THE ALBERTA TROUT FISHERY
A VISION FOR THE FUTURE

Peter Crowe-Swords

March 01, 2020

THE ALBERTA TROUT FISHERY – A VISION FOR THE FUTURE.

Introduction:

The Alberta recreational trout fishery has come under pressure in recent years with reports of declining Westslope cutthroat trout and bull trout populations across all four of the foothills fishing zones [(1)] In 2018, a retrospective data analysis of the Bow River rainbow trout population reported a decline of 40 – 50% over a 10-year period of 2003 to 2013[(2)]. Although the cause/effect for the decline was not determined, it was suggested that angling effort could well be the major contributor to the decline. Alberta Environment & Parks Fishery Management Branch followed this report with a detailed Bow River fish population survey in 2018 and again in 2019 that indicate rainbow trout, brown trout and mountain whitefish populations continue to decline that would suggest the Bow River trout fishery is under serious threat and needs a change in management policy to recover the trout population[(3)] .

Angling effort is not the only possible cause for Alberta trout population decline. Habitat degradation, water management policies, climate change that impacts food source and environmental temperatures, industrial and human encroachment into the watershed, wastewater treatment, invasive species and disease are suggested to be the principal causes from an even larger list of threats. Many of these threats have been present for some time, but the cumulative effect of multiple threats will certainly compound and possibly expedite trout population declines.

The Alberta Government has established several fishery related recovery programs in recent years. In the mid to late 1990s a province-wide recovery program was put together for walleye (**Alberta's Walleye Management Recovery Plan (WMRP))** and northern pike **(Alberta's Northern Pike Management and Recovery Plan (NPMRP))** fisheries throughout the province that have stabilized population. **The West Slope Cutthroat, Bull Trout and Athabasca Trout Recovery Programs** have been established to aid the **Canadian Species at Risk (SASA) legislation. Alberta's North Central Native Trout Recovery Program (NCNT**) a comprehensive, long-term fish conservation initiative aimed recovering populations of native trout and whitefish in the central and northern watersheds of the Eastern Slopes Fish Management Zones was proposed in 2018 but withdrawn later due to stakeholder opposition. **The Southern Alberta Fisheries Habitat Enhancement and Sustainability (FISHES) Program,** developed to effectively restoring flood affected fish habitat has been successful restoring both native and non-native trout habitat in southern Alberta.

But as non-native species, rainbow trout and brown trout population declines have to date not been recognized is the same way. The recent **AEP Fishery Management Workshops** and web engagement surveys have given encouragement that support for policy change will take place. This document addresses the social-economic issues facing the fishing community, possible fishery management policy changes and what should be considered immediately to start a Recreational Trout Fishery Recovery Program.

1. Where and How Many People Fish in Alberta And What Is The Contribution To The Economy?

Alberta Environment and Parks, Fisheries Management Branch's ***Sports Fishing in Alberta, 2010 Survey*** [(4)] reported 239,310 licensed adult anglers in Alberta, Table 1. A total of 85,436 (36%) of those identified in the survey lived in the Eastern Slopes Zones that encompasses Calgary and the eastern slopes of the Rocky Mountains. A further 112,190 (47%) license holders live in the Parkland Prairies Zones that includes the cities of Edmonton, Red Deer and Lethbridge. The remaining 41,684 (17%) licensed anglers

live in the Northern Boreal Zones (Appendix 1). The 2015 survey reported that Alberta has 301,531 licensed adult anglers, a 26% increase from 2010. The 2015 survey did not report regional angling activity within Alberta and therefore the increase in 2015 licensed anglers was distributed equally across all zones.

Alberta residents spent $2,018 per year on their sport in 2010, fishing 14.8 days for an average cost of $137 per day. But unfortunately, a detailed expense analysis is not available for 2015, therefore an annual inflation rate of 1.7% was used to derive the 2015 angler expense data. Alberta anglers spent a total of $482.93 million and their fishing activities in 2010 and increased to $660.35 million in 2015. The largest expense was reported in the Parkland Prairie Zones that includes three of Alberta's larger cities but may not represent fishing activity in the resident zones. A significant number of these residents' fish in one of the four East Slopes Zones that would add to the economic importance of East Slopes fishery. In addition, resident fishing license sales reported by Alberta Environment & Parks have dropped in recent years from a high of 303,213 in 2015 to 267,630 in 2018 which would suggest the struggling Alberta economy is having an impact on angling activity in the province.

Table 1: The Number of Fishing Licenses and Angler Expense by Fish Management Zones in Alberta.

Fish Management Zones	Anglers		Expenses	
	2010	2015	2010	2015
East Slopes 1 - (ES1)	56,519	**71,214**	$ 114,055,342	**$ 155,958,529**
East Slopes 2 - (ES2)	9,280	**11,693**	$ 18,727,040	**$ 25,607,232**
East Slopes 3 - (ES3)	7,205	**9,078**	$ 14,539,690	**$ 19,881,477**
East Slopes 4 - (ES4)	12,432	**15,664**	$ 25,087,776	**$ 34,304,861**
Subtotal	**85,436**	**107,649**	**$ 172,409,848**	**$ 235,752,098**
Parkland Prairie 1 - (PP1)	21,786	**27,450**	$ 43,964,148	**$ 60,116,288**
Parkland Prairie 2 - (PP2)	90,404	**113,909**	$ 182,435,272	**$ 249,460,798**
Subtotal	**112,190**	**141,359**	**$ 226,399,420**	**$ 309,577,086**
Northern Boreal 1 (NB1)	14,581	**18,372**	$ 29,424,458	**$ 40,234,811**
Northern Boreal 2 (NB2)	13,895	**17,508**	$ 28,040,110	**$ 38,341,863**
Northern Boreal 3 (NB3)	9,606	**12,104**	$ 19,384,908	**$ 26,506,796**
Northern Boreal 4 (NB4)	3,602	**4,539**	$ 7,268,836	**$ 9,939,359**
Subtotal	**41,684**	**52,522**	**$ 84,118,312**	**$ 115,022,830**
TOTAL ALBERTA RESIDENTS	**239,310**	**301,531**	**$ 482,927,580**	**$ 660,352,014**
Non-Resident Canadian	8,887	**9,065**	$ 8,247,136	**$ 9,128,193**
Non-Resident Foreigners	4,354	**4,441**	$ 5,708,094	**$ 6,315,216**
TOTAL NON-RESIDENT	**13,241**	**13,506**	**$ 13,955,230**	**$ 15,443,409**

2. Trends in Fish Activity:

The Alberta component of the Canadian recreation fishing trends survey was compiled by Alberta Environment & Parks, Fisheries Management Branch, in March 2012[1] and asked anglers their opinions of certain factors relevant to the management of Alberta fisheries:

- *Nearly two-thirds (62%) of all anglers reported that they preferred to fish for native verses non-native fish.*
- *A similar proportion (66%) felt that eating some of the fish that they caught was important to them.*
- *Less than half (45%) indicated that to them, fishing at stocked trout ponds and lakes was an important feature of angling in Alberta.*
- *Only one-quarter (25%) of anglers were concerned enough about handling or harming too many fish in a day to end their fishing day early.*
- *Just over half (53%) of anglers would choose to catch a few large fish in preference to catching a greater number of small fish, the latter chosen by 30% of anglers.*
- *Fully half (50%) of all anglers are concerned about the effects of climate change on Alberta's fisheries, whereas less than one-quarter (22%) are not worried about this controversial issue.*
- *Not surprisingly, a majority of anglers (74%) are disturbed by the effects of invasive aquatic species on the water bodies of Alberta.*

Although the survey sheds light on a provincial wide perspective of angler opinions, it may not represent fairly those angling activities in the four East Slopes Fishing zones of south-central Alberta where a declining trout population has prompted a heightened awareness and concern for the protection of the fishery. For example, a summary of the 2006 Alberta Conservation Association Bow River Sports Fish Angler Survey [5] sheds light on angler effect in the ES1 Zone Bow River non-native trout sports fishery:

- An estimated 24,675 angling trips were made representing an estimated 172,974 (169,250 - 176,700) angling hours (1730 h/ha km or 161 h/ha) over the entire survey area.
- An estimated 62,755 rainbow trout were captured representing a catch rate of 0.37 trout/h. Sixty percent of the rainbow trout caught were > 35 cm (14") in length.
- *An estimated 15,690 brown trout were captured representing a catch rate of 0.08 trout/h. Large brown trout,> 35 cm in length (14") comprised 55% of the catch.*
- ***Only three rainbow trout and seven brown trout were reported kept by anglers indicating a near complete catch-and-release fishery for these species**.*
- ***Fly-fishing was the preferred method of angling in this study, accounting for 70% of the anglers. Only 1% of the anglers interviewed used bait, with the remainder using lures.***

The survey was repeated by Alberta Environment & Parks in 2019 who have indicated angler effect has increased by 15% since the 2006 ACA survey [3]. This, combined with the 2018 report documenting a 40 to 50% decline in rainbow trout population between 2003 and 2013[3] indicates that immediate action is needed on the part of AEP fishery management regulators to reduce further Bow River fish population declines and hopefully return the river to what was once recognized as a "World-Class Blue-Ribbon Trout Stream".

3. The Diversity of Outdoor Recreation Plays an Important Role.

The 2017 Alberta Recreation Survey [6], conducted by Alberta Culture & Tourism reported 30.7 % of Alberta respondents participated in swimming (lakes & rivers), fishing 19.2%, motor boating 13.9%, canoeing at 11.7% and kayaking at 8.5%. These data suggest that there are large numbers of participants outside of the fishing community using lakes and rivers near major cities. **Table 2** shows the number of Calgarians who participate in the 5 most popular water-based activities. There is a wide range of expenditure in the sports and recreational activities depending at what level of participation and competition takes place. For example, members of Alberta Slalom Canoe Kayak do spend anywhere in the range of $100 to $20,000 / year. For the purpose this data set, an estimate of $500 per year was applied to all categories except for swimming that would generally be supplemental to other outdoor pursuits. The total economic contribution of water-based activities to Calgary is approximately $65 million of which the fishing community contributes 25%.

Table 2: The Number and Percentage of Calgarians who Participate and Actively Engage (20%) In Water Based Activities.

Sports Discipline	Participation % Population	Calgary Participation	Actively Engage	Total Expenditure
Swimming	30.7%	380,680	76,136	
Fishing	19.2%	238,080	47,616	$ 23,808,000
Power boating	13.3%	164,920	32,984	$ 16,492,000
Canoeing	11.7%	145,080	29,016	$ 14,508,000
Kayaking	8.5%	105,400	21,080	$ 10,540,000
		Total		$,65,348,000

The Canadian Parks and Wilderness Association survey, **Albertans' Values and Attitudes Towards Recreation and the Wilderness, 2015** [7] reported recreation use in Alberta**.** Hiking (54%), bicycling (40%), camping (34%) walking (32%) and fishing (17%), topped the list of summer and fall activities for Albertans. Swimming outdoors (13%) Canoeing (8%), power boating (6%) off-road motorcycling or off highway vehicle use (6%) hunting (5%) Mountain biking 5% are popular activities regardless of where people live in Alberta. Bicycling and walking for pleasure or exercise are also popular activities throughout the province, but most popular in urban areas. Fishing ranks third in popularity among those living outside of cities and metropolitan areas. One important finding from the survey was that even when national and provincial parks were nearby as is the case with Calgary, 79% of respondents preferred to use community parks and pathways close to home.

It is important to recognize that no single outdoor recreation pursuit can be discussed in isolation without impacting other user groups, but when combined offer a powerful voice for the benefit of all recreational users. This can be seen very clearly with Calgary River Users' Alliance advocacy and support for the **Calgary River Access Strategy**. Two documents were presented to Calgary City

Council, "**The Economic Importance of Recreational River Use to the City of Calgary"** [8] and **"The Need for a River Recreation Management Plan"** [9] delivered a comprehensive analysis of the benefits to the City of Calgary and all river recreation users with an integrated approach to the protection of the river's habitat and fish population while developing river access infrastructure and amenities. A public debate and approval by City Council reached a satisfactory outcome with the 2017 City Council's $7.60 million commitment to develop a series of designated boat and hand launch sites throughout Calgary that will eventually service all river recreation users.

An example of a less favorable outcome was Alberta Environment and Parks development of the **Bow River Access Plan** in 2017. Although discussions were held with various user and interest groups the decision-making process was kept within the AEP and focused on fishing access needs. The Bow River Access Plan was finally approved in the spring of 2019 as principally an existing site maintenance plan, with no new river access sites that would disperse the fishing boat traffic across the river from Calgary downstream to Carseland. Other outdoor and water-based activities were not considered as major users of river access sites. Unfortunately, it is not clear why this happened, but there appeared to be a focus solely on recreation angling needs and not a broader based outdoor recreational activity initiative. Although the existing river access infrastructure improvements will be made in the future, with road access improvements to McKinnon's Flats, the first item on the agenda. It is understood that the long-term development plans for the McKinnon's Flats is for a provincial park. This should have been in the forefront of discussions when the plan was first discussed.

One can only question why the Bow River Access Plan rolled out the way it did with only a focus on fishery activities. A more diverse engagement process needs to be considered with Alberta Environment & Parks stakeholder engagement initiatives. It is hoped that the current Fishery Management Forms do consider all outdoor recreation activity use of lakes, rivers and land use. Without doing so conflicts and oppositions to proposals will take place.

4. The Future of Fishing in Alberta

Does Alberta Attract Anglers? Alberta has an abundance of lakes, reservoirs, rivers and streams spread across the backdrop of the Rocky Mountains and the Northern Boreal Forest that attracts visitors from across the world. Table 3 illustrates that non-resident anglers represent less than 6% of all fishing licenses sold in Alberta and although a sizable contribution to outfitter and guide businesses in the province has little impact on province wide recreational fishing policy.

Table 3: Alberta Sports Fishing Licenses Sales 2014 – 2018

Year	2014	2015	2016	2017	2018
Resident License	270,750	293,019	287,687	289,812	264,068
Non-resident Canadian License	9,675	10,193	9,550	9,034	8,152
Non-resident Foreign License	4,036	4,701	5,277	5,939	5,786

THE ALBERTA TROUT FISHERY – A VISION FOR THE FUTURE.

The Importance of Angler Activity: The residence of Alberta anglers in either East Slopes or Parkland Prairie Zones has most likely influenced the importance of each zone fishery management policy. But it is important to recognize that three of Alberta's larger cities, Edmonton, Red Deer and Lethbridge are in the Parkland-Prairie Zone with an estimated 30% fishing the East Slopes Zones. This would indicate the data presented in Table 1 does not fairly represent the importance of the East Slopes fishery activity that would be characterized as Alberta's principal trout fishery. **By making the adjustment from 2015 angler residence to angler activity, 42,408 anglers are moved from the Parkland-Prairie Zones to East Slopes Zone. Therefore, active anglers (and expenses) in the East Slope Zones at 150,057 ($328.6 M) as compared to for the Parkland Prairie Zones at 98,951 ($267.1 M).**

Angler Age Demographic: Angler age could well impact the locations within Alberta that are fished. The last age analysis of Alberta fishing activities was conducted in 2010. It showed the majority of anglers were in the 45-64 years old age group with an overall average of 45 for all Alberta Residents. Non-resident anglers tended to be older at 53 for non-resident Canadians and 55 for foreign anglers. The more recent Canadian data reported that 42% of anglers were in the 45-64 age group and 37% in the 25-44 age group and 14% were 65 or older. A younger population of anglers will have more mobility, participate in a wider variety of outdoor activities and especially back-county pursuits. Adding the proximity of Alberta's major cities to the mountain recreation areas, would suggest that an increasing number of younger anglers will gravitate to East Slope fisheries as well as an opportunity to pursue other wilderness activities. **Although purely speculative, the East Slopes fishery may well have become the principal recreation fishing resource in Alberta purely because of a shifting age demographic. Further surveys are needed to support this speculation. One way this hypothesis could be tested is by the introduction of a Conservation License for East Slopes Zones fishery to not only support fishery enhancement Initiatives but also generate much needed information on the East Slopes fishery.**

The Impact of Water Management Policy on Fish Populations: Wherever there is flowing water in Alberta, there are water management practices in place to support industrial, agriculture irrigation use, hydropower generation and human population needs. The Bow River is the most regulated water resource in the province and one of the most important recreation fisheries in Alberta. The recent fish population study by the University of Calgary [(2)] and an AEP fish population survey [(3)] both revealed a dramatic decline in fish populations of the lower Bow River over the last 15 years. The causes for this decline have been suggested to be Whirling disease, angling pressure and flood events. However, flood events are known to replenish the gravel bed river ecosystem, Whirling Disease is known to be transient, and catch and release angler mortality can be negligible if properly implemented. The 2019 report, "**The Impact of Bow River Water Management on Fish Populations** [(10)]asserts the reasons for the fish decline are inadequately studied and documented and are likely the result of the complex nature of the Bow River's highly managed water supply and the interaction with disease, flood events or angling pressure as principal causes and effects. The report argues that a government review/revision of current water management protocols across departments as well as multi-disciplined scientific investigations are needed to protect the Bow River ecosystem and its fishery. Alberta water management policies will continue to be questioned as the impact of climate becomes more apparent. A proactive approach by the GOA is urgently needed.

Catch and Release: C&R angling has a long history in recreational angling worldwide. It has received increasing attention in recent years, especially with depleted wild populations of trout in North America. In Alberta where West Slope Cutthroat and Bull Trout are classified as "endangered" by Canadian Species at Risk (SASA) legislation, C&R is considered a critical component of trout population recovery programs. In general terms, C&R techniques are practiced in most of Alberta East Slopes Trout Fishing Zones even if regulations are not required [(5).]

An extensive world-wide review of catch and release techniques was published in 2007 [(11)]. The authors started by saying,*" The objective of this article is to provide a cohesive, synthetic view of C&R, including historical, ethical, social, and biological perspectives from around the globe. The basis of our syntheses is on peer-reviewed literature, acknowledging that important gray literature on C&R is available, much of which is not covered here".* And went on to say, *"Our aim is to help inform fishery management of policy and societal decisions".* Although C&R has generally aided in stabilizing populations it is unclear as to what degree lethal and non-lethal outcome result from C&R techniques. Capture-release-recapture and the degree of sublethal chronic injuries play an important role in mortality rates were documented. As were types of bait and lures, hook design and type, hook size vs fish size. Single vs treble hooks, barbed vs barbless hooks have not always shown significant differences or improvements in trout survival. But duration of studies could well have influenced outcome. Water and air temperature, both high and low, combined with species differences can also impact C&R survival rates. Although the review did not give a definitive conclusion of the benefits or otherwise for Catch and Release techniques, there is a likelihood that the cumulative effect of variables would impact the outcome (Appendix 2).

Although the fishing community and fishery managers generally recognize the benefits of catch-and-release to protect vulnerable fish populations, the degree of success will depend on the variables discussed previously. Unfortunately, there is an insidious social media component that has crept into the discussion recently. That is the impact of selfie photography on fish survival. Can Smartphones kill trout? AEP researchers, B.A. Joubert and his colleagues reported the following from their investigation [(12):]

> *We found that handling time and air exposure of large bull trout subjected to photography and measurement was long (112 s) and associated post-release mortality was high (10 dead / 30 fish; 33 % after 24 h observation).Immediate release mortality was also high (3 dead / 20 fish; 15 %). These levels of mortality, combined with high angler effort, can potentially lead to population-scale declines at C&R fisheries. The complexity and difficulty of population-scale and field-level measurements of cryptic mortality suggest that adaptive management experiments in reductions in angling effort and improved fish handling may be effective in increasing understanding of sustainable angling*.

Although a 30% mortality was reported from photography and double what it was in the control group would appear to most anglers to be extremely high, it is difficult to see what regulations could be placed on what is becoming an increasing component of modern-day recreational angling. The disturbing fact is that regardless of the regulatory constraints that could be put in place to protect and enhance fish populations, it is countered by a need by society to reward oneself with photos that few will remember within a year.

Cumulative Effect Computer Modeling: Understanding the overall threats within a fishery and the cumulative effect of those threats could play in fishery management policy is considered an important first step to fish population recovery [(1)]. Determining the relative importance that each threat plays is difficult, if not impossible. But with enough credible data available and combined into computer modelling techniques it will be possible identify priorities within fishery management policies. This is clearly the direction that needs to be taken to identify what issues can be addressed in Alberta's East Slopes Zones and specifically the Bow River non-native recreational fishery. Table 4 lists the threats that are considered to have contributed to the decline in the Bow River trout population. A complex list of threats that will be a challenge to change to protect the fishery.

Table 4: Bow River Trout Population Threats

- An ever-increasing number of anglers
- Whirling disease and invasive species.
- Limited regulation enforcement.
- Unknown fish population and reproduction dynamics
- Change in water quality and the impact on invertebrate life.
- Fish habitat degradation.
- Impact of climate change
- Bow Basin Water Supply Management Plan.
- Flood and drought control policy.
- Commitment to management of a non-native trout recreational sports fishery.
- Logging influence on the fishery – Highwood River Basin and others.
- Changing hydrology of the river – floods, flood mitigation
- Seasonal closures – short-term pain for long term gain.
- Fishing regulation change – triple hooks, single fly.
- Management of watercraft use and river access.
- Impact of predators on fish stocks.

5. Immediate Fishery Management Change

The importance of East Slopes recreation fishing activities has not been given enough importance by governments, stakeholders and activists in recent years. Admittedly native trout protection, Whirling Disease control and post-flood habitat enhancement programs have been established, but the economic importance of the East Slopes recreational trout fishery recovery needs more support. AEP Fishery Management Forums and web engagement process should identify initiatives that can be improved within fishery management. The recent announcement of improvements to Alberta's three fish hatcheries will play an important role to supplement fishing opportunities that may be lost from protection of East Slopes trout stream and river protection.

THE ALBERTA TROUT FISHERY – A VISION FOR THE FUTURE.

The proposed **Cumulative Effect Computer Modeling** within the South Saskatchewan River Basin will be an important step to establish future fishery management policies for foothill streams and most importantly the Bow River. Nevertheless, immediate action is needed on the part of Alberta Environment & Parks Fishery Management Branch to stop the decline in all wild trout populations and eliminate industrial threats to the fishery. A variety of regulation change have been put forward for the four East Slopes Zones.

- The 4 East Slopes Zones should be combined into a single **"Coldwater Habitat Subzone"** with the primary objective of supporting self-sustaining populations of both native and non-native trout populations.
- A **Coldwater Fish Conservation Stamp** to support habitat initiatives or development.
- The possible introduction of a **Special Waters Stamp** for those fisheries under increased angling pressure. For example, the Bow and Oldman and Crowsnest Rivers.
- Artificial lures only, single barbless hooks – no treble hooks
- Year-round open seasons for mainstems, lakes and other designated waterbodies with June 1 to October 31 open seasons on foothills rivers and streams.
- Spot closures or daily angling restrictions for high water temperature conditions, disease outbreak or environmental disaster.
- The introduction of an **East Slopes Outfitter and Guide License** to better understand and if needed regulate commercial use of recreation fisheries.
- Creating stocked water angling opportunities to offset the more restrictive angling regulation changes for the East Slopes fishery.

These regulation changes will help to disperse and reduce angling pressure on self-sustaining fisheries. An expansion of the existing put and take trout stocking program or rehabilitation and enhancement activities at existing sites would assure continued fishing opportunities for all anglers. Habitat improvement that result from an integrated approach to manage the growing human footprint will have significant rewards over the long term that will lead to more sustainable fisheries at less risk.

In closing there appear to be very few management changes outside of fishing regulations that would have an immediate positive impact on East Slopes trout populations. Cumulative Effect Computer Modelling will impact future directives, but all wild trout populations have reached or close to a non-sustainable level without immediate intervention.

Peter Crowe-Swords
March 01, 2020

THE ALBERTA TROUT FISHERY – A VISION FOR THE FUTURE.

References:

1. Sinnatamby, N., Cantin A., Post J.R. 2019. Threats to at-risk salmonids of the Canadian Rocky Mountain Region. Ecology of Freshwater Fish, Wiley.
2. Cahill, C., Mogensen, S.M. Wilson, K.L. Cantin, A. Sinnatamby, N. Post J.R. 2018. Multiple challenges confront a high-effort recreational fishery in decline. Bow River Basin Council Science Forum, May 2, 2018. https://www.researchgate.net/publication/326070777_Multiple_Challenges_Confront_an_Inland_Recreational_Fishery_in_Decline
3. Personal Communication, Alberta Environment & Parks
4. Sports Fishing in Alberta, 2010. Zwickel, H. 2012. Summary Report from the Eighth Survey of Recreational Fishing in Canada. Alberta Sustainable Resource Development, Fisheries Management Branch, Edmonton, Alberta
5. Ripley, T.D., and T. Council. 2006. Bow River Sport Fish Angler Survey, 2006. Data Report, D-2007-003, produced by the Alberta Conservation Association, Lethbridge, Alberta, Canada and Alberta Fish and Wildlife, Calgary, Alberta, Canada. 28 pp + App
6. The 2017 Alberta Recreation Survey. Alberta Culture and Tourism. July 2017 https://open.alberta.ca/dataset/58b1254f-9842-4abf-8bb5-86ecb940245e/resource/077024f6-9900-4c70-a101-d0c1c099b0c3/download/recreation-survey-2017.pdf
7. **Albertans' Valves and Attitudes Towards Recreation and the Wilderness,** 2015**.** The Canadian Parks and Wilderness Society Southern and Northern Alberta Chapters (CPAWS). https://s3.amazonaws.com/s3.arpaonline.ca/CPAWS_FINAL_REPORT_2015.pdf
8. **The Economic Importance of Recreational River Use to the City of Calgary** 2016. Calgary river Users Alliance. Presented to the City of Calgary, June 2016. https://www.calgaryriverusers.org/wp-content/uploads/2016/11/crua-economic-position-statement-to-city-of-calgary-revise-19-may-2016-1.pdf
9. **The Need for a River Recreational Management Plan**.2016 Calgary River Users Alliance. Presented to the City of Calgary, June 2016. https://www.calgaryriverusers.org/wp-content/uploads/2016/11/the-case-for-a-river-management-plan.pdf
10. **The Impact of Bow River Water Management on Fish Populations**. 2019. Bow River Trout Foundation. https://bowrivertrout.files.wordpress.com/2019/03/the-impact-of-bow-river-water-management-of-fish-pcs-02mar2019.pdf
11. Arlinghaus, R., et al, 2007. Understanding the complexity of Catch-and-Release in Recreational Fishing: An integrated Synthesis of Global Knowledge from Historical, Ethical, Social, and Biological Perspectives. Canadian Research Knowledge Network Abstract. https://experts.illinois.edu/en/publications/understanding-the-complexity-of-catch-and-release-in-recreational
12. Joubert, B. A, et al. 2020.**Can smartphones kill Trout? Mortality of memorable-sized Bull Trout after photo-releases.** Fisheries Research 223 (2020) 105458

Appendix 1:

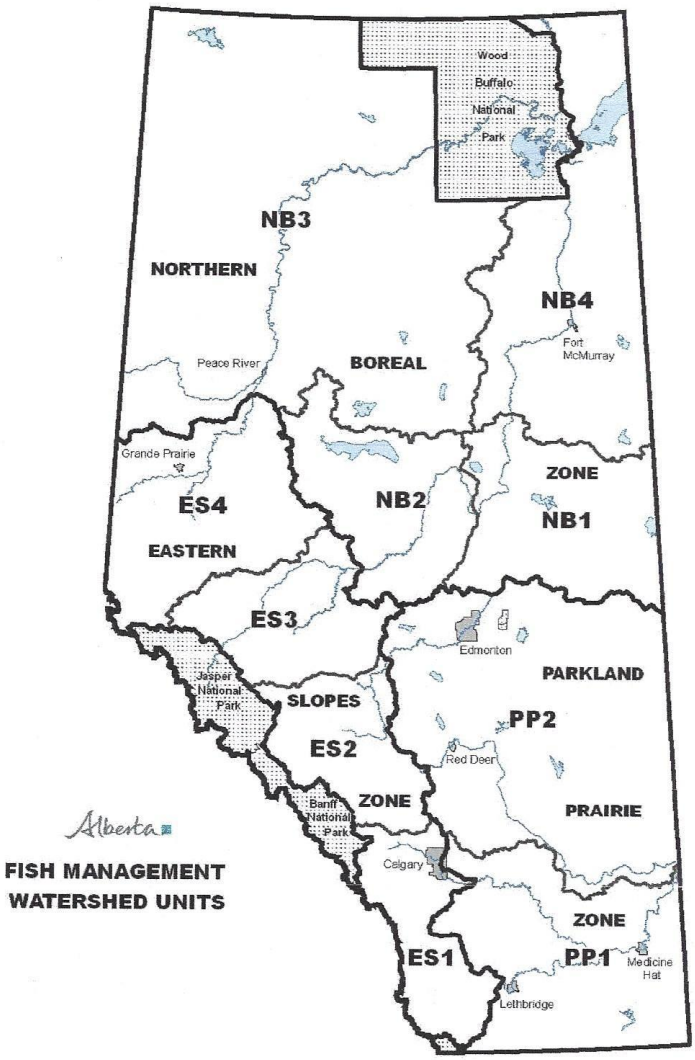

Figure 1. Map of Alberta showing Alberta Sustainable Resource Development's Fish Management Watershed Units and major watershed features.

4

Appendix 2

Table 8

Likely magnitude of impact on catch-and-release (C&R) angling endpoints associated with the primary explanatory variables (categorized as Unlikely, Possible, or Likely) and the relative amount of information that we have on each topic (categorized as None, Some, or Well-studied). Here we have further divided some of the explanatory variables to make this summary table more useful. Categorizations reflect what we know about various mechanisms

Explanatory variables	Potential impact and our knowledge of a particular relationship	Potential C&R endpoints/effects							
		Mortality	Predation	Injury	Stress	Behavior	Fitness/ Reproduction	Growth/ Energetics	Population/ Systems
Bait	Potential impact	Likely	Possible	Likely	Likely	Unlikely	Possible	Possible	Possible
	Knowledge	Well-studied	None	Well-studied	Some	None	None	None	None
Gear–Terminal Tackle	Potential Impact	Likely	Possible	Likely	Likely	Unlikely	Possible	Possible	Possible
	Knowledge	Well-studied	None	Well-studied	Some	None	None	Some	None
Gear–Light vs. Heavy	Potential Impact	Possible	Possible	Unlikely	Likely	Possible	Unlikely	Possible	Possible
	Knowledge	Some	Some	None	Some	Some	None	None	None
Landing Gear–Nets	Potential Impact	Possible	Possible	Likely	Likely	Unlikely	Possible	Unlikely	Possible
	Knowledge	Some	None	Some	None	None	None	None	None
Competitive Events	Potential Impact	Possible	Possible	Possible	Likely	Possible	Possible	Possible	Possible
	Knowledge	Well-studied	None	Some	Well-studied	Some	Some	Some	Some
Other Retention	Potential Impact	Possible	Possible	Likely	Likely	Possible	Possible	Possible	Possible
	Knowledge	Some	None	Some	Some	None	None	None	None
Handling	Potential Impact	Possible	Possible	Likely	Likely	Possible	Possible	Possible	Unlikely
	Knowledge	Some	Some	Some	Well-studied	Some	Some	Some	None
Environment (temp)	Potential Impact	Likely	Possible	Unlikely	Likely	Possible	Possible	Possible	Possible
	Knowledge	Likely	Possible	Unlikely	Likely	Possible	Possible	Possible	Possible
Depth	Potential Impact	Likely	Likely	Likely	Likely	Likely	Possible	Possible	Possible
	Knowledge	Some	None	Some	Some	Some	None	None	None
Intrinsic	Potential Impact	Possible	Possible	Unlikely	Likely	Likely	Possible	Possible	Possible
	Knowledge	Some	Some	None	Some	Some	Some	Some	None