Movement of radio tagged steelhead in the Morice River determined by helicopter and fixed station tracking, 1994/95.

~~SK #125~~

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ABSTRACT

In order to accurately and precisely estimate the Morice River steelhead population, an alternative mark and recapture method was attempted between August 1994 and June 1995 and evaluated. The alternative to the standard angler based mark and recapture enumeration technique was to use a combination of steelhead radio tagged during the ocean based Skeena Radio Tagging Program (BC Environment, Department of Fisheries and Oceans, via LGL Consultants Ltd.), steelhead radio-tagged at the Moricetown fishway (Bulkley River), and steelhead radio tagged by regional fisheries staff using angling methods as the marking portion of a single census mark and recapture estimate. Rather than use a traditional angling or tangle netting recapture method to sample the population prior to spawning, a hydro-acoustic method was to be used in conjunction with a stationary radio telemetry receivers to monitor the post-spawning emigration of marked and unmarked steelhead from the Bulkley River. The hydro-acoustic portion of this study was to be undertaken through a collaborative effort between staff of the BC Environment (Skeena Region) and staff from the Department of Fisheries and Oceans Stock Assessment Division. It was anticipated that this method might improve both the accuracy and precision of the population estimate. The hydro-acoustic portion of this study was not completed as DFO after assessing the objectives of the program and viewing the river conditions felt that estimating the Bulkley River steelhead population would be impossible with this technology.

INTRODUCTION

This project is part of the joint Department of Fisheries and Oceans (DFO) and BC Ministry of Environment program to reduce the incidental interception of steelhead bound for the Skeena River by 50%. Monitoring of key Skeena steelhead stocks will be important if this goal is to be achieved. Additionally, the development of alternative, cost-effective escapement estimation techniques that improve both the accuracy and precision of these estimates will have continuing long-term benefits to the program. This radio telemetry study would add to the knowledge of the life history and migration patterns of Bulkley River steelhead. Ministry of Environment personnel angled steelhead (*Oncorhynchus mykiss*) between November 7-9, 1994. Radio tags were applied to steelhead in the Morice-Bulkley systems to monitor winter movements and downstream migration of kelts. The primary purpose of tagging steelhead on the Morice River was to increase the sample size of tagged fish for proposed hydro-acoustic studies of downstream movements of kelts (spawned out steelhead). The project did not proceed because the hydro-acoustic technology was deemed inappropriate for this application since radio-tags were at large in the Morice River.

METHODS

2.1 Study Area The Morice River is the largest tributary of the Bulkley River system and joins the Bulkley River approximately 6.5 km west of Houston, BC. The Morice watershed drains an area of 1911 km². A detailed description of the Morice River can be found in Whately et al., 1978. The study area on the Morice River included the 75 km of river from the outlet of Morice Lake downstream to the confluence with the Bulkley River (near Houston) and the Bulkley River downstream to its confluence with Toboggan Creek (85 km). The river was segregated into 43 five kilometer sections starting at the confluence of the Bulkley River and the Skeena River (0 km) upstream to Morice lake (218 km). Once spawning was completed, the mending kelts were monitored during their emigration by fixed receiver stations at the Bulkley/Skeena confluence, Zymoetz/Skeena confluence and at the Exchamsiks/Skeena confluence.

Both marked and unmarked steelhead were to be enumerated during their emigration as kelts at a site which was to have a stationary receiver and a hydro acoustic enumeration device monitoring the downstream migration. The combination of these two technologies was to give both the marked and unmarked steelhead counts from which a simple Peterson population estimate could be derived.

2.1 Fish Capture and Tagging

Forty wild adult summer run steelhead were captured using conventional angling gear and bait. Twenty females and twenty males were radio tagged. The forty radio tags were applied to Morice steelhead from November 7, 1994 to November 9, 1994. The nearest landmark and the kilometer reading along the river described all tagging locations. Ministry of Environment personnel (Jeff Lough and Ron Tetreau) spent six rod days on the Morice River to tag the forty steelhead. All steelhead that were in good condition were radio tagged. Fish were held at the water's surface, while radio transmitters were inserted orally into the stomach with the assistance of a hollow, flexible plastic tube. Anaesthetic was not used, as the possible effect on migration was not known. Radio tagged fish were also tagged with an anchor tag at the base of the left side of the dorsal fin. Sex, fork length, anchor tag number and color, any scars and hook marks, fish condition and radio tag number was noted for each fish captured.

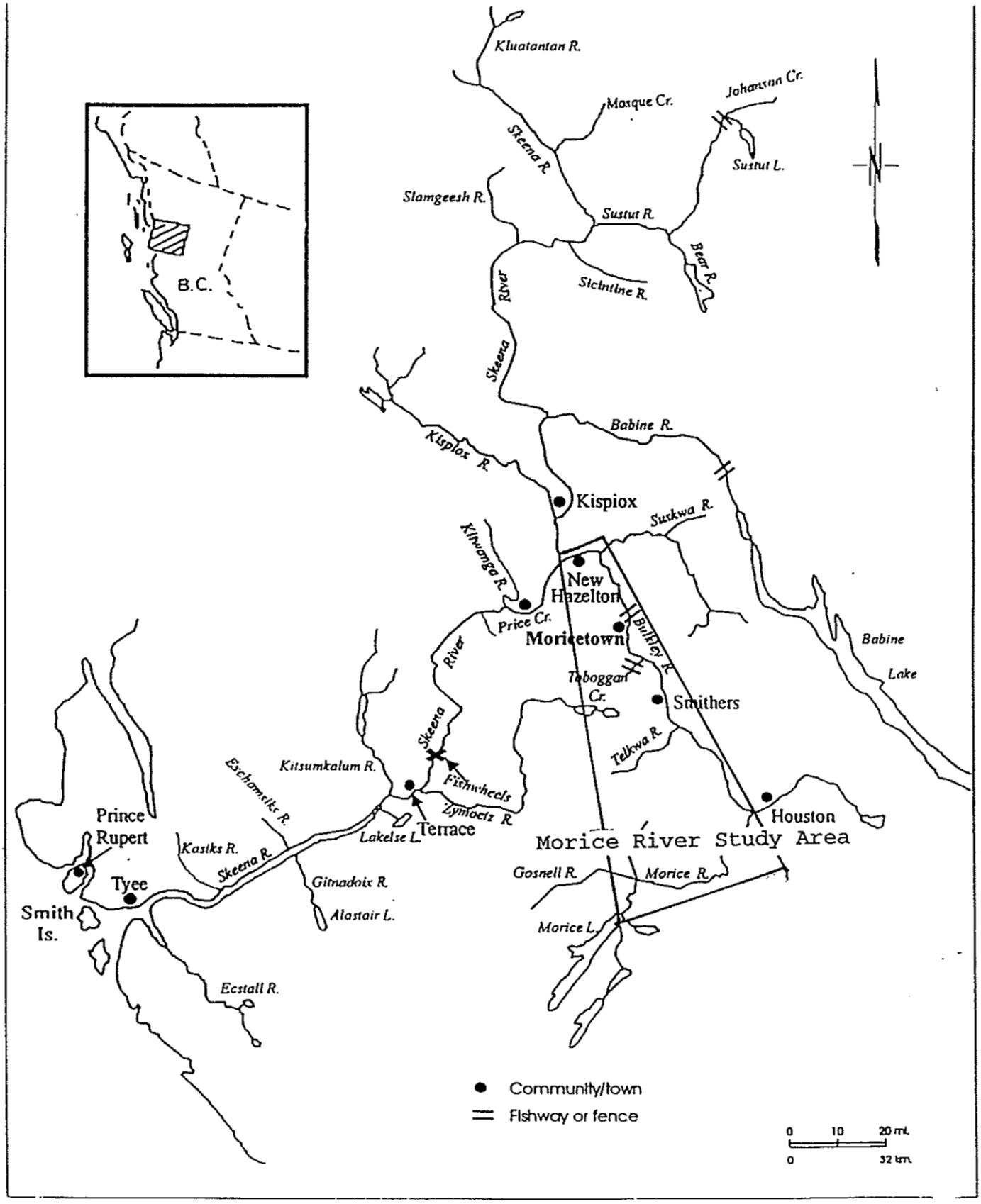

Figure 1a. Map of the Skeena River and tributaries.

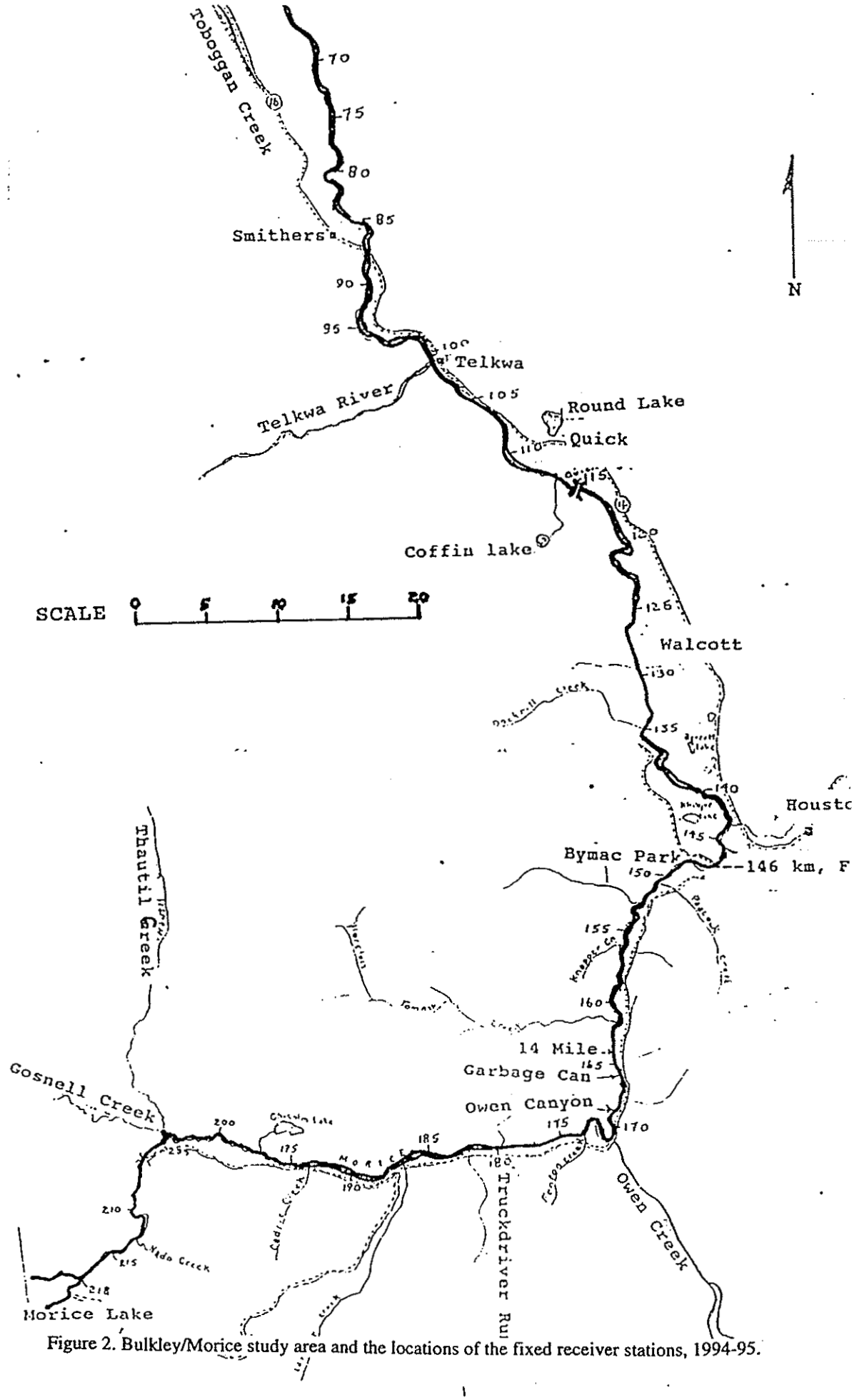

Figure 2. Bulkley/Morice study area and the locations of the fixed receiver stations, 1994-95.

2.2 Radio Telemetry

Radio telemetry equipment used in this study was obtained from Lotek Engineering Ltd. (Newmarket, Ontario). Radio transmitters (model CFRT-3A) were cylindrical, 14.5 mm in diameter, 43 mm in length and had a 440 mm long antenna leading from the anterior end of the transmitter; the antenna protruded from the fishes mouth. The transmitter weighed 10.7 grams in air, 4.2 grams in water and was powered by a 3 volt Lithium battery that had a 260 day life. All transmitters emitted a digitally encoded radio signal at a frequency of 151.101 MHz. Individual radio tag signals were detected and decoded by the telemetry receiver (model SRX-400). This receiver was used in combination with a six metre length of RG-58 A/U double shielded coaxial cable and a three element Yagi antenna for aerial tracking and fixed stations. Stationary receivers were set up upstream of the Bulkley/ Morice confluence (146 km) and upstream of the Toboggan Creek/Bulkley confluence (59 km).

The location of sites was selected to monitor fish moving along the mainstem or entering known spawning systems. Each fixed station consisted of one or two antennas and the SRX-400 receiver, which was powered by a 12-Volt deep discharge (recreational vehicle) battery. The battery and receiver were enclosed in a weatherproof container and could operate for 10 days without servicing. The stations were visited every ten days to replace batteries and download data from the receiver.

Aerial tracking was conducted from a Bell 206B helicopter with one or two 3 or 4- element Yagi antennas attached to the cargo skids. The aircraft flew along the river and its tributaries at 80-190 (usually 130-160) km/h and at 90-300 m above ground level. The location and identities of each fish were determined and stored in real time by a Global Positioning System (GPS) with a built-in data logger and the SRX 400 receiver. The approximate position and the identity of each fish were also recorded manually on data sheets as a backup to the electronic systems. The position of the fish was later confirmed by comparing signal strengths and the GPS positions that were machine recorded. During most surveys, two receivers were operated on different channels, or all channels offset, so that the probability of passing a fish without recording it was reduced. A list of all telemetry surveys conducted during this study is found in Appendix 1 and 3. During the project there were four helicopter flights between January 6, 1995 and May 12, 1996. The fixed station receivers operated from the tagging date (November 7, 1994) to June 30, 1996. The fixed station receiver at Houston (F19) was not operational from January 4, 1996 to January 11, 1996 and from May 4, 1996 to May 17, 1996 due to battery failure. The fixed station receivers located at the Bulkley/Skeena confluence

(F12, km 0), Zymoetz/Skeena confluence (F10, km 131) and the Exchamsiks/Skeena confluence (F5, km -202) were used to record the migration of kelts leaving the Skeena River.

Radio tagging

Radio tags were placed in 40 Morice River steelhead during 1994. Steelhead were tagged over a three day period from November 7 to November 9 (Table 1). The fish were tagged at twelve locations on the Morice river from 149 km (2 km upstream of Bymac Park) to 180 km (Truckdriver Run). The movements of these fish were monitored over the winter and spring by four helicopter flights and continuous monitoring of the two fixed receiver stations at (F19) 146 km (Morice/Houston) and (F15) 59 km (Toboggan Creek).

Tracking Methods

During the study most tracking was done by fixed-station receivers, however, final destinations for most fish were confirmed during helicopter surveys. These data were condensed to records of fish departures from the fixed station receivers and to unique locations for each day that each fish was tracked using mobile tracking methods. Appendix 1 and 3 indicate the number of different fish tracked on each day during each weekly period.

3.0 RESULTS AND DISCUSSION

Only one (male, fish #9) of forty radio tagged steelhead moved upstream; the majority dropped downstream of the original tagging location (Table 2) The distance of downstream movement ranged from 0 km to 202 km (Exchamsiks stationary receiver). One fish (fish #19) was not tracked after tagging, which is probably a result of tag malfunction, removal.or regurgitation. The mean downstream movement by males and females varied from 24 km to 29.8 km. As the tags were applied from November 7- 9, 1994, they were expected to fail around the 25th of July 1995. It is possible that some of the tags may have failed prior to that date and downstream Kelt migration was not monitored to the lower Skeena River. Ten (6 females: 4 males) of the radio tagged fish were monitored emigrating from the Skeena system between May 24 and June 29, 1995 (Table 3).

In 1995, the Morice River steelhead Kelt emigration varied from May 24th to June 29th, with the mean emigration date of June 5th. Commercial gillnet fishery openings for Chinook in June could have a detrimental effect on the emigrating Kelt

populations. A more selective fishery would enable the release of these kelts and increase the numbers of repeat spawners.

It was difficult to ascertain if the behavior of radio-tagged steelhead was similar to that of untagged fish. If angling steelhead during low water temperatures may have contributed to the high proportion of dropback among the tagged fish.

5.0 RECOMMENDATIONS

1. Discontinue radio-tagging steelhead on the Morice River until the hydro-acoustic technology is capable of enumerating emigrating kelts during the high, turbid flows of spring runoff.
2. Inform Department of Fisheries and Oceans of the detrimental effects of commercial Chinook openings on the emigrating steelhead stocks during June and recommend more selective fisheries.

ACKNOWLEDGMENTS

Everyone working on the 1995 Morice River telemetry program contributed to the success of this study and we thank them all. The 1995 Morice River telemetry project was conceived and directed by Bob Hooton. Special contributions were made to the radio tracking and downloading of the fixed receiver stations by Mark Beere (M.O.E.) and Richard Alexander (LGL Consultants Ltd.). Jeff Lough (M.O.E.) provided expertise in assisting with angling and applying the forty radio transmitters. Dana Atagi provided direction and assistance in data computations and analyses. Lotek Engineering.Ltd provided the radio tags and tracking equipment. Northern Mountain Helicopters and Canadian Helicopters were used during flights and assisted us in many other ways.

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Table 1. Information regarding Morice River steelhead that were radio-tagged as part of the 1994-95 telemetry program.

Fish no.	Channel	Code	Sex	Length	Date	Tag Loc. (km)	Comments
1	3	34	M	57	94/11/07	158(11 mile)	tag# N3279/80
2	9	68	F	72.4	94/11/07	157.5(Aspen Tank)	tag# S3738
3	8	46	F	58.4	94/11/07	157.5(Aspen Tank)	tag# S3740
4	3	62	F	68.6	94/11/07	157.5(Aspen Tank)	tag# S3742
5	10	37	M	67.3	94/11/07	157.5(Aspen Tank	tag#S3743, Predator scar
6	9	28	M	61	94/11/07	157.5(Aspen Tank)	tag# S3744
7	8	48	M	61	94/11/07	157.5(Aspen Tank)	tag# S3745
8	10	35	F	69.9	94/11/07	157.5(Aspen Tank)	tag# S3746
9	10	38	M	71.1	94/11/07	166(Garbage can)	Tag# S3747
10	9	59	F	58.4	94/11/07	168(Owen Canyon)	Tag# S3748
11	3	42	F	67.3	94/11/07	168(Owen Canyon)	Tag# S3750
12	8	56	F	54.6	94/11/07	168(Owen Canyon)	Tag# S3503
13	3	61	F	78.7	94/11/07	168(Owen Canyon)	Tag# S3504
14	9	76	F	62.3	94/11/07	168(Owen Canyon)	Tag# S3505
15	10	23	F	67.3	94/11/07	168(Owen Canyon)	Tag# S3506
16	8	67	M	68.6	94/11/07	168(Owen Canyon)	Tag# S3507
17	10	32	M	57.2	94/11/08	180(38.5km Morice rd.)	Tag# S3508
18	10	46	M	59.7	94/11/08	180(38.5km Morice rd.)	Tag# S3509
19	3	77	F	69.9	94/11/08	180(38.5km Morice rd.)	Tag# S3510, ant. disappeared down throat
20	3	69	F	58.4	94/11/08	180(38.5km Morice rd.)	Tag# S3511
21	8	54	M	72.4	94/11/08	180(38.5km Morice rd.)	Tag# S3512
22	8	36	F	58.4	94/11/08	180(38.5km Morice rd.)	Tag# S3513
23	9	43	M	58.4	94/11/08	180(38.5km Morice rd.)	Tag# S3514
24	9	49	F	72.4	94/11/08	164(14 mile)	Tag# S3515
25	10	45	F	71.1	94/11/08	164(14 mile)	Tag# S3516. hook left in ,OK rel.
26	10	25	M	58.4	94/11/09	149(2km U/S Bymac)	Tag# S3517, hook scar
27	9	51	F	73.7	94/11/09	149(2km U/S Bymac)	Tag# S3518
28	3	67	M	55.9	94/11/09	149(2km U/S Bymac)	Tag# S3519
29	3	72	M	52.1	94/11/09	150(3km U/S Bymac)	Tag# S3520
30	8	53	F	52.1	94/11/09	150(3km U/S Bymac)	Tag# S3521
31	8	57	M	66	94/11/09	150(3km U/S Bymac)	Tag# S3522, Gillnet marks
32	10	22	M	61	94/11/09	150(3km U/S Bymac)	Tag# S3523, caudal damage
33	9	72	F	55.9	94/11/09	150(3km U/S Bymac)	Tag# S3524
34	9	78	F	71.1	94/11/09	151(4km U/S Bymac)	Tag# S3525
35	3	78	M	73.7	94/11/09	152(5km U/S Bymac)	Tag# C4090
36	8	79	M	78.7	94/11/09	153(6km U/S Bymac)	Tag# C4091
37	9	73	F	73.7	94/11/09	153(6km U/S Bymac)	Tag# C4092, Gillnet scar
38	3	59	M	57.2	94/11/09	153(6km U/S Bymac)	Tag# C4094
39	10	28	M	53.3	94/11/09	153(6km U/S Bymac)	Tag# C4096
40	8	47	M	76.2	94/11/09	155(8km U/S Bymac)	Tag# S3739

Table 2, . Summary of upstream and downstream movements and summary of mean distance travelled by males and females in the Morice River, 1994-1995.

Sex	Number Upstream		Number Downstream		KM d/s	Total
Male	1	38 km	18	(1 no movement)	29.8 km	20
Female	0		19	(1 tag loss)	24.1 km	20

Table 3. Dates and number of days for Morice river steelhead kelts to emigrate from the Skeena River, 1994-95.

Fish #	Sex	River location					# days emigration Bulkley / Skeena confluence
		Morice(146 km)	Toboggan Cr(59 km)	Bulkley/Skeena(0km)	Zymoetz R.(131 km)	Exchamsiks R.(-202km)	
3	F	07 Jun				18 Jun	
4	F		30 May		01 Jun		
5	M	26 Jun	27 Jun	28 Jun	29 Jun	29 Jun	1
10	F	17 May	07 Jun	09 Jun		12 Jun	3
13	F	20 May		28 May		30 May	2
18	M	28 May	29 May	30 May	31 May	31 May	1
24	F	27 May		30 May	02 Jun	02 Jun	4
35	M	19 May	25 May	27 May	27 May	28 May	1
37	F	12 May	02 Jun	05 Jun	06 Jun	08 Jun	3
40	M	18 May	22 May	23 May	24 May		1

Appendix 1. Tagging information and subsequent locations (river kilometres) from fixed station receivers(Morice and Toboggan) of radio tagged Morice River summer steelhead, 1994 - 1995.

Channel	Code	Sex	Length (FL in cm)	Tagging Location																			
				7 Nov,1994																			
Ch. 3	34	M	57	158	146(19 Nov, 94)	110(6 Jan 95 Hel)	104(22 Mar 95 Hel)	106(12 May 95 Hel)															
Ch. 9	68	F	72.4	157.5	146 (11 Nov,' 94)																		
Ch. 8	46	F	58.4	157.5	146 (12 Nov,' 94)	146(23 May,' 95)	146(7 June,' 95)	-202(18 June,'95)															
Ch. 3	62	F	68.6	157.5	146(19 Nov 95)	134(12 May 95 Hel)	146(21 May 95)	59(30 May,'95)	-131(1 June,'95)														
Ch. 10	37	M	67.3	157.5	162(6 Jan 95 Hel)	157(22 Mar 95 Hel)	165(12 May 95 Hel)	146(15 Jun 95)	146(26 Jun 95)	59(27 June,'95)	0(28 June,'95)	-131(29 June,'95)	-202(29 June,'95)										
Ch. 9	28	M	61	157.5	104(6 Jan 95 Hel)	104(22 Mar 95 Hel)	107(12 May 95 Hel)																
Ch. 8	48	M	61	157.5	160(6 Jan 95 Hel)	156(22 Mar 95 Hel)	146(25 Apr,'95)																
Ch. 10	35	F	69.9	157.5	146 (29 Nov,' 94)	146 (30 Nov,' 94)	146 (3 Dec,' 94)	146(5 Dec,' 94)	146(7 Dec,' 94)	146(11 Dec,' 94)	146(14 Dec,' 94)	133(22 Mar 95 H	134(12 May,.95,Hel)										
Ch. 10	38	M	71.1	166	164(6 Jan 95 Hel)	157(22 Mar 95 Hel)	204(12 May 95 Hel)																
Ch. 9	59	F	58.4	168	165(6 Jan 95 Hel)	154(22 mar 95 Hel)	146(24 mar 95)	146(22 Apr 95)	146(25 Apr 95)	146(1 May 95)	155(12 May 95 Hel)	146(17 May 95)	59(7 Jun 95)	0(9 June,'95)	-202(12 June,'95)								
Ch. 3	42	F	67.3	168	155(6 Jan 95 Hel)	156(22 Mar 95 Hel)	162(12 May 95 Hel)																
Ch. 8	56	F	54.6	168	94(6 Jan 95 Hel)	95(22 Mar 95 Hel)	92(12 May 95 Hel)																
Ch. 3	61	F	78.7	168	163(6 Jan 95 Hel)	146(20 May 95)	0(28 May,'95)	-202(30 May,'95)															
Ch. 9	76	F	62.3	168	90(6 Jan 95 Hel)	92(22 Mar 95 Hel)	92(3 Apr 95 Hel)	90(12 May 95 Hel)															
Ch. 10	23	F	67.3	168	146(3 May,' 95)	59(8 May,' 95)																	
Ch. 8	67	M	68.6	168	170(6 Jan 95 Hel)	165(22 Mar 95 Hel)	65(12 May 95 Hel)																
				8 Nov, ' 94																			
Ch. 10	32	M	57.2	180	175(6 Jan 95 Hel)	156(22 Mar 95 Hel)	146(5 Apr,'95)	59(23 Apr 95)	59(24 Apr 95)	36(12 May 95 Hel)													
Ch. 10	46	M	59.7	180	178(6 Jan 95 Hel)	174(22 Mar 95 Hel)	146(28 May 95)	59(29 May,'95)	0(30 May,'95)	-131(31 May,'95)	-202(31 May,'95)												
Ch. 3	77	F	69.9	180																			
Ch. 3	69	F	58.4	180	176(6 Jan 95 Hel)	151(22 Mar 95 Hel)																	
Ch. 8	54	M	72.4	180	180(6 Jan 95 Hel)	178(22 Mar 95 Hel)	174(12 May 95 Hel)																
Ch. 8	36	F	58.4	180	182(6 Jan 95 Hel)	134(22 Mar 95 Hel)	134(12 May 95 Hel)																
Ch. 9	43	M	58.4	180	147(6 Jan 95 Hel)	147(22 Mar 95 Hel)																	
Ch. 9	49	F	72.4	164	172(6 Jan 95 Hel)	170(22 Mar 95 Hel)	174(12 May 95 Hel)	146(27 May 95)	0(30 May,'95)	-131(2 June,'95)	-202(2 June,'95)												
Ch. 10	45	F	71.1	164	137(6 Jan 95 Hel)	146(2 Feb 95)	156(22 Mar 95 Hel)	154(12 May 95 Hel)															
				9 Nov,' 94																			
Ch. 10	25	M	58.4	149	146 (10 Nov,' 94)	135(6 Jan 95 Hel)	136(22 Mar 95 Hel)	154(12 May 95 Hel)	146(20 Jun 95)														
Ch. 9	51	F	73.7	149	146 (28 Nov,' 94)	146 (30 Nov,' 94)	146 (3 Dec,' 94)	146(5 Dec,' 94)	146(7 Dec,' 94)	146(10 Dec,' 94)	146(14 Dec,' 94)	146(20 Dec,' 94)	146(23 Dec,' 94)	146(26 Dec,' 94)		146(29 Dec,' 94)	146(31 Dec,' 94)	150(6 Jan 95 Hel)	146(16 Jan 95)	146(30 Mar 95)	146(3 Apr		
Ch. 3	67	M	55.9	149	146 (9 Nov,' 94)	134(6 Jan 95 H)(14 Feb,' 9	59(14 Feb 95)	59(3 March,' 95)	59(12 March,' 95)	59(17 March,' 95)	66(22 Mar 95 Hel)	59(5 April,' 95)		59(13 April,' 95)		59(16 April,' 95)	59(20 April,' 95)	59(23 April,' 95)	59(25 April,' 95)	59(29 April,' 95)	58(12 May		
Ch. 3	72	M	52.1	150	146(17 Nov 94	146(26 Nov 94)	130(6 Jan 95 Hel)	123(22 Mar 95 Hel)	123(12 May 95 hel)														
Ch. 8	53	F	52.1	150	143(6 Jan 95 Hel)	143(22 Mar 95 Hel)	142(12 May 95 Hel)																
Ch. 8	57	M	66	150	146 (10 Nov,' 94)	120(6 Jan 95 Hel)	116(22 Mar 95 Hel)	104(12 May 95 Hel)															
Ch. 10	22	M	61	150	146(1 Jan,' 95)	143(6 Jan 95 Hel)	136(22 Mar 95 Hel)	139(12 May 95 Hel)															
Ch. 9	72	F	55.9	150	146 (10 Nov,' 94)	146 (24 Nov,'94)	146 (28 Nov,' 94)	146 (30 Nov,' 94)	146 (3 Dec,' 94)	146(5 Dec,' 94)	146(7 Dec,' 94)	134(6 Jan 95 Hel	106(12 May 95 Hel)										
Ch. 9	78	F	71.1	151	154(6 Jan 95 Hel)	146(7 July 95)																	
Ch. 3	78	M	73.7	152	146 (10 Nov,' 94)	146(18 Nov 94)	143(6 Jan 95 Hel)	140(22 Mar 95 Hel)	173(12 May 95 hel)	146(19 May 95)	59(25 May,'95)	0(27 May,'95)	-131(27 May,'95)	-202(28 May,'95)									
Ch. 8	79	M	78.7	153	146 (10 Nov,' 94)	148(6 Jan 95 Hel)	141(22 Mar 95 Hel)	137(12 may 95 Hel)															
Ch. 9	73	F	73.7	153	146 (9 Nov,' 94)	115(6 Jan 95 Hel)	130(22 Mar 95 Hel)	145(12 May 95 Hel)	59(2 June,'95)	0(5 June,'95)	-131(6 June,'95)	-202(8 June,'95)											
Ch. 3	59	M	57.2	153	146 (24 Nov,' 94)	146 (28 Nov,' 94)	146 (30 Nov,' 94)	146 (3 Dec,' 94	146(5 Dec,' 94)	146(7 Dec,' 94)	146(10 Dec,' 94)	146(14 Dec,' 94)	146(20 Dec,' 94)	146(23 Dec,' 94)		146(26 Dec,' 94)	146(29 Dec,' 94)	146(31 Dec,' 94)	145(6 Jan 95 Hel)	137(22 Mar 95 Hel)	137(12 Ma		
Ch. 10	28	M	53.3	153	154(6 Jan 95 Hel)	156(22 Mar 95 Hel)	153(12 May 95 hel)																
Ch. 8	47	M	76.2	155	146 (12 Nov,' 94)	134(6 Jan 95 hel)	146(18 May 95)	59(22 May,'95)	0(23 May,'95)	-131(24 May,'95)													

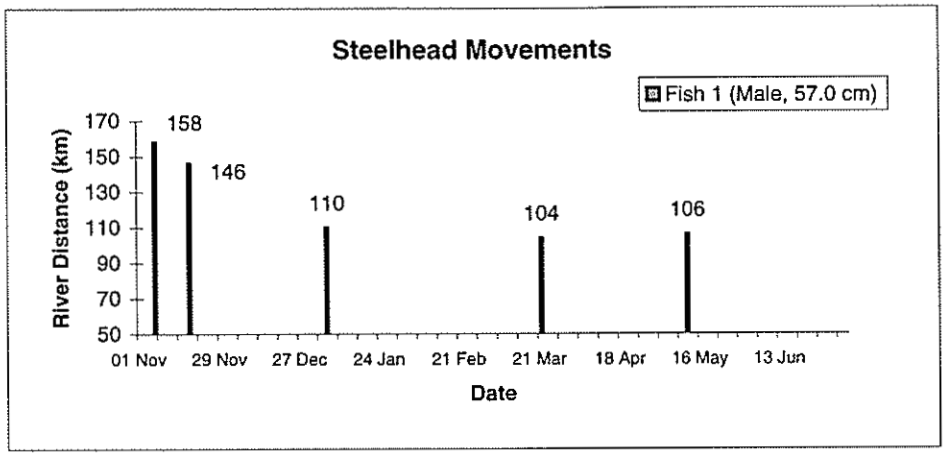
Appendix 2. Summary of upstream and downstream movement (Kelt emigration) of steelhead in the Morice River, 1994-95.

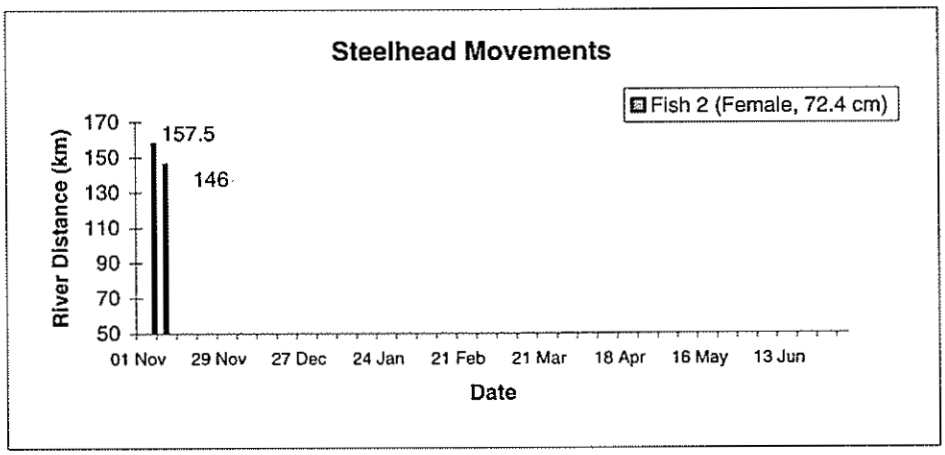
Fish	Distance	Sex	Comments
1	-52	M	
2	-11.5	F	
3	-11.5	F	Kelt migration June 18th
4	-11.5	F	Kelt migration June 1st
5	-11.5	M	Kelt migration June 29th
6	-50.5	M	
7	-1.5	M	
8	-23.5	F	
9	38	M	
10	-22	F	Kelt migration,Bulkley-June 9th,Exchamsiks-June 12th
11	-6	F	
12	-76	F	
13	-22	F	Kelt migration Bulkley-May 28th,Exchamsiks-May 30th
14	-78	F	
15	-22	F	Kelt migration May 8th
16	-3	M	Kelt migration May 12th
17	-121	M	Kelt migration May 12th
18	-34	M	Kelt migration Bulkley-May30th,Exchamsiks-May31st
19	0	F	Tag loss/ removal
20	-29	F	
21	-6	M	
22	-46	F	
23	-33	M	
24	-18	F	Kelt migration Bulkley-May30th,Exchamsiks-June 2nd
25	-10	F	
26	-3	M	
27	-3	F	
28	-90	M	kelt migration-May 12th
29	-27	M	
30	-8	F	
31	-46	M	
32	-11	M	
33	-44	F	
34	-8	F	
35	-6	M	Kelt migration Bulkley-May 27th,Exchamsiks-May 28th
36	-16	M	
37	-8	F	Kelt migration Bulkley-June 5th,Exchamsiks-June 8th
38	-16	M	Kelt migration May 12th
39	0	M	very little movement
40	-9	M	Kelt migration Bulkley-May 23rd, Zymoetz-May 24th

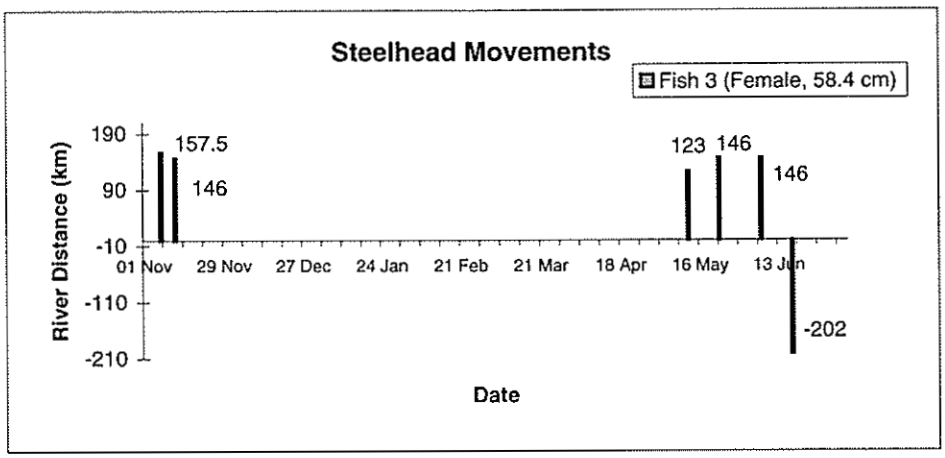
Appendix 3. Summary of tagging information and subsequent locations (River kms) from helicopter flights on the Morice and Bulkley Rivers, 1994-1995.

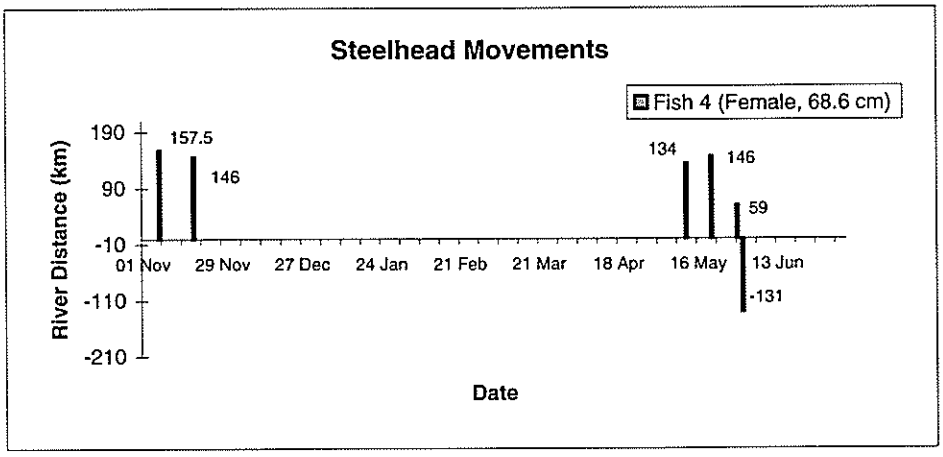
No.	Chan.	Code	Sex	Length	Date	Tagging Location	Helicopter 06 jan, 95	Helicopter 22 Mar, 95	Helicopter 03 Apr, 95	Helicopter 12 May, 95
1	ch. 3	34	M	570	94/11/07	158 km	110 km	104 km		106 km
2	ch. 3	62	F	686	94/11/07	157.5 km				134 km
3	ch. 3	42	F	673	94/11/07	168 km	155 km	1556 km		162 km
4	ch. 3	61	F	787	94/11/07	168 km	163 km			
5	ch. 3	77	F	699	94/11/08	180 km				
6	ch. 3	69	F	584	94/11/08	180 km	176 km	151 km		
7	ch. 3	67	M	559	94/11/09	149 km	134 km	66 km		58 km
8	ch. 3	72	M	521	94/11/09	150 km	130 km	123 km		123 km
9	ch. 3	78	M	737	94/11/09	152 km	143 km	140 km		173 km
10	ch. 3	59	M	572	94/11/09	153 km	145 km	137 km		137 km
11	ch. 8	46	F	584	94/11/07	157.5 km	120 km	119 km		126 km
12	ch. 8	48	M	610	94/11/07	157.5 km	160 km	156 km		
13	ch. 8	56	F	546	94/11/07	168 km	94 km	95 km		92 km
14	ch. 8	67	M	686	94/11/07	168 km	170 km	165 km		65 km
15	ch. 8	54	M	724	94/11/08	180 km	180 km	178 km		174 km
16	ch. 8	36	F	584	94/11/08	180 km	182 km	134 km		134 km
17	ch. 8	53	F	521	94/11/09	150 km	143 km	143 km		142 km
18	ch. 8	57	M	660	94/11/09	150 km	120 km	116 km		104 km
19	ch. 8	79	M	787	94/11/09	153 km	148 km	141 km		137 km
20	ch. 8	47	M	762	94/11/09	155 km	134 km			
21	ch. 9	68	F	724	94/11/07	157.5 km				
22	ch. 9	28	M	610	94/11/07	157.5 km	104 km	104 km		107 km
23	ch. 9	59	F	584	94/11/07	168 km	165 km	154 km		155 km
24	ch. 9	76	F	623	94/11/07	168 km	90 km	92 km	92 km	90 km
25	ch. 9	43	M	584	94/11/08	180 km	143 km	143 km		
26	ch. 9	49	F	724	94/11/08	164 km	172 km	170 km		174 km
27	ch. 9	51	F	737	94/11/09	149 km	150 km		146 km	80 km
28	ch. 9	72	F	559	94/11/09	150 km	134 km			106 km
29	ch. 9	78	F	711	94/11/09	151 km	154 km			
30	ch. 9	73	F	737	94/11/09	153 km	115 km	130 km		145 km
31	ch. 10	37	M	673	94/11/07	157.5 km	162 km	157 km		165 km
32	ch. 10	35	F	699	94/11/07	157.5 km		133 km		134 km
33	ch. 10	38	M	711	94/11/07	166 km	164 km	157 km		204 km
34	ch. 10	23	F	673	94/11/07	168 km				
35	ch. 10	32	M	572	94/11/08	180 km	175 km	156 km		36 km
36	ch. 10	46	M	597	94/11/08	180 km	178 km	174 km		
37	ch. 10	45	F	711	94/11/08	164 km	137 km	156 km		154 km
38	ch. 10	25	M	584	94/11/09	149 km	135 km	136 km		154 km
39	ch. 10	22	M	610	94/11/09	150 km	143 km	136 km		139 km
40	ch. 10	28	M	533	94/11/09	153 km	154 km	156 km		153 km

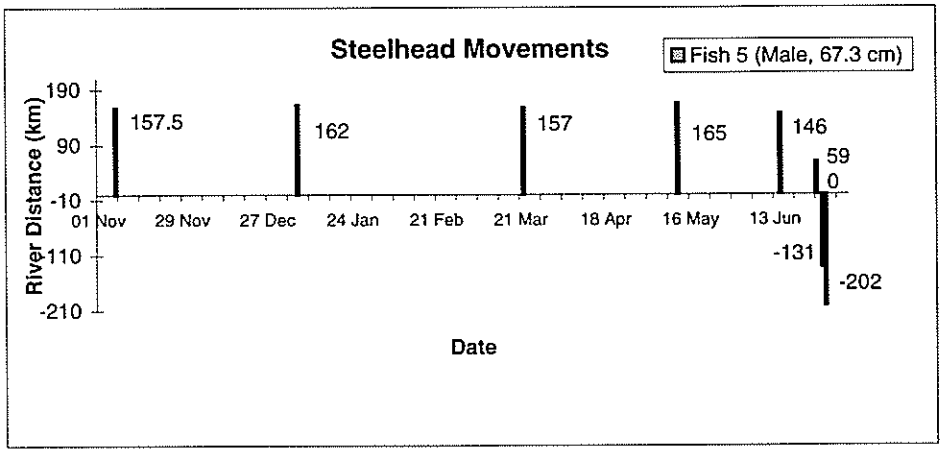
Appendix 4. Movements of individual radio tagged steelhead in the Morice River, 1994-1995.

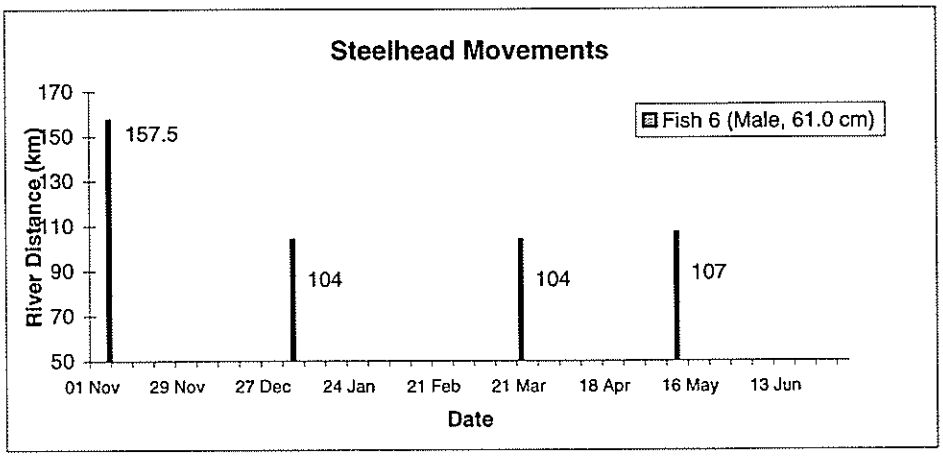


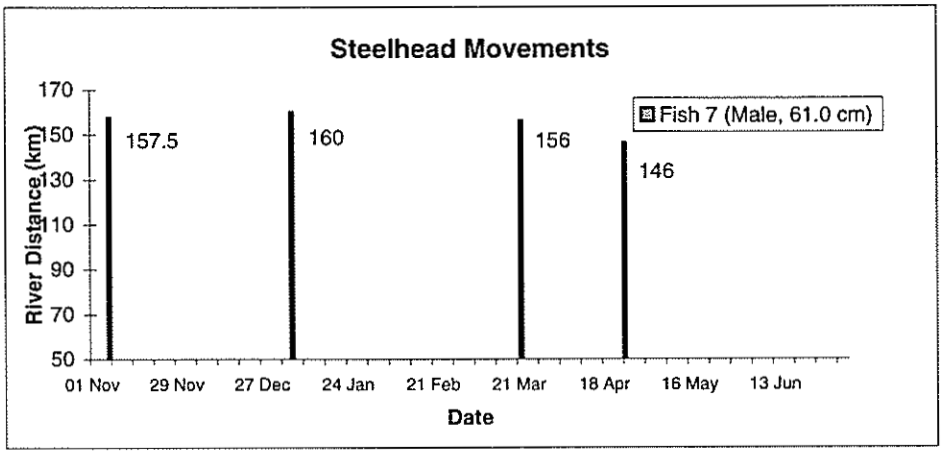


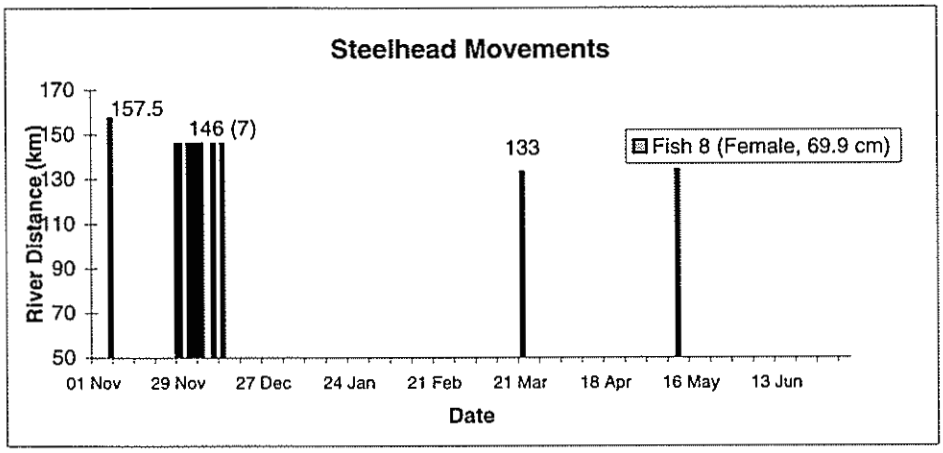


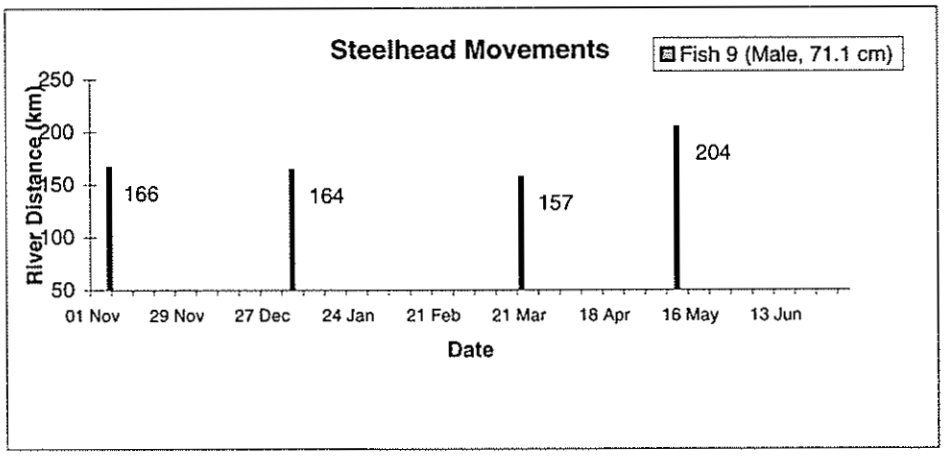

Steelhead Movements
Fish 4 (Female, 68.6 cm)
River Distance (km)
190
90
-10
-110
-210
157.5
146
134
146
59
-131
01 Nov
29 Nov
27 Dec
24 Jan
21 Feb
21 Mar
18 Apr
16 May
13 Jun
Date

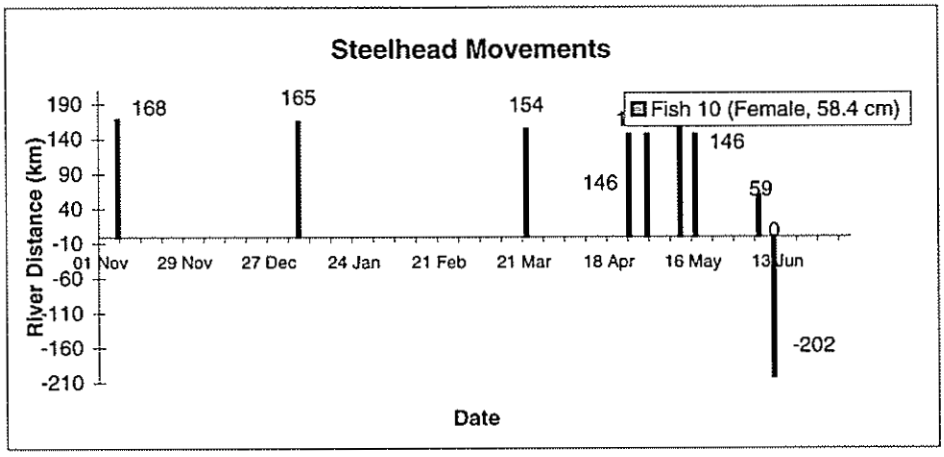

Steelhead Movements
Fish 5 (Male, 67.3 cm)
River Distance (km)
190
90
-10
110
-210
157.5
162
157
165
146
59
0
-131
-202
01 Nov
29 Nov
27 Dec
24 Jan
21 Feb
21 Mar
18 Apr
16 May
13 Jun
Date

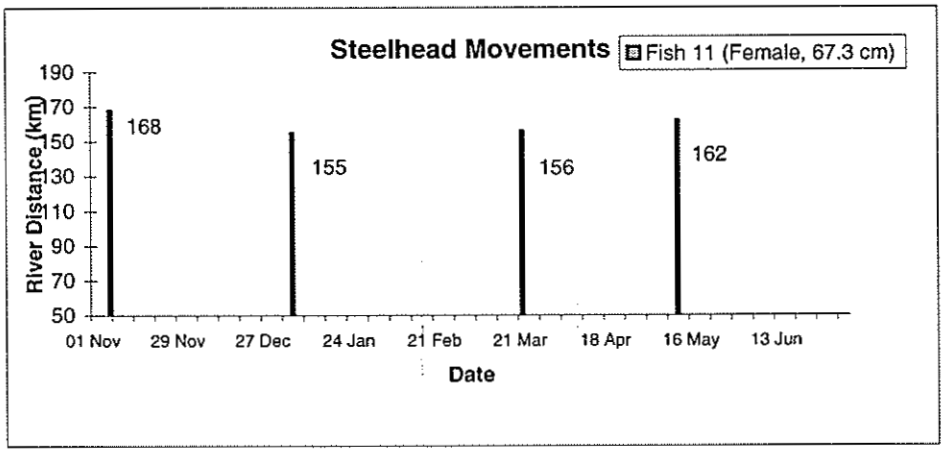

Steelhead Movements
Fish 6 (Male, 61.0 cm)
River Distance (km)
170
150
130
110
90
70
50
157.5
104
104
107
01 Nov
29 Nov
27 Dec
24 Jan
21 Feb
21 Mar
18 Apr
16 May
13 Jun
Date

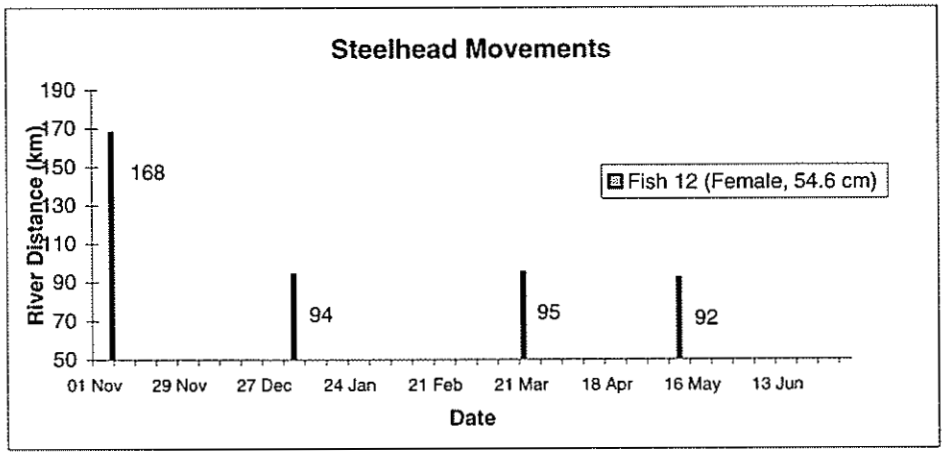

Steelhead Movements
Fish 7 (Male, 61.0 cm)
River Distance (km)
170
150
130
110
90
70
50
157.5
160
156
146
01 Nov
29 Nov
27 Dec
24 Jan
21 Feb
21 Mar
18 Apr
16 May
13 Jun
Date

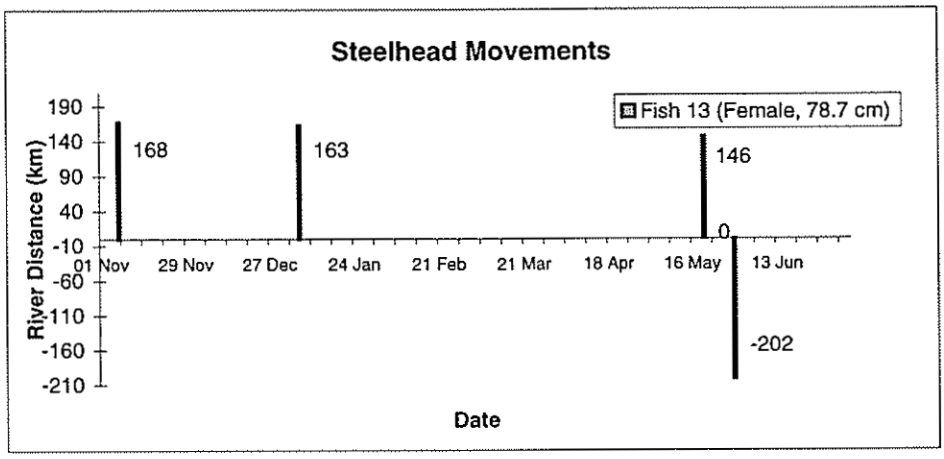

Steelhead Movements
Fish 8 (Female, 69.9 cm)
River Distance (km)
170
150
130
110
90
70
50
157.5
146 (7)
133
01 Nov
29 Nov
27 Dec
24 Jan
21 Feb
21 Mar
18 Apr
16 May
13 Jun
Date

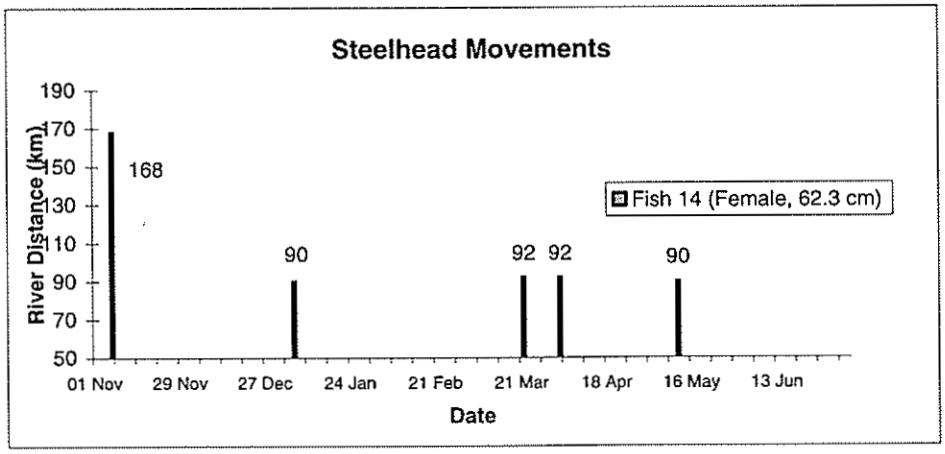

Steelhead Movements
Fish 9 (Male, 71.1 cm)
River Distance (km)
250
200
150
100
50
166
164
157
204
01 Nov
29 Nov
27 Dec
24 Jan
21 Feb
21 Mar
18 Apr
16 May
13 Jun
Date

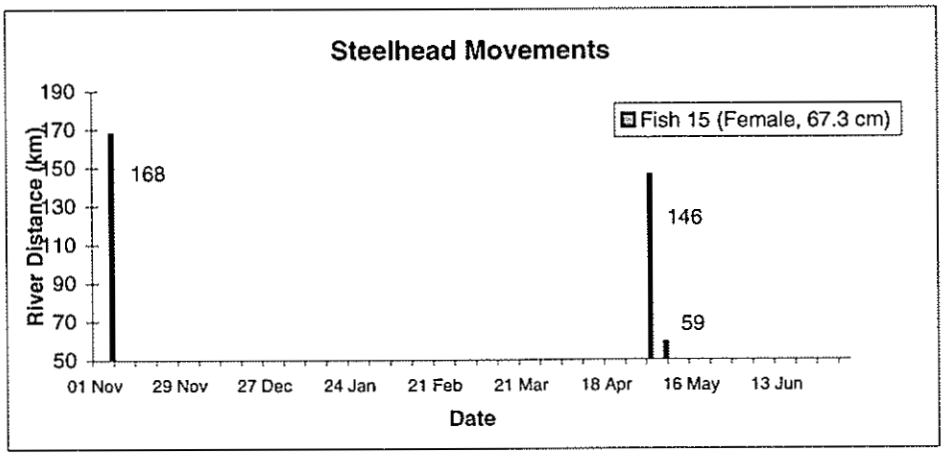

Steelhead Movements
Fish 10 (Female, 58.4 cm)
River Distance (km)
190
140
90
40
-10
-60
-110
-160
-210
168
165
154
146
146
59
0
-202
01 Nov
29 Nov
27 Dec
24 Jan
21 Feb
21 Mar
18 Apr
16 May
13 Jun
Date

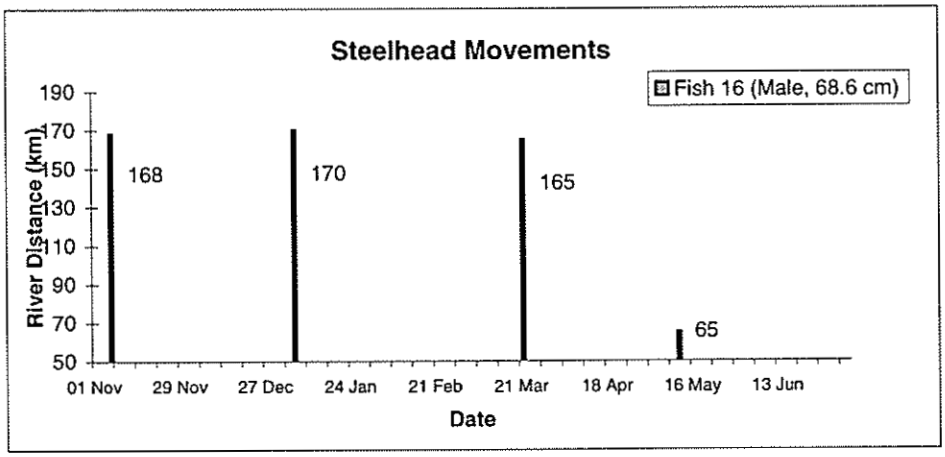

Steelhead Movements
Fish 11 (Female, 67.3 cm)
River Distance (km)
190
170
150
130
110
90
70
50
168
155
156
162
01 Nov
29 Nov
27 Dec
24 Jan
21 Feb
21 Mar
18 Apr
16 May
13 Jun
Date

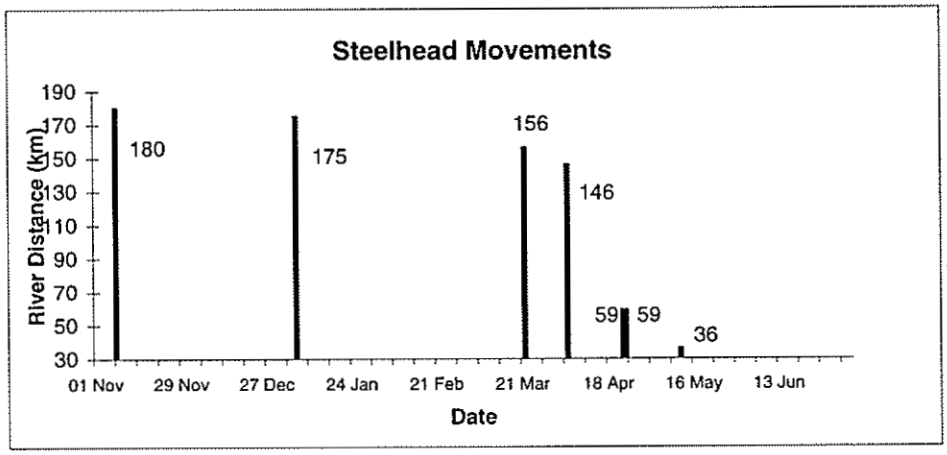

Steelhead Movements
Fish 12 (Female, 54.6 cm)
River Distance (km)
190
170
150
130
110
90
70
50
168
94
95
92
01 Nov
29 Nov
27 Dec
24 Jan
21 Feb
21 Mar
18 Apr
16 May
13 Jun
Date

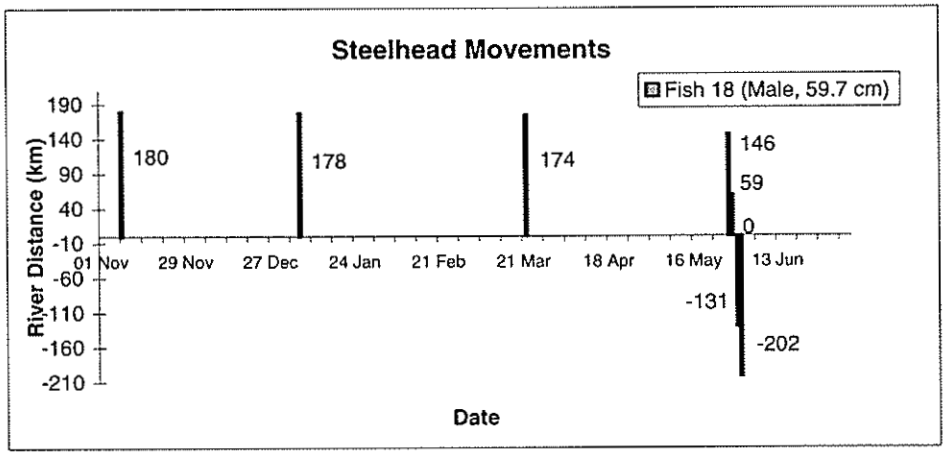

Steelhead Movements
Fish 13 (Female, 78.7 cm)
River Distance (km)
190
140
90
40
-10
-60
-110
-160
-210
168
163
146
0
-202
01 Nov
29 Nov
27 Dec
24 Jan
21 Feb
21 Mar
18 Apr
16 May
13 Jun
Date

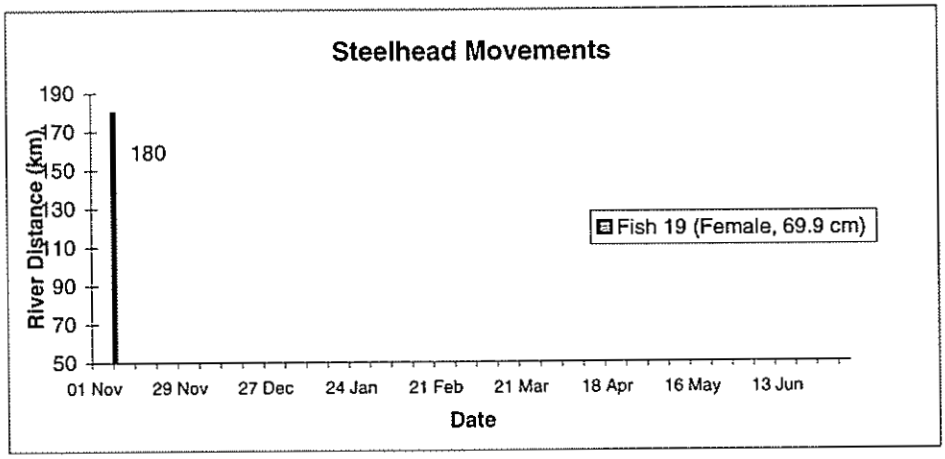

Steelhead Movements
Fish 14 (Female, 62.3 cm)
River Distance (km)
190
170
150
130
110
90
70
50
168
90
92
92
90
01 Nov
29 Nov
27 Dec
24 Jan
21 Feb
21 Mar
18 Apr
16 May
13 Jun
Date

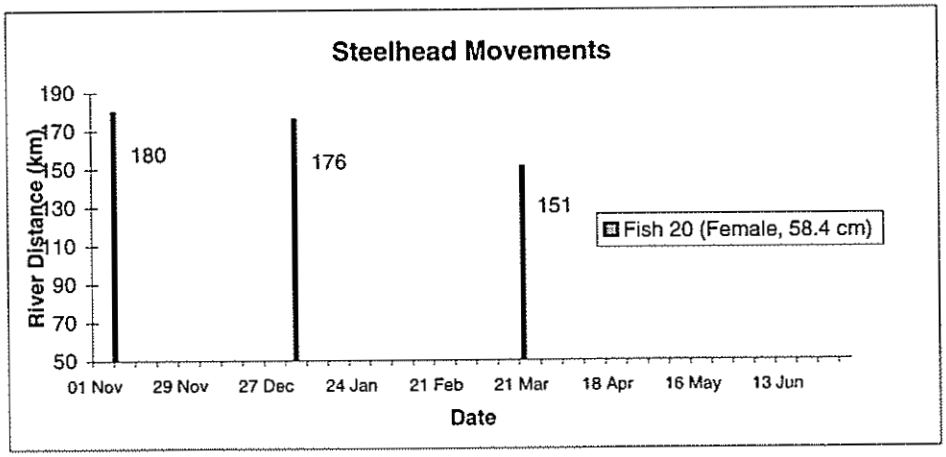

Steelhead Movements
Fish 15 (Female, 67.3 cm)
River Distance (km)
190
170
150
130
110
90
70
50
168
146
59
01 Nov
29 Nov
27 Dec
24 Jan
21 Feb
21 Mar
18 Apr
16 May
13 Jun
Date

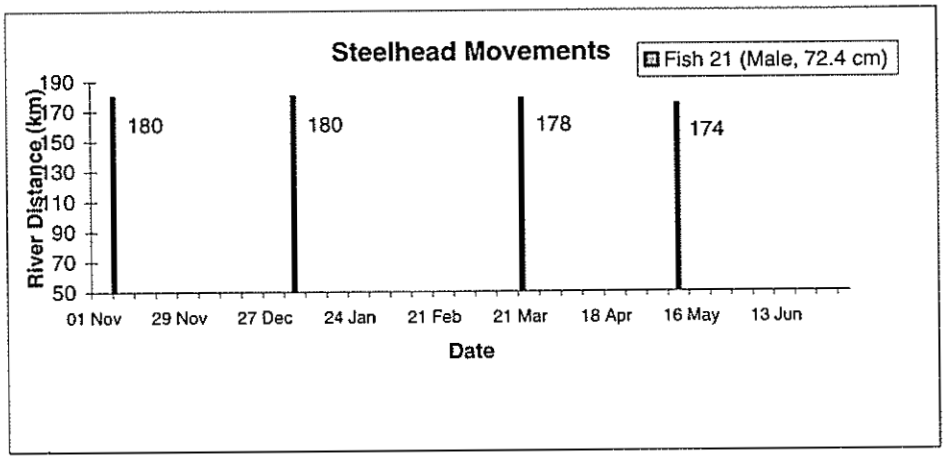

Steelhead Movements
Fish 16 (Male, 68.6 cm)
River Distance (km)
190
170
150
130
110
90
70
50
168
170
165
65
01 Nov
29 Nov
27 Dec
24 Jan
21 Feb
21 Mar
18 Apr
16 May
13 Jun
Date

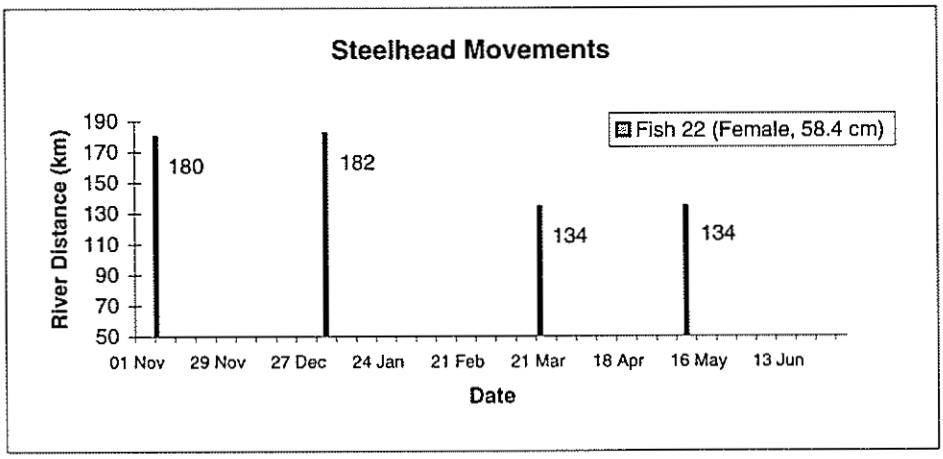

Steelhead Movements
River Distance (km)
190
170
150
130
110
90
70
50
30
180
175
156
146
59
59
36
01 Nov
29 Nov
27 Dec
24 Jan
21 Feb
21 Mar
18 Apr
16 May
13 Jun
Date

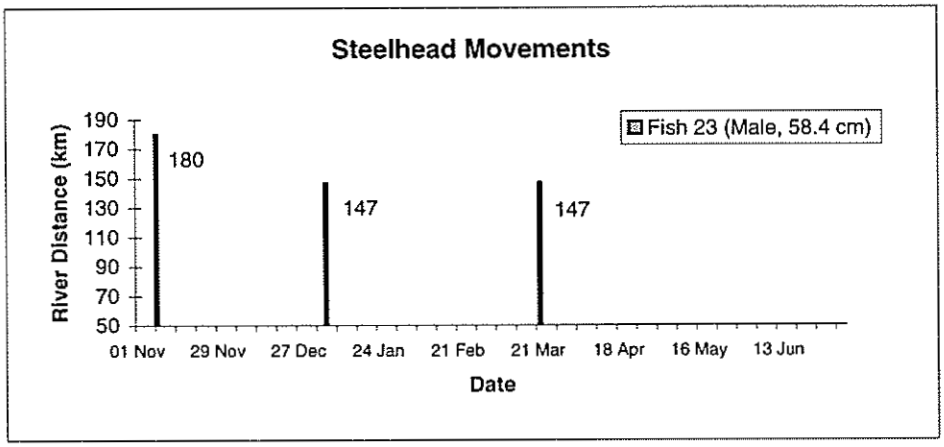

Steelhead Movements
Fish 18 (Male, 59.7 cm)
River Distance (km)
190
140
90
40
-10
-60
-110
-160
-210
180
178
174
146
59
0
-131
-202
01 Nov
29 Nov
27 Dec
24 Jan
21 Feb
21 Mar
18 Apr
16 May
13 Jun
Date

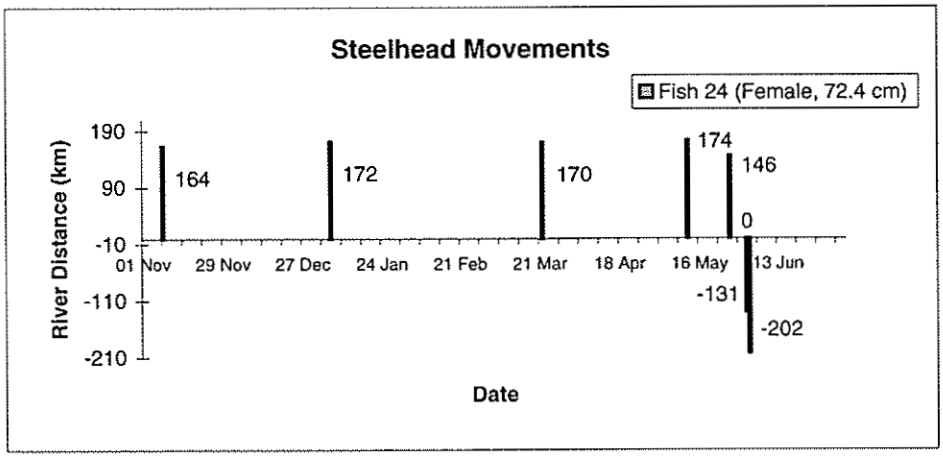

Steelhead Movements
River Distance (km)
190
170
150
130
110
90
70
50
180
Fish 19 (Female, 69.9 cm)
01 Nov
29 Nov
27 Dec
24 Jan
21 Feb
21 Mar
18 Apr
16 May
13 Jun
Date

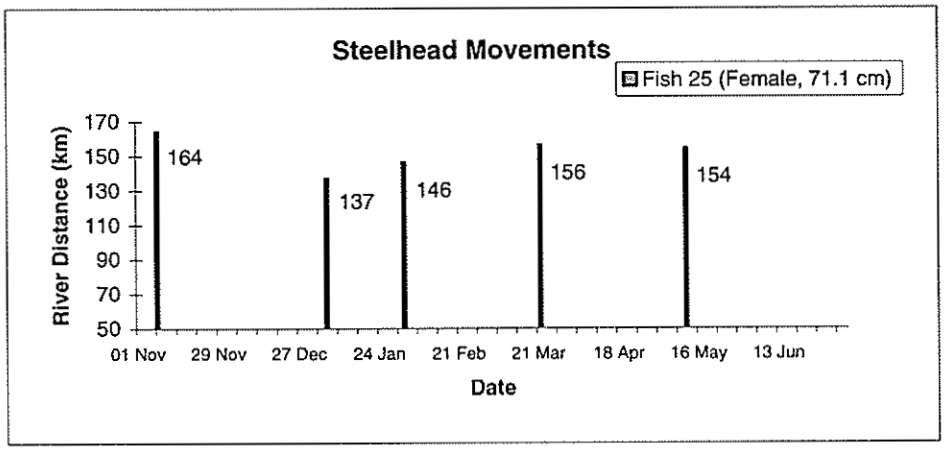

Steelhead Movements
River Distance (km)
190
170
150
130
110
90
70
50
180
176
151
Fish 20 (Female, 58.4 cm)
01 Nov
29 Nov
27 Dec
24 Jan
21 Feb
21 Mar
18 Apr
16 May
13 Jun
Date

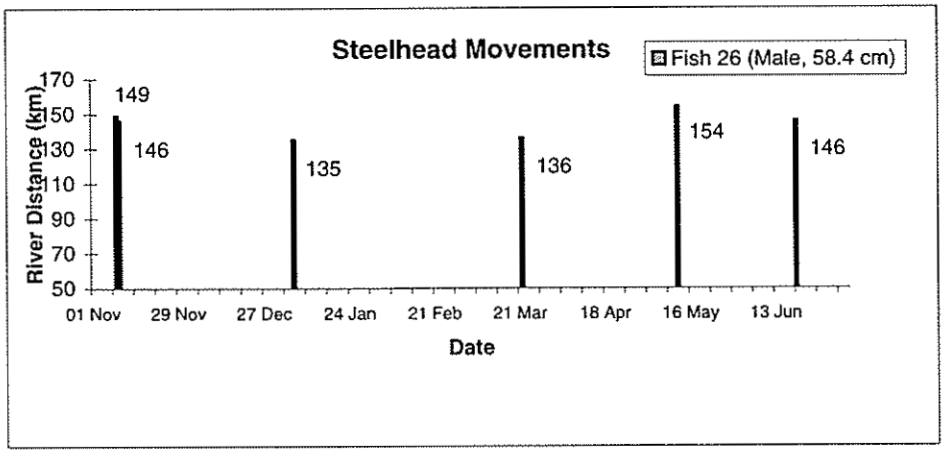

Steelhead Movements
Fish 21 (Male, 72.4 cm)
River Distance (km)
190
170
150
130
110
90
70
50
180
180
178
174
01 Nov
29 Nov
27 Dec
24 Jan
21 Feb
21 Mar
18 Apr
16 May
13 Jun
Date

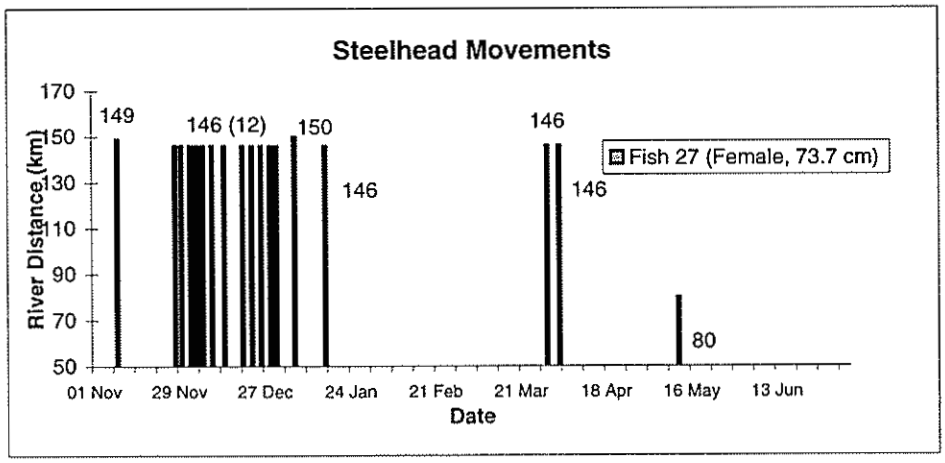

Steelhead Movements
Fish 22 (Female, 58.4 cm)
River Distance (km)
190
170
150
130
110
90
70
50
180
182
134
134
01 Nov
29 Nov
27 Dec
24 Jan
21 Feb
21 Mar
18 Apr
16 May
13 Jun
Date

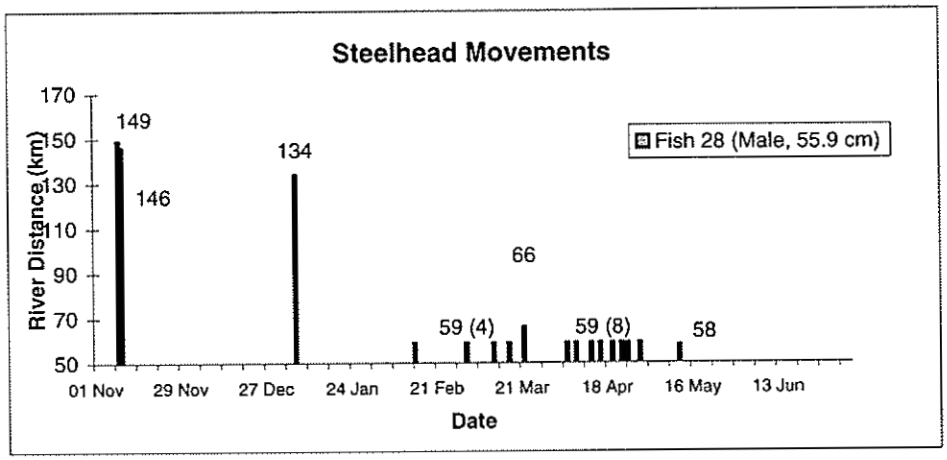

Steelhead Movements
Fish 23 (Male, 58.4 cm)
River Distance (km)
190
170
150
130
110
90
70
50
180
147
147
01 Nov
29 Nov
27 Dec
24 Jan
21 Feb
21 Mar
18 Apr
16 May
13 Jun
Date

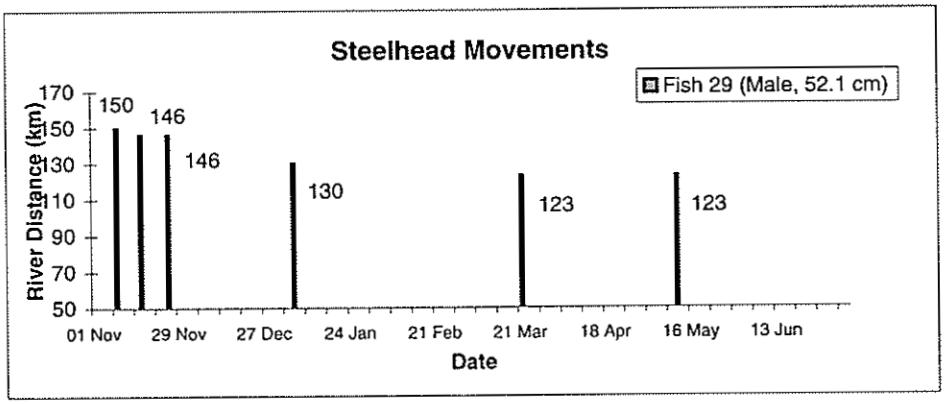

Steelhead Movements
Fish 24 (Female, 72.4 cm)
River Distance (km)
190
90
-10
-110
-210
164
172
170
174
146
0
-131
-202
01 Nov
29 Nov
27 Dec
24 Jan
21 Feb
21 Mar
18 Apr
16 May
13 Jun
Date

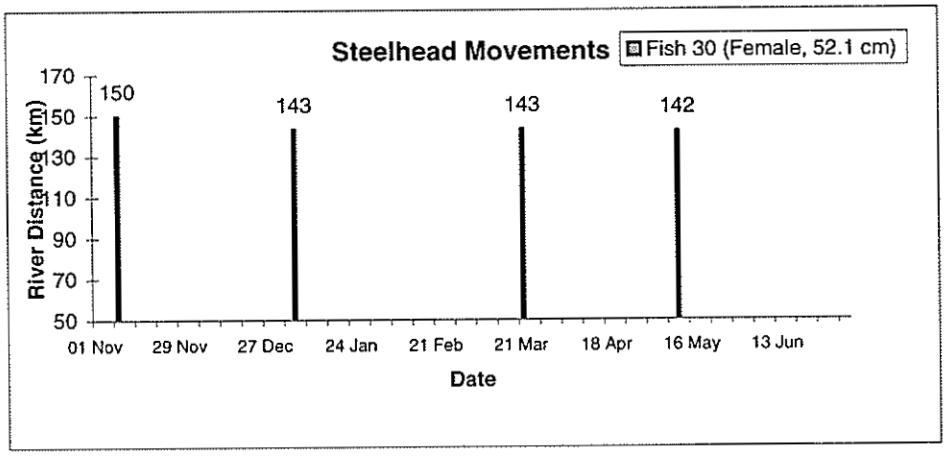

Steelhead Movements
Fish 25 (Female, 71.1 cm)
River Distance (km)
170
150
130
110
90
70
50
164
137
146
156
154
01 Nov
29 Nov
27 Dec
24 Jan
21 Feb
21 Mar
18 Apr
16 May
13 Jun
Date

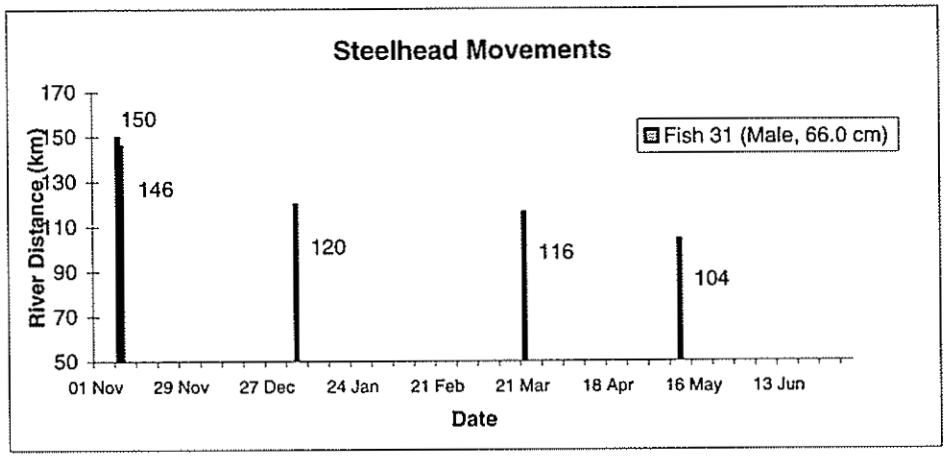

Steelhead Movements
Fish 26 (Male, 58.4 cm)
River Distance (km)
170
150
130
110
90
70
50
149
146
135
136
154
146
01 Nov
29 Nov
27 Dec
24 Jan
21 Feb
21 Mar
18 Apr
16 May
13 Jun
Date

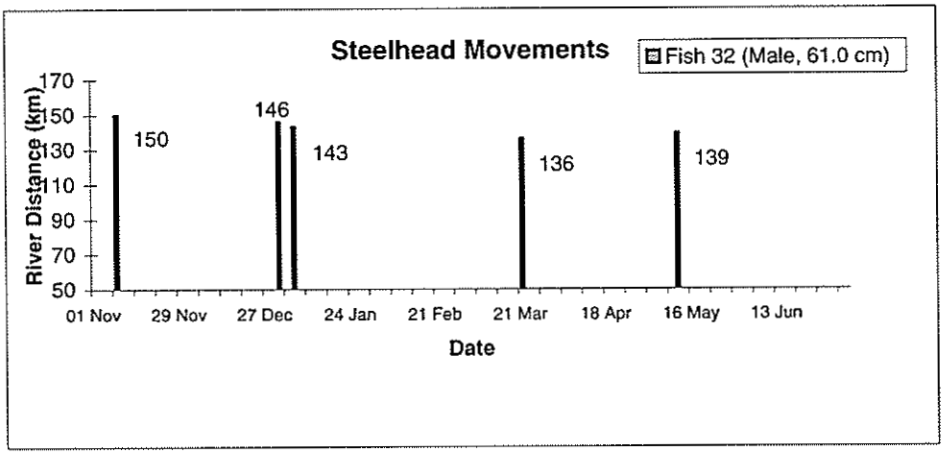

Steelhead Movements
Fish 27 (Female, 73.7 cm)
River Distance (km)
170
150
130
110
90
70
50
149
146 (12)
150
146
146
146
80
01 Nov
29 Nov
27 Dec
24 Jan
21 Feb
21 Mar
18 Apr
16 May
13 Jun
Date

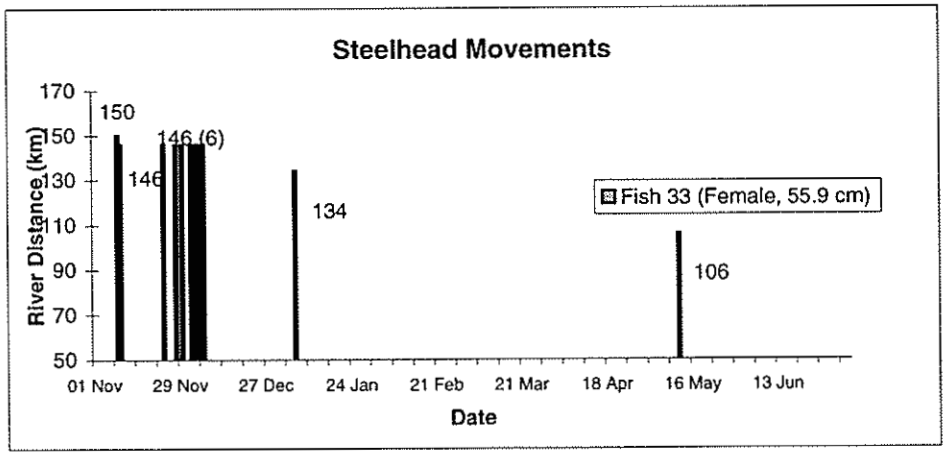

Steelhead Movements
Fish 28 (Male, 55.9 cm)
River Distance (km)
170
150
130
110
90
70
50
149
146
134
66
59 (4)
59 (8)
58
01 Nov
29 Nov
27 Dec
24 Jan
21 Feb
21 Mar
18 Apr
16 May
13 Jun
Date

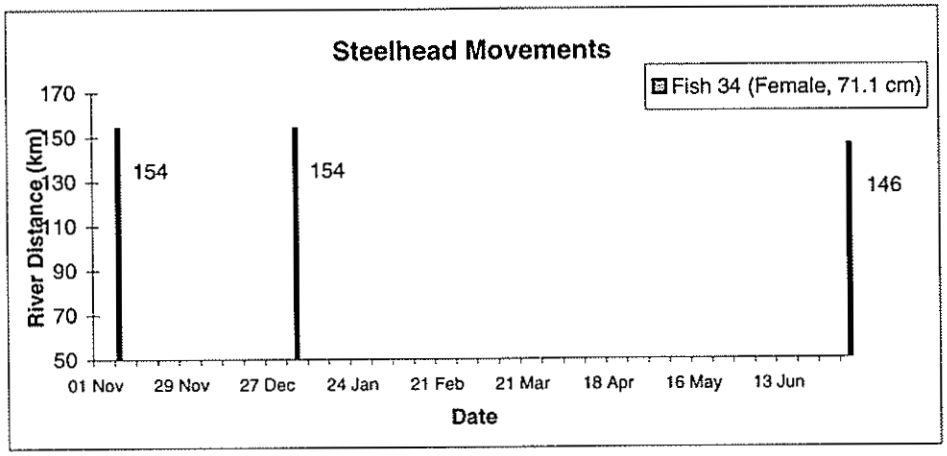

Steelhead Movements
Fish 29 (Male, 52.1 cm)
River Distance (km)
170
150
130
110
90
70
50
150
146
146
130
123
123
01 Nov
29 Nov
27 Dec
24 Jan
21 Feb
21 Mar
18 Apr
16 May
13 Jun
Date

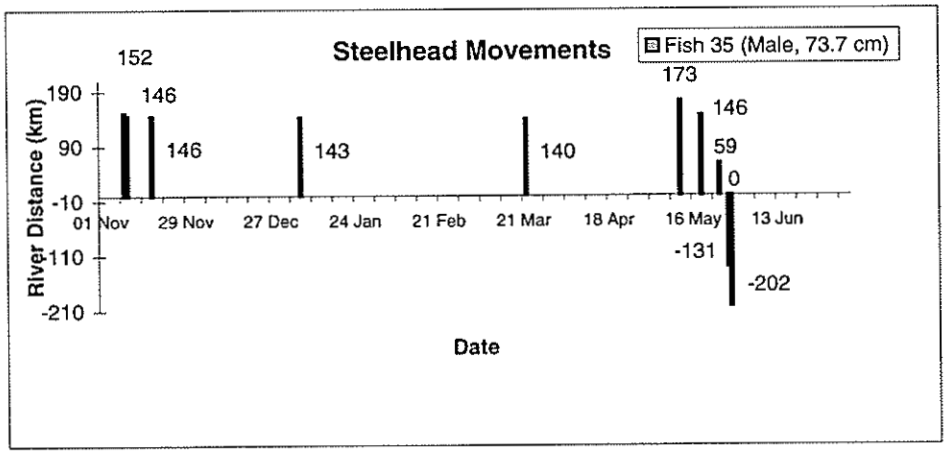

Steelhead Movements
Fish 30 (Female, 52.1 cm)
River Distance (km)
170
150
130
110
90
70
50
150
143
143
142
01 Nov
29 Nov
27 Dec
24 Jan
21 Feb
21 Mar
18 Apr
16 May
13 Jun
Date

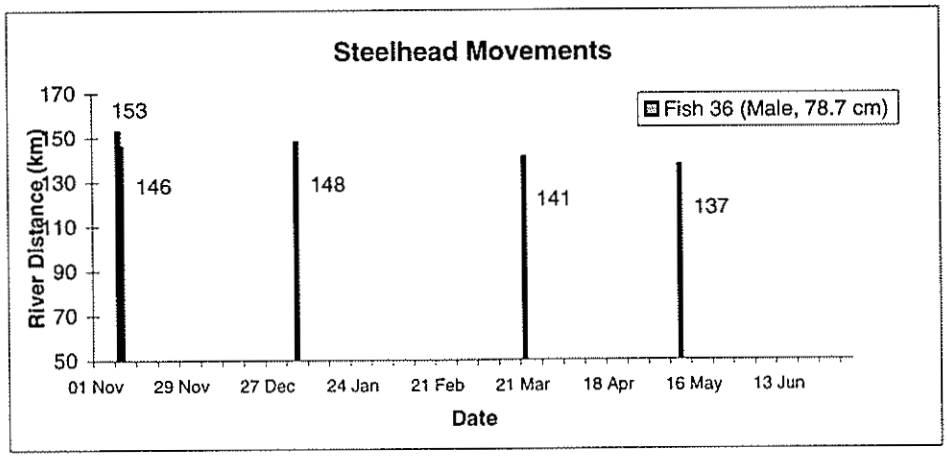

Steelhead Movements
Fish 31 (Male, 66.0 cm)
River Distance (km)
170
150
130
110
90
70
50
150
146
120
116
104
01 Nov
29 Nov
27 Dec
24 Jan
21 Feb
21 Mar
18 Apr
16 May
13 Jun
Date

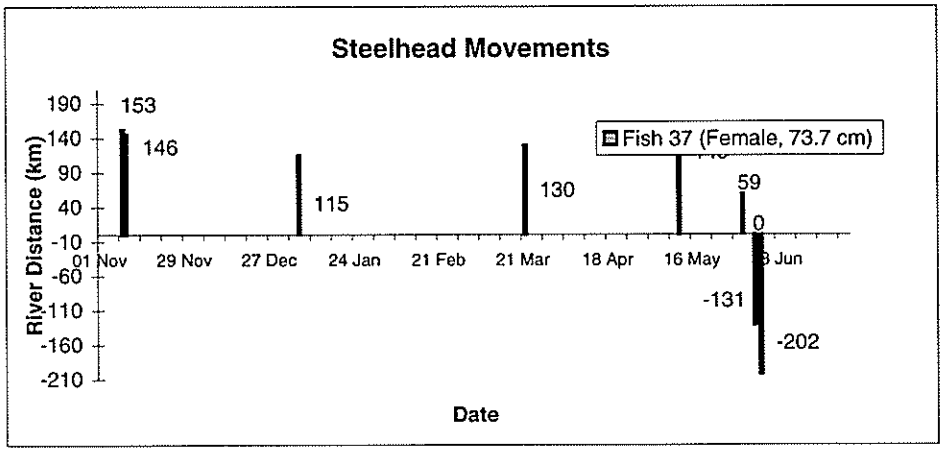

Steelhead Movements
Fish 32 (Male, 61.0 cm)
River Distance (km)
170
150
130
110
90
70
50
150
146
143
136
139
01 Nov
29 Nov
27 Dec
24 Jan
21 Feb
21 Mar
18 Apr
16 May
13 Jun
Date

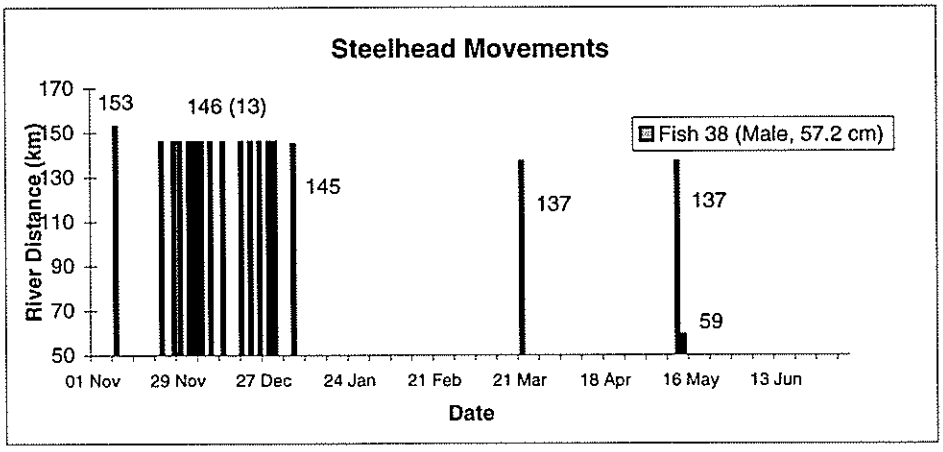

Steelhead Movements
Fish 33 (Female, 55.9 cm)
River Distance (km)
170
150
130
110
90
70
50
150
146 (6)
146
134
106
01 Nov
29 Nov
27 Dec
24 Jan
21 Feb
21 Mar
18 Apr
16 May
13 Jun
Date

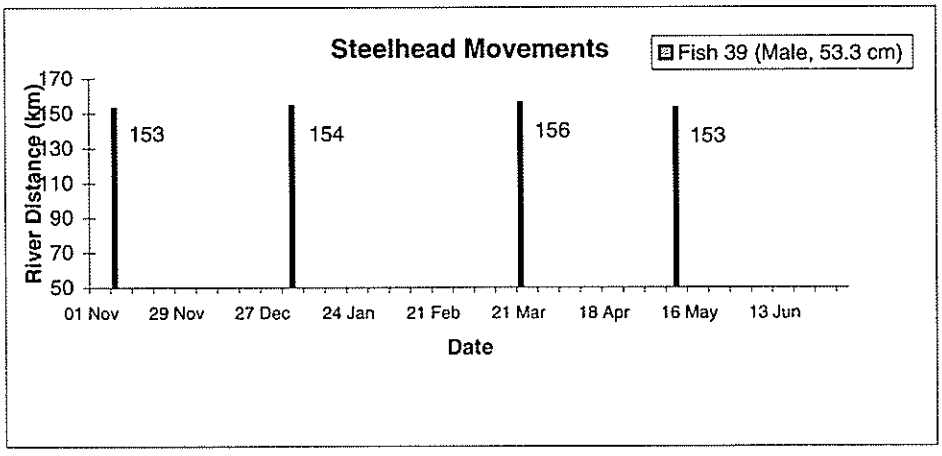

Steelhead Movements
Fish 34 (Female, 71.1 cm)
River Distance (km)
170
150
130
110
90
70
50
154
154
146
01 Nov
29 Nov
27 Dec
24 Jan
21 Feb
21 Mar
18 Apr
16 May
13 Jun
Date

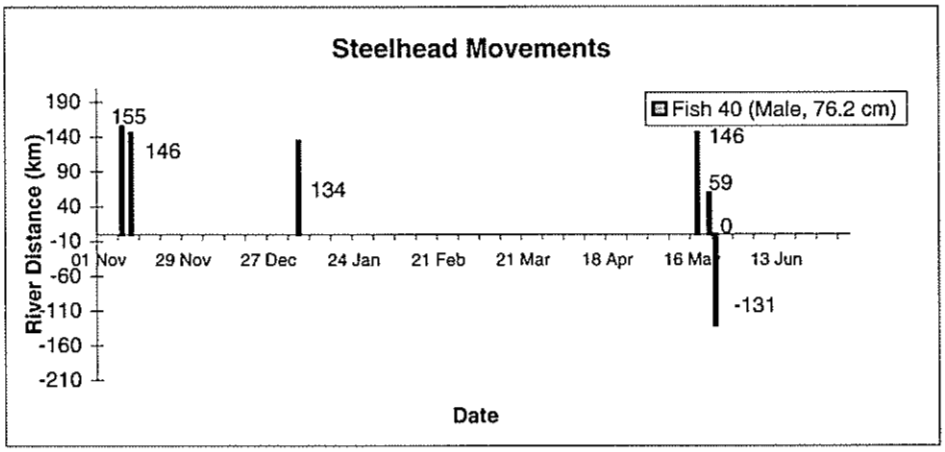

Steelhead Movements
Fish 35 (Male, 73.7 cm)
River Distance (km)
190
90
-10
-110
-210
152
146
146
143
140
173
146
59
0
-131
-202
01 Nov
29 Nov
27 Dec
24 Jan
21 Feb
21 Mar
18 Apr
16 May
13 Jun
Date


Steelhead Movements
Fish 36 (Male, 78.7 cm)
River Distance (km)
170
150
130
110
90
70
50
153
146
148
141
137
01 Nov
29 Nov
27 Dec
24 Jan
21 Feb
21 Mar
18 Apr
16 May
13 Jun
Date


Steelhead Movements
River Distance (km)
190
140
90
40
-10
-60
-110
-160
-210
153
146
115
130
59
0
-131
-202
Fish 37 (Female, 73.7 cm)
01 Nov
29 Nov
27 Dec
24 Jan
21 Feb
21 Mar
18 Apr
16 May
Date


Steelhead Movements
River Distance (km)
170
150
130
110
90
70
50
153
146 (13)
145
137
137
59
Fish 38 (Male, 57.2 cm)
01 Nov
29 Nov
27 Dec
24 Jan
21 Feb
21 Mar
18 Apr
16 May
13 Jun
Date


Steelhead Movements
Fish 39 (Male, 53.3 cm)
River Distance (km)
170
150
130
110
90
70
50
153
154
156
153
01 Nov
29 Nov
27 Dec
24 Jan
21 Feb
21 Mar
18 Apr
16 May
13 Jun
Date


Steelhead Movements
Fish 40 (Male, 76.2 cm)
River Distance (km)
190
140
90
40
-10
-60
-110
-160
-210
155
146
134
146
59
0
-131
01 Nov
29 Nov
27 Dec
24 Jan
21 Feb
21 Mar
18 Apr
16 Ma
13 Jun
Date