Movements of Wild Summer Run Steelhead Tagged with Radio Transmitters in the Babine River during Fall, 1994.

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Skeena Fisheries Report # 96

January, 1997

Table of Contents

List Of Figures

List Of Tables

List Of Appendices

Abstract

Radio telemetry was used for the second consecutive migration year to determine the proportion of wild, Babine River adult summer run steelhead migrating through the Department of Fisheries and Oceans' enumeration weir, near the outlet of Nilkitkwa Lake. The purpose of this investigation was to assess the feasibility of using the weir in conjunction with radio telemetry to conduct annual population estimates for the Babine stock. Conventional angling methods were used to capture steelhead in the upper 45 kilometers of the river on November 7, 1994. Radio transmitters were inserted orally into the stomachs of thirty-nine fish. Steelhead movements were monitored with stationary telemetry receivers and by helicopter. Five (12.8 %) steelhead migrated upstream of the weir and are assumed to have spawned near the outlet of Nilkitkwa Lake. Three (7.7 %) tagged steelhead migrated to the Nilkitkwa River. Three (7.7 %) steelhead emigrated from the Babine River during the winter suggesting possible mortality or atypical behavior induced by stress. The high incidence of suspected mortalities raises concerns about radio tagging summer run steelhead in the initial months after entry into fresh water. Kelt emigration rates between the Babine-Skeena river confluence and the Exchamsiks-Skeena river confluence ranged from 31.2 km/day to 219 km/day; the mean water velocity at the Babine weir during kelt emigration was approximately 130 km/day. The mean date of emigration past the Exchamsiks-Skeena river confluence was June 10th (n=12; 8 males: 4 females). Due to the annual fluctuations in the proportion of Babine steelhead spawning upstream of the weir and the fact that some steelhead migrate through the weir during fall, spring weir counts are not recommended for annual population estimates for the Babine stock.

Introduction

Estimating summer run steelhead (*Oncorhynchus mykiss*) spawning escapements for Skeena River stocks has been difficult to date in the absence of more detailed information than has traditionally been available. Most Skeena River tributaries are too large and volatile to maintain enumeration weirs on and water visibility is rarely sufficiently clear to conduct visual counts by snorkel surveys. As the Babine River commences at British Columbia's largest natural lake, which stabilizes water flows, it is one of the only Skeena tributaries on which it is possible to maintain an enumeration weir in the spring. The weir was constructed by the Department of Fisheries and Oceans (DFO), in 1946, to enumerate sockeye salmon spawners. It is located 1.5 kilometers downstream of the outlet of Nilkitkwa Lake.

Available data suggests that the most important spawning area for Babine River summer run steelhead is at or near the outlet of Nilkitkwa Lake (Beere 1991, 1996). This study was initiated to further refine estimates of the proportion of the Babine River summer run steelhead population that spawn upstream of the fence and to determine if a population estimate could be made using weirs counts in conjunction with radio telemetry data. A second objective was to document other spawning locations within the watershed. The third objective was to monitor kelt emigrations. The final objective was to determine fish movements in the vicinity of the weir.

Study Area

General Description

The 99 km long Babine River flows from the outlet of Nilkitkwa Lake, at a point approximately 78 km northeast of Smithers, northwest to its confluence with the Skeena River, approximately 49 km northeast of Hazelton (Figure 1). Twenty-seven km (28%) of the river consists of a high gradient canyon section, located in the lower one third of the river. The Babine River watershed drainage area upstream of the DFO weir is 10 400 km^2, and at that point the monthly mean discharge ranges from a low in March of 21.1 m^3/s to a high in June of 126 m^3/s (Sebastian 1988; Water Survey of Canada 1989). The majority of the watershed is found within the Sub-Boreal Spruce (SBS) biogeoclimatic zone; downstream of Gail Creek the river flows through the Interior Cedar Hemlock (ICH) zone.

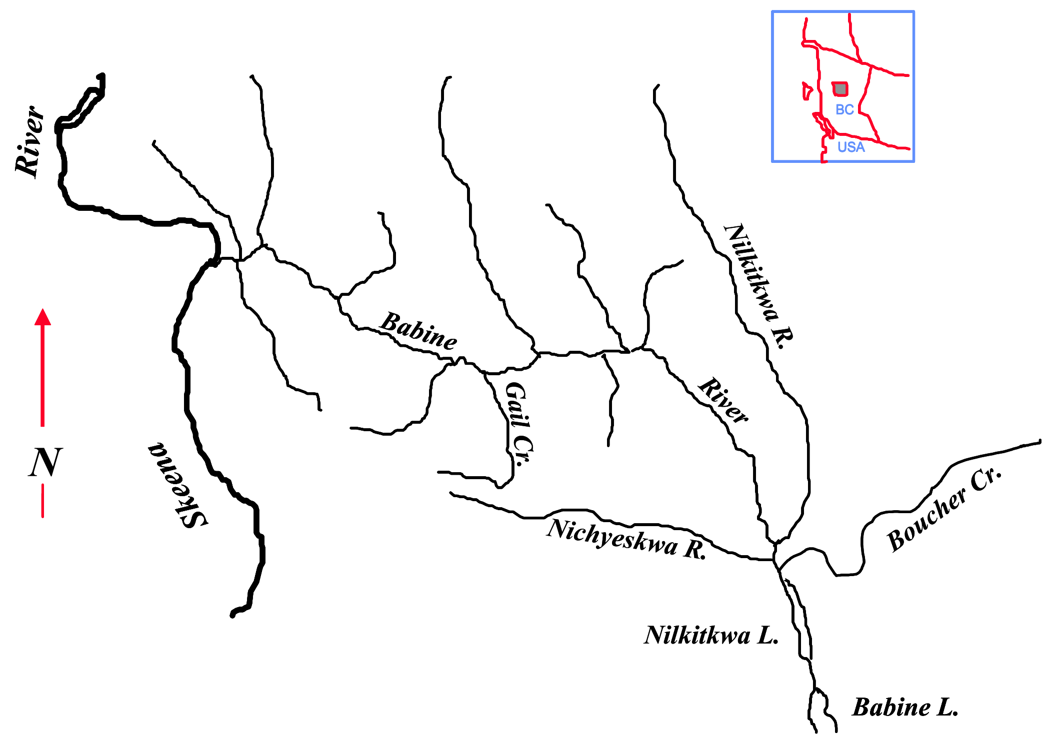

Figure 1. The Babine River watershed.

Fish Populations

In addition to summer run steelhead, sockeye salmon (*O. nerka*), coho salmon (*O. kisutch*), chinook salmon (*O. tshawytscha*), pink salmon (*O. gorbuscha*), chum salmon (*O. keta*), resident rainbow trout (*O. mykiss*), cutthroat trout (*O. clarki*), Rocky Mountain whitefish (*Prosopium williamsoni*) and bull trout (*Salvelinus confluentus*) are all found in the Babine River. The Department of Fisheries and Oceans has estimated average escapement of sockeye, coho, pink, chum and chinook salmon escapement over a ten year period (1980 to 1989) to be 464542, 2960, 60000, 2, and 863 respectively (Anonymous 1991).

Escapement estimates are not available for the other species listed present. Steelhead, salmon (with the exception of chum, which are rare), rainbow trout, cutthroat trout, bull trout and Rocky Mountain whitefish are widely distributed throughout the watershed.

Fisheries

Both Native and recreational fisheries exist on the Babine River; Natives fish for both commercial and sustenance purposes. On average, 474 recreational anglers/year have fished for steelhead over the ten year period between 1985 and 1995, accounting for an average yearly catch of 3678 steelhead (Figure 2; Anonymous 1995). Other species listed are also captured in sport fisheries although no catch data is available. Current freshwater fishing regulations prohibit the retention of steelhead, sockeye, chum and pink salmon in the Babine; coho and chinook salmon, trout, char and whitefish may be retained. The retention of coho, chinook and sockeye salmon has been permitted in the past (Anonymous 1994).

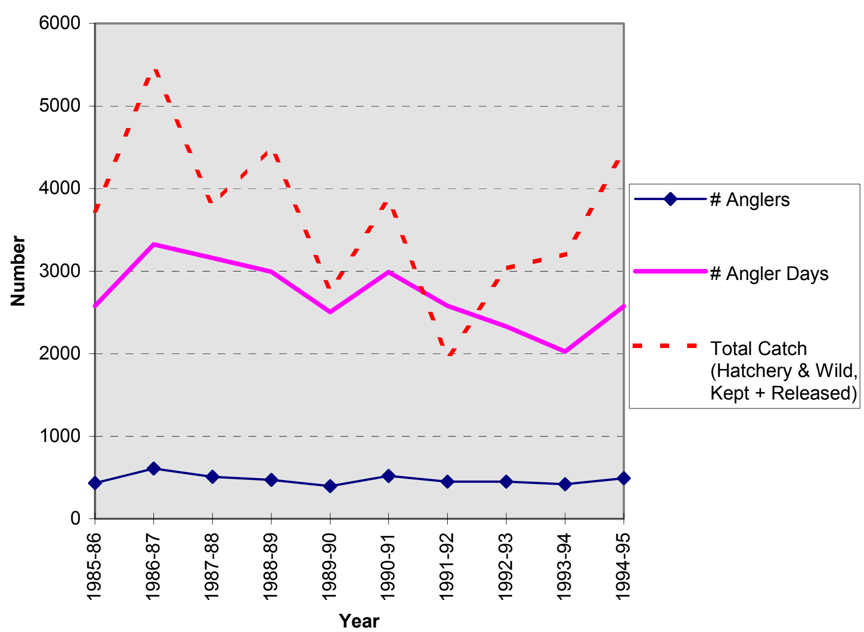

Figure 2. Number of anglers, angler days and total steelhead catch in the Babine River, 1985 to 1995 inclusive, as estimated by the British Columbia Steelhead Harvest Questionnaire.

Methods

Fish Capture and Tagging

Wild adult summer run steelhead were captured using conventional angling methods. Steelhead that were less than 60 cm (fork length) or that appeared to be in less than optimum condition were marked at the base of the left side of the dorsal fin with a single coloured, numbered anchor tag (Floy Tags, Washington, U.S.A.) and released (Figure 3). All fish greater than 60 cm that appeared to be in good condition were radio tagged. While the fish were held at the surface of the water, the radio transmitter was inserted orally into the stomach with a hollow, flexible plastic tube (Figure 4). Anaesthetic was not used as the possible effect on behavior was not known. Radio tagged fish were also marked with two anchor tags at the base of the left side of the dorsal fin. Sex, fork length, anchor tag number, radio tag number (if radio tagged) and colour, fish condition and, where applicable, the presence of scars, net or hook marks were noted for each fish captured. Water temperature was recorded using a pocket thermometer (Ertco -35 ºC to 50 ºC). All tagging locations were described using Global Positioning Satellite (G.P.S.) equipment (Canadian Helicopters' Trimble, model 19437-60, USA and the Fisheries Branch's Magellan Nav 5000 Pro, San Dimas, California).

Radio Telemetry

Radio telemetry equipment used in this study was obtained from Lotek Engineering Inc. (Newmarket, Ontario). Radio transmitters (model CFRT-3B) 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 which protruded from the fishes' mouths. Transmitters weighed 10.7 g in air, 4.2 g in water and were powered by a 3 volt lithium battery which had a guaranteed minimum 260 day life. Transmitters emitted a digitally encoded radio signal at four discrete frequencies ranging from 149.360 to 149.500 MHz.

Individual radio tag signals were detected and decoded by telemetry receiver (model SRX_400 with software version 3.48 W16D) during helicopter flights or with stationary receiver stations. The receiver was used in combination with a 6 m length of RG-58 A/U double shielded coaxial cable and a three element Yagi antenna for aerial tracking flights. The Yagi antenna was mounted to the helicopter's high frequency antenna (Figure 5) with elements orientated perpendicular to the surface of the water to minimize radio signal attenuation (Lotimer, *et al*. 1994). The receiver logged the time, transmitter code and relative signal strength in an internal memory that was later transferred to a computer file.

Stationary receiver stations consisted of a telemetry receiver stored in a steel, weatherproof, locked enclosure box on the riverbank or mounted on a tree trunk with one or three, three element Yagi antennae mounted as far as 20 m above the ground in an adjacent tree(s) (Figure 6). Three stationary receiver stations were installed on the Babine River: two in the vicinity of the DFO weir (immediately upstream and downstream) to detect and record the movements of radio tagged steelhead in proximity to the weir and the third at the Babine-Skeena river confluence. The receiver stations installed in the vicinity of the DFO weir used a single

Figure 3. Anchor tag insertion.

Figure 4. Esophageally implanting a radio transmitter.

Figure 5. Helicopter used for tracking flights showing the location of telemetry antenna, mounted on the aircraft's high frequency antenna, and GPS antenna (white dome over front window).

antenna each. The station at the Babine-Skeena confluence consisted of three antennae that were directed upstream and downstream on the Skeena River and upstream on the Babine River. Receivers were externally powered by a deep cycle 12 volt lead acid battery (195 cold crank amps) and operated for 10 days between battery changes. The Babine-Skeena confluence station was augmented with a 75 watt, 4.4 amp solar panel (Siemens, Procharger 4) in conjunction with a battery charge regulator (Specialty Concepts, Inc., U.S.A.) that facilitated operation for a minimum of 14 days between battery changes. Data was logged by the receiver in the same fashion as for the mobile tracks and data was downloaded with a laptop computer in the field during battery changes.

In addition to the three Babine receiver stations, three others present at the Bulkley-Skeena, Zymoetz-Skeena and Exchamsiks-Skeena river confluences also recorded movements of emigrating radio tagged Babine River steelhead. These stations were installed to track Skeena River steelhead radio tagged in a separate study (Koski et. al. 1995).

Tagged fish locations were recorded on a 1:50 000 scale map to the nearest 500 m.

Weir Operations

The DFO enumeration weir was monitored by B.C. Environment staff from April 20 to May 25, 1995 to estimate the number of adult steelhead spawning upstream of the weir and to evaluate the performance of a computerized video fish counting system. During this period, fence panels were installed to direct migrating steelhead through two 1.8 m wide chutes into box traps. Traps were opened for discrete periods of time during which steelhead passing upstream or downstream through the weir were enumerated. The results of this investigation are presented elsewhere (Atagi in prep.).

Data Interpretation

As steelhead may have exhibited an interrupted migration pattern and tracking flights were conducted at specific points in time, it was assumed that the calculated migration rates were the minimum possible migration rates. Migration rates were calculated by dividing the

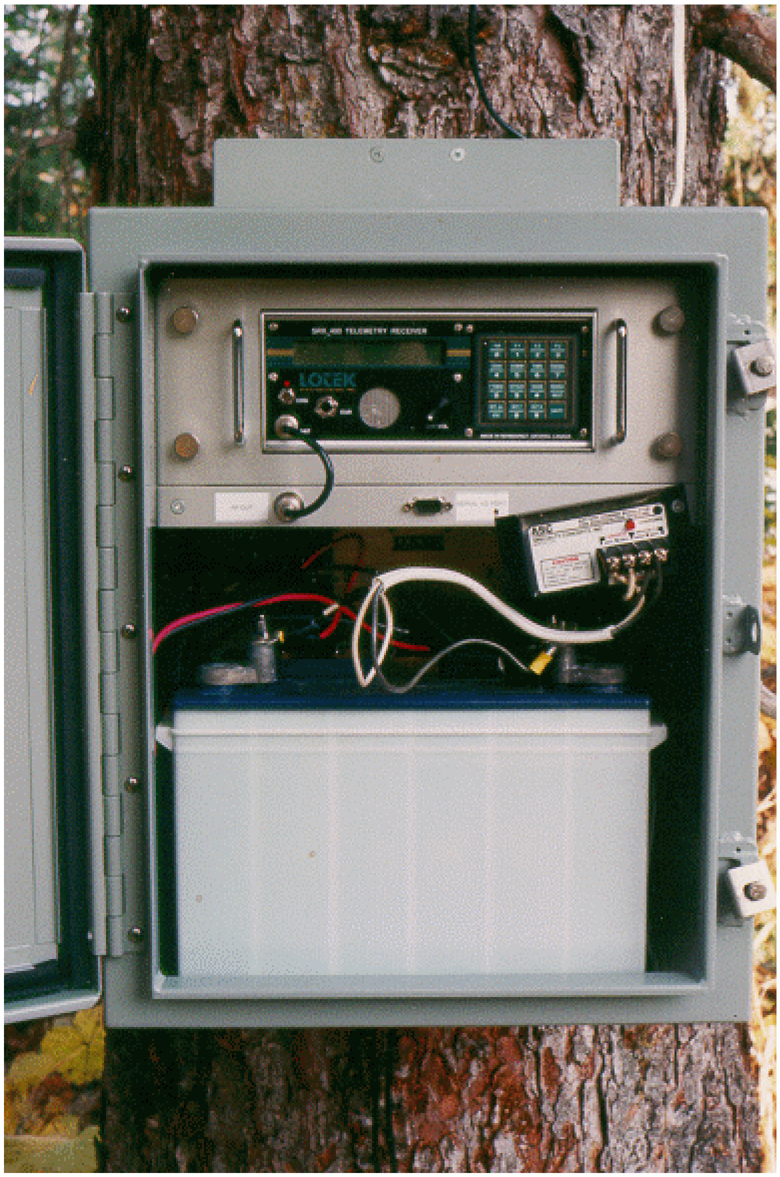

Figure 6. Photograph of stationary radio telemetry tracking station. Note receiver above and 12 volt deep cycle R.V. battery below. A three element Yagi antenna was fixed to the tree, 2 to 3 meters above the receiver.

number of kilometers that an individual fish had migrated since last detection, by the number of days since last detection. Migration rates for individual fish radio tagged fish that were believed to have regurgitated the radio transmitter or that were suspected mortalities were excluded from the data analysis.

Determination of spawning locations was subjective; individual radio tagged fish were not observed spawning. Radio tagged fish that were repeatedly tracked to areas that had spawning potential or that migrated into Babine River tributaries with spawning potential during the spawning period were considered to have spawned at those locations.

Results

Fish Capture and Tagging

Forty four adult summer run steelhead were captured between kilometer 54 and 84 on the mainstem Babine River on November 7, 1994. Fish ranged in fork length from 58 to 98 cm and the sex ratio was 1 male to 1 female. Of the forty four fish, thirty nine fish were radio tagged (0.95 male:1 female; Figure 7); five were anchor tagged only, as they were either less than 60 cm or were in less than optimal condition.

A minimum of 12 (27.3%; 8 male, 4 female) of the forty four fish were found to have hook scars, presumably from being angled and released earlier in the fall in the Babine or Skeena rivers. Fish with hook scars ranged from 62 to 98 cm. A minimum of 4 (9.1%; 1 male, 3 female) were scarred from having encountered either a tidal commercial or in-river (most probably First Nations) gillnet. Gillnet marked fish ranged in length from 57 cm to 79 cm.

Radio Telemetry

Radio tagged steelhead were tracked by helicopter on ten separate flights beginning on November 9, 1994, and concluding on June 9, 1995.

Fixed telemetry stations were operated immediately upstream of the DFO weir from April 3 to June 19, 1995, and immediately downstream of the weir from April 20 to June 19, 1995. Stations at the Babine, Bulkley, Zymoetz and Exchamsiks river confluences with the Skeena operated continuously throughout the study period (August 1994 to July 1995) and provided useful data regarding kelt emigrations.

It was determined from both fixed receiver station data and helicopter tracks that 5 (12.8%) of the 39 radio tagged steelhead migrated upstream of the DFO weir (Table 1 and 2; Appendices 1-39). These fish spent as little as less than half a day (9.7 hours) and as long as more than 5 days (127.5 hours) downstream of the fence before proceeding upstream to the lake outlet area. Four of the 5 tagged steelhead that migrated upstream of the weir did so during the period that it was fished (April 20 to May 25, 1995); a single fish (a 63 cm male) migrated upstream through the weir after the fence panels were removed (May 28, 1995). Only one fish (an 84 cm female) emigrated downstream through the fence during the period it was fished (May 16, 1995; Table 3).

One (2.6%) of 39 migrated to the weir but was not tracked upstream of it. This 82 cm female was detected downstream of the weir for 13 days before moving downstream, presumably after spawning downstream of the weir.

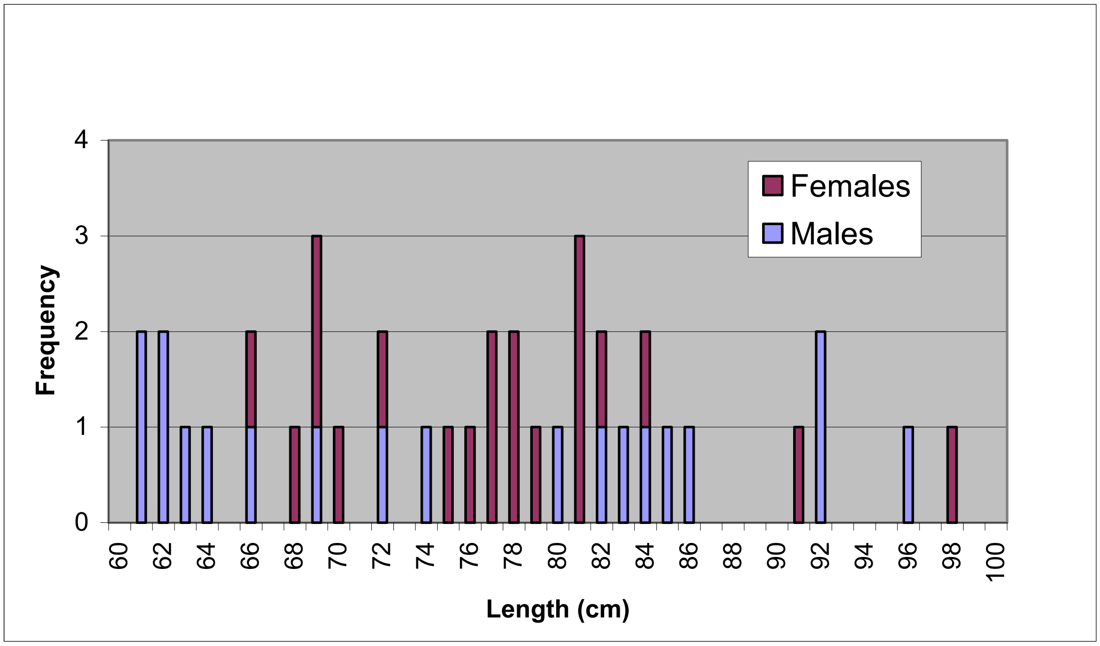

Figure 7. Length-frequency histogram for summer run Babine River steelhead radio tagged November 7, 1994.

One (2.6%) of the 39 fish was never tracked after tagging. This suggests that the transmitter malfunctioned, despite the fact that all tags had been tested prior to implementation.

A further three (7.7%) migrated into the Nilkitkwa River and are assumed to have spawned there. These fish were found between 5 and 49 kilometers upstream of the Nilkitkwa-Babine river confluence, in the mainstem (Nilkitkwa east) river.

A further eleven (28.2%) were tracked only to areas of the mainstem Babine River and may have either spawned in the mainstem or entered a tributary stream to spawn without detection. Eight of these twelve were determined to have emigrated from the Babine River.

A further sixteen (41.0%) steelhead are suspected to have died, as the transmitter was either repeatedly tracked to the same location or downstream of the original tagging site. Three of these 16 (7.7%) emigrated from the Babine River in mid-winter within three months of radio tagging. These fish were detected at the Babine-Skeena confluence fixed station on December 20 and 22, 1994 and January 24, 1995. These fish were subsequently tracked in the mainstem Skeena during flights in the spring and are presumed to have died and passively drifted downstream.

A further two (5.1%) fish are believed to have regurgitated their transmitter, as it was repeatedly located at or near the tagging site.

Table 1. Tagging information and subsequent locations on aerial tracks (river kilometers in brackets) of radio tagged Babine River steelhead, 1994-95. Times of arrival at the Babine weir and confluence were obtained from fixed receiver stations.

	Code	Sex	Length (FL in cm)	Tagging Location 7 November, 1994	Helicopter 9 November, 1994	Helicopter 26 November, 1994	Helicopter 16 December, 1994	Helicopter 16 January, 1995	Helicopter 7 March, 1995	Helicopter 20 March, 1995	Helicopter 3 April, 1995	Helicopter 18 April, 1995	Helicopter 11 May, 1995	Helicopter 9 June, 1995
Ch. 10	31	M	92	Home Run(84)				Home Run(84)		Home Run(84)	Home Run(84)			
	21	M	62			u/s Beaver Flats(73)	u/s Beaver Flats(73)	u/s Beaver Flats(73)	u/s Beaver Flats(73)	u/s Beaver Flats(73)	u/s Beaver Flats(73)	u/s Beaver Flats(73)	u/s Beaver Flats(73)	Beaver Flats(72)
	34	M	96			Home Run(84)	u/s Lobo(86)	Home Run(84)	Home Run(84)	Home Run(84)	Home Run(84)	Home Run(84)	Home Run(84)	Home Run(84)
	29	F	91			d/s Laura's(80)	u/s Laura's(82)	Home Run(84)		Hot Shot(88)		d/s Norlakes(89)	d/s Norlakes(89)	d/s Norlakes(89)
	90	M	61			Home Run(84)	d/s Norlakes(89)	d/s Home Run(83)		Beaver Flats(72)		u/s Laura's(82)	up Nilkitkwa(91+49)	
	44	M	86											
	74	M	83			Home Run(84)		Home Run(84)		Home Run(84)			u/s weir(95)-April 29	
Ch. 3	32	F	66	Beaver Flats(72)		Clearcuts(75)	d/s Beaver Flats(68)	Bonanza(62)		d/s Shelagyote(48)		d/s Triple Header(56)	up Nilkitkwa(91+5)	u/s Shedin(7)
	31	F	81				u/s Beaver Flats(75)	Beaver Flats(72)	d/s Beaver Flats(70)	u/s Beaver Flats(73)	u/s Beaver Flats(73)		u/s Beaver Flats(73)	u/s Beaver Flats(73)
	37	M	64				d/s Triple Header(57)			d/s Shelagyote(48)		d/s Shelagyote(46)	Nilkitkwa(91)	
Ch. 10	42	F	81		d/s Beaver Flats(70)	u/s Beaver Flats(74)	u/s Beaver Flats(73)	Beaver Flats(72)		d/s Beaver Flats(71)		d/s Beaver Flats(71)	d/s Beaver Flats(71)	d/s Beaver Flats(71)
	83	M	84			Beaver Flats(72)	Beaver Flats(72)	Beaver Flats(72)	Beaver Flats(72)	Beaver Flats(72)	Beaver Flats(72)	Beaver Flats(72)	Beaver Flats(72)	Beaver Flats(72)
Ch. 8	62	F	77	Bonanza(62)	Triple Header(58)		u/s Shelagyote(49)	Shenismike(17)	Skeena(0)-Jan 24	d/s Bulk-Skeena(0-65)		d/s Bulk-Skeena(0-65)		
	71	M	82		Beaver Flats(72)	d/s Triple Header(57)	u/s Shelagyote(50)	u/s Shelagyote(50)		u/s Hanawald(61)				
	59	F	70		Bonanza(62)	Bonanza(62)	d/s Triple Header(57)	d/s Triple Header(57)	d/s Triple Header(55)	d/s Triple Header(55)		d/s Triple Header(55)	u/s Shelagyote(50)	u/s Shelagyote(50)
Ch. 3	35	M	92		Coffee Pot(64)		u/s Shelagyote(52)	d/s Triple Header(57)	d/s Shelagyote(46)	Bonanza(62)	d/s Beaver Flats(70)	Home Run(84)	Home Run(84)	u/s Gail Cr.(39)
	57	F	69			Bonanza(62)	d/s Coffee Pot(64)	Bonanza(62)					Shahnagh confl.(62)	Hanawald confl.(60)
	43	F	82			d/s Bonanza(61)	Silver Hilton(49)	Silver Hilton(48)		Shahnagh confl.(62)	u/s Shahnagh Cr.(66)		d/s weir(94)-May 3	
	52	M	69			d/s Bonanza(61)	u/s Shelagyote(52)	Silver Hilton(48)		d/s Shelagyote(48)		d/s Shelagyote(48)		
	30	M	63			d/s Triple Header(57)	Silver Hilton(48)	Silver Hilton(48)		d/s Shelagyote(48)			u/s Home Run(85)	u/s weir(95)-May 28
	45	F	69		Coffee Pot(64)		d/s Beaver Flats(68)	Bonanza(62)	u/s Gail Cr.(40)			u/s Gail Cr.(42)	d/s Gail Cr.(38)	d/s Gail Cr.(38)
	28	F	81		Coffee Pot(64)		Triple Header(58)	Bonanza(62)		d/s Thomlinson(33)		d/s Thomlinson(31)		
Ch. 9	37	F	78	Triple Header(58)		Triple Header(58)	d/s Triple Header(57)	Hanawald confl.(60)	d/s Laura's(80)	u/s Laura's(82)		u/s Laura's(82)	Nichyeskwa(93)	u/s weir(95)-May 16
	65	F	84			Triple Header(58)	u/s Shelagyote(50)	u/s Shelagyote(50)		d/s Shelagyote(48)	u/s Shelagyote(50)	d/s Hanawald(60)	u/s weir(95)-May 5	
	61	M	85		u/s Triple Header(59)	Triple Header(58)	d/s Triple Header(57)	Hanawald confl.(60)	d/s Triple Header(56)	Triple Header(58)	Triple Header(58)	Triple Header(58)	Triple Header(58)	u/s Shelagyote(50)
	47	F	77		Hanawald confl.(60)	u/s Coffee Pot(67)	d/s Beaver Flats(68)	Hanawald confl.(60)	Shelagyote(49)	Shelagyote(49)		d/s Shelagyote(48)		
Ch. 8	43	F	68		Triple Header(58)		u/s Hanawald(61)	Triple Header(58)		d/s Silver Hilton(48)		d/s Silver Hilton(48)	d/s Silver Hilton(48)	
	32	F	75		u/s Triple Header(59)	Triple Header(58)	u/s Shelagyote(54)	u/s Shelagyote(54)	d/s Thomlinson(32)	d/s Thomlinson(32)		d/s Thomlinson(32)		d/s Thomlinson(32)
	27	F	78		d/s Triple Header(55)			Skeena(0)-Dec 22		d/s Skeena(0-36)			d/s Skeena(0-36)	d/s Skeena(0-36)
	78	F	76		Hanawald confl.(60)	u/s Shelagyote(50)	u/s Shelagyote(50)	u/s Shelagyote(50)					Shelagyote(49)	
	37	M	61		d/s Triple Header(56)	Triple Header(58)	u/s Shelagyote(50)	Triple Header(58)		d/s Gail Cr.(38)		d/s Gail Cr.(37)	u/s weir(95)-May 25	
	40	M	72		Triple Header(58)	Triple Header(58)	Triple Header(58)	Bonanza(62)	d/s Triple Header(56)	d/s Hanawald(60)	d/s Hanawald(60)	d/s Hanawald(60)		d/s Hanawald(60)
	66	F	79		Triple Header(58)		u/s Shelagyote(53)	u/s Shelagyote(53)	u/s Shelagyote(50)	u/s Shelagyote(50)	u/s Shelagyote(50)	u/s Shelagyote(50)	u/s Shelagyote(50)	u/s Shelagyote(50)
Ch. 9	64	M	66	u/s Shelagyote(54)	u/s Shelagyote(53)	u/s Shelagyote(50)	d/s Silver Hilton(36)	Silver Hilton(48)		u/s Gail Cr.(39)		u/s Gail Cr.(44)		d/s Skeena(0-57)
	29	M	74				u/s Shelagyote(54)	u/s Shelagyote(54)	d/s Shelagyote(48)	d/s Shelagyote(48)	d/s Shelagyote(48)	d/s Shelagyote(48)	d/s Shelagyote(48)	
	62	F	72		u/s Shelagyote(53)		d/s Silver Hilton(44)	d/s Silver Hilton(48)		Thomlinson Cr.(34)	u/s Thomlinson Cr.(35)	u/s Gail Cr.(42)	up Nilkitkwa(91+22)	
	36	M	62		d/s Triple Header(56)	d/s Triple Header(56)	u/s Shenismike(17)			d/s Skeena(0-38)			d/s Skeena(0-44)	
	75	M	80		u/s Shelagyote(53)	u/s Shelagyote(54)	u/s Shelagyote(54)	u/s Shelagyote(54)	u/s Shelagyote(51)	u/s Shelagyote(50)	u/s Shelagyote(50)	u/s Shelagyote(50)	u/s Shelagyote(50)	u/s Shelagyote(50)
	56	F	98					Skeena(0)-Dec 22						u/s Shahnagh(62)

Table 2. Date and time of first detection of upstream migrating radio tagged steelhead in the vicinity of the Babine Weir.

	Code	Sex	Length (FL in cm)	Tagging Location 7 November, 1994	Downstream of Babine Fence (fs 69)	Upstream of Babine Fence (fs 26)	Time Elapsed Downstream of Fence d,hrs,mins	Time Elapsed Downstream of Fence hrs
Ch. 10	31	M	92	Home Run(84)				
	21	M	62					
	34	M	96					
	29	F	91					
	90	M	61					
	44	M	86					
	74	M	83		29 April 0647 hrs	29 April 1627 hrs	0,9,40	9.7
Ch. 3	32	F	66	Beaver Flats(72)				
	31	F	81					
	37	M	64					
Ch. 10	42	F	81					
	83	M	84					
Ch. 8	62	F	77	Bonanza(62)				
	71	M	82					
	59	F	70					
Ch. 3	35	M	92					
	57	F	69					
	43	F	82		3 May 1843 hrs			
	52	M	69					
	30	M	63		*30 May 1804 hrs	28 May 0703	n/a	n/a
	45	F	69					
	28	F	81					
Ch. 9	37	F	78	Triple Header(58)	13 May 1809 hrs	16 May 0818 hrs	2,14,9	62.2
	65	F	84		4 May 0211 hrs	5 May 2234 hrs	1,20,23	44.4
	61	M	85					
	47	F	77					
Ch. 8	43	F	68					
	32	F	75					
	27	F	78					
	78	F	76					
	37	M	61		20 May 0410 hrs	25 May 1139 hrs	5,7,29	127.5
	40	M	72					
	66	F	79					
Ch. 9	64	M	66	u/s Shelagyote(54)				
	29	M	74					
	62	F	72					
	36	M	62					
	75	M	80					
	56	F	98					

* This fish was not detected at fixed station 69 during it's upstream migration

Table 3. Date and time of first detection of emigrating, radio tagged Babine River steelhead at fixed station telemetry receivers, 1995, distances between fixed stations and corresponding rates of movement.

	Code	Sex	Fork Length (cm)	Tagging Location 7 November, 1994	Upstream of Babine Fence (fs 26)	Downstream of Babine Fence (fs 69)	93.1 km km/day	Babine-Skeena Confl.(fs 25)	65.4 km km/day	Bulkley-Skeena Confluence (fs 12)	131.1 km km/day	Zymoetz-Skeena Confluence (fs 10)	71.4 km km/day	Exchamsiks-Skeena Confluence (fs 05)	Babine-Skeena - Exchamsiks-Skeena (fs 25-fs 05) 267.9 km km/day
Ch. 10	31	M	92	Home Run(84)				31 May 1756 hrs	34.4	2 June 1431 hrs			76.3	5 June 0613 hrs	59.4
	21	M	62												
	34	M	96												
	29	F	91												
	90	M	61					17 June 1420 hrs	22.8	20 June 1100 hrs	103.7	21 June 1720 hrs	66.6	22 June 1903 hrs	51.6
	44	M	86												
	74	M	83		30 May 2021 hrs	30 May 2037 hrs	99.5	31 May 1904 hrs			175.9	1 June 2153 hrs	184.6	2 June 0710 hrs	178.1
Ch. 3	32	F	66	Beaver Flats(72)				9 June 1809 hrs	35.6	11 June 1417 hrs	41.9	14 June 1720 hrs	29.0	17 June 0233 hrs	36.4
	31	F	81												
	37	M	64					28 June 1551 hrs							
Ch. 10	42	F	81												
	83	M	84												
Ch. 8	62	F	77	Bonanza(62)				24 Jan 1556 hrs	1.0	30 March 1518 hrs					
	71	M	82					22 June 2017 hrs	92.7	23 June 1313 hrs	72.1	25 June 0851 hrs	194.0	25 June 1741 hrs	92.6
	59	F	70												
Ch. 3	35	M	92												
	57	F	69												
	43	F	82			16 May 1144 hrs	16.8	22 May 0027 hrs	60.6	23 May 0221 hrs					
	52	M	69					31 May 1724 hrs	190.3	1 June 0139 hrs	246.1	1 June 1426 hrs	207.3	1 June 2242 hrs	219.4
	30	M	63		1 June 0419 hrs		199.5	1 June 1531 hrs	239.6	1 June 2204 hrs	110.1	3 June 0239 hrs	21.8	6 June 0845 hrs	56.8
	45	F	69												
	28	F	81					30 May 2304 hrs	15.3	4 June 0554 hrs	50.6	6 June 2009 hrs	200.3	7 June 0441hrs	37.0
Ch. 9	37	F	78	Triple Header(58)	24 May 2216 hrs	25 May 2108 hrs	21.1	30 May 0712 hrs	181.8	30 May 1550 hrs	33.1	3 June 1459 hrs	195.8	3 June 2344 hrs	57.1
	65	F	84		16 May 0435 hrs	16 May 0734 hrs	24.7	20 May 0157 hrs	55.4	21 May 1616 hrs					
	61	M	85												
	47	F	77					4 June 2321 hrs	67.1	5 June 2245 hrs	136.1	6 June 2152 hrs	196.6	7 June 0635 hrs	116.4
Ch. 8	43	F	68												
	32	F	75												
	27	F	78					22 Dec 0932 hrs							
	78	F	76												
	37	M	61		6 June 1709 hrs		50.1	8 June 1347 hrs	21.2	11 June 1555 hrs	31.1	15 June 2101 hrs	56.0	17 June 0338 hrs	31.2
	40	M	72												
	66	F	79												
Ch. 9	64	M	66	u/s Shelagyote(54)				9 June 0351 hrs	42.7	10 June 1648 hrs	66.8	12 June 1553 hrs	108.9	13 June 0737 hrs	64.4
	29	M	74												
	62	F	72												
	36	M	62					20 Dec 1236 hrs							
	75	M	80												
	56	F	98												

The first tracking flight was conducted on November 9, 1994, 2 days after tagging took place. During that track, 20 (51.3%) of the 39 radio tagged fish were located. Nine (45.0%) of the fish tracked were upstream of the original tagging location, 4 (20.0%) remained at the tagging site while 7 (35.0%) were downstream. Seven (77.8%) of the 9 fish that migrated upstream immediately after tagging subsequently died or regurgitated their radio transmitter.

The second tracking flight was conducted on November 26, 1994, 19 days after tagging. Twenty five (64.1%) of the 39 tagged fish were located. At that time, 4 (16.0%) of the fish tracked were upstream of the original tagging location, 13 (52.0%) remained at the tagging site while 8 (32.0%) were downstream. Three (75.0%) the 4 fish that migrated upstream subsequently died or regurgitated their radio transmitter.

The third tracking flight was conducted on December 16, 1994, 39 days after tagging. Thirty four (87.2%) of the 39 tagged fish were located. At that time, 8 (23.5%) of the fish tracked were upstream of the original tagging location, 4 (11.8%) remained at the tagging site while 22 (64.7%) were downstream. Seven (87.5%) of the 8 fish that migrated upstream subsequently died or regurgitated the radio transmitter.

Migration rates between November and April tracking dates ranged from -1.0 km/day (downstream migration) to 1.2 km/day. Between mid-April and mid-May, when water temperatures rose to 5º C (Figure 8), fish began to leave overwintering locations and migration rates ranged from 0.21 km/day to 3.1 km/day.

Spawning was completed for the five (3 male, 2 female) radio tagged steelhead that migrated upstream of the Babine weir between May 16 and June 6 (females: May 16, May 24; males: May 30, June 1, June 6). Other radio tagged steelhead believed to have spawned successfully elsewhere within the Babine watershed emigrated past the Babine-Skeena river confluence between May 22 and June 28, indicating that spawning had been completed prior to those dates.

Radio tagged kelt emigrations were monitored by fixed receiver stations (Table 2) between the DFO weir and the Exchamsiks-Skeena river confluence, a total distance of 361 river kilometers. The six radio tagged steelhead that had migrated to the DFO weir emigrated from the weir to the Babine-Skeena confluence, a total distance of 93.1 km, in as little as 11.2 hours (82 cm female) and as long as 107.1 hours (63 cm male; mean emigration time of 68.1 hours), with corresponding emigration rates ranging from 16.8 km/day to 199.5 km/day within the Babine River. Twelve (30.8%) radio tagged steelhead kelts were successfully tracked during emigration between the Babine-Skeena confluence and the Exchamsiks-Skeena confluence, a total distance of 267.9 km. Twice as many of these fish were males than females (8:4), the mean fork length was 73.3 cm, and the mean date past the Exchamsiks station was June 10, 1995. This distance was traveled in as little as 29.3 hours (69 cm male) and as long as 206.1 hours (61 cm male; mean emigration time of 108.7 hours), with corresponding emigration rates ranging from 31.2 km/day to 219.4 km/day (mean emigration rate of 83.4 km/day) within the Skeena River.

One steelhead (64 cm male) was captured and killed on July 4 in a Native gillnet fishery on the Skeena River downstream of the Kispiox-Skeena river confluence near Glen Vowell village. This fish had been recorded emigrating past the Babine-Skeena fixed station on June 28, 1995.

Water and Temperature Data

Total daily discharge steadily increased from approximately 20 m^3/s on April 18 to a peak of approximately 96 m^3/s on May 30, after which it receded gradually (Figure 6; Water Survey of Canada, 1989). Water temperatures recorded during the study period are found in Figure 7 (Water Survey of Canada, 1989). The water temperature of the Babine River at kilometer 54 at the beginning of tagging operations on November 7, 1994 (1015 hours) was 3.0 degrees Celsius.

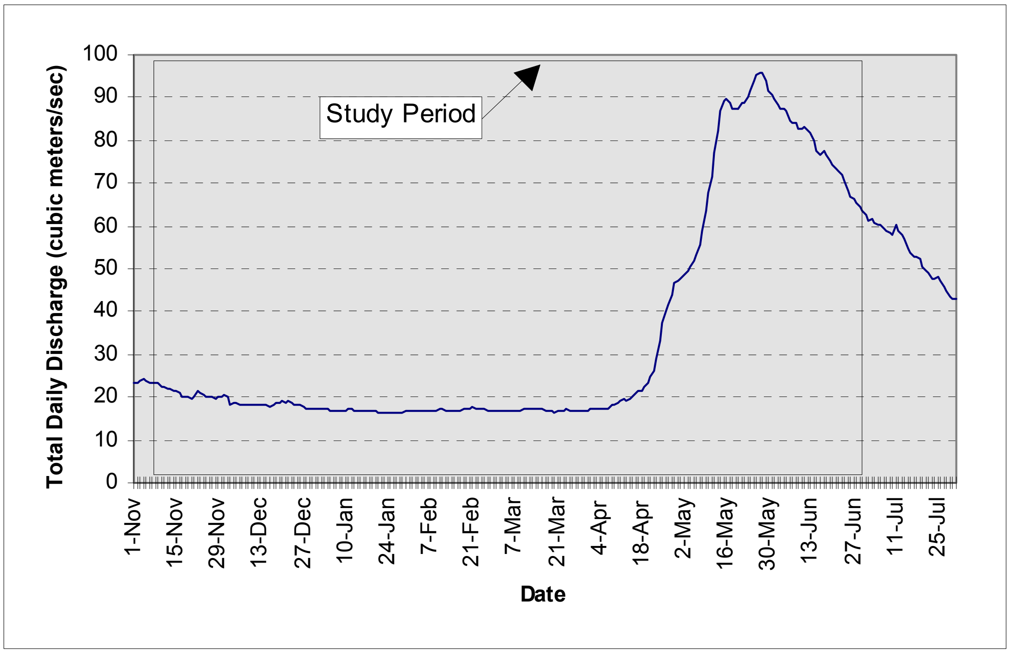

Figure 8. Total daily discharge of the Babine River at the outlet of Nilkitkwa Lake, November 1994 through July, 1995.

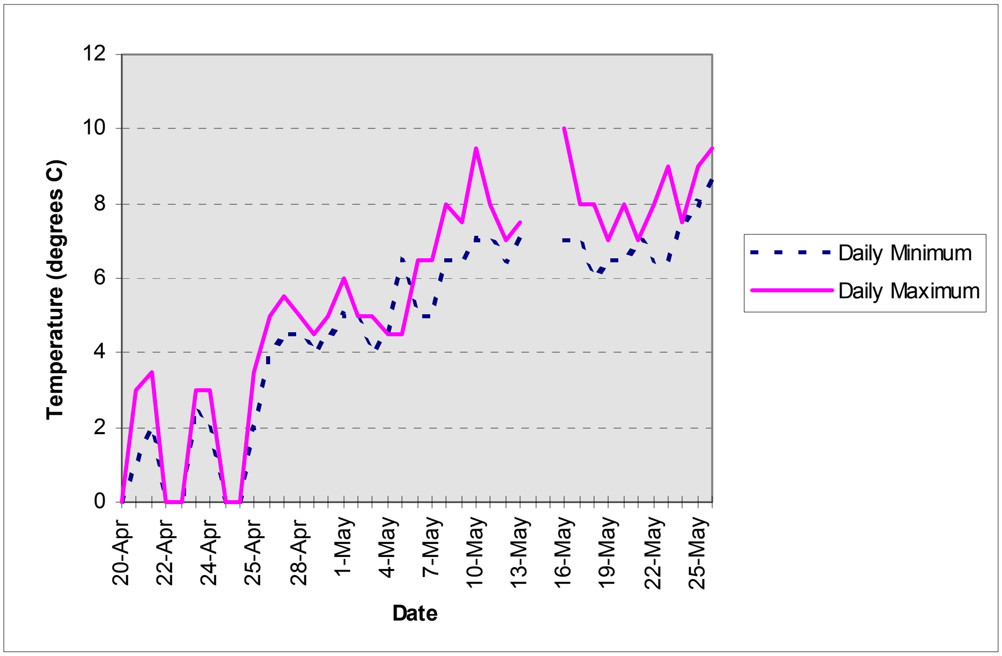

Figure 9. Daily water temperatures at the Babine River enumeration fence, April 20 through May 26, 1995.

Discussion

Five (12.8%) of the 39 Babine River summer steelhead radio tagged in November of 1994 were found to have migrated upstream of the DFO enumeration weir in the spring of 1995. During previous studies on the Babine River (Beere 1991c, 1996) where steelhead were radio tagged in April of 1990 and in April of 1994, it was found that a greater percentage of those fish migrated and spawned upstream of the weir. A fourth study, whose results have yet to be reported, found that 20.0% and 53.3% of fish radio tagged in each of two replicates migrated upstream of the DFO weir (Beere 1998 in prep.; Table 4). These results confirm that estimating the size of the Babine River steelhead population could not be accomplished by simply counting steelhead migrating through the DFO weir, as a significant proportion of the run spawn in other locations. The fact that a proportion of the Babine steelhead population migrates upstream of the weir in fall also compromises the accuracy of spring counts.

Suspected mortality/regurgitation rates were also significantly higher than in the previous two studies on the Babine River. In fact, this was the lowest survival to spawning destination of angled and radio tagged steelhead of any Fisheries Branch project conducted since 1990 (Beere 1991b, 1991c, 1991d, 1995, 1996, 1998; Table 5). Capture and tagging operations during this project progressed favorably and an explanation for the resultant mortality is puzzling. Babine River steelhead radio tagged in the fall demonstrated a higher mortality rate than those captured and tagged in the spring. This finding is also supported by a most recent study involving Babine River steelhead radio tagged using two different methods of transmitter application in both spring and fall (Beere 1998); fall tagged fish were found to experience a lower survival to destination even though radio tagged fish were captured from the same population and at the same location.

Table 4. Number of radio tagged steelhead from three different Babine River radio telemetry projects migrating upstream of the DFO weir.

Tagging Date	Number Radio Tagged	Number (percent) of Radio Tags u/s of DFO Weir
April 11, 1990	15	11 (73.3%)
April 14, 1994	25	12 (48.0%)
November 7, 1994	39	5 (12.8%)
October 25, 1995	30	6 (20.0%)
April 10, 1996	30	16 (53.3%)

Table 5. Percentage survival of steelhead angled and radio tagged by the Fisheries Branch since 1990.

Project	Number of Steelhead Angled and Radio Tagged	Percent Survival To Destination
Bulkley River Fall, 1989	23	95.6
Babine River Spring, 1990	15	86.7
Zymoetz River Fall, 1990/Spring 1991	7	100.0
Zymoetz River Spring, 1994	14	85.7
Babine River Spring, 1994	25	72.0
Babine River Fall, 1994	39	51.3
Babine River Fall, 1995	30	63.3
Babine River Spring, 1996	30	96.7

The migration rates documented between November and April tracking dates (from -1.0 km/day downstream migration to 1.2 km/day) and for mid-April to mid-May, after water temperatures rose to 5º C (from 0.21 km/day to 3.1 km/day) were similar to those found by Beere (1996) (between 0.1 and 2.6 km/day), Lough (1979), for steelhead angled between July 30 and August 2, 1978, 96 km upstream of Tyee (1.4 - 1.8 km/day), and Beere (1995) on the Zymoetz River in April, 1994 (0.5 - 2.1 km/day). Conversely, Spence (1989), who was studying the migrations of steelhead seined in tidal waters in the fall of 1988, and for the most part, in the mainstem Skeena River, found that the average rate of travel for radio tagged steelhead less than 10 km upstream of the mouth of the Skeena was 7.5 km/day; up to kilometer 54 he found an average rate of 8.3 km/day; 10.4 km/day downstream of the

Zymoetz River, 20.2 km/day between the Zymoetz and Bulkley rivers (individuals as high as 26.2 km/day), as high as 32 km/day upstream of Bulkley River and as low as 1.5 km/day. Spence documented that migration rates were reduced once steelhead had entered their natal stream in the fall, and that the final migration from an overwintering location to the spawning destination in the spring was slower than most fall migrations.

The fact that fish passing through the DFO weir spent between less than half a day (9.7 hours) and more than 5 days (127.5 hours) downstream of the fence before proceeding upstream indicates a reluctance of fish to pass through a man made obstruction. Previously, Beere (1996) determined that only 6 (50%) of 12 radio tagged steelhead that migrated upstream of the DFO weir did so during the period that the weir was actively fished (April 28 to May 16); only 2 (17%) of those 12 migrated downstream through the weir during that period. These results suggest that fish avoided the weir as long as possible when there was human activity on the weir, that the funnel traps used (reducing the width of the migration corridor) and the hours of operation disrupted normal migration behaviour. In a similar study conducted on the Babine in 1990 (Beere 1991), when the weir was not actively monitored, a greater proportion (11/15; 73.3%) of radio tagged steelhead migrated upstream of the weir. Nine (82%) of the 11 migrated upstream during the April 28 to May 16 period but only 2 (18%) of 11 had emigrated prior to May 16. This limited data suggests that steelhead migration through the weir may have been delayed in the current study as a result of actively fishing the weir. However further information must be gathered to eliminate the possibility that migration behaviour differences were due to between year differences in migration timing of Babine River steelhead.

It was estimated that spawning was completed between May 16 and June 28. This corroborates with the results noted by Beere (1996)(prior to May 27), and Beere (1990), where spawning was estimated to occur between May 16 and May 24. It was difficult to ascertain time of spawning for other fish radio tagged because, as Lough (1983) noted in a study on the Zymoetz River, although spawning took place in mid-May to early June, some remained in the river until July 10. In the present and 1990 studies, time of spawning could only be estimated by monitoring emigration timing.

Radio tagged kelt emigration rates within the Babine River ranged from 16.8 km/day to 199.5 km/day; within the Skeena River, between the Babine-Skeena confluence and the Exchamsiks-Skeena confluence, emigration rates ranged from 31.2 km/day to 219.4 km/day. The current speed in the Babine River was calculated to be approximately 129.6 km/day using mean water velocity data (Water survey of Canada 1989) for the month of July (1.596 m/s). Therefore, some kelts actively emigrated at greater than current speed.

The steelhead killed in a Native gillnet fishery on the Skeena River is a reminder that steelhead that survive spawning and emigrate back to the ocean are vulnerable to harvest as kelts just as upstream migrants are vulnerable on route to their natal streams. The radio tagged fish that was killed in this study emigrated past the Babine-Skeena confluence on June 28, 1995. It is assumed that later emigrating kelts, predominantly males, are more vulnerable to capture in summer fisheries for chinook and sockeye salmon, in both in-river Native and coastal commercial fisheries.

During this study, a 98 cm, ~11 kilogram (~24 pound) female steelhead was captured on the Babine River upstream the Shelagyote River (km 54) and radio tagged (Figure 10). This is remarkable in that, in addition to the considerable length for a female steelhead, this fish was one of the oldest steelhead ever sampled (13 years) and had spawned an estimated four times, perhaps the most spawning migrations ever recorded for a steelhead. This female had been captured previously by a guided angler and anchor tagged in October, 1987. In 1987, the fish was estimated to be 4.5 kilograms (~10 pounds).

Figure 10. A 98 cm, 11 kilogram female Babine River steelhead estimated to be returning to spawn for a remarkable fourth time in it's 14th year of life.

Recommendations

1. Operating the Babine enumeration weir in conjunction with radio telemetry is not recommended for estimating the Babine River summer steelhead population, as some fish pass through the weir in the fall and the proportion of fish utilizing habitat upstream of the weir varies annually.

2. If the Babine weir is to be used for fisheries management, care should be taken to minimize activity on the fence and maximize the number of openings available for steelhead to migrate upstream and downstream through the weir. Available data suggests that the fence disrupts steelhead migrations and it is possible that fish may be prevented from spawning in desired habitat upstream of the weir.

3. The importance of small and particularly lake headed streams to steelhead must again be emphasized. Forest harvest operations often overlook small streams, rationalizing their lack of importance due to size. The utmost of care must be taken to inventory and protect these steelhead spawning/juvenile rearing streams when preparing forest harvest plans/carrying out forest harvest/development activities.

4. Further investigation of the mortality rate in spring versus fall tagged summer steelhead projects may assist biologists in mitigating incidental fish losses.

Acknowledgments

This study was conceived and directed by Bob Hooton and he participated in the tagging of fish as did Dana Atagi. Canadian Helicopters transported Fisheries Branch personnel for tracking flights; thanks to pilots Darrell Adzich and Tom Brooks and engineers Terry Grant and Tracy Torunski. Thomas Leewondowski and Boyd Taylor at Lotek Engineering provided telemetry equipment and answered telemetry related questions. Davin Harris at Environment Canada provided water discharge data. LGL Environmental Consultants maintained mainstem Skeena River telemetry stations under contract to the Fisheries Branch.

This project was funded by BC Environment's Habitat Conservation Trust Fund and developed by personnel of BC Environment. The Habitat Conservation Trust Fund was created by an act of the legislature to preserve, restore and enhance key areas of habitat for fish and wildlife throughout British Columbia. Hunters, anglers, trappers and guides contribute to HCTF enhancement projects through license surcharges. Tax deductible donations to assist in the work of HCTF are welcome.

HABITAT
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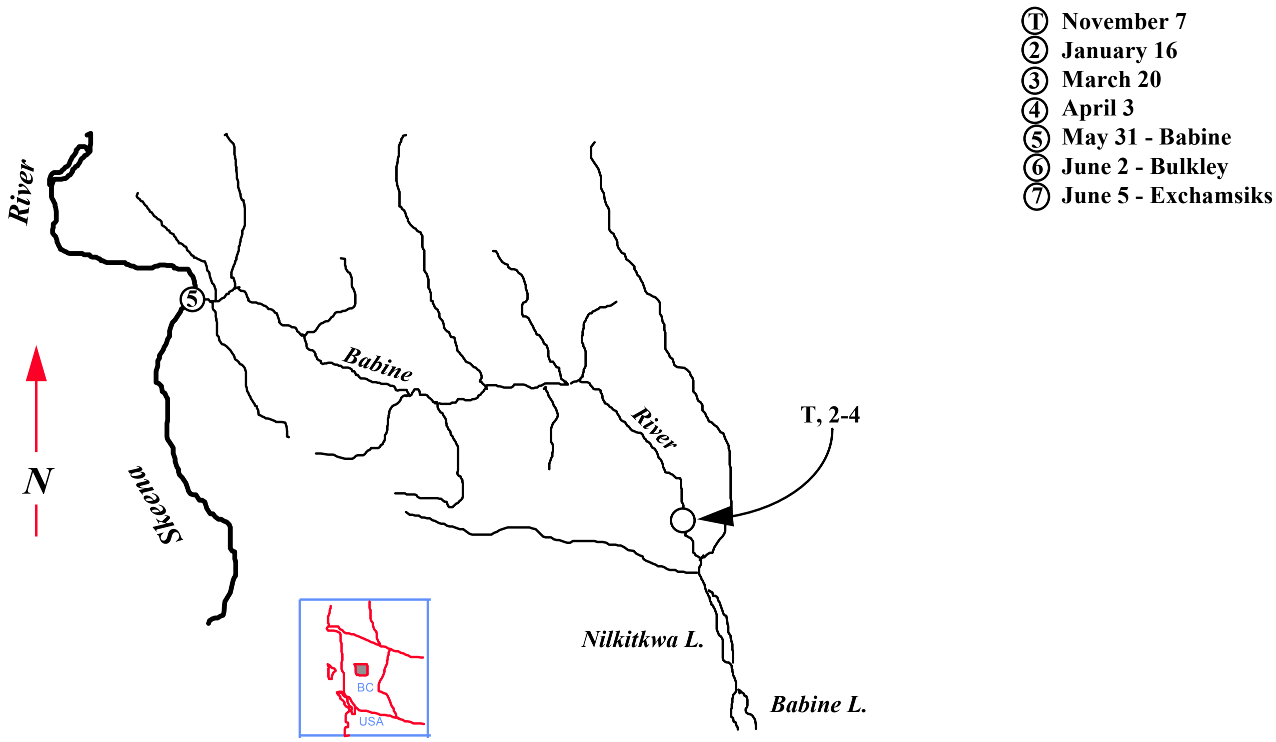
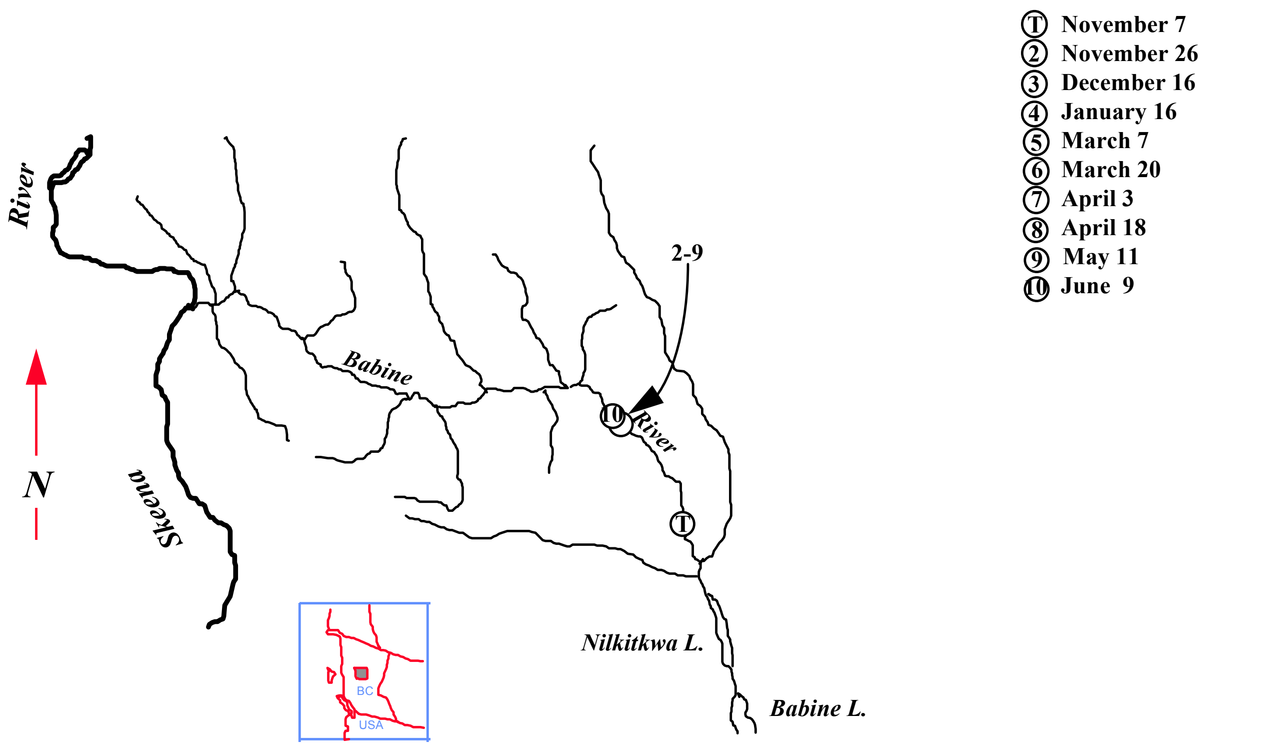
Appendices

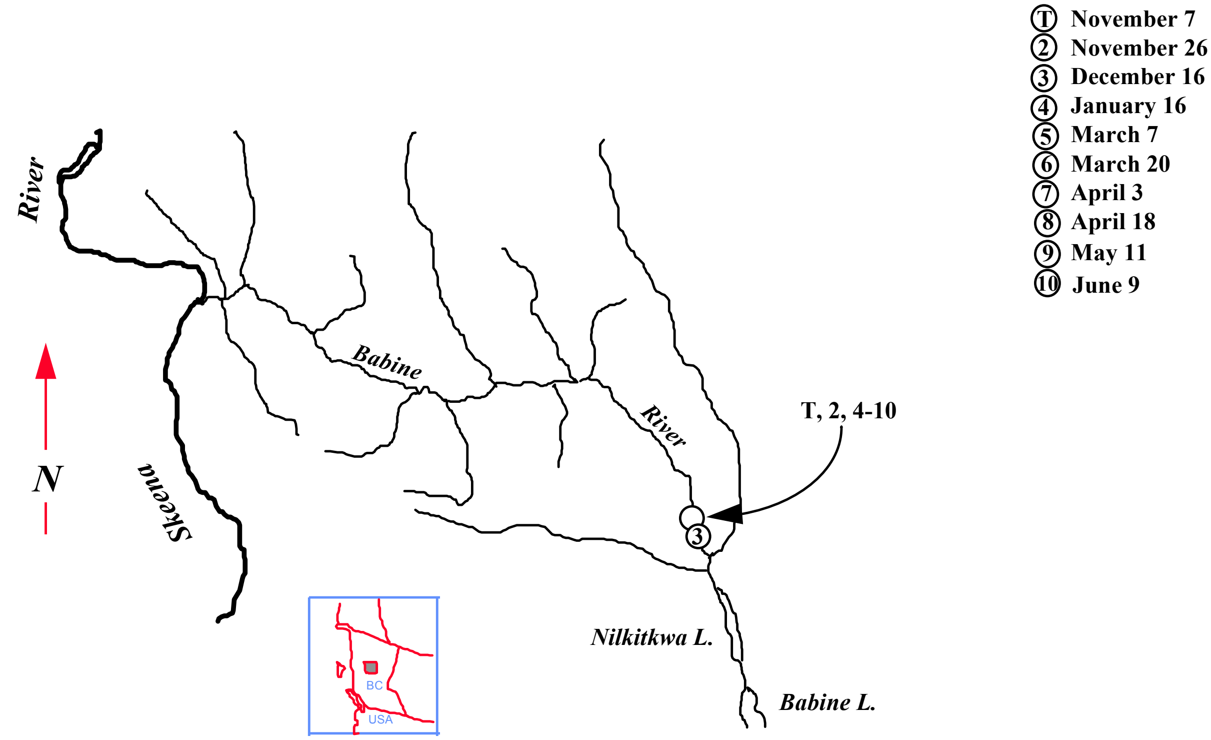
Appendices 1-39. Movements of individual radio tagged steelhead as determined by tracking flights and fixed tracking station data. T designates tagging location while S designates suspected spawning location. Babine, Bulkley, Zymoetz and Exchamsiks designations denote fixed tracking stations located at the confluences of those rivers with the Skeena.



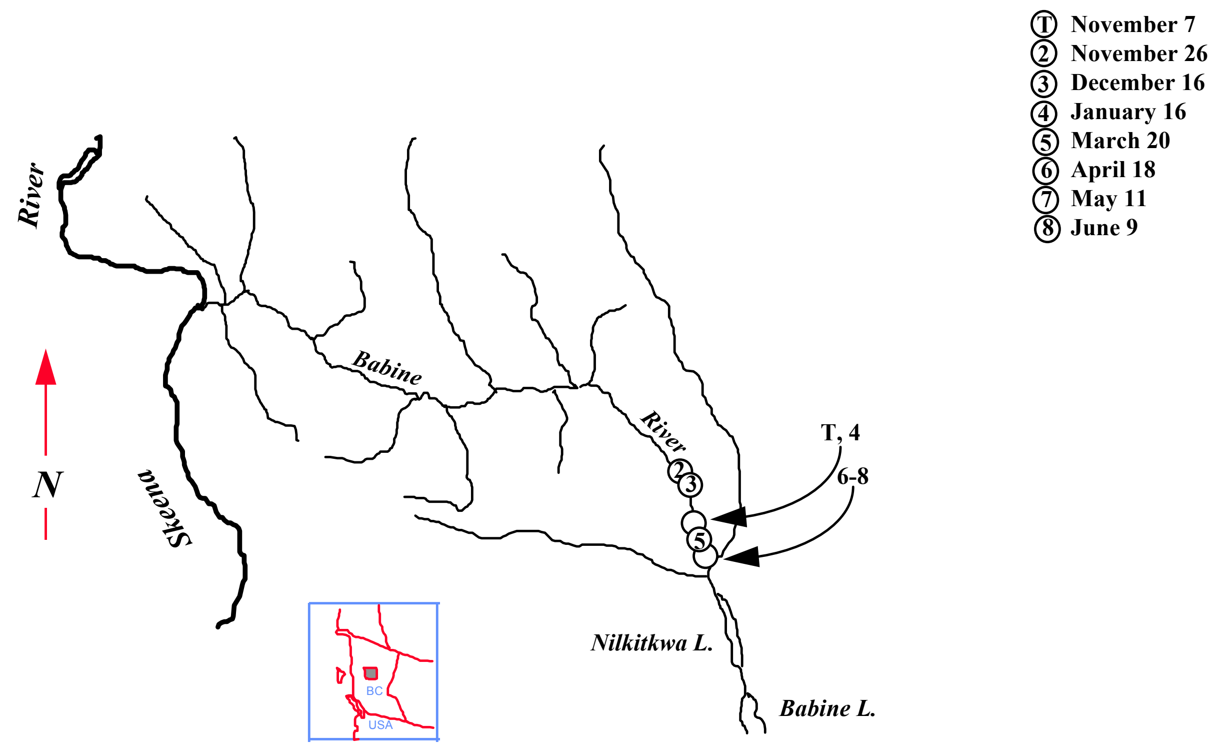
Appendix 1. Movements of radio tagged steelhead #1, 92 cm male. Ch. 10, code 31.



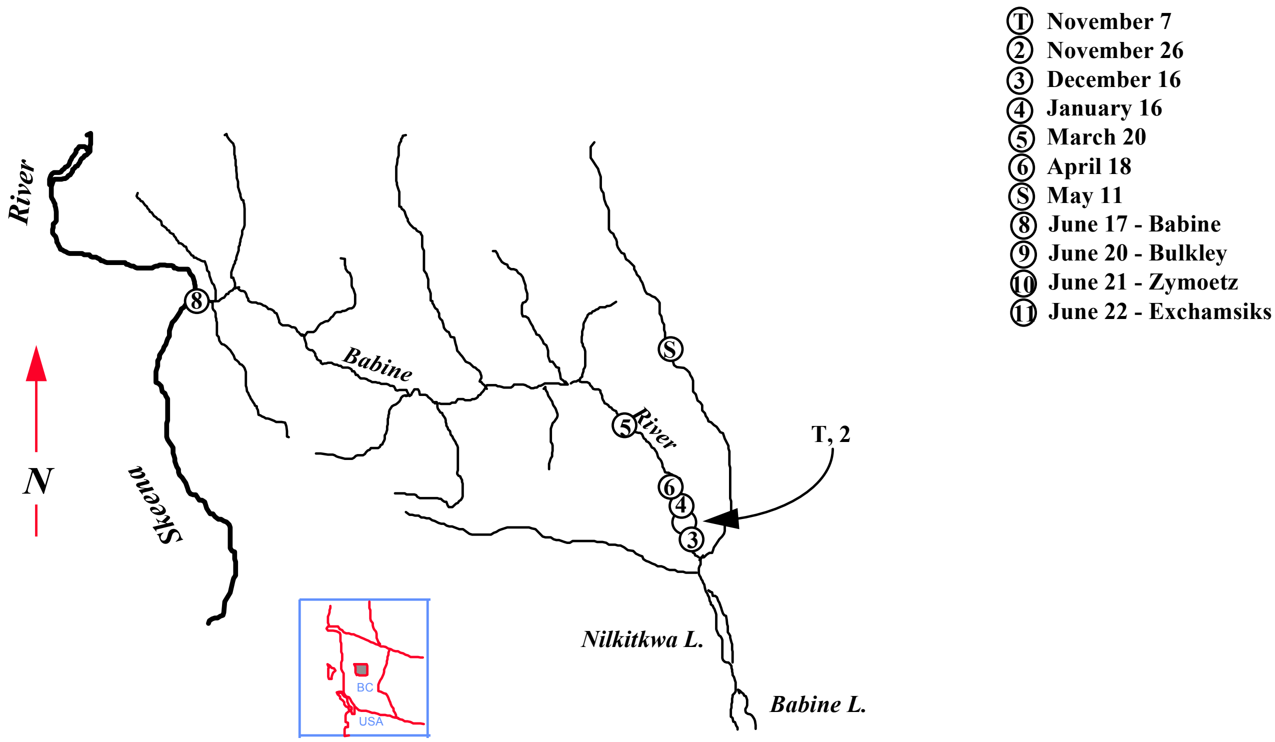
Appendix 2. Movements of radio tagged steelhead #2, 62 cm male. Ch. 10, code 21.



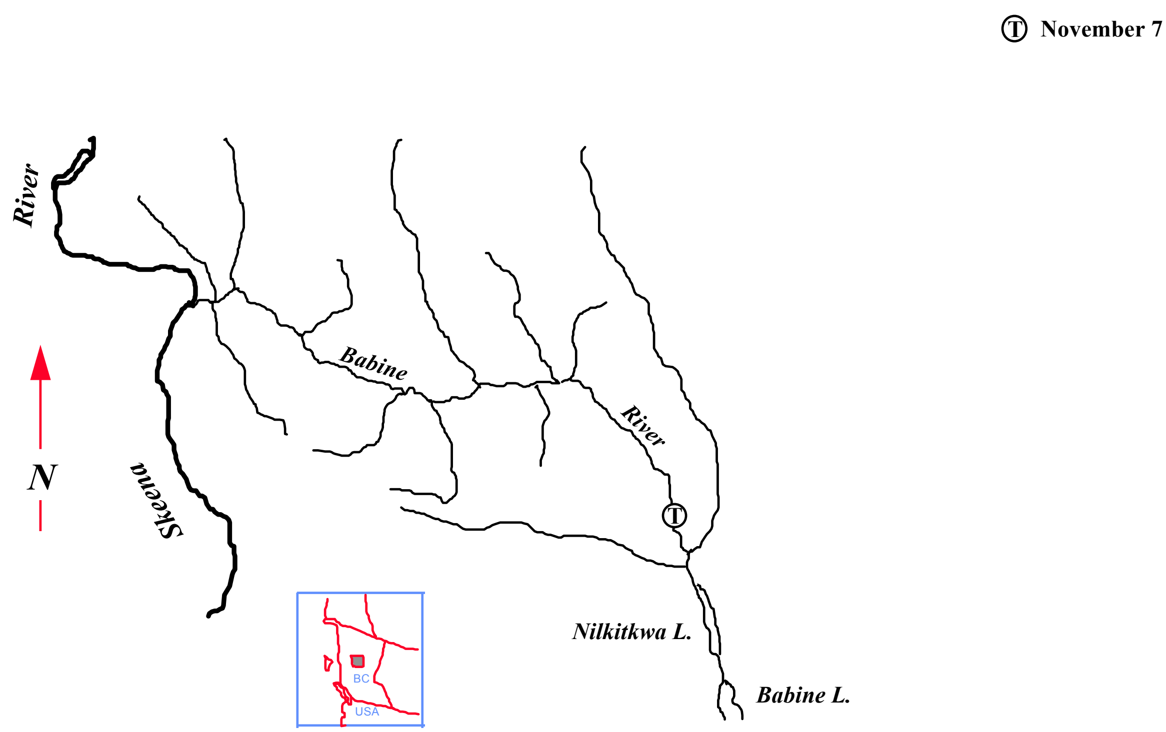
Appendix 3. Movements of radio tagged steelhead #3, 96 cm male. Ch. 10, code 34.



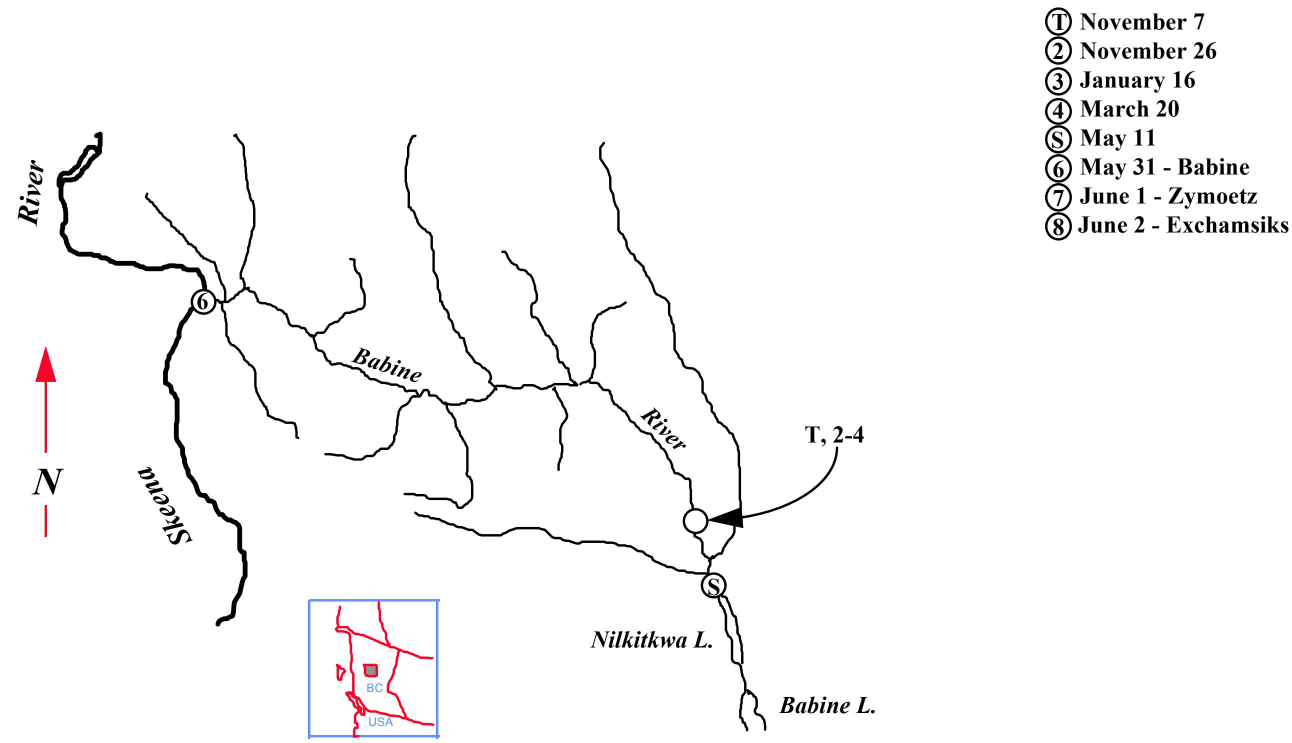
Appendix 4. Movements of radio tagged steelhead #4, 91 cm female. Ch. 10, code 29.



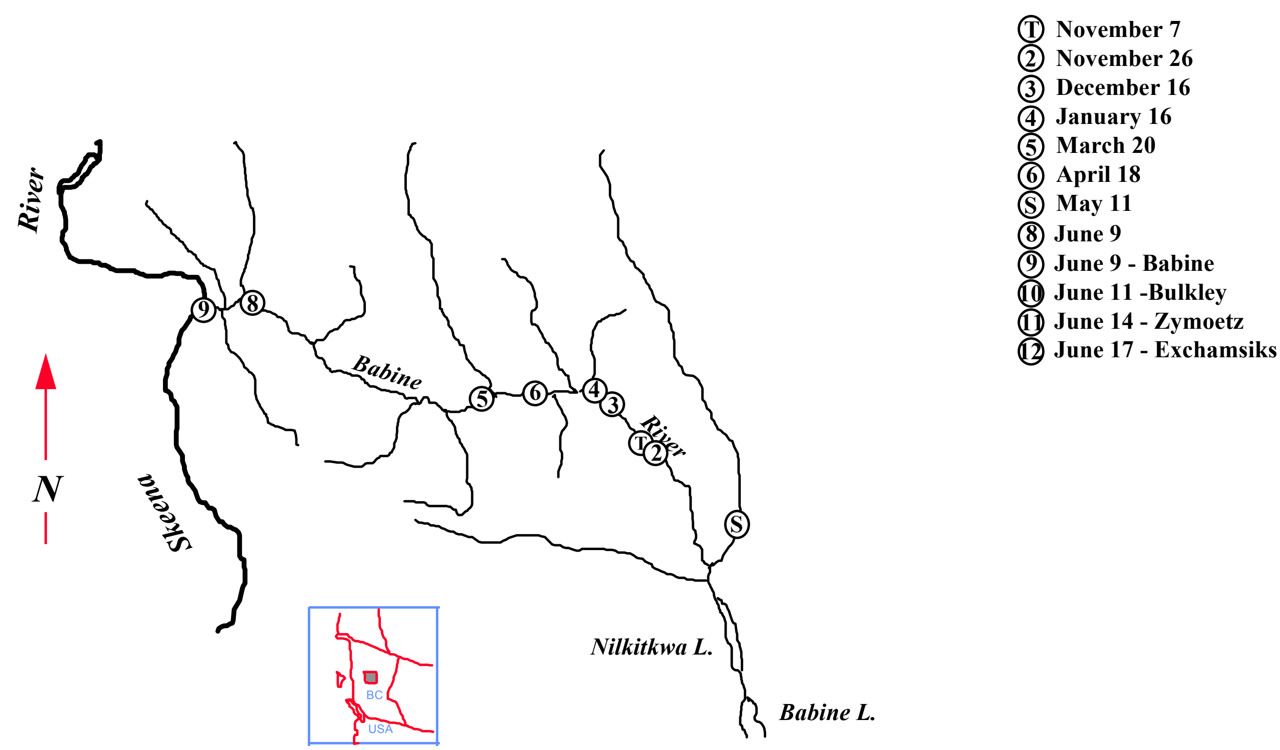
Appendix 5. Movements of radio tagged steelhead #5, 61 cm male. Ch. 10, code 90.



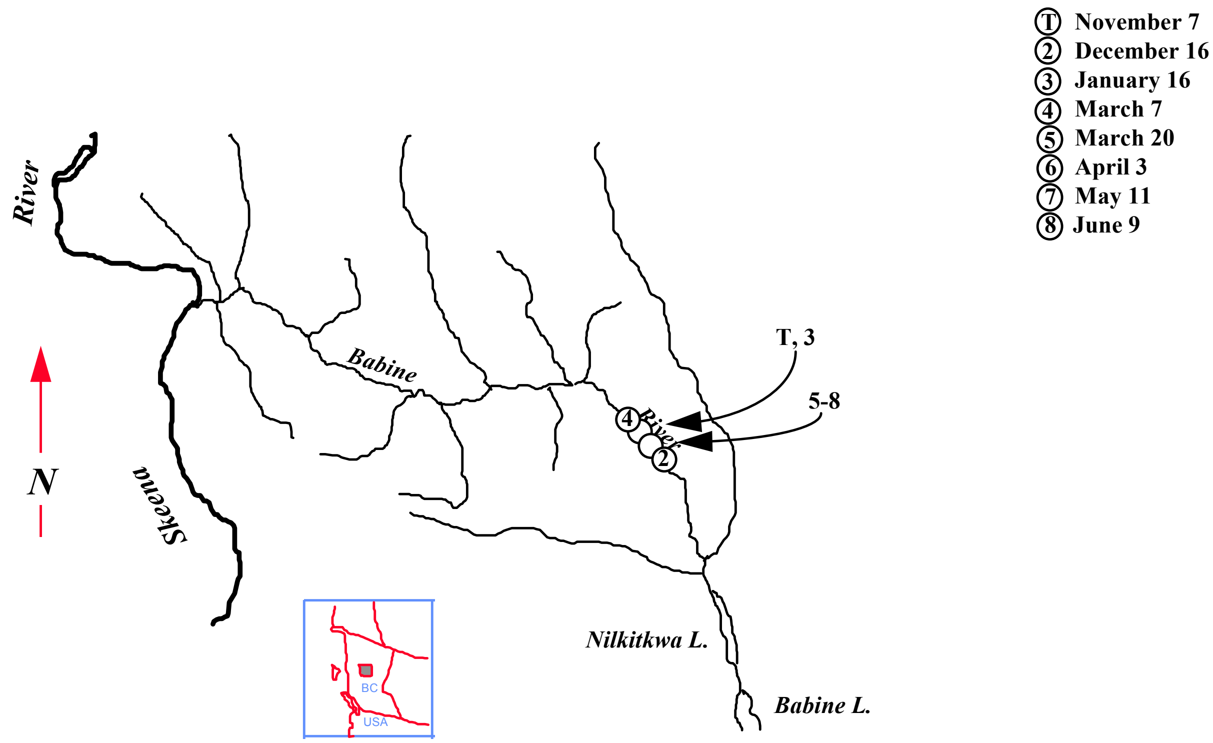
Appendix 6. Movements of radio tagged steelhead #6, 86 cm male. Ch. 10, code 44.



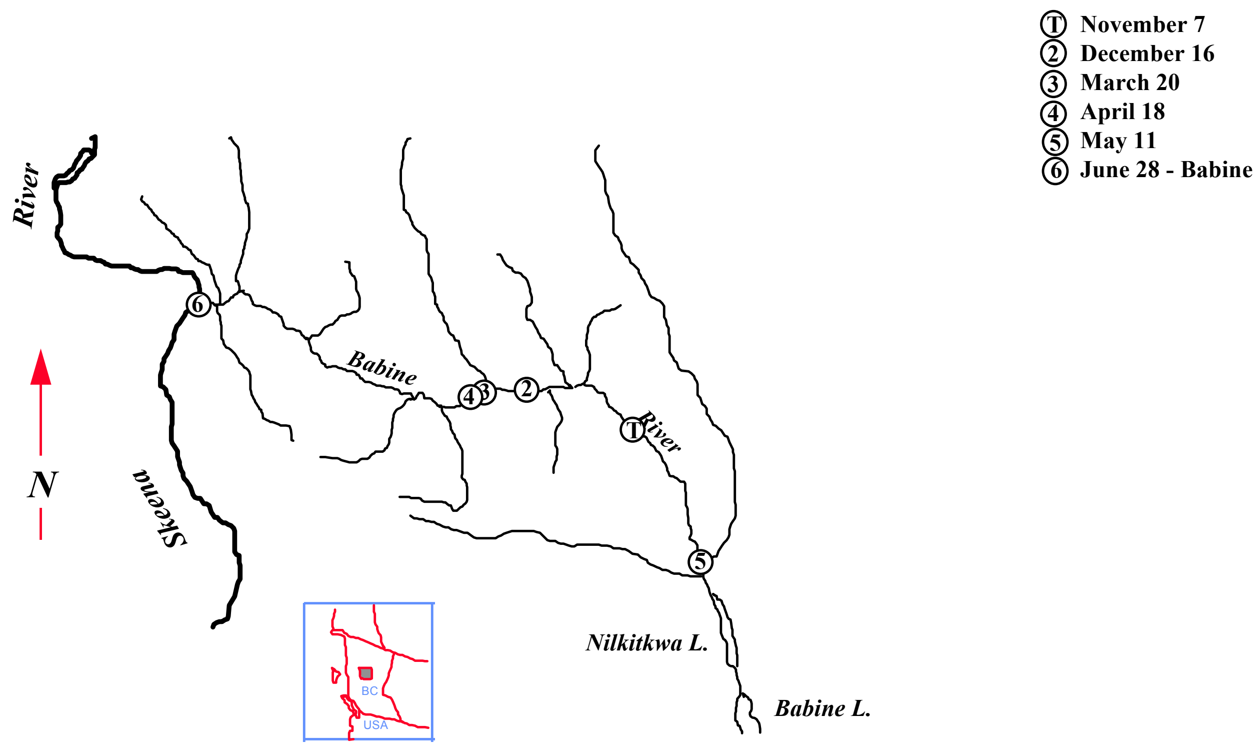
Appendix 7. Movements of radio tagged steelhead #7, 83 cm male. Ch. 10, code 74.



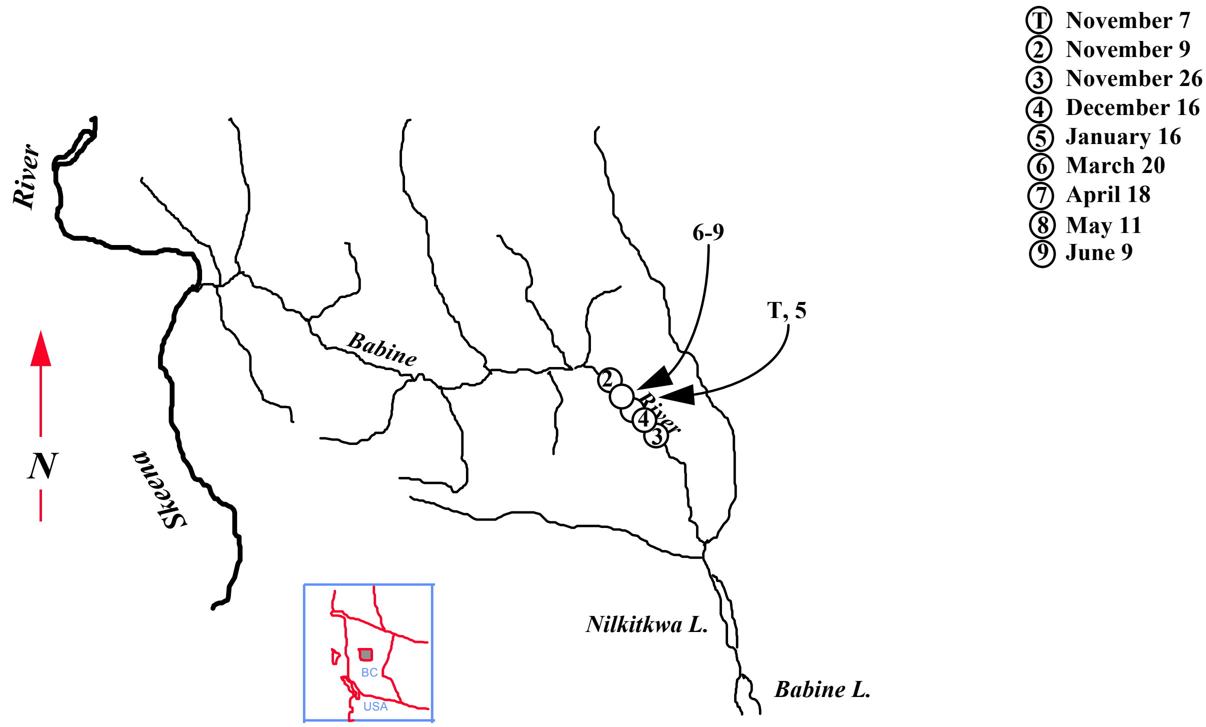
Appendix 8. Movements of radio tagged steelhead #8, 66 cm female. Ch. 3, code 32.



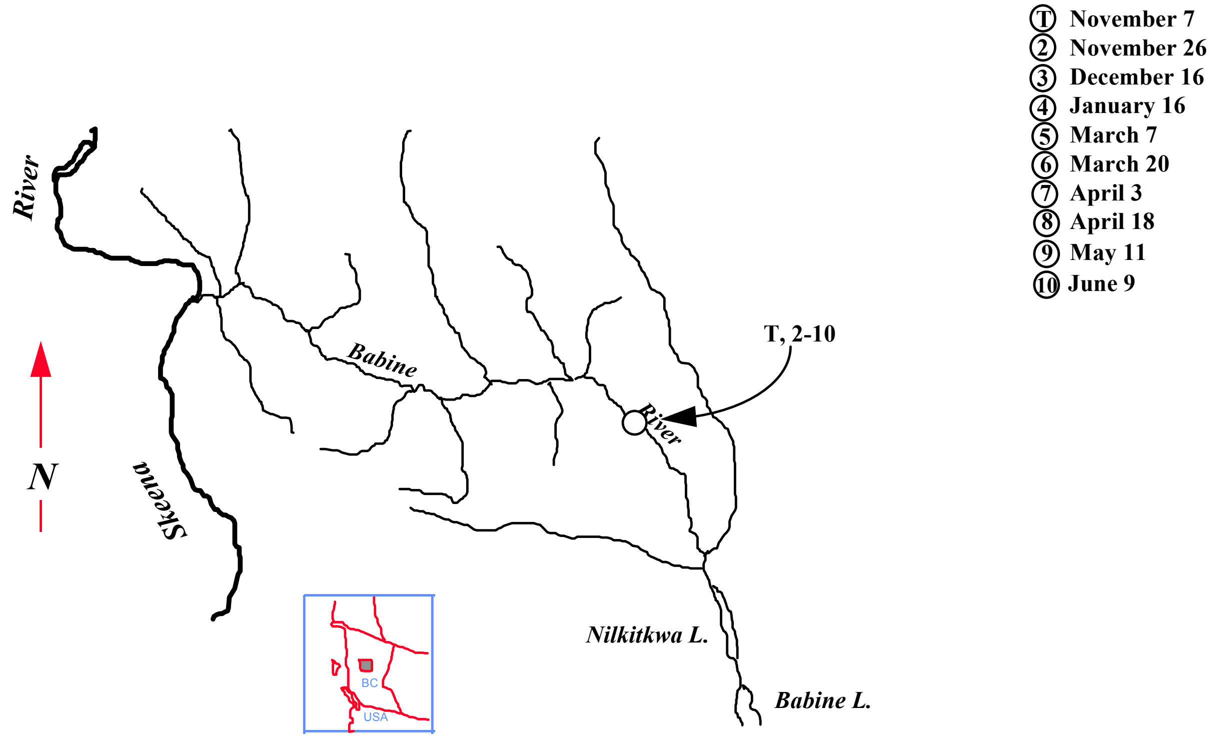
Appendix 9. Movements of radio tagged steelhead #9, 81 cm female. Ch. 3, code 31.



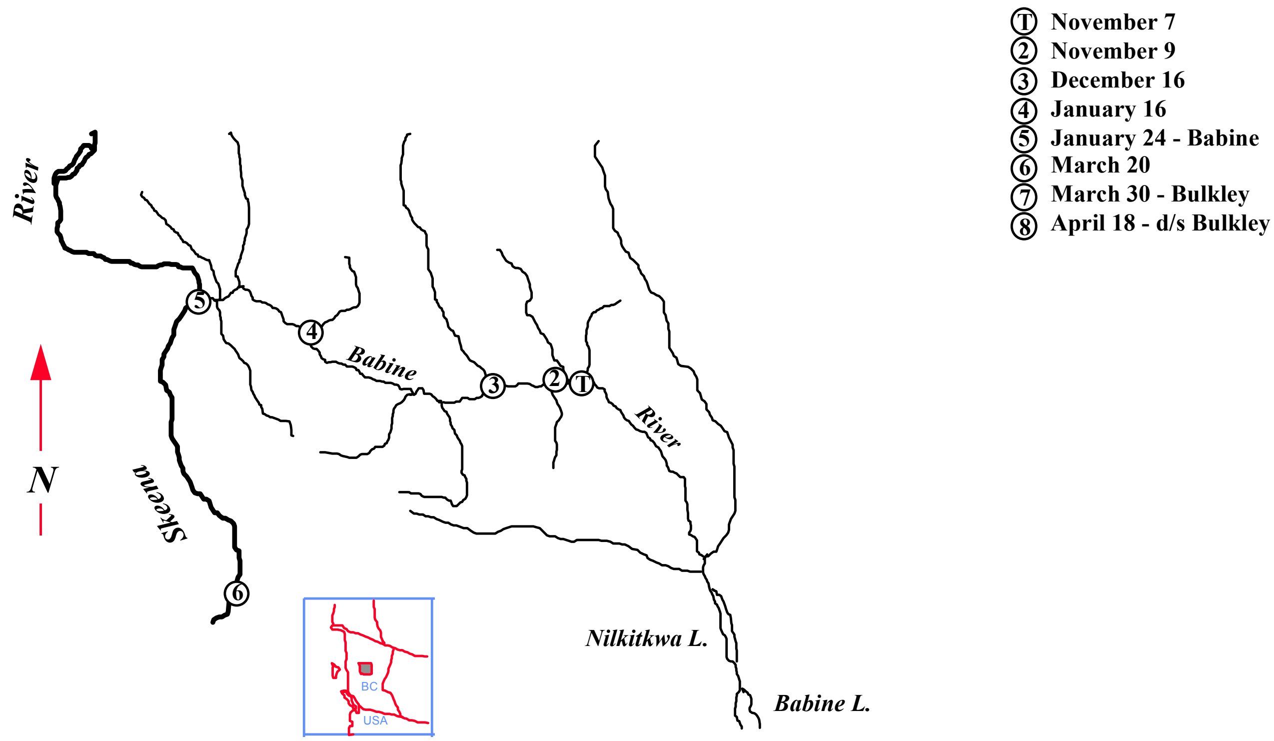
Appendix 10. Movements of radio tagged steelhead #10, 64 cm male. Ch. 3, code 37.



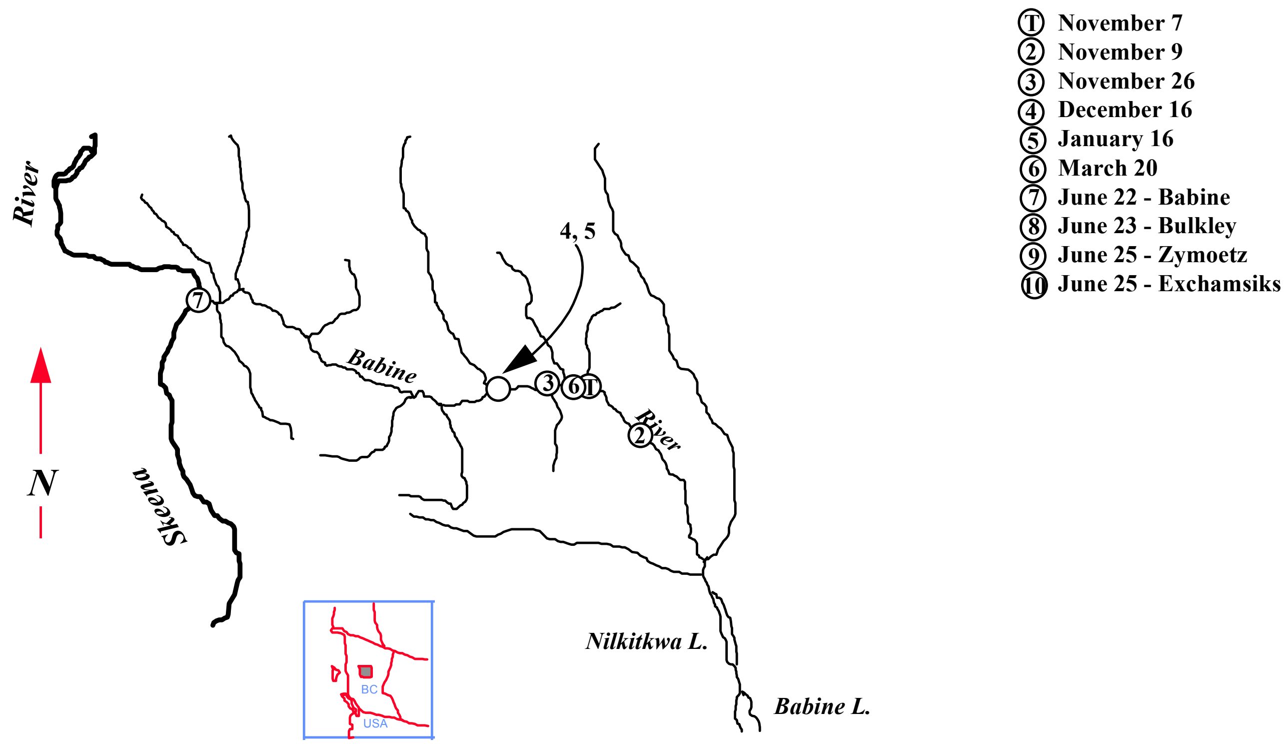
Appendix 11. Movements of radio tagged steelhead #11, 81 cm female. Ch. 10, code 42.



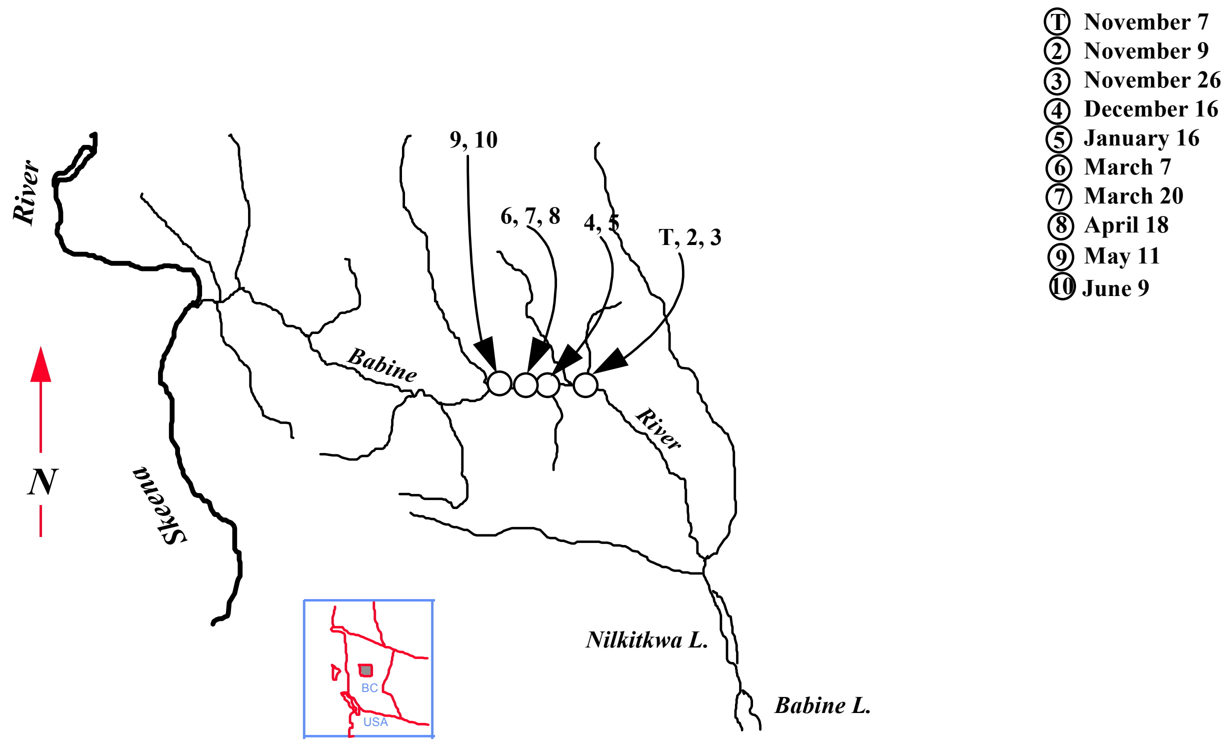
Appendix 12. Movements of radio tagged steelhead #12, 84 cm male. Ch. 10, code 83.



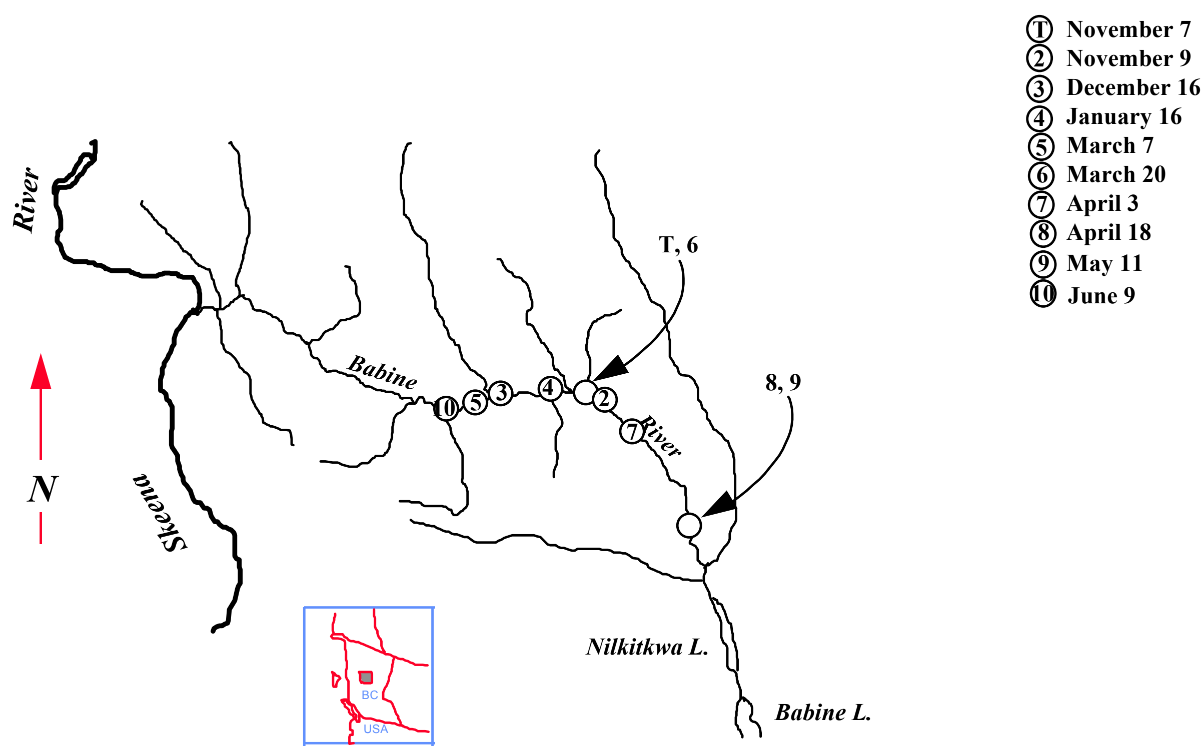
Appendix 13. Movements of radio tagged steelhead #13, 77 cm female. Ch. 8, code 62.



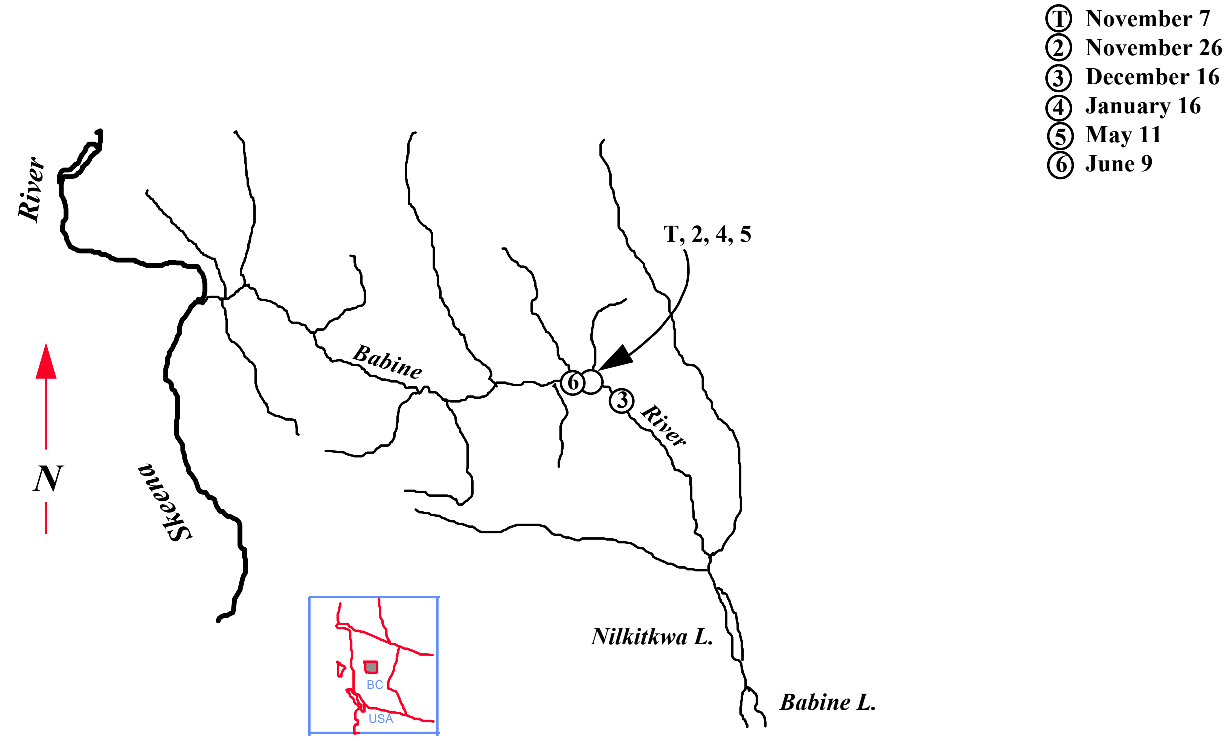
Appendix 14. Movements of radio tagged steelhead #14, 82 cm male. Ch. 8, code 71.



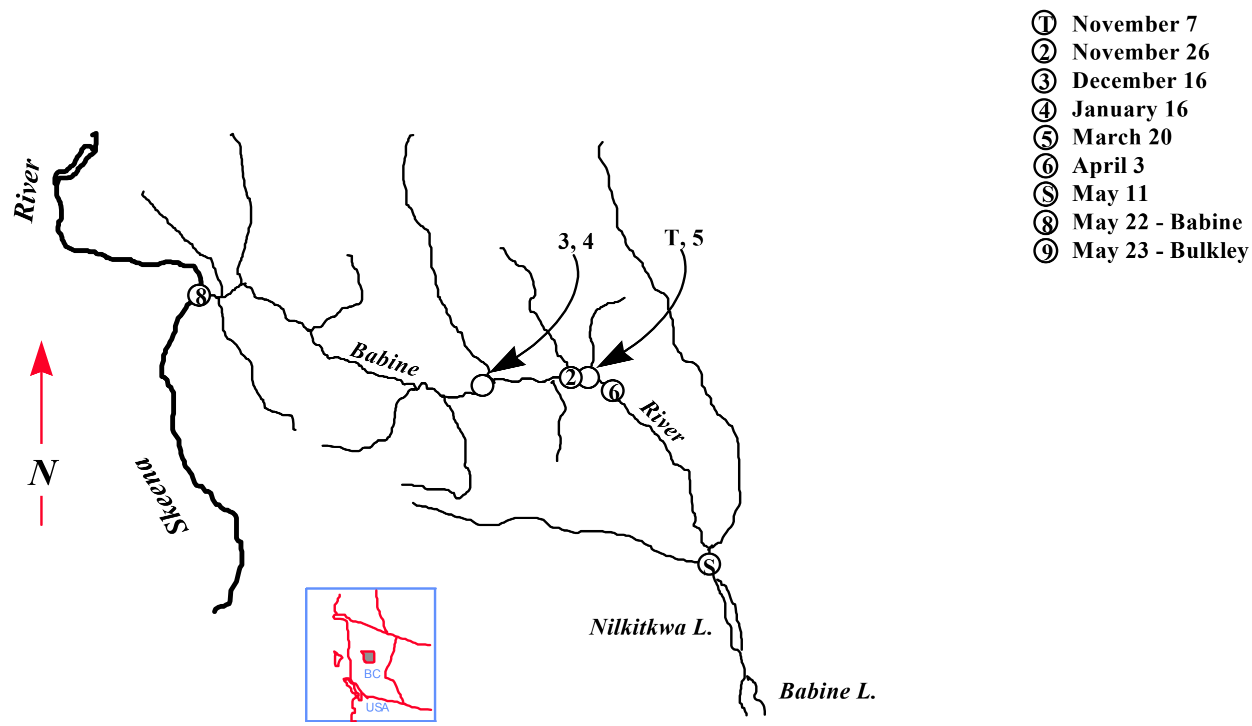
Appendix 15. Movements of radio tagged steelhead #15, 70 cm female. Ch. 8, code 59.



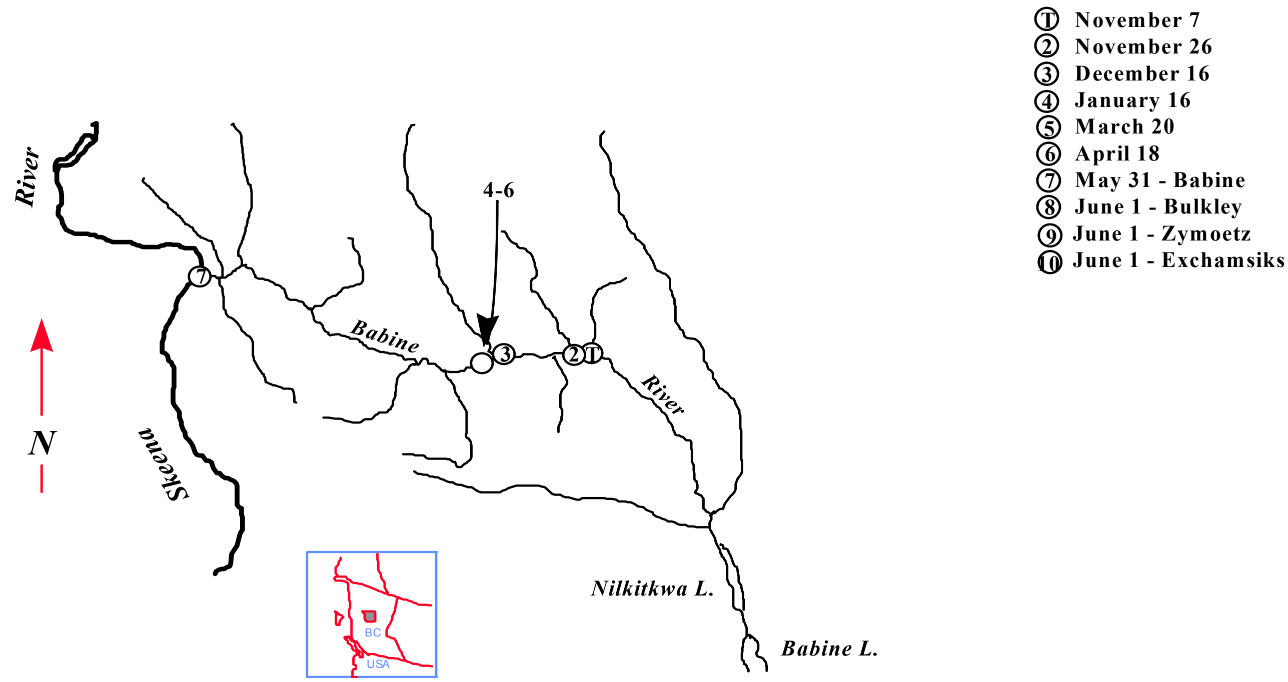
Appendix 16. Movements of radio tagged steelhead #16, 92 cm male. Ch. 3, code 35.



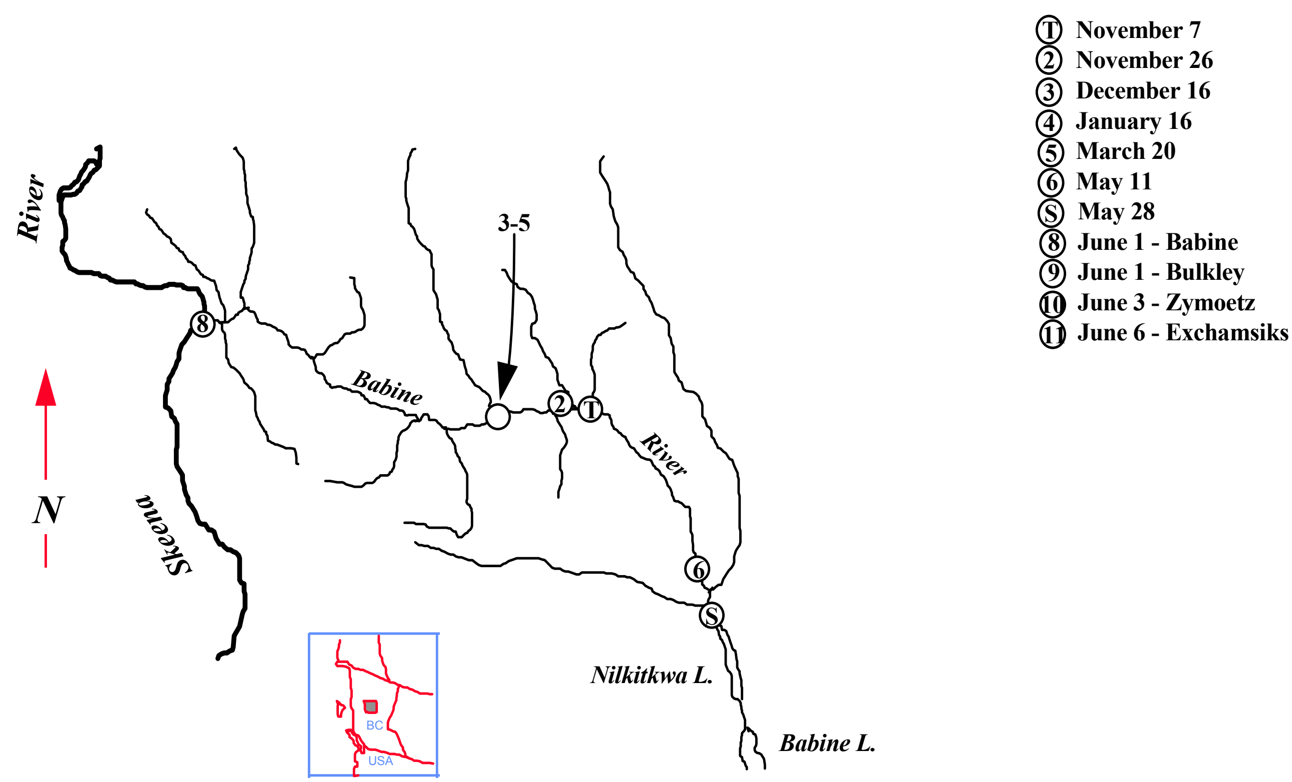
Appendix 17. Movements of radio tagged steelhead #17, 69 cm female. Ch. 3, code 57.



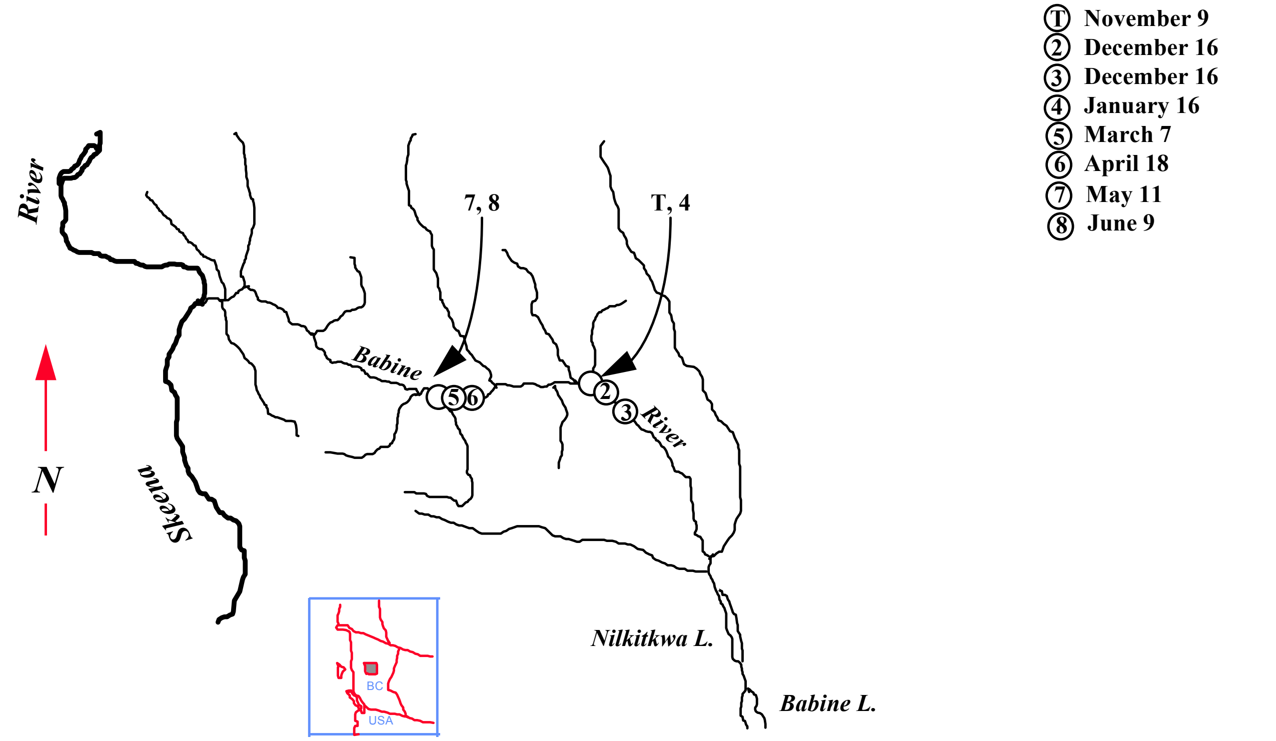
Appendix 18. Movements of radio tagged steelhead #18, 82 cm female. Ch. 3, code 43.



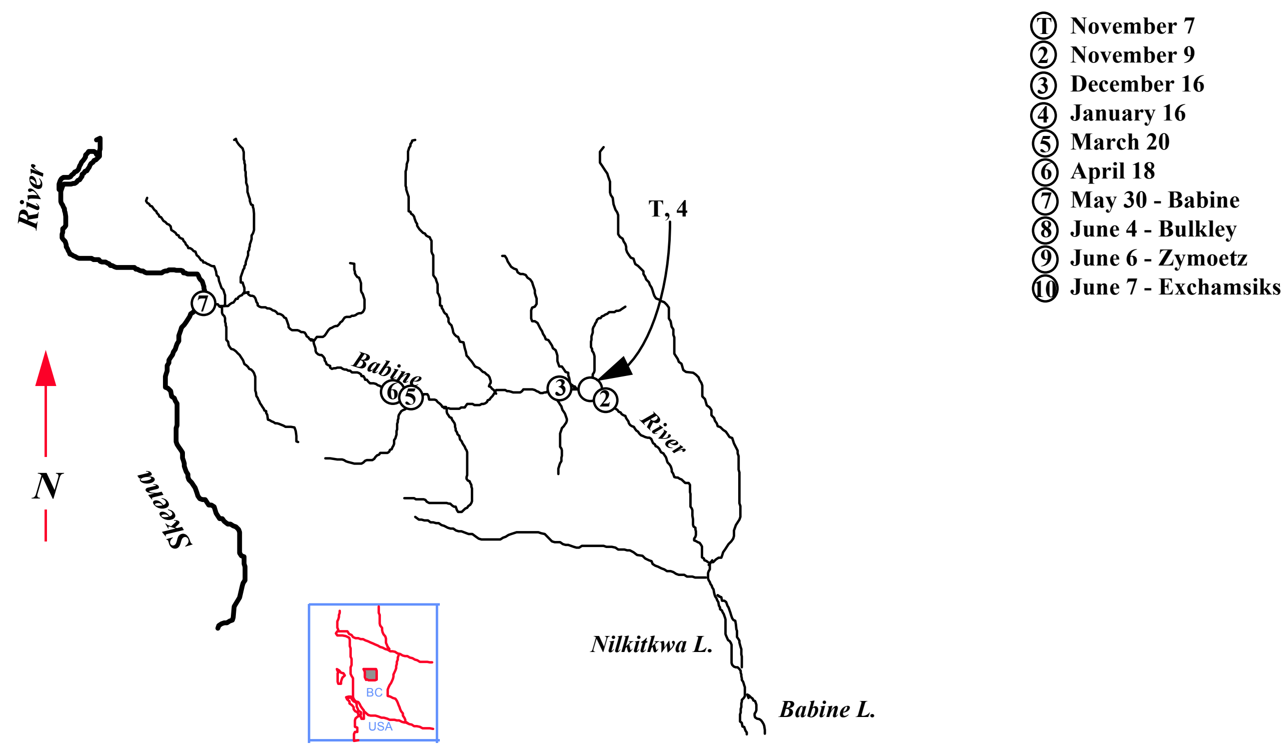
Appendix 19. Movements of radio tagged steelhead #19, 69 cm male. Ch. 3, code 52.



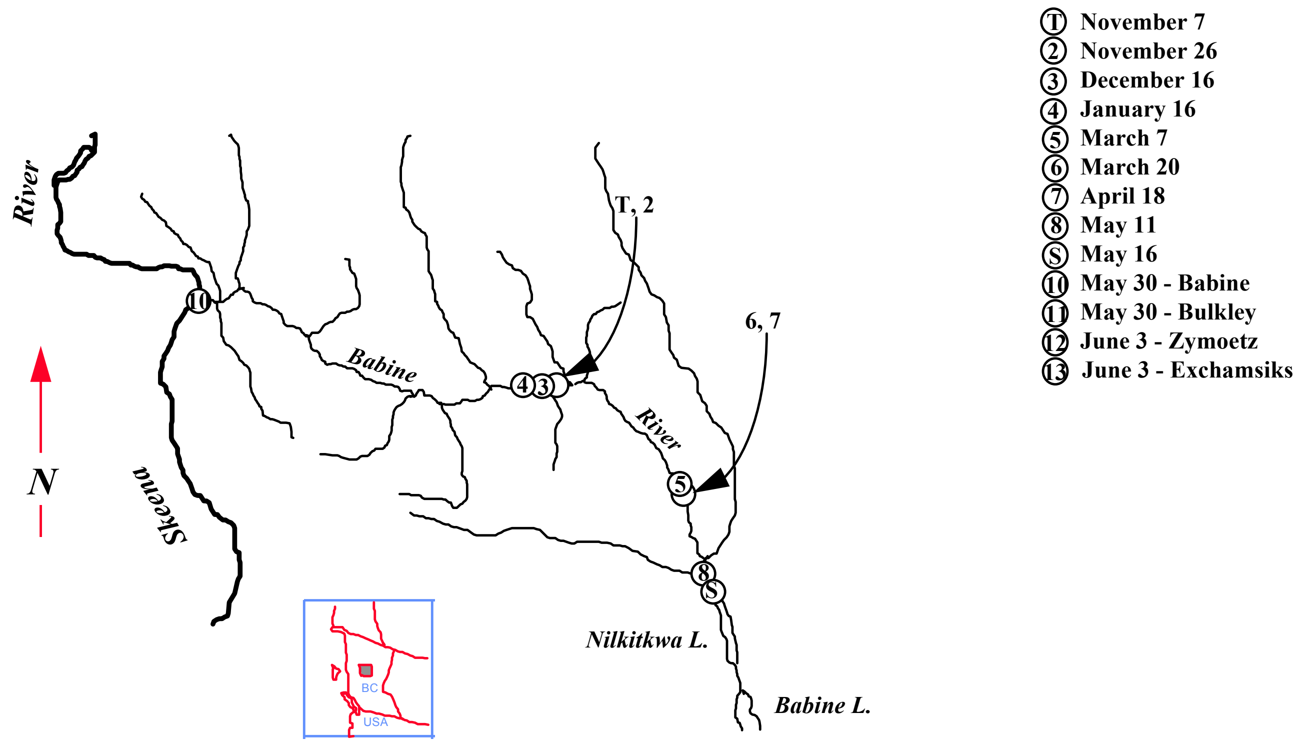
Appendix 20. Movements of radio tagged steelhead #20, 63 cm male. Ch. 3, code 30.



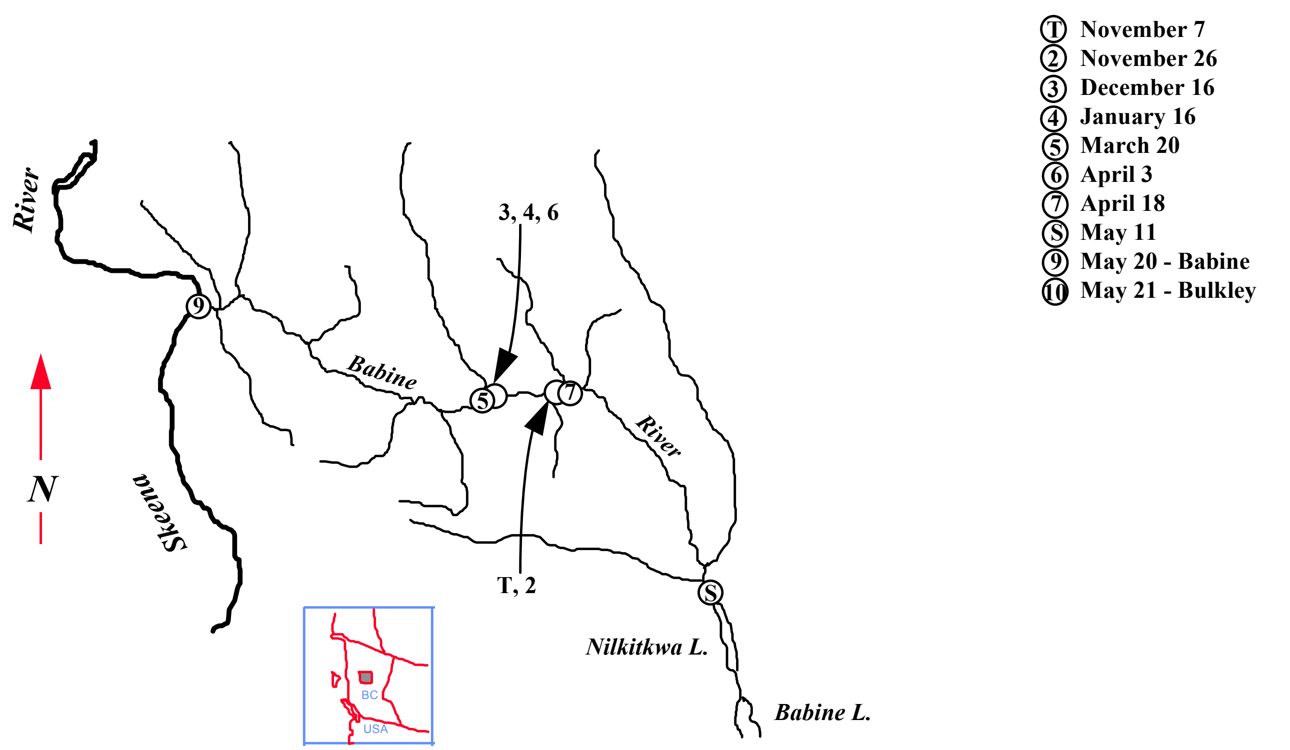
Appendix 21. Movements of radio tagged steelhead #21, 69 cm female. Ch. 3, code 45.



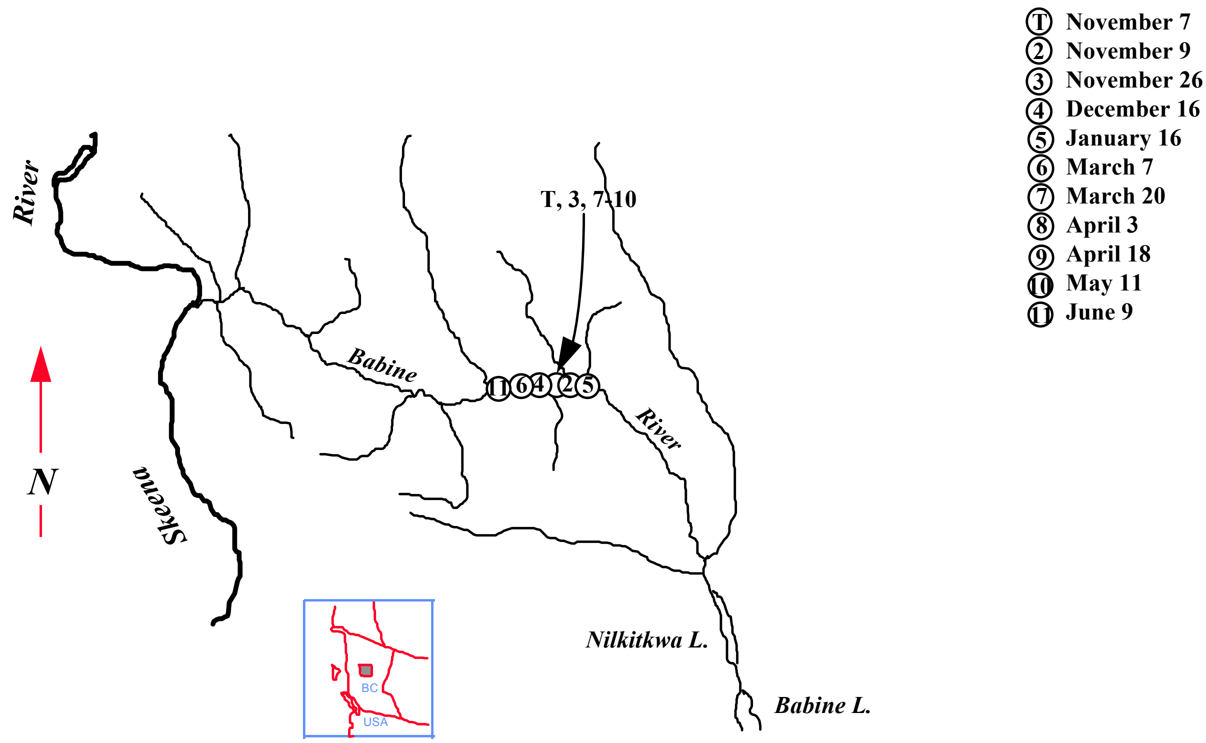
Appendix 22. Movements of radio tagged steelhead #22, 81 cm female. Ch. 3, code 28.



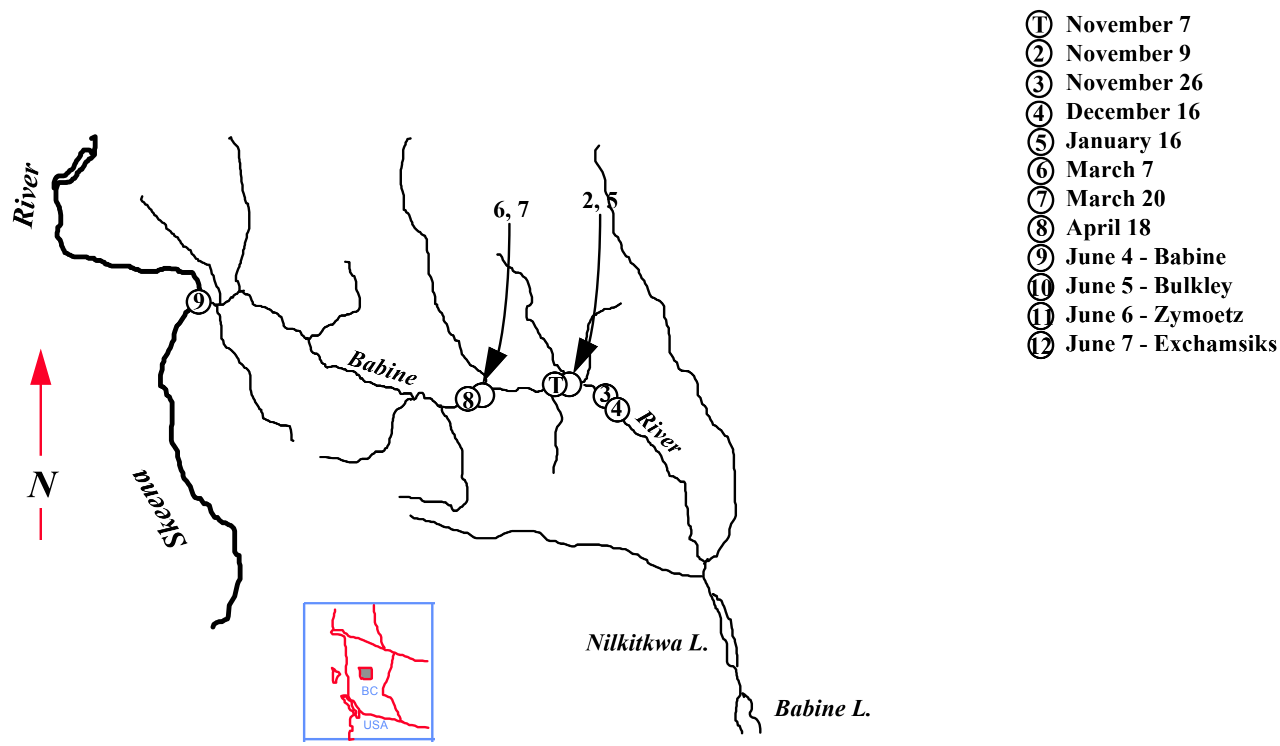
Appendix 23. Movements of radio tagged steelhead #23, 78 cm female. Ch. 9, code 37.



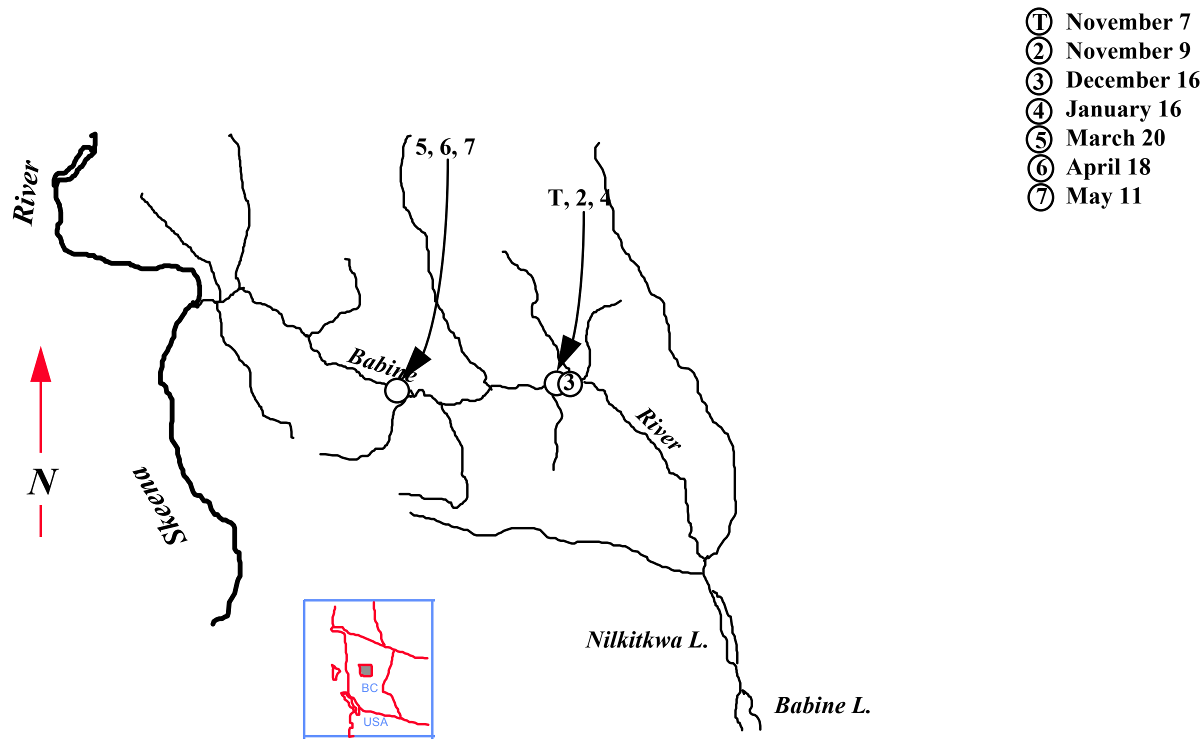
Appendix 24. Movements of radio tagged steelhead #24, 84 cm female. Ch. 9, code 65.



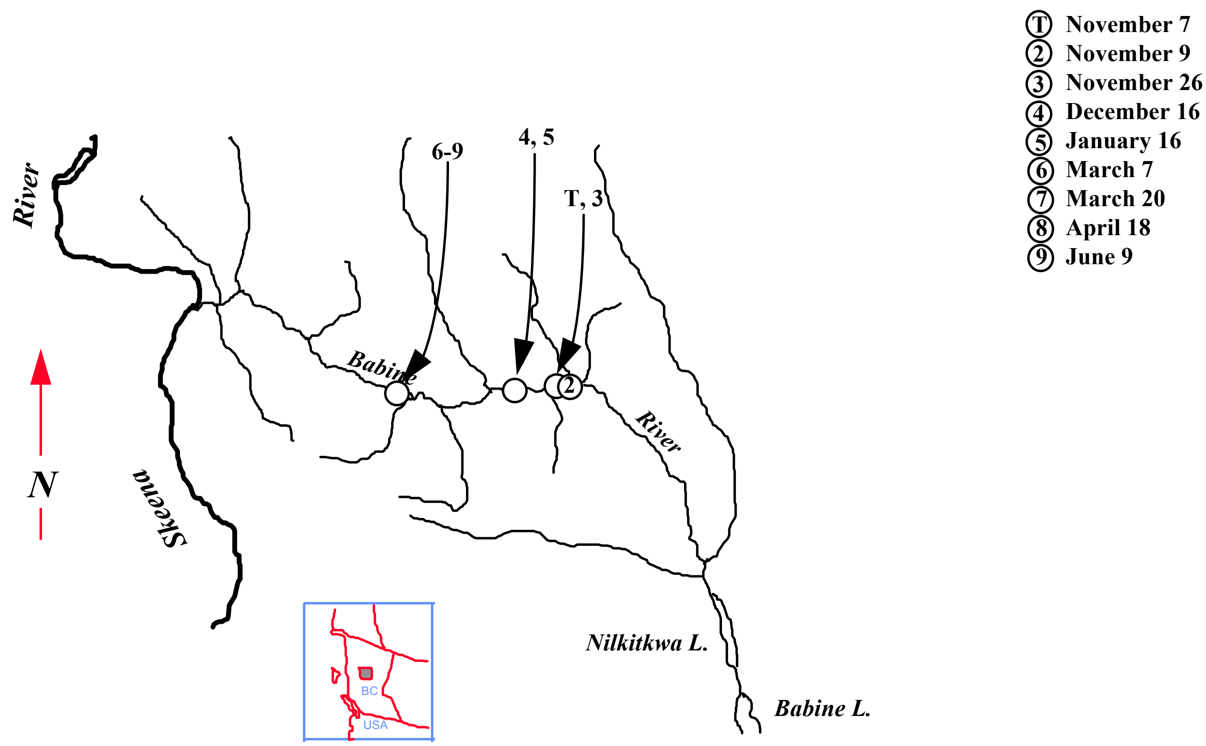
Appendix 25. Movements of radio tagged steelhead #25, 85 cm male. Ch. 9, code 61.



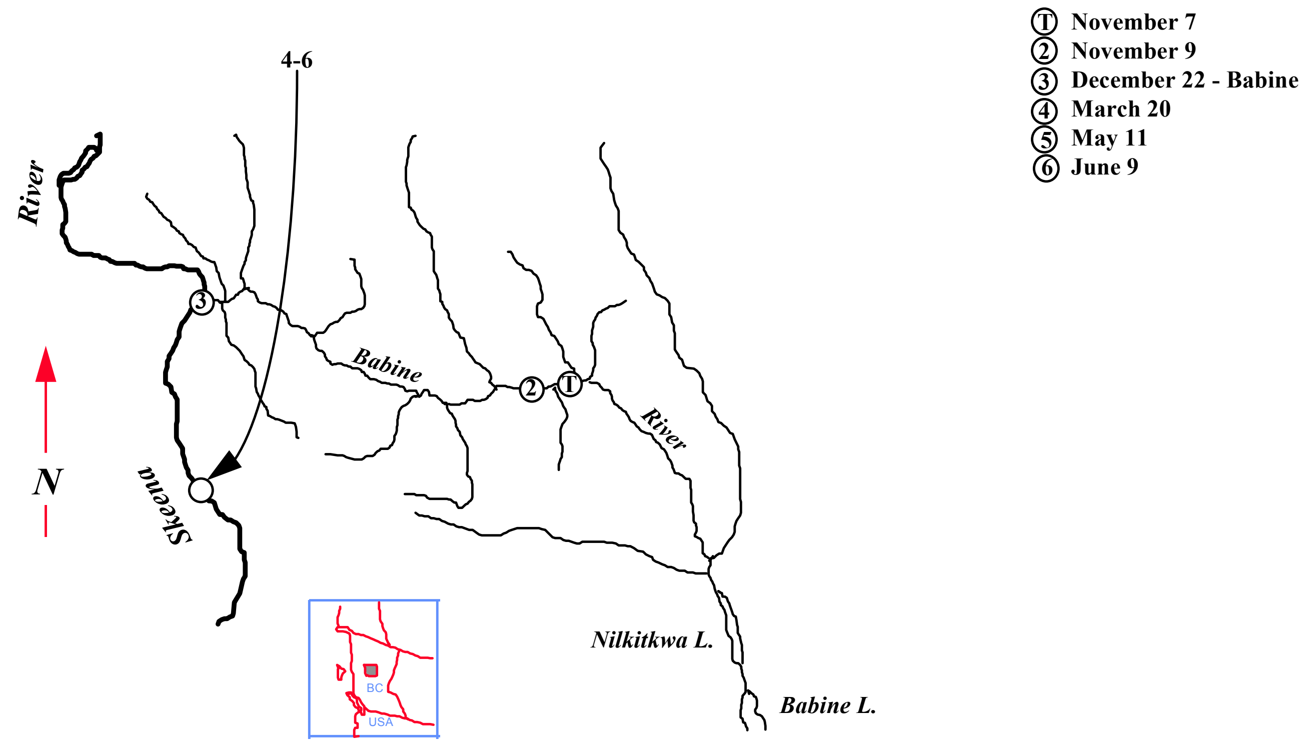
Appendix 26. Movements of radio tagged steelhead #26, 77 cm female. Ch. 9, code 47.



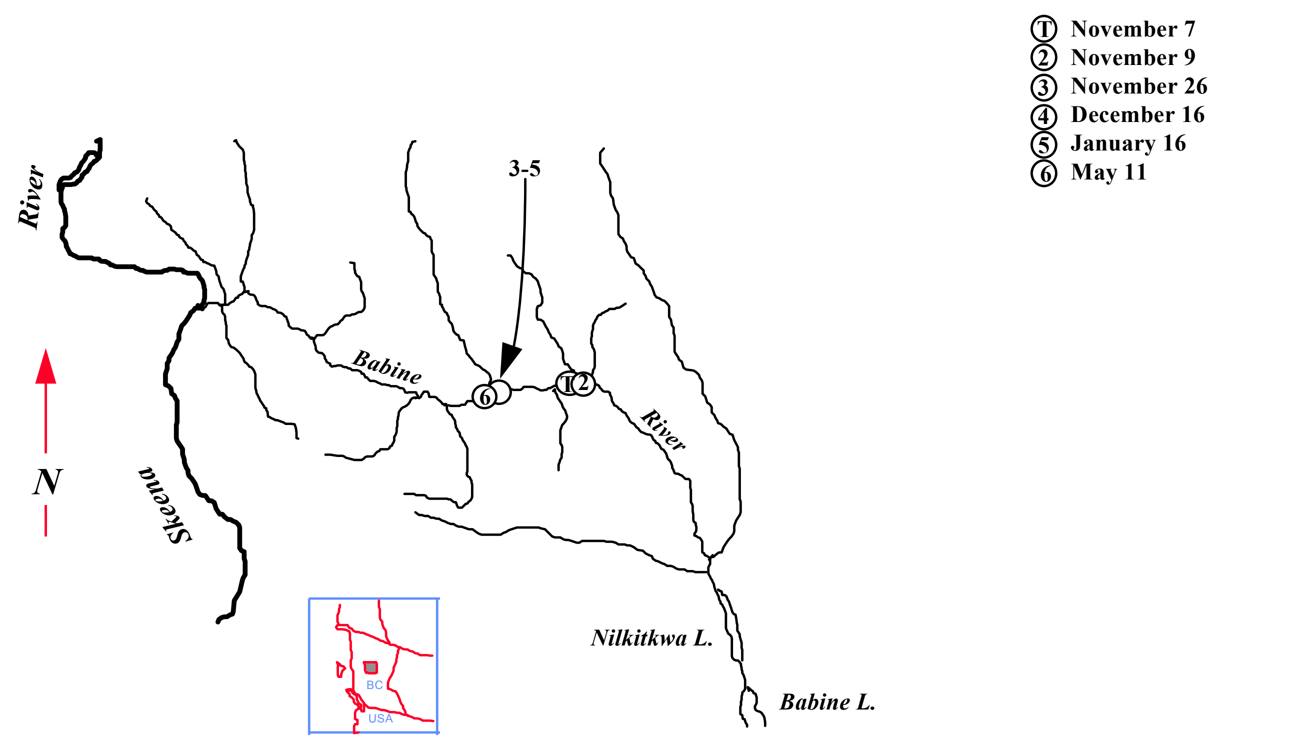
Appendix 27. Movements of radio tagged steelhead #27, 68 cm female. Ch. 8, code 42.



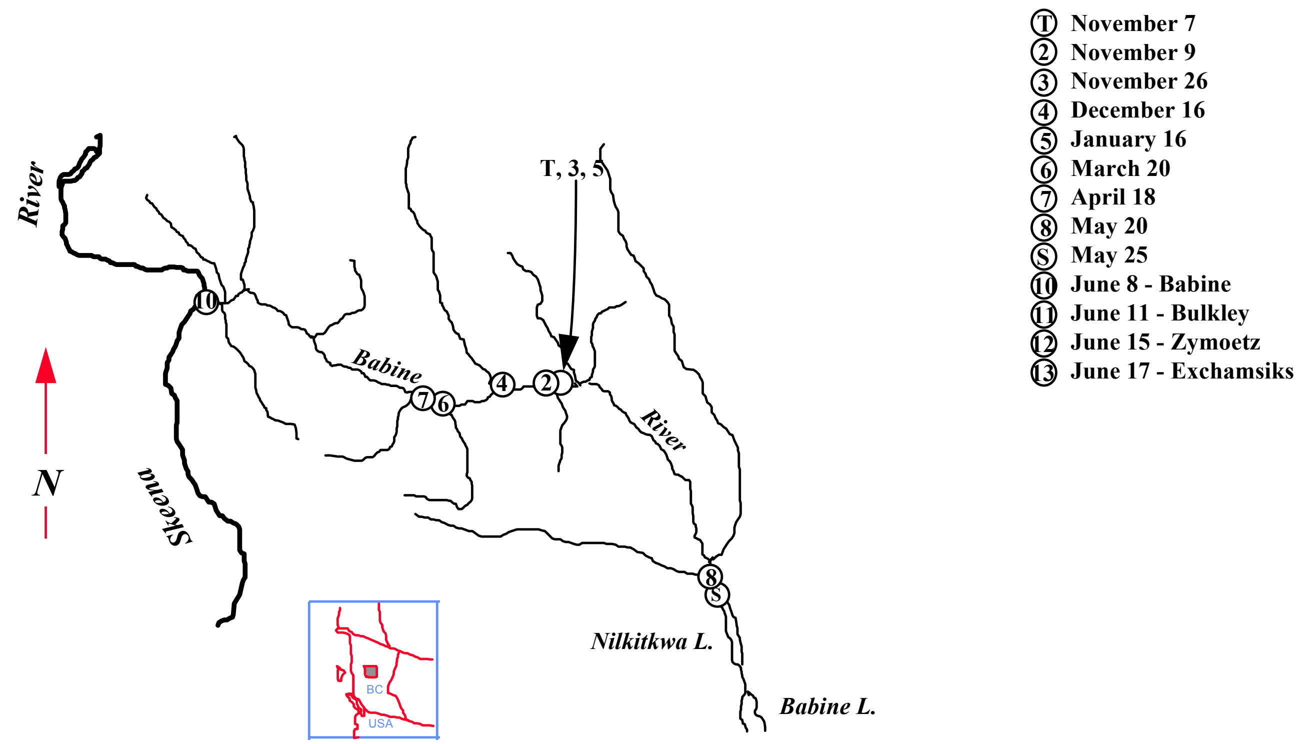
Appendix 28. Movements of radio tagged steelhead #28, 75 cm female. Ch. 8, code 32.



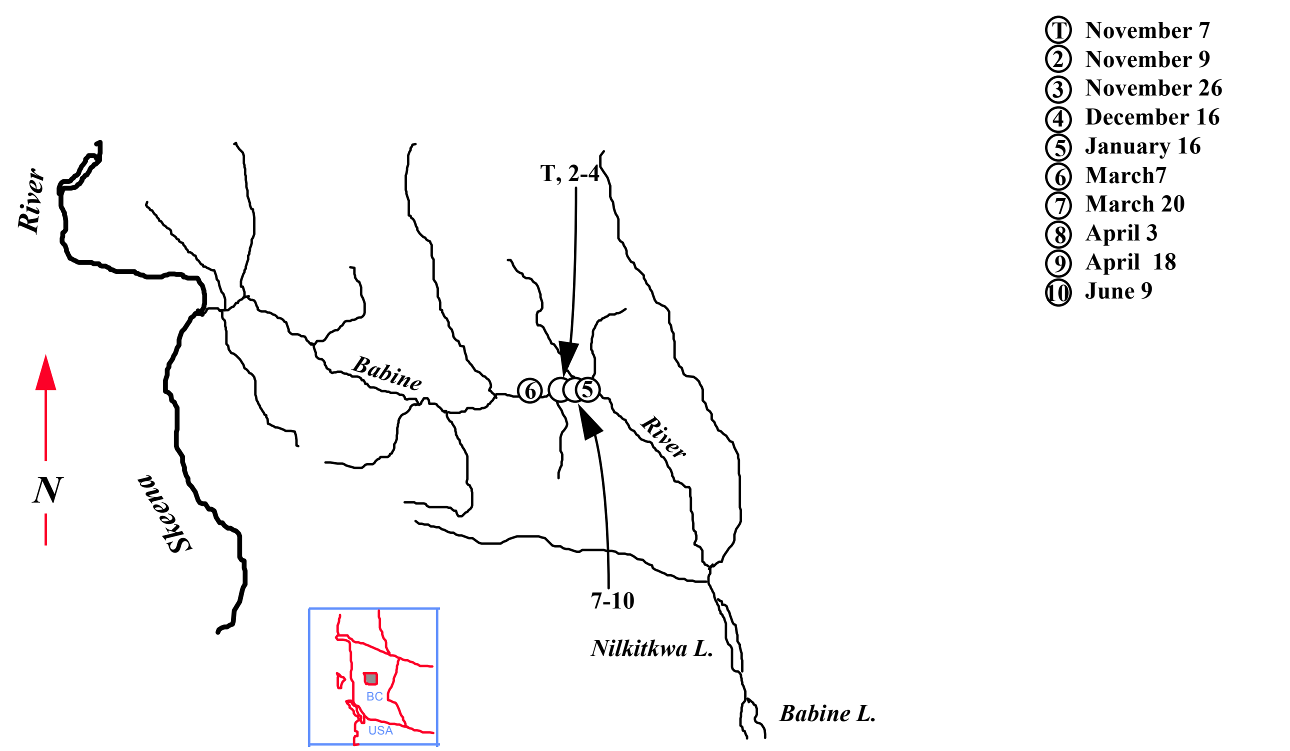
Appendix 29. Movements of radio tagged steelhead #29, 78 cm female. Ch. 8, code 27.



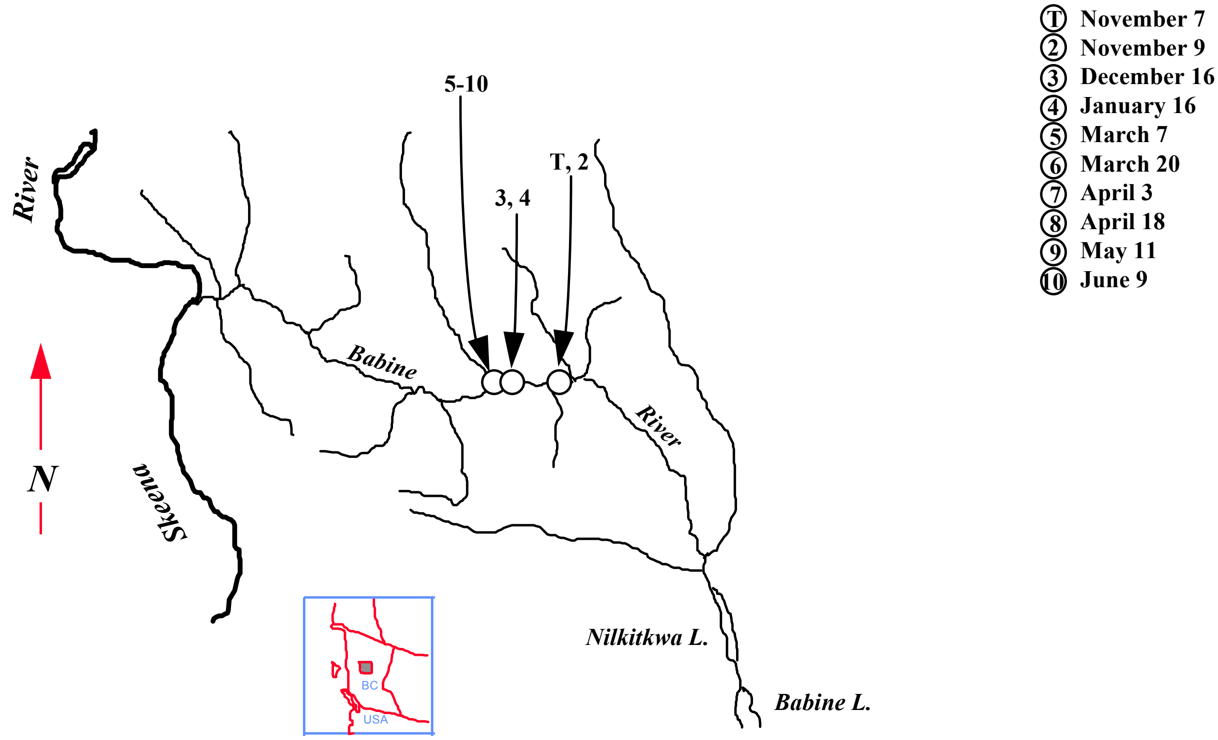
Appendix 30. Movements of radio tagged steelhead #30, 76 cm female. Ch. 8, code 78.



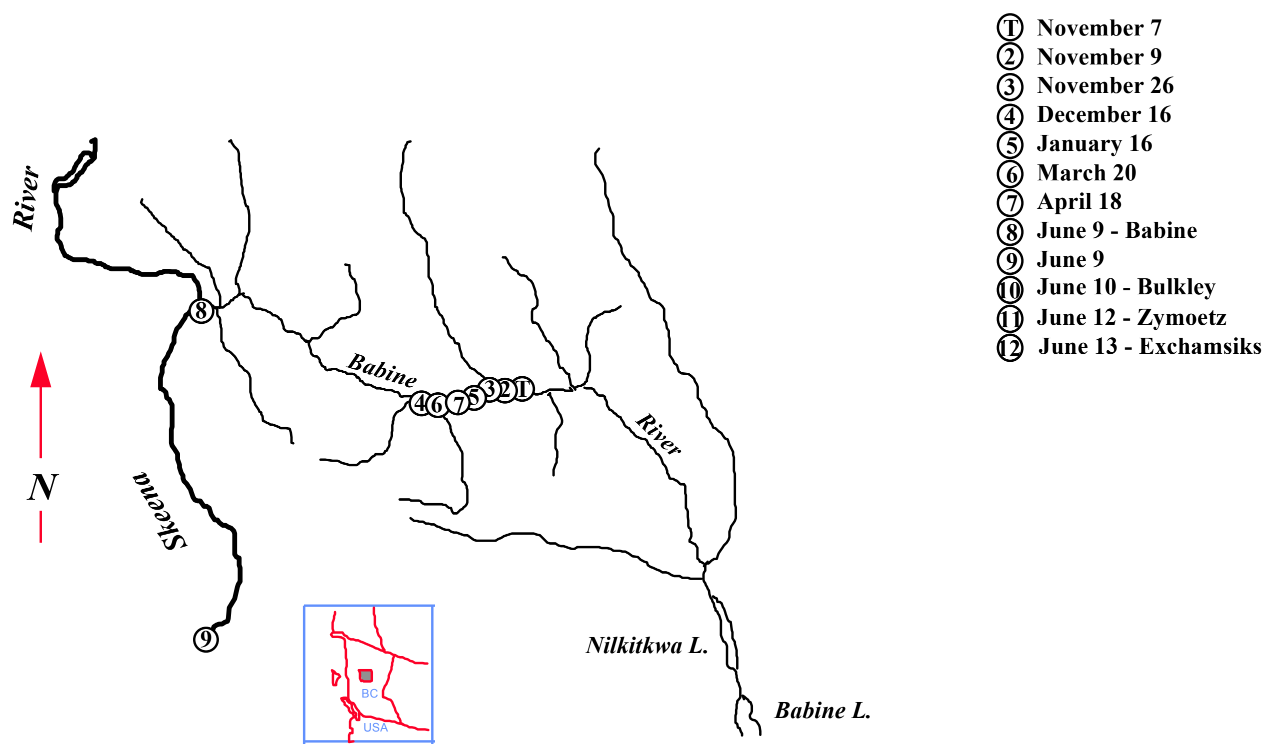
Appendix 31. Movements of radio tagged steelhead #31, 61 cm male. Ch. 8, code 37.



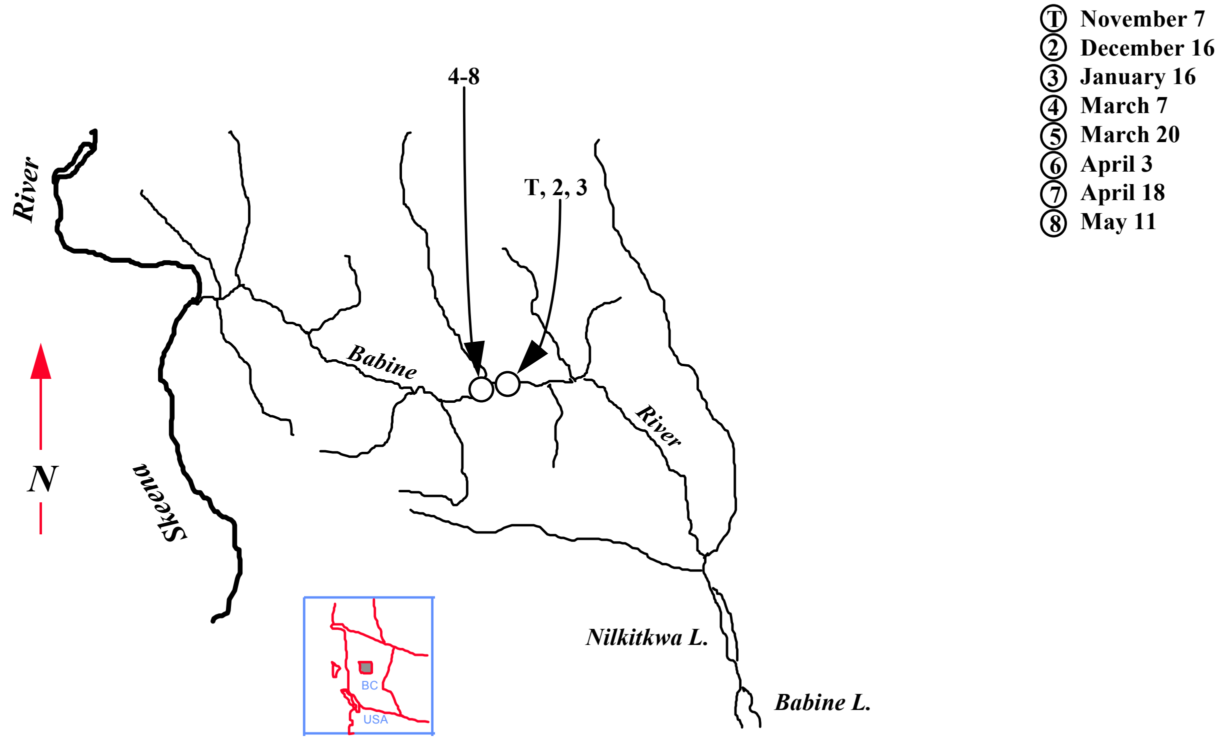
Appendix 32. Movements of radio tagged steelhead #32, 72 cm male. Ch. 8, code 40.



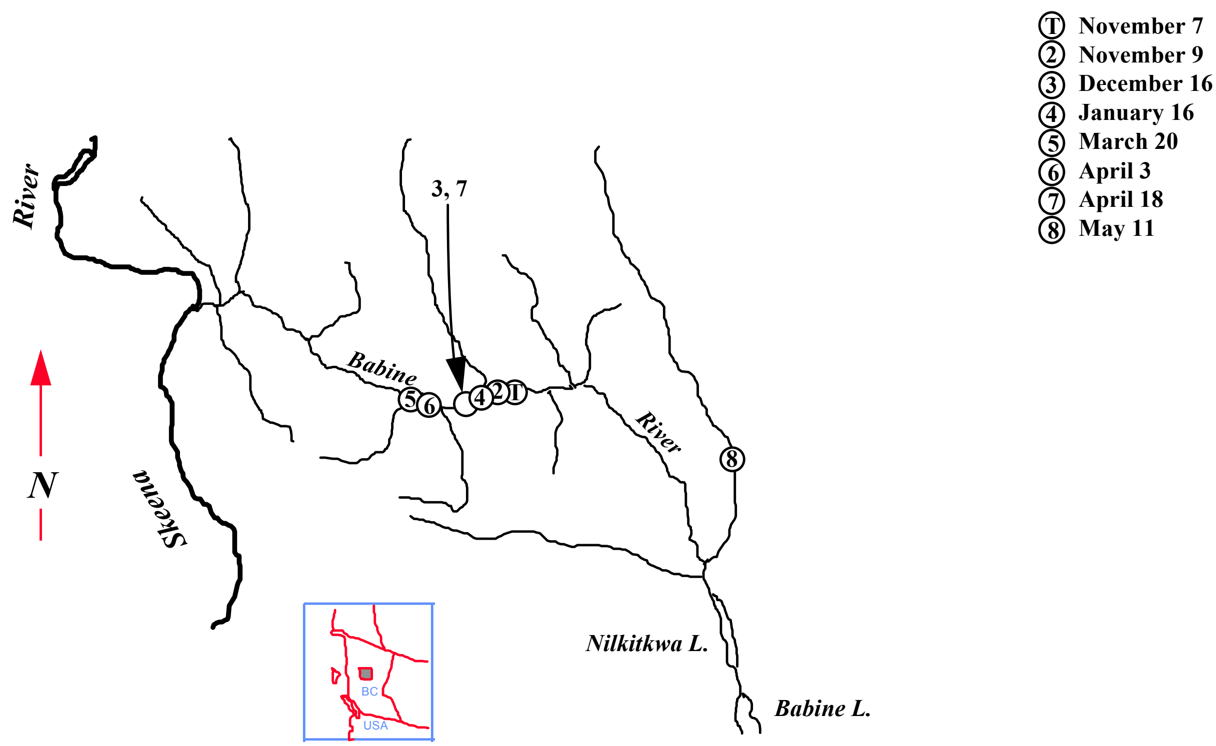
Appendix 33. Movements of radio tagged steelhead #33, 79 cm female. Ch. 8, code 66.



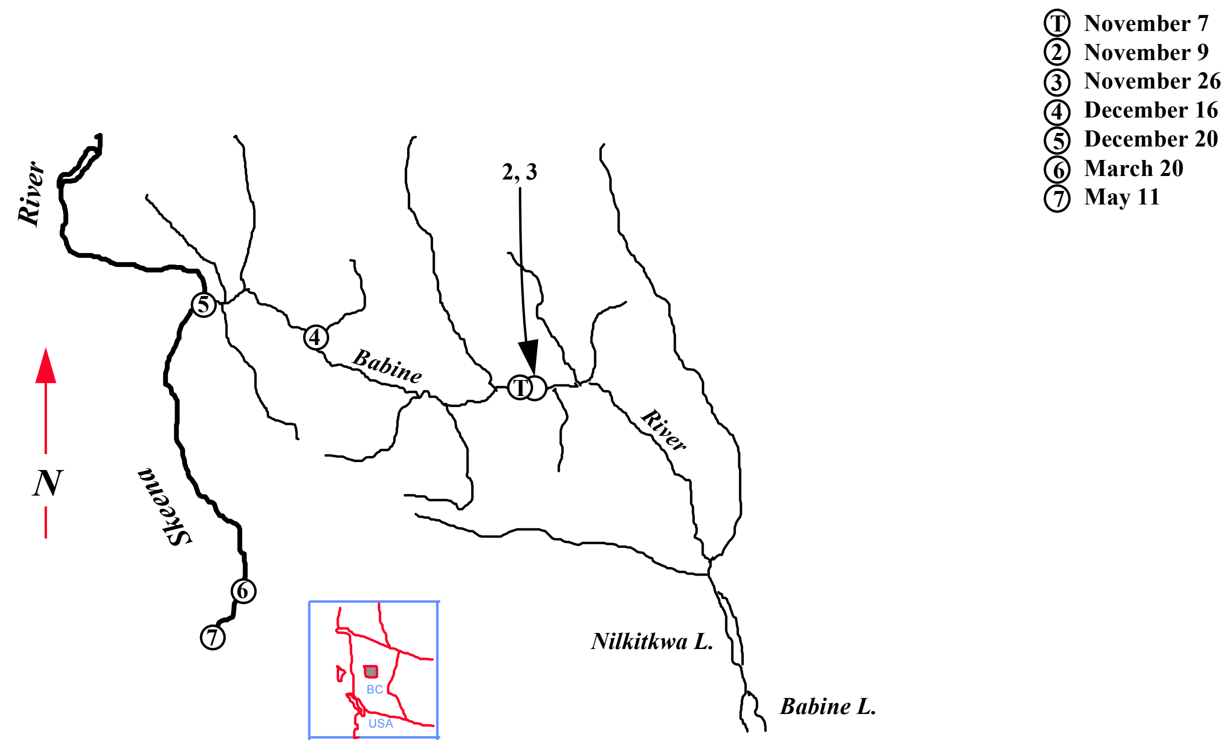
Appendix 34. Movements of radio tagged steelhead #34, 66 cm male. Ch. 9, code 64.



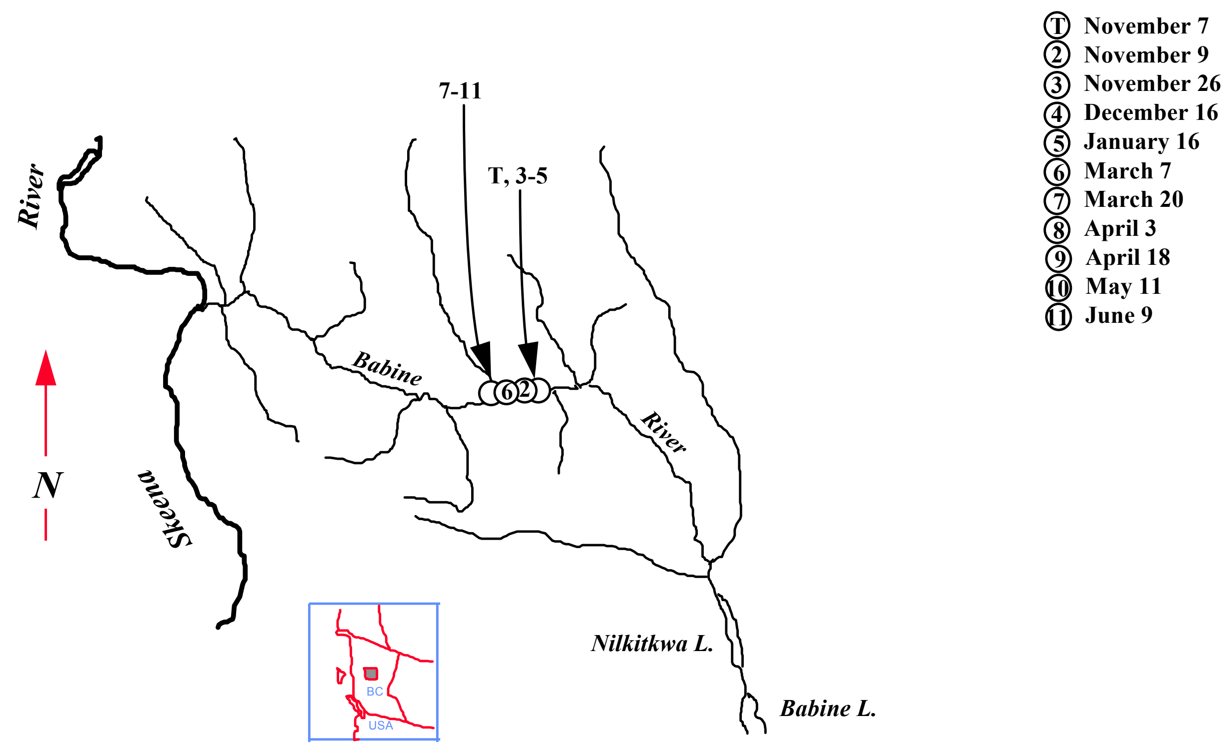
Appendix 35. Movements of radio tagged steelhead #35, 74 cm male. Ch. 9, code 29.



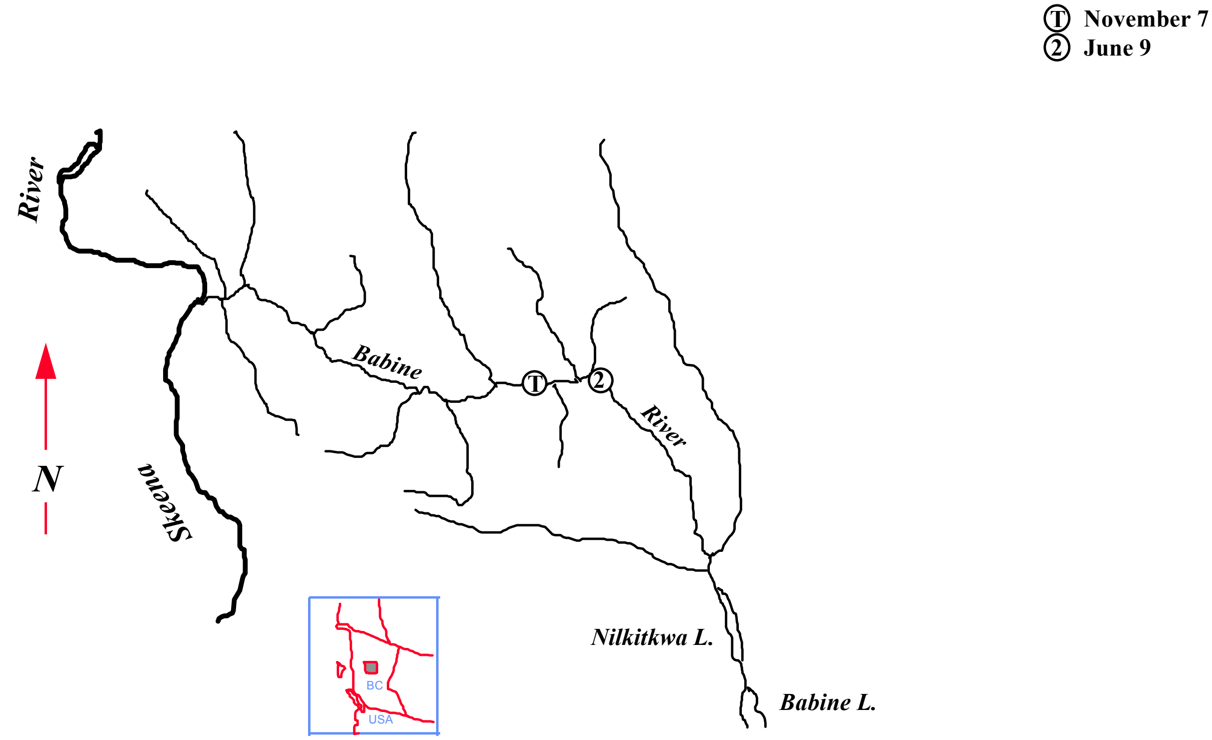
Appendix 36. Movements of radio tagged steelhead #36, 72 cm female. Ch. 9, code 62.



Appendix 37. Movements of radio tagged steelhead #37, 62 cm male. Ch. 9, code 36.



Appendix 38. Movements of radio tagged steelhead #38, 80 cm male. Ch. 9, code 75.



Appendix 39. Movements of radio tagged steelhead #39, 98 cm female. Ch. 9, code 56.