Site C Clean Energy Project

Peace River Recreational Angling Creel Survey (Mon-2, Task 2c)

Construction Years 8 and 9 (2022 and 2023)

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Peace River Recreational Angling Creel Survey 2022-2023
FINAL Report



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EXECUTIVE SUMMARY

Recreational fishing has been an important activity in the Peace Region, and BC Hydro is interested in determining how the construction and operation of the Site C Clean Energy Project (the Project) might change angling patterns relative to the baseline levels estimated in previous creel surveys. To that end, BC Hydro contracted Aski Reclamation LP and LGL Limited to conduct a creel survey, from 1 July 2022 until 30 June 2023, from Peace Canyon Dam to Many Islands, Alberta. The goal of the survey was to describe angler demographics and to obtain statistically valid stratified estimates of fishing activity patterns, fishing effort levels, and catch for the harvestable species.

The general method for calculating species-specific catch (done separately for harvested and released fish) was to multiply estimates of fishing effort with estimates of catch per unit effort (CPUE). Data were stratified by month, day type (weekday vs. weekend/holiday), river reach, and access method (boat- vs. shore-based angling).

Fishing effort was estimated either by counting anglers (both on shore and in boats) from aircraft or from trail camera data. Eight fixed-wing overflights that spanned the study area were conducted on random dates at the expected peak activity time, and were evenly distributed between day types and months (July and August only). In addition, 20 motion-sensing or timed-trigger cameras were deployed at boat launches and angling beaches, which were collectively assumed to have near complete coverage for boat- and shore-based fishing effort monitoring. A total of 642,278 photos were processed. Note that the overflights were meant chiefly to ground-truth the data collected using the newer trail camera method. Effort estimated from the overflights was not wildly different from camera-based estimates, and since the standard error was smaller for the latter, all catch estimation was derived from the camera data exclusively.

CPUE was derived from shore-based interviews of anglers, who were asked to provide details of their current fishing trip, including hours of effort and species-specific catch (tallied separately for retained and released fish). Interviews involving 212 anglers in 108 parties were conducted over 133 observer shifts, taking place at locations selected randomly from seven access sites, and using a work schedule that was randomized with respect to month (with fewer shifts scheduled during the winter months from October 2022 to March 2023), day type, and start time (morning vs. afternoon). Also obtained during the interviews were angling activity times and locations, and angler demographic data.

Angler activity patterns (pooled over day type and river stratum) differed by season and access method. Angler activity was bimodal in July and August, but with a different peak activity time for boat- vs. shore-based anglers. Activity was more unimodal in the other seasons, with peaks in the early afternoon. Fishing trip durations (pooled over day type) were longer on average in May and June, especially between Hudson's Hope and Site C, than in other seasons or river strata.

Angling effort, derived from the camera data, varied significantly among seasons, among river strata, and between day types, but did not differ significantly between boat and shore anglers. Total annual angling effort was estimated to be 15,672 angler-hours (SE = 637), including 3,204 and 3,447 angler hours per month in the high (July-August) and shoulder (May-June) season, respectively, and 296 angler hours per month during the low (September–April) season. Overall, 37% of the angling effort occurred in the relatively small stratum from Peace Canyon Dam to Hudson's Hope, 20% from Hudson's Hope to Site C, and 43% between Site C and Many Islands. Boat-based angling made up a minority (11-22%) of the effort upstream of Hudson's Hope and downstream of Site C, whereas it accounted for 80% of the effort between Hudson's Hope and Site C.

The annual catch (fish harvested + released) was estimated for 11 fish taxa. Rainbow Trout (*Oncorhynchus mykiss*) was the species that was caught in greatest numbers (4,621 fish per year, SE = 597), with catch strongly skewed toward shore anglers in the area upstream of Hudson's Hope in July and August. Walleye (*Sander vitreus*), Bull Trout (*Salvelinus confluentus*), Mountain Whitefish (*Prosopium williamsoni*), and Northern Pike (*Esox lucius*) were the next most likely species to be caught. Mountain Whitefish (356 fish per year, SE = 71) were only caught during the high season (entirely by shore-based anglers). Northern Pike (303 fish per year, SE = 111) were caught only, and Walleye (381 fish per year, SE = 135) nearly only, in the low season, downstream of Site C, by boat-based anglers. Bull Trout (384 fish per year, SE = 95) were caught year-round, largely upstream of Site C. Few Goldeye (*Hiodon alosoides*, 109 fish, SE = 60), Lake Trout (*Salvelinus namaycush*, 84 fish, SE = 52), or Arctic Grayling (*Thymallus arcticus*, 78 fish, SE =46) were caught over the study year. Goldeye were only caught downstream of Site C and only by boat-based anglers. Lake Trout were only caught in July and August, largely upstream of Hudson's Hope, and mainly from shore. Arctic Grayling were only caught in the high season. Northern Pikeminnow (*Ptychocheilus oregonensis*), kokanee (*Oncorhynchus nerka*), and suckers (*Catostomus* sp.) were rarely caught (fewer than 40 fish). No Burbot (*Lota lota*) were reported as caught during the study period.

As was the case for overall catch, Rainbow Trout was the most harvested species (275 fish, SE = 49), amounting to 1% of the total catch of that species. Walleye was the second most harvested species (101 fish, SE = 37, 10% of total Walleye catch). Northern Pike harvest was estimated at 67 fish (SE = 25, 8% of the total pike catch). The total annual harvest of Bull Trout, summed across all strata, was estimated at 28 fish (SE = 7; 2% harvest) despite being a catch and release species in the Peace River system, possibly indicating issues with species identification. Harvest of all other species was negligible (3 fish for Lake Trout and Northern Pikeminnow) or zero.

Anglers that were interviewed were overwhelmingly (73%) from the local Peace River area, and to a lesser extent (8%) the rest of BC. For the most part, anglers were not being guided by a professional. Anglers said they were fishing with lures (67%, including spoons, spinners and jigs), artificial flies (22%), or bait (12%; contrary to regulations, including worms, fish eggs, and various arthropods). Anglers overwhelmingly (80% overall) used spin casting as the fishing method of choice, whereas 20% of anglers were fly casting. The most popular target species was Rainbow Trout (57% of respondents), with Bull Trout being second in popularity, followed by Walleye. The average age of the responding Peace River anglers was 34 years old, and the average amount of fishing experience held by the anglers was 23 years.

Effort estimates from 2022-23 were similar to those of previous mainstem Peace River creel surveys. Despite similarities in effort, the annual catches estimated in the 2022-23 study period differed markedly from those reported from 2008-09 for the Peace River, showing a large increase for Rainbow Trout, and marked declines for Arctic Grayling, Bull Trout, Mountain Whitefish, Walleye, and Goldeye. Some of the among study differences may be reflective of changes in species abundances, but some may be artifacts of the year-to-year variability in angler effort levels or CPUE.

A key methodological innovation adopted for the 2022-23 study year was the use of cameras to monitor fishing effort. A major advantage of having sample data from almost every day is that sampling variances were reduced to almost zero. In addition, bias was reduced relative to the previous overflight method because flights are often cancelled in the type of weather that also deters angler activity. The disadvantage of the camera method was the post-season processing time required, and considerable data loss. In some deployments, there was a potential bias introduced since the technician's ability to identify whether a party had been counted previously in the day was not absolute. Another adopted innovation was to use a deep learning computer vision (CV) algorithm to scan photographs, and identify only those that included a boat, car, truck, or person, which reduced the number of photos for human review by 73%, and had the added advantage of being able to blur faces and licence plates, which was a condition set by BC Hydro to ensure that the privacy of Peace River recreational users was maintained. The rate of false negatives (i.e., failing to identify a photo that included an object of interest) produced by the CV algorithm was 0% for trail and beach cameras, and 2.1% for launch cameras.

Another new method that was adopted for the 2022-23 study year was the use of traffic counters and motion-sensor cameras to monitor fishing site access roads and trails. Trail cameras were effective (in each case the effort estimated from the trail cameras was more precise than that from beach camera deployments), but the access road deployments were unsuccessful. The sites where they were deployed had too much industrial activity, the cameras took far too many photos to process efficiently, some of the traffic counter units were destroyed by the construction vehicles, and there were too many gaps in the data series of cameras deployed to effectively ground truth the traffic counters.

The results of this angling survey should help inform decisions regarding trends in recreational fisheries, as well as provide further baseline data against which to compare future impacts during operation of the Project.

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INTRODUCTION

BC Hydro is constructing the Site C Clean Energy Project (the Project), which will be the third dam and hydroelectric generating station on the Peace River in northeast BC. The Project will provide 1,100 megawatts (MW) of capacity and about 5,100 gigawatt hours (GWh) of energy each year to the province's integrated electricity system.

To meet some of the provincial and federal conditions for the Project, BC Hydro developed the Site C Fisheries and Aquatic Habitat Monitoring and Follow-up Program (FAHMFP). The FAHMFP (BC Hydro 2015) consists of eighteen spatially and logistically distinct monitoring programs that aim to:

- monitor fish and fish habitat during the construction and operation of the Project;
- understand the effects of the Project and the effectiveness of mitigation measures; and
- evaluate and implement future mitigation and compensation options.

The Peace River Creel Survey (Mon-2, Task 2c) represents one component of the FAHMFP. The preliminary design of the Creel Survey included cameras and angler interviews at select boat launches, and a goal to estimate recreational angler effort and catch (both retained and released) and harvest rates for the main harvestable species. The Creel Survey was designed to be conducted in Construction Year 6 and again every five years between Operations Years 2 and 30. The Creel Survey was originally scheduled for 2020, but implementation was delayed until 2022 because it was assumed that data collected during the COVID-19 pandemic would not be representative of normal or typical angling activity in the region. Regardless, the Creel Survey was designed to be compatible with BC Hydro's 2008-09 creel survey (Robichaud et al. 2010), which was meant to act as a baseline against which subsequent results could be compared, and for the purposes of building a long-term dataset.

Recreational fishing has been an important activity in the Peace Region. A roving creel census in 1985 estimated that 8,600 anglers fished the short section of the Peace River between Peace Canyon Dam and Hudson's Hope between June and October, for a total of 16,890 angler-hours (Hammond 1986). A subsequent exit creel survey (conducted from May to October 1989; and April to June 1990), which monitored a larger geographic area, estimated a total angling effort of 18,500 angler-hours between Peace Canyon Dam and Taylor (including the lower reaches of the Pine, Halfway, and Moberly rivers; DPA 1991). Robichaud et al. (2010) pooled data over 16 months (mid-May 2008 to October 2009) to estimate that the average annual angling effort was 18,489 hours in the Peace River from Peace Canyon Dam to the border with Alberta. All three creel surveys showed similar patterns of river-use: the majority of fishing effort took place upstream of the Project.

Construction and operation of the Project will likely change the pattern of river-use (e.g., a shift from river- to reservoir-based activities; BC Hydro, 2008), affect angling opportunities (e.g., by changing river and reservoir access); and could therefore modify pressure on fish species, relative to the baseline levels estimated in the previous creel surveys. This report summarizes the methods and results from BC Hydro's Creel Survey, conducted from 1 July 2022 until 30 June 2023 from Peace Canyon Dam to Many Islands, Alberta. The results include descriptions of fishing activity patterns, fishing effort levels, and catch for the harvestable species. In addition, the collected angler demographic data were summarized.

SCOPE

In order to estimate annual angling effort, the temporal scope of the study was designed to span 12 months, and ran specifically from 1 July 2022 to 30 June 2023. Angler interviews and effort data collection occurred year-round, with the intention to produce monthly estimates from April to September, along with a single 'wintertime' (October to March) estimate. The study was also stratified into two day types (weekday vs. weekend/holiday[1]) and two access methods (shore vs. boat).

The spatial scope of the study area was the Peace River, extending from Peace Canyon Dam to Many Islands, Alberta, a distance of 210 river km (Figure 1). For the purposes of data collection and analysis, the study area was divided into three geographic strata (called river strata), selected to align with previous surveys. These strata were:

1) Peace Canyon Dam to Hudson's Hope;
2) Hudson's Hope to Site C (includes the Halfway River and the mouth areas of the smaller tributaries); and
3) Site C to Many Islands, Alberta (includes the mouth of the Pine and Beatton rivers).

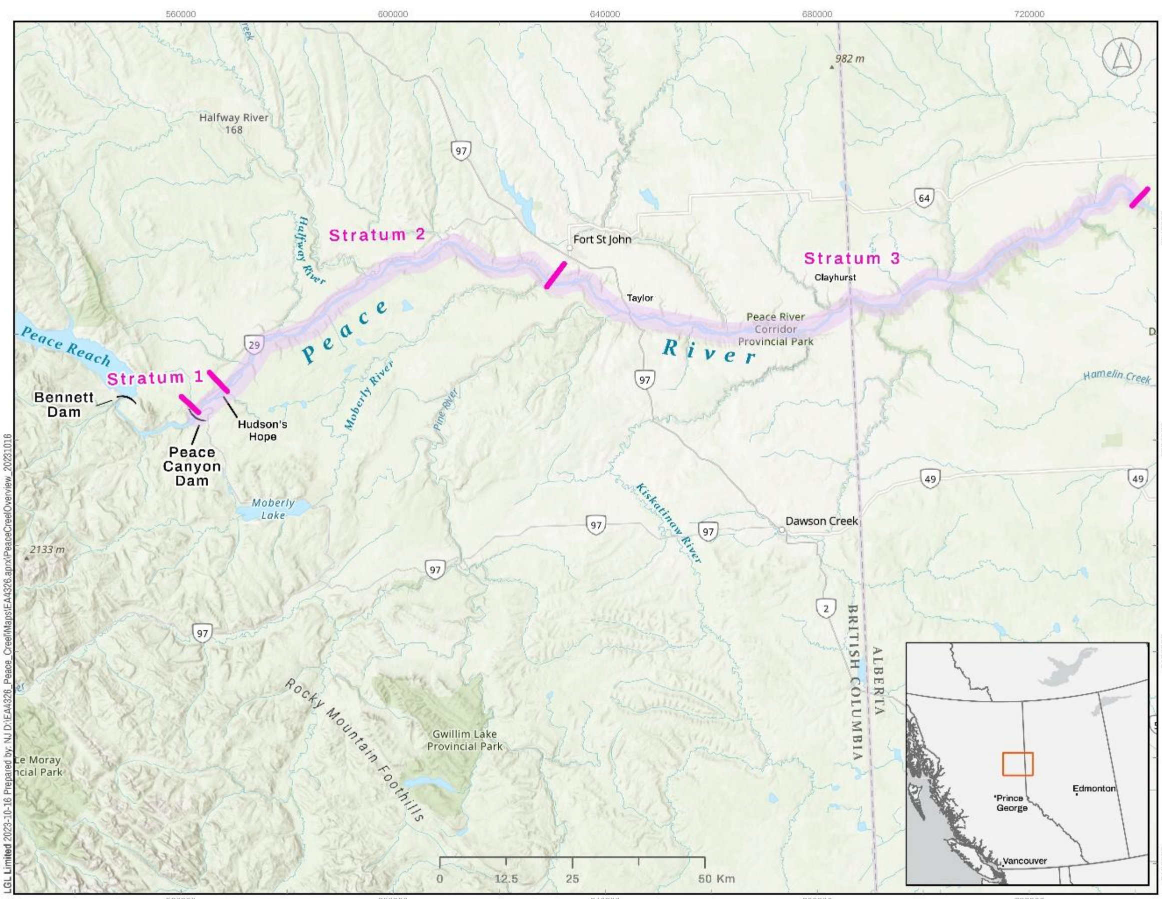

Figure 1. Peace River and its tributaries in northeast British Columbia and northwest Alberta showing river strata boundaries, and overall study area in pink shading.

[1] including federal or provincial 'bank' holidays (New Year's Day, Family Day, Good Friday, Victoria Day, Canada Day, British Columbia Day, Labour Day, Reconciliation, Thanksgiving, Remembrance Day, and Christmas).

The spatial scope along the Peace River extended further in 2022-23 than in 2008-09. In the previous survey, the coverage ended at the Alberta border (Robichaud et al. 2010), whereas the current study included another 60 river km to Many Islands, Alberta. Extending the study area to Many Islands created continuity with BC Hydro's concurrent fish community monitoring and fish movement studies (e.g., WSP Canada 2023, Hatch et al. 2023). For the same reason, the Pine River watershed was not included in the current geographic scope, despite its inclusion in 2008-09. All other details of the study area were the same in 2022-23 as in 2008-09.

The study included all seven fish taxa that were identified by the BC Ministry of Environment (BC Government 2011) as 'indicator species' for the assessment of management objectives, i.e., Arctic Grayling (*Thymallus arcticus*), Bull Trout (*Salvelinus confluentus*), Burbot (*Lota lota*), Goldeye (*Hiodon alosoides*), Mountain Whitefish (*Prosopium williamsoni*), Rainbow Trout (*Oncorhynchus mykiss*), and Walleye (*Sander vitreus*).

MANAGEMENT QUESTION AND HYPOTHESIS

The Peace River Creel Survey (Mon-2, Task 2c) represents one component of the Peace River Fish Community Monitoring Program (Mon-2). The overarching fisheries management question of Mon-2 reflects that the construction and operation of the Project can affect fish in different ways, specifically,

> *"How does the Project affect fish in the Peace River between the Project and the Many Islands area in Alberta during the short (10 years after Project operations begin) and longer (30 years after Project operations begin) term?"*

The Mon-2 Program focuses on monitoring fish abundance and biomass, species distribution, community composition, and population structure, and assessing whether any changes observed in these metrics are related to the construction or operation of the Project (BC Hydro 2015). Additionally, local provincial management objectives include the sustainable use of fisheries resources, and the optimization of recreational angling opportunities (BC Ministry of Environment 2009).

The Management Hypothesis in Mon-2 that relates to Task 2c is,

"*H_5: The fish community can support angling effort that is similar to baseline conditions*".

Data from Peace River Creel Survey can provide information on these high-level objectives as well as information on fish harvest rates that can inform analysis of changes in the fish community. The purpose of the Peace River Creel Survey is to determine the use of the Peace River for recreational angling. During Project construction, it will monitor changes in river use associated with construction activities. During Project operation, it will monitor changes associated with the Project's operations. The survey will quantify the timing, duration, location of effort, gear type, and species caught in the river to generate spatial and temporal estimates of recreational angling effort, and catch (both retained and released) by species. It will follow similar methodologies to those employed during the baseline creel survey (Robichaud et al. 2010) to ensure comparable results and a compatible long-term dataset.

It is noted in the FAHMFP (BC Hydro 2015) that precise estimates of angler effort from creel surveys are challenging to obtain with multi-species fisheries over large areas. Changes in angler behaviour and other angling opportunities in the region can also affect trends in angling effort. As a result, information from this survey is expected to provide supporting information to be interpreted in the context of other data on the fish community, and general information on angling effort and fish harvest rates.

OBJECTIVE

The specific objective of this study was to obtain statistically valid, stratified estimates of total angler effort and catch during the 2022-2023 period (Construction Years 8-9). Recreational angling is an important activity to the communities and economy of the Peace Region and BC Hydro is interested in determining how the construction and operation of the Project may change the pattern of recreational river-use.

METHODS

The Creel Survey was designed to quantify the timing, duration, location of effort, gear type, and species caught in the river in order to generate spatial and temporal estimates of recreational angling effort and of catch (both retained and released) by species.

Statistically Valid Estimates of Angler Effort and Catch

The study area spanned a very large geographic extent, and it was therefore too logistically challenging and cost prohibitive to conduct a complete direct (interview-based) census of the entire catch. Therefore, the approach relied on statistical methods to estimate catch by the multiplication of vectors of effort data by vectors of CPUE data, for each river stratum, month, day type (weekday vs. weekend/holiday), access method (shore vs. boat), and species. The analytical methods used were adapted from those developed and documented for the Georgia Strait Creel Survey (English et al. 2002). The methods used to estimate the statistical precision associated with creel survey catch and effort estimates are documented in English et al. (2002) and Blakley et al. (2003). The same statistical approach was used in the 2008-09 Peace River baseline study (Robichaud et al. 2010), and is superior to catch reporting calendars in four ways:

1) It is based on first-hand interviews conducted by trained interviewers rather than on the fisherman's memory or diligence in accurately filling out a form;
2) It enables interviewers to interact directly with the fisherman and validate the catch;
3) It provides timely estimates of catch and effort and allows for adaptive control of the sampling procedure; and
4) It allows for computation of statistical confidence in the estimates.

For each river stratum during both day types in each month, fishing effort was estimated either by counting anglers (both on shore and in boats) from aircraft (Appendix 1) or from trail camera data; and CPUE was estimated from shore-based interviews (Appendix 2). Interviews were conducted at known access points. At these locations, anglers were interviewed about their catch, effort, and fishing locations. Anglers were also asked about their hourly fishing activity patterns both on the current and previous days and whether they were finished their fishing activity for the day.

Each interview was conducted with a single party that were angling together. Specific data collected during interviews included:

- Angler effort – number of anglers, total fishing effort (in angler-hours), vessel type (if any), fishing location, access location, target species, gear and bait types used;

- Angler activity – the hours during which angling activity was conducted, both on the day of the interview and on the previous day, and whether or not the trip was 'complete';
- Fish kept – number of captured fish that were kept, by river stratum and by species;
- Fish released – number of captured fish that were intentionally released, by river stratum and by species;
- Whether the catch was verified and counted;
- Whether the trip was guided by a professional;
- Angler demographics – age, level of experience, and community of origin;
- Angler access methods (shore vs. boat); and
- Timestamp, including date, month, 'day type' (i.e., weekday vs. weekend/holiday) and time of day.

Anglers were also asked about the number of days they fish in a year, whether they ever fish in the winter; and which other angling sites they use in the region (locations and use levels, by season). All interview data also included the observer's name, the interview location (access point), weather conditions, and general field notes.

This procedure provides a statistically unbiased estimate of CPUE, provided the anglers interviewed are representative of the entire fishery. As such, the interview schedule was stratified by river stratum, landing site, day type, time of day, and month. Interview shifts were randomly allocated within each stratum to maximize the probability that data were captured from representative anglers in each river stratum, on both day types, and over all time periods of the day.

Interviewing locations were based initially on the access locations identified in DPA (1991) and Robichaud et al. (2010), but were later refined to include the seven locations shown in Table 1. The access points surveyed were considered to be a complete list of all access points (barring a negligible number of singleton anglers that might bushwhack into other minor areas). Within each river stratum, the busiest (i.e., most accessible) access sites were selected preferentially in order to obtain the maximum number of interviews. This approach was based on two important observations: 1) CPUE (catch per unit effort) tends to be more variable among fishing parties landing at a single access point than among different access points within a river stratum; and 2) CPUE and effort can vary substantially both within and between days at a single site (English et al. 2002). Under these conditions it is better to obtain a large number of interviews covering all temporal strata for a small number of sites than to sample a larger number of sites and obtain fewer interviews and less complete temporal coverage for any specific site.

Sampling intensity levels (Table 2) were selected to ensure adequate coverage in all geographic and temporal strata, and to produce estimates of catch (or harvest) and effort that are precise enough to allow the detection of large changes over time. Within each river stratum and day type, the sampling dates were selected randomly. Once a date was selected, a site within that stratum was randomly selected, where the probability of selection was based on (approximate) *a priori* expected frequencies of use by anglers (Table 1). During temporary or permanent periods when a site was closed or inaccessible (Table 3), the site was removed from the random selection process.

Durations of interview sampling sessions included driving time for the observer, and were 10 hours long from April to September; or 8 hours long from October to March. For morning shifts, observers were present at the site at 8 AM from April to September, 9 AM in March and October, or

Table 1. Seven shore-based access sites at which angler interviews were conducted and where remote-sensing gear was deployed. Two to three sites were located within each river stratum (strata listed within the pale yellow subheaders).

Stratum / Site	*Prob of Selection**	*Prob of AM Shift time*	*Remote Sensing Gear †*
Peace Canyon Dam to Hudson's Hope			
Highway 29 Bridge / Fingers	0.5	0.5	T+3B
Alwin Holland Park	0.5	0.5	T+4B
Hudson's Hope to Site C			
Lynx Creek Launch	0.5	0.9	2X+L+B
Halfway River Bridge	0.5	0.9	2X+2R+L
*Site C to Many Islands ***			
Peace Island	0.6	0.9	X+2L
Clayhurst	0.2	0.5	2B (+L‡)
Many Islands	0.2	0.9	X+L+R

** For each interviewing session, the stratum was randomly selected. Then, within a stratum, a site was randomly selected, where the probability of selection was based on (approximate) expected frequencies of use by anglers.*

*** In 2008-09, the lowermost stratum ended at the BC-Alberta border.*

† T = Motion sensing trail camera on access trail; R = Motion sensing trail camera on access road; L = Time lapse photos at launch; B = Time lapse photos to count anglers; X = Traffic Counter.

‡ stolen almost immediately and not included in any analyses.

Table 2. Scheduled annual sampling effort (number of interviewer shifts, and interviewer hours), by month and river stratum. (PCD = Peace Canyon Dam; HH = Hudson's Hope; MI = Many Islands). Specific sampling dates were selected randomly, and were split evenly between weekday and weekend/holidays.

Type / Month	*PCD-HH*	*HH-Site C*	*Site C-MI **	*Total Shifts*	*Hours per Shift*	*Total Hours*
Stationary						
April	6	6	6	18	10	180
May	6	6	6	18	10	180
June	6	6	6	18	10	180
July	6	6	6	18	10	180
August	6	6	6	18	10	180
September	6	6	6	18	10	180
Roving †						
October	2	2	2	6	8	48
November	2	2	2	6	8	48
December	2	2	2	6	8	48
January	2	2	2	6	8	48
February	2	2	2	6	8	48
March	2	2	3	6	8	48
TOTAL				*144*		*1,368*

** In 2008-09, the lowermost stratum ended at the BC-Alberta border.*

† In 2008-09, there were 3 shifts per river stratum per month from October to March.

Table 3. Access considerations for seven shore-based access sites.

Stratum / Site	*Access Considerations*
Peace Canyon Dam to Hudson's Hope	
Highway 29 Bridge /Fingers	The fingers are only exposed at low water
Alwin Holland Park	None
Hudson's Hope to Site C	
Lynx Creek Launch	Temporary closures began in November 2022 (before the 17th). On 31 March 2023 the launch was permanently closed. *There were periods in the winter when the launch was covered in ice and unusable.*
Halfway River Bridge	The old highway access road closed on 30 March 2023 (the gate was left open, but a sign saying road closed was definitely a deterrent). The old highway was intermittently inaccessible due to road deactivation for the spring and summer. This launch was officially closed to the public in September 2023. *The Halfway River itself is completely frozen over and un-boatable for most of the winter.*
Site C to Many Islands	
Peace Island	The boat launch itself was an industrial worksite for a good part of the winter (most of November and December). *There were periods in the winter when the launch was covered in ice and unusable.*
Clayhurst	The regional park is closed from Thanksgiving to Victoria Day. There is no official launch here and people can launch from just about anywhere, including on the other side of the river. *There were periods in the winter when the launches were covered in ice and unusable.*
Many Islands	The park was closed all winter (1 November to 1 May). The Clearwater fire started on 2 May 2023 and was still smoldering on 25 May. The park was spared via fire suppression efforts, but we don't know when campers were allowed back, but the fire impacted the entire area, thus there were fewer campers and more bears.

10 AM from November to February. For evening shifts, observers departed the site at 9 PM from April to September, 8 PM in March and October, or 5 PM from November to February. Every shift was randomly assigned to be either a morning or evening shift based on (approximate) *a priori* expected frequencies of use by anglers (Table 1). Subsequent analyses do not include morning vs. evening stratification because randomization of the shift start times was expected to account for any associated effects.

In total, 144 shifts were scheduled over the year (Table 2), summing to 1,368 hours of effort, and with the majority of the interviewing effort focused on the summer months. Due to fire/smoke, winter storms, personal emergencies, and difficulty retaining a consistent observer, a total of 133 shifts (92% of those scheduled) were carried out over the study duration.

During the winter months (October to March), a roving creel survey format was implemented. On random days within these months, interviewers started off at a randomly selected site within a randomly selected river stratum, and moved among the sites within that stratum (and sometimes into adjacent strata) over the course of the day. The intent was to increase angler contact during the off-peak fishing period.

Ground-truthing Data Collection

During interview shifts, observers were asked to keep notes on the number of people, number of anglers, number of boats, and number of boat-based angling parties that were encountered (Appendix 3). The tallies were used to ground-truth data from cameras, and to develop proportional benchmarks that could be used for further photo interpretation. For example, it was expected that photos of boats would not always provide enough information to determine if the party was going to be angling. However, an interviewer at that site, in that month, and on that day type may have collected tallies that could be used to estimate the proportion of all boats that were angling.

Angler Activity Proportions

Hourly activity proportion data were collected during interviews by asking the angler to list all of the hours during which fishing activity occurred (responses took the form of boolean ('yes/no') responses for each one-hour time block). For each hourly time-block, we calculate the proportion of all angling effort that was active. Hourly activity proportions are used during effort calculations to upconvert a single-point-in-time effort counts (i.e., overflights and time-triggered camera photos) based on the proportion of total daily effort that is active during that point in time. For this calculation, interviews must be conducted at the end of the angler's fishing trip, thus data from incomplete trips are excluded. However, sample sizes were bolstered by asking anglers about their 'prior day' activity as well. Hourly booleans were adjusted using two weighting factors, and pooled over all interviews in order to generate a distribution of activity.

Weighting Factors

The first weighting factor, $W1$, expanded the numbers of days spent interviewing in each stratum, to account for the total number of days available for sampling. That is, it was assumed that the daily activity pattern recorded during the interview shifts in stratum *s* were consistent for stratum s, even during the days when no interviews occurred. A specific $W1$ was calculated for each stratum during each month and day type as:

$$W1_{mds} = \frac{N_{md}}{K_{mds}} \qquad \text{(Eqn. 1)}$$

where N_{md} was the total number of type d days in month m; and K_{mds} was the number of interview shifts that occurred in river stratum s, on type d days during month m.

The second weighting factor, $W2$, expanded the number of interviews conducted, to account for the anglers that were *not* interviewed. That is, it was assumed that the activity pattern recorded during the interview shifts also held for those anglers that were not interviewed. A specific $W2$ was calculated for each shift (k) at each site during each month and day type as:

$$W2_{mdsak} = \frac{L_{mdsak}}{A_{mdsak}} \qquad \text{(Eqn. 2)}$$

where L_{mdsik} was the number of anglers observed and A_{mdsik} was the number of anglers interviewed during shift k, at access location a, in river stratum s, during day type d, and month m.

The term $n_{mdsfakq}$ was used to denote the number of anglers that were part of the fishing party (q) that was interviewed on survey date k, at access site a in river stratum s, with access method

f, during month m, and on day type d , and $A_{mdsfakqt}$ to indicate how many in the party were actively fishing during time block t. The two weighting factors were applied, and the data were summed over survey dates, interview locations, and fishing parties (within month, day type, river stratum, access method, and time-block):

$$A'_{mdsft} = W1_{mds} \cdot \sum_a \sum_k \sum_q W2_{mdsak} \cdot A_{mdsfakqt} \quad . \qquad \text{(Eqn. 3)}$$

Summing the adjusted number of anglers over the 16 time-blocks gave:

$$T'_{mdsf} = \sum_t A'_{mdsft} \quad . \qquad \text{(Eqn. 4)}$$

The same two adjustments ($W1$ and $W2$) were also applied to the angler demographic data, where similar adjustments were made to counts before calculating the proportions of the population that had various behavioural or demographic attributes.

Proportion of Anglers Active

The proportion of anglers (P_{mdsft}) that were active during each of the hourly time-blocks was calculated for each month, day type, river stratum, and access method:

$$P_{mdsft} = \frac{A'_{mdsft}}{W1_{mds} \cdot \sum_a \sum_k \sum_q W2_{mdsak} \cdot n_{mdsfakq}} \quad . \qquad \text{(Eqn. 5)}$$

'Prior day' activity was included in the analyses, after being careful to assign the data to the correct temporal categories. For example, if an interview was conducted on a Monday, the 'prior day' activity data would be counted under day type 'weekend/holiday'. Since the number of 'prior day' anglers was unknown, it was not possible to calculate $W2$ weights for the 'prior day' activity, and a weighting value of 1 was assumed. $W1$ weights for calculations of 'prior day' activity were those appropriate for the prior day's period and day type.

Using this method, 84 unique angler activity patterns could theoretically be estimated (i.e., 7 month strata[2] × 2 day types × 3 river strata × 2 access methods). To reliably describe angler activity, a relatively large number of anglers (~ 60) needed to be interviewed in each of the 84 blocks. In the end, far too few interviews were obtained (Table 4), and several levels of detail needed to be removed from the analysis of angler activity pattern. To help decide which data to pool, angler activity was plotted by river stratum, day type, access method (Figure 2), and month (Figure 3). Mainly as a result of sample size limitations, it was decided to pool over day type and river stratum, and to pool months into three seasons (e): high (July-August), low (September-April), and shoulder (May-June):

$$P_{eft} = \frac{\sum_m \sum_d \sum_s A'_{mdsft}}{\sum_m \sum_d \sum_s (W1_{mds} \cdot \sum_a \sum_k \sum_q W2_{mdsak} \cdot n_{mdsfakq})} \quad \text{where } m \in e, \qquad \text{(Eqn. 6)}$$

and the associated variance was:

$$S^2_{P_{eft}} = \frac{(P_{eft})(1 - P_{eft})}{\sum_m \sum_d \sum_s (W1_{mds} \cdot \sum_a \sum_k \sum_q W2_{mdsak} \cdot n_{mdsfakq})} \quad \text{where } m \in e. \qquad \text{(Eqn. 7)}$$

It was also necessary to pool over access method during the shoulder and low seasons.

[2] Note that data from October to March were pooled together into a single temporal stratum, thus we only needed to calculate estimates for 7 'month strata', despite 12 months of interview effort.

Table 4. The amount of data (number of anglers) available to estimate angler activity patterns, for all levels of each factor. No category had adequate sample size to reliably estimate activity, thus data pooling was required.

	Day	*Access*	*River Stratum*			
Month	*Type*	*Method*	*PCD-HH*	*HH-Site C*	*Site C-MI*	*Total*
July	WD	Boat	0	0	0	0
		Shore	1	0	0	1
	WE	Boat	0	15	0	15
		Shore	14	25	1	40
August	WD	Boat	0	6	7	13
		Shore	0	6	0	6
	WE	Boat	0	20	6	26
		Shore	0	5	0	5
September	WD	Boat	0	3	2	5
		Shore	0	0	0	0
	WE	Boat	0	0	9	9
		Shore	0	0	4	4
October-March	WD	Boat	0	0	0	0
		Shore	1	2	0	3
	WE	Boat	0	0	0	0
		Shore	7	0	0	7
April	WD	Boat	0	0	0	0
		Shore	5	0	5	10
	WE	Boat	0	0	0	0
		Shore	12	0	0	12
May	WD	Boat	0	0	0	0
		Shore	3	0	0	3
	WE	Boat	0	16	1	17
		Shore	3	1	0	4
June	WD	Boat	0	9	2	11
		Shore	0	0	0	0
	WE	Boat	0	9	2	11
		Shore	7	2	0	9
July Total			15	40	1	56
August Total			0	37	13	50
Sept Total			0	3	15	18
October-March Total			8	2	0	10
April Total			17	0	5	22
May Total			6	17	1	24
June Total			7	20	4	31
	WD Total		10	26	16	52
	WE Total		43	93	23	159
		Boat Total	0	78	29	107
		Shore Total	53	41	10	104

PCD = Peace Canyon Dam; HH = Hudson's Hope; MI = Many Islands;
WD = Weekday; WE = Weekend/Holiday.

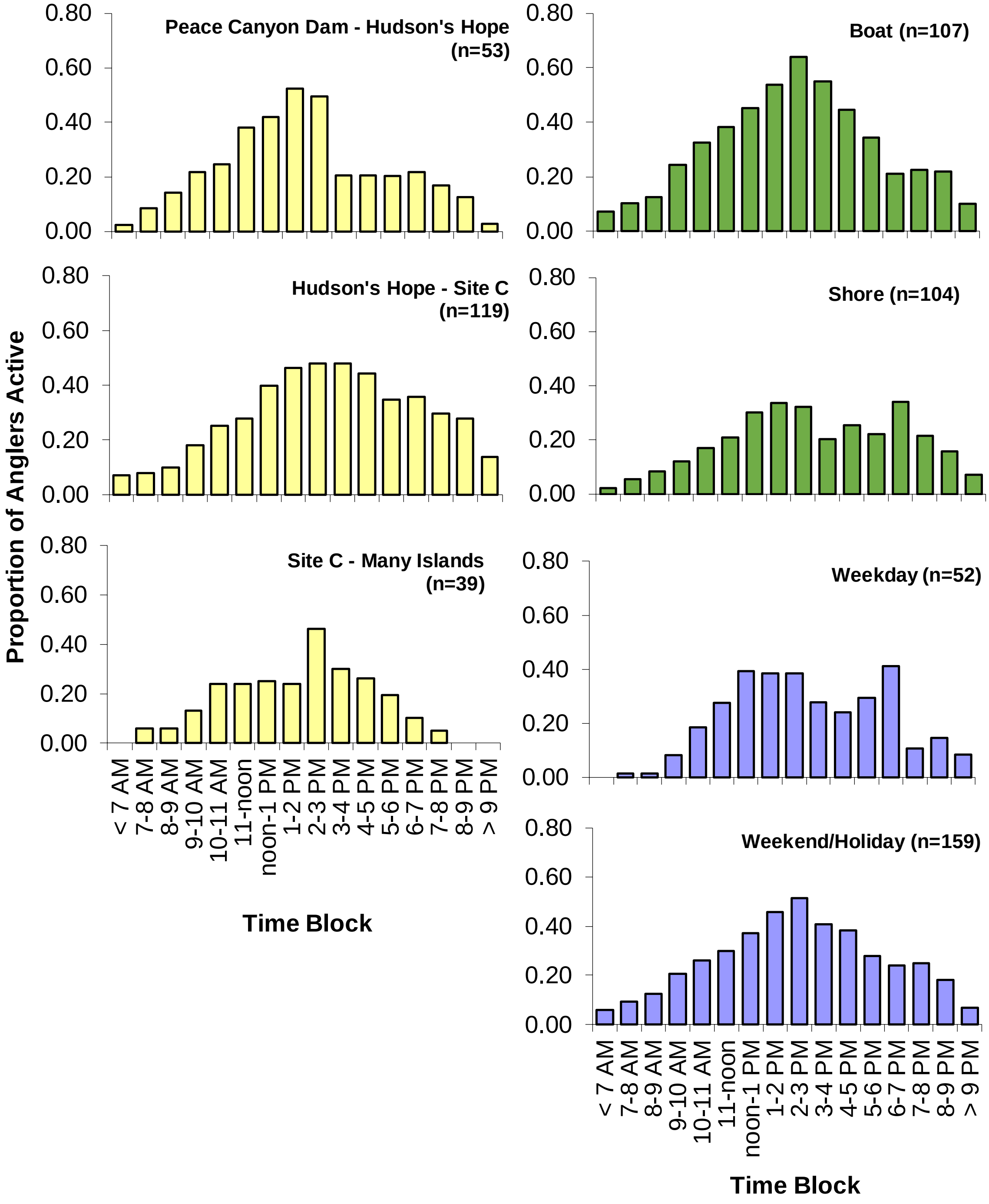

Figure 2. Angler activity patterns, by river stratum (left column), access method (upper right column), and day type (lower right column) from interview data collected from 1 July 2022 to 30 June 2023. The number of anglers (n) available to estimate angler activity patterns are shown in each panel.

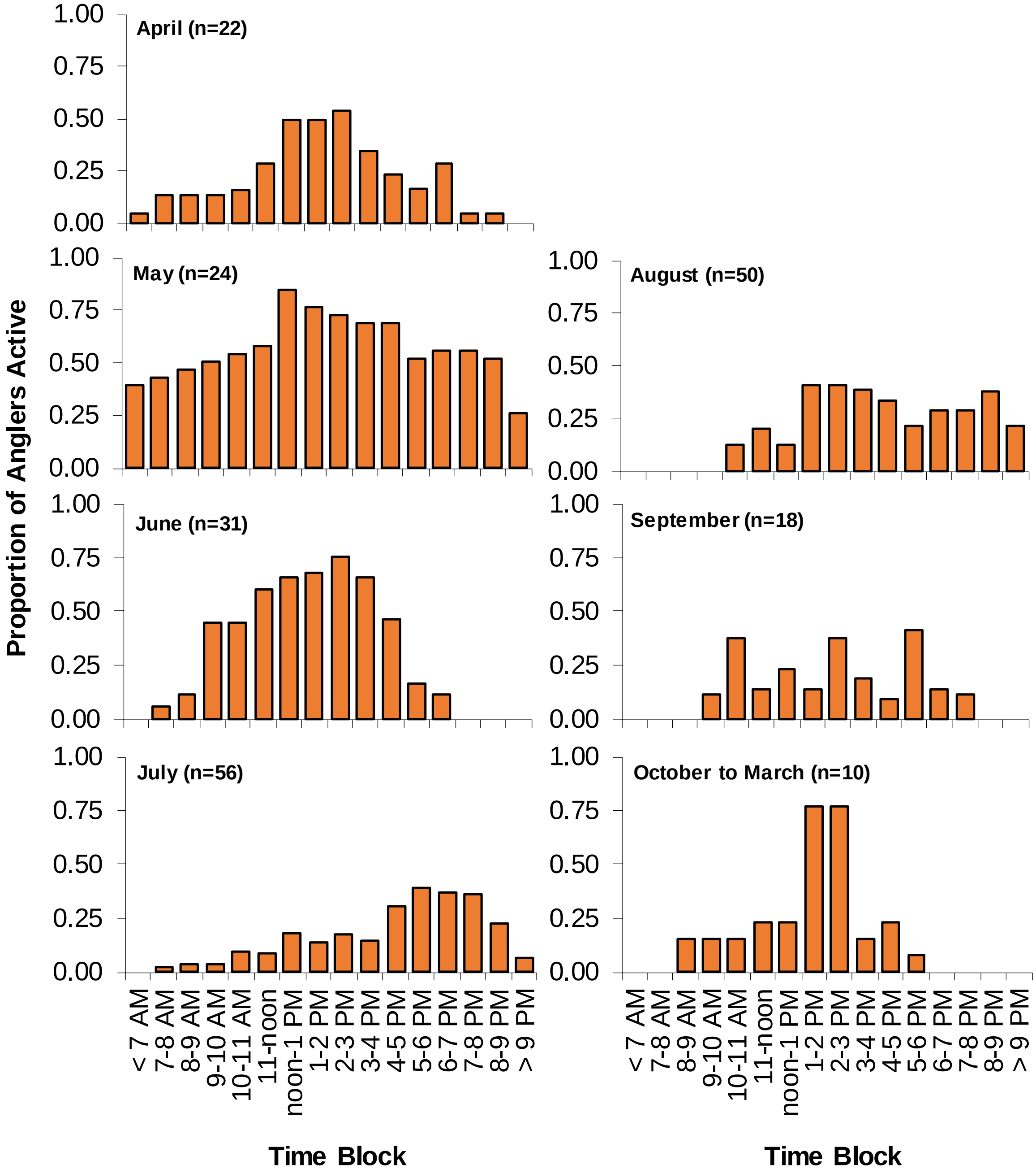

Figure 3. Angler activity patterns, by month (Oct-Mar were pooled), from interview data collected from 1 July 2022 to 30 June 2023. The number of anglers (n) available to estimate angler activity patterns are shown in each panel.

Activity Durations

The average number of hours fished per angler (G_{mdfs}) was calculated for each combination of month, day type, access method, and river stratum using weighted observations:

$$G_{mdsf} = \frac{T'_{mdsf}}{\left(W1_{mds} \cdot \sum_a \sum_k \sum_q \left(W2_{mdsak} \cdot n_{mdsfakq}\right)\right)} \quad . \qquad \text{(Eqn. 8)}$$

Similar to the proportions of anglers active, there were 84 unique G values possible, but with far too few interviews obtained, some level of detail needed to be removed from the analysis. Based on preliminary values, it was decided to pool over day type, and to pool months into three seasons:

$$G_{esf} = \frac{\sum_d \sum_m T'_{mdsf}}{\sum_d \sum_m \left(W1_{mds} \cdot \sum_a \sum_k \sum_q \left(W2_{mdsak} \cdot n_{mdsfakq}\right)\right)} \quad \text{where } m \in e. \qquad \text{(Eqn. 9)}$$

The variance was calculated from the weighted values using the standard formula. It was also necessary to pool over access method in the easternmost river stratum in the shoulder season, and to pool all strata (day type, access method, river stratum) into a single estimate for the low season.

Catch Per Unit Effort Estimation

Catch per unit effort (and, similarly, harvest per unit effort) was estimated for each species of fish from interviews of anglers returning with their catch, conducted at the shore-based access sites. For each interview (i), the month (m), day type (d), and access method (f) was recorded, along with the catch (C) of each species (r), the number of anglers (A), and the number of hours spent fishing (H) in each river stratum (s). Using these data, CPUE would ideally be calculated for each sample as:

$$CPUE_{mdsfri} = \frac{C_{mdsfri}}{A_{mdsft} \cdot H_{mdsfi}} \quad . \qquad \text{(Eqn. 10)}$$

However, too few interviews were obtained to provide adequate sample size (n ~3) to reliably estimate *CPUE* and its variance for each of the 84 blocks (Table 5). As *CPUE* was *expected* to change with month, river stratum and access method, it was decided to pool interview data by day type. Yet, sample size issues pervaded, and required further reductions in detail, thus months were merged into three seasons (e). Individual sample CPUE was calculated as:

$$CPUE_{esfri} = \frac{C_{mdsfri}}{A_{mdsft} \cdot H_{mdsfi}} \quad . \qquad \text{(Eqn. 11)}$$

In most cases, mean *CPUE* was calculated by summing the catch for all n_{edsf} interviews that occurred in a given season, pooling over day type, and dividing by the total number of angler-hours of fishing effort recorded for these interviews:

$$\widehat{CPUE}_{esfr} = \frac{\sum_m \sum_d \sum_{i=1}^{n_{edsf}} C_{mdsfri}}{\sum_m \sum_d \sum_{i=1}^{n_{edsf}} \left(A_{mdsfi} \cdot H_{mdsfi}\right)} \quad \text{where } m \in e. \qquad \text{(Eqn. 12)}$$

The variance for the estimate of mean CPUE was calculated as:

$$S^2_{\widehat{CPUE}_{esfr}} = \frac{\sum_{i=1}^{n_{esf}} \left(CPUE^2_{esfri}\right) - \frac{\sum_{i=1}^{n_{esf}} \left(CPUE_{esfri}\right)^2}{n_{esf}}}{\left(n_{esf} - 1\right)} \quad . \qquad \text{(Eqn. 13)}$$

In several instances, the month/access method/river stratum-specific sample size was too low, even after the data were pooled. Due to low shore interview counts, boat and shore interviews were pooled in the Site C to Many Islands stratum in May and June. The same pooling was done due to low boat interviews in the other two river strata from September to April. Also, the July and August shore angler data from the strata upstream of Site C were pooled (Table 5).

The CPUE of fish that were harvested and that of fish that were released were calculated by repeating the creel analyses with released or harvested fish excluded from the interview database.

Statistical tests of the effects of season, river stratum, or access method on CPUE were done separately for each species using Wilcoxon tests (non-parametric ANOVA equivalent), with the experiment-wise alpha controlled at the 0.05 level using the Bonferroni adjustment (Abdi 2007).

Table 5. The sample size of angler CPUE data (i.e., the number of interviewed parties reporting catch and effort) for each river stratum, and for each period, day type, and access method. For analyses, data were pooled over day type, and months were combined into seasons. Further access-method or river stratum pooling occurred in some river strata during some seasons (see coloured blocks). Abbreviations are as shown in previous tables.

	Day		*River Stratum*			*TOTAL*
Period	*Type*	*Access*	*PCD-HH*	*HH-Site C*	*Site C-MI*	
July	WD	Boat				0
		Shore	2			2
	WE/H	Boat	2	3	1	6
		Shore	11	7	1	19
August	WD	Boat			2	2
		Shore		4		4
	WE/H	Boat	3	5	1	9
		Shore	1	3		4
September	WD	Boat		1	2	3
		Shore	1	1		2
	WE/H	Boat			6	6
		Shore			3	3
October to March	WD	Boat				0
		Shore	1	2		3
	WE/H	Boat				0
		Shore	3			3
April	WD	Boat				0
		Shore	4		3	7
	WE/H	Boat				0
		Shore	11			11
May	WD	Boat				0
		Shore	1			1
	WE/H	Boat		7	1	8
		Shore	7	4		11
June	WD	Boat		4		4
		Shore				0
	WE/H	Boat	3	5	1	9
		Shore	12	1		13
TOTAL			*62*	*47*	*21*	*130*

Angler Effort Estimation

Angler effort estimates were generated using fixed-wing overflights (July and August) or remote sensing (year-round). Data from overflights and time-triggered cameras were treated as point counts, and were divided by the proportion of anglers that were active at the time of the count to estimate whole-day effort. Data from motion-activated cameras were assumed to provide complete coverage of the fishing effort for the areas they monitor.

Overflight Method

During overflights, anglers were counted from a fixed-wing aircraft (chartered through Trek Aerial Surveys, Fort St. John) flying over the study area. It was scheduled to take 4.25 hours to survey the Peace River from Peace Canyon Dam to Many Islands, Alberta (210 km). Flights would generally target a speed of 150-165 km/h at an altitude of 90-150 m above ground level. Aerial surveys only occurred in the first two months of the study period, in July and August 2022. The dates of the overflights were selected randomly within each month, and were equally divided between weekday and weekend/holiday day types.

To maximize statistical precision, timing of angler effort surveys corresponded, to the greatest extent possible, with peak hourly angling effort. The specific timing of flights (i.e., late afternoon) was based on data from previous summertime creel surveys (e.g., DPA 1991, Robichaud et al. 2010). Note that monthly overflights were chartered before collecting the corresponding hourly angling effort data (from interviews), thus flight timing was not expected to always exactly match that of peak angling effort.

During overflight o (conducted during month m and on day type d), observers tallied the total number of anglers (boating and shore-based counted separately, f) that were actively fishing in river stratum s, which was surveyed from a start to end time with a midpoint that fell into time block t, A_{mdsfot}. The number of anglers that were observed at the moment of the overflight was divided by the proportion of average daily shore and boat-based angling effort that occurred during the time block when the observations were recorded (P_{eft}), which resulted in a full-day count for each river stratum. The full-day counts were multiplied by the average angler trip duration (G_{esf}) to determine full-day angling effort in hours on day o, by river stratum and access method, B_{mdsfo}:

$$B_{mdsfo} = \frac{A_{mdsfot} \cdot G_{esf}}{P_{eft}} \quad , \qquad \text{(Eqn. 14)}$$

with variance of

$$S^2_{B_{mdsfo}} = (A_{mdsfot})^2 \cdot \left[\frac{S^2_{G_{mds}}}{{P_{eft}}^2} + \frac{{G_{mds}}^2 \cdot S^2_{P_{eft}}}{{P_{eft}}^4} \right] \quad . \qquad \text{(Eqn. 15)}$$

These estimates were then averaged over the number of overflights conducted, n_{mds}, as:

$$\hat{B}_{mdsf} = \frac{\sum_{o=1}^{n_{mds}} B_{mdsfo}}{n_{mds}} \quad . \qquad \text{(Eqn. 16)}$$

with variance of

$$S^2_{\hat{B}_{mdsf}} = \frac{\sum_{o=1}^{n_{mds}} S^2_{B_{mdsfo}}}{{n_{mds}}^2} \quad . \qquad \text{(Eqn. 17)}$$

Total monthly fishing effort, was calculated for each day type, river stratum, and access method by multiplying the average daily effort by N_{md}:

$$E_{mdsf} = \hat{B}_{mdsf} \cdot N_{md} \quad , \qquad \text{(Eqn. 18)}$$

where N_{md} was the number days of day type d that occurred in month m. The variance of the estimate of the total monthly fishing effort was:

$$S^2_{E_{mdsf}} = S^2_{\hat{B}_{mdsf}} \cdot {N_{md}}^2 \cdot \left[\frac{N_{md} - n_{mds}}{N_{md} - 1}\right] \quad . \qquad \text{(Eqn. 19)}$$

The standard error of the total monthly fishing effort estimate, after pooling over day types, was:

$$S_{E_{msf}} = \sqrt{\sum_d S^2_{E_{mdsf}}} \quad . \qquad \text{(Eqn. 20)}$$

Remote Sensing Method

Cameras were installed to monitor angler activity at seven access points along the Peace River (Table 1, Figure 4). All cameras were Reconyx Model HP2X, deployed inside specially designed metal boxes that were padlocked into position.

There were four planned camera deployment types, including *trail*, *beach*, *launch*, and *road* types. 1) Cameras were to be deployed along all access *trails* (set to take three photos over nine seconds when triggered by motion). 2) Cameras were to be set up on shore-based angling *beaches,* deployed to provide complete coverage along the shoreline (set to take one photo per hour). 3) Cameras were to be deployed at all boat *launches* (set to take three photos over nine seconds when triggered by motion). 4) Cameras were to be deployed on *roads* (set to take three photos over three seconds when triggered by motion) with traffic counters (see below) to determine the proportion of vehicle movements that were associated with fishing boats. Together these camera deployments were assumed to have captured the entirety of the shore-angling locations (barring a negligible number of singleton anglers that might bushwhack into other minor areas), and all of the possible boat launching sites, and should therefore provide a census of effort.

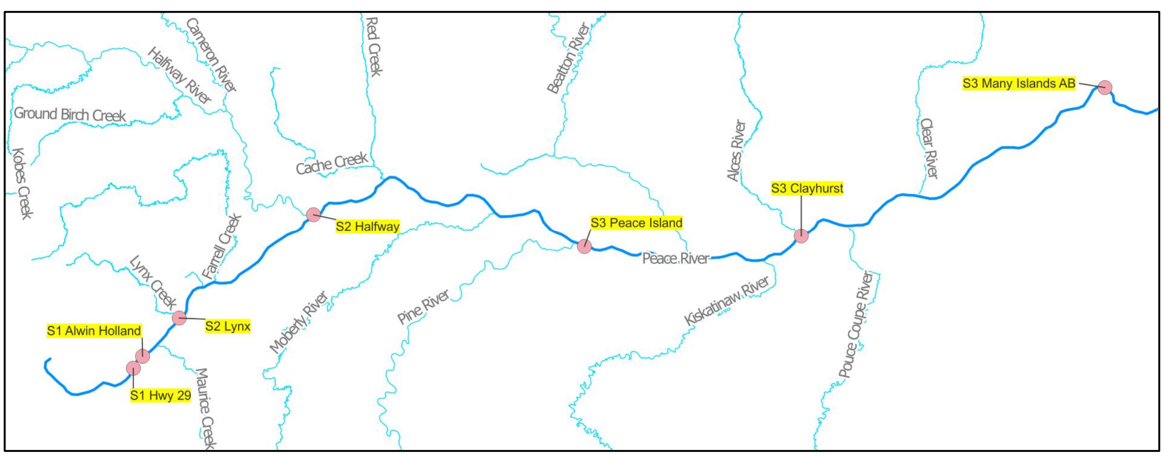

Figure 4. Locations of seven camera monitoring access points along the Peace River mainstem. Site names are prefixed by a two-letter code that indicates the river stratum (S1 = Peace Canyon Dam to Hudson's Hope; S2 = Hudson's Hope to Site C; S3 = Site C to Many Islands) in which the access point was located.

Table 6. Camera and traffic counter deployments, including location, deployment type, and settings, at each of seven access points along the mainstem of the Peace River.

Access Point	Equipment ID	Latitude	Longitude	Type	Settings
Highway 29	PRC001	55.98890	-121.98078	Trail	Motion sensing (3 pics over 9 sec)
	PRC002	55.99051	-121.98085	Beach	Every hour
	PRC003	56.00368	-121.95346	Beach	Every hour
	PRC004	56.00368	-121.95346	Beach	Every hour
Alwin Holland	PRC005	56.00814	-121.95531	Beach	Every hour
	PRC006	56.00815	-121.95536	Beach	Every hour
	PRC007	56.00861	-121.95056	Beach	Every hour
	PRC008	56.00806	-121.95295	Beach	Every hour
	PRC009	56.00861	-121.95222	Trail	Motion sensing (3 pics over 9 sec)
Lynx Creek	PRC010	56.06537	-121.84267	Beach	Every hour
	LC01	56.06525	-121.84308	TRAFx	6 m range, 1 sec delay
	LC02	56.06555	-121.84248	TRAFx	6 m range, 1 sec delay
	PRC024 [a]	56.06545	-121.84201	Lauch	Motion sensing (3 pics over 9 sec)
Halfway Mouth	PRC011	56.21690	-121.44064	Lauch	Every 3 minutes (daytime only)
	HWR01	56.21647	-121.44006	TRAFx	6 m range, 1 sec delay
	HWR02	56.21649	-121.44005	TRAFx	6 m range, 1 sec delay
	PRC012	56.21655	-121.44004	Road	Motion sensing (3 pics over 3 sec)
	PRC013	56.21684	-121.44049	Road	Motion sensing (3 pics over 3 sec)
Peace Island	PRC014	56.13500	-120.67417	Launch	Motion sensing (3 pics over 9 sec)
	PRC015 [b]	56.13500	-120.67417	Launch	Motion sensing (3 pics over 9 sec)
	PIB01	56.13488	-120.67391	TRAFx	6 m range, 1 sec delay
Clayhurst	PRC016 [c]	56.12502	-120.05345	Beach	Every 3 minutes
	PRC017	56.12500	-120.05342	Beach	Every 3 minutes
	PRC018 [d]	56.12534	-120.05026	Launch	Motion sensing (3 pics over 9 sec)
Many Islands	PRC020 [e]	56.31638	-119.14766	Launch	Every 3 minutes
	MIA01/02 [f]	56.31652	-119.14517	TRAFx	6 m range, 1 sec delay
	PRC021	56.31645	-119.14498	Road	Motion sensing (3 pics over 3 sec)

[a] PRC024 was removed on 1 December 2022 and not redeployed (site was closed to the public by this time).

[b] PRC015 was down from 6 to 12 December 2022, and from 19 December 2022 to 5 April 2023. Since this camera overlapped with PRC014 (which did not go down), the data from this camera were ignored.

[c] PRC016 was down 12 October to 17 November 2022, and from 21 January to 1 May 2023.

[d] PRC018 was stolen/lost almost immediately (last data from 18 September 2022) and is not included in any analyses.

[e] PRC020 was down from 14 October to 17 November 2022, and from 23 January 2023 onwards.

[f] Original unit MIA01 was destroyed by excavator, replaced mid-season with a different unit MIA02.

The seven access points each had a different configuration of camera numbers and deployment types (Tables 1 and 6, Appendix 4), depending on site-specific topography and modes of angler access. All sites with a boat launch (Lynx Creek, Halfway River Bridge, Peace Island, Many Islands) included at least one launch camera, set up to count boat deployments and retrievals. The Alwin Holland and Highway 29 sites both included a trail camera along the paths that most anglers would have used to access these sites. Wherever shore-angling was a prominent activity (Highway 29, Alwin Holland, Lynx Creek, and Clayhurst), beach cameras were deployed to cover as much of the shoreline as possible. Road cameras were deployed at sites where an obvious and well-defined road was expected to be the main route for angler access (Halfway, Many Islands). Four of the cameras were deployed with settings that did not match the plan (see settings in Table 6). Specifically, the two Clayhurst beach cameras took a photo every three minutes instead of every hour, and the Many Islands and Halfway launch cameras took a photo every three minutes instead of being triggered by motion to take 3 photos over nine seconds. None of these deployment errors significantly impacted the interpretation of the photo data.

Cameras were visited regularly by field staff who checked deployment angles and battery levels, made adjustments if required, and swapped out memory cards. “Raw” photos from the memory cards were uploaded onto the Aski server, and then transferred to LGL over SharePoint. LGL processed all photos (n = 642,278) using a YOLO (You Only Look Once) object detection deep learning network. Specifically, YOLOv7 (Wang et al. 2023), the latest and best performing release, was used to detect the boat, car, truck, and person occurrences in the dataset. The YOLOv7 network was pre-trained on the COCO (Common Objects in Context) dataset that includes 330,000 images of 1.5 million objects and can identify 80 classes of objects, including boat, car, truck, and people, out-of-the-box. The subset of photos with detections (n = 173,472) was further processed and anonymized by blurring faces and licence plate numbers. The outputted photos were posted to another SharePoint folder for retrieval and examination by Aski and LGL technicians.

Technicians looked at every outputted photo for most of the main cameras, but examined photos from a randomly selected subset of days for cameras that had very large numbers of outputted photos. Where subsetting was required for a given camera (χ), the average daily numbers of boat- or shore-based anglers was calculated for each month and day-type ($\bar{A}_{mdf\chi}$) from the days that were examined, and were then expanded to account for the days that were skipped (see formulas below). The same equations were used to fill in gaps caused where cameras were jostled out of position, batteries failed, or memory cards were lost.

The result of the technician’s review of photos was a dataset including a row for every detection event (i.e., multiple photos of the same subject were counted as one event). Each row included the date, time (or first time, if the subject appeared in a series of photos), and camera number, along with a description of the photo subject and its movements. For photos that included people, the number of people was noted, and the technicians added a field to identify whether they were angling (carrying rods, tackle, etc.). For trail cameras, a field was included to indicate if the person was arriving at the fishing site or departing. For launch cameras, technicians identified the number of people, number of boats, the direction of boat movement (being launched or hauled back out), and whether any boat appeared be used for recreational angling (many boats could not be positively identified as being specifically for angling, and were flagged as unknown).

For sites with both trail and beach cameras, surveying the same group of shore anglers, the two shore angling effort values were compared and the most realistic was selected for further analysis.

Beach Cameras

Beach cameras were timer-trigged (hourly photos), and the resulting data were treated as point counts. For each deployment, the hourly for which photos showed the greatest number of anglers was used as that which represented peak activity. The peak angler count was divided by the proportion of anglers that were active at the time of the count to estimate whole-day effort for the area being monitored.

For beach cameras (χ_b), photo reviewers identified beach users (β) at each access site (a) in each hour (h) of each day (o) from each camera (i) as either being anglers ($\beta_{mdaioh,(f=shore)}$), certainly non-anglers ($\beta_{mdaioh,(not)}$), or unknown ($\beta_{mdaioh,(unk)}$). The relative numbers of anglers to non-anglers were used to apportion the unknown people into the two categories, calculated for each access site by season and day type, as

$$\kappa_{eda,(f=shore),\chi_b} = \frac{\sum_i \sum_o \sum_h \beta_{mdaioh,(f=shore)}}{\sum_i \sum_o \sum_h \left(\beta_{mdiaoh,(f=shore)} + \beta_{mdiaoh,(not)}\right)} \quad \text{where } m \in e. \qquad \text{(Eqn. 21)}$$

and the total number of anglers (A) was calculated as:

$$A_{mdaioh,(f=shore),\chi_b} = \beta_{mdaioh,(f=shore)} + \beta_{mdaioh,(unk)} \cdot \kappa_{eda,(f=shore),\chi_b} \qquad \text{(Eqn. 22)}$$

with variances of:

$$S^2_{\kappa\, eda,(f=shore),\chi_b} = \frac{(\kappa_{eda,(f=shore),\chi_b})(1-\kappa_{eda,(f=shore),\chi_b})}{\sum_o \sum_h \left(\beta_{mdaioh,(f=shore)} + \beta_{mdaioh,(not)}\right)} \quad \text{and} \qquad \text{(Eqn. 23)}$$

$$S^2_{A_{mdaioh,(f=shore),\chi_b}} = \beta_{mdaioh,(unk)}{}^2 \cdot S^2_{\kappa\, eda,(f=shore),\chi_b} \quad . \qquad \text{(Eqn. 24)}$$

At each access site, the various beach cameras were considered additive (shoreline coverage was non-overlapping), so that shore angler counts ($A_{mdaioh,(f=shore),\chi_b}$) from each camera ($i$) were added together. For these beach cameras, photos were taken hourly, hence there was a risk of counting the same person repeatedly over a day. To account for this, hourly total shore angler counts were calculated by summing over each of the cameras for that hour (n = $n_{\chi_{b,a}}$), and the largest of those site-wide hourly totals was selected for each day:

$$A_{mdao,(f=shore),\chi_b} = \max_h\left(\sum_i^{n_{\chi_{b,a}}} A_{mdaioh,(f=shore),\chi_b}\right) \quad . \qquad \text{(Eqn. 25)}$$

The selected total, along with its variance and its timestamp, was used to calculate whole-day effort, in angler hours for each day, as:

$$\hat{B}_{mdao,(f=shore),\chi_b} = \frac{A_{mdao,(f=shore),\chi_b} \cdot G_{esf}}{P_{eft}} \quad . \qquad \text{(Eqn. 26)}$$

with variances of:

$$S^2_{G/P} = S^2_{G_{esf}} / P_{eft}{}^2 + S^2_{P_{eft}} \cdot G_{esf}{}^2 / P_{eft}{}^4 \quad \text{and} \qquad \text{(Eqn. 27)}$$

$$S^2_{\hat{B}_{mdao,(f=shore),\chi_b}} = S^2_{A_{mdaoh,(f=shore),\chi_b}} \cdot \left(\frac{G_{esf}}{P_{eft}}\right)^2 + A_{mdao,(f=shore),\chi_b}{}^2 \cdot S^2_{\frac{G}{P}} + S^2_{A_{mdaoh,(f=shore),\chi_b}} \cdot S^2_{G/P} \quad . \qquad \text{(Eqn. 28)}$$

The angler hour estimates were averaged over season and day type for each site, as:

$$\hat{B}_{eda,(f=shore),\chi_b} = \frac{\sum_m \sum_{o_{ab}}^{n_{o_{eda,\chi_b}}} \hat{B}_{mdao,(f=shore),\chi_b}}{n_{o_{eda,\chi_b}}} \quad \text{where } m \in e\text{, and} \qquad \text{(Eqn. 29)}$$

$$S^2_{\hat{B}_{eda,(f=shore),\chi_b}} = \frac{\sum_m \sum_{o_{ab}}^{n_{o_{eda,\chi_b}}} S^2_{\hat{B}_{mdao,(f=shore),\chi_b}}}{{n_{o_{eda,\chi_b}}}^2} \quad \text{where } m \in e, \qquad \text{(Eqn. 30)}$$

where o_{eda,χ_b} denoted the individual days with complete (all cameras functional) beach camera data available for access site a in season e and for day type d, and $n_{o_{eda,\chi_b}}$ was the number of those days.

Effort was calculated for the season by multiplying by N_{ed} (i.e., by the number of days of day type d that occurred during season e of our study year),

$$E_{eda,(f=shore),\chi_b} = \hat{B}_{eda,(f=shore),\chi_b} \cdot N_{ed} \quad , \qquad \text{(Eqn. 31)}$$

with variances accounting for the large portion of the finite population sampled ($n_{o_{eda,\chi_b}}/N_{ed}$), as:

$$S^2_{E_{eda,(f=shore),\chi_b}} = S^2_{\hat{B}_{eda,(f=shore),\chi_b}} \cdot {N_{ed}}^2 \cdot \left[\frac{N_{ed} - n_{o_{eda,\chi_b}}}{N_{ed} - 1}\right] \quad . \qquad \text{(Eqn. 32)}$$

Due to general sample size limitations from the early part of the study period (e.g., at the Highway 29 access site, there were no beach photos from July 2022), photo data from 1-15 July 2023 were included in the dataset and used as representative of the activity in July 2022. Similarly, photography from 1 to 8 July 2023 was included in the Clayhurst estimates as representative of July 2022.

As an additional detail, it was noted that the launch cameras deployed at Halfway, Many Islands, Peace Island, and Lynx Creek, sometimes detected beach anglers. The photos from the launch cameras needed to be processed differently from the method described above because the launch cameras were triggered by motion (beach cameras took pictures hourly), and were thus assumed to be complete surveys of the activity in the area. See below for details.

Trail Cameras

Data from trail cameras (χ_t), which were motion-activated, were assumed to provide complete coverage of the fishing effort for the areas they monitored. For these cameras, photo reviewers tried to identify individuals based on clothing, body shape, pets, and things in their possession, to avoid double counting parties. The reviewers typically noted a party's arrival, ignoring their departure, or else noted only the departure if the arrival was somehow missed. As such, tallying over each day (d) provided counts of trail users (ζ) on each day (o) (hence month, m, and day type, d) that were anglers ($\zeta_{mdao,(f=shore)}$), certainly non-anglers ($\zeta_{mdao,(not)}$), and the number of people whose activity (with respect to angling or not) was unknown ($\zeta_{mdao,(unk)}$). The relative numbers of anglers to non-anglers were used to apportion the unknown people into the two categories, as

$$\kappa_{mda,(f=shore),\chi_t} = \frac{\sum_o \zeta_{mdao,(f=shore)}}{\sum_o\left(\zeta_{mdao,(f=shore)} + \zeta_{mdao,(not)}\right)} \quad , \qquad \text{(Eqn. 33)}$$

and the total daily number of anglers (A) was calculated as:

$$A_{mdao,(f=shore),\chi_t} = \zeta_{mdao,(f=shore)} + \zeta_{mdao,(unk)} \cdot \kappa_{mda,(f=shore),\chi_t} \qquad \text{(Eqn. 34)}$$

with variances of:

$$S^2_{\kappa_{mda,(f=shore),\chi_t}} = \frac{\left(\kappa_{mda,(f=shore),\chi_t}\right)\left(1 - \kappa_{mda,(f=shore),\chi_t}\right)}{\sum_o\left(\zeta_{mdao,(f=shore)} + \zeta_{mdao,(not)}\right)} \quad \text{and} \qquad \text{(Eqn. 35)}$$

$$S^2_{A_{mdao,(f=shore),\chi_t}} = \zeta_{mdao,(unk)}{}^2 \cdot S^2_{\kappa\, mda,(f=shore),\chi_t} \quad . \qquad \text{(Eqn. 36)}$$

The total daily counts were translated into angler hours as:

$$\hat{B}_{mdao,(f=shore),\chi_t} = A_{mdao,(f=shore),\chi_t} \cdot G_{esf} \quad , \qquad \text{(Eqn. 37)}$$

with variance of:

$$S^2_{\hat{B}_{mdao,(f=shore),\chi_t}} = A_{mdao,(f=shore),\chi_t}{}^2 \cdot S^2_{G_{esf}} + G_{esf}{}^2 \cdot S^2_{A_{mdao,(f=shore),\chi_t}} + S^2_{A_{mdao,(f=shore),\chi_t}} \cdot S^2_{G_{esf}} \quad . \qquad \text{(Eqn. 38)}$$

and averaged over $n_{o_{mda_t}}$, the number of days with trail camera data available for the access site a in month m and for day type d as:

$$\hat{B}_{mda,(f=shore),\chi_t} = \frac{\sum_{o_{at}}^{n_{o_{mda_t}}} \hat{B}_{mdao,(f=shore),\chi_t}}{n_{o_{mda_t}}} \quad \text{, and} \qquad \text{(Eqn. 39)}$$

$$S^2_{\hat{B}_{mda,(f=shore),\chi_t}} = \frac{\sum_{o_{at}}^{n_{o_{mda_t}}} S^2_{\hat{B}_{mdao,(f=shore),\chi_t}}}{n_{o_{mda_t}}{}^2} \quad . \qquad \text{(Eqn. 40)}$$

Effort was calculated for the month by multiplying by N_{md}:

$$E_{mda,(f=shore),\chi_t} = \hat{B}_{mda,(f=shore),\chi_t} \cdot N_{md} \quad , \qquad \text{(Eqn. 41)}$$

with variances accounting for the large portion of the finite population sampled ($n_{o_{mda_t}}/N_{md}$), as:

$$S^2_{E_{mda,(f=shore),\chi_t}} = S^2_{\hat{B}_{mda,(f=shore),\chi_t}} \cdot N_{md}{}^2 \cdot \left[\frac{N_{md} - n_{o_{mda_t}}}{N_{md} - 1}\right] \quad . \qquad \text{(Eqn. 42)}$$

Due to sample size limitations at the Highway 29 access site (no photos prior to October 2022), photo data from 1-15 July 2023 were used as representative of the activity in July and August 2022; and average $\hat{B}_{mda}$ estimates for September were derived from photo data from October 2022 to April 2023 pooled with those from July 2023.

Launch Cameras

Boat Angling

Data from launch cameras (χ_l), which were motion-activated, were assumed to provide complete coverage of the fishing effort for the areas they monitored. For these cameras, technicians tried to avoid double-counting parties by identifying them based on the colour and model of the boat and truck, people's clothes and body shape, pets, and things in their possession. The photo reviewers typically noted a party's launch, ignoring their haul out, or else noted only the haul out if the launch was somehow missed. As such, total counts of boat-based anglers for each day ($A_{mdao,(f=boat),\chi_l}$) could be easily generated by tallying the day's detections.

It was noted during photo processing that most boats could not be reliably identified as containing either angling vs non-angling parties (a large majority were marked as unknown, and an unreliable number were marked as certainly angling). As such, tallies of angling ($\nu_{mdaoh,(f=boat)}$) vs. nonangling ($\nu_{mdaoh,(not)}$) boats from the interview shifts (conducted at site a on day o with counts made in hour h) were used to estimate relative proportions ($\kappa_{eds,(f=boat)}$) specific to river stratum (s), season (e), and day type (d), as:

$$\kappa_{eds,(f=boat)} = \frac{\sum_m \sum_s \sum_o \sum_h \nu_{mdaoh,(f=boat)}}{\sum_m \sum_s \sum_o \sum_h \left(\nu_{mdaoh,(f=boat)} + \nu_{mdaoh,(not)}\right)} \quad \text{where } m \in e \text{ and } a \in s. \qquad \text{(Eqn. 43)}$$

These proportions were used to apportion the total daily number of photographed boat-based people (ω_{mdao,χ_l}) between the two categories, where the total daily number of boats-based anglers (A) was calculated as:

$$A_{mdao,(f=boat),\chi_l} = \omega_{mdao,\chi_l} \cdot \kappa_{eds,(\,f=boat)} \qquad \text{(Eqn. 44)}$$

with variances of:

$$S^2_{\kappa\,eds,(f=boat)} = \frac{(\kappa_{eds,(f=boat)})(1-\kappa_{eds,(f=boat)})}{\sum_m \sum_s \sum_o \sum_h \left(\nu_{mdaoh,(f=boat)} + \nu_{mdaoh,(not)}\right)} \quad \text{and} \qquad \text{(Eqn. 45)}$$

$$S^2_{A_{mdao,(f=boat),\chi_l}} = \omega_{mdao,\chi_l}{}^2 \cdot S^2_{\kappa\,eds,(f=boat)} \quad . \qquad \text{(Eqn. 46)}$$

The total daily counts were translated into angler hours as:

$$\hat{B}_{mdao,(f=boat),\chi_l} = A_{mdao,(f=boat),\chi_l} \cdot G_{esf} \quad , \qquad \text{(Eqn. 47)}$$

with variance of:

$$S^2_{\hat{B}_{mdao,(f=boat),\chi_l}} = A_{mdao,(f=boat),\chi_l}{}^2 \cdot S^2_{G_{esf}} + G_{esf}{}^2 \cdot S^2_{A_{mdao,(f=boat),\chi_l}} + S^2_{A_{mdao,(f=boat),\chi_l}} \cdot S^2_{G_{esf}} \quad , \qquad \text{(Eqn. 48)}$$

and averaged over $n_{o_{mda_l}}$, the number of days with launch camera data available for access site a in month m and for day type d as:

$$\hat{B}_{mda,(f=boat),\chi_l} = \frac{\sum_{o_{al}}^{n_{o_{mda_l}}} \hat{B}_{mdao,(f=boat),\chi_l}}{n_{o_{mda_l}}} \quad \text{, and} \qquad \text{(Eqn. 49)}$$

$$S^2_{\hat{B}_{mda,(f=shore),\chi_t}} = \frac{\sum_{o_{al}}^{n_{o_{mda_l}}} S^2_{\hat{B}_{mdao,(f=boat),\chi_l}}}{n_{o_{mda_l}}{}^2} \quad . \qquad \text{(Eqn. 50)}$$

Effort was calculated for the month by multiplying by N_{md}:

$$E_{mda,(f=boat),\chi_l} = \hat{B}_{mda,(f=boat),\chi_l} \cdot N_{md} \quad , \qquad \text{(Eqn. 51)}$$

with variances accounting for the large portion of the finite population sampled ($n_{o_{mda_l}}/N_{md}$), as:

$$S^2_{E_{mda,(f=boat),\chi_l}} = S^2_{\hat{B}_{mda,(f=boat),\chi_l}} \cdot N_{md}{}^2 \cdot \left[\frac{N_{md} - n_{o_{mda_l}}}{N_{md} - 1}\right] \quad . \qquad \text{(Eqn. 52)}$$

Note that closures at Many Islands and Lynx affected the N_{md} values used in Equations 51 and 52.

All angling conducted by boats that launched downstream of Site C occurred in the 'Site C to Many Islands' river stratum. However, boats that launched upstream of Site C (at Lynx or Halfway) could have fished in either of the two nearby strata (i.e., Peace Canyon Dam to Hudson's Hope or Hudson's Hope to Site C). Thus, the effort estimated from photos at Lynx or Halfway were apportioned between the two strata based on the relative proportions (ϑ_{esa}) of boat-based (f=boat) angler (A) hours (H) reported for each stratum (s) in the angler interviews conducted at those sites (a), pooling over day type (d) and grouping months (m) into seasons (e), as:

$$\vartheta_{esa} = \frac{\sum_m \sum_d \sum_i A_{mdsfai} \cdot H_{mdsfai}}{\sum_m \sum_d \sum_s \sum_i A_{mdsfai} \cdot H_{mdsfai}} \quad \text{where } m \in e \text{ and } f = \text{boat.} \qquad \text{(Eqn. 53)}$$

and

$$E_{mds,(f=boat),\chi_l} = E_{mda,(f=boat),\chi_l} \cdot \vartheta_{esa} \quad , \qquad \text{(Eqn. 54)}$$

with variances of

$$S^2_{\vartheta_{esa}} = \frac{\vartheta_{esa}(1-\vartheta_{esa})}{\sum_m \sum_d \sum_s \sum_i A_{mdsfai} \cdot H_{mdsfai}} \quad \text{where } m \in e \text{ and } f = \text{boat.} \qquad \text{(Eqn. 55)}$$

and

$$S^2_{E\,mds,(f=boat),\chi_l} = E_{mda,(f=boat),\chi_l}{}^2 \cdot S^2_{\vartheta_{esa}} + S^2_{E_{mda,(f=boat),\chi_l}} \cdot \vartheta_{esa}{}^2 + S^2_{E_{mda,(f=boat),\chi_l}} \cdot S^2_{\vartheta_{esa}} \quad . \qquad \text{(Eqn. 56)}$$

Due to sample size limitations at the Peace Island access site (no photos prior to 28 August 2022), photo data from 28-29 August 2022, plus Camera 15 data from 1-3 July 2023 were pooled together as representative of the activity in July and August 2022. Similarly for the Many Islands access site (no photos prior to 30 July 2022), photo data from 30 July to 31 August 2022 were pooled together (i.e., pooled over season) as representative of the activity in July and August 2022. At Lynx Launch, data were processed by season rather than by month. Also, due to samples size limitations, the Halfway September $\hat{B}_{mda}$ estimate was derived from photo data from August through October 2022.

Shore Angling

As noted above, the motion sensors of the launch cameras were sometimes triggered by shore anglers. The photos from the launch cameras needed to be processed differently from the method described above for ‘beach deployments’ because the launch cameras were triggered by motion (beach cameras took pictures hourly), and were thus assumed to be complete surveys of the activity in the area. See below for details.

Shore anglers photographed by launch cameras were processed by photo reviewers who tried to identify individuals based on clothing, body shape, pets, and things in their possession, to avoid double counting parties. As such, and since the cameras were triggered by motion, the data were assumed to be complete, and were treated as additive over the course of a day.

Beach users with unknown activity were apportioned into anglers and non-anglers using site-specific rates, $\kappa_{eda,(f=shore),\chi_l}$, as in Equations 21 to 24. Derived angler counts were summed over time, and multiplied by trip duration to calculate daily angler hours, as:

$$A_{mdao,(f=shore),\chi_l} = \frac{\sum_h^{n_{mdao}} A_{mdaoh,(f=shore),\chi_l}}{n_{mdao}} \quad , \qquad \text{(Eqn. 57)}$$

$$S^2_{A_{mdao,(f=shore),\chi_l}} = \frac{\sum_h^{n_{mdao}} S^2_{A_{mdaoh,(f=shore),\chi_l}}}{n_{mdao}{}^2} \quad \text{, and} \qquad \text{(Eqn. 58)}$$

$$\hat{B}_{mdao,(f=shore),\chi_l} = A_{mdao,(f=shore),\chi_l} \cdot G_{esf} \quad , \qquad \text{(Eqn. 59)}$$

with a variance of:

$$S^2_{\hat{B}_{mdao,(f=shore),\chi_b}} = S^2_{A_{mdao,(f=shore),\chi_l}} \cdot {G_{esf}}^2 + {A_{mdao,(f=shore),\chi_l}}^2 \cdot S^2_{G_{esf}} + S^2_{A_{mdao,(f=shore),\chi_l}} \cdot S^2_{G_{esf}} \quad . \qquad \text{(Eqn. 60)}$$

The angler hour estimates were averaged over season and day type for each site, as in Equation 29 and 30, and effort was calculated as in Equations 31 and 32. Note that closures at Many Islands affected the N_{ed} values used in Equations 31 and 32. Also note that as a way to bolster sample sizes, camera 15 photography from 1 to 3 July 2023 was included in the Peace Island estimates as representative of July 2022.

YOLO Model Error Rates

The error rate of the deep learning YOLO model was considered as a source of variance. The rate of false positive output was irrelevant, since all outputted photos underwent a review by a human technician, and outputted photos without vehicles or people were simply skipped over. To estimate the false negative error rate ($\varepsilon_{\chi,neg}$), a random subset of N_χ raw photos from each of three (i.e., trail, beach, launch) camera deployment types (χ) were selected. From these, the 'positive id' photos that had been identified by the YOLO routine were removed. The remaining photos were examined by a technician, who identified any photos that contained a person or a boat. These photos were then examined in the context of the temporally adjacent outputted photos to determine if the boat or person had in fact already been counted (e.g., a single angler could appear in varying positions in all three photos triggered by motion at a trail camera; and if two photos were selected and outputted by the YOLO routine, and the angler was counted by the technician, then the inclusion of the third photo, although originally missed by the routine, would not actually change the resulting count of anglers). If the missed photo would have resulted in a change in the count of people or boats, it was flagged as a false negative ($n_{y,F.neg}$). The number of false negative photos was divided by the original sample size to calculate the false negative rate for each deployment type,

$$\varepsilon_{\chi,neg} = \frac{n_{\chi,F.neg}}{N_\chi} \quad , \qquad \text{(Eqn. 61)}$$

with variance of

$$S^2_{\varepsilon_{\chi,neg}} = \frac{(\varepsilon_{\chi,neg}) \cdot (1 - \varepsilon_{\chi,neg})}{N_\chi} \quad . \qquad \text{(Eqn. 62)}$$

All counts of people or boats determined from photo review were increased to account for the false negative error rate:

$$A'_{mdaof\chi} = \frac{A_{mdaof\chi}}{1 - \varepsilon_{\chi,neg}} \quad , \qquad \text{(Eqn. 63)}$$

with the appropriate variance propagation:

$$S^2_{A'_{mdaof\chi}} = \frac{S^2_{A_{mdaof\chi}}}{(1 - \varepsilon_{\chi,neg})^2} + \frac{\left(A_{mdaof\chi}\right)^2 \cdot S^2_{\varepsilon_{\chi,neg}}}{(1 - \varepsilon_{\chi,neg})^4} \quad . \qquad \text{(Eqn. 64)}$$

Traffic Counters

Another remote sensing tool was used to monitor activity: traffic counters (TRAFx) were deployed to count vehicle movements along roads that led to fishing access points. Traffic counters were deployed at four locations (Tables 1 and 6). All were buried next to gravel roads, and were set to have a 6 m range (i.e., monitor both directions of traffic). Counters were calibrated as per the manufacturer's instructions. The devices recorded the hourly number of heavy ferrous objects that passed through the detection field, and after each detection they delayed recording of a new object for one second.

Statistical Tests on Effort

Statistical tests of the effects of season, day type, river stratum, or access method on effort estimates were done using Wilcoxon tests with the experiment-wise alpha controlled at the 0.05 level using the Bonferroni adjustment (Abdi 2007).

Catch Estimation

Catch was calculated for each season, access method, river stratum, and species by multiplying total angling effort by CPUE, and summing over day type and, where applicable, over period, access sites, and camera deployment types, as:

$$C_{esfr} = \sum_{\chi}\sum_{a}\sum_{m}\sum_{d}\left(E_{msdaf\chi} \cdot \widehat{CPU}E_{esfr}\right) \quad \text{where } m \in e \text{ and } a = \in s. \qquad \text{(Eqn. 65)}$$

where $E_{msdaf\chi}$ was the effort estimate for month m (or season e) in river stratum s, on day type d, for access method f, as recorded based on cameras of deployment type χ at access site a. For beach cameras this was denoted in Equation 31 as $E_{eda,(f=shore),\chi_b}$, for trail cameras it was denoted in Equation 41 as $E_{mda,(f=shore),\chi_t}$, and for launch cameras it was denoted as $E_{mds,(f=boat),\chi_l}$ for boat-based angling (Equation 54) and as $E_{eda,(f=shore),\chi_l}$ for shore-based angling (see details after Equation 60). The standard errors for these catch estimates were derived using the following equation:

$$S_{C_{esfr}} = \sqrt{\sum_{\chi}\sum_{a}\sum_{d}\left(E_{msdaf\chi}{}^2 \cdot \frac{S^2_{CPUE_{esfr}}}{n_{esf}} + CPUE_{esfr}{}^2 \cdot \frac{S^2_{E_{msdaf\chi}}}{n_{o_{mdaf\chi}}} + \frac{S^2_{CPUE_{esfr}}}{n_{esf}} \cdot \frac{S^2_{E_{msdaf\chi}}}{n_{o_{mdaf\chi}}}\right)} \qquad \text{(Eqn. 66)}$$

where $n_{o_{mdaf\chi}}$ was the number of days with complete data available to estimate effort during month m (or season e), on day type d, for access method f, as recorded based on cameras of deployment type χ at access site a. For beach cameras this was denoted in Equation 29 as $n_{o_{eda,\chi_b}}$, for trail cameras it was denoted in Equation 39 as $n_{o_{mda_t}}$, and for launch cameras it was denoted as $n_{o_{mda_l}}$ in Equation 49. The formula in Equation 66 was based on the standard formula for combining the variance of the product of two independent random variables (Goodman 1960).

To estimate the number of fish that were harvested annually, and the annual number of fish that were released after capture, the creel analyses were repeated with released or harvested fish excluded from the interview database.

Statistical tests of the effects of season, river stratum, or access method on per-day catch or harvest estimates were done separately for each species using Wilcoxon tests, with the experiment-wise alpha controlled at the 0.05 level using the Bonferroni adjustment (Abdi 2007).

Sample Size Limitations

To investigate the effect of the relatively limited number of interviews collected, a simple simulation was constructed in which the interview data were repeated one time. The doubling effectively increased sample sizes for variance calculations but did not increase the variability inherent in the interview data themselves. The asymptotic precision of the overall annual catch estimates were compared between the actual and doubled datasets.

Angler and Angling Characteristics

The angler interview data were used to describe angler demographic characteristics, including their locality of origin (Peace Region, rest of BC, rest of Canada, USA, or other), their age, and their experience level. In addition, the data were used to calculate the relative use of bait (vs. lures or flies), the relative popularity of certain target species, and the use of guides. Also, the proportion of interviewees who said they had previously fished or planned to fish elsewhere was tabulated by location. Descriptions of the various behavioural or demographic attributes were made from the raw interview data, after making adjustments ($W1$ and $W2$) to account for sampling distributions. Responses were categorized, and when the anglers from a certain interview fell into multiple categories (e.g., used more than one type of gear), their adjusted angler count was distributed evenly over the appropriate bins.

RESULTS

Estimates of Angler Effort and Catch

Angler Interviews

Over the 12-month study period, 212 anglers were surveyed during 108 interviews. Of these, 158 reported complete trips, including 70 that fished from shore, and 88 that fished from a boat (the remaining 54 anglers had not completed their trips). Of the 212 anglers interviewed, 53 anglers (34 from shore, and 19 boat-based) reported their previous-day's fishing activity. In all, 65 anglers were interviewed in the Peace Canyon to Hudson's Hope Stratum, 108 from Hudson's Hope to Site C, and 39 in the Site C to Many Islands Stratum. July and August were the months that produced the greatest numbers of anglers interviewed (54 and 49, respectively), followed by June (32), May (25), April (22), and September (20). Only 10 anglers were interviewed from October to March.

Angler Activity Proportions

Creel analyses in this report were based on data from 211 anglers, including 'same-day' data from 158 anglers, and 'previous-day' data from 53 anglers. As described in the Methods, low sample sizes required interview data to be pooled into seasons, to be pooled over day-type and river strata, and to also be pooled over access method in the low and shoulder seasons. The resulting sample sizes were 54 and 52 for boat and shore anglers, respectively, in the July-August high season, 50 from September to April (low season), and 55 in May and June (shoulder season). In July and August, both shore- and boat-based activity patterns were bimodal, but the larger peak occurred at different times: the shore-based angler activity was more skewed toward evening fishing times (peak at 6-7 PM), whereas boat-based angler activity peaked at 3-4 PM (Figure 5). Activity was more unimodal in the other seasons, with peaks in the early afternoon. In May and June, fishing trip durations were longer (see below) thus any given hour was more likely to include a larger proportion of any given day's fishing effort (Figure 5).

July and August overflights were faster than expected (see below), and counts of shore anglers occurred between 1-3 PM, a period during which a small portion of shore fishing effort occurred.

Activity Durations

The average number of hours fished per trip (G_{efs}) ranged from 2.1 to 10.9 hours, as shown in Table 7. The longest trips were observed during the shoulder (May to June) season, especially from Hudson's Hope to Site C. The overall average was 4.14 hours per trip (variance 0.38).

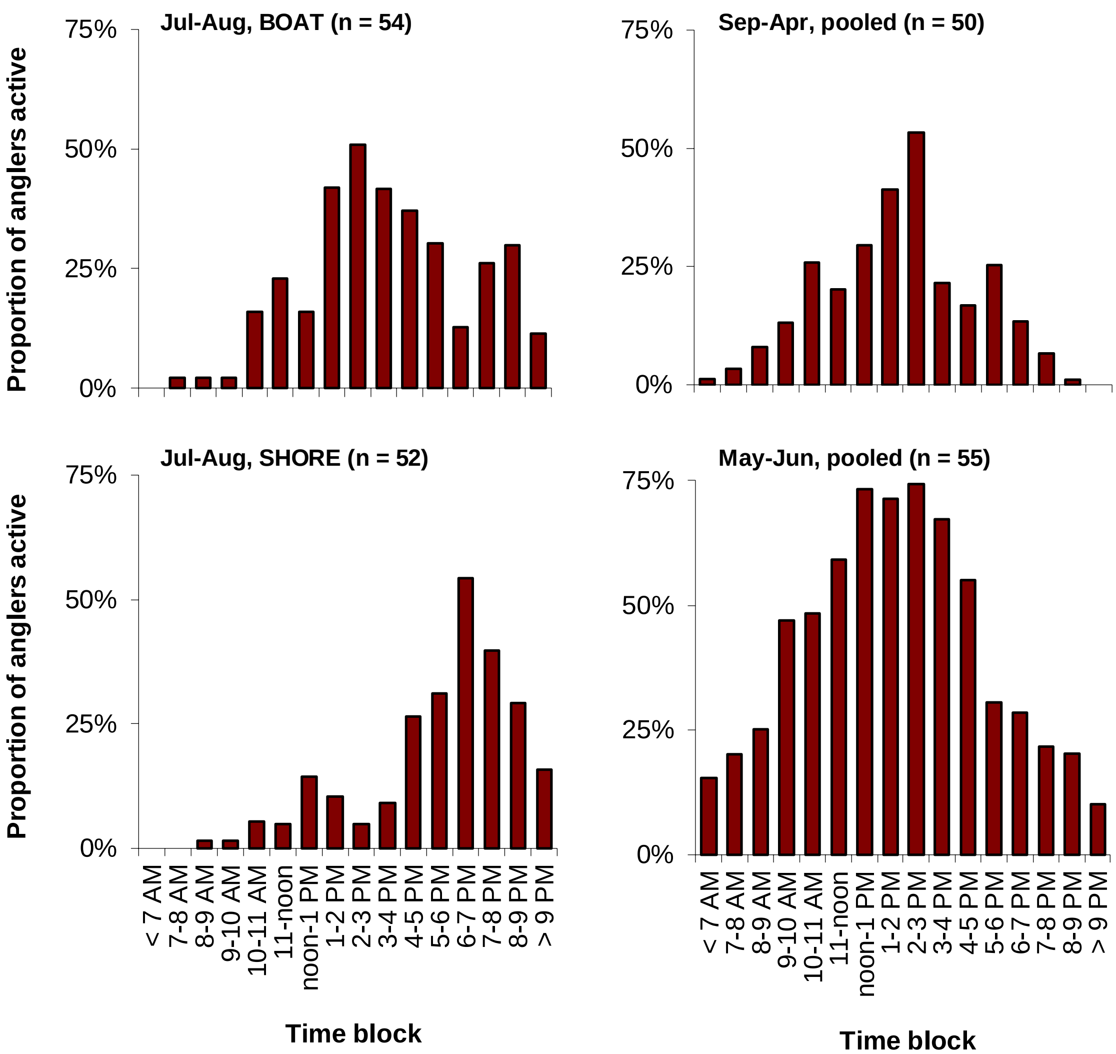

Figure 5. Activity patterns of Peace River shore and boat-based anglers from 1 July 2022 to 30 June 2023. Bars show the proportion of the daily angling effort that was active during any given time block.

Table 7. Mean duration of fishing trips, with variance and sample size (n), by season, river stratum, and access method. Sample sizes required pooling over day-type, and over other strata in some cases. Abbreviations are as shown in previous tables.

Season	*River Stratum**	*Access Method*	*n*	*Mean Trip Duration (h)*	*Variance*
High (Jul-Aug)	PCD-HH	Boat	0 †		
		Shore	15	2.8	1.3
	HH-Site C	Boat	35	4.2	6.0
		Shore	31	2.3	1.1
	Site C-MI	Boat	19	2.1	0.5
		Shore	6	3.2	1.4
Low (Sep-Apr)	pooled	pooled	50	2.8	5.1
Shoulder (May-Jun)	PCD-HH	Boat	0 †		
		Shore	13	3.5	2.3
	HH-Site C	Boat	34	9.1	12.2
		Shore	3	10.9	28.9
	Site C-MI	pooled	5	5.8	6.7

* PCD = Peace Canyon Dam; HH = Hudson's Hope; MI = Many Islands.
† Used omnibus average, 4.14 (0.38) hrs/trip.

Catch Per Unit Effort Estimates

To obtain adequate sample sizes for CPUE estimation, interview data were pooled over day type, and months were pooled into seasons. In some cases, pooling was also done over access method or river stratum. After pooling, a total of 14 separate CPUE estimates were calculated for each taxon, including estimates by season, river stratum, and sometimes access method (Tables 8 and 9).

Table 8. Catch per unit effort (CPUE) estimates (fish per angler-hour) for seven main target fish species, by season, access method, and river stratum. Variance in parentheses. Abbreviations are as shown in previous tables.

Season	*Access Method*	*River Stratum*	*Rainbow Trout*	*Bull Trout*	*Arctic Grayling*	*Mountain Whitefish*	*Kokanee*	*Walleye*	*Goldeye*
High (Jul-Aug)	Shore	PCD to HH	0.766 (1.544)	0.019 (0.018)	0	0.037 (0.024)	0	0	0
		HH to Site C	0.148 (0.449)	0	0.013 (0.004)	0.054 (0.006)	0	0	0
		Site C to MI	(see HH-Site C)	(see HH-Site C)	(see HH- Site C)	(see HH- Site C)	(see HH- Site C)	(see HH- Site C)	(see HH- Site C)
	Boat	PCD to HH	0.369 (0.619)	0.078 (0.048)	0.058 (0.050)	0	0	0	0
		HH to Site C	0.344 (0.460)	0.306 (0.274)	0	0	0	0	0
		Site C to MI	0	0	0	0	0	0	0.107 (0.008)
Low (Sep-Apr)	Shore	PCD to HH	0.046 (0.013)	0.012 (0.000)	0	0	0	0	0
		HH to Site C	0.250 (0.028)	0.125 (0.007)	0	0	0	0	0
		Site C to MI	0.172 (0.267)	0	0	0	0	0.086 (0.383)	0
	Boat	PCD to HH	(see shore)	(see shore)	(see shore)	(see shore)	(see shore)	(see shore)	(see shore)
		HH to Site C	(see shore)	(see shore)	(see shore)	(see shore)	(see shore)	(see shore)	(see shore)
		Site C to MI	0	0.052 (0.143)	0	0	0.052 (0.036)	0.517 (0.176)	0.103 (0.155)
Shoulder (May-Jun)	Shore	PCD to HH	0.069 (0.053)	0.017 (0.006)	0	0	0	0	0
		HH to Site C	0	0	0	0	0	0	0
		Site C to MI	(see boat)	(see boat)	(see boat)	(see boat)	(see boat)	(see boat)	(see boat)
	Boat	PCD to HH	0.300 (0.037)	0	0	0	0	0	0
		HH to Site C	0.025 (0.004)	0.025 (0.012)	0	0	0	0.005 (0.000)	0
		Site C to MI	0	0	0	0	0	0	0

Table 9. Catch per unit effort (CPUE) estimates (fish per angler-hour) for four other fish taxa, by season, access method, and river stratum. Variance in parentheses. Abbreviations are as shown in previous tables.

Season	*Access Method*	*River Stratum*	*Lake Trout*	*Northern Pike*	*Northern Pikeminnow*	*Sucker sp.*
High (Jul-Aug)	Shore	PCD to HH	0.019 (0.018)	0	0	0
		HH to Site C	0	0	0	0
		Site C to MI	(see HH-Site C)	(see HH-Site C)	(see HH- Site C)	(see HH- Site C)
	Boat	PCD to HH	0	0	0	0
		HH to Site C	0.013 (0.000)	0	0.013 (0.001)	0
		Site C to MI	0	0	0	0
Low (Sep-Apr)	Shore	PCD to HH	0	0	0	0
		HH to Site C	0	0	0	0.125 (0.007)
		Site C to MI	0	0	0	0
	Boat	PCD to HH	(see shore)	(see shore)	(see shore)	(see shore)
		HH to Site C	(see shore)	(see shore)	(see shore)	(see shore)
		Site C to MI	0	0.466 (0.143)	0.052 (0.009)	0
Shoulder (May-Jun)	Shore	PCD to HH	0	0	0	0
		HH to Site C	0	0	0	0
		Site C to MI	(see boat)	(see boat)	(see boat)	(see boat)
	Boat	PCD to HH	0	0	0	0
		HH to Site C	0	0	0	0
		Site C to MI	0	0	0	0

Table 10. Statistical tests of the effect of season, river stratum and access method on median catch per unit effort (CPUE) estimates for the 11 fish taxa with non-zero catch.

	Season		*River Stratum*		*Access Method*	
Taxon	χ_2^2	P	χ_2^2	P	χ_1^2	P
Rainbow Trout	2.8	0.24	4.8	0.09	0.3	0.61
Bull Trout	1.6	0.46	1.7	0.43	0.4	0.51
Arctic Grayling	3.9	0.14	0.9	0.65	0.0	0.92
Mountain Whitefish	3.9	0.14	0.9	0.65	2.2	0.14
Kokanee	2.5	0.29	2.5	0.29	1.0	0.32
Walleye	3.5	0.17	3.5	0.17	0.4	0.53
Goldeye	1.2	0.55	5.4	0.07	2.2	0.14
Lake Trout	3.9	0.14	0.9	0.65	0.0	0.92
Northern Pike	2.5	0.29	2.5	0.29	1.0	0.32
Northern Pikeminnow	1.3	0.52	1.3	0.52	2.2	0.14
Sucker sp.	2.5	0.29	1.8	0.41	1.0	0.32

The $C\hat{P}E_{esfr}$ estimates were strongly skewed toward low values, and 79% of the estimates were zero. In general there was no statistically significant effect of season, river stratum, or access method on CPUE for any species (Table 10), which had highest catch rates in the October-March period, and lowest rates in April. Six of the species reported as caught in the Peace River during the study period were never retained. The HPUE (harvest per unit effort) is shown for each of the other six species by season, river stratum, and access method in Table 11.

Table 11. Harvest per unit effort (HPUE) estimates (fish per angler-hour) for six target fish species with non-zero retention rates, by season, access method and river stratum. Abbreviations are as shown in previous tables.

Season	*Access Method*	*River Stratum*	*Rainbow Trout*	*Bull Trout*	*Walleye*	*Lake Trout*	*Northern Pike*	*Northern Pikeminnow*
High (Jul-Aug)	Shore	PCD to HH	0.019 (0.004)	0	0	0	0	0
		HH to Site C	0	0	0	0	0	0
		Site C to MI	(see HH-Site C)	(see HH-Site C)	(see HH- Site C)	(see HH- Site C)	(see HH- Site C)	(see HH- Site C)
	Boat	PCD to HH	0.078 (0.002)	0	0	0	0	0
		HH to Site C	0.051 (0.010)	0	0	0.013 (0.000)	0	0.013 (0.001)
		Site C to MI	0	0	0	0	0	0
Low (Sep-Apr)	Shore	PCD to HH	0.023 (0.006)	0	0	0	0	0
		HH to Site C	0.250 (0.028)	0.125 (0.007)	0	0	0	0
		Site C to MI	0.086 (0.167)	0	0	0	0	0
	Boat	PCD to HH	(see shore)	(see shore)	(see shore)	(see shore)	(see shore)	(see shore)
		HH to Site C	(see shore)	(see shore)	(see shore)	(see shore)	(see shore)	(see shore)
		Site C to MI	0	0	0.155 (0.016)	0	0.103 (0.007)	0
Shoulder (May-Jun)	Shore	PCD to HH	0	0	0	0	0	0
		HH to Site C	0	0	0	0	0	0
		Site C to MI	0	0	0	0	0	0
	Boat	PCD to HH	0	0	0	0	0	0
		HH to Site C	0.005 (0.000)	0	0	0	0	0
		Site C to MI	(see boat)	(see boat)	(see boat)	(see boat)	(see boat)	(see boat)

Angler Effort Estimates

Overflight Method

A total of eight overflights were conducted over the first two months of the study period, including two weekday and two weekend/holiday flights per month. The flight durations were expected to be about 4.25 hours, but took between 1.1 and 1.6 hours (mean 1.3 h), as a result of low numbers of anglers that needed to be counted (e.g., wintertime flights in 2008-09 averaged 1.1 h; Robichaud et al. 2010). A total of 17 anglers (12 shore-based and 5 boat-based) were counted during eight flights. Three flights counted no anglers at all. The maximum number of anglers encountered during a single flight was six.

Flights occurred at a time of day when a small minority (5-10%) of the shore-based anglers were active, hence counts were adjusted upwards by 10-21 times. These adjusted counts were multiplied by trip lengths of 2.3-3.2 hours to calculate daily angler hours. The overflights were better timed with respect to boat-based anglers, having taken place near the peak activity hours, when 42-51% of boat anglers were active (2.0-2.4 times up-conversion). Trip lengths for these boat-based anglers were estimated at 2.1-4.2 hours.

The overflight-based effort estimates are shown in Table 12 for each month, day type, river stratum, and access method. Total effort over the two months was estimated to be 160 angler hours for boat-based anglers and 3,950 hours for shore-based anglers.

Table 12. Effort estimates (angler-hours) from overflight data, by month, day type, access method, and river stratum. Standard errors in parentheses. 'Weekend" day type includes federal/provincial holidays. Abbreviations are as shown in previous tables.

			River Stratum			
Month	*Day Type*	*Access Method*	*PCD to HH*	*HH to Site C*	*Site C to MI*	*Total*
July	Weekday	Boat	0	0	0	0
		Shore	0	940 (463)	0	940 (463)
	Weekend	Boat	0	55 (31)	68 (23)	123 (38)
		Shore	335 (99)	0	1,111 (331)	1,446 (345)
		July Total	335 (99)	995 (464)	1,179 (332)	2,509 (579)
August	Weekday	Boat	0	0	0	0
		Shore	0	0	0	0
	Weekend	Boat	0	37 (20)	0	37 (20)
		Shore	515 (240)	0	1,049 (362)	1,564 (434)
		August Total	515 (240)	37 (20)	1,049 (362)	1,601 (435)
Overall Total			850 (260)	1,032 (465)	2,228 (491)	4,110 (724)

Remote Sensing Method

Camera Data Processing

Camera deployments were effective, but unfortunately there were persistent file management issues. SD cards from cameras were lost before they could be uploaded to the server, and sometimes erased before checking to see if server uploads were successful (which they sometimes were not). That coupled with some dead batteries that were not noticed for an extended period, meant that considerable amounts of the potential data were not available for analysis (Table 13). Data retrieval and storage success (i.e., the proportion of days deployed for which data were available for analysis) ranged from 100% (Camera 5, Alwin Holland beach camera 1) to 14% (Camera 24, Lynx beach camera). Since beach cameras were analyzed as an aggregate within each access site, all cameras had to be available for data from a given day to be included in the analyses. Total monthly sample sizes by access and deployment type (including deductions related to subsampling) are shown in Table 14. The result of these shortcomings was the need to pool data into seasons, with the concomitant loss of resolution and accuracy.

Effort estimates derived from beach cameras are shown by access site, day type, and season in Appendix 5 (Table A5-1). Trail camera-derived effort estimates are in Table A5-2. Boat-based effort estimates from launch cameras are in Table A5-3. Estimates are shown for the three deployment types together, pooled over day type, in Table 15.

Since beach and trail cameras monitored the same pool of activity (i.e., shore angling in the Peace Canyon Dam to Hudson's Hope stratum), the independent estimates were compared (Table 16), such that one could be selected for use in further analysis. The advantages of using the beach camera data were that the results would be derived from the same method as used for the other river strata, and there was no need to examine individual parties to avoid double counting within a day (a process which introduced an unknown level of bias). Some disadvantages of using beach camera data included additional processing steps (for beach data, we summed hourly values over multiple cameras, and found a maximum daily sum, which was divided by imperfect estimates of angler proportions; each step introducing additional variance), and the need for all cameras at a site to be functional for any of them to be used (e.g., beach cameras at Alwin Holland provided fewer days of available data than did trail cameras in August and September of 2022; Table 14). Resulting effort estimates were higher for beach-camera data (157% to 250% of the trail-derived value) at Highway 29 during the July-August season and on weekend/holidays during the September-April season, but was lower during other periods, and was always lower at Alwin Holland (beach values were 27% to 65% of the trail values; Table 16). It is possible that the beach camera coverage at Alwin Holland was not complete (places for people to fish that were not monitored), and this could also have been true at Highway 29 during certain times of year (season affected water levels and hence whether the cameras were effectively monitoring the shoreline). It is not clear how the beach cameras at Highway 29 could have counted more effort than the trail cameras in the early study period, but note that these values were based on very little data (most data for these months were lost). Regardless, the ratio of standard errors for the effort estimates were always notably in favour of the trail cameras (SEs were 1.5 to 4.7 times higher for beach estimates). For this reason, it was decided to use the trail data rather than beach data wherever estimates were available.

A comparison of effort estimates and standard errors, derived from camera and overflight methods during the July-Aug season, is shown by river stratum, access method, and day type in Table 17.

Table 13. The proportion of days in each month for which photo data were available for analysis. Not all of the available data were analyzed, since some subsampling occurred at sites with heavy activity (cameras 14, 16, and 17). Shaded area indicates the months that were pooled together in a single period.

Access Site	*Highway 29 / Fingers*				*Alwin Holland*					*Lynx*		*Half-way*	*Peace Island*	*Clayhurst*		*Many Islands*
Deployment	*Trail*	*Beach*	*Beach*	*Beach*	*Trail*	*Beach*	*Beach*	*Beach*	*Beach*	*Beach*	*Launch*	*Launch*	*Launch*	*Beach*	*Beach*	*Launch*
Camera Number	*1*	*2*	*3*	*4*	*9*	*5*	*6*	*7*	*8*	*24*	*10*	*11*	*14*	*16*	*17*	*20*
July 2022	0%	0%	3%	3%	100%	100%	100%	100%	100%	42%	42%	77%	0%	16%	16%	6%
August 2022	0%	0%	100%	100%	84%	100%	84%	65%	65%	0%	0%	100%	16%	100%	100%	100%
September 2022	0%	0%	100%	100%	100%	100%	27%	27%	27%	0%	0%	3%	37%	57%	57%	100%
October 2022	29%	29%	100%	100%	100%	100%	100%	100%	100%	32%	32%	58%	61%	42%	100%	42%
November 2022	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	80%	100%	100%	47%	100%	na
December 2022	100%	100%	100%	100%	100%	100%	100%	100%	100%	3%	100%	100%	100%	100%	100%	na
January 2023	100%	87%	90%	97%	100%	100%	100%	100%	100%	0%	100%	100%	100%	68%	100%	na
February 2023	100%	100%	100%	100%	100%	100%	100%	100%	100%	0%	100%	100%	100%	0%	100%	na
March 2023	100%	100%	100%	100%	100%	100%	100%	100%	100%	0%	100%	100%	100%	0%	100%	na
April 2023	100%	100%	100%	100%	100%	100%	100%	100%	100%	0%	100%	100%	100%	0%	100%	na
May 2023	100%	100%	100%	100%	100%	100%	100%	100%	100%	0%	58%	100%	100%	100%	100%	0%
June 2023	100%	100%	100%	100%	100%	100%	100%	100%	100%	0%	na	83%	63%	100%	100%	0%
1-15 July 2023	100%	93%	87%	93%	93%	100%	93%	93%	93%	0%	na	0%	0%	53%	53%	0%
Whole Study	70%	69%	91%	92%	98%	100%	93%	91%	91%	14%	67%	82%	70%	53%	88%	38%

Table 14. The number of days in each month for which photo data were analyzed, by site and deployment method. Shaded area indicates the months that were pooled together in a single period.

Access Site	*Highway 29 / Fingers*		*Alwin Holland*		*Lynx*		*Halfway*	*Peace Island*	*Clayhurst*	*Many Islands*
Deployment	*Trail*	*Beach*	*Trail*	*Beach*	*Beach*	*Launch*	*Launch*	*Launch*	*Beach*	*Launch*
Camera Number	*1*	*2-4*	*9*	*5-8*	*24*	*10*	*11*	*14*	*16-17*	*20*
July 2022	0	0	31	31	13	13	24	0	1	2
August 2022	0	0	26	20	0	0	31	2	10	31
September 2022	0	0	30	8	0	0	1	3	14	30
October 2022	9	9	31	31	10	10	18	2	13	13
November 2022	30	30	30	30	30	24	30	4	14	na
December 2022	31	31	31	31	1	31	31	4	31	na
January 2023	31	24	31	31	0	31	31	4	21	na
February 2023	28	28	28	28	0	28	28	4	0	na
March 2023	31	31	31	31	0	31	31	4	0	na
April 2023	30	30	30	30	0	30	30	8	0	0
May 2023	31	31	31	31	0	18	31	8	8	0
June 2023	30	30	30	30	0	na	25	5	8	0
1-15 July 2023	15	13	0	0	0	na	0	3*	3	0

* Three days of data from Camera 15 were used in July 2023 as a proxy for Camera 14.

Table 15. Total angling effort (angler hours) by access site, season, and camera deployment. Beach and Trail cameras estimated the same shore-based effort pool (were independent estimates and are not additive). Shading indicates the data that were used for subsequent analyses, by access type.

		Shore Angling		*Boat Angling*
Access Site	*Season*	*Beach*	*Trail*	*Launch*
Highway 29	High (Jul-Aug)	1,317.8	686.4	
	Low (Sep-Apr)	204.9	270.3	
	Shoulder (May-Jun)	271.7	699.8	
Highway 29 Total		*1,794.5*	*1,656.5*	
Alwin Holland	High (Jul-Aug)	907.1	1,424.4	
	Low (Sep-Apr)	401.3	836.5	
	Shoulder (May-Jun)	587.8	1,159.4	
Alwin Holland Total		*1,896.2*	*3,420.2*	
Lynx	High (Jul-Aug)	0.0		86.3
	Low (Sep-Apr)	33.3		0
	Shoulder (May-Jun)	0		0
Lynx Total		*33.3*		*86.3*
Halfway	High (Jul-Aug)	228.7		696.2
	Low (Sep-Apr)	27.8		166.3
	Shoulder (May-Jun)	360.9		2,257.2
Halfway Total		*617.3*		*3,119.7*
Peace Island	High (Jul-Aug)	1,304.3		316.6
	Low (Sep-Apr)	229.0		621.0
	Shoulder (May-Jun)	1,134.0		430.3
Peace Island Total		*2,667.3*		*1,367.8*
Clayhurst	High (Jul-Aug)	1,491.9		
	Low (Sep-Apr)	4.4		
	Shoulder (May-Jun)	366.6		
Clayhurst Total		*1,863.0*		
Many Islands	High (Jul-Aug)	584.8		73.8
	Low (Sep-Apr)	151.6		30.6
	Shoulder (May-Jun)	0.0		0
Many Islands Total		*736.5*		*104.4*

Table 16. Comparison of effort estimates, sample sizes, and standard errors derived from beach vs. trail cameras at Highway 29 and Alwin Holland.

		Effort Estimates			*Sample Size*			*Standard Error*		
Season	*Day Type*	*Beach*	*Trail*	*Ratio*	*Beach*	*Trail*	*Ratio*	*Beach*	*Trail*	*Ratio*
Highway 29 / Fingers										
High (Jul-Aug)	WD	676	430	1.57	0	0	-	260	79	3.29
	WE	642	257	2.50	0	0	-	276	59	4.71
Low (Sep-Apr)	WD	46	170	0.27	126	247	0.51	15	8	1.80
	WE	159	101	1.58	57	103	0.55	39	9	4.46
Shoulder (May-Jun)	WD	125	421	0.30	44	44	1.00	0	0	-
	WE	147	278	0.53	17	17	1.00	0	0	-
Alwin Holland										
High (Jul-Aug)	WD	382	590	0.65	34	38	0.89	28	18	1.50
	WE	525	834	0.63	17	19	0.89	38	19	1.98
Low (Sep-Apr)	WD	87	275	0.32	151	166	0.91	15	0	∞
	WE	314	561	0.56	69	76	0.91	41	0	∞
Shoulder (May-Jun)	WD	254	510	0.50	44	44	1.00	0	0	-
	WE	334	649	0.51	17	17	1.00	0	0	-

Table 17. Comparison of effort estimates and standard errors, derived from camera and overflight methods during the July-Aug season, by river stratum, access method, and day type. Abbreviations as in other tables.

River Stratum	*Access Method*	*Day Type*	*Effort Estimates*			*Standard Error*		
			Camera	*Flight*	*Ratio*	*Camera*	*Flight*	*Ratio*
PCD - HH	Boat	WD	0	0	-	0	0	-
		WE	0	0	-	0	0	-
	Shore	WD	1,020	0	∞	81	0	∞
		WE	1,091	850	1.28	62	260	0.24
HH - C	Boat	WD	0	0	-	0	0	-
		WE	782	92	8.49	62	37	1.66
	Shore	WD	173	940	0.18	7	463	0.02
		WE	55	0	∞	4	0	∞
C – MI	Boat	WD	159	0	∞	69	0	∞
		WE	231	68	3.38	101	23	4.48
	Shore	WD	1,312	0	∞	228	0	∞
		WE	2,066	2,160	0.96	350	490	0.71
		TOTAL	6,893	4,110	1.68	451	724	0.62

The distribution of daily effort ($\hat{\boldsymbol{B}}$) estimates (ignoring beach-camera data from the PCD-HH stratum, see above) was strongly skewed toward lower values (Figure 6). There was no statistically significant effect of access method on angler effort (Table 18; χ_1^2 = 2.2, *P* = 0.14). Daily effort was strongly influenced by season (χ_2^2 = 13.1, *P* = 0.001), day type (χ_1^2 = 9.3, *P* = 0.002), and river stratum (χ_2^2 = 18.6, *P* < 0.0001; Figure 6). After adjusting for the number of tests performed (i.e., using the Bonferroni adjustment), the effects of month, river stratum, and day type remained statistically significant (Table 18).

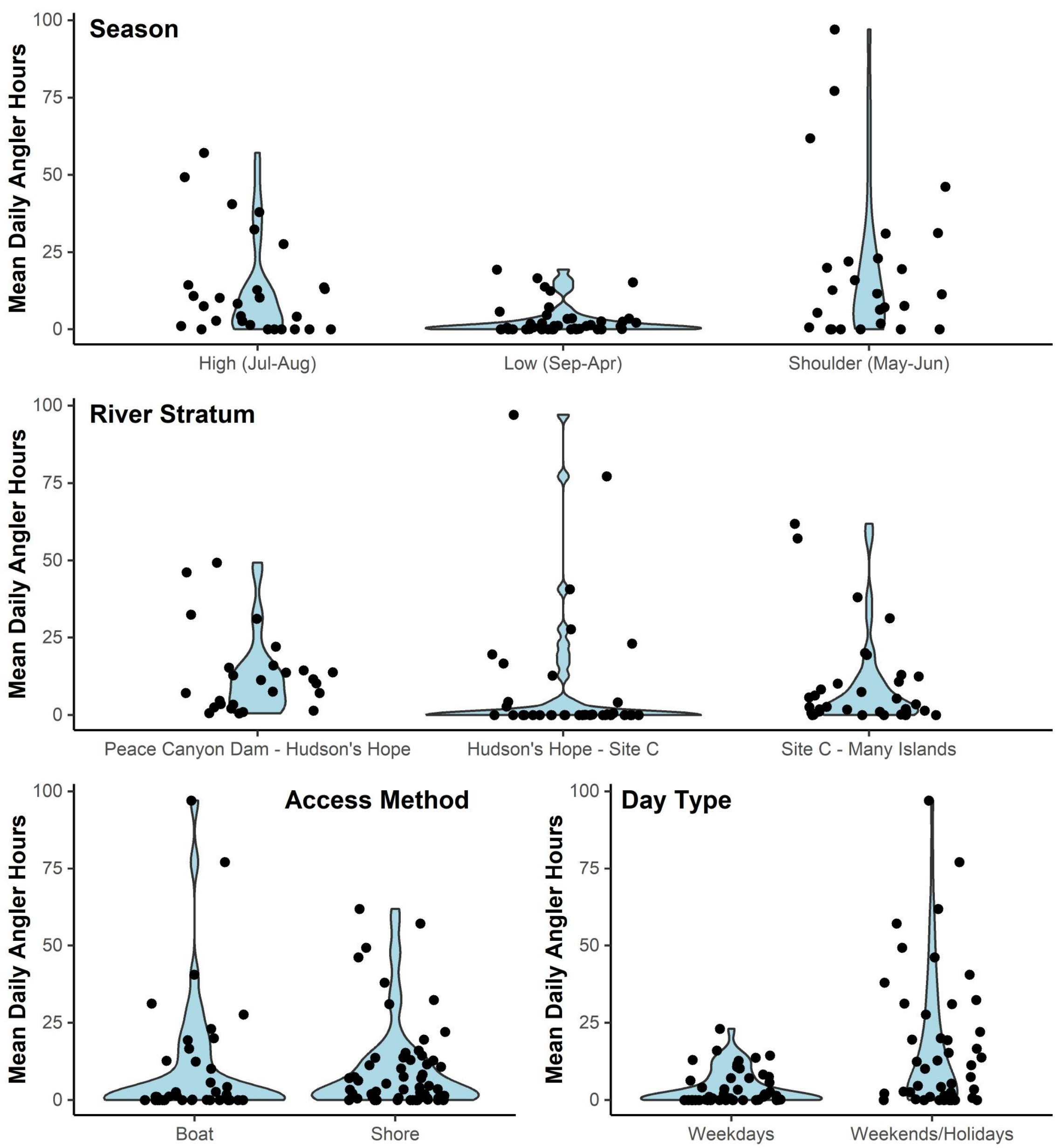

Figure 6. Daily mean angling effort (angler hours) by season (upper panel), river stratum (middle panel), access method (lower left panel), and day type (lower right panel). Points have been jittered (randomly plotted along x-axis within a category) to minimize their overwriting each other. Polygons (blue) are mirrored density plots and are wider where there are more observations.

Table 18. Statistical tests of the effect of season, day type, river stratum, and access method on median daily effort estimates ($\widehat{\boldsymbol{B}}$) during the study period. *P*-values that are in bold are statistically significant after the Bonferroni adjustment.

Effect Test	χ^2	*df*	P
Season	13.1	2	0.001
Day Type	9.3	1	0.002
River Stratum	18.6	2	< 0.0001
Access Method	2.2	1	0.14

Table 19. Effort estimates (angler-hours) from camera data, by season, day type, access method, and river stratum. Shore angler data from beach and launch cameras, unless from trail cameras where noted (*). Boat angler estimates derived from launch cameras and observer tally data. Standard errors, derived from sampling error, in parentheses. 'Weekend" day type includes federal/provincial holidays. Abbreviations are as shown in previous tables.

			River Stratum			
Season	*Day Type*	*Access Method*	*PCD to HH*	*HH to Site C*	*Site C to MI*	*Total*
High (Jul-Aug)	Weekday	Boat	0	0	159 (69)	159 (69)
		Shore	1,020 (81)*	174 (7)	1,314 (228)	2,507 (243)
	Weekend	Boat	514 (39)	269 (30)	231 (101)	1,014 (113)
		Shore	1,091 (62)*	55 (4)	2,067 (351)	3,213 (356)
		Jul-Aug Total	2,625 (109)	497 (31)	3,771 (436)	6,893 (451)
Low (Sep-Apr)	Weekday	Boat	0	0	154 (174)	154 (174)
		Shore	445 (8)*	41 (6)	255 (130)	740 (130)
	Weekend	Boat	0	166 (49)	497 (205)	664 (211)
		Shore	662 (9)*	21 (7)	130 (30)	812 (32)
		Sep-Apr Total	1,107 (12)	227 (50)	1,037 (300)	2,371 (304)
Shoulder (May-Jun)	Weekday	Boat	48 (4)	739 (55)	0	786 (55)
		Shore	931 (0)*	28 (4)	358 (100)	1,318 (100)
	Weekend	Boat	89 (0)	1,382 (0)	430 (174)	1,901 (174)
		Shore	928 (0)*	333 (0)	1,142 (259)	2,403 (259)
		May-Jun Total	1,996 (4)	2,482 (55)	1,931 (327)	6,408 (332)
Overall Total			5,727 (110)	3,206 (80)	6,739 (622)	15,672 (637)

* based on data from trail cameras

Final effort estimates are presented for each river stratum, by season, day type, and access method in Table 19. Total annual effort, summed across all strata was estimated to be 15,672 angler-hours per year (Table 19). The high and shoulder seasons, including July-August, and May-June each had over 6,400 angler hours, or about 3,204 to 3,447 angler hours per month. Total effort during the low season (Sep-Apr) was estimated at 2,371 angler hours over the eight-month period, or about 296 angler hours per month (Table 19).

Angling effort was distributed unequally over the entire study area (Table 19), with 37% occurring in the relatively small stratum from Peace Canyon Dam to Hudson's Hope, 20% occurring from Hudson's Hope to Site C, and 43% between Site C and Many Islands. For the upstream and downstream river strata, boat-based angling effort was estimated to represent a minority of the overall effort (11% from Peace Canyon Dam to Hudson's Hope; 22% from Site C to Many Islands). The converse was true from Hudson's Hope to Site C, where 80% of the effort was boat-based. (Table 19).

Traffic Counters

The attempts to use traffic counters to estimate fishing effort was unsuccessful. The sites where they were deployed had too much industrial activity in 2022-23, some of the units were destroyed, and there were too many gaps in the data series of cameras deployed to monitor the traffic counter sites.

YOLO Model Detection Error Rates

A subset of the raw photos were ground-truthed to estimate the reliability of the YOLO deep learning program in terms of its false negative rate (Table 20). Five random sets of 1,000 raw photos were selected, and the ones that had not been flagged by YOLO were examined by a photo review technician. In all there were 111 photos (of 2,367, 4.7%) that featured people or vehicles but that had not been flagged by the YOLO software. However, most of the missed photos had no impact on the analytical data set. For example, a photo of an angler missed by the YOLO routine (seen 20 March 2023 on the Highway 29 trail camera) was one of a burst of three, the others having been flagged by the YOLO routine – the 'missed' angler had already been entered into the detection data set. Indeed, no anglers were observed in the examined photos that were not already detected by the YOLO algorithm. In all, there was one detection event, spanning 42 photos, all missed by the YOLO program, that showed as many as seven people at the edge of the photo – the people were near a chair and an air-mattress which may have affected the algorithm's ability to detect the forms as people. From the above, the false negative rate was determined to be 0% for trail and beach cameras, and 2.1% for launch cameras, which was applied to increase the overall number of beach users with unknown activity (prior to application of Equation 57).

Table 20. False negative rate for the YOLO model (used to select photos for review that contained a person or a boat), by camera deployment type.

Deployment Type	*Camera Number*	*Photos Selected*	*Positive ID by YOLO*	*Examined for False Negatives*	*False Negatives*	*Events Missed*
Trail	1	1000	194	806	10	0
	9	1000	568	432	12	0
Beach	17	1000	933	67	3	0
Launch	11	1000	338	662	76	1 event (7 people), over 42 photos
	14	1000	600	400	10	0

Catch Estimates

Estimates of total season catch were generated by calculating E × CPUE, and then summing over day types, and over months as appropriate. Depending on the species, estimated catches varied over season, access method, and river stratum (Table 21). However, after adjusting for the number of tests performed (i.e., using the Bonferroni adjustment), no differences were statistically significant (Table 22). Nevertheless, *P*-values from the unadjusted statistical tests are provided below in order to show the magnitude of the differences.

Rainbow Trout was the species that was caught in greatest numbers. The total annual catch of Rainbow Trout, summed across all strata, was estimated at 4,621 fish (SE = 597; Table 21). The distribution of catch estimates across river strata was strongly skewed to the area upstream of Hudson's Hope (83% of annual catch, Figure 7, χ^2_2 = 3.6, P = 0.16). Catches of Rainbow Trout varied among season, with 90% coming from the July to August ('high') season (χ^2_2 = 4.5, P = 0.10), and most Rainbow Trout were caught by shore anglers (91% of catch; χ^2_1 = 0.7, P = 0.39). These three trends were largely driven by a single 'outlier' value of 3,323 fish (53.6 fish per day), estimated for shore anglers in the high season in the river stratum upstream of Hudson's Hope (Table 21), which likely explains why the ranked effects were not statistically significant.

Walleye, Bull Trout, Mountain Whitefish, and Northern Pike (*Esox lucius*) were the next most likely species to be caught (303-384 fish per year; Table 21). Mountain Whitefish were only caught during the high season (χ^2_2 = 6.7, P = 0.035), and Northern Pike only in the low season. Walleye were overwhelmingly caught in the low season (97%), whereas Bull Trout were caught year-round (53% in the high season from July to August; 21% in the low season over eight months from September to April; 26% in the shoulder season from May to June). Northern Pike catch was entirely made downstream of Site C and entirely by boat-based anglers. Walleye catch was made similarly (97% downstream of Site C, and 91% by boat). Mountain Whitefish were caught entirely by shore-based anglers, either upstream of Hudson's Hope (46%) or downstream of Site C (51%). Bull Trout were caught largely upstream of Site C (49% above Hudson's Hope, 42% below Hudson's Hope), and about equally by boat (60%) and shore-based (40%) anglers.

The next most caught species were Goldeye (109 fish, SE = 60), Lake Trout (*Salvelinus namaycush*, 84 fish, SE = 52), and Arctic Grayling (78 fish, SE =46). Goldeye were only caught downstream of Site C and only by boat-based anglers. Lake Trout were only caught in July and August, largely upstream of Hudson's Hope (96%) and mainly from shore (96%). Arctic Grayling were only caught in the high season of July and August (χ^2_2 = 6.7, P = 0.035), taken from all three zones by both shore and boat anglers.

Northern Pikeminnow (*Ptychocheilus oregonensis*), kokanee (*Oncorhynchus nerka*), and suckers (*Catostomus* sp.) were rarely caught (fewer than 40 fish). No Burbot were reported as caught during the study period.

Table 21. Estimated catch (harvest + release) for seven main target fish species (this page) and for four other fish species (next page), by season, access method, and river stratum. Catches are rounded to the closest whole number. Standard errors in parentheses. Abbreviations are as shown in previous tables.

Season	*Access Method*	*River Stratum*	*Rainbow Trout*	*Bull Trout*	*Arctic Grayling*	*Mountain Whitefish*	*Kokanee*	*Walleye*	*Goldeye*
High (Jul-Aug)	Shore	PCD to HH	3,323 (501)	81 (52)	0	162 (61)	0	0	0
		HH to Site C	34 (32)	0	3 (3)	12 (4)	0	0	0
		Site C to MI	499 (285)	0	45 (27)	182 (37)	0	0	0
	Boat	PCD to HH	190 (130)	40 (36)	30 (37)	0	0	0	0
		HH to Site C	92 (39)	82 (30)	0	0	0	0	0
		Site C to MI	0	0	0	0	0	0	42 (14)
Low (Sep-Apr)	Shore	PCD to HH	79 (14)	20 (1)	0	0	0	0	0
		HH to Site C	15 (3)	8 (2)	0	0	0	0	0
		Site C to MI	66 (46)	0	0	0	0	33 (54)	0
	Boat	PCD to HH	0	0	0	0	0	0	0
		HH to Site C	42 (14)	21 (7)	0	0	0	0	0
		Site C to MI	0	34 (54)	0	0	34 (28)	337 (123)	67 (59)
Shoulder (May-Jun)	Shore	PCD to HH	187 (43)	47 (14)	0	0	0	0	0
		HH to Site C	0	0	0	0	0	0	0
		Site C to MI	0	0	0	0	0	0	0
	Boat	PCD to HH	41 (8)	0	0	0	0	0	0
		HH to Site C	52 (17)	52 (31)	0	0	0	10 (6)	0
		Site C to MI	0	0	0	0	0	0	0
Overall Total			4,621 (597)	384 (95)	78 (46)	356 (71)	34 (28)	381 (135)	109 (60)
Asymptotic Precision			25%	48%	115%	39%	165%	69%	109%

…continued on next page

Table 21 continued.

Season	*Access Method*	*River Stratum*	*Lake Trout*	*Northern Pike*	*Northern Pikeminnow*	*Sucker sp.*
High (Jul-Aug)	Shore	PCD to HH	81 (52)	0	0	0
		HH to Site C	0	0	0	0
		Site C to MI	0	0	0	0
	Boat	PCD to HH	0	0	0	0
		HH to Site C	3 (1)	0	3 (1)	0
		Site C to MI	0	0	0	0
Low (Sep-Apr)	Shore	PCD to HH	0	0	0	0
		HH to Site C	0	0	0	8 (2)
		Site C to MI	0	0	0	0
	Boat	PCD to HH	0	0	0	0
		HH to Site C	0	0	0	21 (7)
		Site C to MI	0	303 (111)	34 (17)	0
Shoulder (May-Jun)	Shore	PCD to HH	0	0	0	0
		HH to Site C	0	0	0	0
		Site C to MI	0	0	0	0
	Boat	PCD to HH	0	0	0	0
		HH to Site C	0	0	0	0
		Site C to MI	0	0	0	0
Overall Total			84 (52)	303 (111)	37 (17)	28 (7)
Asymptotic Precision			121%	72%	90%	50%

Table 22. Statistical tests of the effect of season, river stratum, and access method on median catch (harvest + release) per day estimates for the 11 target fish taxa with non-zero catch. *P*-values that are underlined are less than 0.05, but none are statistically significant after the Bonferroni adjustment.

	Season		*River Stratum*		*Access Method*	
Taxon	χ_2^2	P	χ_2^2	P	χ_1^2	P
Rainbow Trout	4.5	0.10	3.6	0.16	0.7	0.39
Bull Trout	0.6	0.75	3.6	0.16	0.5	0.48
Arctic Grayling	6.7	<u>0.035</u>	0.0	0.99	0.4	0.54
Mountain Whitefish	6.7	<u>0.035</u>	0.0	0.99	3.4	0.07
Kokanee	2.0	0.37	2.0	0.37	1.0	0.32
Walleye	2.2	0.33	2.2	0.33	0.6	0.45
Goldeye	1.1	0.59	4.2	0.12	2.1	0.15
Lake Trout	4.2	0.12	1.1	0.59	0.0	0.94
Northern Pike	2.0	0.37	2.0	0.37	1.0	0.32
Northern Pikeminnow	1.1	0.59	1.1	0.59	2.1	0.15
Sucker sp.	4.2	0.12	4.2	0.12	0.0	0.94

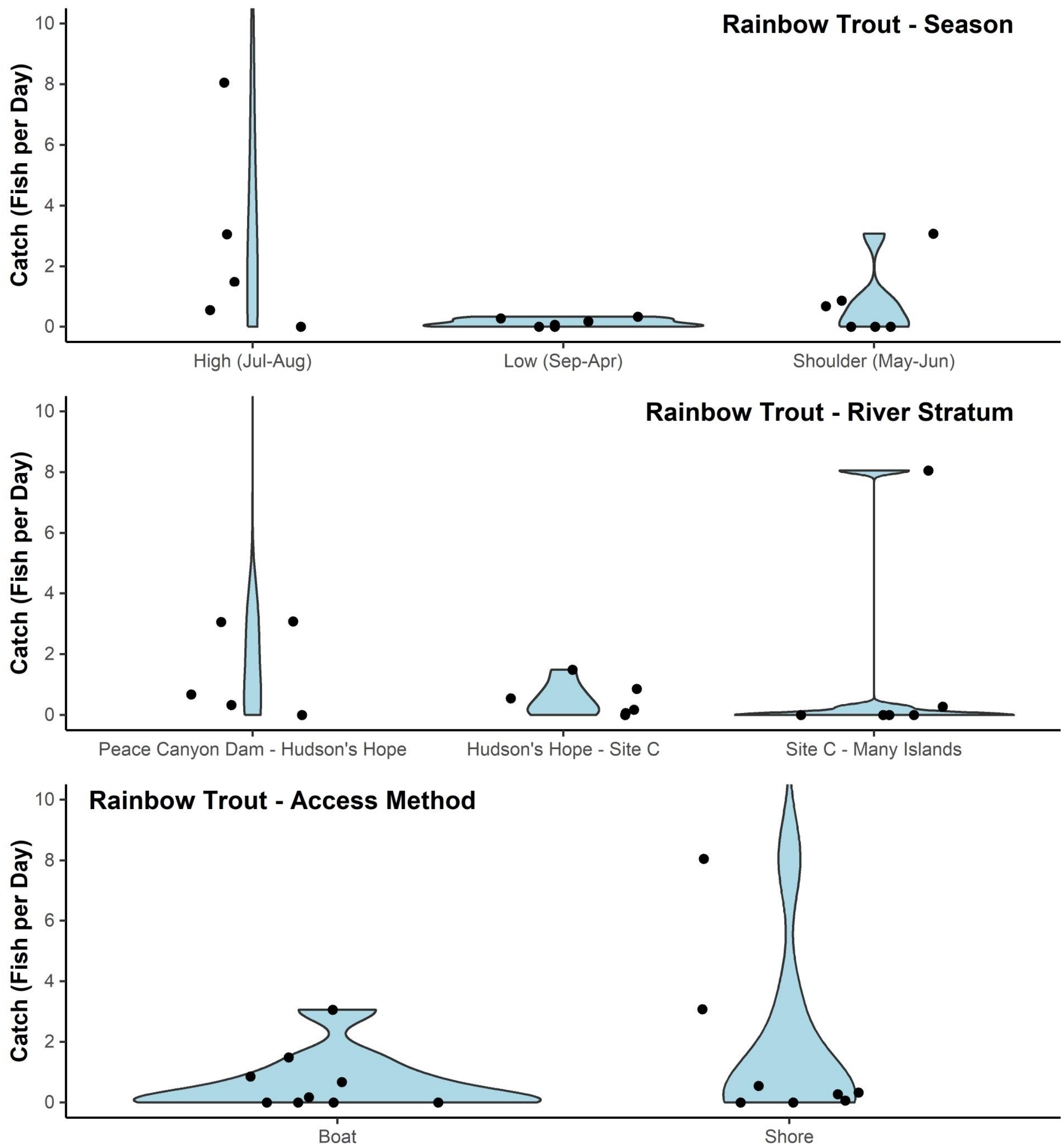

Figure 7. Rainbow Trout catch (harvest + release) estimates (number of fish per day) by season (upper panel), river stratum (middle panel), and access method (lower panel). Points have been jittered (randomly plotted along x-axis within a category) to minimize their overwriting each other. Polygons (blue) are mirrored density plots and are wider where there are more observations. Outlier value of 53.6 fish per day (high season, Peace Canyon Dam to Hudson's Hope, shore) clipped from plots in order to provide resolution to the lower values.

Harvest (Retention) Estimates

Harvest estimates were strongly skewed toward small values, and 94% of the estimates were zero. Harvest varied by season, river stratum, or access method (Table 23), yet no effects were statistically significant (Table 24).

As was the case for overall catch, Rainbow Trout were the most harvested species (Table 23). Harvest for Rainbow Trout was estimated at 275 fish (SE = 49), or about 1% of the total catch. Rainbow Trout harvest occurred in all river strata, and by both access methods, with most of the fish harvested upstream of Site C (49% above Hudson’s Hope, 47% below Hudson’s Hope).

Walleye were the second most harvested species (101 fish, SE = 37), with all harvest (10% of total Walleye catch) by boat-based anglers, coming from the low season and from downstream of Site C (Table 23). Similarly, Northern Pike harvest (67 fish, SE = 25), which represented 8% of the total pike catch, was by boat-based anglers in the low season and downstream of Site C.

The total annual harvest of Bull Trout, summed across all strata, was estimated at 28 fish (SE = 7; Table 23). All Bull Trout harvest occurred in the low season, between Hudson’s Hope and Site C. Bull Trout are a catch and release species in the Peace River system but were nonetheless retained 2% of the time. This result may be indicative of anglers’ misidentification of between Bull Trout versus Lake Trout (the latter can be retained) – an issue that has been noted by other fisheries biologists working in the area (Nich Burnett, BC Hydro, pers. comm.).

Harvest of all other species was negligible (3 fish for Lake Trout and Northern Pikeminnow) or zero (Table 23).

Sample Size Limitations

Using the dataset with doubled interview data, the asymptotic precision of the overall annual catch estimates reduced to from 25% to 18% for Rainbow Trout but remained >25% for all other species (Table 25).

Table 23. Estimated harvest for six target fish species with non-zero harvest, by season, access method, and river stratum. Catches are rounded to the closest whole number. Standard errors in parentheses. Abbreviations are as shown in previous tables.

Season	*Access Method*	*River Stratum*	Rainbow Trout	Bull Trout	Walleye	Lake Trout	Northen Pike	Northen Pikeminnow
High (Jul-Aug)	Shore	PCD to HH	81 (26)	0	0	0	0	0
		HH to Site C	0	0	0	0	0	0
		Site C to MI	0	0	0	0	0	0
	Boat	PCD to HH	40 (8)	0	0	0	0	0
		HH to Site C	14 (6)	0	0	3 (1)	0	3 (1)
		Site C to MI	0	0	0	0	0	0
Low (Sep-Apr)	Shore	PCD to HH	40 (9)	0	0	0	0	0
		HH to Site C	15 (3)	8 (2)	0	0	0	0
		Site C to MI	33 (36)	0	0	0	0	0
	Boat	PCD to HH	0	0	0	0	0	0
		HH to Site C	42 (14)	21 (7)	0	0	0	0
		Site C to MI	0	0	101 (37)	0	67 (25)	0
Shoulder (May-Jun)	Shore	PCD to HH	0	0	0	0	0	0
		HH to Site C	0	0	0	0	0	0
		Site C to MI	0	0	0	0	0	0
	Boat	PCD to HH	0	0	0	0	0	0
		HH to Site C	10 (2)	0	0	0	0	0
		Site C to MI	0	0	0	0	0	0
Overall Total			275 (49)	28 (7)	101 (37)	3 (1)	67 (25)	3 (1)

Table 24. Statistical tests of the effect of season, river stratum, and access method on median harvest per day estimates for six target fish species taxa with non-zero harvest.

	Season		*River Stratum*		*Access Method*	
Taxon	χ_2^2	P	χ_2^2	P	χ_1^2	P
Rainbow Trout	2.6	0.27	3.3	0.20	0.2	0.70
Bull Trout	4.2	0.12	4.2	0.12	0.0	0.94
Walleye	2.0	0.37	2.0	0.37	1.0	0.32
Lake Trout	2.0	0.37	2.0	0.37	1.0	0.32
Northern Pike	2.0	0.37	2.0	0.37	1.0	0.32
Northern Pikeminnow	2.0	0.37	2.0	0.37	1.0	0.32

Table 25. Asymptotic precision for annual catch estimates from the creel data collected from July 2022 through June 2023 ("Actual"), and from the same dataset with all interviews duplicated once ("Doubled n").

Dataset	Rainbow Trout	Bull Trout	*Arctic Grayling*	*Mountain Whitefish*	*Kokanee*	Walleye	Goldeye
Actual	25%	48%	115%	39%	165%	69%	109%
Doubled n	18%	33%	78%	28%	121%	62%	80%

Dataset	Lake Trout	Northen Pike	Northen Pikeminnow	Sucker sp.
Actual	121%	72%	90%	50%
Doubled n	84%	67%	74%	34%

Angler and Angling Characteristics

The anglers interviewed were overwhelmingly from the local area (Table 26), although an influx of people from the rest of BC was noted in September. Few anglers were from other parts of Canada, and no US or overseas anglers were interviewed. Overall, 73% of anglers were from the Peace River area, 8% were from the rest of BC, and 3% were from the rest of Canada. For the most part, anglers were not being guided by a professional. Only in June was there ever any guided anglers interviewed, when 16% of anglers were guided (all were from the Peace Region).

The largest portion of respondents (67%; Table 26) said they were fishing with lures (including spoons, spinners and jigs), 22% were fishing with artificial flies, and 12% said they were using bait (including worms, fish eggs, and various arthropods). Anglers overwhelmingly (80% overall) used spin casting as the fishing method of choice, whereas 20% of anglers were fly casting, and none were still fishing (Table 26). In September, all anglers were spin casting with artificial lures.

The most popular target species was Rainbow Trout (57% of respondents; Table 26). Bull Trout was second in popularity (25%), followed by Walleye (13%). Anglers that targeted Walleye did so mainly in August and September. In May, most anglers that were targeting fish (99%) were after Rainbow Trout. Other reported targets included Arctic Grayling (June only, 10% of June respondents, 2% overall), Mountain Whitefish (August only, 7% of August respondents, 2% overall), and Goldeye (October to April; 22% of respondents in October to March, 6% in April, 1% overall).

The average age of the responding Peace River anglers was 34 years old (range 3 to 70 years). Overall, 24% of the respondents were 21-30 years old, another 25% were 31-40 years, and 20% were 41-50 years old (Table 26). The other four age categories made up the remaining 31% of anglers. Youngest anglers (under age 10) were active only from July to September.

The average amount of fishing experience held by Peace River anglers was 23 years (range 0 to 64). Overall, 31% of respondents had less than 10 years of experience, and 16-21% of anglers fit into each of the next three decadal experience bins. Few anglers had more than 40 (14%) or 50 (7%) years experience (Table 26). Two respondents had more than 60 years of experience (both out in August), representing 1% of the overall angling community.

Table 26. Characteristics of Peace River anglers, by period.

Month	*Jul*	*Aug*	*Sep*	*Oct-Mar*	*Apr*	*May*	*Jun*	*Overall*
Guide Status								
Guided	0%	0%	0%	0%	0%	0%	16%	2%
Residency								
Peace	100%	96%	46%	93%	97%	100%	83%	73%
Rest of BC	0%	4%	47%	7%	0%	0%	6%	8%
Rest of Canada	0%	0%	8%	0%	3%	0%	11%	3%
US	0%	0%	0%	0%	0%	0%	0%	0%
Overseas	0%	0%	0%	0%	0%	0%	0%	0%
Fishing Methods								
Fly Cast	25%	30%	0%	22%	23%	8%	18%	20%
Spin Cast	75%	70%	100%	78%	77%	92%	82%	80%
Still	0%	0%	0%	0%	0%	0%	0%	0%
Bait Types								
Artificial Flies	25%	28%	0%	64%	30%	10%	20%	22%
Artificial Lures	67%	52%	100%	36%	38%	67%	80%	67%
Bait	9%	20%	0%	0%	32%	23%	0%	12%
Target Species								
Rainbow Trout	56%	46%	65%	39%	28%	99%	55%	57%
Bull Trout	44%	9%	16%	39%	63%	1%	26%	25%
Walleye	0%	38%	19%	0%	0%	0%	10%	13%
Arctic Grayling	0%	0%	0%	0%	0%	0%	10%	2%
Mt. Whitefish	0%	7%	0%	0%	2%	0%	0%	2%
Kokanee	0%	0%	0%	0%	2%	0%	0%	0.2%
Goldeye	0%	0%	0%	22%	6%	0%	0%	1%
Angler Age								
1-10	19%	4%	2%	0%	0%	0%	0%	6%
11-20	11%	16%	11%	11%	8%	1%	0%	9%
21-30	21%	10%	38%	30%	43%	10%	37%	24%
31-40	35%	16%	3%	41%	34%	51%	14%	25%
41-50	9%	19%	33%	18%	3%	27%	34%	20%
51-60	1%	8%	7%	0%	10%	11%	5%	6%
61-70	3%	27%	7%	0%	2%	0%	11%	10%
Angler Experience (Years)								
1-10	49%	29%	33%	54%	36%	5%	15%	31%
11-20	10%	10%	11%	40%	10%	7%	39%	17%
21-30	24%	9%	32%	0%	22%	56%	17%	21%
31-40	15%	22%	2%	7%	20%	28%	13%	16%
41-50	0%	9%	11%	0%	9%	4%	14%	7%
51-60	2%	16%	11%	0%	2%	0%	2%	6%
61-70	0%	5%	0%	0%	0%	0%	0%	1%

DISCUSSION

The current creel survey followed similar methodologies to those employed during the baseline 2008-09 creel survey (Robichaud et al. 2010) to ensure comparable results and a compatible long-term dataset. The researchers that conducted the baseline survey were involved with the design of the current survey, and with the training of field personnel and interviewer staff. To ensure consistency, the interviewer training manual and data forms from the 2008-09 survey were consulted when developing those for the current work. For the most part, the two surveys were designed the same way, with identical levels of stratification (months, day types, river strata[3], access methods), and produced the same types of results (i.e., annual species-specific catch or harvest expressed as numbers of fish, and annual recreational angler effort levels expressed in angler hours, both stratified into the same three river reaches). The two surveys ran for different durations (the current survey for 12 months, and the 2008-09 survey for 17.5 months), but in the baseline survey months that were sampled more than once were treated as replicates in the service of producing average estimates on an annual scale (i.e., on the same temporal scale as the 2022-23 survey). In addition, there was a major methodological difference between the two surveys in terms of effort estimation (overflights in 2008-09 vs. trail cameras in 2022-23), but the new method was designed to be equivalent to, and hence produce a set of results that was comparable with those from the baseline. By contrast, there were specific differences in geographic scope between the two surveys that must be considered when comparing their results. Specifically, the study area extended along the Peace River from Peace Canyon Dam to the Alberta border in 2008-09, whereas it continued a further 60 river km to Many Islands in 2022-23. Extending the study area to Many Islands created continuity with BC Hydro's concurrent fish community monitoring and fish movement studies (e.g., WSP Canada 2023, Hatch et al. 2023), and with the spatial scope of the Mon-2 Program of which the creel survey is a part. For the same reason, the Pine River watershed was not included in the current geographic scope, despite its inclusion in 2008-09. All other details of the study area were the same in 2022-23 as in 2008-09.

Total annual angling effort was estimated during the current creel survey to be 15,672 (SE = 637) angler hours, a value that is remarkably close to the mainstem estimate from 2008-09 of 18,489 (SE = 3,498) angler-hours between Peace Canyon Dam and the Alberta border (Robichaud et al. 2010), and the 1989-90 estimate of 18,510 angler-hours between Peace Canyon Dam and Taylor (DPA 1991). The similarity in effort estimates is agreement with the province-wide recreational fishing licence sale numbers which were virtually unchanged between the 2010-11 and 2021-22 licence years (~341k for residential and non-residential sales of all basic licence types combined[4]), and with the small change (9% decrease) in the numbers of active BC freshwater anglers estimated for 2010 by the National angling survey (Fisheries and Oceans Canada 2019), and for 2022 by the Internet Socio-Economic (iSEA) survey[5]. On the other hand, this study and DPA's results contrast strongly with those of another survey from the 1980s (Hammond 1986). Hammond (1986) estimated total angling effort for a limited part of the current study area (from the Peace Canyon Dam to Farrell Creek) over a five-month period (June to October 1985) to be 16,898 angler-hours: a value similar to what has since been found for the entire Peace River over the entire year. It is possible that some of the differences among studies resulted from year-to-year variability in angler effort levels. However, it is also important to note that these studies have been limited for sample size, which required pooling of data across strata (and the concomitant loss of resolution and decrease in accuracy), and standard errors are generally large (confidence bounds sometimes swamp the among-study differences. Moreover, Hammond's calculation methods are not described, thus the reasons for the differences between reports cannot be fully determined.

Despite similarities in effort, the annual catches estimated in the 2022-23 study period differed markedly from those reported from 2008-09 for the Peace River mainstem (Figure 8). Specifically, catch of Rainbow Trout, while the dominant species in both studies (and in Hammond 1986), was

[3] excluding the sites from 2008-09 that no longer provide public access.
[4] https://open.canada.ca/data/dataset/ebbe3328-43ac-4440-be2d-b3f83ae03780
[5] iSEA (Internet Socio-Economic Analysis). BC Freshwater Recreational Fishing 2000-2022 Trends. Accessed in May 2024 from https://www.pac.dfo-mpo.gc.ca/analyses-econom-analysis/analyses/rec-fresh-douce-2022-eng.html#trends

4,621 (SE = 597) fish in 2022-23, but only 1,786 fish (SE = 436) in 2008-09. By contrast, mainstem catches declined by 1.6 to 2.7 times since 2008-09 for Bull Trout (983 to 384 fish), Mountain Whitefish (978 to 356 fish), Walleye (638 to 381 fish), and Goldeye (242 to 109). Moreover, mainstem catches of Arctic Grayling declined by 5 times from 395 fish in 2008-09 to 78 fish in the current period. Northern Pike catches remained relatively stable between studies (350 in 2008-09; 303 in 2022-23). Hammond (1986) reported a similar dominance by Rainbow Trout, and found Mountain Whitefish to be the next most frequently caught species, but reported Bull Trout and Arctic Grayling catches to be very minor. DPA (1991) reported Mountain Whitefish to be the species most commonly caught, followed by Rainbow Trout and Arctic Grayling, and reported very little catch of Bull Trout or Walleye. Some of the among study differences may be reflective of changes in species abundances (e.g., decline in Arctic Grayling since 2008-09, WSP Canada 2023), but some may be artifacts of the year-to-year variability in angler effort levels or CPUE, as evidenced from the single-year differences between 2008 and 2009 reported by Robichaud et al. (2010).

Catches on either side of the Site C Dam were compared between the 2008-09 and current creel studies. In the areas downstream of Site C, catches of Bull Trout declined from 317 in 2008-09 to 34 in the present study (Figure 8). Mountain Whitefish catch downstream of Site C declined from 346 to 182, Walleye declined from 550 to 370, and Arctic Grayling from 95 to 45 fish. Goldeye catches downstream of Site C remained stable (111 and 109 fish) over these two study periods. By contrast, catches below Site C of Northern Pike increased from 236 to 303, and those of Rainbow Trout increased markedly from 70 to 565. In the areas upstream of Site C, Northern Pike catches declined to zero in 2022-23 from 114 fish in 2008-09 (Figure 8). Goldeye are not known to be present and have never been sampled upstream of Site C (Mainstream Aquatics 2012, WSP Canada 2023), and the present creel study confirms zero catch in this area (catches of Goldeye reported upstream of Site C in the 2008-09 creel study (Robichaud et al. 2010) were an artefact of sample size limitations requiring the pooling of boat-based CPUE over all river strata for September). Declines upstream of Site C were also observed for Bull Trout (666 to 351), Walleye (87 to 10), Arctic Grayling (300 to 33), and Mountain Whitefish (632 to 174). Conversely, catches upstream of Site C of Lake Trout increased from 45 to 84, and those of Rainbow Trout increased markedly from 1,716 to 4,055.

Mountain Whitefish was not the most commonly caught species, according to angler interviews, in either the current study, or during the 2008-09 creel survey (Robichaud et al. 2010), despite community indexing studies (e.g., Pattenden et al. 1991, Mainstream Aquatics and Gazey 2009, WSP Canada 2023) which have shown it to be the most numerically dominant species in the Peace River. Boat electroshocking surveys in the Peace River in 2022 and 2023 encountered Mountain Whitefish ~50-55 times more frequently than Rainbow Trout, ~18-19 times more often than Walleye, and ~17-28 times more than Bull Trout (WSP Canada 2023, WSP Canada *in prep*). Pattenden et al. (1991) estimated Mountain Whitefish to be 100 times more numerous than Rainbow Trout, and 80 times more numerous than Walleye. Despite their numerical domination, Peace River mainstem catch estimates of Mountain Whitefish were on par with Bull Trout and Walleye, and < 10% of those of Rainbow Trout (Table 21). Although this could be evidence for a difference in catchability among species, especially with respect to access methods and river stratum, it likely also stems from the fact that anglers preferentially targeted Rainbow Trout (57% of respondents), Bull Trout (25%), and Walleye (13%) over Mountain Whitefish (2%; Table 26), and likely made gear choices that favoured larger-bodied fish.

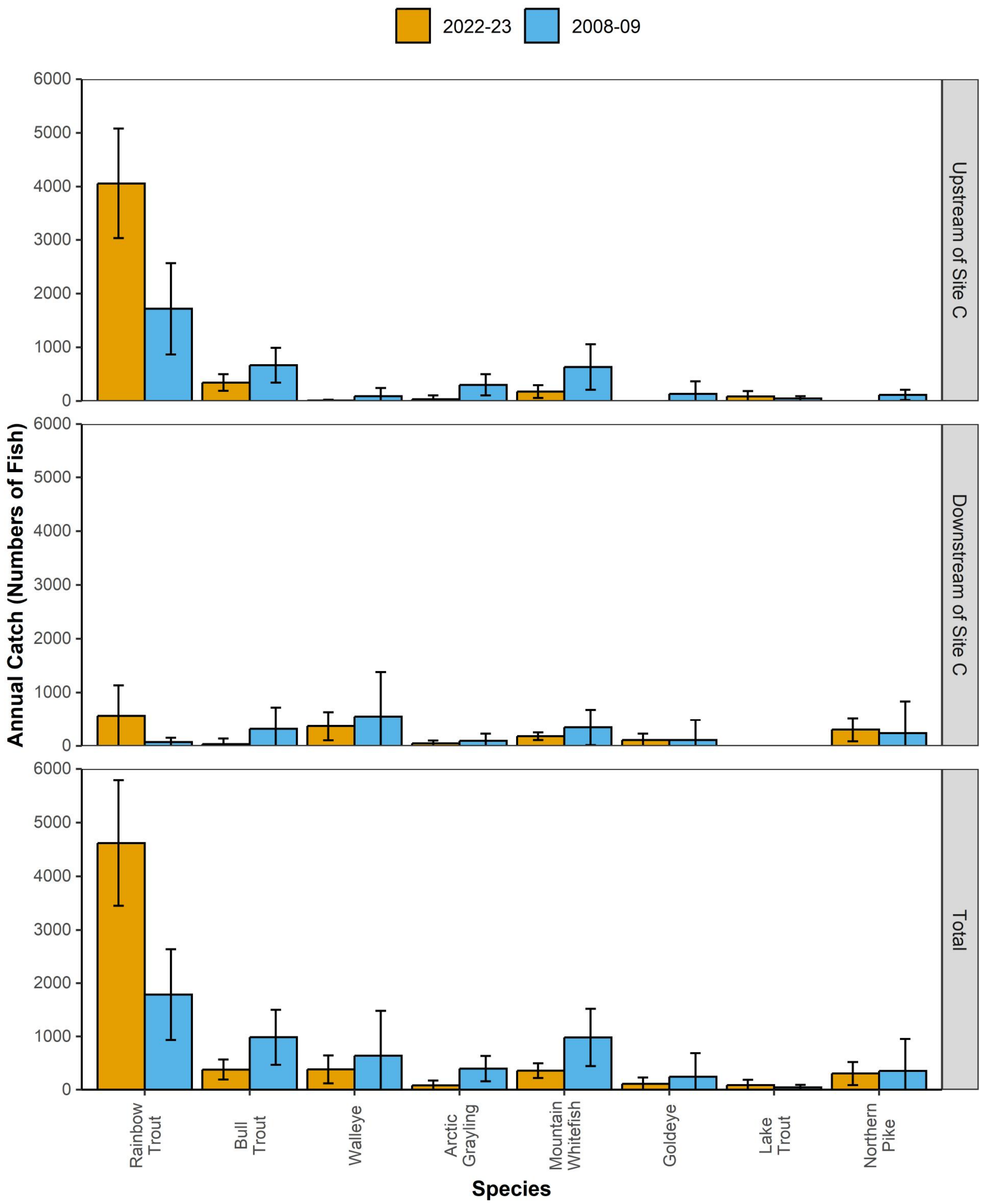

Figure 8. Annual mainstem Peace River catch estimates for eight target fish species, upstream and downstream of Site C, compared between two creel studies: one the present study, from 2022-23, and the other from 2008-09. Error bars show 95% confidence intervals.

The catch of Bull Trout made in the Peace River mainstem was likely comprised primarily of the population that spawns in the Halfway River system, and that regularly moves into the Peace River. Radio telemetry results (AMEC and LGL 2009) indicated that 64% of the Bull Trout radio-tagged in the Halfway moved into the Peace River, both upstream and downstream of the Halfway-Peace confluence. More recent telemetry work (Hatch et al. 2023) shows that Bull Trout continue to move past Site C, in both upstream and downstream directions, apparently not impeded by the construction of the Project. As long as connectivity can be maintained for this population, it is expected that anglers will be able to encounter migratory Bull Trout in all three river strata into the future.

Over the 108 interviews conducted in 2022-23, data from a total of 212 anglers were collected. This sample size was considerably lower than the numbers collected in 2008-09. Specifically, in the previous creel study, 291 interviews were conducted over 16 months, comprising 622 anglers. The head-to-head comparison of interviews per month (~18 vs. ~9) is not exactly fair given the 2008-09 study sampled the high and shoulder season twice. Indeed, a plot of sampling success (Figure 9) shows large within-month variation within the 2008-09 study, showing large differences in sample size from the first year to the next. And for some of the months (e.g., June), the 2022-23 sample sizes were not the lowest of the three samples. As such, it would appear the low sample sizes (and low numbers of anglers encountered) in 2022-23 could be the result of among-year variation, and may not be an indication of a long-term declining trend between the 2008-09 period and the present one. Indeed, the wildfires (and resulting smoke) that occurred in the region during the study period were likely a deterrent to local angler activity. Also, the closure of Lynx Creek Launch mid-season, and the rearrangement of the access to the Halfway launch may have also led to decreased availability of anglers to interviewers during the 2022-23 study season.

Regardless of the root cause for the low sample sizes in 2022-23, the impacts were apparent. For many of the indices (e.g., activity profiles, CPUE, effort, catch) it was necessary to pool months together into seasons. In addition, there were too few interviews to fully develop activity pattern profiles, to calculate fishing trip durations, or to generate CPUE estimates for all levels of each stratum. The impact is a loss of resolution (e.g., there are not separate estimates for July and August, only a combined value for the two months together), a damping of variability in the dataset, and a decrease in accuracy. For example, there were too few shore anglers interviewed downstream of Site C in the high season to calculate CPUE, despite there being a relatively large estimate of effort for that stratum. Data from other strata needed to be 'borrowed' so that there would be a value to multiply with effort to calculate catch. One option was to borrow boat-angler data from the same river stratum and season; but multiplying a boat-based CPUE of Goldeye with a shore-based estimate of effort would have 'created' a large catch of that species by shore anglers, a result that did not seem accurate as no Goldeye were ever reported as caught from shore. Instead, shore angler data from the next river stratum (Hudson's Hope to Site C) were borrowed, which meant that estimates of shore catch downstream of Site C would include some species that were more commonly encountered upstream of the Project (i.e., Arctic Grayling and Mountain Whitefish). Neither pooling choice was ideal, highlighting the issues with low sample sizes for creel studies.

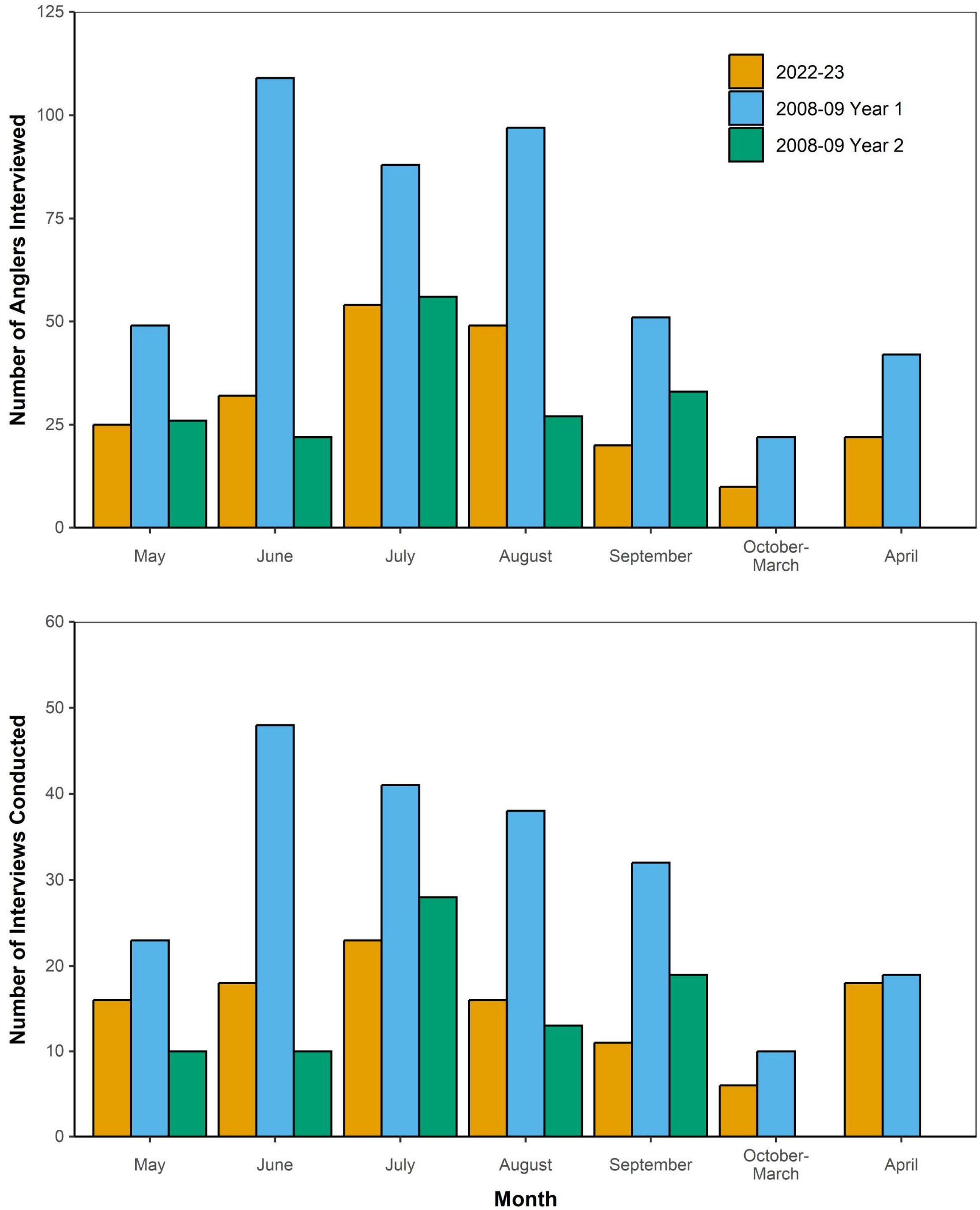

Figure 9. Number of interviews conducted (bottom) and anglers interviewed (top), by month, during the 12-month current creel study ('2022-23"), and the 16-month prior ('2008-09") study (with repeat months plotted separately).

Camera Deployments

One innovation that was adopted for the 2022-23 creel study was the use of cameras to monitor fishing effort. Cameras were deployed at all known angling beaches, focused on the shoreline, and set to take hourly photos, such that the sum of all the hourly photos for a given hour could be processed the same way as a count of all shore anglers from an overflight. In addition, cameras were deployed at all known boat launches, set to take a series of photos when activated by motion, which together provided the number of boats launched and retrieved each day (which was apportioned into angling and non angling boats using average proportions drawn from observer data).

The disadvantages of overflights include cost, fossil fuel consumption, and risk to field crew safety. In addition, remote photography can provide coverage for every day of the year (days can later be subsampled if photo review funds are limited), whereas overflight data are only available for the limited number of days on which flights were conducted. A major advantage of having data from almost every day is that sampling variances are reduced to almost zero. For example, to get a whole-month effort estimate from a pair of overflights requires that a daily mean effort value be calculated (with variance) and applied to all the unsampled days in the month; whereas if photography is available for all of the days in the month, no means need to be calculated, and no variance is introduced into the whole-month estimate. In fact, since flights are often cancelled in the type of weather that also deters angler activity, the average daily effort values from overflights can be biased in favour of effort overestimation, another reason to favour the gathering of data from every day.

There are disadvantages to the camera method. Cameras can be stolen, jostled into an inappropriate position, damaged by wildlife, blocked by fast-growing shrubbery, or have dead batteries, and not be collecting data for an extended period unbeknownst to the field technicians. This issue can be alleviated by visiting and servicing cameras more frequently over the field season. However, the problem is additive because, in the cases where multiple cameras are required to monitor a large fishing beach, all cameras must be in a functional state in order to make use of any of the data from the site. In addition, changes in water levels can be rapid and frequent, making it difficult to position cameras so they always capture the water's edge. Another disadvantage is the sheer number of photos that can be collected over the course of a field season, and the need for someone to review them. This problem can be alleviated by subsampling the photo data from randomly selected dates (selected with respect to month and day type strata), a tool that was used in 2022-23 at the Halfway boat launch (too many photos to review) and at Clayhurst (due to constraints on technician availability). Additionally, for trail and launch cameras, double counting of parties could have been an issue, since a technician's ability to identify whether a party had been counted previously in the day (they sometimes would move back and forth between the beach and the road) was not absolute.

Another disadvantage of the camera method is the sheer volume of data that gets collected (large number of files/photographs, and large size (~1 MB) for each file), which comes with file management issues. The Microsoft Windows operating systems do not function well when a large number of files is placed in a single folder. This issue can be alleviated to a degree with more frequent camera data downloads (using a new folder for each download event), or by adopting a file folder workflow that separates photos into week-specific folders (a method that requires some technician time and good attention to detail to adopt). These methods were not adopted in 2022-23, which resulted in several issues, including data loss and inefficient time use when reviewing photos. Data loss occurred when photos were being stored on a server, the upload failed, and the technician did not notice the failure before erasing the camera SD cards (this issue could be alleviated by never erasing SD cards, buying a number that will last the duration of the study). Failure to notice a failed upload was the result of the sluggish and unreliable performance of the file directories when too many files were stored in a single folder. Inefficient time use resulted from the sluggish performance of the Windows environment when file counts were large, making it slow and difficult to find a photo of interest, or to pan through multiple photos during review. Part of the problem for the 2022-23 study was the need for Aski technicians to send all photos to LGL for processing (blurring faces, see below), and the need for LGL to send all processed photos back to Aski for human review. This could have been alleviated if the deep learning algorithm could have been made to run on a local computer in the Aski offices.

Regardless of the advantages and disadvantages of cameras vs. flights, both methods were used in parallel for the first two months of the study period. Independent effort estimates were derived from the two methods (Tables 12 and 19), and a comparison is shown in Table 17 for July and August. The overflights produced separate estimates for each month, river stratum, day type, and access method (Table 12), where, ironically, the camera method was data limited, and months had to be pooled into seasons (Table 19). This was the result of widespread photo data loss in the early part of the study (Table 13), with July and August being particularly affected. In fact, there were no photo data available in either month for the Highway 29 access site, and almost none from the Peace Island Launch. In the end, photography from July 2023 was used to derive average daily estimates that were used to calculate season-wide effort estimates for July-August at these two sites and at Clayhurst. It has already been shown that angler activity can change markedly from year to year (Robichaud et al. 2010), so the July 2023 photographs may not have been an ideal proxy for determining July 2022 activity (or August 2022 for that matter) – for example, wildfires that may have impacted angler activity in 2023 were not a factor in 2022. The result was that the overflight data were not directly comparable to the camera-derived estimates. Despite this, the two sets of estimates were not wildly different from each other: both showed peak activity in weekend/holiday shore angling downstream of Site C, and substantial shore angling effort on weekend/holidays above Hudson's Hope; and both identified a general lack of boat-based angling effort above Hudson's Hope, and on weekdays below Hudson's Hope. Notable differences between the methods were seen for weekday shore angling downstream of Site C, and for weekend/holiday boat angling between Hudson's Hope and Site C. The overall estimates of 6,893 (SE = 451) and 4,110 (SE = 724) from the camera and overflight methods differed by 1.7 times, but the standard error for the camera work was smaller than that for the overflight methods, even despite the larger estimate, by a ratio of 0.6.

As another innovation for the 2022-23 survey, adopted to reduce the overall number of photos that needed to be reviewed by a technician, all photos were first scanned by a deep learning computer algorithm that identified only those that included a boat, car, truck, or person. The algorithm reduced the number of photos for review by 73%, and had the added advantage of being able to blur faces and licence plates, which was a condition set by BC Hydro to ensure that the privacy of Peace River recreational users was maintained. The deep learning rate of false positives was relatively high, and photo reviewers still had to look at a lot of photos of sticks, snowflakes, and deer. But the rate of false negatives (i.e., failing to identify a photo that included an object of interest), the more critical rate for the successful use of the method, was very low (0% for trail and beach cameras, and 2.1% for launch camera).

A final new method that was adopted for the current creel study was the use of traffic counters and motion-sensor cameras to monitor fishing site access roads and trails. At beach sites accessible mainly by trail, cameras were deployed trailside, set to take a series of three photos each time they were triggered by motion. As long as technicians could avoid double-counting parties that move back and forth along the trail, then the people counted from the photos are a simple total count for the day, and are therefore not impacted by the same variance-introducing elements of the beach camera processing (e.g., no need to sum over multiple cameras for each hour, no need to divide hourly sums by activity proportion; no need to adjust the camera view to account for changing water levels). Two angling beaches had trail access in 2022-23 (Highway 29/Fingers, and Alwin Holland), both were monitored independently by both trail and beach camera deployments, and in each case the effort estimated from the trail cameras was more precise. At sites accessible by a well-defined road, traffic counters were deployed, along with motion-sensitive cameras to take photos that would ground-truth the traffic counter data. The traffic counters incremented an internal tally whacker each time a large ferrous object passed within their detection fields, outputting total tallies per hour. Photos could be consulted in order to apportion the hourly tallies between vehicles towing angling boats vs. all other vehicle types. While the method may be useful in other locations, in the Peace area in future, the data were not considered for the 2022-23 creel analysis because the sites where they were deployed had too much industrial activity, the cameras took far too many photos to process efficiently, some of the traffic counter units were destroyed by the construction vehicles, and there were too many gaps in the data series of cameras deployed to effectively ground truth the traffic counters.

<u>Precision and Accuracy</u>

Typical of creel surveys, this Peace River creel analysis produced estimates with a relatively low level of precision. The asymptotic precision (at $\alpha = 0.05$) was 25% of the point estimate for Rainbow Trout, 39% for Mountain Whitefish, 48% for Bull Trout, and 69-165% for the other main fish target species. While creel surveys often strive to estimate catch with 15% precision (19 times out of 20; e.g., Robichaud and Addison 2023), this can typically only be achieved when variances are low. Variance in the catch estimates result from two factors: 1) the natural variability within the population; and 2) the sampling error. In the present study, both factors played important roles in generating variability in the estimates, and each is discussed below.

One of the main factors affecting estimation error is natural variability. The natural variability in catch rates is such that they tend to follow a negative binomial distribution: most catches are of zero fish; and the larger the catch the rarer the event. For example, the Rainbow Trout CPUE for the Peace River study area was 0 fish per angler-hour for 75 of the 108 angler parties interviewed, <1 fish per angler-hour for 23 other parties, was >1 for only 16 parties, and only one group had a catch rate over four fish per rod-hour. If catches always tended to be the same, then there would be considerably less variability in the CPUE estimates. However, given the wide range of possible outcomes for a fishing event (due to moment-to-moment changes in fish availability in the area, catchability, etc.), it is difficult to predict with confidence how many fish an angler is going to catch. This difficulty translates into wide confidence limits around the estimates of total catch.

Sampling error is the other main source of estimation variance. As with any sampling program, the confidence you have in your final estimate is greater when sample sizes contributing to point estimates are large; and for finite populations, when a larger proportion of the population has been sampled. In this study, the number of interviews per period ranged from 6 (October to March, pooled) to 23 (July); this equates to 0.5 to 1.9 interviews for each of the 12 “day type × access method × river stratum” categories. With catches expected to be widely variable, it follows that the precision of estimates drawn from a sample of $n \leq 5$ would be low. One solution is to pool data among categories, but this is not ideal since there is *a priori* knowledge that catch rates differ among months, river strata, and between boat and shore-based anglers. Another solution is to increase interviewing shift numbers. But a simulation in which interview data were doubled showed little improvement in precision (Rainbow Trout to 18%, all other main species 28-121%) despite a doubling of some program costs. In contrast to the sample size limitations for interviews, the sample sizes for effort estimation, as derived from the trail camera data, were large, relative to the population (i.e., data were available for most of the study days for some access sites, with very little in-filling required), which resulted in relatively low sampling error for some of the effort-related study elements.

In addition to the preceding discussion about precision of the creel results, a comment should also be made about their accuracy. The accuracy of our creel methodology is only as good as that of the data provided by the anglers to the interviewers. In this study, interviewers were not always able to inspect the catch that was reported by anglers. For the most part, corroboration of catch rate data was impossible, since the majority of the reported catch was released after capture. Moreover, relying on anglers to have accurately identified their catch can also lead to some biases. Without verification of the catch, we cannot be sure of the level of accuracy of the data provided by the anglers to the interviewers, a caveat that must be made clear when the results of this report are interpreted. Catch was rarely shown to interviewers, but even when it was, there is no way to confirm the accuracy of the species identifications made by the interviewers when catch was observed, another potential source of inaccuracy that should be considered.

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Appendix 1 Angling Effort Data Form

2022-2023 Peace River Creel Survey - Flight Effort Form Form:

Surveyor (s): ____________________

Weather: ____________________

Date: ____________________

Stratum #	1		2	3
Stratum Name	Peace Canyon Dam to Hudson's Hope		Hudson's Hope to Site C	Site C to Many Islands
Substratum	Remainder of Stratum 1 (counts exclude Fingers site)	Highway 29 Fingers Site	All	All
Start Time:		Time:		
End Time:				
# Shore Anglers:				
# Boat Anglers:				
# Angling Boats:				

Comments: ____________________

Appendix 2. Creel Survey Form.

2022-2023 Peace River Creel Survey - Interview Form

Form:

Surveyor Name:	Date:
Location of Int:	Int Time:

# Anglers (Lines) in Today's Party:		Vessel type:
Depart Time:	Landing Time:	
Type of Fishing: Boat / Shore	Guided: Y / N	Completed Trip: Y / N

Age (approx):	A:	B:	C:	D:	E:	F:
Experience level:	A:	B:	C:	D:	E:	F:
Community From:						

Times lines were in the water ** TODAY

	Before 7		10 - 10:59		2 - 2:59		6 - 6:59
	7 - 7:59		11 - 11:59		3 - 3:59		7 - 7:59
	8 - 8:59		12 - 12:59		4 - 4:59		8 - 8:59
	9 - 9:59		1 - 1:59		5 - 5:59		After 9

Target Species (circ): RB BT WP GR MW KO GE Catch seen? : Y or N or N/A

Gear Used: ________________ Bait Used: ________________

	Site 1	Site 2	Site 3
Stratum Fished:			
River Locat'n Fished:			
Access Location:			
# of Hours Fished:			

Today's Catch:	Kept	Rel.	Kept	Rel.	Kept	Rel.
Rainbow Trout						
Bull Trout						
Walleye						
Arctic Grayling						
Mtn Whitefish						
Kokanee						
Goldeye						
Other (insert comments)						

Biosampling Done? : Y or N

Times lines were in the water ** YESTERDAY Yesterday's Stratum: ________

	Before 7		10 - 10:59		2 - 2:59		6 - 6:59
	7 - 7:59		11 - 11:59		3 - 3:59		7 - 7:59
	8 - 8:59		12 - 12:59		4 - 4:59		8 - 8:59
	9 - 9:59		1 - 1:59		5 - 5:59		After 9

No. of days fished per year:	No. of days fished per winter:

USE (Days per Month)	Site 1	Site 2	Site 3
Site Name:			
Year-round Use:			
Wintertime Use:			

Comments: ________________________

Weather: ________________________

Appendix 3. Shift Tally Sheets.

2022-2023 Peace River Creel Survey - Daily Tally Form   Form:

Surveyor: ____________________ Date: ____________

Location of Interview: ____________________ Survey Period: ____________

Boat Launch Interview

	Angling Boats				Non-angling Boats		
	# anglers interviewed	# angling boats interviewed	# angling boats observed but not interviewed	# angler refusals	# FSC fishing boats observed	# BCH Contractor Boats observed	# Other non-angling boats observed
Before 7							
7 - 7:59							
8 - 8:59							
9 - 9:59							
10 - 10:59							
11 - 11:59							
12 - 12:59							
1 - 1:59							
2 - 2:59							
3 - 3:59							
4 - 4:59							
5 - 5:59							
6 - 6:59							
7 - 7:59							
8 - 8:59							
After 9							

Comments:

2022-2023 Peace River Creel Survey - Daily Tally Form Form:

Surveyor: ______________________ Date: __________

Location of Interview: ______________________ Survey Period: __________

Shore Interview

	Activity		Rec Angler Interviews		Rec Anglers Missed	FSC
	# anglers actively fishing (not including Fingers site)	# anglers actively fishing (fingers site only)	# anglers interviewed	# angler refusals	# anglers not interviewed who departed	# FSC anglers observed
Before 7						
7 - 7:59						
8 - 8:59						
9 - 9:59						
10 - 10:59						
11 - 11:59						
12 - 12:59						
1 - 1:59						
2 - 2:59						
3 - 3:59						
4 - 4:59						
5 - 5:59						
6 - 6:59						
7 - 7:59						
8 - 8:59						
After 9						

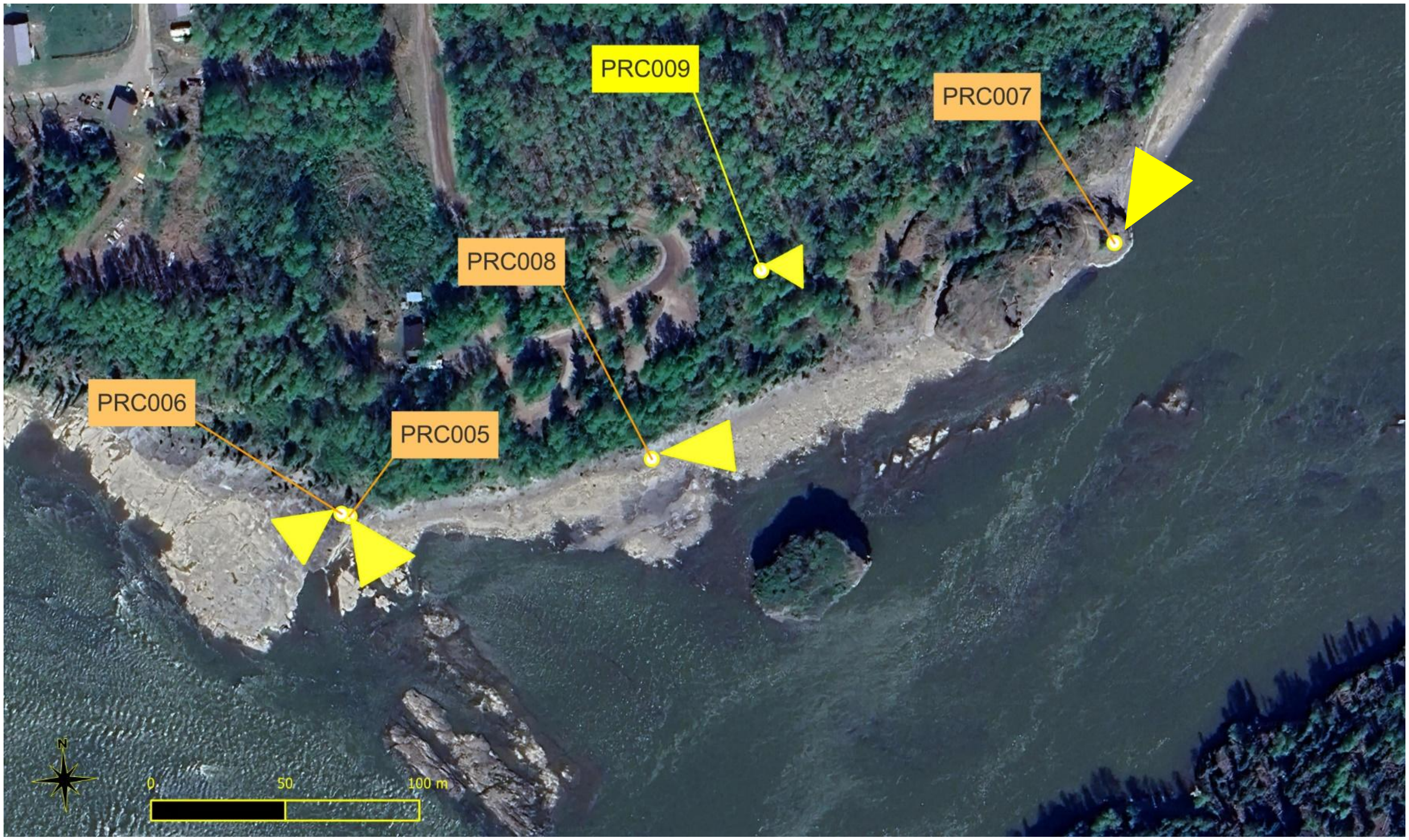
Comments: ______________________

Appendix 4. Camera Positions and Views.

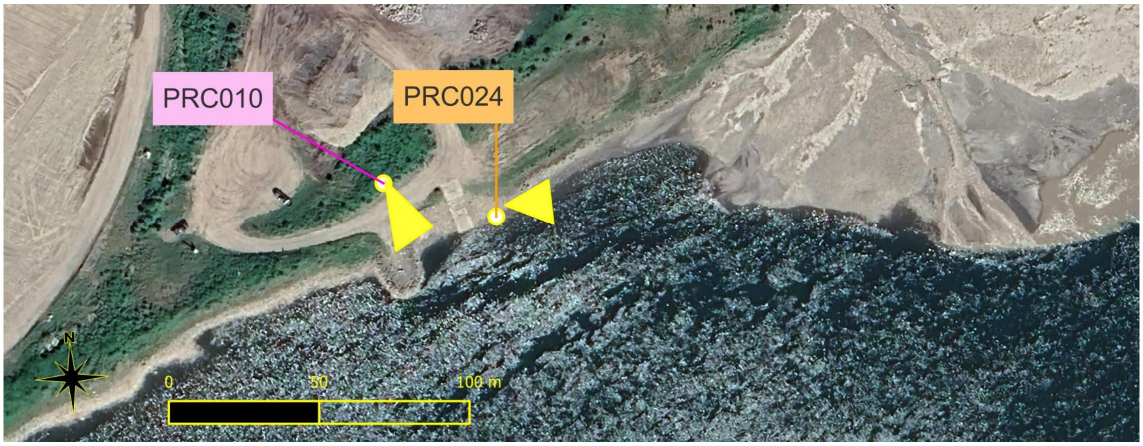
The following images show the positions of individual cameras (circles), along with view directions (triangles), by location. Camera name callout boxes are coloured yellow for trail cameras, orange for beach cameras, pink for launch cameras, and blue for road cameras. All images are screen captures from QGIS showing a 2015 Google Earth base map (out of date in many places where construction associated with the Site C project has occurred) at 1:2500 scale.

Highway 29 (one trail and three beach cameras):

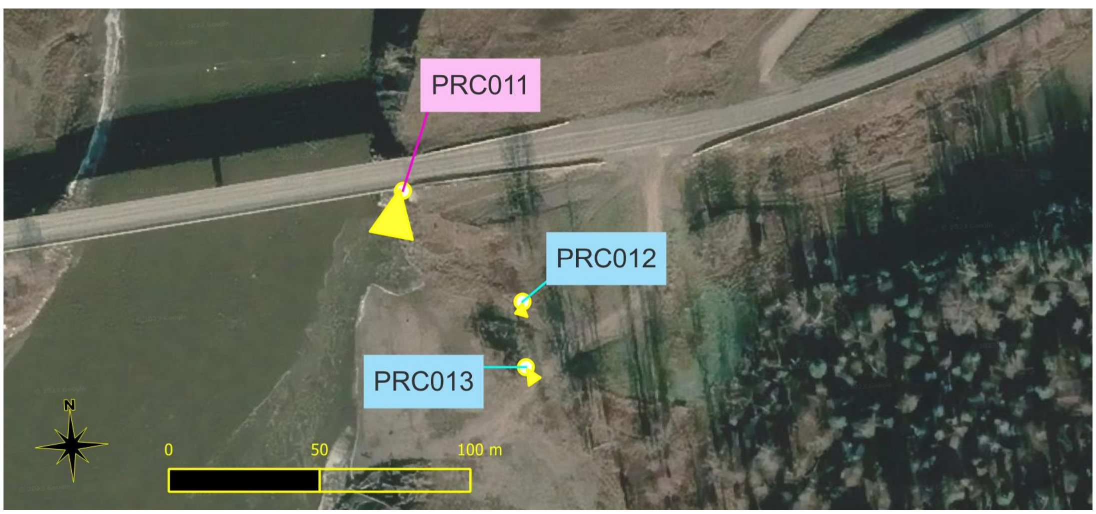
Alwin Holland (one trail and four beach cameras):



Lynx Creek (one launch and one beach camera):

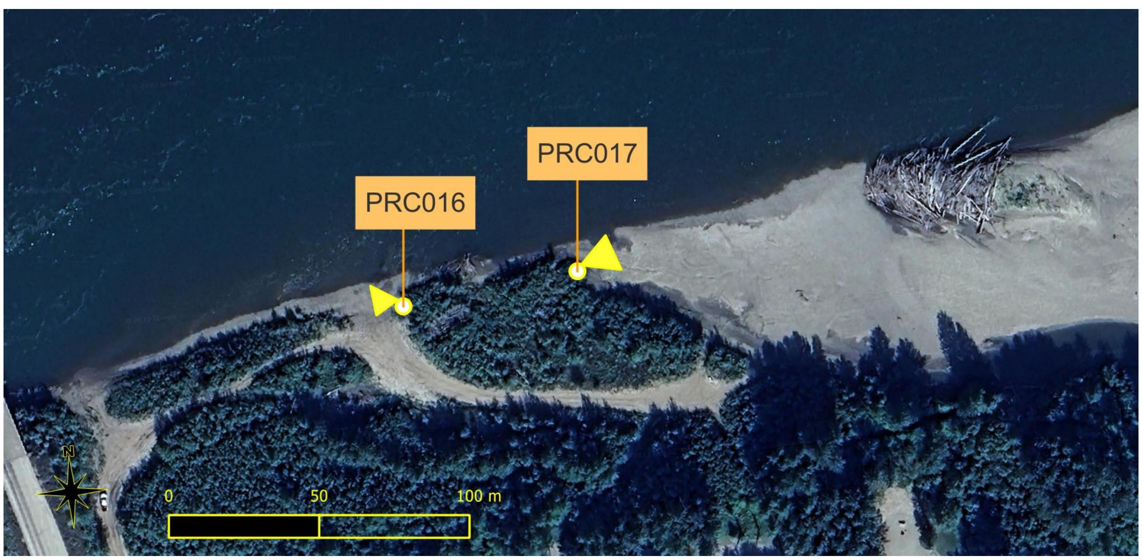


Halfway River Mouth (one launch and two road cameras):



Peace Island Park (two launch cameras):

Clayhurst (two beach cameras):



Many Islands (one launch and one road camera):

Appendix 5. Details of Camera-based Effort Estimates.

The following tables show the details of effort calculation, including mean daily effort ($\hat{B}$), sample sizes (n), days in the timeframe, and standard errors of $\hat{B}$ and Effort. Separate tables are provided showing the results for each of three deployment types: beach (Table A5-1), trail (Table A5-2), and launch (Table A5-3).

Table A5-1. Average shore angler effort ($\hat{\boldsymbol{B}}$) and total Effort (angler hours) by season, day type, and access site, from beach cameras. Also, standard errors and sample sizes.

Season	*Day type*	*Effort (Angler Hours)*	$\hat{B}_{eda}$, *daily effort*	*n **	*Days in Time Frame*	$SE_{\hat{B}_{eda}}$	$SE_{E_{eda}}$
Highway 29 / Fingers (Stratum 1 – Peace Canyon Dam to Hudson's Hope)							
Jul-Aug	WD	676.2	16.10	9 (9)	42	6.1	260.2
	WE	641.6	32.08	4 (4)	20	13.4	275.6
Sep-Apr	WD	46.1	0.28	126	166	0.2	14.6
	WE	158.8	2.09	57	76	1.0	39.1
May-Jun	WD	125.0	2.84	44	44	0.8	0
	WE	146.7	8.63	17	17	1.7	0
Alwin Holland (Stratum 1 – Peace Canyon Dam to Hudson's Hope)							
Jul-Aug	WD	382.2	9.10	34	42	1.5	27.5
	WE	524.9	26.25	17	20	4.7	37.5
Sep-Apr	WD	87.2	0.53	151	166	0.3	15.1
	WE	314.1	4.13	69	76	1.8	40.8
May-Jun	WD	253.7	5.77	44	44	1.2	0
	WE	334.1	19.65	17	17	4.3	0
Lynx via Beach Camera (Stratum 2 – Hudson's Hope to Site C)							
Jul-Aug	WD	0	0	9	42	0	0
	WE	0	0	4	20	0	0
Sep-Apr	WD	0	0	29	166	0	0
	WE	0	0	12	76	0	0
May-Jun	pool	no data					
Lynx via Lauch Camera (Stratum 2 – Hudson's Hope to Site C)							
Jul-Aug	WD	0	0	9	42	0	0
	WE	0	0	4	20	0	0
Sep-Apr	WD	33.3	0.2	129	166	0.1	5.9
	WE	0	0	56	76	0	0
May-Jun	WD	0	0	14	44	0	0
	WE	0	0	4	17	0	0
Halfway (Stratum 2 – Hudson's Hope to Site C)							
Jul-Aug	WD	173.5	4.13	37	42	0.5	7.0
	WE	55.1	2.76	18	20	0.6	4.1
Sep-Apr	WD	7.3	0.04	140	166	0	2.2
	WE	20.5	0.27	60	76	0.2	6.9
May-Jun	WD	27.8	0.63	39	44	0.3	4.2
	WE	333.1	19.59	17	17	4.5	0

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Table A5-1 continued.

Season	Day type	Effort (Angler Hours)	$\hat{B}_{eda}$, daily effort	n *	Days in Time Frame	$SE_{\hat{B}_{eda}}$	$SE_{E_{eda}}$
Peace Island (Stratum 3 – Site C to Many Islands)							
Jul-Aug	WD	544.2	12.96	1	42	4.7	196.1
	WE	760.1	38.01	1	20	13.7	274.2
Sep-Apr	WD	174.6	1.05	17	166	0.8	128.3
	WE	54.4	0.72	16	76	0.4	24.1
May-Jun	WD	82.2	1.87	8	44	0.5	21.0
	WE	1051.8	61.87	5	17	17.5	257.7
Clayhurst (Stratum 3 – Site C to Many Islands)							
Jul-Aug	WD	348.7	8.30	6 (1)	42	2.7	108.5
	WE	1,143.2	57.16	8 (2)	20	12.7	217.5
Sep-Apr	WD	4.4	0.03	64	166	0	3.7
	WE	0	00	29	76	0	0
May-Jun	WD	276.2	6.28	10	44	2.5	97.7
	WE	90.4	5.32	6	17	1.6	22.9
Many Islands (Stratum 3 – Site C to Many Islands)							
Jul-Aug	WD	421.1	10.80	22	42	1.7	44.6
	WE	163.8	7.44	11	20	1.4	21.7
Sep-Oct	WD	76.0	1.95	27	39	0.9	19.3
	WE	75.6	3.44	16	22	1.5	18.0
Nov-Apr	pool	0	0	closed			
May-Jun	pool	no data			61		

* numbers in brackets represent samples from July 2023.

Table A5-2. Average shore angler effort ($\widehat{\boldsymbol{B}}$) and total Effort (angler hours) by season, day type, and access site, from trail cameras. Also, standard errors and sample sizes.

Month	*Day type*	*Effort (Angler Hours)*	$\widehat{\boldsymbol{B}}_{eda}$, *daily effort*	*n **	*Days in Time Frame*	$SE_{\widehat{B}_{eda}}$	$SE_{E_{eda}}$
Highway 29 (Stratum 1 – Peace Canyon Dam to Hudson's Hope)							
Jul-Aug	WD	429.5	10.23	10 (10)	42	1.9	79.0
	WE	256.9	12.84	5 (5)	20	2.9	58.5
Sep	WD	27.8	1.39	124 (10)	20	0.2	4.4
	WE	21.1	2.11	51 (9)	10	0.4	4.4
Oct-Mar	WD	78.3	0.62	114	127	0.2	6.8
	WE	51.8	0.94	46	55	0.3	7.6
Apr	WD	63.6	3.35	19	19	1.0	0.0
	WE	27.6	2.51	11	11	0.9	0.0
May	WD	166.9	7.59	22	22	1.0	0.0
	WE	101.7	11.30	9	9	1.9	0.0
Jun	WD	254.5	11.57	22	22	1.3	0.0
	WE	176.7	22.09	8	8	4.9	0.0
Alwin Holland (Stratum1 – Peace Canyon Dam to Hudson's Hope)							
Jul	WD	288.2	14.41	20	20	1.8	0.0
	WE	542.6	49.33	11	11	7.4	0.0
Aug	WD	302.1	13.73	18	22	1.9	18.3
	WE	291.5	32.39	8	9	5.9	18.9
Sep	WD	71.4	3.57	20	20	1.4	0.0
	WE	152.8	15.28	10	10	5.5	0.0
Oct-Mar	WD	68.4	0.54	127	127	0.1	0.0
	WE	256.4	4.66	55	55	1.1	0.0
Apr	WD	135.3	7.12	19	19	2.6	0.0
	WE	152.3	13.84	11	11	4.3	0.0
May	WD	157.2	7.15	22	22	0.9	0.0
	WE	280.0	31.11	9	9	5.5	0.0
Jun	WD	352.7	16.03	22	22	1.8	0.0
	WE	369.5	46.19	8	8	8.3	0.0

* numbers in brackets represent samples from July 2023.

Table A5-3. Average boat angler effort ($\widehat{\boldsymbol{B}}$) and total Effort (angler hours) by season, day type, and access site, from launch cameras. Also, standard errors and sample sizes.

Month	*Day type*	*Effort (Angler Hours)*	$\widehat{B}_{eda}$, *daily effort*	*n **	*Days in Time Frame*	$SE_{\widehat{B}_{eda}}$	$SE_{E_{eda}}$
Lynx (Stratum 2 – Hudson's Hope to Site C)							
Jul-Aug	WD	0	0	9	42	0	0
	WE	86.3	4.31	4	20	1.7	30.4
Sep-Mar	WD	0	0	129	147	0	0
	WE	0	0	56	65	0	0
Apr-Jun	pool	0	0	closed			
Halfway (Stratum 2 – Hudson's Hope to Site C)							
Jul	WD	0	0	15	20	0	0
	WE	446.8	40.61	9	11	10.9	53.5
Aug	WD	0	0	22	22	0	0
	WE	249.4	27.72	9	9	7.8	0
Sep	WD	0	0	35	20	0	0
	WE	166.3	16.63	15	10	4.7	49.1
Oct-Mar	WD	0	0	120	127	0	0
	WE	0	0	49	55	0	0
Apr	WD	0	0	19	19	0	0
	WE	0	0	11	11	0	0
May	WD	279.9	12.72	22	22	4.1	0
	WE	694.7	77.19	9	9	15.0	0
Jun	WD	506.5	23.02	17	22	5.4	58.3
	WE	776.1	97.01	8	8	18.9	0
Peace Island (Stratum 3 – Site C to Many Islands)							
Jul-Aug	WD	113.4	2.70	2 (1)	42	1.6	69.1
	WE	203.2	10.16	3 (2)	20	5.1	101.2
Sep	WD	113.4	5.67	1	20	8.6	172.0
	WE	194.3	19.43	2	10	15.8	148.5
Oct-Mar	WD	0	0	11	127	0	0
	WE	142.5	2.59	11	55	2.4	117.6
Apr	WD	33.9	1.79	5	19	1.7	28.8
	WE	136.8	12.44	3	11	7.9	77.5
May	WD	0	0	5	22	0	0
	WE	180.3	20.03	3	9	11.9	92.4
Jun	WD	0	0	3	22	0	0
	WE	250	31.25	2	8	19.9	147.3
Many Islands (Stratum 3 – Site C to Many Islands)							
Jul-Aug	WD	45.9	1.09	22	42	0.2	6.7
	WE	27.9	1.39	11	20	0.5	6.6
Sep	WD	4.3	0.21	20	20	0.1	0.0
	WE	11.4	1.14	10	10	0.6	0.0
Oct	WD	2.5	0.13	7	19	0.1	1.7
	WE	12.4	1.04	6	12	0.6	5.1
Nov-Apr	pool	0	0	closed			
May-Jun	pool	no data			61		

* numbers in brackets represent samples from July 2023.