Survey to Estimate Angler Effort on the Bow River

Near Calgary during June to September 2018

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Abstract

A survey to quantify angling effort on the Bow River near Calgary was conducted from June to September 2018. Instantaneous counts of shore-based and boat-based anglers were made along four sections of river from the Bearspaw Dam downstream to the Carseland Weir. Counts were conducted by ground-based observers, and an independent survey was conducted by helicopter-based observers. A sub set of angler interviews were conducted to determine if anglers were guided or non-guided. The fishery was entirely catch-and-release, and the survey was not designed to estimate angling catch rates due to challenges related to quantifying self-reported catch rates that cannot be accurately verified by observers.

Surveys were conducted on 86 days by ground-based clerks, and 15 days by helicopter-based observers. The estimate of angler-effort from ground surveys was estimated at 196,092 angler hours (angler-h). The helicopter-based observers had difficulty counting all anglers, therefore that estimate was considerably lower at 152,989 angler-h (overall mean estimate). The ground-based survey estimate in 2018 was approximately 15% (+/- 13%) higher than the 170,522 angler-h estimated in 2006 for the same months and sections. During the 2018 angler survey effort was mainly from shore anglers (49%), followed by non-guided boat anglers (31%) and guided boat anglers (20%).

The Bow River is one of Alberta's highest effort fisheries consisting of both recreational anglers and commercially guided anglers. Angling effort is hypothesized to be a significant factor affecting Bow River fish populations over time, even under catch and release angling regulations, in addition to other environmental factors. Changes to angling regulations that are strongly supported by the broad angling community may be required to prevent further declines to the fishery, as Alberta's human population continues to grow and effort on the fishery increases.

Introduction

The Bow River near Calgary supports one of Alberta's most popular fisheries. Although these trout (rainbow and brown trout) are not native species to this river, the recreational and social value of the fishery is immense and supports both recreational angling and commercially guided angling. Alberta Environment and Parks' goal of maintaining a high quality fishery in the Bow River requires an understanding of the angling effort, the trout populations, and the subsequent effects of angling on the fishery.

The objective of this study was to quantify the angling effort in the Bow River in 2018 and make comparisons to the angler use assessment conducted in 2006. The survey was partitioned to determine angling effort for each of the four summer months (June through September), as well as partitioned by shore-based anglers, guided boat-based anglers, and non-guided boat-based anglers. Additionally the survey was designed to provide estimates of angling effort distributed spatially along the Bow River in the same survey reaches as 2006. The survey was not specifically designed to quantify catch rates, nor catches of trout, however it should be noted that catch rate is an important parameter when calculating the overall effect of angling on the fishery. The results of this study will be used to inform management choices and trade-offs required to maintain this important fishery.

Methods

Study Area

The study area extended from the Bow River downstream of Bearspaw Dam in the City of Calgary to the Carseland Weir (Figure 1). The assessed reach of the Bow River is approximately 100 km in length with an estimated surface area of 1,076 hectares. Large tributaries include the Elbow River and Nose Creek which drain into the Bow River within the city, Fish Creek which enters the Bow River near the southern city limit and the Highwood River which enters the Bow River downstream of the city.

The study area corresponded to the river sections assessed in 2006. The river was stratified into four sections similar to the previous survey (Ripley and Council 2006). Section 1 consisted of the reach from Bearspaw Dam to the Western Irrigation District (WID) weir near Sam Livingston Fish Hatchery. Section 2 extended from the WID weir down to Fish Creek Provincial Park at Highway 22x. Section 3 extended from Highway 22x to the McKinnon's Flats angler access location, and Section 4 consisted of the area downstream of McKinnon's Flats to the Carseland Weir.

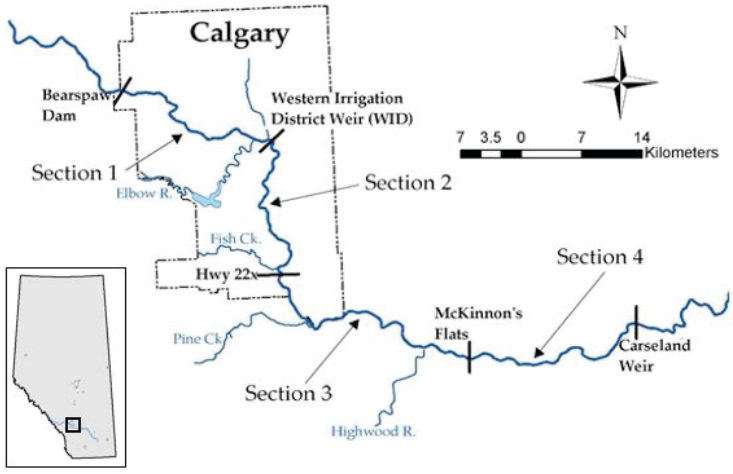


FIGURE 1.
Study area for the angler survey conducted on the Bow River (Ripley and Council 2006).

Field Methods

The primary angler survey (from which angling effort was derived) was conducted from June to September 2018. The angler survey method consisted of a progressive instantaneous count with interviews of anglers, which was also completed in 2006 using methodologies described in Pollock et. al (1994). Due to the easy accessibility of the river within Calgary city limits, anglers in sections 1 and 2 were intercepted by a clerk on a bicycle along the Bow River pathway system. Sections 3 and 4 were surveyed using a vehicle and clerks counted anglers at locations where the river was publicly accessible. Information collected from angler interviews was primarily trip length and whether the angler was guided or non-guided.

The count of anglers observed fishing from shore during a section survey were summed and considered an instantaneous count of shore anglers. Anglers observed fishing from boats during a section survey were considered a separate instantaneous count of boat anglers.

Aerial surveys by helicopter were also conducted with flights along the Bow River. Observers counted boat and shore anglers in each section and during each month. This survey was independent of the ground surveys.

In order to compare the results from the 2018 survey to the 2006 survey the instantaneous counts from 2006 were reanalyzed to correspond directly to the 2018 methods over a comparable time interval (i.e. June to September).

Data Analysis

Observed instantaneous counts of anglers were multiplied by the number of potential angler-hours (angling-h) in the survey period, termed the “sampling frame”. The number of potential angler-h in the survey period was calculated as 14 hours per day (i.e., AM survey shift 0800-1500 and a PM survey shift 1500-2200) with 30 or 31 days in each month of the survey period (i.e., June through September). Therefore, total angling-h for each month was the mean instantaneous count of anglers multiplied by 420 or 434 sampling frames (i.e., 14 hours per day x either 30 or 31 days in the survey month). The total of shore and boat angler-h was summed for each month. A distribution in total angler-h was developed by bootstrapping the observed instantaneous counts of anglers (dataset resampled 5000 times; Haddon 2001) to provide likelihood-frequency distributions. Estimates were reported as the overall mean of estimates of sections and months, with maximum likelihood frequency distributions used to measure variance.

Guided anglers were assumed to be exclusively using boats (because all shore-based anglers, except one, reported being non-guided). The ratio of guided and non-guided angler-h was estimated from the interview data of boat anglers for each section and month. This ratio was applied to the total angler-h estimate for each section and month to derive estimates of guided and non-guided angling effort.

The aerial (helicopter) survey used instantaneous counts of shore and boat anglers for each river section and month. This data was analyzed independently from the shore-based counts to derive an independent estimate of total angling-h. Helicopter observations were analyzed using the same procedure used to derive the shore-based estimates of angler-h.

Results

From June to September 2018 ground surveys were conducted on 86 days, with a total of 161 instantaneous counts conducted. In 2018, 14% of the total sampling frames were surveyed in section 1, 17% in section 2, 16% in section 3 and 17% in section 4. Aerial surveys were conducted on 15 days, with a total of 62 instantaneous aerial counts being conducted. A total of 2,196 anglers were interviewed. The temporal and spatial schedule of instantaneous counts is shown in Appendix 1.

Ground Surveys

The mean instantaneous counts (IC) of boat and shore anglers for each section and month are shown in Table 1. The instantaneous count data is shown in Appendix 2.

TABLE 1
Ground surveys: mean instantaneous counts (number of anglers) on the Bow River, 2018.

	June	July	August	September	Section sum
Section 1	3.8	6.1	8.4	4.5	22.8
Section 2	21.4	38.3	39.0	30.4	129.1
Section 3	32.7	47.6	44.9	21.7	146.9
Section 4	22.7	53.4	54.2	28.0	158.4
Monthly sum	80.7	145.4	146.4	84.6	

A graphical summary of ground survey estimates of instantaneous counts for June to September are shown in Figure 2. The mean estimates of total angler-h (i.e., boat and shore, by section and month) are shown in Table 2, with an overall total estimate of 196,092 angler-h (95% CI 180,221 to 210,451) (Figure 3).

Aerial Surveys

Observers in the aerial survey (helicopter) reported considerable difficulty counting all anglers. Difficulties included people being only partially visible along shore (e.g., hidden by vegetation), difficulty in determining if person was angling or engaged in other activities, and if people in boat were anglers or non-anglers. Because of these difficulties the observers reported that aerial surveys were likely underestimates of true angler counts. The mean instantaneous counts of anglers counted during helicopter flights is shown in Table 3, with the instantaneous count data shown in Appendix 3. The mean estimate of total angler-h (i.e., boat and shore) is shown in Table 4, with an overall total estimate of 152,989 angler-h (95% CI 137,494-167,811) (Appendix 5).

Bow River 2006 Survey

From June to September 2006, ground surveys were conducted on 84 days with a total of 259 instantaneous counts conducted. In 2006, 23% of the total sampling frames were surveyed in section 1, 25% in section 2, 35% in section 3 and 23% in section 4. The mean instantaneous counts of anglers from 2006 for each section and month are shown in Table 5, with the instantaneous count data shown in Appendix 4. In 2006, boat and shore anglers were not counted separately. A graphical summary of the 2006 estimates of instantaneous counts for June to September are shown in Figure 2. The mean estimate of the 2006 total angler-h is shown in Table 6, with an overall total estimate of 170,522 angler-h (95% CI 155,428-184,464 (Figure 3).

FIGURE 2
Bootstrapped means of instantaneous counts of anglers from sections 1 to 4, June to September, collected during the 2006 and 2018 surveys. Boxplots showing median instantaneous counts as centerline, mean values as a single dot within the box, upper and lower box limits are 25th and 75th percentile, whiskers are 1.5 times interquartile range, with outliers showing as fading dots outside of whisker margins

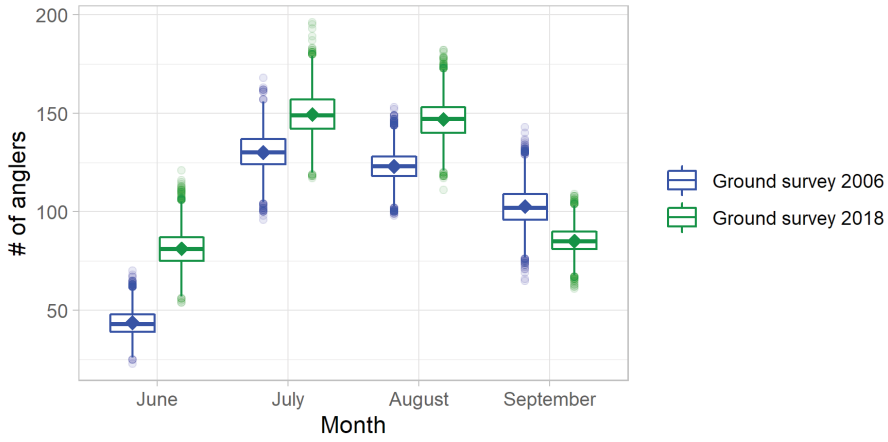


TABLE 2
Ground surveys: overall mean estimate of angler-hours on the Bow River, 2018

	June	July	August	September	Section sum
Section 1	1,609	2,630	3,645	1,906	9,790
Section 2	9,008	16,622	16,909	12,756	55,296
Section 3	13,730	20,661	19,479	9,108	62,977
Section 4	9,549	23,191	23,516	11,772	68,028
Monthly sum	33,897	63,104	63,549	35,542	
Total					196,092

FIGURE 3
Estimates of angling effort (2006 and 2018), based on frequency distribution of instantaneous counts multiplied by number of sampling frames.

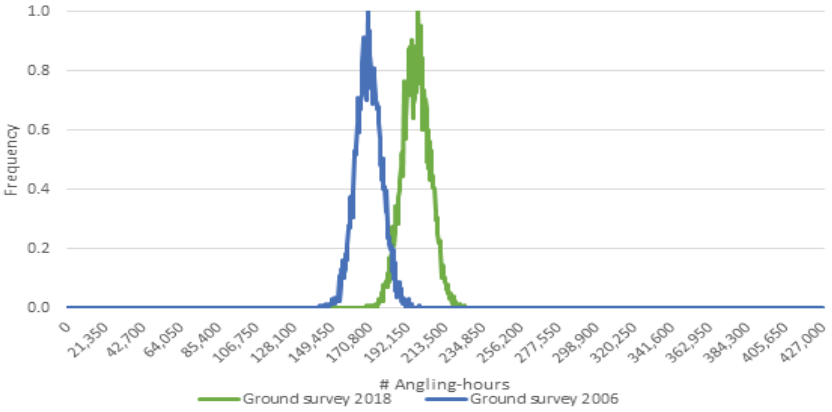


TABLE 3
Aerial surveys: mean instantaneous counts (number of anglers) on the Bow River 2018.

	June	July	August	September	Section sum
Section 1	5.5	4.5	3.6	1.2	14.7
Section 2	26.5	35.0	19.9	14.5	95.8
Section 3	32.1	43.2	49.3	27.5	152.0
Section 4	19.3	31.9	30.4	12.7	94.4
Monthly sum	83.3	114.6	103.1	55.9	

TABLE 4
Aerial surveys: estimate of angler-hours on the Bow River, 2018.

	June	July	August	September	Section sum
Section 1	2,292	1,955	1,560	493	6,300
Section 2	11,119	15,178	8,615	6,097	41,010
Section 3	13,470	18,738	21,393	11,549	65,150
Section 4	8,122	13,866	13,193	5,348	40,529
Monthly sum	35,003	49,737	44,761	23,488	
Total					152,989

TABLE 5
Ground survey: mean instantaneous counts (number of anglers) on the Bow River, 2006.

	June	July	August	September	Section sum
Section 1	5.7	6.3	7.5	6.9	26.3
Section 2	15.2	29.4	21.0	18.8	84.4
Section 3	13.2	48.5	52.5	42.7	156.8
Section 4	9.2	45.4	41.6	33.8	130.0
Monthly sum	43.3	129.7	122.5	102.2	

TABLE 6
Ground survey: estimate of angler-hours on the Bow River, 2006.

	June	July	August	September	Section sum
Section 1	2,388	2,748	3,245	2,879	11,260
Section 2	6,380	12,778	9,121	7,894	36,173
Section 3	5,543	21,037	22,772	17,919	67,271
Section 4	3,861	19,710	18,034	14,213	55,818
Monthly sum	18,172	56,272	53,173	42,905	
Total					170,522

Angler Effort Comparisons

The estimated angler effort in 2018 from the ground survey was 15% higher than the angler effort estimated from the 2006 survey.

Guided Boat, Non-Guided Boat, and Shore Angling Effort

A total of 935 boat anglers were interviewed, of which 356 said they were being guided. The numbers of guided and non-guided boat anglers for each section and month are shown in Tables 7 and 8. The proportions of these numbers were applied to the estimates of total boat angler-h in each section and month (i.e., means of likelihood frequency distributions) to derive mean estimates of guided and non-guided angler effort, as shown in Tables 9 and 10, and compared to estimated shore angler effort in Table 11. These estimates are illustrated in Figure 5. In total, of the estimated 196,092 angler-h spent fishing on the Bow River during June to September 2018, shore anglers spent approximately 96,900 angler-h (49%), non-guided boat anglers spent approximately 60,000 angler-h (31%) and guided boat anglers spent approximately 39,100 angler-h (20%).

TABLE 7
Number of guided interviews (boat interviews only, randomly interviewed) on the Bow River, 2018.

	June	July	August	September
Section 1	NA	NA	0	NA
Section 2	4	7	17	29
Section 3	18	29	37	18
Section 4	4	87	69	37

TABLE 8
Number of non-guided interviews (boat interviews only, randomly interviewed) on the Bow River 2018.

	June	July	August	September
Section 1	NA	NA	2	NA
Section 2	1	20	6	7
Section 3	47	55	49	33
Section 4	22	170	111	56

TABLE 9
Ground surveys: estimate of guided boat angling effort (number of hours) on the Bow River 2018.

	June	July	August	September	Section sum
Section 1	NA	NA	0	NA	0
Section 2	580	1,518	4,526	3,600	10,224
Section 3	1,650	4,116	4,245	1,769	11,780
Section 4	619	6,087	6,954	3,405	17,065
Monthly sum	2,849	11,721	15,725	8,774	
Total					39,069

TABLE 10
Ground surveys: estimate of non-guided boat angling effort (number of hours) on the Bow River, 2018.

	June	July	August	September	Section sum
Section 1	NA	NA	434	NA	434
Section 2	145	4,336	1,597	869	6,948
Section 3	4,308	7,807	5,622	3,244	20,980
Section 4	3,405	11,894	11,187	5,153	31,639
Monthly sum	7,858	24,037	18,840	9,266	
Total					60,001

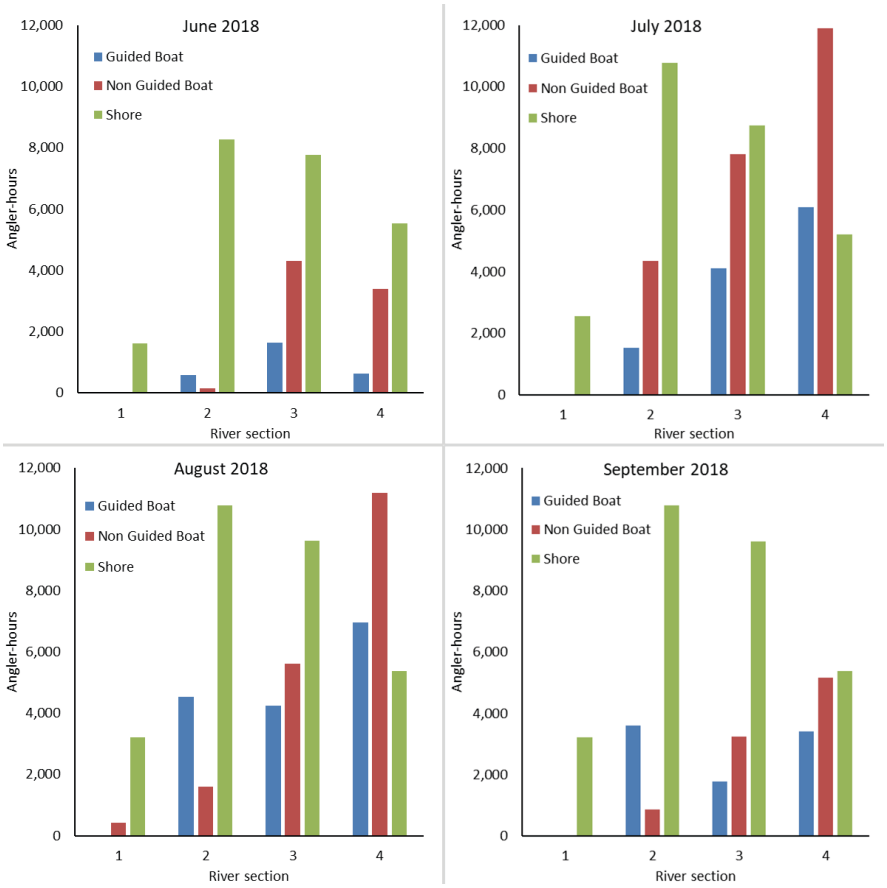
TABLE 11

Ground surveys: estimate of shore angling effort (number of hours), on the Bow River 2018.

	June	July	August	September	Section sum
Section 1	1,609	2,544	3,211	1,830	9,194
Section 2	8,283	10,768	10,786	8,288	38,124
Section 3	7,773	8,737	9,612	4,095	30,217
Section 4	5,525	5,210	5,375	3,214	19,324
Monthly sum	23,190	27,259	28,984	17,426	
Total					96,859

FIGURE 5

Estimates of 2018 angler effort; guided boat, non-guided boat and shore angling by month and survey section



Discussion

Population analysis undertaken by Cahill et al (2018) for index sites immediately below Policeman's Flats boat launch showed a population level decline of rainbow trout between 2003 and 2013 on the Bow River in a fishery experiencing multiple stressors. In order to ensure sound management of the Bow River fishery, it is vital to understand how angler effort will change in the future, as angler effort may be a key driver of fish populations in addition to other environmental factors, which are discussed in more detail below. The last angler use survey on the Bow River was conducted in 2006 and it was expected that angler use would have increased due to Alberta's human population growth over that period. According to the 2018 survey, angler effort has increased approximately 15% (1.2% annually) since 2006, which is less than Calgary's population growth rate of 32% (2.1% annually) over the same period (Calgary Economic Development 2019).

The 2018 angler survey showed that the Bow River is one of Alberta's most heavily used fisheries (196,092 angler/hours during June-September 2018), with only Lesser Slave Lake having similar levels of angler effort (194,149 angler-h (95% CI 175,902-213,114) between May 16 and August 31, 2013). Notably, the Bow River has experienced a +15% change between 2006 and 2018 surveys while Lesser Slave Lake experienced a -31% change between 2005 and 2013 surveys. Another fishery in Alberta considered as "high effort" is Pigeon Lake, which had 43,000 angler hours in 2007. A graphical comparison of angler use for select Alberta waterbodies is presented in Figure 6. Though not directly comparable between lentic and lotic systems the density of angler hours on the Bow River was 185.8 hours/ha in 2018 compared to 4.0 hours/ha on Pigeon Lake in 2007, and 1.6 hours/ha on Lesser Slave Lake in 2013. A graphical comparison of angler hours/ha for select Alberta waterbodies is presented in Figure 7. The Bow River fishery remains extremely popular all year, and angler effort between October and May remains a key uncertainty to assessing the overall impact of angling on the fishery. Anecdotal information obtained from local angler groups and local Alberta Government enforcement staff indicate that effort in this period is considerable, even during the winter months.

Estimates derived through ground-based counts vs. helicopter counts were significantly different, with helicopter counts estimating lower effort than ground-based counts. It is assumed that ground-based counts are more reliable estimators of angler use, as ground crews have the ability to accurately discern and count boat anglers (vs. passive boat passengers), and are able to count shore anglers that would otherwise be missed by helicopter-based observers. Additionally, helicopter surveys are generally biased to complete surveys in periods of good weather (i.e. during clear, sunny days), whereas ground based observers are not constrained by weather conditions. Helicopter surveys were further constrained by Transport Canada and Calgary Airport Authority aviation requirements, which requires helicopters to avoid flying at certain times, in certain locations, and at elevations necessary to accurately count anglers. Given these constraints (and the significant expense), it is recommended that future surveys on the Bow River focus solely on ground or river based counts.

FIGURE 6
Comparison of total angler hours at various Alberta waterbodies

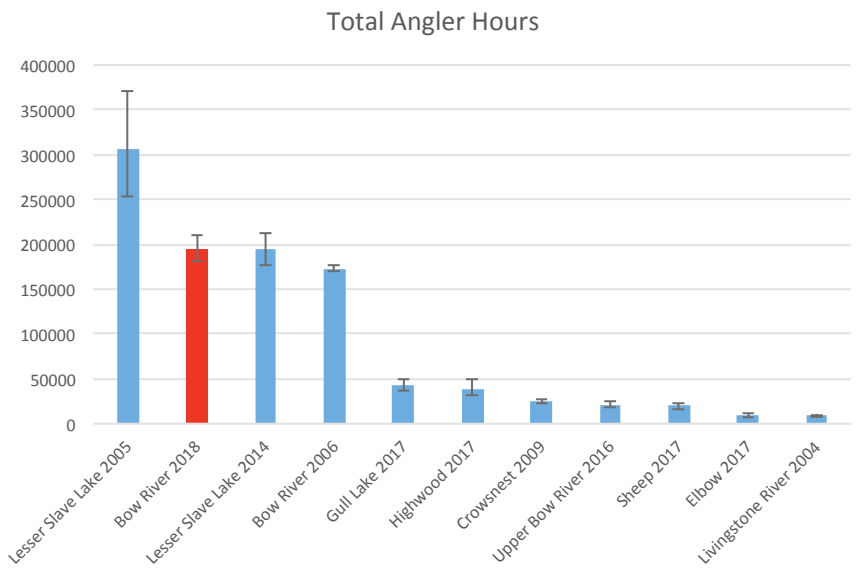
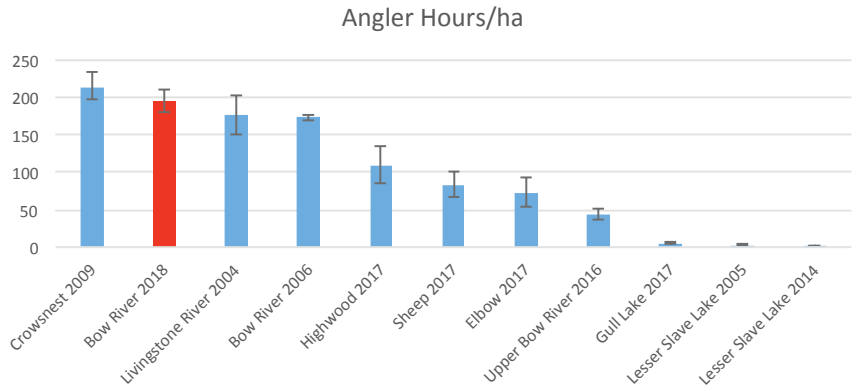


FIGURE 7
Comparison of angler hours/ha at various Alberta waterbodies



Though discussed in the 2006 Creel Survey Catch-per-unit-effort (CUE) was not measured in the 2018 survey, as self-reported catch rates are considered biased, and not reliable (Sullivan 2003). Due to the unreliability of this metric it should not be used to infer population trends for the Bow River. Hyperstability of catch rates (i.e. catch rates remain high but population data shows declines) has been observed in several fisheries globally. Thus, stability in catch rates should not be inferred as stability in population abundance, however, significant reductions in catch rate (i.e. anglers reporting no catches over significant time periods, or for experienced anglers) may be indicative of significant population level effects that occur with rapid onset (i.e. whirling disease response).

Recommendations

Although the focus of this study was to measure angling effort the Bow River fishery, it is important to note that there other key drivers that affect the overall abundance and structure of fish populations. These other key drivers (i.e. environmental flows, water quality, habitat alteration, flooding, high water temperatures, whirling disease, productivity changes, dams, avian predator dynamics and others) need to be modelled and evaluated within a cumulative effects framework to better understand the effects of various stressors on the Bow River fish populations. While some of these factors may be beyond the control of fisheries managers (e.g. dams, climate change), it is nonetheless important to understand how these factors interact synergistically so that appropriate management strategies can be developed to ensure long term sustainability of Bow River fish population. Perhaps most importantly management strategies (and corresponding management actions) must be implemented and monitored to determine which actions are useful and can be applied into the future.

Given the high angling effort on the Bow River, catch and release mortality may be a key driver affecting trout populations on the Bow River. Future work needs to be conducted to better understand the extent to which high angling effort is an issue, and how different angling variables affect fish mortality (i.e. interaction of catch rates, water temperatures, flow rates, gear type, season etc.) To maintain fish populations at current levels, or to increase trout populations to a higher level of abundance, changes to existing angling regulations could be required, particularly since the number of anglers in Alberta is expected to increase in the future. Anglers and the public should be engaged in discussions related to the desired state and future management options for the Bow River fishery (including a clear understanding of management options and tradeoffs) and ultimately be supportive of future angling regulation changes to ensure sustainability of the fishery.

Future angler use surveys for the Bow River could focus on using more contemporary methods, which obtain suitable estimates of angler effort at lower effort and cost than conventional angler use surveys. These methods may include camera-based surveys at key access or vantage points, or smart-phone “app” based estimates of angler effort, which allow anglers to directly contribute to fisheries management surveys. Additionally, future smart phone surveys should include a component of photo-verification to ensure that fish identification (and therefore catch per unit effort calculations) are accurate in a multi-species fishery, but being mindful that additional handling stress may cause additional mortality.

Appendices

Appendix 1
The temporal and spatial schedule of instantaneous counts by month and section (2018). The ground and aerial surveys are indicated in red and blue font, respectively. Surveys were scheduled from June to September during AM (0800-1500) or PM (1500-2200) shifts.

June 2018, Section 1						
Sat	Sun	Mon	Tue	Wed	Thur	Fri
						1
2	3	4	5	6	7	8 AM
9	10	11	12	13	14	15 PM
16 AM PM	17	18 AM	19 PM	20	21 AM PM	22 AM
23	24	25	26	27	28	29
30						

June 2018, Section 2						
Sat	Sun	Mon	Tue	Wed	Thur	Fri
						1
2	3	4	5	6 AM	7	8
9	10	11	12	13	14	15 PM PM
16 AM AM	17	18	19 PM	20	21 AM	22 PM
23 AM	24	25	26	27	28	29
30 PM						

Appendix 1

June 2018, Section 3						
Sat	Sun	Mon	Tue	Wed	Thur	Fri
						1
2	3	4	5 PM	6	7	8
9 PM	10	11	12	13	14	15 PM
16 AM	17 PM	18 AM	19	20 PM	21 AM	22
23 PM	24 AM	25	26	27	28	29 PM
30 PM						

June 2018, Section 4						
Sat	Sun	Mon	Tue	Wed	Thur	Fri
						1
2	3	4	5	6	7 PM	8
9	10	11	12	13	14	15 PM PM
16 AM	17 AM	18	19	20 PM	21 AM PM	22
23	24 PM	25	26	27	28	29 PM
30						

Appendix 1

July 2018, Section 1						
Sat	Sun	Mon	Tue	Wed	Thur	Fri
	1 AM PM	2 PM AM	3	4 PM	5	6
7	8 AM	9	10	11	12	13 PM
14 PM	15	16 AM	17	18 PM AM	19 AM	20 PM PM
21	22	23	24	25	26	27
28	29 PM	30	31			

July 2018, Section 2						
Sat	Sun	Mon	Tue	Wed	Thur	Fri
	1 AM PM	2 PM AM	3	4	5 PM AM	6 PM
7	8	9	10	11	12	13 PM
14 PM	15	16	17 AM	18 PM	19 AM	20 PM
21 PM	22 AM	23	24	25	26	27 PM
28 AM	29	30	31			

Appendix 1

July 2018, Section 3						
Sat	Sun	Mon	Tue	Wed	Thur	Fri
	1 AM	2 PM	3 AM	4	5	6 PM
7 AM	8	9	10	11	12	13
14	15 PM	16	17 PM	18 PM	19 AM PM	20 PM
21 AM	22	23	24	25	26	27
28	29	30 AM	31 PM			

July 2018, Section 4						
Sat	Sun	Mon	Tue	Wed	Thur	Fri
	1 AM	2 PM	3	4 AM	5	6 AM
7 PM	8 PM	9	10	11	12	13
14	15 PM	16 PM	17	18 PM AM	19 AM PM	20 PM AM
21	22	23	24	25	26	27
28 AM	29 PM	30	31 AM			

Appendix 1

August 2018, Section 1						
Sat	Sun	Mon	Tue	Wed	Thur	Fri
				1	2 PM	3
4 PM AM	5 AM AM	6	7	8	9	10 PM
11	12	13	14 PM	15 PM	16	17 PM
18 PM	19	20	21	22	23	24
25	26 AM AM	27 AM	28 PM	29 PM	30	31

August 2018, Section 2						
Sat	Sun	Mon	Tue	Wed	Thur	Fri
				1 PM	2 AM	3
4 PM AM	5 AM	6	7	8	9	10 PM
11	12	13	14 PM	15	16 PM	17
18	19	20	21	22	23	24 PM
25 AM	26 AM PM	27 AM	28 PM PM	29	30 AM	31

Appendix 1

August 2018, Section 3						
Sat	Sun	Mon	Tue	Wed	Thur	Fri
				1	2	3
4 PM PM	5 AM	6 AM	7	8	9	10
11 AM	12 PM	13 PM	14	15 PM	16	17
18	19 AM	20	21	22	23	24 PM
25	26 AM	27 AM AM	28 PM PM	29	30 AM	31 PM

August 2018, Section 4						
Sat	Sun	Mon	Tue	Wed	Thur	Fri
				1 AM	2	3
4 PM	5 AM	6	7	8	9	10
11 PM	12 PM	13 PM	14	15	16	17 AM
18 PM	19 PM	20	21	22	23	24
25 AM	26 AM	27 AM PM	28 PM	29 PM	30	31 PM

September 2018, Section 1						
Sat	Sun	Mon	Tue	Wed	Thur	Fri
1	2	3	4	5	6	7 PM
8	9 PM	10	11	12 AM	13	14
15	16 AM	17	18	19	20	21
22 PM	23 PM PM	24 AM PM	25	26 AM	27 PM	28
29 AM PM	30					

September 2018, Section 2						
Sat	Sun	Mon	Tue	Wed	Thur	Fri
1 AM	2	3 AM	4	5	6	7
8 PM	9 PM	10 AM	11 PM	12	13	14
15 PM	16	17	18	19	20	21
22	23 PM PM	24 AM PM AM	25 PM	26	27	28
29 AM	30 AM					

Appendix 1

September 2018, Section 3						
Sat	Sun	Mon	Tue	Wed	Thur	Fri
1	2 PM	3	4	5	6	7
8	9	10 PM	11 PM	12	13	14 AM
15 PM	16	17	18	19	20	21 PM
22 PM	23 PM	24 AM PM	25	26 AM	27 PM	28 AM
29 AM	30					

September 2018, Section 4						
Sat	Sun	Mon	Tue	Wed	Thur	Fri
1 PM	2 PM	3	4	5	6	7 PM
8 AM	9	10	11	12	13 AM	14 PM
15	16 AM	17	18	19	20	21 PM
22	23 PM	24 AM PM PM	25 AM	26	27	28
29 AM PM	30					

Appendix 2

Instantaneous count data of boat and shore anglers collected during ground surveys (2018).

June Boat				June Shore			
Section 1	Section 2	Section 3	Section 4	Section 1	Section 2	Section 3	Section 4
0	0	12	0	1	13	19	4
0	0	17	10	6	22	23	2
0	0	29	16	3	16	40	55
0	0	17	14	3	43	16	2
0	3	15	19	8	12	11	12
0	6	2	4	2	3	13	9
	3	7	4		28	13	8
		16				13	
		13				19	

July Boat				July Shore			
Section 1	Section 2	Section 3	Section 4	Section 1	Section 2	Section 3	Section 4
2	3	12	17	6	38	6	6
0	21	7	29	1	10	9	14
0	17	59	76	5	29	21	24
0	7	27	81	6	12	33	2
0	2	21	50	6	10	24	15
0	8	19	12	13	18	34	18
0	14	55	30	6	50	15	7
0	9	30	39	3	20	12	18
0	6	17	30	9	34	27	8
0	32		39	4	19		13
	9		78		29		13
	34		16		29		6

Appendix 2

August Boat				August Shore			
Section 1	Section 2	Section 3	Section 4	Section 1	Section 2	Section 3	Section 4
6	5	9	30	7	19	26	14
2	11	57	33	7	22	24	20
2	24	40	64	28	26	27	9
0	5	13	37	3	4	29	9
0	9	11	45	9	24	32	15
0	21	14	80	3	18	14	14
0	8	56	52	3	45	38	21
0	36	7	40	1	37	14	17
0	5	11	10	6	40	5	1
0	5	16	41	7	22	21	8
	26	23	27		16	18	8
		15				17	

September Boat				September Shore			
Section 1	Section 2	Section 3	Section 4	Section 1	Section 2	Section 3	Section 4
2	22	28	19	10	16	28	13
0	17	2	40	7	14	7	32
0	4	26	47	3	29	9	10
0	14	5	34	4	25	2	15
0	8	17	14	3	14	13	2
0	5	3	7	8	28	6	1
0	20	8	8	2	11	7	2
0	4	11	5	4	35	14	6
0	2	7	8	2	6	4	4
0	18	20	16	2	31	15	6
0	3	4	29	3	8	2	1
			18				0

Appendix 3

Instantaneous count data of boat and shore anglers collected during aerial surveys (2018).

June Boat				June Shore			
Section 1	Section 2	Section 3	Section 4	Section 1	Section 2	Section 3	Section 4
0	12	22	22	13	15	16	2
0	5	11	12	2	24	15	13
0	13	28	6	2	12	6	4

July Boat				July Shore			
Section 1	Section 2	Section 3	Section 4	Section 1	Section 2	Section 3	Section 4
2	25	29	19	8	19	12	9
0	2	32	28	1	9	6	2
0	32	28	29	5	25	7	2
0	27	55	22	3	3	10	11
		35	37			4	3

August Boat				August Shore			
Section 1	Section 2	Section 3	Section 4	Section 1	Section 2	Section 3	Section 4
1	5	11	17	5	15	11	5
0	21	70	20	6	18	21	8
1	10	45	26	4	9	22	9
0	5	22	37	0	0	2	2
0	2	23	23	2	15	22	8

September Boat				September Shore			
Section 1	Section 2	Section 3	Section 4	Section 1	Section 2	Section 3	Section 4
0	4	16	13	2	8	6	1
0	6	14	14	2	3	7	3
0	19	31	8	0	5	10	0

Appendix 4

Instantaneous count data of anglers collected with ground surveys (2006).

June			
Section 1	Section 2	Section 3	Section 4
15	22	24	23
5	13	1	50
3	11	25	4
1	5	22	2
5	11	3	7
11	11	45	16
5	14	12	2
2	10	0	4
1	4	2	2
1	0	4	0
18	16	2	1
1	52	0	0
	24	3	
	20	2	
		10	
		56	
		13	

July			
Section 1	Section 2	Section 3	Section 4
4	39	73	70
15	24	45	28
9	30	25	40
4	28	14	16
1	14	31	47
4	21	21	60
5	36	58	66
16	68	45	28
8	29	95	58
1	30	25	76
2	26	83	63
6	13	67	9
2	21	18	47
6	21	57	28
12	41	3	
		23	
		44	
		78	
		138	
		24	

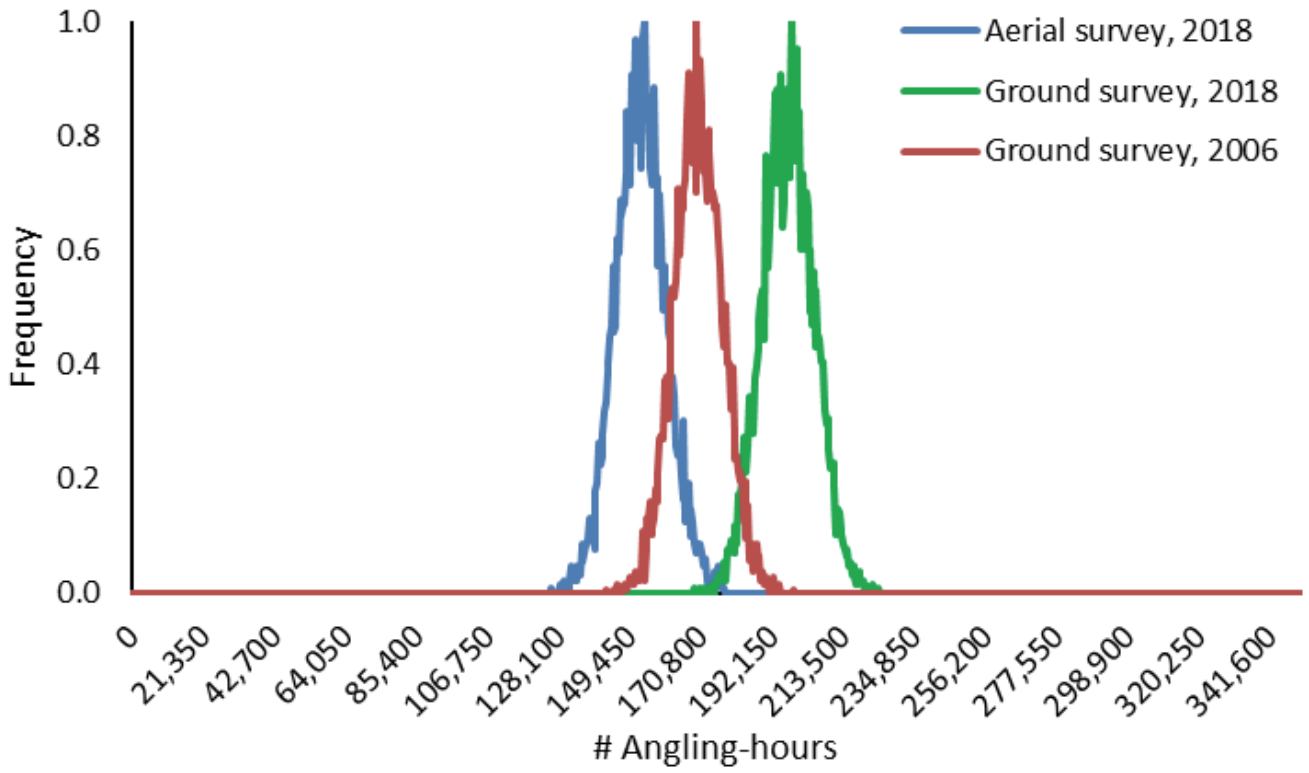
Appendix 4

August			
Section 1	Section 2	Section 3	Section 4
7	12	10	36
8	10	54	36
0	25	39	30
8	30	59	64
7	48	71	21
24	14	96	37
6	19	97	28
3	15	75	47
5	23	37	31
3	25	35	81
12	37	49	65
12	22	94	18
7	13	67	53
3	12	27	51
7	10	37	27
		82	
		33	
		24	
		22	
		43	

September			
Section 1	Section 2	Section 3	Section 4
5	29	46	26
15	20	49	43
13	46	118	52
5	43	71	73
4	53	71	21
1	3	37	21
0	18	44	0
10	1	1	2
9	0	7	9
8	6	35	52
0	4	26	69
4	33	53	15
4	7	38	14
10	5	24	32
15	14	27	80
		21	
		38	
		60	

Appendix 5

Estimates of angling effort (2006 and 2018), based on frequency distribution of instantaneous counts multiplied by number of sampling frames.



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