BC hydro
FOR GENERATIONS

Report Title: *Peace River Fisheries Investigation - Peace River and Pine River Radio Telemetry Study 2007*
Project: Peace River Site C Hydro Project
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Prepared for: BC Hydro

NOTE TO READER:

This is a report on a study commissioned toward the development of engineering, environmental and technical work conducted to further define the potential Site C project.

For environmental studies, the focus is on the development of an environmental and socio-economic baseline around the area of the potential Site C Project. Baseline studies are generally a survey of existing conditions within a project study area.

This report and other information may be used for future planning work or an environmental assessment or regulatory applications related to the potential Site C Project.

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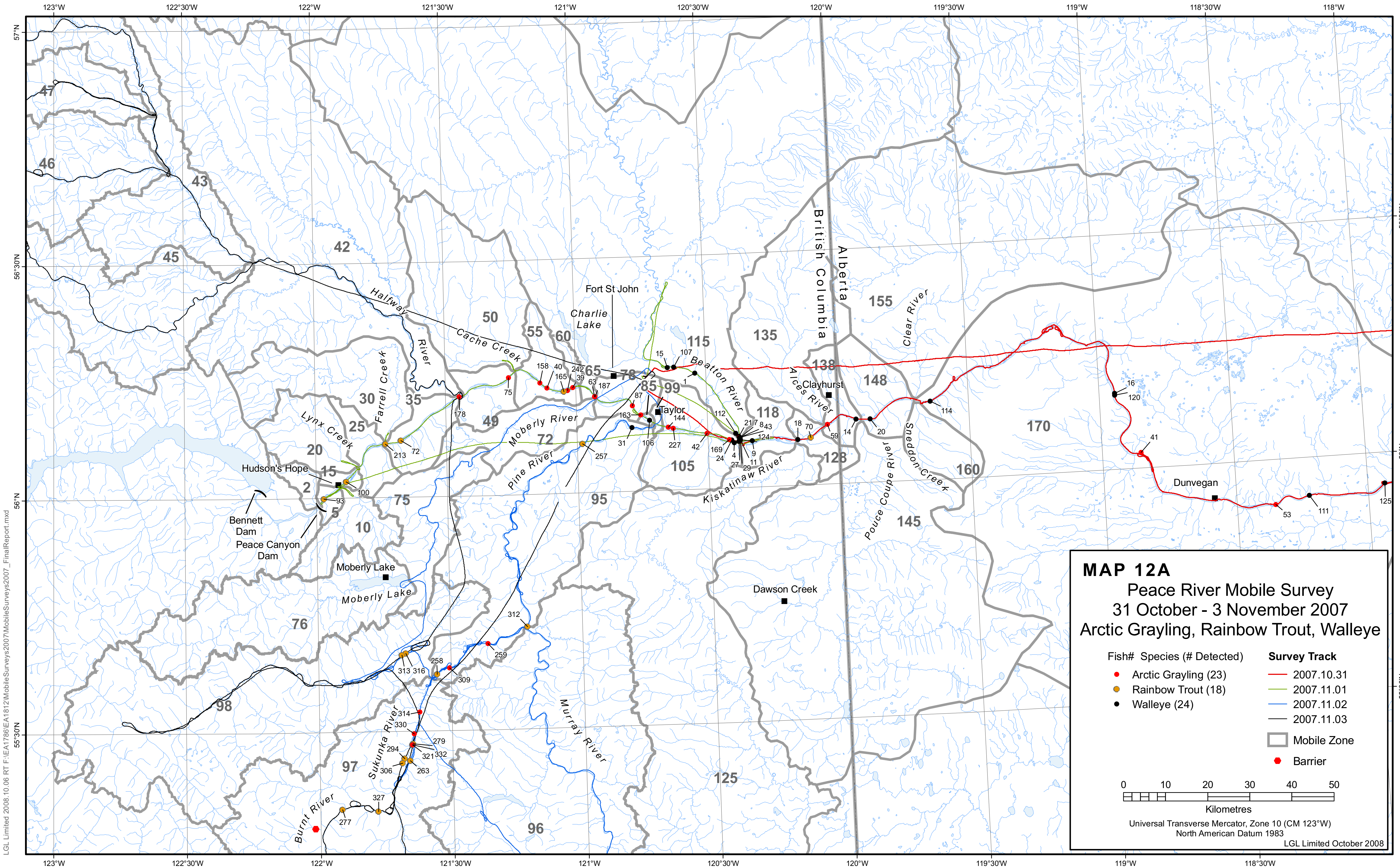
Second Track, 31 October-3 November (Map 12)

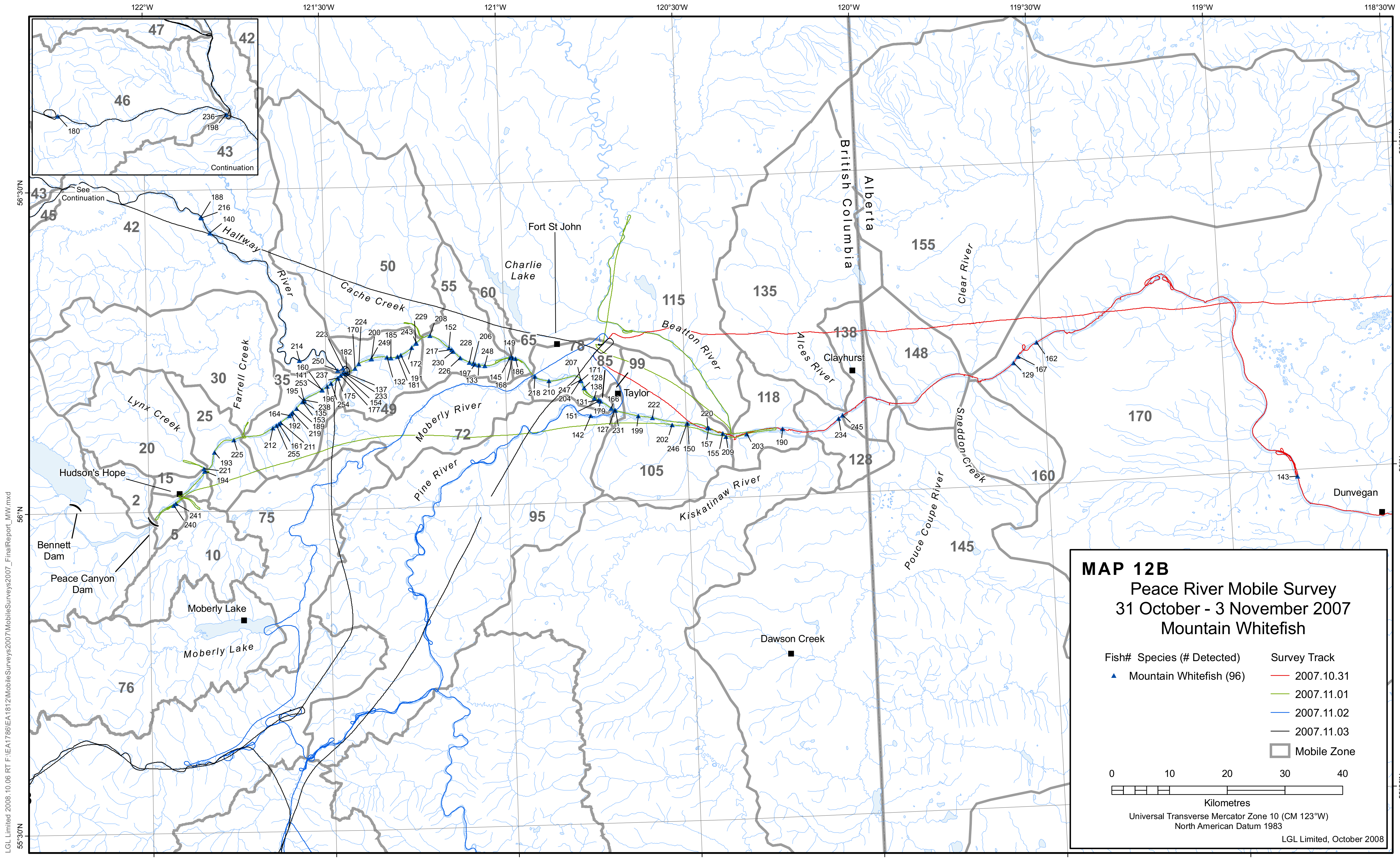
The distribution of bull trout in the final track of 2007 is much the same as in the previous track, with only one fish (2%) detected in the Peace River mainstem (in the same location as previously) and all others in the Pine River drainage distributed similarly to that described in the first October track.

Walleye detections were down considerably in the final track, with only 24 fish detected in all. Of these, one was in the Peace River mainstem near the mouth of the Pine River and one in the Pine River approximately 5 km from the mouth; the rest were distributed as follows: 13% in the Beatton River, 37% in the Peace River mainstem downstream of the Beatton River with several fish well into Alberta, and 42% at the Beatton River mouth.

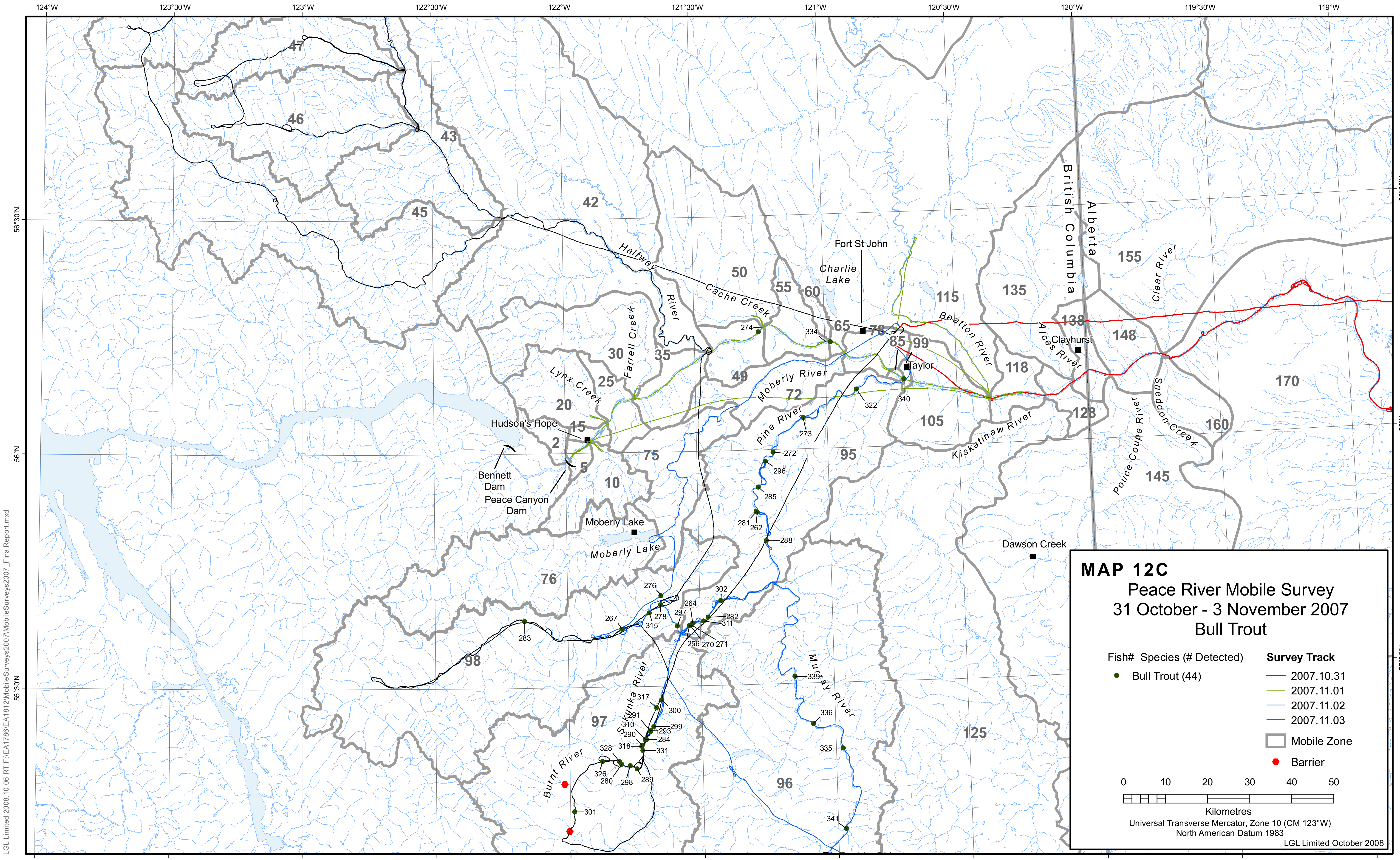
Although the number of detections of Arctic grayling, rainbow trout and mountain whitefish was down from that of earlier surveys (due to tag exhaustion), the distributions of these species in the final track are reasonably similar to those of previous surveys. In fact, in the final track, the distribution of detections of releases in both the Peace River mainstem and Pine River system is similar to that of the late March track, and probably represents the winter distribution of these populations.



Map 12a: Mobile survey for Arctic grayling, rainbow trout and walleye (October 31-November 3, 2007).



Map 12b: Mobile survey for mountain whitefish (October 31-November 3, 2007).



Map 12c: Mobile survey for bull trout (October 31-November 3, 2007).

Assessment of Overall Detections (Mobile Tracking)

From the detections shown on Maps 1-12 for the period March to October, the movements for these species can be broadly summarized as follows. Overall, the movements of mountain whitefish and rainbow trout were minor (i.e., frequently <10 km), those of Arctic grayling were slightly greater than those of mountain whitefish and rainbow trout, whereas those of walleye and bull trout were extensive with some individuals of both species moving long distances within and between the Peace River mainstem and major tributaries.

From March to October, mountain whitefish were mainly detected in the Peace River mainstem from Peace Canyon Dam to Dunvegan, Alberta. The most mountain whitefish ever detected in the tributaries occurred in October when 11 fish (12% of those detected) were observed in the Halfway and Pine rivers. Throughout fall, a few fish were detected in the lower and upper reaches of the Halfway River and in the lower Pine River, with a slight increase in their numbers in these areas between August and October, the period when they are likely to be spawning.

Rainbow trout released in the Peace River mainstem were seldom detected anywhere else, with only a single fish detected in a tributary. This fish was detected in Maurice Creek in spring 2007. Their distribution was mainly focused between the Peace Canyon Dam and Cache Creek. Similarly, rainbow trout released in the Pine River drainage showed relatively little movement generally, with the exception of some movement from the Sukunka River to the Burnt River beginning in June, and then returning later in the season. There is no evidence of these fish exiting the Pine River drainage.

Among the Arctic grayling released in the Peace River mainstem, 18% were detected in the Moberly River and only one fish (3%) in the Beatton River during spring (April/May), but otherwise all detections for these fish were in the Peace River mainstem, mainly between Cache Creek and the Beatton River. Examples of representative movement of these fish between the Peace River mainstem and the Moberly River, indicative of the spawning migration, are shown in Figures 24 and 25. Neither of these fish was detected in the Moberly River in the aerial surveys in 2006. Fish *Tag # 242* was released on 26 June 2006 so would not be expected to have moved into the Moberly River in that year. However, the migration of fish *Tag # 63* into the Moberly River in 2006, if it occurred, could have been missed as spring was earlier in that year and the period between tracking intervals at the start of the season was greater than that deployed in 2007. This fish was detected at the Moberly River mouth fixed-station between 10 April and 21 May in 2006, so it is likely that it migrated up the Moberly River and back out during that period and was missed in the spring aerial surveys.

In contrast to the Peace River mainstem population, Arctic grayling released in the Pine River watershed show no evidence of a spring migration into tributary streams, and probably spawn within the general area in which they were released.

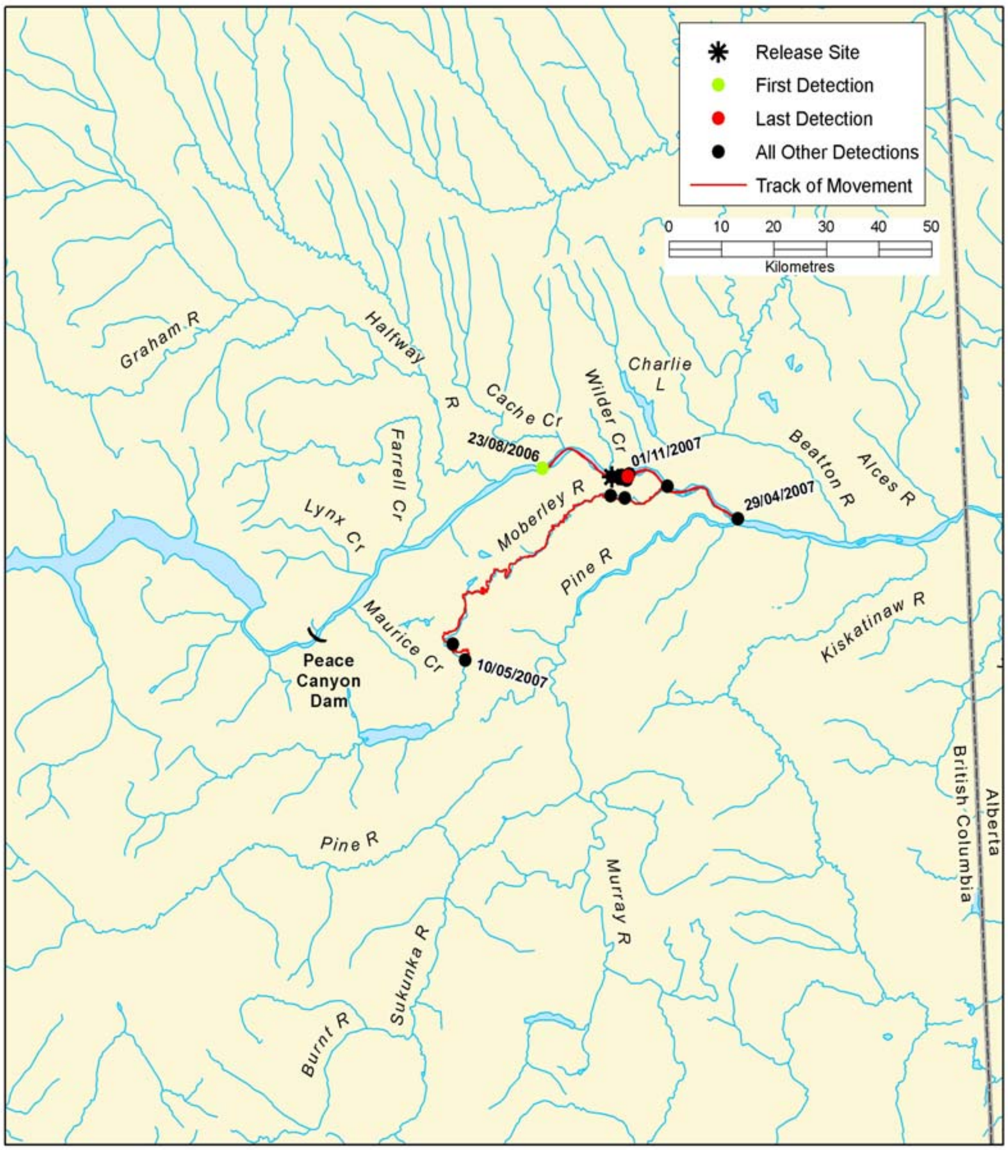


Figure 24: ***Individual track of an Arctic grayling (tag # 242) with a total track distance of 339 km***

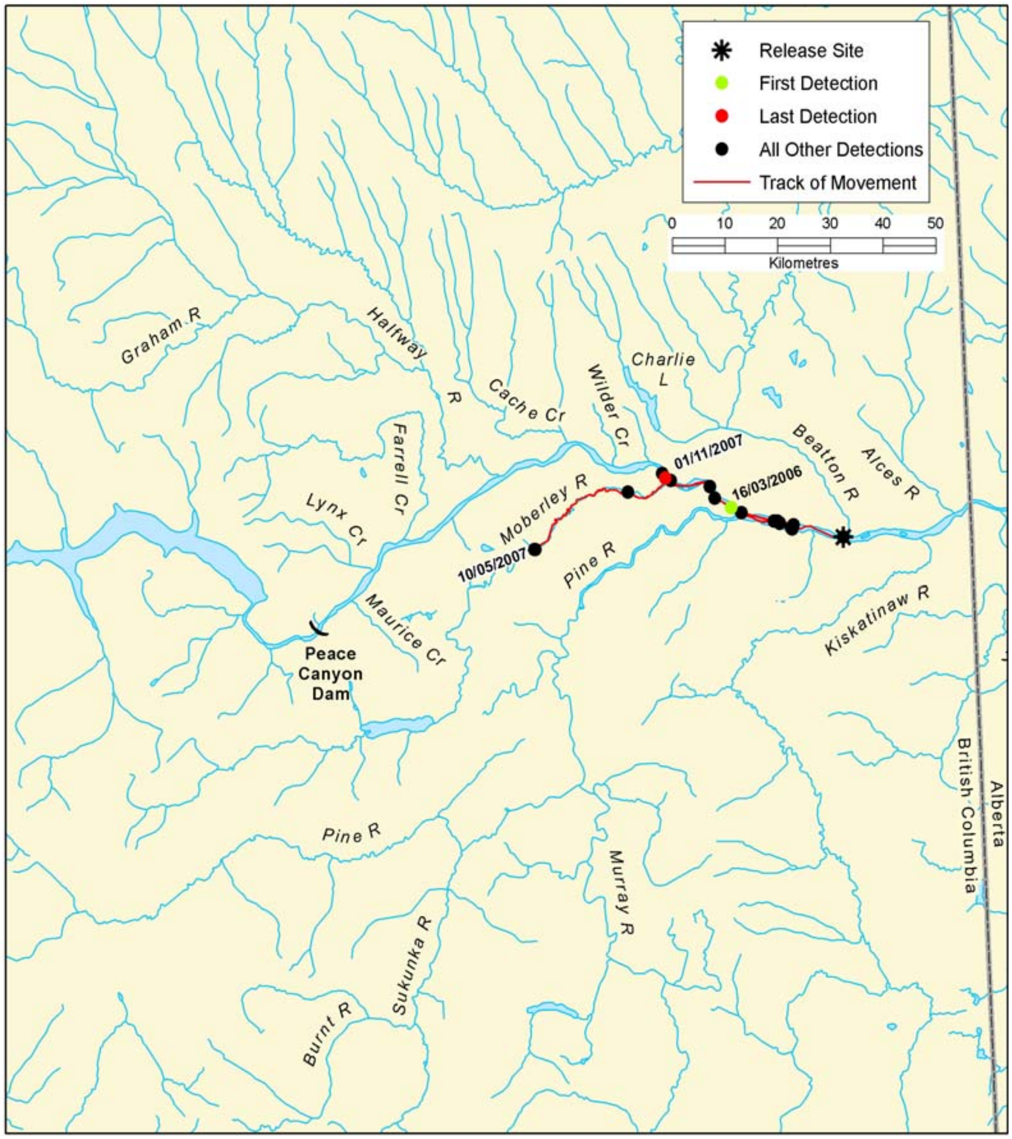


Figure 25: ***Individual track of an Arctic grayling (tag # 63) with a total track distance of 225 km***

Walleye tracking from March through October shows evidence of distinct seasonal movements within and between the mainstem and major tributaries, with some individuals moving extensive distances. In late March, approximately half of the radio-tagged population was detected within the vicinity of the Beatton River mouth, whereas the other half was widely distributed in the Peace River mainstem downstream of the Beatton River as far as Peace River, Alberta. The fish that congregated at the Beatton River mouth subsequently moved within and between major tributaries seasonally (see example in Figure 26). Fish of this sector of the radio-tagged population were detected well upstream in the Beatton River during the spawning season (May-June). During the post-spawning season (July onward), most of them moved out of the Beatton River into areas primarily upstream of the Beatton River mouth to as far as the Moberly River, with several fish going into the Pine River well upstream from the mouth, and eventually back into the Peace River mainstem. By late October, these fish were mainly detected within the Beatton River mouth area.

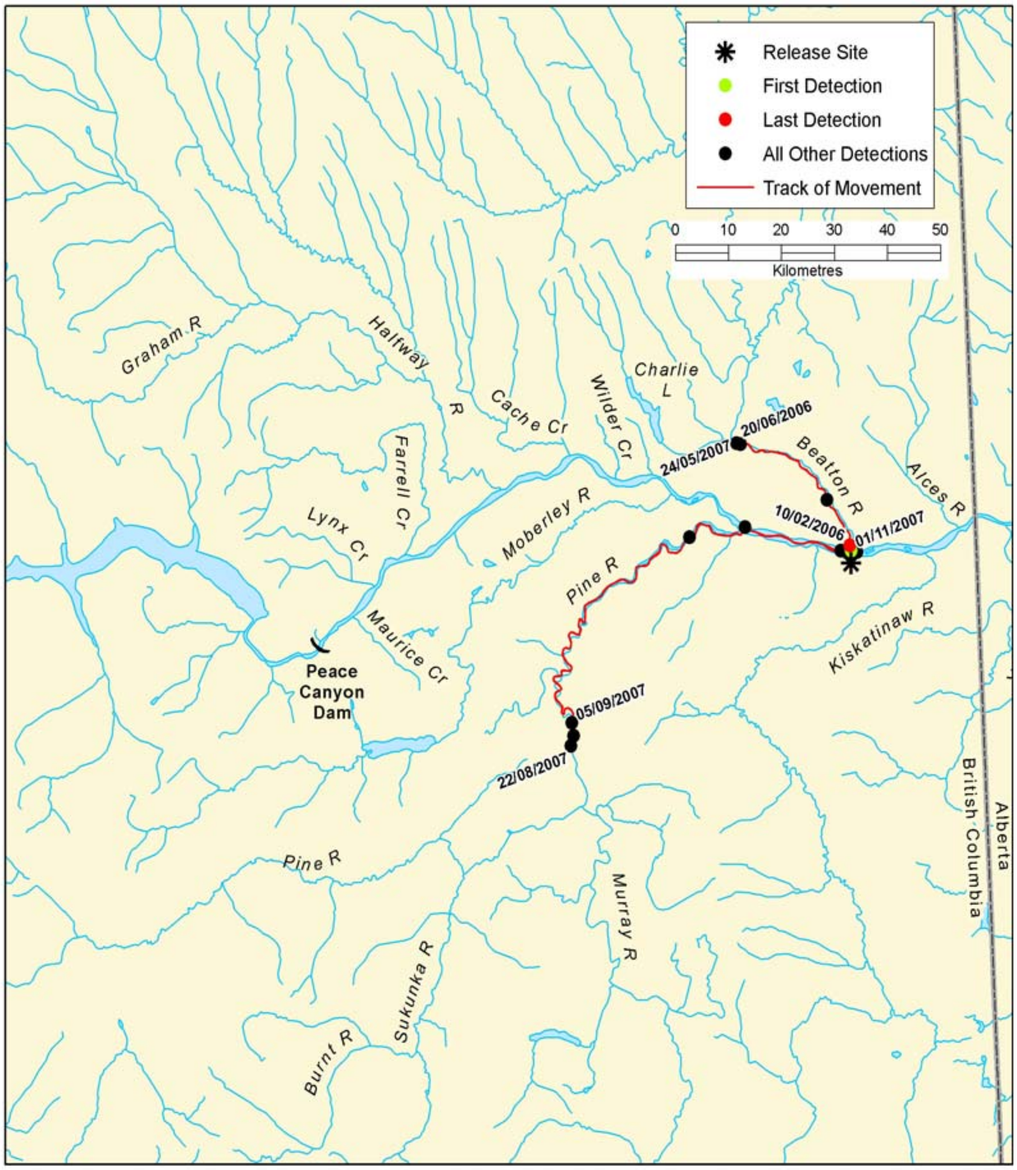


Figure 26: ***Individual track of a walleye (tag # 21) with a total track distance of 416 km***

The sector of the walleye population that remained primarily in the Peace River mainstem downstream of the Beatton River, showed no distinct seasonal movements although, some individuals moved extensively within the mainstem of the river. One particular individual moved major distances in the mainstems of the Peace and Pine rivers (Figure 27). This fish is an example of extreme long-distance movement, having travelled some 600 km from where it was released in 2005 to where it was last detected in 2007. From the Beatton River mouth (where it was released), it moved extensively downstream into Alberta in 2006, returned in 2007 and moved into the Pine River in July from which it exited in September, and was last detected at the Beatton River mouth on 26 September. On 11 October, the fish was caught by an angler some 350 km downstream from the Beatton River. This fish travelled about 25 km/d, on average, to cover this distance within two weeks.

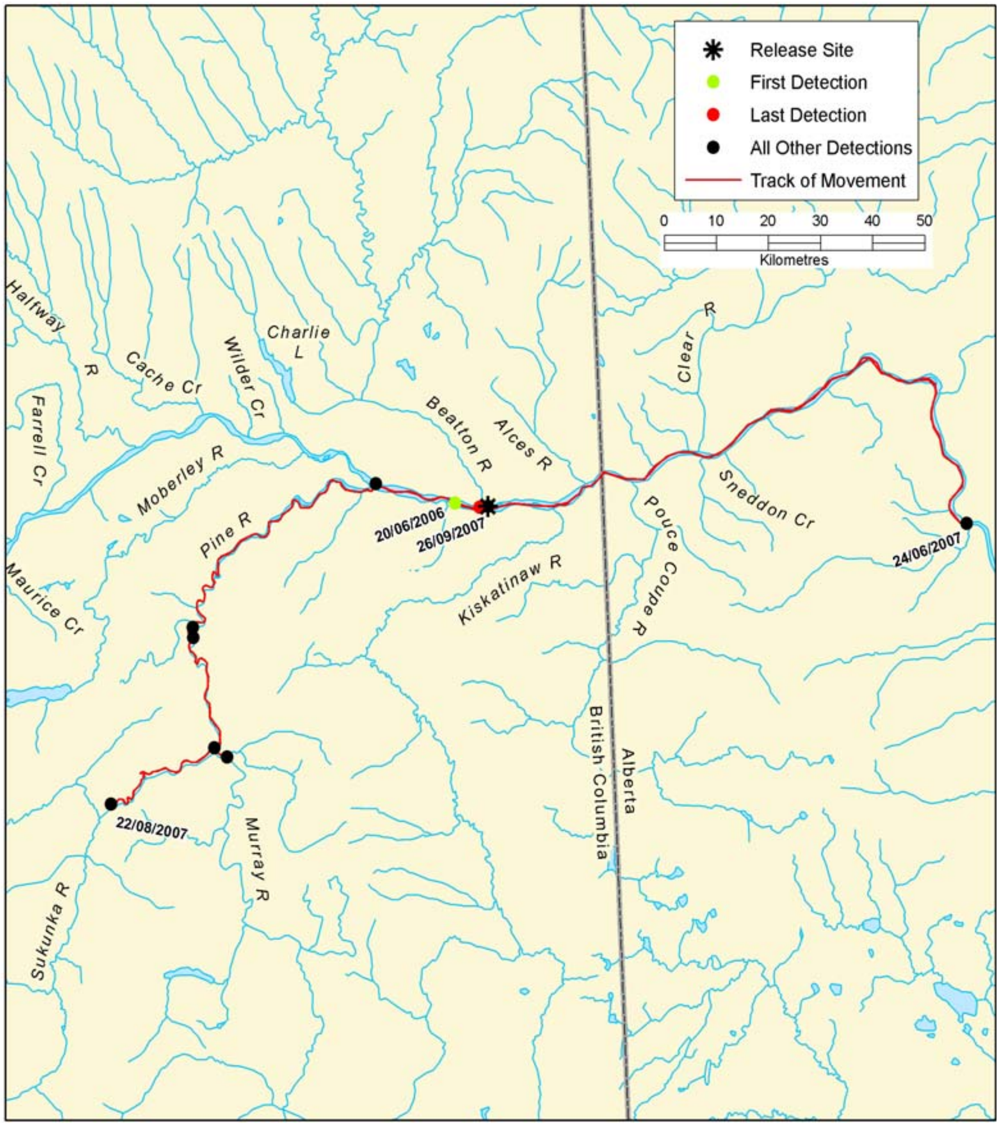


Figure 27: ***Individual track of a walleye (tag # 126) with a total track distance of 607 km. This fish was subsequently captured by an angler in the Peace River mainstem near Carcajou, Alberta, 11 October 2007***

Bull trout showed considerable variation in movements among the radio-tagged population over the duration tracked. From March to October 2007, some fish moved relatively little, others moved moderate distances, and a few moved extensively between the Pine River and Halfway River drainages as shown in Figures 28 and 29. From March to mid May, none of the bull trout were detected outside of the Pine River drainage. At least 60% of them were in the Pine River mainstem (headwaters to lower reach) and the rest were in the Burnt/Sukunka rivers. In late May, a single bull trout moved from the Pine River into the Peace River mainstem, but no additional out-movement from the Pine River was recorded in June. From July to October, the majority were in the Burnt/Sukunka rivers, but a few fish moved from the Pine River to the headwaters of the Halfway River (August-September) all, but one of these returned to the Pine River. The fish that did not return was last detected in the Peace River mainstem near Cache Creek on 2 November. Of those that moved between the Pine River and Halfway River drainages, one had travelled some 740 km from the release site to site of last detection (see Figure 29; also refer to Maps 7-11). This fish moved extensively within the Pine River (from headwaters to lower reach) to end July, then migrated from the Pine River to the headwaters of the Halfway River in August, and returned to the Pine River in early October.

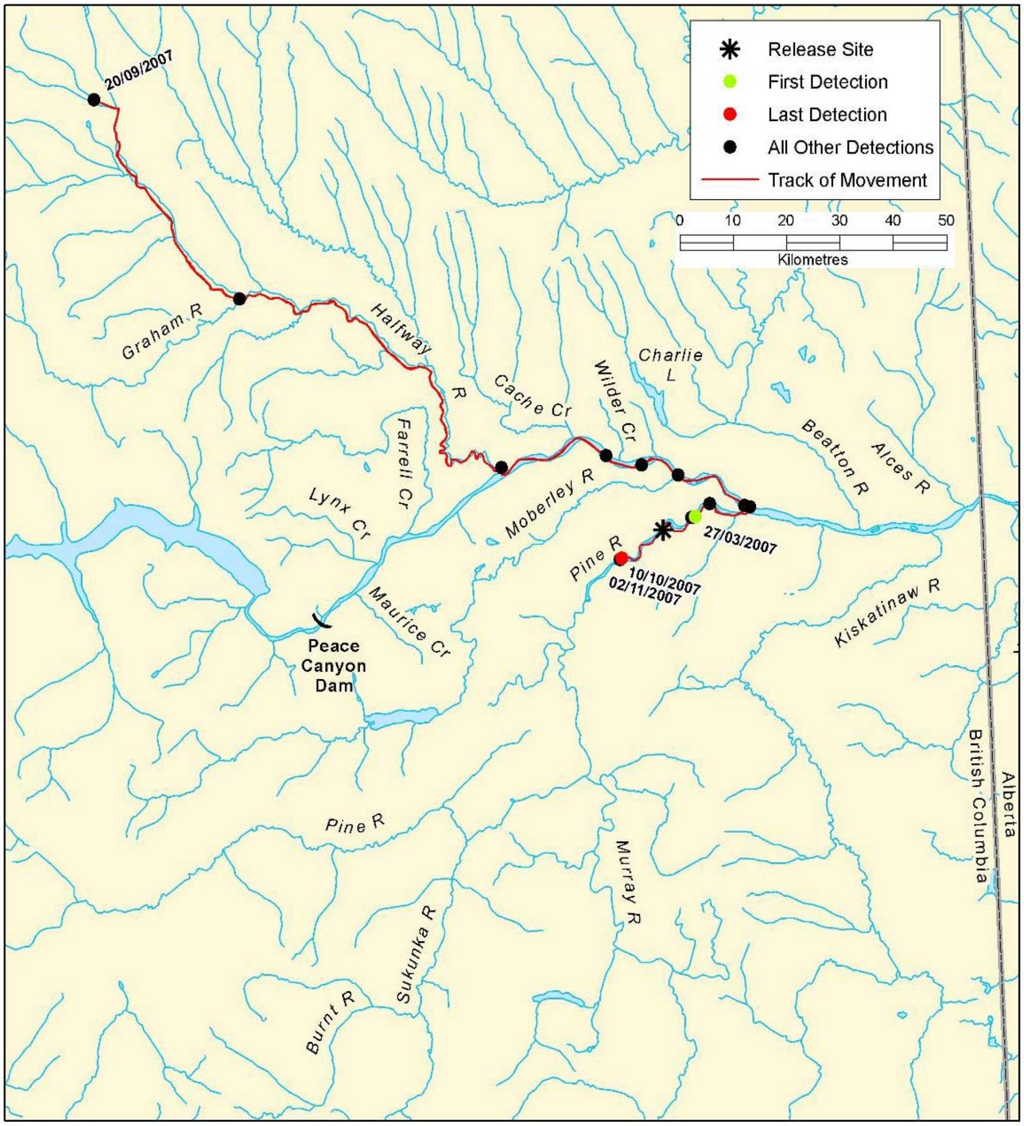


Figure 28: ***Individual track of a bull trout (tag # 273) with a total track distance of 447 km***

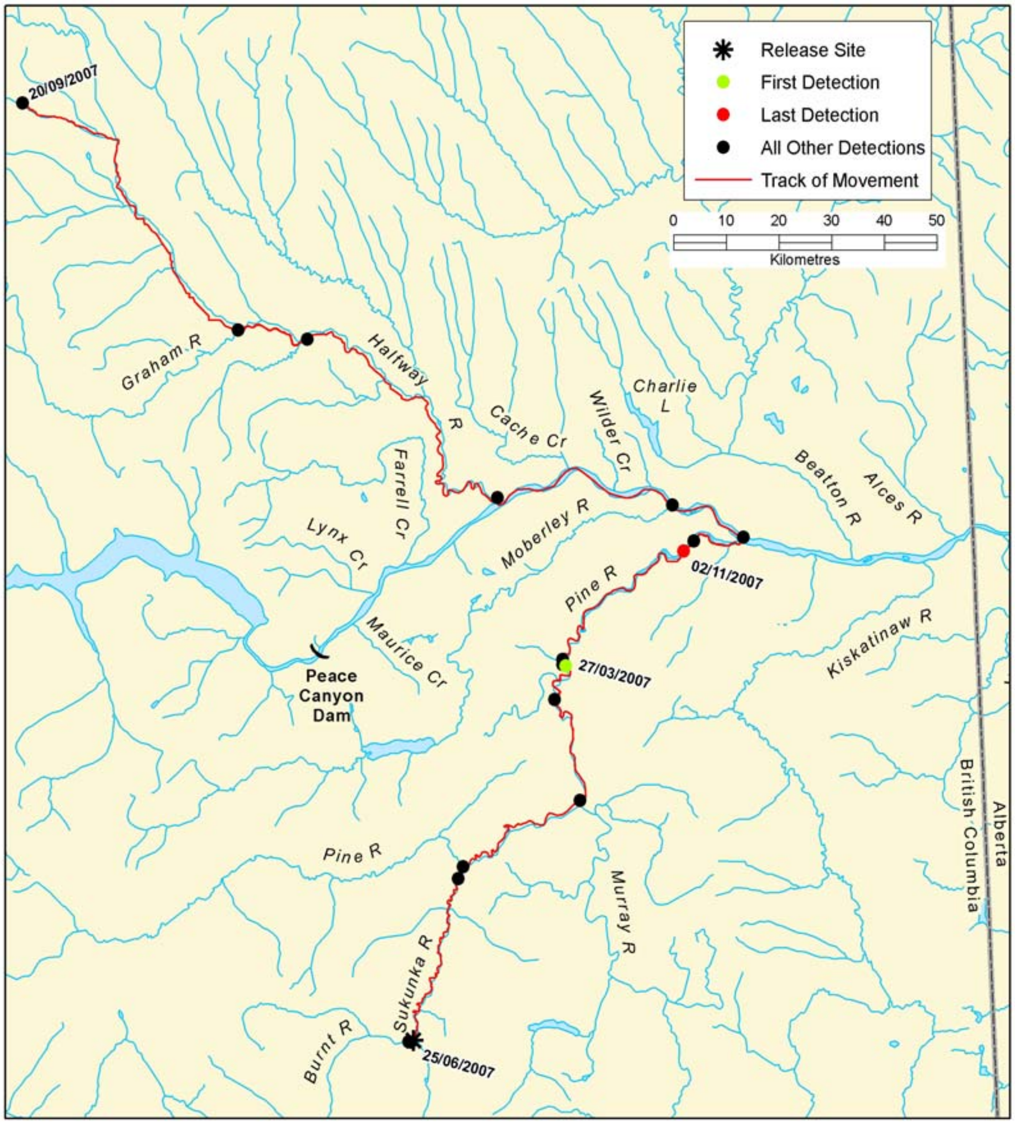


Figure 29: ***Individual track of a bull trout (tag # 322) with a total track distance of 741 km***

3.2.1.3 Further Assessment of Walleye Movement

The detections of walleye warranted further investigation to assist in understanding their relatively complex seasonal distribution changes. For this investigation, the study area was divided into four divisions: the Beatton River, the Peace River at the Beatton River mouth, the Peace River (and tributaries) downstream of the Beatton River mouth; and the Peace River (and tributaries) upstream of the Beatton River mouth. In this analysis, both 2006 and 2007 data were used. Figure 30 shows for each month and each year the relative proportion of the walleye that were detected in these four locations.

Walleye that were detected in the Beatton River during the spawning season (May-June) are referred to as “potential spawners”. The total number of potential spawners was 28, including 23 fish (82%) that were detected in both years. Five walleye were detected during only one of the study years (2 in 2006; 3 in 2007). The total number of potential spawners observed in each year was 25 in 2006, and 26 in 2007.

The post-spawning (July-Oct) movements of the potential spawners were also explored. Of the potential spawners detected in 2006, 72% moved out of the Beatton River after the spawning period and into areas upstream of the Beatton River mouth. Upstream movements ranged into the Pine River, and throughout the Peace River mainstem as far as the Moberly River mouth, but rarely past it. Of the remaining potential spawners, 16% remained in the Beatton River; and 12% moved into the Peace River and were detected both upstream and downstream of the Beatton River mouth. Of the potential spawners detected in 2007, 21 fish (81%) moved out of the Beatton River after the spawning period and into areas upstream of the Beatton River mouth. These post-spawning upstream movements ranged into the Pine and Moberly rivers, and throughout the Peace River mainstem as far as the Moberly River mouth, with the exception of one fish detected approximately 5 km past it. Of the remaining potential spawners, 1 (4%) moved to areas downstream of Sneddon Creek, 1 (4%) remained in the Beatton River; and 3 (12%) were detected in the Beatton River and in the Peace River around the Beatton River mouth.

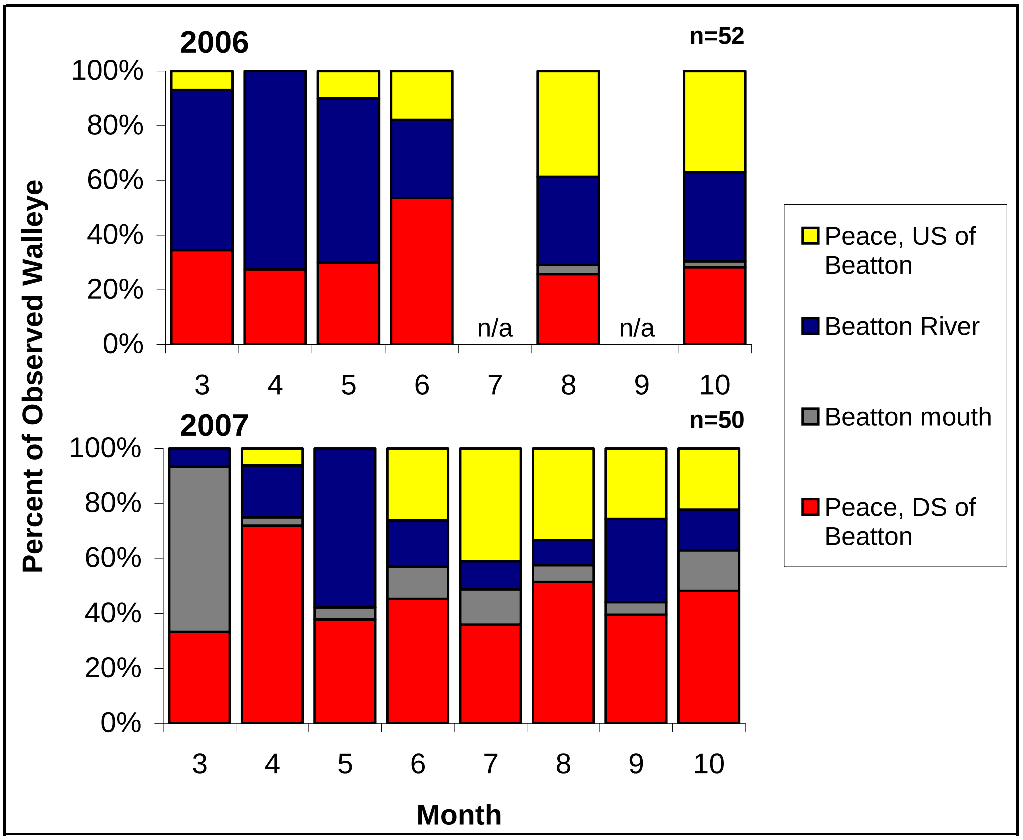


Figure 30: Seasonal pattern in the distribution of walleye, by year

3.2.1.4 Further Assessment of Bull Trout Movement

The detections of bull trout were investigated further to assist in summarizing their movements seasonally within and between watersheds of the Peace River system. For this investigation, the study area was divided into five divisions: 1) the Pine River mainstem; 2) the Sukunka/Burnt River drainage; 3) the Murray River/Wolverine River drainage; 4) the Halfway River drainage; and 5) the Peace River mainstem and its other tributaries. Figure 31 shows the relative proportions of bull trout that were detected in these five locations in each month in 2007.

From March to June, the majority of bull trout were detected in the Pine River mainstem. From July to October, the majority were in the Sukunka/Burnt River drainage. The appearance of bull trout in the Murray River system starting in August (Figure 31) is mainly the result of the tagging and release of 8 bull trout in the Wolverine River between 16 August and 1 September, 2007. However, a single bull trout, tagged in the Pine River in October 2006, did move into the Murray River system in September 2007, and then retreated back into the Pine River in mid-October.

Two bull trout performed interesting long-distance movements. In July, one fish left the Pine River, travelled through the Peace River mainstem, and entered the Halfway River drainage. In August, another individual left the Sukunka River, and similarly travelled into the Halfway River. Both of these bull trout moved out of the Halfway River drainage in September, and both returned to the Pine River, where they were last detected on 2 Nov 2007.

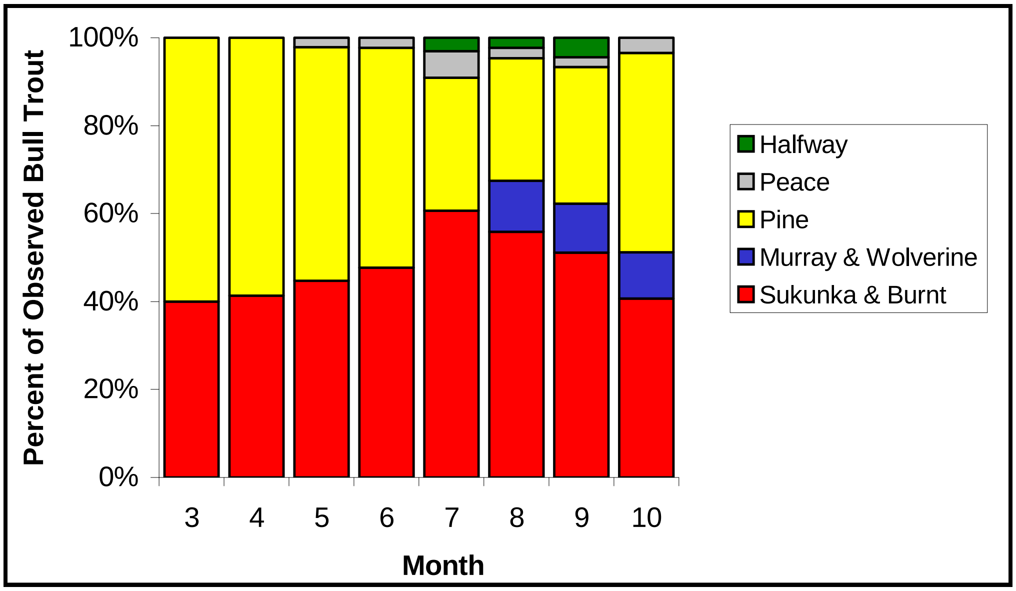


Figure 31: Seasonal pattern in the distribution of bull trout, 2007.

3.2.2 Magnitude, Direction and Seasonal Variability of Movement by Species

3.2.2.1 Over-winter Displacement

With the tributaries still frozen-over in late March, the first track of the year indicated the winter distribution of the radio-tagged fish populations in the Peace River study area. Overall, the tagged populations were distributed almost exclusively in the Peace River mainstem and Pine River system depending on tagging location (Figure 32).

Arctic grayling tagged in the Peace River mainstem were all found in the mainstem downstream of the Halfway River in March 2007. In October 2006, most Arctic grayling were tagged in the Burnt River. However in March 2007, these fish were found downstream in the Pine and Sukunka rivers.

Rainbow trout tagged in the Peace River mainstem were detected between the Peace Canyon Dam and Cache Creek, with few individuals widely scattered downstream to as far as the Montagnuese River. Rainbow trout tagged in the Pine River system were split evenly between the Pine and the

Sukunka rivers in late March 2007, even though, most were tagged in the Burnt River in fall 2006.

Walleye were concentrated around the confluence of the Beatton River with some additional walleye located downstream of the Beatton River. An additional fish was found in the Beatton River.

In March 2007, most of the mountain whitefish were distributed in the Peace River mainstem throughout the study area. However, in addition to the fish in the mainstem one and six mountain whitefish were located in the Pine and Halfway rivers, respectively.

Detections of bull trout, released in the Pine River system in 2006 were found in the Pine (60%), Sukunka (32%) and Burnt (6%) rivers. In addition, one bull trout was located near the Beatton River mouth.

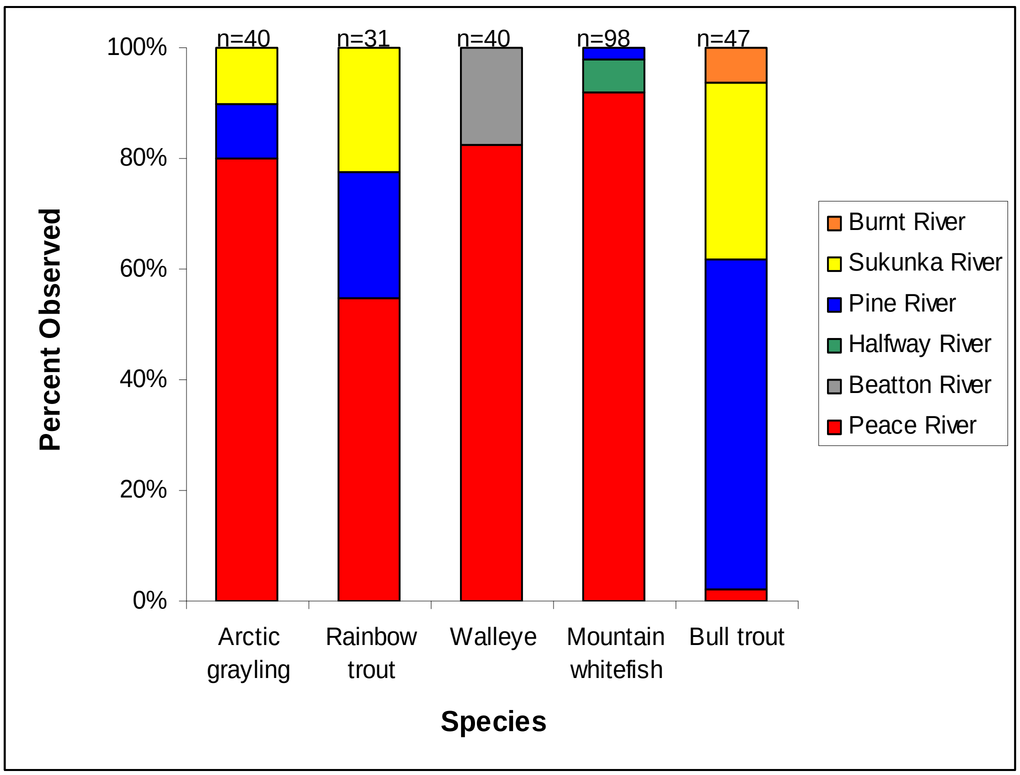


Figure 32: ***Distribution by species for late winter track (March 2007)***

3.2.2.2 Displacement During the Monitoring Period

The relationships between displacement and time at large are shown for all species and both years in Figure 33. A second-order fully-factorial ANCOVA (displacement as the dependent variable; species, year and time at large as predictor variables) showed that the relationship between displacement and time at large (i.e., the slope) varied significantly among species (species X time at large interaction: $F_{3,3419}$ = 8.3; P < 0.0001). Statistically significant slopes were observed for Arctic grayling, walleye, and bull trout but not for the other species. Species-specific slopes did not vary between years (species X time at large X year interaction: $F_{3,3419}$ = 0.35; P = 0.79).

For most species, median displacements showed significant variation among months (Table 8). The most striking of the seasonal displacement patterns were those of bull trout (Figure 34). Bull trout typically made downstream movements in the spring and fall (October to March, especially March), and generally made upstream movements in the summer (June to August, especially July). Walleye displacement was most variable in the late spring and summer. Their movements tended to be in the upstream direction in May and July, and in the downstream direction in June. Arctic grayling displacements were sporadic in 2006, with downstream movements most likely in February, March and especially July; and upstream movements were most common from April to June. In 2007, Arctic grayling were more sedentary, only showing long-distance displacements in March (i.e., over-winter). Rainbow trout displacements did not vary significantly among months in 2006 (Table 8). In 2007, some long-distance downstream over-winter movements were observed in March whereas many upstream movements were observed from May to July. Median mountain whitefish displacements in 2006 were typically in the downstream direction, whereas 2007 displacements were of shorter distances and with more variable direction.

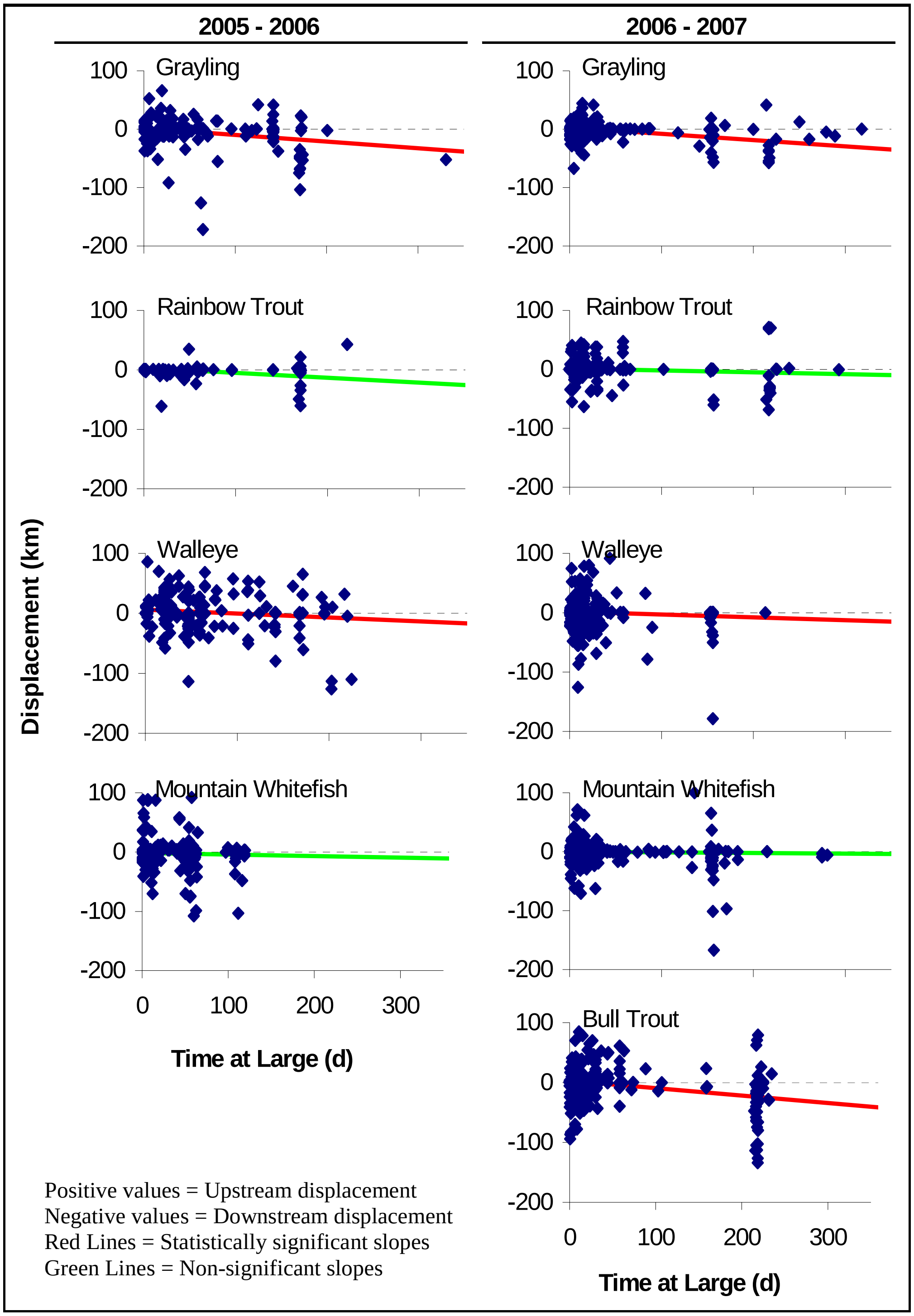


Figure 33: ***Displacements (km) as a function of time at large (d), by species and year***

Table 8: Median displacement (meter) by species, month and year

Year	Month	Species				
		Bull trout	Arctic grayling	Mountain whitefish	Rainbow trout	Walleye
2006	February		-3282		-16	221
	March		-583		-1030	252
	April		1040		-771	9744
	May		142		-519	11126
	June		479	-1319	-168	-200
	July		-16954	-9786	x	24937
	August		13	-2239	235	171
	September		x	x	x	x
	October		-280	173	-135	204
2007	February	-18480	-899	-200	-516	-266
	March	-185	-22	-33	66	-144
	April	134	-79	108	222	3439
	May	544	-161	73	489	-99
	June	6680	-34	91	142	704
	July	301	-21	-234	-285	-930
	August	-98	-156	-33	-178	122
	September	-143	187	165	262	-319
	October	-802	-265	-377	-560	409
p (2006)			<0.0001	<0.0001	0.14	<0.0001
p (2007)		<0.0001	0.0094	<0.0001	0.0019	<0.0001

Notes: Over-winter movements are included in these data; P values are from Kruskal Wallis tests of the effects of month on displacement; Cells with n < 10 have been excluded (marked with “x”).

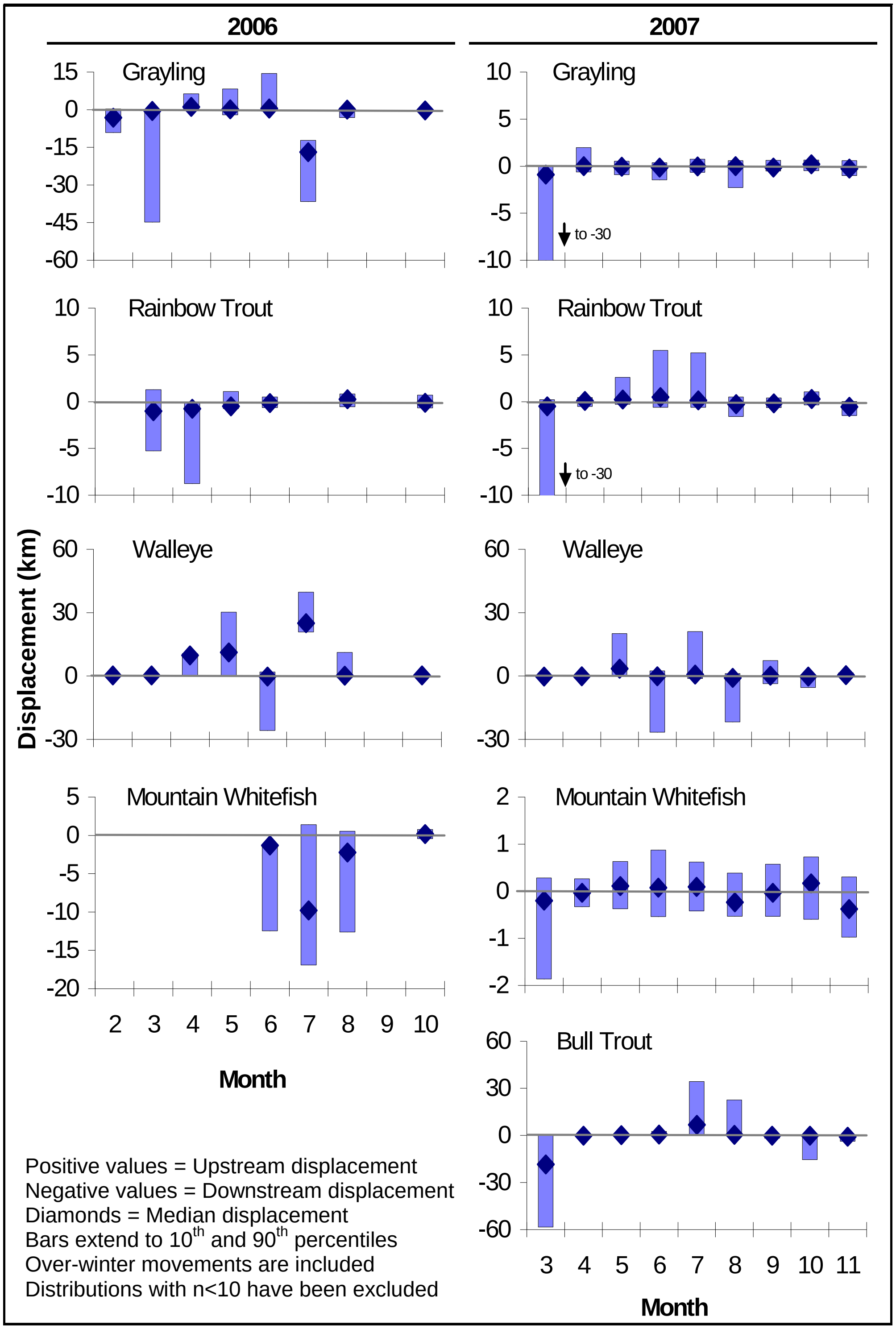


Figure 34: ***Distribution of observed displacement (km) events, by species, month and year.***

Displacement rates, in meters per day (m/d) (Figure 35), varied significantly among species ($H_{3,547}$ = 17.6; P = 0.001) and between years ($H_{1,547}$ = 7.3; P = 0.007). There was no significant interaction effect between species and years ($H_{3,547}$ = 1.3; P = 0.73). The differences among species were driven largely by the differences between walleye, which was the only species to have median displacement rates in the upstream direction (14 and 24 m/d in 2006 and 2007, respectively), and all other species. The differences among species were most pronounced in 2006, when the median displacement rate of mountain whitefish was 69 m/d in the downstream direction. The median displacement rate of mountain whitefish in 2007 was -2.6 m/d, which was significantly different from the 2006 rate (P < 0.0001). The significantly greater displacement in 2006 was probably largely due to insufficient time allowed for recovery before tracking these fish.

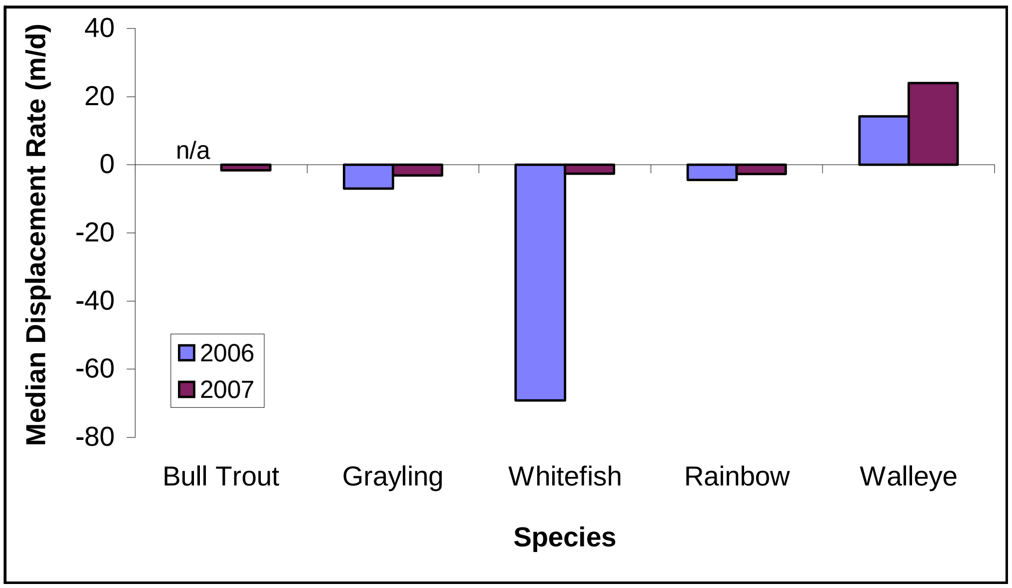


Figure 35: ***Median displacement rates (m/d) by species and year***

3.2.2.3 Distances Moved During Monitoring Periods

Overall distances moved (Figure 36) varied significantly among species ($H_{3,457}$ = 32.5; P < 0.0001) and between years ($H_{1,457}$ = 6.3; P = 0.012). There was no significant interaction effect between species and years ($H_{3,457}$ = 2.9; P = 0.41). When the 2007 data were analyzed in isolation (which allowed bull trout to be included in the test), the same species-effect was observed (H_4 = 65.6; P < 0.0001).

In both years, the median distance moved by walleye (2006: 80.1 km; 2007: 117.7 km) was significantly longer than that of any other species. In 2006, the median distance moved by Arctic grayling (45.4 km) was significantly greater than all other species except walleye. There were no significant differences in the distances moved between the remaining species (mountain whitefish: 20.3 km; rainbow trout: 8.9 km) in 2006. In 2007, the median distance moved by bull trout (51.2 km) was significantly greater than all other species except walleye. There were no significant differences in the distances moved between the remaining species (Arctic grayling: 8.9 km; mountain whitefish: 6.3 km; rainbow trout: 7.4 km) in 2007 (Figure 36).

Between year differences in median movement distance were statistically significant for Arctic grayling (difference = 36.6 km; P = 0.003) and mountain whitefish (difference = 14.0 km; P = 0.0002). The difference between years for walleye (37.6 km) was large, but not statistically significant (P = 0.10) due to the large variance in distances observed in each year. The difference between years for rainbow trout (1.5 km) was negligible (P = 0.72).

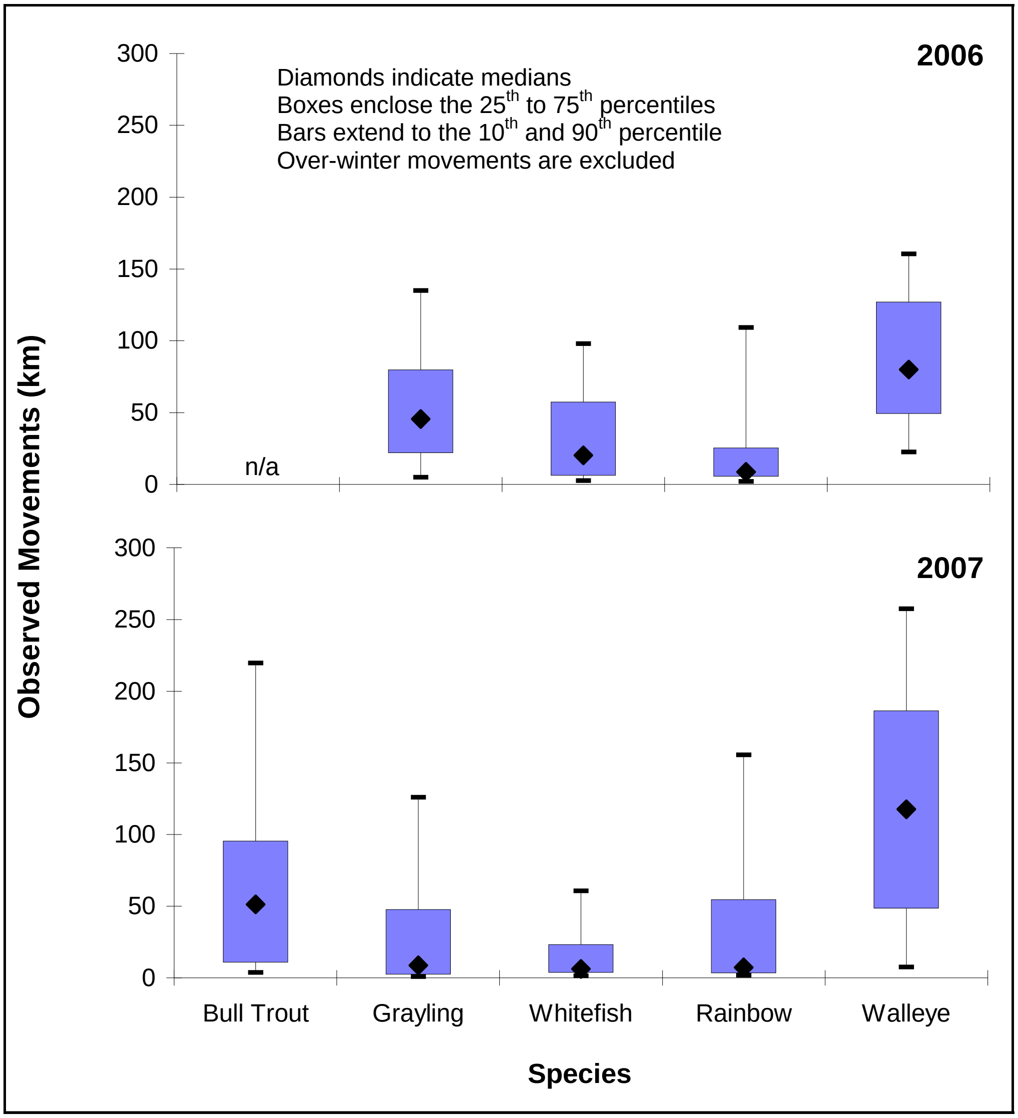


Figure 36: Distribution of observed movements (km) summed by species and year

Bull trout moved longer distances in late summer and in the fall, than in the spring and early summer (Figure 37). Arctic grayling and rainbow trout movements peaked in the spring. Walleye movements were sporadic in both years. In Figure 37, differences between years could be the result of survey effort, but within-year comparisons among species should be valid.

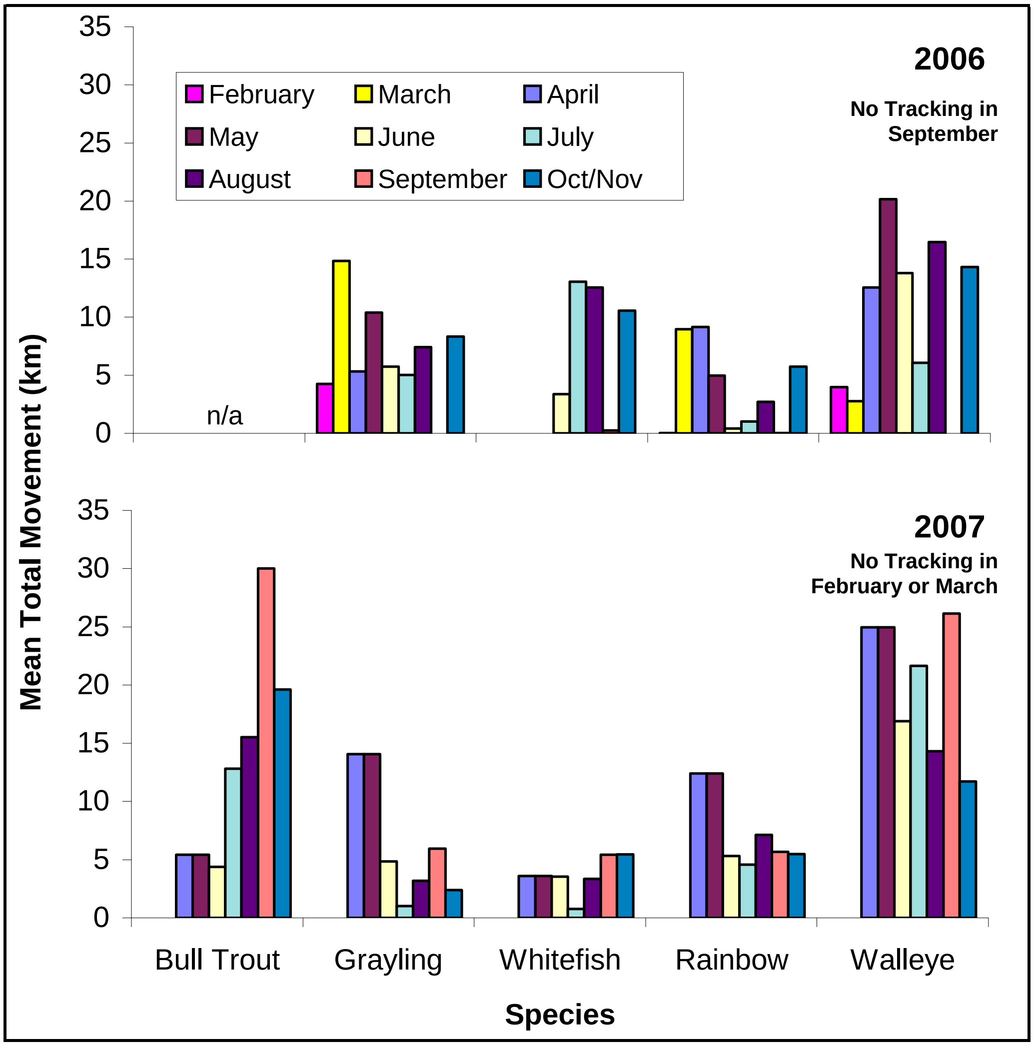


Figure 37: ***Total distance moved (in km; summed for each individual), averaged by month, species and year***

3.2.3 Magnitude and Seasonal Variability of Fish Movement Past Site C

The proportion of radio-tagged fish that passed Site C was significantly different among species ($H_{3,457}$ = 18.5; P = 0.0003) and between years ($H_{1,457}$ = 21.7; P < 0.0001). No significant interaction between species and year was detected (Figure 38; $H_{3,457}$ = 6.8; P = 0.08).

In 2006, the percentage of Arctic grayling (72%; 33 fish) that passed Site C was significantly greater than that of all three other study species. The percentage of mountain whitefish (29%; 32 fish) was significantly greater than that of walleye (6.0%; 3 fish), but not statistically different from that of rainbow trout (15%; 4 fish). Rainbow trout were not significantly different from walleye in their propensity to pass Site C.

In general, significantly smaller proportions of the radio-tagged populations passed Site C in 2007 (Figure 38). Nevertheless, the relative pattern of differences among species in 2007 was similar to that in 2006 (as indicated from the lack of statistical significance in the interaction term in the SRH ANOVA). In both years, Arctic grayling was the species most likely to pass Site C. In 2007, 24% of the radio-tagged Arctic grayling (10 fish) passed Site C. This was significantly fewer than the proportion that passed in 2006, and significantly higher than that observed for all other species in 2007, except walleye. The proportion of bull trout that passed Site C in 2007 was 10% (5 fish).

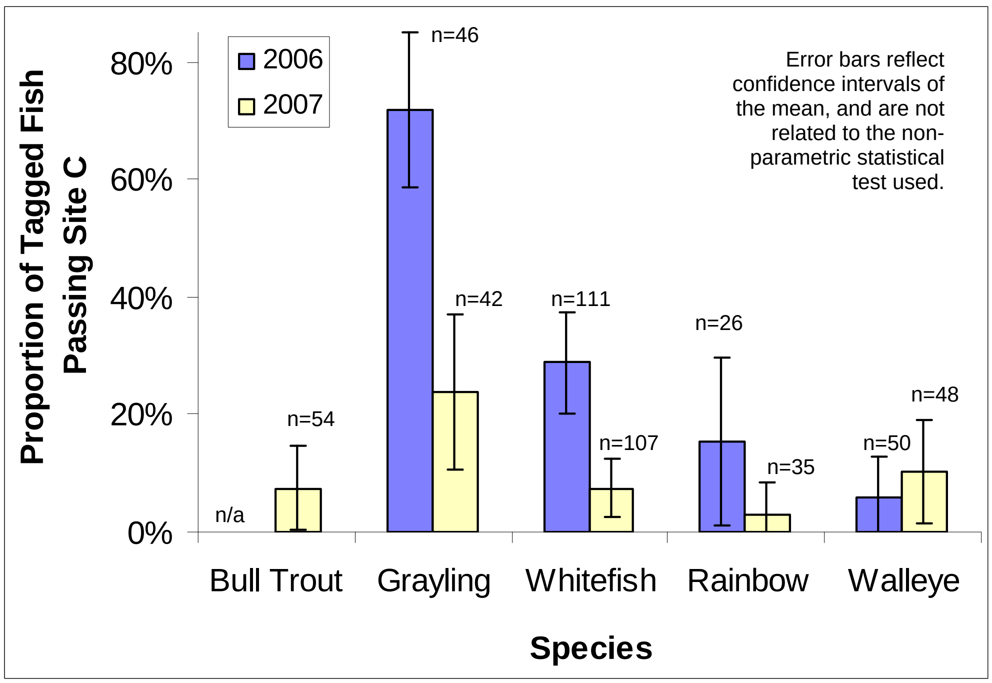


Figure 38: ***Proportion of radio-tagged fish that moved past Site C, by species and year***

Site C passage events occurred throughout the year, and some species showed seasonal passage patterns (Figure 39). Arctic grayling passage peaked in April and May in both years, with lower proportions of fish passing in June of both years, July 2006, and March 2007. Mountain whitefish passage peaked in June and July in 2006, but was relatively constant throughout the year in 2007. The lack of pre-June mountain whitefish detections in 2006 is an artefact of the sampling program: no mountain whitefish were tagged before June 2006. In both years, rainbow trout and walleye passage past Site C was sporadic. Bull trout passage showed a small peak in September.

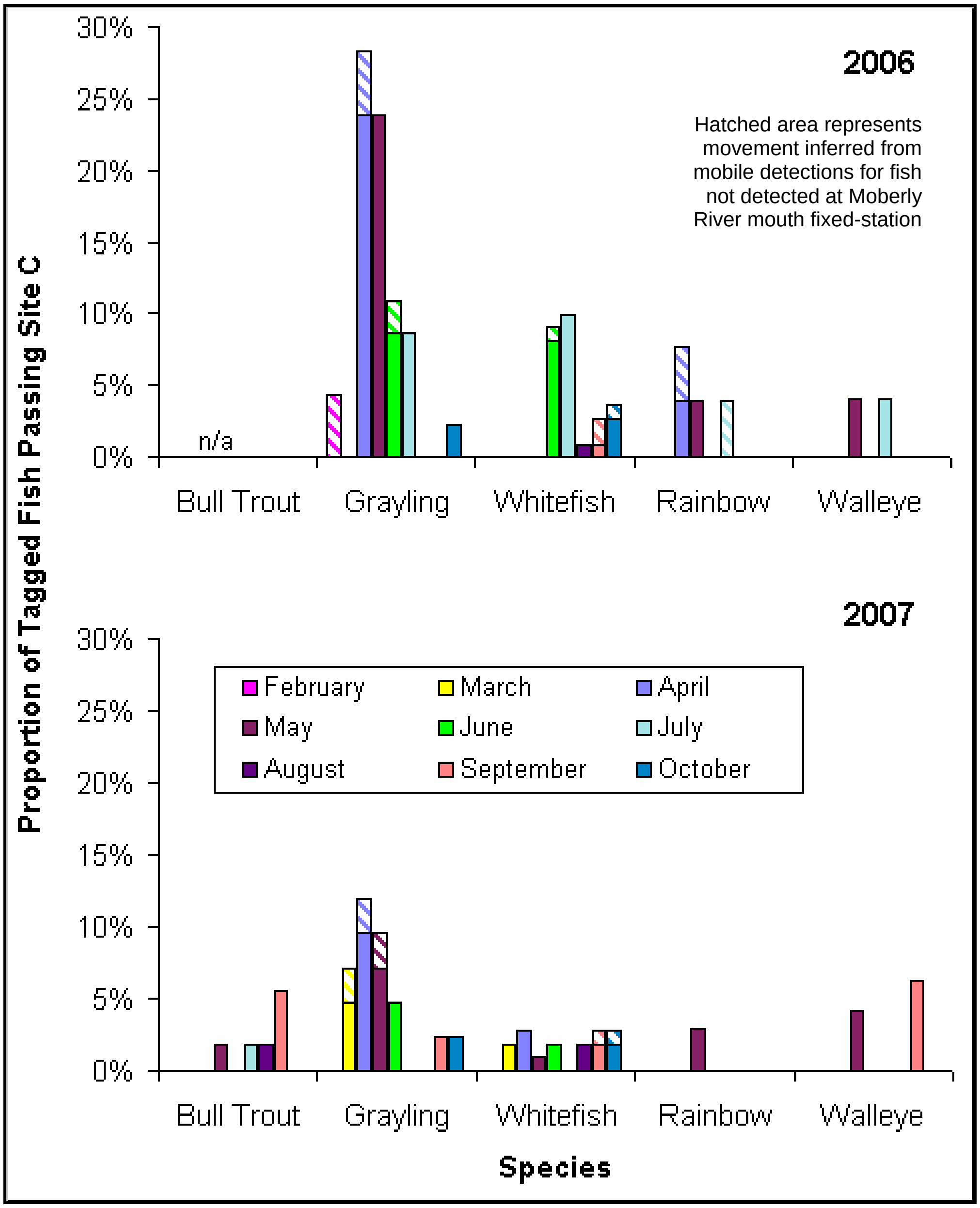


Figure 39: ***Proportion of radio-tagged fish that moved past Site C, by month species and year***

3.2.4 Fish Movement Past the Moberly River Potential Zone of Inundation

Arctic grayling was the only species that passed the potential zone of inundation in the Moberly River. In total, 19% of the radio-tagged Arctic grayling moved past the potential inundation zone. The distribution of passage events was split 50/50 between the upstream and downstream directions. Most (62%) of the movements into the Moberly River occurred in April, and an equivalent proportion moved out in May.

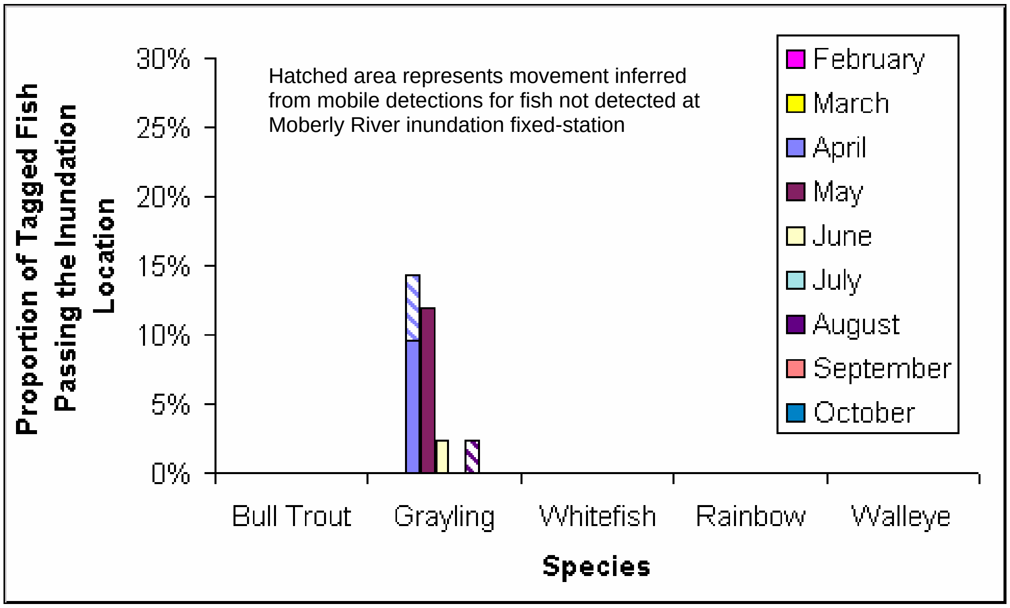


Figure 40: ***Proportion of radio-tagged fish that moved past the potential zone of inundation on the Moberly River, by month and species, 2007***

4.0 DISCUSSION

4.1 Fish Movements in the Peace River

4.1.1 Arctic Grayling

In previous reports (AMEC & LGL 2007) it was stated that 'Arctic grayling spawn and rear in the Moberly River and that this river likely contributes more to annual recruitment of the Peace River Arctic grayling population than any other tributary upstream of the proposed Site C dam'. The results of the 2007 tracking study support this statement. From April to May, several Arctic grayling from the Peace River mainstem were detected well upstream in the Moberly River, and by June had retreated back to the mainstem. These results are consistent with those of previous studies (ARL 1991b, RRCS 1978), which found more Arctic grayling in the Moberly River in spring than any other tributary. Further corroboration of the Moberly River as a spawning and rearing area for Arctic grayling comes from the hoop-netting surveys carried out by AMEC & LGL in spring 2006, in which adult and ripe Arctic grayling were captured moving into the Moberly River (AMEC & LGL 2007). Also, small numbers of young-of-the-year Arctic grayling were captured by electrofishing in the lower Moberly River in summer, suggestive that spawning occurs upstream.

In the present study, Arctic grayling were not detected in any of the smaller tributaries (Maurice, Lynx, Farrell, and Cache creeks) upstream of Site C. This result is consistent with that of previous surveys (AMEC & LGL 2007) in which neither adults nor young-of-the-year were captured in the smaller tributaries (an adult fish was captured in the lower Halfway River). However, small upstream movements of Arctic grayling were recorded in Farrell, Lynx, and Maurice creeks in earlier studies (RRCS, 1978). Based on current results, it would appear that smaller tributaries upstream of Site C are of limited importance for Arctic grayling spawning and rearing.

As for tributaries downstream of Site C, it is possible that some spawning by Arctic grayling occurs in the Beatton River. A few fish were detected within the vicinity of the Beatton River confluence and one fish was detected some 20 km upstream from the mouth in May of the present study.

From the 2007 tracking results, it is very likely that a large portion of Arctic grayling in the upper Pine River watershed represent a resident population that remains there year round. This population showed relatively little movement from March through to October, in the mainstem of the upper Pine and Sukunka rivers, with none detected in the tributaries. These findings are similar to those reported for the population of Arctic grayling in the upper Halfway River watershed, which spawns and rears in the upper tributaries (ARL 1997), and largely remains there year round with very few fish detected moving downstream into the Peace River mainstem (AMEC & LGL, 2006b). In contrast, the Peace River mainstem Arctic grayling populations use tributaries such as the Moberly and Beatton rivers for spawning and rearing and retreat to the mainstem to over-winter.

The 2007 tracking results show clear evidence of several Arctic grayling moving well upstream of the potential zone of inundation in the Moberly River in spring, and then retreating back into the Peace River mainstem. In spring 2006, two radio-tagged adult Arctic grayling were also detected above the potential zone of inundation in the Moberly River (AMEC & LGL 2007). In addition, a young-of-the-year Arctic grayling was captured in the upper reach of Moberly River in the summer of 2006 (AMEC & LGL 2007). The distribution of Arctic grayling spawning and rearing in the Moberly River is not precisely known, but based on locations of tagged grayling in the spring, it appears to occurs both downstream and upstream of the potential inundation line.

4.1.2 Bull Trout

Bull trout showed considerable variation in movements among the radio-tagged population over the duration tracked. From March to October, some fish, particularly those in the upper Pine River area, moved relatively little, others moved moderate distances, and a few others moved extensively between the Pine River and Halfway River drainages in the late summer to autumn period. In general, the mean monthly distance moved by bull trout was low from March through June (~5 km) and increased in the following months to a peak in September (~30 km). Except for the few fish that performed long-distance movements between the Pine River and Halfway River drainages, the movements of bull trout were confined to within the Pine River system, mostly within the upper reaches of the drainage. From July to October, the majority were in the Sukunka/Burnt River portion of the drainage. Overall, the median distance moved over the duration of the tracking period in 2007 was 51.2 km, and was significantly greater than that of all other species except walleye.

Based on the movement of a couple of fish from the Pine River system to the Halfway River drainage during the spawning window, it appears that two adult populations of bull trout were radio-tagged and released in the Pine River system in 2006. One population rears and forages primarily in the Pine River system and spawns in the Burnt River, while the other forages in the Pine River, but spawns and rears (juvenile stages) in the upper Halfway River drainages (e.g., Chowade, Graham, and Cypress rivers). Throughout the 2007 tracking period (March-October), most of the bull trout remained within the Pine River drainage with only a few fish moving long distances between the Pine and Halfway rivers during the spawning season, but returning to the Pine River before winter.

The findings from other studies provide supporting evidence that the Halfway and the Pine rivers are important drainages for bull trout in this study area as juveniles have been captured in various locations in the Halfway River (RRCS 1978, ARL 1991a, 1991b, R.L.&L. 1991a, 1991b, AMEC and LGL 2006b, Burrows, et al. 2000). A few bull trout juveniles were captured in Maurice and Lynx creeks in spring and summer 2006 (AMEC & LGL 2007), No bull trout have been observed in the other smaller tributaries so they appear to provide limited habitat.

4.1.3 Mountain Whitefish

The findings from two years of tracking of a fairly large sample of radio-tagged adult mountain whitefish consistently indicate that the Peace River mainstem population moves relatively little within and between the mainstem and tributaries. Throughout the 2006 and 2007 tracking periods, this population remained widely distributed in the Peace River mainstem from the Peace Canyon Dam to Dunvegan, Alberta. Eleven (12% of those detected) were the most fish ever detected in the tributaries and this occurred in October. Small numbers were detected in the lower and upper reaches of the Halfway River and lower Pine River, with a slight increase in numbers in both tributaries (though not in the upper reach of the Halfway River) between August and October, the time when the species is likely to be spawning. While a limited mountain whitefish migration to the upper reaches of Halfway River may be plausible, the small number of detections in the upper Halfway River may not have been that of radio-tagged mountain whitefish, but from transmitters in the stomachs of large bull trout that had eaten radio-tagged fish somewhere downstream in the system (e.g., Peace River mainstem or lower Halfway River). Predation by large bull trout on radio-tagged fish in this study has been confirmed on two occasions (see Table 4, page 26). The minor movements shown by mountain whitefish do not support the notion of a large-scale spawning migration from the Peace River mainstem to the headwaters of the Halfway River.

However, some movement from the mainstem to the lower reaches of the Halfway and Pine rivers were noted, which may have been associated with spawning, since these rivers are deep enough in places to avoid freezing to the bottom during winter thereby allowing over-wintering eggs to survive. Some indirect evidence to support this notion is the numbers of mountain whitefish in the lower reaches of these tributaries increased slightly in the September-October period. Moreover, their mean monthly movement was slightly greater during these two months, probably attributable to increased movement during the spawning season particularly between the mainstem and tributaries. R.L. & L. (1991a, 1991b) reported large numbers of spawning mountain whitefish present in the lower Halfway River in autumn 1989, with the highest numbers of larval mountain whitefish recorded in the Peace River mainstem downstream of the Halfway River in the following spring and summer.

Young-of-the-year (YOY) mountain whitefish were also captured in the lower reaches of the Moberly River and Maurice, Lynx, Farrell, and Cache creeks in summer 2006, with their numbers being highest in Lynx and Maurice creeks (AMEC & LGL 2007). It is surmised that these fish have either come from the Peace River mainstem, which is not inconceivable since the distance is minor, or are the progeny of fish that spawned in the lower reaches of these tributaries. Spawning in these tributaries is probably limited given that they probably freeze to the bottom during most winters (with the possible exception of Moberly River). Yet surprisingly, mountain whitefish adults were found to be the most common large-bodied fish in the Moberly River, Halfway River, Cache Creek, Lynx Creek, and Maurice Creek in autumn 2005 (AMEC and LGL 2006a); similar findings have also been reported by others for the Moberly River (ARL 1991a) and Farrell and Lynx creeks (RRCS 1978). The reason for the presence of adults in the smaller tributaries in autumn is unclear, but may be foraging-related.

The findings of the present study, and to some extent those of others, lead to the conclusion that the majority of the adult mountain whitefish population in the Peace River study area remains within the mainstem year round, with their movements in general being no more than minor. They have been found to move relatively little in either an upstream or downstream direction seasonally, which aligns with information reported by Mainstream Aquatics Ltd (2006, 2007) on the distribution and movements of these fish in the Peace River mainstem from a long-term mark and recapture study. In the present study, the median distance moved by mountain whitefish was 20.3 km and 6.3 km in 2006 and 2007 respectively, with the movement in 2006 being almost exclusively in the downstream direction at a rate of 69 m/d. In the following year, their displacement was markedly lower (2.6 m/d) and was similar to that of rainbow trout. Their significantly greater displacement in 2006 is most probably related to the short recovery period after tagging (~1 month) before tracking was began and should not be taken as representative of the movement of the untagged population. More realistically, relative to what we know about the species from longer-term study, the median distance moved in 2007 (6.3 km) is considered to be representative of the movement of the untagged population of mountain whitefish.

It is concluded that the lower Halfway and Pine rivers contribute to some extent to recruitment in the Peace River mainstem, but it is highly doubtful that spawning of any significance occurs in the smaller tributaries, with the possible exception of the Moberly River and localized areas of adequate groundwater inflows, due to risk of eggs freezing during winter. These tributaries provide some rearing habitat for young mountain whitefish moving in from nearby areas in the Peace River mainstem, but survival in them is likely to be low with fish becoming stranded in isolated pools during summer low flows (AMEC & LGL 2007).

4.1.4 Rainbow Trout

The adult rainbow trout population in the Peace River mainstem of the study area showed minor movement throughout the two-year tracking period, with the fish distributed mainly between the Peace Canyon Dam and Cache Creek, with their greatest movement occurring during the spawning season

(April-May). The median distance moved by rainbow trout was respectively 8.9 km and 7.4 km in 2006 and 2007, and was very similar to that of mountain whitefish (6.3 km) in 2007; the greater distance recorded for mountain whitefish in 2006 (20.3 km) is not considered representative of the untagged population because of potential tagging effects (explanation given in the preceding Section.)

Movement of the radio-tagged rainbow trout population into the tributaries during the spawning season was either largely missed, or very few fish moved into the tributaries to spawn in 2007. Despite biweekly aerial tracking in April and May, only one rainbow trout was detected in the tributaries (Maurice Creek). However, since the distance a fish would have to travel to spawn in these small tributaries is short (<5 km), some movement into the tributaries may have gone undetected. Other studies have reported evidence of rainbow trout in these waters. A high proportion (90%) of the rainbow trout captured in fisheries investigations in the Peace River study area in autumn 2005 were from Lynx and Maurice creeks (AMEC & LGL 2006a). Additionally, adult rainbow trout was the second most common sportfish captured in Maurice, Lynx, and Farrell creeks in spring 2006, and juveniles (age 1^+) were found in Maurice and Lynx creeks in summer of that year (AMEC & LGL 2007). Also, spawned out rainbow trout were captured in Maurice and Lynx creeks during spring in 1989, and large numbers of YOY fish were caught in these streams in autumn of that year (ARL 1991b).

Rainbow trout released in the Pine River drainage showed relatively little movement generally, with the exception of some movement from the Sukunka River and upper Pine River to the Burnt River beginning in early summer, with most of the fish returning later in the season. There is no evidence of these fish exiting the Pine River drainage. It is presumed to be a resident population of the Sukunka/upper Pine rivers as is the Arctic grayling in this drainage.

4.1.5 Walleye

Two years of tracking has provided good documentation of the movements of the walleye population in the Peace River study area. This population moves extensively within and between the Peace River mainstem and major tributaries, with a well-defined spawning migration up the Beatton River in May and back out in June. The median distance moved by walleye was significantly greater than that of all other species in both years, being 80 km in 2006 and 118 km in 2007. Their mean monthly distance moved was sporadic, but clearly highest in spring (April-May) and autumn (September). A major proportion of those that moved up the Beatton River in spring were fish that over-wintered (October-April) within the vicinity of the Beatton River confluence. In contrast, those that did not move up the Beatton River remained mostly downstream in the Peace River mainstem, widely distributed, with some as far as Peace River, Alberta. Of these, some individuals moved long distances with one fish moving over 600 km from the release site in 2005 to site of capture by an angler in 2007.

The total number of potential Beatton River spawners observed was virtually the same in both years; 25 in 2006 and 26 in 2007, with a high proportion (82%) of these being the same fish in both years. It cannot be ascertained if the incidence of repeat spawning annually is the same or different between males and females as the fish were not sexed when tagged. During the post-spawning season, most of these fish moved upstream from the Beatton River in the Peace River mainstem to as far as the Moberly River (though none entered it), with several fish going into the Pine River and later back out and subsequently (by late October) congregating within the Beatton River confluence area .

Our findings regarding the distribution and movements of walleye in the present study are consistent with those of previous works. With the exception of a spawning pair found in Farrell Creek in 2006, walleye were not captured in any of the tributaries in the Peace River study area upstream of the Pine River in autumn (2005) and in spring and summer (2006) by AMEC & LGL (2006a, 2007). Moreover, others have found walleye to be primarily in areas downstream of the Pine River (R.L. & L. 1991a, 1991b, 2001, P & E 2002; Mainstream Aquatics 2004, 2005, 2006) and increasingly more abundant with distance downstream from the Pine River (Hillebrand, 1990; R.L. & L., 2001). Clearly, this population utilizes an extensive range within the Peace River mainstem and specific major tributaries, but it is likely that only a small proportion of the population (<5%) moves upstream in the Peace River mainstem past the Moberly River.

4.2 Limitations of the Study

4.2.1 Environmental Conditions

Conclusions regarding environmental conditions are based on the best available information at reporting time and all 2007 discharge data are preliminary and subject to change upon final calibration by the Water Survey of Canada.

4.2.2 Radio Telemetry

In previous reports (AMEC & LGL 2006b, 2006c), several limitations and assumptions inherent in the use of radio telemetry for tracking fish movements were listed. Most of these are reiterated here (with minor modification where appropriate) as they remain applicable to the 2007 study, which in essence is a continuum of the telemetry program begun in 2005. The list of limitations and assumptions includes the following:

- The limitation of realistically tagging only a small number of adult fish which are assumed to represent the movements of the greater untagged population.
- The assumption that tagged fish behave in a manner similar to that of untagged fish (i.e., capture, tag implantation, and holding procedures impart only a short-term [one week to one month] behavioural change).
- The assumption that the potentially confounding effects of noise from other sources of radio waves (e.g., hydroelectric facilities, other tagged wildlife).can be filtered and any false records existing in the receiver files can be removed through consistent application of appropriate noise-filtering criteria.
- The assumption that mortalities of potentially dead fish can be detected over time through application of minimum movement threshold criteria applicable to the species tracked and removed from the data set to avoid biasing data interpretation.
- The assumption that the species tagged actually make movements of sufficient magnitude and duration to be detected on the spatial and temporal scales deployed in the tracking program.

As stated previously, the effects of most assumptions and limitations of radio telemetry on data quality and interpretation can be minimized by having clear objectives, well thought-out study design, and rigorous data quality control and assurance protocol. We maintain that all of these factors have been adequately addressed for the Peace River radio telemetry study from its inception in 2005 to the present. To reiterate, for the Peace River study, the objectives of the radio telemetry program formulated in 2005 were: 1) determine the timing, direction, distance traveled, and relative magnitude of migrations of rainbow trout, Arctic grayling, mountain whitefish, and walleye in the Peace River study area. Bull trout tagged and released in the Pine River system were added to the study program in August 2006; 2) determine if any of these species move into Peace River tributaries at any time during the year; and 3) determine if any migrations involve obligatory movements past the proposed Site C dam site. Calculation of median displacement rates (ie, displacement divided by time at large) for both upstream and downstream movements by species for both years was added to the data analysis in the current year for comparison among species and between years.

The study design criteria to meet these objectives and reduce the effects of the above listed limitations and assumptions included: 1) tagging and tracking the five sportfish species most likely to make migrations in the Peace River past Site C dam (including fish in the Pine River); 2) maximizing the number of tags implanted on each of the five species in approximate proportion to the species' abundance in the river; 3) distributing tags in approximate proportion to the natural distribution of the population of each fish species in the study area; 4) tagging fish when river conditions (e.g., favourable water temperatures) maximized survival rates; 5) using only highly experienced personnel for tag implantation; 6) holding tagged fish for a minimum of 20 minutes before release; and 7) combining monthly aerial tracks of the entire Peace River and its major tributaries from Peace Canyon Dam to Dunvegan, Alberta, with data from strategically placed fixed-stations on the Peace River to monitor spatial and temporal movements of radio-tagged fish. Since the Peace River system is rarely >4 m deep, radio-tags were determined to be appropriate for use in this study.

Quality control and assurance measures used during the study included biweekly downloading of fixed-stations and rigorous data filtering for noise and mortalities using LGL's proven *Telemetry Manager* software. Filtering of noise recorded by the receivers and assessing mortality were rigorously carried out on both datasets (2006 and 2007). The application of a well defined minimum movement threshold covering all the five species that were tracked has been effective in providing a realistic assessment of mortality. The declining detection rates in the final stages of the 2007 tracking period for those species tagged in 2005 was unavoidable due to a proportion of the radio transmitters having reached their maximum two-year period of operation.

Possible limitations of the current radio telemetry program are:

1. For all species, with the possible exception of mountain whitefish, the movements in both years of tracking are assumed to be representative of the movements of untagged fish as they had ample time (~8 months) to recover from tagging before being tracked. The median distance moved by mountain whitefish was significantly greater in 2006, with most of it being in the downstream direction, probably because insufficient time was allowed for recovery before tracking was begun. For this reason, the 2007 movement data for mountain whitefish are considered more representative of untagged fish.

2. Small localized movements may have been missed if they occurred between mobile tracking events and between fixed-stations. The effect of this limitation on assessing movements past Site C was eliminated by having a fixed-station at the mouth of the Moberly River, approximately 500 m upstream from the proposed dam site, and at the potential inundation line on the Moberly River.

The calculated median displacement rates for each species are considered reasonable estimates of their overall movement in either an upstream or downstream direction.

While the possibility exists that some of these limitations and assumptions may have affected our interpretation of the 2006 and 2007 data, it is our view that no important results drawn from the study to date are erroneous or biased. The movements of the Arctic grayling, walleye, rainbow trout, and mountain whitefish populations are considered to be reasonably well documented and the conclusions drawn are within the bounds of the known movements of these populations. However, the conclusions regarding movements of the bull trout populations are tentative and will not be finalized until data from further tracking have been collected and analyzed.

5.0 CONCLUSIONS

In 2007, portions of the tagged population moving past the proposed Site C location were 7%, 24%, 8%, 3%, and 10% for the 54 bull trout, 42 Arctic grayling, 107 mountain whitefish, 35 rainbow trout and 48 walleye, respectively. For all species except walleye, the portion of the tagged population that moved past Site C was less in 2007 than in 2006.

Over-winter habitat was investigated during the March 2007 aerial track. Almost all fish tagged in the Peace River in 2005 and 2006 were found in the Peace River mainstem with the exception of 7 (18%) of the walleye and 6 (6%) of the mountain whitefish that were observed in the Beatton and Halfway rivers, respectively. For bull trout, Arctic grayling, and rainbow trout tagged in the Pine River system, all remained in the Pine River drainage, with the exception of one bull trout that moved to the mouth of the Beatton River. Although, a high proportion of the bull trout (76%) were tagged and released in the Burnt River in fall 2006, only three (6% of those detected) remained there in March 2007. Most released in the Burnt River were found downstream in the mainstem of the Sukunka and Pine rivers in March 2007.

The Moberly River appears to provide important spawning habitat for Arctic grayling. The 2007 tracking results show clear evidence of several Arctic grayling (19%) moving well upstream of the potential zone of inundation in the Moberly River in spring, and then retreating back into the Peace River mainstem in June. Arctic grayling were not detected in any of the smaller tributaries (Maurice, Lynx, Farrell, Cache creeks) upstream of Site C. Two fish were detected within the vicinity of the Beatton River confluence and one fish was detected some 20 km upstream from the mouth in May 2007, suggesting that spawning might also occur in this river.

Based on telemetry results, the smaller tributaries upstream of the proposed Site C dam (i.e Maurice, Lynx, Farrell, Cache and Wilder creeks) appear to provide limited habitat for Peace River sportfish. The only radio-tagged fish every detected in these creeks was a rainbow trout that moved into Maurice Creek in the spring.

Based on 2007 tracking results, it appears likely that Arctic grayling and rainbow trout in the upper Pine River watershed are resident populations that remain in the drainage year round. No radio-tagged Arctic grayling or rainbow trout moved from the Pine River into the Peace River in 2007. However, it should be noted that only limited numbers of rainbow trout (15) and Arctic grayling (8) were radio-tagged in the Pine River system. The movement observed by these fish in 2007 should be confirmed with another season of data collection.

Bull trout showed considerable variation in movements among the radio-tagged population over the duration tracked. From March to October, some fish, particularly those in the upper Pine River area, moved relatively short distances. Two bull trout made extensive migrations of approximately 450 km. These fish moved from the Pine River system to the upper Halfway River drainage in the late summer, remained in the Halfway River system until the end of the spawning period and then returned to the Pine River in late fall.

From the results to date, it appears that there may be two populations of bull trout radio-tagged in the Pine River drainage in 2006. It is possible that one population rears and forages primarily in the Pine River system and spawns in the Burnt River, while another forages in the Pine River, but spawns and rears (juvenile stages) in the upper Halfway River drainage. The proportion of bull trout that conduct this migration is not clearly understood. Currently, our results for bull trout are limited to a single year of data. It is very likely that the proportion of fish that move from the Pine River to the Halfway River is under-represented in our study because 2006 tagging was conducted in upper regions of the Pine River system in mid-August, after the date when bull trout would have shifted into spawning locations.

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This report was prepared by Rachel Keeler, Gordon Glova, and Dave Robichaud. Ingrid Shen and Carol Lavis of AMEC formatted and prepared the document.

7.0 CLOSURE

Recommendations presented herein are based on an evaluation of the findings of the fish and aquatic investigations described. If conditions other than those reported are noted during subsequent phases of the study, AMEC and/or LGL Ltd. should be notified and given the opportunity to review and revise the current recommendations, if necessary.

This report has been prepared for the exclusive use of BC Hydro for specific application to the area within this report. Any use which a third party makes of this report, or any reliance on or decisions made based on it, are the responsibility of such third parties. AMEC and LGL Ltd. accept no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report. It has been prepared in accordance with generally accepted practices. No other warranty, expressed or implied, is made.

AMEC and LGL Ltd. appreciate the opportunity to assist BC Hydro with this project. If you have any questions, or require further assistance, please do not hesitate to contact the undersigned.

Respectfully Submitted,

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