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Overwintering habitat of juvenile Dolly Varden (*Salvelinus malma*)(*W.*) in the Rat River, NT, as determined by radio telemetry.

Établissement par radiotélémesure de l'habitat d'hivernage des juvéniles de la Dolly Varden (*Salvelinus malma*)(*W.*) dans la rivière Rat, au Nunavut.

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ABSTRACT

In late-September 1995, a survey of the Rat River Dolly Varden (*Salvelinus malma*) stock was conducted by seining the various pools and riffle areas at the spawning and overwintering site on Fish Creek, a headwater tributary. Although this study determined the main overwintering location of the adult component of the population, it failed to find appreciable numbers of anadromous juvenile char (i.e., < 400 mm) at this site. In an attempt to determine where the juvenile component of the stock resides during the late-fall, and perhaps document whether additional overwintering habitat exists for this stock, sixteen anadromous juvenile char were radio tagged on August 26 and 27, 1996 near the mouth of the river, approximately 150 km downstream of the spawning/overwintering site. Four radio-tracking flights were made along the Rat River and the Fish Creek tributary on August 30, October 6, November 9, 1996 and March 20, 1997. Results of these tracking flights found that juvenile char use the same areas for overwintering as do the adult char, i.e., several deep pools just upstream of the aufeis field. However, unlike adults juvenile char do not move into these areas until well after freeze-up. Upon completing their upstream migration to the Fish Creek tributary by mid- to late-September juvenile char first occupy areas in Fish Creek within and below the main aufeis field. Final upstream movement into the overwintering pools above the main aufeis field likely does not occur until sometime in late November. It is speculated that this behaviour may be to avoid antagonistic interactions with the spawning adult char upstream. This region of the river may also provide better cover from predators and/or may provide an area of lower energy requirement prior to freeze-up.

RÉSUMÉ

Un relevé à la senne des divers seuils et mouilles des frayères et des aires d'hivernage de la Dolly Varden (*Salvelinus malma*) dans le ruisseau Fish, tributaire d'amont de la rivière Rat, a été effectué à la fin septembre 1995. Bien que l'on ait réussi à établir la principale aire d'hivernage des adultes, très peu de juvéniles anadromes (c.-à-d. < 400 mm) ont été trouvés à cet endroit. Afin d'établir où ceux-ci vivent à la fin de l'automne et peut-être de documenter s'il existe d'autres habitats d'hivernage de ce stock, seize juvéniles anadromes capturés près de l'embouchure de la rivière, à environ 150 km en aval des frayères et des aires d'hivernage ont été munis d'un radio-émetteur les 26 et 27 août 1996. Quatre survols de radio-repérage ont été faits le long de la rivière Rat et le ruisseau Fish, soit le 30 août, le 6 octobre et le 9 novembre 1996 et le 20 mars 1997. Les résultats ont révélé que les juvéniles passent l'hiver aux mêmes endroits que les adultes, soit plusieurs mouilles profondes situées juste en amont du champ de dômes de glace. Mais au contraire des adultes, les juvéniles ne s'y rendent que bien après la prise des glaces. Après avoir atteint le ruisseau Fish vers le milieu ou la fin de septembre, les juvéniles fréquentent des secteurs du principal champ de dômes de glace ou en aval de celui-ci. Il est probable qu'ils ne se remontent vers les mouilles d'hivernage situées en amont de ce champ qu'à la fin novembre. On se demande si ce comportement vise à éviter les interactions antagonistes avec les adultes reproducteurs en amont. Il se peut aussi que cette partie de la rivière offre une meilleure protection des prédateurs et/ou exige la dépense de moins d'énergie avant la prise des glaces.

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INTRODUCTION

The Rat River (Figure 1) is used by Dolly Varden (*Salvelinus malma*) for spawning, juvenile rearing and overwintering. Thermal springs in Fish Creek, a headwater tributary of the Rat River, maintain a stretch of unfrozen water throughout the winter. Anadromous char spawn in this area during the late-summer and then remain throughout the winter until break-up in late May. Studies on other neighboring char rivers with Dolly Varden populations have shown that, along with the freshwater juvenile life history stages and mature spawning component of the stock, these spring-fed areas are used for overwintering by both the anadromous adult non-spawning stage (i.e., >400mm) and the anadromous juvenile non-spawning stages (250-400mm) (Bain 1974; Glova and McCart 1974). In the Rat River however, a survey of the overwintering site on Fish Creek in late September 1995 found very few non-spawning anadromous juveniles (Figure 2) (Harwood and Sandstrom, unpublished data). Also, the maturity ratio of spawning to non-spawning char found at the overwintering site during this study contradicted that obtained by the summer fishery in the lower river and Mackenzie Delta (Fishery = 83% non-spawners to 17% spawners; Census = 33% non-spawners to 67% spawners).

These findings in the Rat River suggested that the anadromous juvenile life history stage may occupy other unsurveyed areas of the river in the fall. This component of stock may only be holding in these areas during this time and later move up to join the anadromous adults at the main overwintering site on Fish Creek. Conversely, these other areas may represent additional overwintering habitat that this stock can utilize throughout the winter. Regardless, it is important to document where this life history stage is during the period when the fall-seining survey is conducted so that it can be adequately censused and the areas where they are found protected if necessary.

In other north slope rivers where the majority of the lower river is shallow and freezes to the substrate, non-spawning char appear to be obligated to occupy the headwater spring sites where the only available overwintering habitat is located. However in the Rat River, deep areas in the lower reaches and in the adjoining channels in the Mackenzie Delta may not freeze to the bottom in the winter and could offer additional overwintering areas for this stock. The use of the lower river by non-spawning Dolly Varden has been documented in some Alaskan systems (DeCicco 1989). There is also some historical evidence that char from the Rat River may also exhibit this behaviour. Baker (1987), in a review of the literature on the Rat River char stock, reported that the tag returns in the early 1970's suggested some char from this system may overwinter in parts of Husky and Peel channels.

Questionnaires developed to solicit input on whether local people were aware of additional overwintering locations outside of Fish Creek were distributed, but failed to provide any further information on winter char distribution (Chetkiewicz, unpublished data). As a consequence, a project was designed using radio telemetry to determine the location of anadromous juvenile char during the fall and winter of 1996-97, and determine whether alternative location(s) and type(s) of overwintering habitat were used by this component of the stock in the Rat River. This report summarizes the results from this study.

MATERIAL AND METHODS

CAPTURE

The field camp was established on the Rat River at Destruction City (67° 44' 53.9": 135° 22' 59.8") on August 25, 1996 (Figure 1). Tagging commenced on August 26 and was completed by the evening of August 27. Initially, an attempt was made to capture all juvenile char using 60 cm diameter ace oval hoopnet with six meter wings as this was the least stressful and physically damaging method of capture. The hoopnet was installed on the evening of August 25 but had to be removed due to rising water levels on the afternoon of August 26. Experimental monofilament gillnets checked hourly were used to capture the remaining char. Char captured in the gillnets were quickly and carefully untangled or cut free of the net and placed in a large cooler of water for transportation back to camp. Only char that were not badly tangled in the gillnets were taken back to camp for tagging. All char that were captured using the hoopnet were tagged (n= 5). Once at the camp, char were held under observation for 10-15 minutes prior to tagging to ensure that there no adverse affects (e.g., bleeding) as a result of capture. Water in the holding tank was oxygenated using a battery powered pump and large airstone, and the water temperature was monitored throughout the tagging procedure to ensure it remained relatively constant. Water in the holding tank was periodically refreshed with water from the river during the post-operation recovery phase.

Of the twenty char tagged, four of these were greater than 410 millimetres and could have been small adult char (i.e., spawned previously). However, as tagging took place during late August it is likely that these were non-spawning char. In neighboring Dolly Varden systems, it has been observed that the migration of spawning char occurs during early to mid-March (Sandstrom, personal observation). As the behaviour of these larger individuals was not observed to vary from that of the juvenile char, they will be included in the discussion of juvenile movements.

TAGGING

Internal Tags

Char were lightly anaesthetized using approximately five millilitres of benzocaine solution (40 g benzocaine to one litre of undenatured ethanol) in 10 litres of water. Char were then measured, weighed and moved to a wooden holding trough for tagging. The fish were laid on their backs in the trough and secured upright by adjustable walls. The trough was inclined to permit the head and gills of the fish to remain in a reservoir of water throughout the procedure. Fresh water was added regularly to the reservoir and the opercula monitored to ensure the fish was properly ventilating throughout the procedure.

All surgical equipment used in the tagging and the radio tags were soaked in a commercial veterinary disinfectant and rinsed in distilled water prior to each surgery. Latex gloves were worn throughout the procedure. The area of tag insertion and the exit point for the antenna was swabbed with Betadine antiseptic solution and a small (1.5-2.5 cm) incision made ventrally into the body cavity approximately one centimetre anterior to the insertion point of the pelvic fins,

just off the dorsal midline, using a number 12 hooked scalpel blade. For larger fish (i.e., >425mm, n=1), sufficient space between the anus and the pelvic fins was available for the incision to be made in this location. A 25 cm 15 gauge stainless steel cannula (with head removed) was gently inserted along the length body cavity using care not to puncture any body organs. At the posterior end of the body cavity the cannula was then inserted into the muscle of the caudal peduncle, just under the skin, and pushed down the length of the peduncle until it exited near the flex point for the tail. The tag was inserted into the body cavity and the antennae threaded through the cannula. The cannula was then removed from the tail end leaving the tag and antennae in place. The incision was sutured (typically three to four square knot sutures) using a 3-0 braided polyglycolic acid suture (Dexon II) and a CE-4 19 mm curved cutting needle. A petroleum- based antibiotic, Baciguent, was applied to the incision site and the exit site of the antenna. The total operation took on average eight minutes to complete and no mortalities were recorded during tagging.

Tagged char were then moved to a recovery tank for approximately 45 minutes and their recovery closely monitored. Once tagged fish had recovered sufficiently (i.e., swam actively away when the tail was lightly tugged) and tags checked to ensure they were operating, the fish were transported back to the river in a cooler for release. All tagged char were released in a large calm back eddy just below a set of rapids (67° 45' 19.1"; 135° 23' 13.9") approximately 0.8 km above Destruction City and 0.3 km above subsistence fishermen's nets. Of the 20 char tagged during this project, none were caught by the subsistence fishery in the Rat River later that summer or fall, nor where any recaptures recorded in subsequent years.

External Tags

Externally tagged char were anaesthetized, measured and weighed as described above, then placed right side up in a wooden holding trough. Fresh oxygenated water was regularly added to the head and gills of the char and the opercula monitored throughout the tagging procedure to ensure the fish were properly ventilating. Insertion and exit points for the external tags were swabbed with betadine, and two 16 gauge 5.0 cm long stainless steel needles were inserted through the skin and pterygiophores at the base of the dorsal fin approximately 2.0 - 2.5 cm apart matching the spacing of the attachment wires on the tag. The nylon-coated attachment wires for the external tag were threaded through the needles and the needles withdrawn from the opposite side of the dorsal fin. A small 1 cm plastic backing disk was place on each wire and the tag secured in place by pinching a small brass bead on each attachment wire next to the backing plate. Baciguent (antibiotic) was applied to both insertion and exit points for the attachment wires and excess wire cut off approximately 0.5 cm from the brass bead. External tagging took approximately five minutes per tag to complete. Immediately after tagging the char were moved to an oxygenated recovery tank for up to 30 minutes. Once it had been determined that the char had fully recovered and the tag checked to ensure it was operating properly, the fish was released upstream of Destruction City at the same site as the internally tagged char.

TAGS

The radio receiver and radio tags used for this project were obtained from Advanced Telemetry Systems (ATS) of Isanti, Minnesota. Three different types of low frequency (48.000 to 49.000 mHz range) epoxy-encased radio transmitters with a whip antenna were used.

Fifteen radio tags (Model 10-18, 56 pulses per minute (ppm), 11.0 mm x 31.0 mm, 6.0 grams) were applied (Table 1) - five external and ten internal. All these tags were pre-programmed with the following duty cycle; 12 hours on - 12 hours off for seven days, off for 30 days, then 12 hours on - 12 hours off every day until the batteries expire. Tags were expected to function until mid- to late-summer 1997.

Five 70-day internal radio tags (Model 10-12, 56 ppm, 11.0 mm x 25.0 mm, 4.0 grams) were applied to five very small juvenile silver char (Table 1). These tags were pre-programmed with the following duty cycle; 12 hours on - 12 hours off for seven days, off for 30 days, then 12 hours on - 12 hours off every day until the batteries expired. These tags were expected to function until mid-winter 1997.

TRACKING

An ATS (Challenger 200 model) programmable scanning receiver was used to locate the tagged char both by boat and aircraft. All radio-tag frequencies were stored in the scanning receiver's memory and scanned at a rate of two seconds per frequency. Some preliminary tracking of the radio-tagged char was conducted by boat during two days of field work following initial tagging. A small 12.0 cm directional loop antenna mounted on a wooden paddle was used to find the approximate location of the fish around Destruction City using a boat. Radio-tracking flights were conducted along the Rat River drainage basin using a helicopter on August 30, October 6, November 9, 1996 and March 20, 1997 to determine the location of the radio-tagged char. Tracking altitude was between 150 m to 400 m and speeds between 50 and 90 knots depending on the ceiling and prevailing wind speed. A single large 1/4 wavelength loop antennae mounted under the nose of the helicopter cabin was used during the radio-tracking flights to determine the approximate locations from the air. In addition by hooking the large loop antennae and small paddle antenna (handheld inside the helicopter) to the receiver by a left/right/both-side switchbox permitted a more accurate determination of the location of some of the tagged char. Using the large long-range external loop antennae to determine the general location (± 0.5 km) of tagged char, and by switching to the small internal short-range directional antennae the specific location (± 50.0 m) could be ascertained. Because flying time was limited, the specific location of only a few char could be determined during each of the tracking flights. The general locations (± 0.5 km) of all tags located were marked on a map and the specific location (± 50.0 m) of a tagged char taken from the global positioning system onboard the helicopter. Areas where tagged char were found to be concentrated were circled several times to ensure all tagged char present were located.

RESULTS / DISCUSSION

Results of the four tracking flights are summarised in Table 1. Two of the 180-day radio tags (48:152 and 48:191) appeared to be faulty at the time of tagging with weak and sporadic signals and these tags probably malfunctioned shortly after the fish were released. In addition, three other tagged char were never located, either shortly after tagging using a boat, or later during any of the aerial tracking flights. Thus, it appears that as many as five tags may have malfunctioned during the course of the study. Eighty percent (10 of 15) of the long-duration tags (model # 10.18), and 70% (3 of 5) of the short-duration tags (model #10.12) were determined to be working over the operational duration of the respective tag.

Several of the tagged char dropped downstream upon being released, one (which did eventually make it to the overwintering site) at least as far as 15 kms, and several (n= 4) of the tagged char were still in the vicinity of the release site three days after tagging. These results suggest that the upstream migration of some of the char did appear to be temporarily halted by the tag and/or tagging procedure. However, as all of the tags that subsequently were found to be operating (n= 15 of 20) were heard at least once in the vicinity of the Fish Creek tributary, it appears there was little immediate mortality due to the tagging procedure and no long-lasting effects on behaviour.

The locations where tagged char were found during the November and March tracking flights are summarised in Figures 3 and 4. Results of the tracking flights indicated that the majority of juvenile char moved upstream and held (late fall - beginning of October) in the upper portions of the Rat River near the mouth of Fish Creek and in areas along the very lower reaches of Fish Creek in the area of the secondary aufeis field (Figure 3). During and after freeze-up juveniles became more concentrated as they moved upstream in early winter (late-October to early November). However, at this time of year the majority of juveniles are still within the mid- to lower-half of the main aufeis field (Figure 3). These areas could not be surveyed by seine net in 1995 given the prevalence of large rocks deposited within the main stream channel by a past landslide. The resident population of Arctic grayling (*Thymalles arcticus*) in the fall also heavily utilizes this region of the river (Sandstrom, personal observation). By early November Fish Creek is almost completely frozen over except for a few locations near areas of groundwater upwelling and the primary aufeis field is well developed. Sometime after mid-November, there is a final movement by the juveniles up to main pools just above the northern limit of the main aufeis field (Figure 4). All of the tagged char (excluding 48.091) located during the late winter tracking flight in March, 1997 were found in one of two pools (100 and 400 m) above the top of the aufeis field (Figure 5). A late-September seining survey of the pools above the aufeis field in 1995 determined that the main concentrations of adult spawning and non-spawning char were located in these two pools prior to freeze-up. These pools were also the traditional subsistence fishing sites during the late-fall (Johnny Charlie Sr, Fort McPherson Renewable Resource Committee, personal communication), and are two of the deepest and largest pools found above the main aufeis field on Fish Creek. It is assumed that these pools are likely the primary overwintering habitat for the anadromous spawning and non-spawning (resting) adult components of the Rat River char stock, and furthermore, appear to be the primary overwintering habitat for the anadromous juvenile component of the population.

One tagged char (48:091) was located in October in what seemed to be a shallow braided stretch of Fish Creek approximately six kilometres above the upstream limit of the aufeis field (Figure 3). As there was no further movement by this fish from this location over the winter, it was thought that this fish had perhaps died shortly after reaching the overwintering site. However, more recent work in the fall of 1997 revealed that this area is used for spawning by the stock and a large deep pool exists near the location where the tagged fish was located. It is possible that this fish had not died, but in fact had made use of this pool for overwintering. This fish was likely too small (384 mm) to be a current-year spawning fish; however, a few char of this size and smaller have been observed to mature in this system (Sandstrom, personal observation). The occurrence of spawning in this location suggests that there may also be an area of groundwater upwelling which would provide the necessary oxygenated water for char to make use of this upper area for overwintering. Further investigation would be required to confirm this area as either spawning or overwintering habitat.

The reason for the late or delayed movement of juvenile char into the overwintering pools above the aufeis fields is still uncertain; however, the most likely explanation is that this behaviour allows them to avoid antagonistic interactions with the physically larger adult component of the stock. In addition, this lower habitat may provide better protection from avian and mammalian predators afforded by presence of numerous large boulders and deep riffle areas within the stream course. Also, this boulder-strewn region of the river may represent an area of lower energy due to slower flows which may facilitate energy conservation for the juveniles as they wait for freeze-up.

CONCLUSIONS

In the Rat River the majority of juvenile char use the same areas for overwintering as do the spawning and non-spawning adult component of the stock. However, juvenile char appear to not move into these areas until well after the adults do and well after freeze-up. Upon completing their upstream migration sometime in mid- to late-September, juveniles first occupy areas of Fish Creek within and primarily below the main aufeis field. Final movement into the overwintering pools above the main aufeis field likely occurs sometime in late-November or early-December. Further results of this study suggest that additional overwintering habitat may exist six kilometres above the main overwintering area(s).

ACKNOWLEDGEMENTS

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McCart, P.J. 1980. A review of the systematics and ecology of Arctic Char, Salvelinus alpinus, in the western Arctic. Can. Tech. Rep. Fish. Aquat. Sci. 935: vii + 89 p.

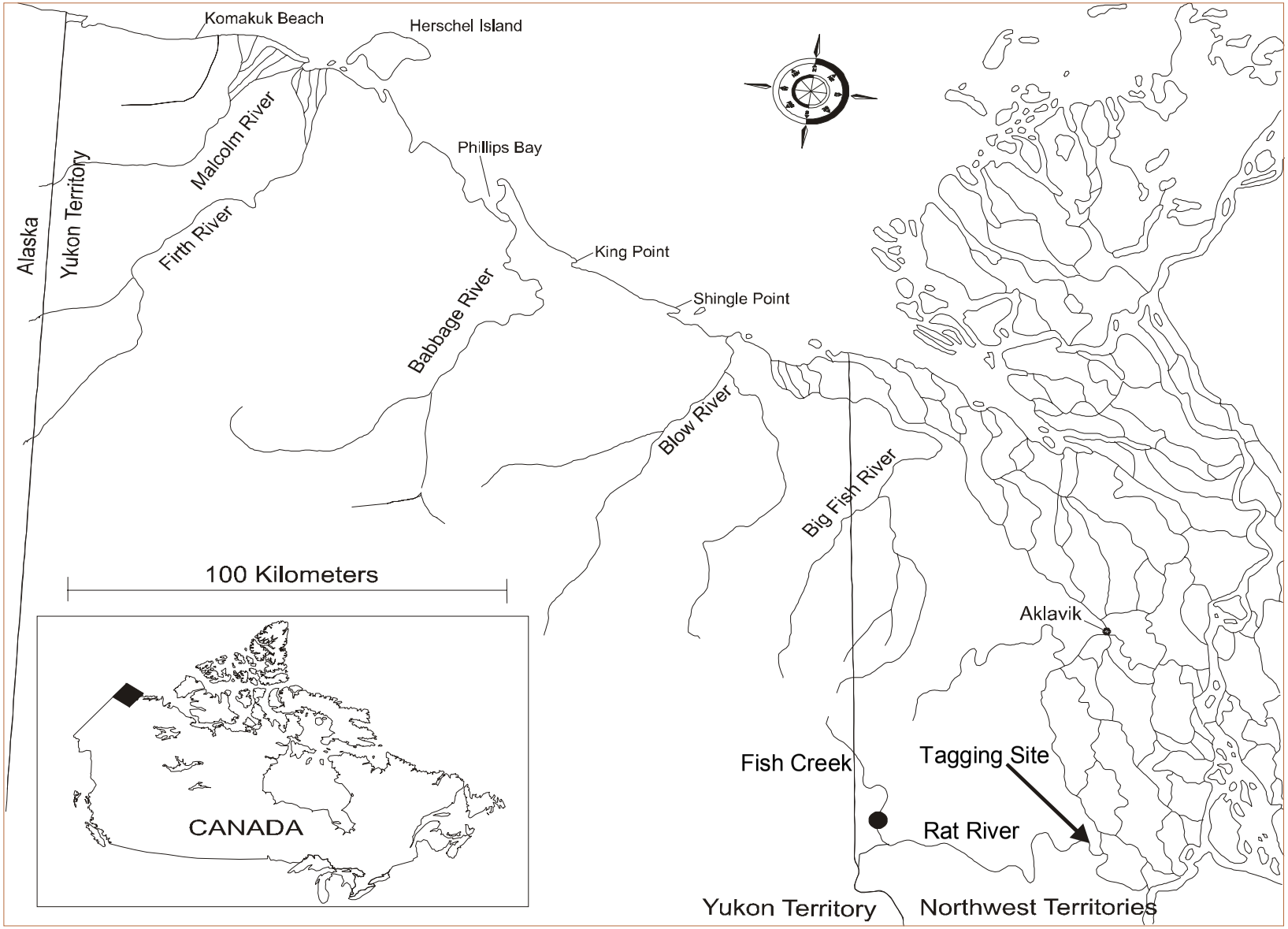

Figure 1. Map of the Yukon north slope and adjoining Mackenzie Delta. The (●) symbol denotes the only known spawning and overwintering sites for the Rat River stock on Fish Creek. Also indicated is the 1995 location of the tagging site near the mouth of the Rat River.

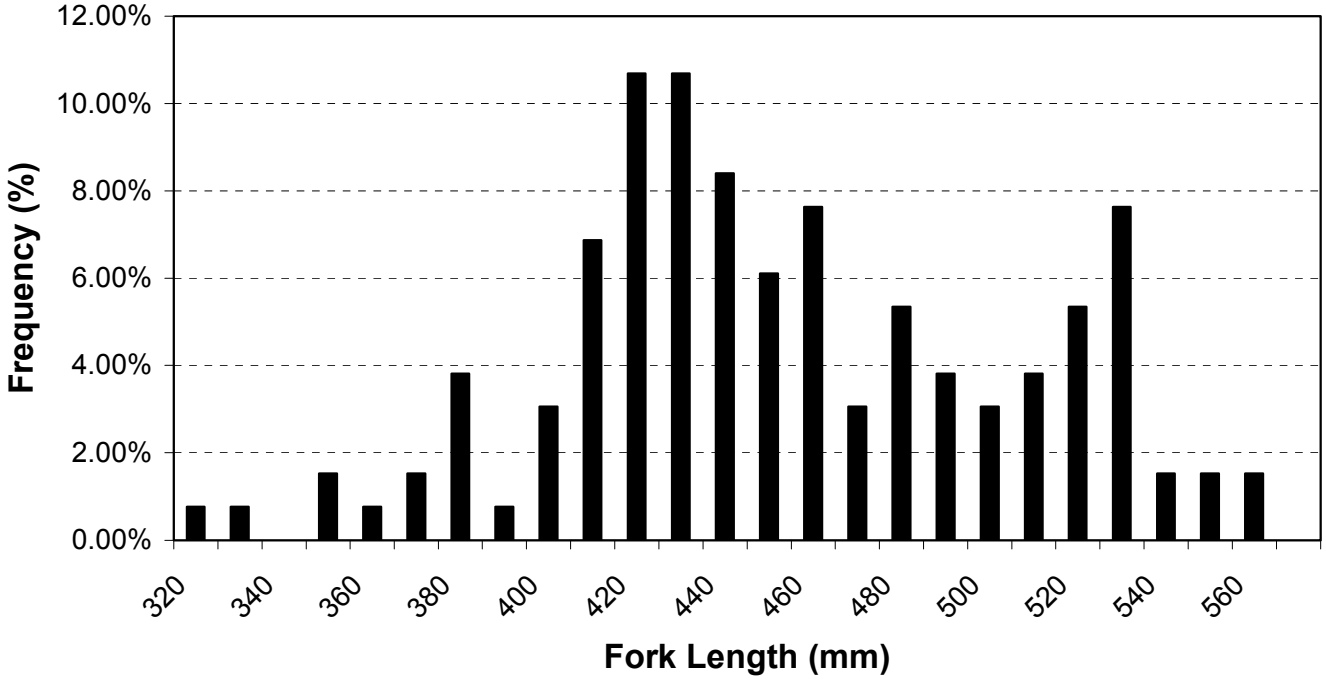

Figure 2. Length distribution of non-spawning Dolly Varden (*Salvelinus malma*) caught by seine net at the spawning and overwintering site on Fish Creek, Rat River Drainage in the fall of 1995. Few juvenile char (<400 mm) were caught during the project which lead to the speculation that this component of the stock may use other areas within or outside this system for overwintering.

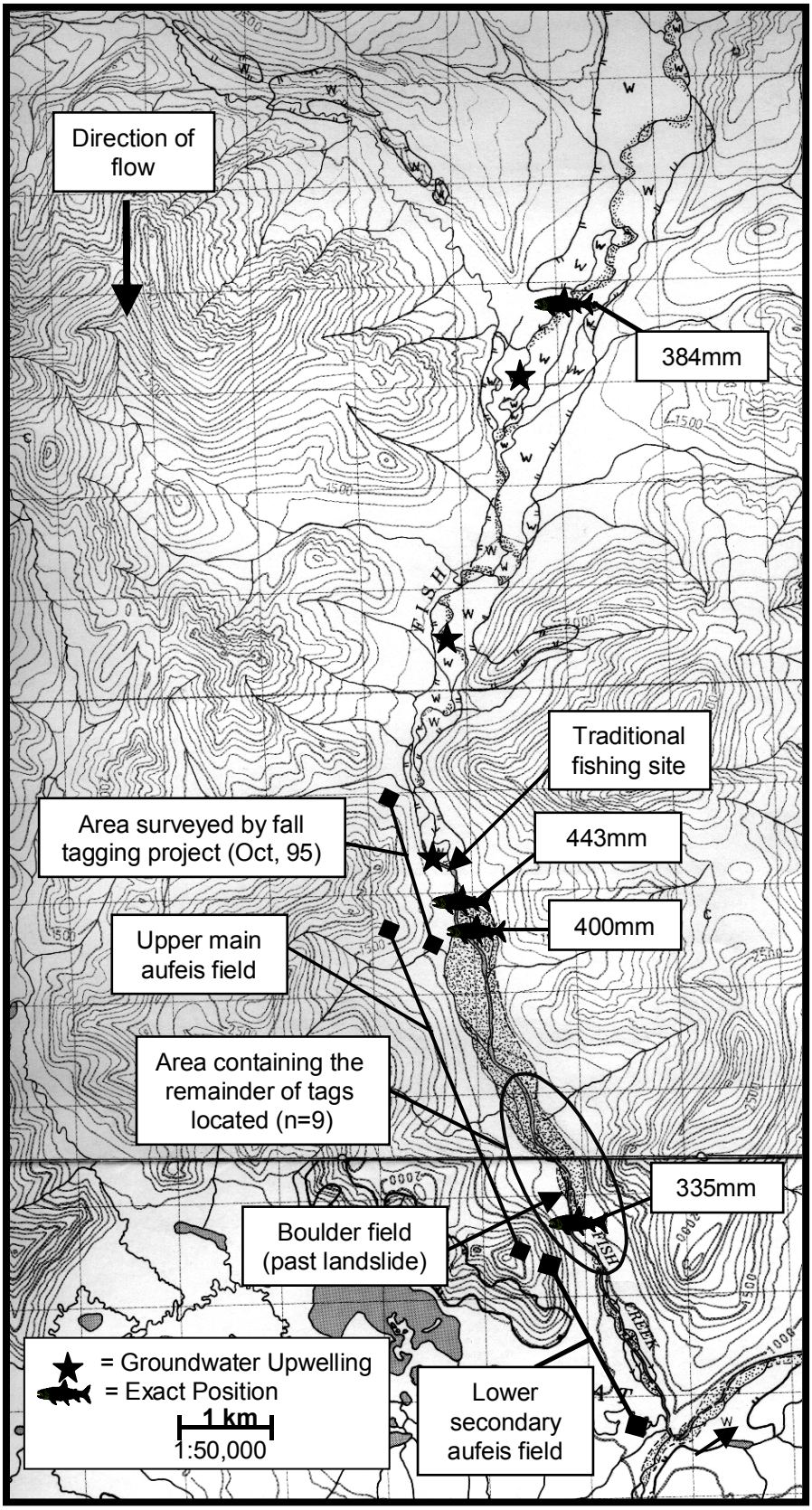

Figure 3. Map of Fish Creek showing the location of the radio-tagged char on November 9, 1996. Measurements refer to the length of fish.

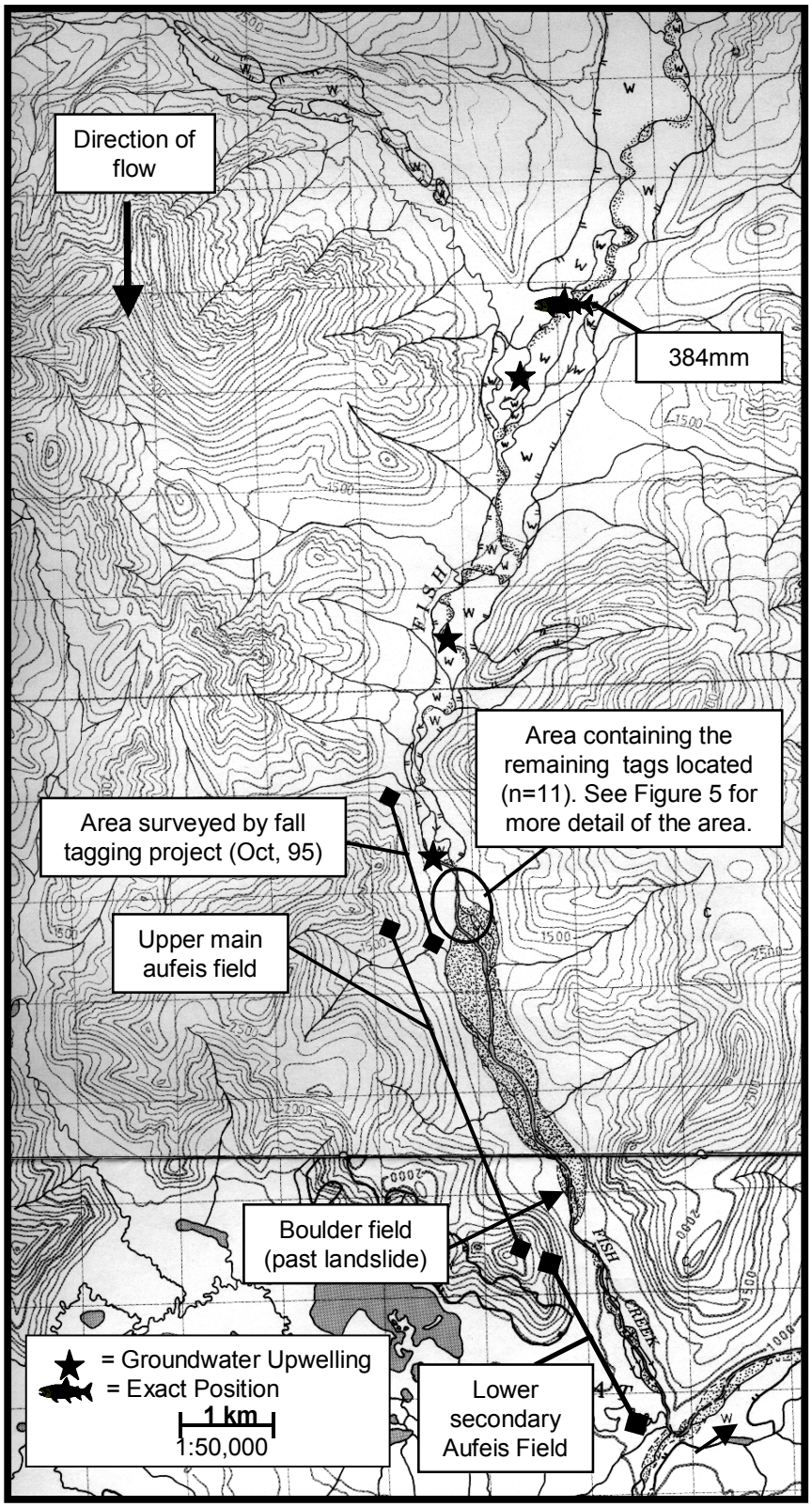

Figure 4. Map of Fish Creek showing the location of the radio-tagged char on March 19, 1997. See Figure 5 for a detailed map of the overwintering pools where most of the char were found.

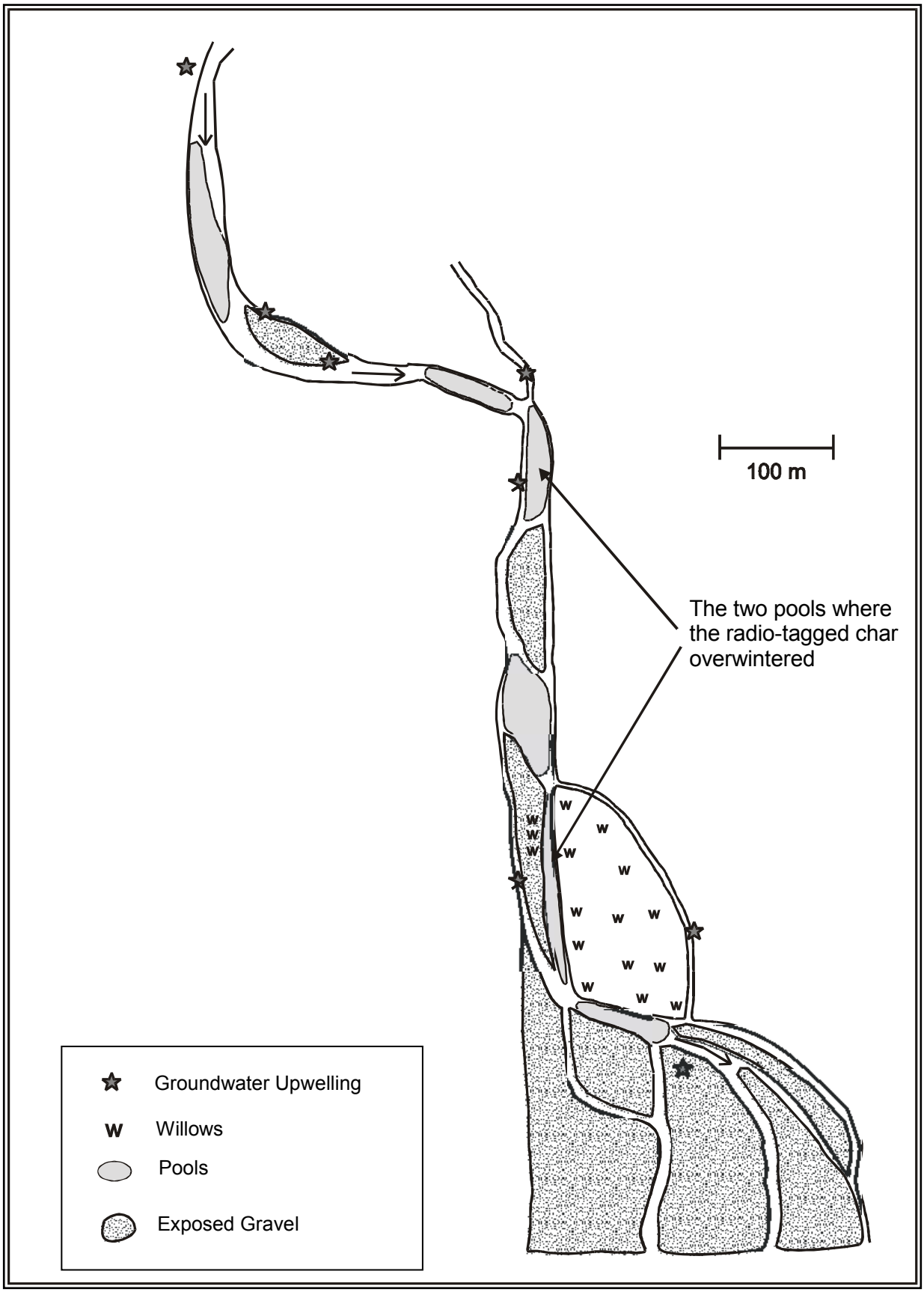

Figure 5. Location of main pools above the top of the primary gravel/aufeis field on Fish Creek, Rat River, October.

Table 1. Specifications of the radio-tags used and the Dolly Varden (*Salvelinus malma*) tagged with them near the mouth of the Rat River, NT in August 1995. In addition, results of telemetry flights are also reported as to whether a particular char was located (X) or not during the tracking flight.

	Tag		Tag	Tag	Date	Capture	Fork	Round	Tracking Flight (X = located)			
Tag Freq.	**Model #**	**Tag Wt**	**Application**	**Duration**	**Tagged**	**Method**	**Lth.**	**Wt.**	**Aug. 96**	**Oct. 96**	**Nov. 96**	**Mar. 96**
48.012	10-18	6	Internal	180	26/08/96	Gillnet	335			X	X	X
48.032	10-18	6	Internal	180	26/08/96	Gillnet	400		X	X	X	X
48.051	10-18	6	Internal	180	26/08/96	Gillnet	405					
48.071	10-18	6	Internal	180	26/08/96	Gillnet	335		X	X	X	X
48.091	10-18	6	Internal	180	27/08/96	Gillnet	384	1300	X	X	X	X
48.112	10-18	6	Internal	180	26/08/96	Gillnet	400		X	X		X
48.131	10-18	6	Internal	180	27/08/96	Gillnet	443		X	X	X	X
48.152	10-18	6	Internal	180	27/08/96	Gillnet	380	1250		*Probable Tag Malfunction*		
48.172	10-18	6	Internal	180	26/08/96	Gillnet	405		X	X	X	X
48.191	10-18	6	Internal	180	27/08/96	Gillnet	415			*Probable Tag Malfunction*		
48.212	10-18	6-8	External	180	27/08/96	Gillnet	435	2000	X	X	X	X
48.231	10-18	6-8	External	180	27/08/96	Gillnet	418	1900	X	X		X
48.252	10-18	6-8	External	180	27/08/96	Gillnet	390	1550	X	X	X	X
48.271	10-18	6-8	External	180	27/08/96	Gillnet	400	1400	X	X	X	X
48.291	10-18	6-8	External	180	27/08/96	Gillnet	403	1600		X	X	X
48.311	10 -12	4	Internal	70	26/08/96	Hoopnet	310					
48.332	10 -12	4	Internal	70	26/08/96	Hoopnet	298		X	X	X	
48.352	10 -12	4	Internal	70	26/08/96	Hoopnet	305					
48.372	10 -12	4	Internal	70	26/08/96	Hoopnet	315		X	X	X	
48.392	10 -12	4	Internal	70	26/08/96	Hoopnet	298		X	X	X	