions resultant from entrainment by hydraulic dredging can be summarized into two problem areas: concentrations of foreign material in the gill region, oral cavity and stomach; and haemorrhagic lesions found in the lateral muscles, gill filaments, liver, kidney, all or some being indicative of free blood cells in the peritoneal fluid.

The conditions identified are the result of mechanical injuries caused by entrainment of high volume hydraulic pumps and transport through the dredging operation. All organisms so entrained are exposed to rigorous passage via pump blades, pressure changes and possible pump cavitation, turbulence and extreme turbidity. These conditions result in damage to internal organs, lacerations, contusions, mutilation and body severance. Only 4.5 percent of the entrained fry emerge from the spoil site and it is assumed the remaining 95.5 percent of fry die of entrapment in the spoil mass or from massive physical damage. These figures were a result of Fisheries and Dept. of Public Works tests conducted in 1974, ("Phase II, Monitoring the Effects of Hydraulic Suction Dredging on Migrating Fish in the Fraser River" by F. Braun, June 1, 1974), enclosed. Of the 4.5 percent fry emerging from the spoil pond, 70 percent mortality occurred after a 96-hour bioassay in the Fraser River, realizing a total mortality rate of 98.8 percent. The post-dredging mortalities are no doubt caused by one or more of the pathological conditions stated previously.

The histopathological examination on the sockeye smolts was not as firm as the chum fry analysis. This was due to the

much larger size of the smolts. However, the same general pathological conditions remained evident and can be noted from the lab report. The massive descaling of sockeye may be a significant factor in post-dredging mortality. It must be noted that it may also be a function of the crude sampling techniques used aboard the Dept. of Public Works #312 dredge.

Reference is made to "Studies on Selected Myxobacteria Pathogenic for Fishes and on Bacterial Gill Disease in Hatchery - Reared Salmonids" by G. Bullock, Technical Paper #60, Bureau of Sports Fisheries and Wildlife, Washington, D.C., February, 1972. It was found that irritation of gill surfaces by particulate matter in water, produced infection of gill tissue by myxobacteria. The experiments indicate that the numbers of all bacterial types increased more rapidly in environmentally stressed salmonids than in controls. The high occurrence of foreign matter in the gill region along with the stress situation produced from the dredging operation, would certainly predispose fry to colonization by bacteria or fungii on the freshly abraded or irritated surfaces of those surviving fry. This would result in mortality or secondary predation due to the weakened state of the salmon fry indirectly caused by the dredging operation. It can be concluded that survival is extremely remote once salmon fry are entrained by a hydraulic dredge.

I hope this fills the information gap we have experienced in dealing with hydraulic dredging.

B. Tutty

Environment Canada Environnement Canada

MEMORANDUM NOTE DE SERVICE DATE

FROM: DE: Mr. J. McBride
Scientist, Vancouver Laboratory
Fisheries & Marine Service

Our file Notre référence

TO: À: Mr. B. Tutty
Biologist, Habitat Control Section
Fisheries & Marine Service

Your file Votre référence

SUBJECT: SUJET: Histopathological Examination of Juvenile Salmon Exposed to Dredging Operations in the Fraser River

In Tables B-1 and B-2, I have compiled the results of the histopathological survey for the salmon supplied by your group. A total of 94 salmon fry and 16 sockeye smolts were examined during the course of this study. Figures B-1 to B-8 show the most frequently noted pathological conditions.

Referring to Tables B-1 and B-2, you will note that I have attempted to semi-quantify the concentrations of foreign material observed in the gill region, as well as in the stomach contents. One item not included in either table, and yet, possibly of some significance, concerns the numerous minor ruptures noted in the skin epithelium. These appeared to be more frequently encountered in the fry. This, however, may only be a reflection of the fact that we were able to examine smolts. Past experience has shown that such minor abrasions can result from handling the fish with dry surfaces, i.e., gloves. On the other hand, it is conceivable that these minute lesions are the result of the turbulence experienced during exposure to the dredging operation. The absence, however, of any haemorrhaging or derangement of the subcutaneous tissues in the immediate area of the ruptures, tends to support the first interpretation.

The processing of the sockeye smolt samples presented a number of problems. The size of the fish precluded any attempt in preparing serial sections. Rather, longitudinal sections of the head region were prepared to enable examination of the oral cavity and gill region. Transverse sections from the area just caudal to the pectoral fins and from the mid-section were taken to assess the structural state of the internal organs. In a number of fish, alterations in the general tissue structure as well as irregularities in staining differentiation indicated that autolysis had occurred. The latter fish were excluded from the study.

Descaling of the skin was noted in every sockeye smolt examined. Note, descaling does not indicate a clear lesion in the skin epithelium. Based on visual estimations, the scale loss in the majority of the samples ranged between 30-50% but, in a few cases, the loss appeared to run as high as 80-90%. Whether this damage was the result of improper handling or due to the turbulence of the dredging operation, is unknown. Two conditions, however, tend to favour the identifying of the dredging operation as the culprit. First, these fish are fairly large and it is unlikely that, in sampling, the operator's hand came in direct contact with a large portion of the skin surface. Second, the affected skin surface was not concentrated in one or two areas, as say to approximate the area of a person's hand, but usually involved numerous small patches of skin distributed over the entire body surface. While there may exist some question as to how this damage was inflicted, there can be little doubt that descaling of this magnitude would not only be very stressful to the fish, but also offer excellent sites for bacterial infections. In such a situation one could anticipate a high mortality.

Yours sincerely,

J. McBride

TABLE B-1

Pathological Conditions and Their Frequency in Salmon Fry Exposed to Dredging Operations in the Fraser River (94 Fry Examined).

Pathological Condition	No. of Fish Recorded	Percentage Proportion of Total Sample	Total Percentage
1. Foreign Matter*			
(a) Oral Cavity			
Trace	2	12.50	
Moderate	6	37.50	50.0
Abundant	2	12.50	
(b) Gill Region			
Trace	3	18.75	
Moderate	2	12.50	50.0
Abundant	3	18.75	
(c) Stomach Contents			
Trace	2	12.50	
Moderate	1	6.25	25.0
Abundant	1	6.25	
2. Lesions			
(a) Lateral Muscle	2	12.50	18.7
(b) Gill Filaments	1	6.25	

* Trace - minute amounts noted only occasionally.

Moderate - considerable amounts in small area or small amounts in most areas.

Abundant - medium to heavy concentrations in most areas.

TABLE B-2

Pathological Conditions and Their Frequency in Sockeye Smolts Exposed to Dredging Operations in the Fraser River (16 Smolts Examined)

Pathological Condition	No. of Fish Recorded	Percentage Proportion of Total Sample	Total Percentage
1. Foreign Matter*			
(a) Oral Cavity			
Trace	2	12.50	
Moderate	6	37.50	50.0
Abundant	2	12.50	
(b) Gill Region			
Trace	3	18.75	
Moderate	2	12.50	50.0
Abundant	3	18.75	
(c) Stomach Contents			
Trace	2	12.50	
Moderate	1	6.25	25.0
Abundant	1	6.25	
2. Lesions			
(a) Lateral Muscle	2	12.50	18.7
(b) Gill Filaments	1	6.25	

*Trace - minute amounts noted only occasionally.

Moderate - considerable amounts in small area or small amounts in most areas.

Abundant - medium to heavy concentrations in most areas.

FIGURE B-1

Foreign Matter Trapped Between Gill Lamella Haematozylin & Eosin. X160.

Significance: Presence of foreign material acts not only as a deterrent to normal gaseous exchange, but also as an irritant or stressor. Such conditions have been shown to predispose the animal to gill infections.

FIGURE B-2

Portion of Oral Cavity Showing a Mass of Foreign Material Located just Anterior to the Entrance of the Stomach. Haematozylin & Eosin. X40.

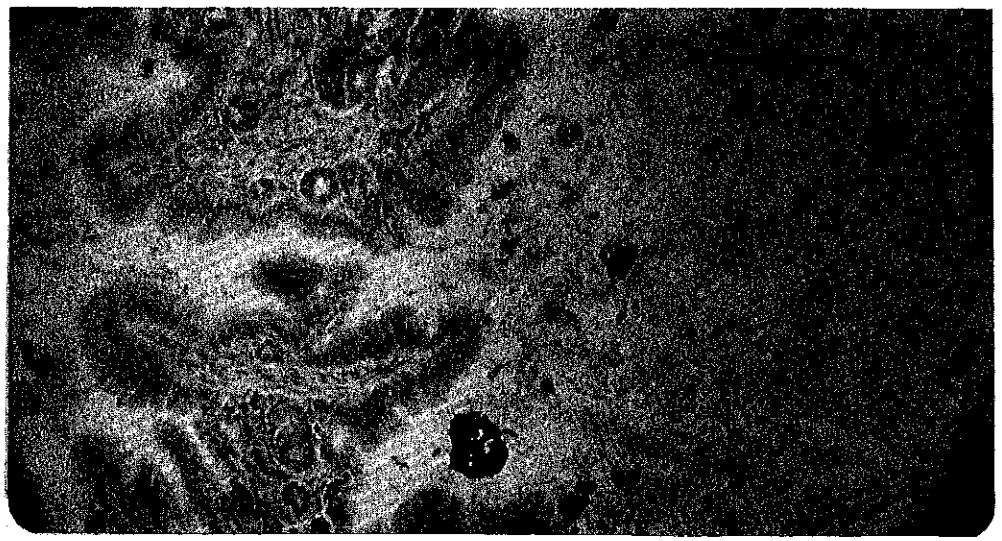

FIGURE B-3

Foreign Matter Present in Anterior Segment of Stomach. Note the Similarity in the Consistency of the Foreign Material in Figures B-1 and B-2.

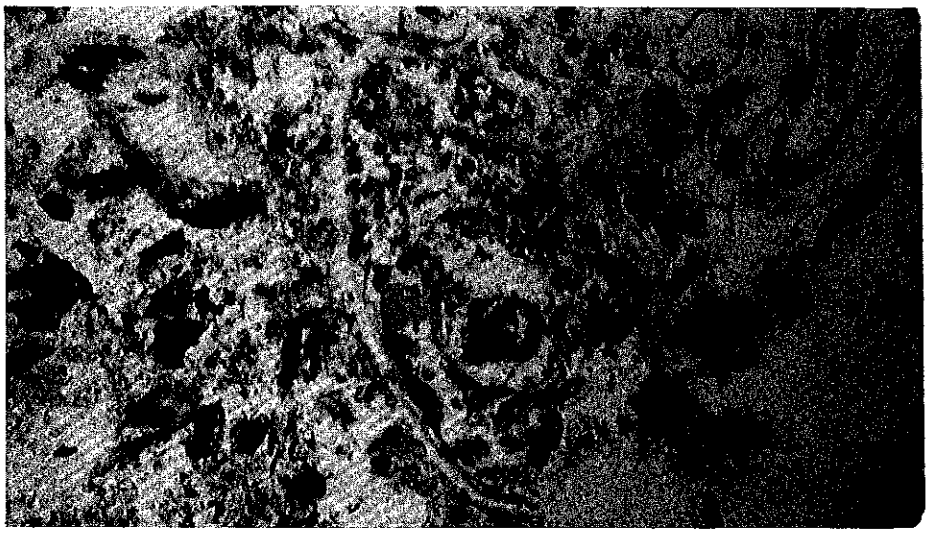

FIGURE B-4

Foreign Matter Present in Mid-section of Stomach. Note Distinct Separation of Partially Digested Natural Products shown on the Left, and the Foreign Material on the Right. Also, Note the Similarity of the Foreign Matter with that Shown in Figures B-1 to B-3.

Significance: Foreign material may act as an irritant and possibly impede normal digestive processes. The possibility of toxic effects cannot be excluded.

FIGURE B-5

Haemorrhagic Lesions Located in Lateral Muscle. Haematoxylin & Eosin. X40.

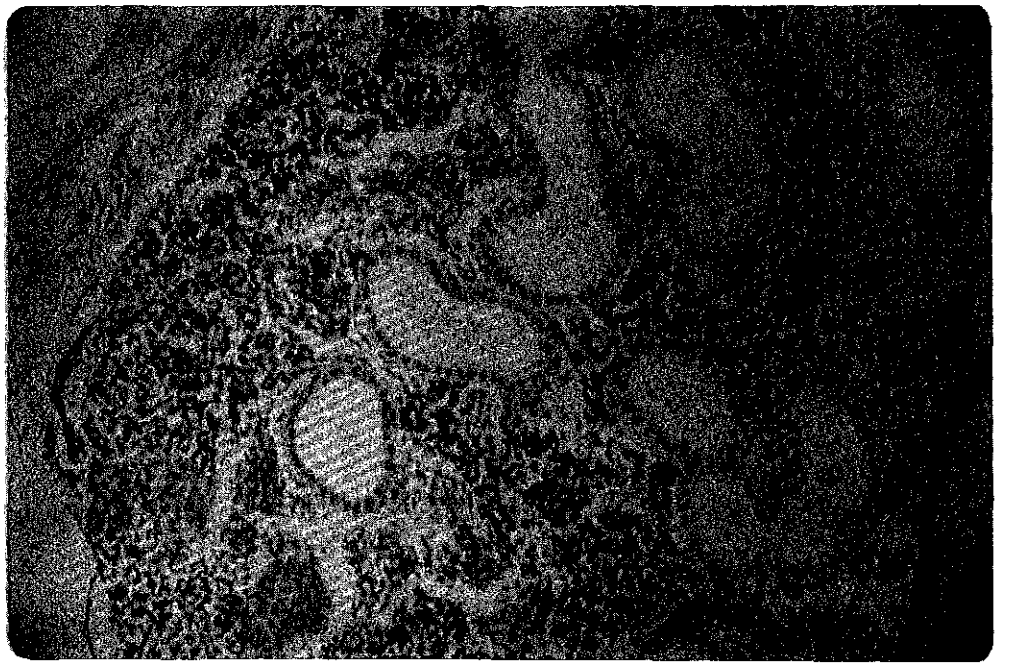

FIGURE B-6

Massive Haemorrhage Involving Large Portion of Hemopoietic Tissue in Kidney. Haemotoxylin & Eosin. X50.

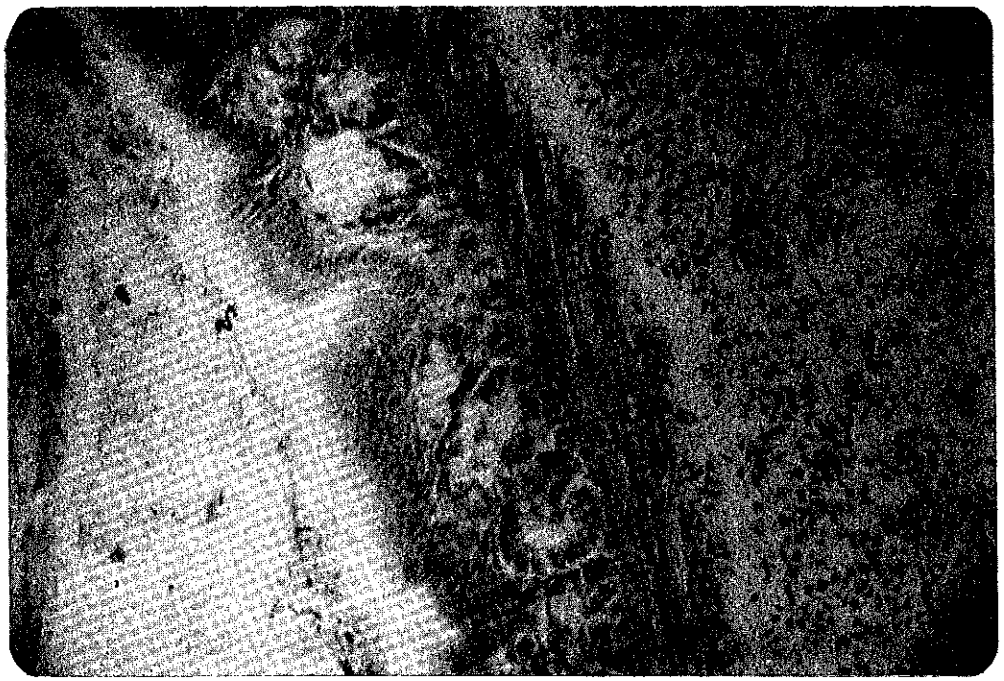

FIGURE B-7

Large Pool of Blood Bordering the External Surface of the Stomach. Haematoxylin & Eosin. X64.

Significance: In addition to immediate effect(s) of injury, e.e., impaired function, shock, etc., the damaged areas are potential sites for subsequent infections.

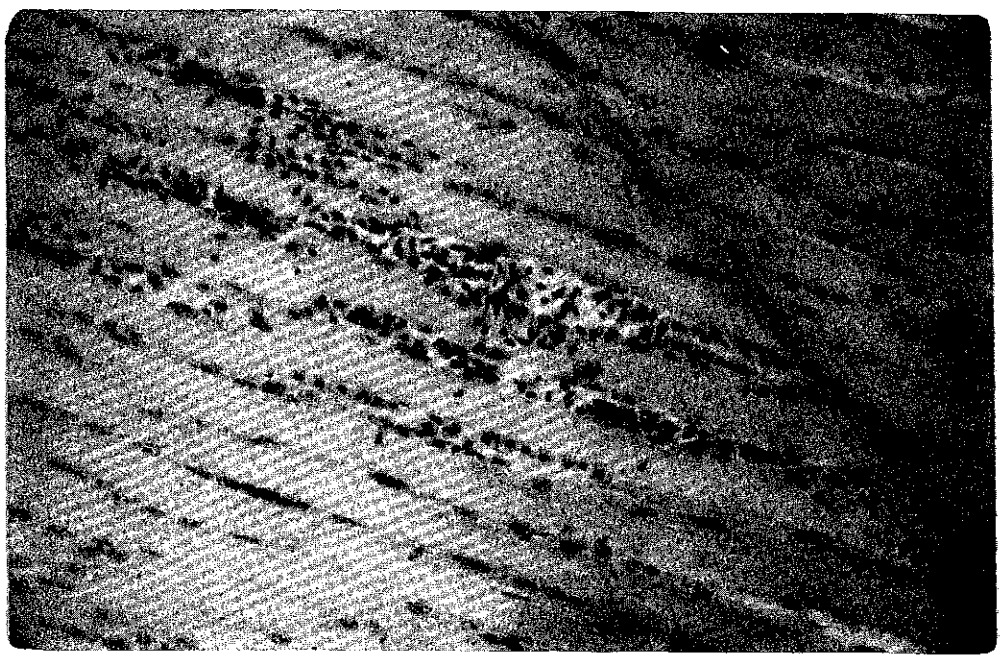

FIGURE B-8

Environment Canada Environnement Canada

MEMORANDUM NOTE DE SERVICE DATE

Our file Notre référence

FROM: B.C. Pearce
DE:

Your file Votre référence

TO: O. Langer, Biologist
À: H.P.U.

SUBJECT: Dredging North Arm Jetty
SUJET:

On April 17, 1975, I accompanied B. Tutty and P. Sookachoff to the D.P.W. dredge site on the North Arm Jetty to monitor water quality. Specifically pH, conductivity, temperature, dissolved oxygen and hydrogen sulfide determinations were carried out in the main stem of the North Arm and on the dredgeate returning to the river from the spoil pond.

Samples were obtained using a 2-litre VanDorn water bottle suspended one-metre off the bottom, approximately 10 metres downstream of the cutterhead. There was no detectable H_2S in using the Hack HS7 test kit. It should be mentioned, however, that this is not the most accurate test procedure for H_2S + 0.2 ppm. The pH was measured at 8.5 using a Siebold Wein, type GKA portable field pH meter.

A profile was made from the dredge directly at the cutterhead using a Hydrolab multiprobe analyzer, yielding the following results:

	DEPTH (M)	PH	COND (μMHO/cm)	TEMP (°C)	D.O. (% Saturation)
	0	8.25	19.0	8	100
	2	8.25	22.5	8	100
	4	8.10	34.0	8	100
	6	8.15	35.0	8	97
Bottom	6.5	8.10	36.5	8	100

No samples were obtained and analyzed for suspended solids, although there was an evident plume from the dredge which could have a negative impact on downstream habitat. It was the concensus of those involved that water quality as determined was not appreciably altered and the only question raised was the removal of this littoral zone from production.

B.C. Pearce

B.C. RESEARCH 3650 Wesbrook Crescent, Vancouver 167, Canada.

May 5, 1975

PROJECT REPORT

To: Department of Public Works
1444 Alberni Street
Vancouver, B.C.
V6G 1A1

Attention: Mr. O. Isfeld

Subject: 96-HR LC50 BIOASSAY OF SAMPLES RECEIVED APRIL 17, 1975

A. OBJECT

To measure by standard bioassay procedures the toxicity to juvenile rainbow trout (Salmo gairdneri) of samples of Fraser River silts.

B. PROCEDURES

1. Sample Processing

Twelve 1-pint samples of Fraser River Silts were received at B.C. Research from Department of Public Works on April 17, 1975. Silt collected at 2.25, 2.45, 3.05, 3.25, 3.45, 4.05 were mixed as composite sample A, and silts collected at 2.35, 2.55, 3.15, 3.35, 3.55, and 4.15 as composite sample B.

2. Test Fish

Juvenile rainbow trout (Salmo gairdneri) were used as test fish and were taken from a homogeneous population of hatchery-reared fish acclimated to laboratory conditions of water and temperature. Ten fish were used in each concentration tested.

TABLE 2

OXYGEN DEMAND RESULTS OF APRIL 17, 1975 SILT SAMPLES TAKEN FROM NORTH ARM - FRASER RIVER

Sample	O.D. 0 hr (mg/l)	O.D. 6 hr (mg/l)	O.D. 24 hr (mg/l)
100% Composite A	0	1.6	2.8
100% Composite B	0	1.8	3.2
Control (dechlorinated tap water)	0	0.4	0.6

TABLE 1

96-HR LIMIT BIOASSAY RESULTS OF APRIL 17, 1975,
SILT SAMPLES TAKEN FROM NORTH ARM - FRASER RIVER

Samples taken: April 17, 1975
Samples received: April 17, 1975
Test started: April 18, 1975
Test fish: Juvenile rainbow trout (*Salmo gairdneri*) acclimated to 11± 1 C; 10 fish/test solution

Clean fish weight: 0.3 ± 0.1 g
Test volume: 3.5 litres
Test temperature: 11 ± 1 C
Dissolved oxygen content: 9 mg/litre
96-hr static bioassay without solution exchange; pH not adjusted.

Sample	pH	Conductance (micromhos/cm)	Test Concentration (% v/v)	% Survival			
				24 hr	48 hr	72 hr	96 hr
Composite A	7.5	13,420	100	100	100	100	100
Composite B	7.5	13,600	100	100	100	100	100
Control (dechlorinated tap water)	6.3	25.0	-	100	100	100	100

3. Bioassay Procedures

Bioassay were carried out according to procedures outlined in "Standard Methods for the Examination of Water and Wastewater", 13th Edition, 1971, published by the American Public Health Association. Specific test conditions are given in Table D-1.

4. Oxygen Demand

Composite samples A and B were saturated with air, transferred to B.O.D. bottles, stoppered and D.O. measurements made at 6-hr and 24-hr intervals using a Bechman D.O. meter. Tests were made at 11° C.

C. RESULTS

Bioassay results are outlined in Table D-1. All fish survived 96-hr exposure to 100% concentrations of composite A & B samples received April 17, 1975.

Oxygen demand results are outlined in Table D-2. Both samples A & B have an oxygen demand, 2.8 mg/l and 3.2 mg/l, respectively. Oxygen demand at these levels would not be a cause for concern in the main run of a river, but if they occurred in a closed lagoon, they would indicate a problem.

D.D. Monteith
Water Quality Group
Division of Applied Biology

D.J. McLeay
Research Officer, Water Quality
Division of Applied Biology

APPENDIX E

SUMMARY OF

"FRASER RIVER DREDGING GUIDELINES"

(Excerpt from Report No. PAC/T-75-2 entitled, "Fraser River Dredging Guidelines", Fisheries and Marine Service, Pacific Region.)

General Dredging Restrictions

1. Areas zoned as ecologically valuable, including highly utilized rearing areas and major sources of fish food production may be exempted from dredging at all times.

2. Areas subject to timing restrictions include spawning areas, critical migration routes, and adult-holding areas.

3. Fraser River mouth upstream to the Sumas River.

   (a) Clam shell dredges allowed year 'round.

   (b) Suction dredges authorized to operate, unrestricted, June 1 to March 15, of the following year.

   (c) Suction dredges used for sandborrow, reclamation, or excavation of berthing facilities will not be authorized March 15 to June 1.

   (d) Suction dredges used for emergency situations will be allowed March 15 to June 1, under the following conditions:

(i) The operation is adequately monitored to determine the magnitude of fish losses.

(ii) The proposed method of monitoring shall be submitted to and approved by the Fisheries Service prior to commencement of operations.

(iii) All manpower, equipment and facilities required for monitoring operations shall be provided at the expense of the proponent.

(iv) In the event that monitoring indicates significant losses of fish, the operation shall cease immediately. Resumption of dredge operations shall be subject to the discretion and explicit direction of the Fisheries Service.

(e) Suction dredge operators are advised to:

(i) Complete all work prior to March 15.

(ii) Schedule operations between June 1 - March 15 of the year following.

(iii) Cease operations during fry migration period March 15 - June 1.

(iv) Note that the restriction period may be extended to include March 1 - March 15 or June 1 - June 15 to protect unusually early or late fry migrations.

APPENDIX F

THE FISHERIES ACT

(Excerpts from the pertinent sections of The Fisheries Act, R.S.C. 1970, Chapter F-14

SALMON FISHING

Section 12 Salmon fry, parr and smolt shall not at any time be fished for, caught or killed and no salmon or grilse of less weight than three pounds shall be caught or killed, otherwise than by angling with hook and line.

Section 28(1) In the Provinces of British Columbia, Manitoba, Saskatchewan and Alberta, the Northwest Territories and the Yukon Territory, every ditch, channel or canal constructed or adapted for conducting water from any lake, river or stream, for irrigating, manufacturing, domestic or other purposes, shall, if the Minister deems it necessary in the public interest, be provided at its entrance or intake with a fish guard or a metal or wire grating, covering or netting, so fixed as to prevent the passage of fish from any lake, river or stream into such ditch, channel or canal.

Section 28(2) The fish guards referred to in subsection (1) shall have meshes or holes of such dimensions as the Minister may prescribe, and shall be built and maintained by the owner or occupier of such ditch, channel or canal, subject to the approval of the Minister or of such officer as he may appoint to examine it.

(3) The owner or occupier of such ditch, channel or canal shall maintain such fish guard in a good and efficient state of repair, and shall not permit its removal except for renewal or repair, and during the time such renewal or repair is being effected the sluice or gate at the intake or entrance shall be closed, and the passage of fish into the ditch, channel or canal prevented.

Section 30 The eggs or fry of fish on the spawning grounds, shall not at any time be destroyed.

Section 33(1) No one shall throw overboard ballast, coal ashes, stones, or other prejudicial or deleterious substances in any river, harbour or roadstead, or in any water where fishing is carried on, or leave or deposit or cause to be thrown, left or deposited, upon the shore, beach or bank of any water or upon the beach between high and low water, remains or offal of fish, or of marine animals,

or leave decayed or decaying fish in any net or other fishing apparatus; such remains or offal may be buried ashore, above high water mark.

Section 33(2) Subject to subsection (4), no person shall deposit or permit the deposit of a deleterious substance of any type in water frequented by fish or in any place under any conditions where such deleterious substance or any other deleterious substance that results from the deposit of such deleterious substance may enter any such water.

APPENDIX G

THE PUBLIC WORKS ACT

(Excerpt from The Public Works Act, R.S., 1952, Part II, Chapter 228, p. 12.)

POWER TO DREDGE, ETC., BEDS OF NAVIGABLE WATERS

Section 37 Whenever the Governor in Council, or the Minister charged with any work for the improvement of navigation, directs any work to be performed in any navigable water for the improvement of the navigation thereof, it is lawful for the officers or servants of Her Majesty or the contractors for the work, under the direction of the Governor in Council or of the Minister, to enter upon, dig up, dredge and remove any part of the bed of such navigable water, or to build or erect any works thereon, as may be directed or authorized by the Governor in Council or by the Minister for the improvement of the navigation.

APPENDIX H

THE NAVIGABLE WATERS PROTECTION ACT

(Excerpts from the pertinent sections of The Navigable Waters Protection Act, R.S.C. 1968-69

Section 5(1) No work shall be built or placed in, upon, over, under, through or across any navigable water unless:

(a) The work and the site and plans thereof have been approved by the Minister upon such terms and conditions as he deems fit prior to commencement of construction.

Section 8(1) The local authority, company or person proposing to construct any work in navigable waters, for which no sufficient sanction otherwise exists, may deposit the plans thereof and a description of the proposed site with the Minister, and a duplicate of each in the office of the registrar of deeds for the district, county or province in which such work is proposed to be constructed, and may apply to the Minister for approval thereof.

Section 19 No person shall throw or deposit or cause, suffer or permit to be thrown or deposited any sawdust, edgings, slabs, bark or like rubbish of any description whatever that is liable to interfere with navigation in any water, any part of which is navigable or that flows into any navigable water.

Section 20 No person shall throw or deposit or cause, suffer or permit to be thrown or deposited any stone, gravel, earth, cinders, ashes or other material or rubbish that is liable to sink to the bottom in any water, any part of which is navigable or that flows into any navigable water, where there are not at least twenty fathoms of water at all times, but nothing in this section shall be construed so as to permit the throwing or depositing of any substance in any part of a navigable water where such action is prohibited by or under any other Act.

APPENDIX I

TEST REPORT OF MAY 10, 1974

Excerpt from the Technical Report No. PAC/T-75-26 entitled "Assessing the Impact of a 24" Suction Pipeline Dredge on Chum Salmon Fry in the Fraser River", prepared by L.K. Dutta, and P. Sookachoff, Habitat Protection Unit, Southern Operations Branch, Fisheries and Marine Service, Pacific Region.

The Fisheries and Marine Service, in collaboration with Public Works Canada conducted a test at Annacis Island to assess the effects of a Hydraulic Suction Dredging operation on sea-bound juvenile salmonids on May 10, 1974.

Known numbers of chum salmon fry were inserted into the suction pipe of an operating dredge and were recovered at the spoil site. A 96-hr viability test was conducted on those fry recovered alive at the spoil runoff outlet to ascertain the number of fry that would survive after passing through the dredge system.

The following results were obtained:

1. It was observed that for every fry recovered (irrespective of whether it was dead or alive) twenty-two (22) were buried in the spoil mass.

2. 96-hr viability test confirmed that of those fry that could escape into the river via the spoil runoff outlet, 70.6% would die during the first 96-hr period.

3 Overall mortality rate (including those that were buried in the spoil mass, those recovered dead, and those which escaped into the river alive but would die during the first 96-hr period) was 98.8%.