

Inseason Harvest and Effort Estimates for the 2021 Kuskokwim River Subsistence Salmon Fisheries During Block Openers

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ABSTRACT

Management of the Kuskokwim River Chinook salmon (*Oncorhynchus tshawytscha*) subsistence fishery has historically been conducted with minimal inseason harvest information. Due to this lack of information, it was challenging to make well-supported and defensible inseason management decisions regarding fishing opportunities that simultaneously achieve conservation and subsistence harvest objectives, particularly during years of weak Chinook salmon runs. In response to conservation concerns for the 2021 Kuskokwim River Chinook salmon run, the Orutsararmiut Native Council and the Kuskokwim River Inter-Tribal Fish Commission, in collaboration with the United States Fish and Wildlife Service and independent contractors, collected and processed data to produce inseason subsistence salmon harvest estimates from a portion of the mainstem Kuskokwim River within the boundaries of the Yukon Delta National Wildlife Refuge between and including the villages of Tuntutuliak and Akiak. Input data included drift and set gillnet counts from aerial surveys and subsistence harvester interviews at the Bethel boat harbor, Bethel area fish camps, and community-based harvest monitors from the Lower Kuskokwim River villages of Eek, Tuntutuliak, Napakiak, Napaskiak, and Kwethluk. Using methods developed and refined during 2016–2018, the best estimate of total subsistence salmon harvest in the study area was 49,440 (95% confidence limits [CL]: 46,820–52,070) during nine fishing opportunities with data collection between June 2 and July 16, 2021. Most salmon harvested were sockeye salmon (*O. nerka*; 23,600; 95% CL: 22,020–25,340), followed by Chinook salmon (21,630; 20,300–23,040), and chum salmon (*O. keta*; 4,220; 3,640–4,870). These estimates do not include harvests that (a) occurred in tributaries of the lower Kuskokwim River, (b) arose from non-gillnet capture methods, or (c) occurred during fishing opportunities on July 9, July 10, and July 17. While the sampling and analytical methods remained standardized and generally consistent with previous years, harvest, and effort estimation for the 2021 season was facilitated by a new customized software package for program R (termed ‘KuskoHarvEst’) that provides an intuitive menu-driven workflow. This allowed all co-authors to independently execute the estimation model and confer on results. This software will be useful for future seasons in which inseason harvest and effort estimates are desired for the lower Kuskokwim River subsistence salmon fishery and during which similar sampling occurs.

INTRODUCTION

Inseason management of Kuskokwim River salmon fisheries is undertaken in the face of a severe lack of information, due in a large part to the size and remoteness of the system and limited funds to monitor inseason harvests. To manage in a fully informed way, a manager would require continuous and accurate information on run timing, harvest, and escapement (Staton and Catalano 2019). With knowledge on these

three components, it would be possible to know how much of the run is yet to come, how much escapement potential remains, and how many more fish may be harvested. Inseason management of Kuskokwim River salmon has historically been conducted with little of this information and has instead relied largely on a single and highly uncertain index (the Bethel Test Fishery¹ [BTF]) of run abundance, run timing, and species composition to inform decision-making. Methods have been developed to obtain more detailed information on run timing (Staton et al. 2017) and run size (e.g., a relatively new mainstem sonar project, and a Bayesian approach to update run size forecasts with inseason data on a daily basis; Staton and Catalano 2019), and delivering this information to managers and stakeholders in a timely manner for decision-making. However, even with perfect information on these run characteristics, the number of fish harvested to date is unknown, which is important for structuring future fishing opportunities and ensuring adequate escapement. Timely inseason subsistence harvest estimates have only been available relatively recently in the Kuskokwim River (2015–2021) to inform inseason management and remain a critical information source necessary to successfully manage weak salmon runs. This document follows previous procedures (Staton and Coggins 2016, 2017; Staton 2018; Decossas 2019, 2020) to present inseason salmon harvest estimates from short-duration Kuskokwim River subsistence fishing opportunities during the 2021 season.

In response to multi-year conservation concerns for the 2021 Kuskokwim River Chinook salmon (*Oncorhynchus tshawytscha*) season (Larson 2021), the Refuge Manager of the Yukon Delta National Wildlife Refuge (YDNWR), through action by the Federal Subsistence Board², assumed primary management authority of the Kuskokwim River Chinook subsistence fishery within the boundaries of the YDNWR on June 1, 2021 (Figure 1).

The Refuge Manager decided that the use of restricted fishing time, area closers, and gear type restrictions would provide an adequate means to manage the fishery. The restricted fishing time or “block openings” provided limited harvest opportunity with periods between openings allowing for Chinook salmon to escape and harvest estimation and decision-making to identify the nature of subsequent fishing opportunities. Additionally, both the Refuge Manager and the Kuskokwim River Inter-Tribal Fish Commission (KRITFC) agreed that several “block opening” fishing opportunities should be announced prior to the beginning of the Chinook salmon season for people to plan for fishing, which provides greater certainty for subsistence harvesters and reduces complexity of inseason management. The Refuge manager and the KRITFC also agreed that 6-inch set gillnet opportunities should be provided to Federally-qualified subsistence users in order to provide a “taste of salmon” between June 1 to June 11. The Refuge Manager announced, effective June 1: (1) closures of Chinook salmon spawning tributaries; (2) set gillnet opening of 18 hours each on June 2, 5, and 9; and (3) 12-hour drift and set gillnet openings on June 12 and 15. This approach of announcing a limited number of fisheries openings was intended to provide subsistence harvest opportunity without risking Chinook salmon escapement until additional data become available. The Refuge Manager subsequently announced additional openings shown below, and ADF&G announced one additional opening. These subsistence opportunities were limited to Federally-qualified subsistence users, which includes all residents of the Kuskokwim River drainage, except for the announced ADF&G June 28 opener.

The Refuge Manager expected relatively few Chinook salmon would be harvested during these early opportunities because of past low numbers of Chinook salmon in the river during the front-end closure, plus the net length and operational restrictions for gillnets during this time. Additionally, subsistence fishing with dip nets, beach seines, fish wheels, and rod and reel remained open with live release of Chinook salmon required, and later chum salmon. Harvests from these non-gillnet methods are not included in the estimates provided in this report. In addition, harvests that occurred in non-spawning tributaries are not included. These sources of harvest were not included because aerial surveys do not monitor these areas and methods,

¹ <http://www.adfg.alaska.gov/index.cfm?adfg=commercialbyareakuskokwim.btf>

² https://www.fws.gov/uploadedFiles/3-KS-01-21_Final_5.7.2021.pdf

interview data coverage is variable, and harvests are generally thought to be small relative to mainstem harvests with gillnet gear.

There were 12 subsistence fishery opportunities between June 1 and July 22, 2021, within the YDNWR boundaries:

1. 6/2/21 6:00 am – 10:00 pm; 16 hours; FSA 3-KS-01-21; Set Gillnet Only
2. 6/5/21 6:00 am – 10:00 pm; 16 hours; FSA 3-KS-01-21; Set Gillnet Only
3. 6/9/21 6:00 am – 10:00 pm; 16 hours; FSA 3-KS-01-21; Set Gillnet Only
4. 6/12/21 06:00 am – 06:00 pm; 12 hours; FSA 3-KS-01-21; Drift or Set Gillnet
5. 6/15/21 06:00 am – 06:00 pm; 12 hours; FSA 3-KS-01-21; Drift or Set Gillnet
6. 6/19/21 06:00 am – 06:00 pm; 12 hours; FSA 3-KS-02-21; Drift or Set Gillnet
7. 6/28/21 10:00 am – 10:00 pm; 12 hours; ADF&G EO 3-S-WR-07-21; Drift or Set Gillnet
8. 7/2/21 06:00 am – 03:00 pm; 9 hours; FSA 3-KS-03-21; Drift or Set Gillnet
9. 7/9/21 06:00 am – 06:00 pm; 12 hours; FSA 3-KS-03-21; Drift or Set Gillnet
10. 7/10/21, 12:01 am – 7/11/21, 11:59 pm; 24 hours, FSA 3-KS-03-21; Set Gillnet Only
11. 7/16/21 06:00 am – 06:00 pm; 12 hours; FSA 3-KS-03-21; Drift or Set Gillnet
12. 7/17/21, 12:01 am – 7/18/21, 11:59 pm; 24 hours, FSA 3-KS-03-21; Set Gillnet Only

A harvest estimate was not produced for the 7/9/21 opening because poor weather prevented airplane flights to count nets; harvest estimates were not made for the 7/10/21 and 7/17/21 set gillnet opportunities because no data were collected.

Federal restrictions for the harvest of Chinook salmon were rescinded on July 22, 2021, per Refuge Manager action. After July 22, ADF&G continued subsistence fishing restrictions until July 31, 2021.

METHODS

The inseason harvest estimation framework that was developed and applied to the 2016–2021 Kuskokwim River salmon seasons required two primary types of information: (1) an estimate of the total number of fishing trips each day (termed “effort”); and (2) completed trip interview information from subsistence harvesters for a fishing trip documenting gear characteristics, total trip time, fishing location, active fishing time, and catch (Staton and Coggins 2016, 2017; Staton 2018). For a complete description of analytical and sampling methods, see Staton (2018).

Aerial Net Counts

The openings on June 2, 5, and 9 were of 16-hour duration for set gillnet only, and the goal was for one aerial survey flight to count nets fishing during each opening within the YDNWR boundaries between the communities of Tuntutuliak and Akiak (Figure 1). For each opener of 12 hours or more in duration that involved drift gillnets, the goal was two aerial survey flights to count the number of drift boats and set nets fishing, but flights were subject to weather, anticipated fishing effort, and budget considerations. Flights were scheduled to capture boat counts between low and high tides when the tides were moving the strongest, which are the most popular times to fish, and flights were spaced relatively evenly throughout the opener. Individual flights lasted from 1 to 1.5 hours, with 2 to 4.5 hours between flights when multiple flights occurred on a given day (Tables 1 and 2). Only on July 9 did inclement weather prevent USFWS from completing scheduled effort surveys. The analytical method for converting aerial counts to estimates of total effort accounts for trips that were likely to have been counted on multiple flights, and for trips that were unlikely to have been counted on any flight, is described in Staton (2018).

Aerial surveys were flown for the set gillnet-only openings on June 2, 5, and 9 due to the high uncertainty in early season run strength, but flights were not flown for the set gillnet openings on July 10–11 and 17–18 due to an anticipation of reduced fishing effort and budget limitations for both flights and harvest interviews.

Completed Trip Interviews

Information from harvester trips was obtained from three sources: (1) the Bethel boat harbor, (2) Bethel area fish camps, and (3) five lower Kuskokwim villages other than Bethel. Interview data from sources (1) and (2) were collected by personnel from Orutsararmiut Native Council (ONC) using the same methods that have been used since 2015. Data from source (3) were collected by the Kuskokwim River Inter-Tribal Fish Commission (KRITFC) using the same methods that have been used since 2017 as part of a community-based monitoring (CBM) project designed to provide interview data from areas of the YDNWR other than the Bethel area. In 2021, nine KRITFC village monitors were located in the villages of Eek, Tuntutuliak, Napaskiak, Napakiak, and Kwethluk. Data from all sources were compiled in a timely manner to be included in harvest estimates. However, in a small number of cases (interviews on three openers), some interview data were received as the inseason harvest reports were being finalized or had been distributed. These interview data are included in this final report and had little effect on harvest estimates, but did slightly increase sample sizes.

Analytical Methods

The analytical methods in 2021 were similar to those used in 2016–2020 and are described in Staton (2018). Some notable changes in 2021 involved introducing consistency in the decision rules that deem an interview unsuitable to be used in the estimation. These changes included: (1) exclusion of net-in-water times that were more than three standard deviations from the average for a given opening and gear type; (2) capping net-in-water times to not exceed the reported trip duration; and (3) excluding CPUE data from interviews that changed the estimate of average total salmon catch per trip by more than 5%. New to the 2021 season, and available for future seasons, was a custom software package for program R entitled ‘KuskoHarvEst³’ (Staton 2021). ‘KuskoHarvEst’ aims to: (1) facilitate installation of all software needed to perform estimation and generate reports; (2) remove the need to edit the software to produce estimates for each harvest opportunity; and (3) enforce consistency and remove subjectivity in data quality checking and censoring. The package accomplishes these tasks by being self-contained, easily downloadable, and providing an intuitive menu-driven workflow for all data processing and estimation steps. Routines in the R package are automated for conducting calculations developed in the 2016–2018 seasons (Staton and Coggins 2016, 2016; Staton 2018). Each co-author had the opportunity to provide feedback in the development of the software, was trained in its use prior to the season, and independently used the software inseason to produce the estimates for each harvest opportunity. Results were consistent among co-authors, with the biggest issue being data formatting errors that were often, but not always, identified by the interface computer code. Following the conclusion of the season, development of the software has continued based on feedback from the 2021 experience with the first version, and it now improved abilities to detect and handle data formatting issues.

³ <https://github.com/bstaton1/KuskoHarvEst>

RESULTS

6/2/2021 Opener

An estimated total of 29 set net trips occurred in the study area (Table 3; Figures 2 and 3). The estimated total salmon harvest was 30 (95% CL: 10–40), with all harvested salmon being Chinook salmon (Table 4; Figure 4). All Chinook salmon harvested during this opportunity were with set gillnets and from above the Johnson River (Strata B, C, and D). Although 2 drift boats were also counted, harvest estimates were not produced because no drift net interviews were obtained (only set gillnets were allowed by regulation). Harvest estimates were produced from 23 trip interviews, of which 14 (61%) came from the Bethel boat harbor, 1 (4%) from a Bethel area fish camp, and 8 (35%) from KRITFC community monitors (Figure 5).

6/5/2021 Opener

An estimated total of 91 set net trips occurred between Tuntutuliak and Akiak (Table 3; Figures 2 and 3). The estimated total salmon harvest was 360 (95% CL: 150 – 660). Most of the harvest was Chinook salmon (300; 120 – 590), followed by sockeye salmon (40; 10 – 80), and chum salmon (10; 0 – 40) (Table 4; Figure 4).

Harvest estimates were produced from 42 trip interviews, of which 22 (52%) came from KRITFC community monitors, 15 (36%) from the Bethel boat harbor, and 5 (12%) from Bethel area fish camps (Figure 5). This harvest estimate includes 4 additional trip interviews completed by KRITFC monitors that were added after the initial harvest estimate was produced on June 6, 2021.

6/9/2021 Opener

An estimated total of 107 set net trips occurred between Tuntutuliak and Akiak (Table 3; Figures 2 and 3). The estimated total salmon harvest was 410 (95% CL: 310 – 520). Most of the harvest was Chinook salmon (390; 290 – 490), followed by sockeye salmon (20; 10 – 40), but with no chum salmon harvested (Table 4; Figure 4).

Harvest estimates were produced from 66 trip interviews, of which 36 (55%) came from KRITFC community monitors, 26 (39%) from the Bethel boat harbor, and 4 (6%) from Bethel area fish camps (Figure 5). This harvest estimate includes 3 additional trip interviews completed by KRITFC monitors that were added after the initial harvest estimate was released on June 10, 2021.

6/12/2021 Opener

An estimated total of 383 drift boat trips and 26 set net trips occurred in the study area on 6/12/2021 during the 12-hour opener (Table 3; Figures 2 and 3). The estimated total salmon harvest was 3,680 (95% CL: 3,220 – 4,160). The majority of the harvest (89%) was Chinook salmon (3,260; 2,860 – 3,670), followed by smaller amounts of sockeye salmon (350; 240 – 460) and chum salmon (70; 50 – 100) (Table 4, Figure 4). In terms of total harvest, this first combined drift and set gillnet opportunity in 2021 resulted in the smallest total salmon harvest since inseason harvest monitoring began in 2016. The number of Chinook salmon harvested in this opportunity was the third smallest for this date since 2016, higher than the 2,400 Chinook salmon harvested in 2017 but well below the 8,040 harvested in 2019. The total harvest of 420 chum and sockeye salmon in this opportunity was the lowest since 2016, notably for chum salmon (70 compared to an average chum salmon harvest of 1,110 during 2016 – 2020).

Harvest estimates were produced from 226 trip interviews, of which 121 (54%) came from the Bethel boat harbor, 76 (34%) from KRITFC community monitors, and 29 (13%) from Bethel area fish camps, and

(Figure 5). Eleven interviews were from set net fishers with the remaining 215 interviews from drift net fishers.

Based on the distribution of relevant interview quantities from this opener (Figure 6), trip duration varied widely among harvesters (average 6.7 hours), and soak time was skewed towards less than 7 hours (average 4.5 hours). Nearly half the harvesters caught 5 or fewer salmon per trip (average of 8.8 salmon/trip among all interviews). As in recent years, the average fisher interviewed by KRITFC community monitors and at Bethel area fish camps had higher catch rates and spent more time actively fishing than most people interviewed at the Bethel boat harbor. Overall, Chinook salmon made up approximately 90% of catches across all interviews.

6/15/2021 Opener

An estimated total of 468 drift boat trips and 33 set net trips occurred within the study area on 6/15/2021 (Table 3; Figures 2 and 3). The estimated total salmon harvest was 8,580 (95% CL; 7,510 – 9,620). As in the June 12 opener, most of the harvest was Chinook salmon (80%; 6,820; 5,970 – 7,680), followed by sockeye salmon (16%; 1,400; 1,140 – 1,700), and chum salmon (4%; 360; 260 – 470) (Table 4, Figure 4).

Harvest estimates were produced from 235 completed trip interviews, of which 124 (53%) came from the Bethel boat harbor, 85 (36%) came from KRITFC community monitors, and 26 (11%) came from Bethel area fish camps (Figure 5). Six of these interviews were from set net fishers and the remaining 229 were from drift boat fishers. Based on the distribution of relevant interview quantities from this opportunity (Figure 7), a majority of fishers soaked longer (average 5.2 hours) and stayed out on the river longer (average 7.3 hours) compared to the June 12, 2021, opportunity.

The average catch of total salmon per trip (average 13.9) and Chinook salmon per trip (average 11.0) increased from the June 12 opportunity (Figure 7). Combined chum and sockeye salmon catch rates tripled compared to June 12. Chinook salmon comprised 80% of catches across all interviews.

6/19/2021 Opener

An estimated total of 513 drift boat trips and 34 set net trips occurred within the study area on 6/19/2021 (Table 3, Figures 2 and 3). The estimated total salmon harvest was 9,680 (95% CL; 8,490 – 11,030). The majority of the harvest was Chinook salmon (65%; 6,250; 5,380 – 7,190), followed by sockeye salmon (25%; 2,430; 2,100 – 2,770), and chum salmon (10%; 1,000; 670 – 1,410) (Table 4, Figure 4). A relatively high harvest of Chinook salmon was expected during this opportunity given the low run strength of chum/sockeye salmon and the timing of this opportunity being close to the historical peak of the Chinook salmon run.

Harvest estimates were produced from 237 completed trip interviews, of which 119 (50%) came from the Bethel boat harbor, 88 (37%) from KRITFC community monitors, and 30 (13%) from Bethel area fish camps (Figure 5). Eleven of these interviews were from set net fishers and the remaining 226 were from drift boat fishers.

Based on the distribution of relevant interview quantities from the sixth opener (Figure 8), average trip duration, soak hours, total salmon catch per trip, and chum/sockeye catch per trip increased slightly compared to the previous opportunities, while Chinook salmon catch per trip and the percent of the catch that was Chinook salmon declined from the last opportunity.

Overall, Chinook salmon made up 65% of the catches across all interviewed fishers, which was roughly a 15% decrease from the previous opportunity.

6/28/2021 Opener

An estimated total of 222 drift boat trips and 9 set net trips occurred within the study area on 6/28/2021 (Table 3; Figures 2 and 3). The estimated total salmon harvest was 10,940 (95% CL; 9,750 – 12,280). For the first time in 2021, the largest portion of the harvest was sockeye salmon (64%; 6,960; 5,980 – 8,020), followed by Chinook salmon (27%; 3,010; 2,640 – 3,390), and chum salmon (9%; 970; 800 – 1,160) (Table 4, Figure 4).

These harvest estimates were produced from 112 completed trip interviews, of which 51 (45%) came from KRITFC community monitors, 42 (38%) from the Bethel boat harbor, and 19 (17%) from Bethel area fish camps (Figure 5). Six of these interviews were from set net fishers and 106 were from drift boat fishers. This was the smallest number of interviews collected during a drift and set gillnet opportunity in June 2021. The dramatic decline in the number of both interviews and aerial survey net counts for this opportunity compared to the previous drift and set gillnet opportunities indicated a substantial reduction in subsistence fishing effort. Bethel boat harbor surveys declined from an average of 121 drift and set gillnet interviews in the previous three openers to 42 surveys in this opportunity. The same trend was apparent in the CBM surveys and fish camp surveys. The reduced fishing effort likely resulted from conflicting Federal and State regulations for this date, causing confusion among fishers and concerns over being cited if fishing (ADF&G Emergency Order #3-S-WR-07-21).

Based on the distribution of relevant interview quantities from the June 28 opener (Figure 9), average trip duration (4.2 hours) and trip soak time (2.7 hours) were substantially reduced compared to the previous opportunity on June 19. The average number of salmon caught per boat increased from 15 in the previous opportunity to 41 in the June 28 opportunity. This increase in salmon per boat is primarily due to about a 182% increase in sockeye salmon catch. However, there was a 51% decline in Chinook salmon catch per trip between the June 19 and June 28 fishing periods.

For the first time in the 2021 subsistence fishery, Chinook salmon catch composition was below 50% across all interviews (average 30%).

7/2/2021 Opener

An estimated 211 drift boat trips occurred within the study area on 7/2/2021; set nets trips were not estimated due to an insufficient number of set net harvester interviews (Table 3; Figures 2 and 3). The estimated total salmon harvest was 11,460 (95% CL; 10,120 – 12,880). To an even greater extent than the June 28 opener, most of the harvest was sockeye salmon (78%; 8,990; 7,790 – 10,170), followed by Chinook salmon (12%; 1,330; 1,100 – 1,570), and chum salmon (10%; 1,150; 820 – 1,510) (Table 4, Figure 4).

Harvest estimates were produced from 122 completed trip interviews, of which 55 (45%) came from KRITFC community monitors, 48 (39%) from the Bethel boat harbor, and 19 (16%) from Bethel area fish camps (Figure 5). Three of these interviews were from set net fishers and the remaining 119 were from drift boat fishers. Based on the distribution of relevant interview quantities from this opportunity (Figure 10), average trip duration (4.1 hours) and soak duration (2.9 hours) were similar to the June 28, 2021 opportunity.

The average catch of total salmon per trip (average 40.2) was similar to that of the June 28 opportunity (average 41). Combined chum and sockeye salmon catch rates (average 35.1) were slightly higher compared to June 28 (average 29.1) (Figure 10), with the majority of these catches being sockeye.

7/9/21 Opener

A harvest estimate was not produced for the 7/9/21 opening because poor weather prevented flights to count nets. Instead, a data summary was produced.

A total of 107 trip interviews were conducted, of which 57 (53%) came from the Bethel boat harbor, 36 (34%) from KRITFC community monitors, and 14 (13%) from Bethel area fish camps (Figure 5). Only one interview was a set net fisher with the remaining 106 for drift boat trips.

Average catch of total salmon catch per trip (41.7) was similar to that of the June 28 and July 2 opportunities. Compared to previous openings, Chinook salmon catch per trip (average 3.7) continued to decline, whereas combined chum and sockeye salmon catch per trip (average 38) increased to the highest level observed in 2021, with the majority of these catches being sockeye (Figure 11).

7/10/21 - 7/11/21 Opener

Harvest estimates were not made for the 7/10/21 - 7/11/21 (24 hour) set gillnet opportunity because no data were collected.

7/16/21 Opener

An estimated total of 190 drift boat trips and 6 set net trips occurred within the study area on 7/16/2021 (Table 3; Figures 2 and 3). The estimated total salmon harvest was 4,320 (95% CL; 3,590 – 5,120). The majority of the harvest was sockeye salmon (79% 3,400; 2,820 – 4,050), followed by chum salmon (15%; 660; 450 – 880), and Chinook salmon (6%; 250 180 – 330) (Table 4, Figure 4).

Harvest estimates were produced from 73 completed trip interviews, of which 55 (75%) came from the Bethel boat harbor, 12 (16%) from Bethel area fish camps, and 6 (8%) from KRITFC community monitors (Figure 5). The Bethel boat harbor surveys were conducted by YDNWR and KRITFC staff after receiving training from ONC staff for this opener. Five of these interviews were from set net fishers and the remaining 68 were from drift boat fishers. Based on the distribution of relevant interview quantities from this opportunity (Figure 12), average trip duration (4.0 hours) and average soak duration (2.4 hours) were similar to the July 9, 2021 opportunity.

The average catch of total salmon per trip (average 15.8) was far lower than the average of 41.7 on the July 9, 2021 opener. Combined chum and sockeye salmon catch rates were 14.6 (with the majority of these catches being sockeye), again far lower than the July 9 opener.

7/17/21 - 7/18/21 Opener

Harvest estimates were not made for the 7/17/21 - 7/18/21 (24 hour) set gillnet opportunity because no data were collected.

Total Harvest across All Openers

Note that unlike most previous years for the inseason harvest monitoring program, the July 9 drift and set gillnet harvest opportunity lacked an aerial survey, and no interview or aerial survey data were available for the July 10-11 and July 17-18 openings. In addition, stratum O harvests (primarily non-spawning tributaries) continue to represent a relatively small number of catches (compared to mainstem lower Kuskokwim River catches) not expanded to total estimates because of no corresponding aerial survey data

and uncertainty in availability of these interviews. Therefore, the total harvest estimates in this section should be interpreted with caution considering these aspects.

Across all openers, an estimated total of 49,440 (95% CL; 46,820–52,070) salmon was harvested. This estimate does not include harvests that (a) occurred in tributaries of the lower Kuskokwim River, (b) were from non-gillnet capture methods, or (c) occurred during fishing opportunities on July 9, July 10, and July 17. Although a larger total harvest of all salmon was estimated in 2021 compared to 2020 (35,500; Decossas 2020), this is likely due to harvest monitoring during the federal management period that extended well into July and the resulting closure of gillnet fishing between openers on the Kuskokwim River between and including the villages of Tuntutuliak and Akiak by the Refuge Manager to far later in the summer (July 22 in 2021 compared to July 1 previously), resulting in more specified fishing openers where harvest monitoring occurred to document inseason harvest, particularly of sockeye. In terms of historical total harvest, this was a particularly small harvest of Chinook and chum compared to historical averages. The 2020 inseason salmon harvest estimate represented the smallest amount of total salmon harvested in the study area since the inseason harvest monitoring program's inception in 2016; the 2021 harvest estimate represents about a 7% decrease in Chinook harvest from 2020 and about a 25% decrease in chum salmon harvest from 2020. This observation is believed to be fairly accurate because the 2021 abundances of salmon, particularly Chinook salmon and chum salmon, were far below the overall average. Most of the harvest was sockeye salmon (48%; 23,600; 22,020 – 25,340), followed by Chinook salmon (44%; 21,630; 20,300 – 23,940), and chum salmon (8%; 4,220; 3,640 – 4,870) (Table 4; Figure 13).

Fishers within geographic stratum C (Napaskiak to Akiachak) harvested the most total salmon, accounting for 39% of all salmon harvest, followed by stratum A (Eek Island to Johnson River; 27%), stratum B (Johnson River to Napaskiak; 25%), and stratum D1 (Akiachak to Akiak; 9%) (Tables 4; Figure 14). In 2021, it appeared that the number of boats drifting increased as the season reached the historical peak of the Chinook salmon run, reaching peak drift effort on June 19.

Synthesis of Key Information on 6/12 Openers

Given that June 12 is a key opener date, it is important to continue synthesizing information that has been gathered from 2016 to 2021, during which 12-hour openers were implemented.

There are several notable findings from the synthesis of key information from June 12 fishing opportunities during 2016–2021. The number of drift boat trips between Tuntutuliak and Akiak were similar in magnitude, but have steadily decreased since 2016 (524 in 2016, 523 in 2017, 466 in 2018, 446 in 2019, 406 in 2020; and 383 in 2021; average 458; Table 7). The total harvest of 3,680 total salmon on June 12, 2021, was also the lowest for the drift and set gillnet opportunities on June 12 since 2016. Chum and sockeye salmon harvest for the 6/12/2021 opener was the lowest for this date since the inseason harvest estimation program began in 2016. The species ratio (chum+sockeye:Chinook) in 2021 (0.1) was also the lowest since 2016. In most years over the past decade, the species ratio at the BTF averages around 1:1 near or soon after June 12.

DISCUSSION

Overall Summary

For the 2021 season, an estimated total of 49,440 (46,820 – 52,070) salmon were harvested. Most of the harvest was sockeye salmon (48%; 23,600; 22,020 – 25,340), followed by Chinook salmon (44%; 21,630; 20,300 – 23,940), and chum salmon (8%; 4,220; 3,640 – 4,870) (Table 4; Figure 13). Total salmon harvest was not the smallest since the inseason program harvest monitoring program began in 2016, but the Chinook

and chum salmon harvests decreased by about 7% and 25%, respectively, from 2020 which was the smallest amount of total salmon harvested in the study area since the inseason harvest monitoring program's inception in 2016. The 2021 sockeye salmon harvest increased by 72% from 2020. This is likely due to the closure of gillnet salmon fishing later in the summer on the Kuskokwim in 2021 compared to previous years and additional gillnet fishing openers later into the summer, which allowed for more harvest monitoring later into the summer than in previous years.

Additionally, as stated previously, total harvest estimates do not include harvest estimated from the 7/9/21 harvest opportunity because poor weather prevented flights to count nets, or from the 7/10/21 and 7/17/21 set gillnet harvest opportunities because no data were collected.

One other aspect that complicated the 2021 sampling design was the occurrence of the on-going novel coronavirus (COVID-19) pandemic. In order to protect the safety of local residents and interviewers, face-masking and/or social distancing protocols were applied if interviewing people in the field. These measures may have impacted communication between interviewers and interviewees.

Reliability of Assumptions

All reported analyses assumed the interview information was a random sample from the population of fishers during the opener. This assumption is not unique to this analysis, or even creel surveys in general, but is made in every statistical analysis where samples are used to make inferences on a population. We must highlight that sampling for the completed trip interviews was not implemented in a truly random sense, but was opportunistic. The potential for non-randomness could raise questions about the harvest estimates in terms of accuracy and precision. If data were systematically biased (e.g., fishers in the sample fished longer and had higher catch rates than non-sampled fishers), then the resulting estimates would also be biased. While surveys had both high and low catches, we believe these estimates well represent the available harvest results and efforts. Although information was treated as if random, harvest estimate presentations to stakeholders and decision-makers identified limitations of the analysis. Results included estimates of uncertainty.

We believe that the samples, although gathered in an opportunistic sense, provide a good representation of the lower Kuskokwim River subsistence fishery during block openers. As in previous years, the fishing opportunities in the 2021 season were short in duration meaning that surveyor coverage at interviewed locations could sample a representation of fishers returning to these locations, leading us to believe temporal representation was high (i.e., the samples should identify variability due to the time-of-day different trips occurred). Due to the size of the study area and the number of communities it contains, however, spatial representation is more difficult to guarantee. The lower Kuskokwim River can be generally separated into three major sections based on river morphology, fisher behavior, and fishery density: (1) upriver from Bethel, (2) around Bethel, and (3) downriver from Bethel. A majority of the surveys collected were from around Bethel, primarily through the Bethel boat harbor surveys conducted by ONC. While most of the harvester population in the subsistence fishery is based in and around Bethel, catch rates outside of Bethel can differ substantially from Bethel area harvests. The CBM program had a presence in the village of Napaskiak, which is just a several minute boat ride (about 6 river miles) from Bethel but exhibits different effort and harvest characteristics. Overall, gathering information from these locations gave a respectable indication of the subsistence fishery in and around the Bethel area. With respect to the areas above and below Bethel, coverage was provided by community-based monitors. The above Bethel area had community-based monitors stationed in the village of Kwethluk, a prominent and large community upriver of Bethel. In contrast to previous years, community-based monitor coverage did not occur in Akiak, or other stratum D villages, which limited the coverage and accuracy of harvest estimation. The area downstream of Bethel was primarily informed by the community-based monitors stationed in Napaskiak, Napakiak, Eek (represented for the first time in 2021), and Tuntutuliak. Given this broad geographic

coverage within the study area, we believe data collected through the monitoring program are representative of the lower river subsistence fishery.

Other Harvest Not Monitored or Accounted For

Harvest estimates in this document for salmon within the study area are likely biased low. For example, fishing with selective gear types (i.e., rod and reel, beach seine, fish wheels, and dip nets) for salmon was allowed for Federally qualified users throughout the gillnet salmon fishing closure in the mainstem Kuskokwim River, but with live release of Chinook salmon required by Federal Emergency Special Actions starting May 7, 2021 (3-KS-01-21, 3-KS-02-21, 3-KS-03-21). As of July 2, 2021, State Emergency Order #3-S-WR-08-21 made additional live release requirements that subsistence fishing with fish wheels and beach seines would continue to be allowed with live release of chum salmon. Although many subsistence users do not traditionally use these gears when gillnets are allowed, it is reasonable to assume some subsistence users fished for and retained Pacific salmon species, aside from Chinook salmon (and chum salmon after 7/2), using these alternative gear types in between gillnet opportunities. The number of salmon harvested with these gear types is probably minimal, but still worth mentioning.

In addition, gillnet harvests occurred in areas designated as non-spawning tributaries that were still part of the Kuskokwim River drainage. Harvest in these areas is poorly documented. The 2021 inseason interviews collected some information from subsistence users who fished in the non-salmon spawning tributaries (i.e., Johnson, Tuntutuliak, and Pailleq), which indicated more salmon harvest occurs in those locations than previously thought. This difference is further amplified because data from non-salmon tributaries are only collected when the mainstem fishery is open, whereas non-salmon tributaries are open every day with few gear restrictions (e.g., gillnets with $\geq 6''$ mesh are allowed). No data collected from non-salmon spawning tributaries were included in the 2021 harvest estimates. Harvest estimates were not generated for these locations, similar to previous years, because subsistence harvest surveys are generally collected only during announced opportunities, and aerial surveys are not typically flown over these areas. While harvests in these locations are not believed to be detrimental to meeting escapement needs, the magnitude of Chinook salmon harvest in these locations remains unknown.

Finally, federally-qualified users were also able to harvest Chinook salmon before June 1 with $\leq 6''$ mesh size gillnets. During this time period, harvest and effort was not monitored, although the number of Chinook in the Kuskokwim River is believed to be minimal prior to June 1.

Sensitivity of Harvest Estimates

Sensitivity of the estimates to assumption violations was investigated by producing effort and harvest estimates using data from smaller subsets of all of the available interviews (e.g., removing Bethel boat harbor interviews). Results of these analyses showed that the estimates were generally robust to leaving out information (i.e., making the information used presumably less representative), and the results ranged from small changes ($<5\%$) in point estimates to larger changes (25-50%). Typically, harvest estimates increased when Bethel boat harbor data were removed and decreased when the CBM interviews were removed. In most cases, the point estimate of the analysis with left-out data fell within the 95% CL of the original estimate and in no cases did the qualitative conclusion change.

Technical Review of Harvest Estimates

The technical review team in 2021 included representatives from KRITFC, ONC, and two independent contractors. Following each opening, the review team discussed independently-obtained estimates to identify data entry errors and clarify distribution of resulting estimates. After resolving data issues, harvest estimates were sent to an open email list and results presented at meetings of USFWS-KRITFC inseason managers and to the Kuskokwim River Salmon Management Working Group.

Scalability of the Model

The current methods for estimating inseason salmon harvests are effective when applied to fishery conditions that have occurred since 2016 (i.e., relatively few opportunities and each short in duration). However, if the frequency and duration of fishing opportunities were to increase, a more carefully designed random sampling program would be necessary to produce reliable harvest estimates. This is because longer opportunities make it more difficult to justify the assumption of random sampling at existing locations with interview coverage. Unlike 12-hour opportunities, it is unreasonable to keep an interviewer at an access site for most of an opportunity that is several times longer. This implies decisions would have to be made about the most appropriate time and place to have the monitors gathering information (while also ensuring they are collecting a representative sample of the fishery at the time). In 2021, data were collected at the 16-hour openers with near 100% temporal coverage, but, for example, ONC monitors would rotate shifts so they would not be asked to monitor for an unreasonable amount of time. During the two 24-hour openings in 2021, no data were collected, so the issue of monitors staying for an unreasonable amount of time was not a concern.

If managers wish to have inseason harvest estimates should fishery management become less restrictive (more and/or longer fishing periods), a more rigorous sampling program will be required. There are common and well-practiced methods in existence today that can be implemented (Bernard et al. 1998). Here are two major considerations that will be faced in such an effort:

- (1) Longer opportunities would likely result in lower fisher density at access points as compared to short duration opportunities. As fisher traffic becomes more dispersed, decisions would have to be made as to when and where is most appropriate to sample returning fishers (typically accomplished through random sampling of time slots, like AM versus PM). Similarly, decisions on what day of the week to sample are also very common. One standard practice to accomplish this task is to sample in proportion to effort (e.g., weekends versus weekdays). However, the fishery has never been monitored in a fashion that would help answer these questions and careful consideration must be given to choosing dates and times to minimize bias.
- (2) Longer opportunities would also likely result in fishing effort being more dispersed. Given that aerial surveys place a high demand on agency resources, the subsampling program would have to be refined to accurately characterize effort in a more open fishery when fishers are not limited to a tight block opener. Additionally, the current effort expansion model would need to be adapted to accommodate the change in methodology.

While these considerations present challenges to the current inseason harvest estimate program, they are not impossible to complete with proper direction and time. In particular, simulation studies could be useful for identifying sampling strategies that allocate limited resources to return estimates with accuracy and precision similar to those obtained by the current framework.

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Table 1. Raw drift gillnet/boat counts from each flight and geographic stratum. The first three openers were opportunities for set gillnets only. No flights were conducted for the July 9, 10-11, and 17-18 opportunities.

Opener	Date	Flight Times ¹		Geographic Stratum ²				Total
		Start	Stop	A	B	C	D	
1	6/2/2021	18:12	19:47	0	0	2	0	2
2	6/5/2021	16:25	17:40	0	0	0	0	0
3	6/9/2021	18:11	19:32	0	2	0	0	2
4	6/12/2021	09:17	10:50	49	41	150	34	274
4	6/12/2021	15:00	16:30	60	48	122	20	250
5	6/15/2021	9:20	10:43	91	66	168	35	360
5	6/15/2021	15:10	16:34	81	87	135	24	327
6	6/19/2021	9:34	11:00	118	95	181	43	437
6	6/19/2021	15:13	16:32	86	51	113	21	271
7	6/28/2021	14:47	16:12	28	23	43	25	119
7	6/28/2021	18:12	19:47	2	8	33	7	50
8	7/2/2021	10:05	11:40	38	40	64	6	148
9	7/9/2021	ND	ND	ND	ND	ND	ND	ND
10	7/10/2021	ND	ND	ND	ND	ND	ND	ND
11	7/16/2021	15:45	16:50	17	20	54	10	101
12	7/17/2021	ND	ND	ND	ND	ND	ND	ND

¹ND = No data

²Geographic strata: A = below Johnson River, B = Johnson River to Napaskiak, C = Napaskiak to Akiachak, D = Akiachak to Akiak.

Table 2. Raw set gillnet counts from each flight and geographic stratum. Openings on June 2, 5, and 9 and July 10–11 and 17–18 were set gillnet only opportunities. No flights were conducted for the July 9, 10–11, and 17–18 opportunities.

Opener	Date	Flight Times ¹		Geographic Stratum ²				Total
		Start	Stop	A	B	C	D	
1	6/2/2021	18:12	19:47	0	2	19	8	29
2	6/5/2021	16:25	17:40	1	20	52	18	91
3	6/9/2021	18:11	19:32	0	7	74	26	107
4	6/12/2021	09:17	10:50	0	2	14	3	19
4	6/12/2021	15:00	16:30	2	2	17	3	24
5	6/15/2021	9:20	10:43	0	2	19	5	26
5	6/15/2021	15:10	16:34	2	5	18	4	29
6	6/19/2021	9:34	11:00	3	1	5	3	12
6	6/19/2021	15:13	16:32	0	2	24	2	28
7	6/28/2021	14:47	16:12	0	0	0	2	2
7	6/28/2021	18:12	19:47	0	0	6	1	7
8	7/2/2021	10:05	11:40	0	0	3	1	4
9	7/9/2021	ND	ND	ND	ND	ND	ND	ND
10	7/10/2021	ND	ND	ND	ND	ND	ND	ND
11	7/16/2021	15:45	16:50	0	0	2	2	4
12	7/17/2021	ND	ND	ND	ND	ND	ND	ND

¹ND = No data

²Geographic strata: A = below Johnson River, B = Johnson River to Napaskiak, C = Napaskiak to Akiachak, D = Akiachak to Akiak.

Table 3. Estimated drift and set gillnet trips by date and geographic stratum. These quantities were derived from the raw counts presented in Tables 1 and 2.

Gear	Opener	Date	Duration ²	Geographic Stratum ¹				Total
				A	B	C	D	
Drift	1	6/2/2021	16	NA	NA	NA	NA	NA
Boat	2	6/5/2021	16	NA	NA	NA	NA	NA
	3	6/9/2021	16	NA	NA	NA	NA	NA
	4	6/12/2021	12	80	66	198	39	383
	5	6/15/2021	12	117	105	206	40	468
	6	6/19/2021	12	151	104	213	45	513
	7	6/28/2021	12	31	39	113	39	222
	8	7/2/2021	9	54	57	91	9	211
	9	7/9/2021	12	ND	ND	ND	ND	ND
	11	7/16/2021	12	32	38	101	19	190
	Set Net	1	6/2/2021	16	0	2	19	8
2		6/5/2021	16	1	20	52	18	91
3		6/9/2021	16	0	7	74	26	107
4		6/12/2021	12	1	3	18	4	26
5		6/15/2021	12	2	4	21	6	33
6		6/19/2021	12	4	3	21	6	34
7		6/28/2021	12	0	0	4	5	9
8		7/2/2021	9	ND	ND	ND	ND	ND
9		7/9/2021	12	ND	ND	ND	ND	ND
10		7/10-11/2021	24	ND	ND	ND	ND	ND
11		7/16/2021	12	0	0	3	3	6
12		7/17-18/2021	24	ND	ND	ND	ND	ND

¹Geographic strata: A = below Johnson River, B = Johnson River to Napaskiak, C = Napaskiak to Akiachak, D = Akiachak to Akiak

²Duration is the number of hours in the opener.

³ND = No data, NA = not applicable

Table 4. Salmon harvests from both drift and set gillnets by subsistence opening, species, and geographic stratum in 2021. Numbers within parentheses are 95% confidence limits.

Opener	Species	Geographic Stratum ¹				Total
		A	B	C	D	
6/2/2021	Chinook	0 (0-0)	0 (0-0)	20 (10-30)	10 (0-10)	30 (10-40)
	Chum	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)
	Sockeye	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)
	Total	0 (0-0)	0 (0-0)	20 (10-30)	10 (0-10)	30 (10-40)
6/5/2021	Chinook	0 (0-0)	70 (20-130)	170 (70-340)	60 (20-120)	300 (120-590)
	Chum	0 (0-0)	0 (0-10)	10 (0-20)	0 (0-10)	10 (0-40)
	Sockeye	0 (0-0)	10 (0-20)	30 (10-50)	10 (0-20)	40 (10-80)
	Total	0 (0-10)	80 (30-150)	200 (90-380)	70 (30-130)	360 (150-660)
6/9/2021	Chinook	0 (0-0)	30 (20-30)	270 (200-340)	90 (70-120)	390 (290-490)
	Chum	0 (0-0)	0 (0-0)	0 (0-10)	0 (0-0)	0 (0-10)
	Sockeye	0 (0-0)	0 (0-0)	20 (10-30)	10 (0-10)	20 (10-40)
	Total	0 (0-0)	30 (20-30)	280 (220-360)	100 (80-130)	410 (310-520)
6/12/2021	Chinook	680 (460-940)	780 (610-950)	1,510 (1,260-1,770)	300 (250-360)	3,260 (2,860-3,670)
	Chum	20 (0-30)	10 (10-30)	30 (20-50)	10 (0-10)	70 (50-100)
	Sockeye	140 (60-250)	90 (50-130)	100 (70-130)	20 (10-30)	350 (240-460)
	Total	840 (580-1,150)	880 (690-1,060)	1,630 (1,370-1,920)	330 (270-390)	3,680 (3,220-4,150)
6/15/2021	Chinook	2,230 (1,640-2,850)	1,970 (1,600-2,350)	2,170 (1,850-2,480)	450 (390-520)	6,820 (5,970-7,680)
	Chum	130 (50-210)	90 (60-130)	110 (70-170)	20 (10-40)	360 (260-470)
	Sockeye	600 (380-860)	330 (220-440)	390 (300-500)	80 (60-110)	1,400 (1,140-1,700)
	Total	2,960 (2,170-3,750)	2,390 (1,950-2,870)	2,680 (2,290-3,050)	560 (470-640)	8,580 (7,510-9,620)

-continued-

Table 4–(Page 2 of 2).

Opener	Species	Geographic Stratum ¹				Total
		A	B	C	D	
6/19/2021	Chinook	2,070 (1,410-2,860)	1,370 (1,090-1,670)	2,310 (1,890-2,790)	500 (410-620)	6,250 (5,380-7,190)
	Chum	520 (440-920)	210 (150-270)	230 (100-410)	50 (20-90)	1,000 (670-1,410)
	Sockeye	740 (520-1,020)	490 (390-600)	980 (780-1,200)	210 (170-260)	2,430 (2,100-2,770)
	Total	3,330 (2,390-4,450)	2,070 (1,710-2,440)	3,520 (2,910-4,130)	770 (630-910)	9,680 (8,490-11,030)
6/28/2021	Chinook	540 (440-650)	670 (540-800)	1,330 (1,040-1,680)	470 (360-590)	3,010 (2,640-3,390)
	Chum	230 (150-330)	290 (190-410)	330 (220-440)	120 (80-160)	970 (800-1,160)
	Sockeye	1,420 (1,030-1,860)	1,530 (1,240-1,850)	2,950 (2,210-3,800)	1,070 (820-1,350)	6,960 (5,980-8,020)
	Total	2,200 (1,770-2,670)	2,490 (2,110-2,840)	4,600 (3,660-5,760)	1,650 (1,310-2,020)	10,940 (9,750-12,280)
7/2/2021	Chinook	9,460 (260-490)	310 (220-400)	600 (430-800)	60 (40-80)	1,330 (1,100-1,570)
	Chum	430 (220-680)	440 (230-700)	260 (160-360)	30 (20-40)	1,150 (820-1,510)
	Sockeye	2,960 (2,280-2,850)	2,580 (2,110-3,150)	3,130 (2,410-3,900)	310 (240-390)	8,990 (7,790-10,170)
	Total	3,750 (3,000-4,730)	3,320 (2,760-3,940)	3,990 (3,140-4,880)	400 (310-490)	11,460 (10,120-12,880)
7/9/2021	No data					
7/16/2021	Chinook	30 (0-60)	60 (40-80)	140 (90-210)	30 (20-40)	250 (180-330)
	Chum	100 (30-180)	140 (80-210)	360 (190-560)	70 (40-100)	660 (450-880)
	Sockeye	440 (240-640)	700 (510-910)	1,860 (1,360-2,430)	410 (310-520)	3,400 (2,820-4,050)
	Total	560 (300-840)	890 (680-1,150)	2,360 (1,750-3,090)	500 (390-630)	4,320 (3,590-5,120)
Total	Chinook	5,910 (5,040-6,930)	5,230 (4,720-5,780)	8,510 (7,830-9,230)	1,970 (1,790-2,150)	21,630 (20,300-23,000)
	Chum	1,420 (1,040-1,890)	1,190 (930-1,490)	1,330 (1,050-1,630)	290 (230-360)	4,220 (3,590-5,120)
	Sockeye	6,310 (5,380-7,340)	5,720 (5,120-6,430)	9,450 (8,330-10,680)	2,110 (1,840-2,430)	23,600 (22,020-25,340)
	Total	13,640 (12,050-15,360)	12,140 (11,220-13,180)	19,290 (17,720-20,860)	4,380 (3,980-4,800)	49,440 (46,820-52,070)

¹Geographic strata: A = below Johnson River, B = Johnson River to Napaskiak, C = Napaskiak to Akiachak, D = Akiachak to Akiak

Table 5. Salmon harvests from drift gillnets by subsistence opening, species, and geographic stratum in 2021. Numbers within parentheses are 95% confidence limits.

Opener	Species	Geographic Stratum ¹				Total
		A	B	C	D	
6/12/2021	Chinook	670 (460-940)	760 (590-940)	1,410 (1,170-1,660)	280 (230-330)	3,120 (2,750-3,530)
	Chum	20 (10-30)	10 (0-20)	30 (10-40)	0 (0-10)	60 (40-80)
	Sockeye	140 (60-250)	80 (50-130)	80 (60-110)	20 (10-20)	330 (230-440)
	Total	830 (570-1,140)	860 (680-1,040)	1,510 (1,260-1,790)	300 (250-360)	3,500 (3,060-3,970)
6/15/2021	Chinook	2,200 (1,600-2,820)	1,910 (1,550-2,280)	1,870 (1,590-2,160)	370 (310-420)	6,340 (5,560-7,120)
	Chum	120 (50-210)	90 (60-130)	100 (60-150)	20 (10-30)	330 (240-440)
	Sockeye	680 (380-350)	320 (220-440)	360 (270-450)	70 (50-90)	1,350 (1,070-1,650)
	Total	2,920 (2,140-3,700)	2,320 (1,890-2,780)	2,320 (2,010-2,650)	450 (400-520)	8,020 (7,030-8,990)
6/19/2021	Chinook	2,020 (1,360-2,810)	1,330 (1,060-1,640)	2,050 (1,650-2,490)	430 (340-520)	5,830 (4,990-6,760)
	Chum	510 (230-910)	200 (150-270)	180 (70-350)	40 (20-70)	930 (610-1,340)
	Sockeye	720 (500-980)	480 (370-580)	860 (670-1,080)	180 (140-220)	2,240 (1,920-2,580)
	Total	3,250 (2,310-4,370)	2,010 (1,650-2,380)	3,090 (2,520-3,750)	650 (530-770)	8,990 (7,860-10,270)
6/28/2021	Chinook	540 (440-650)	670 (540-800)	1,310 (1,020-1,660)	450 (350-570)	2,980 (2,620-3,360)
	Chum	230 (150-330)	290 (190-410)	330 (220-440)	100 (80-150)	960 (790-1,150)
	Sockeye	1,420 (1,030-1,860)	1,530 (1,240-1,850)	2,890 (2,170-3,750)	1,000 (750-1,260)	6,830 (5,840-7,890)
	Total	2,200 (1,770-2,670)	2,490 (2,110-2,840)	4,530 (3,590-5,640)	1,560 (1,230-1,920)	10,780 (9,580-12,120)
7/2/2021	Chinook	360 (260-490)	310 (220-400)	600 (430-800)	60 (40-80)	1,330 (1,100-1,570)
	Chum	430 (220-680)	440 (230-700)	260 (160-360)	30 (20-40)	1,150 (820-1,510)
	Sockeye	2,960 (2,280-3,850)	2,580 (2,110-3,150)	3,130 (2,410-3,900)	310 (240-390)	8,990 (7,790-10,170)
	Total	3,750 (3,000-4,730)	3,320 (2,760-3,940)	3,990 (3,140-4,880)	400 (310-490)	11,460 (10,120-12,880)

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Table 5-(Page 2 of 2).

Opener	Species	Geographic Stratum¹				Total
		A	B	C	D	
7/9/2021		No data				
7/16/2021	Chinook	30 (0-60)	60 (40-80)	140 (90-210)	30 (20-40)	250 (180-330)
	Chum	100 (30-180)	140 (80-210)	360 (190-560)	70 (30-100)	660 (450-880)
	Sockeye	440 (240-640)	700 (510-910)	1,790 (1,290-2,360)	340 (250-440)	3,260 (2,670-3,900)
	Total	560 (300-940)	890 (680-1,150)	2,290 (1,670-3,010)	430 (320-560)	4,170 (3,430-4,980)
All Openers	Chinook	5,820 (4,940-6,840)	5,030 (4,530-5,570)	7,380 (6,710-8,040)	1,610 (1,450-1,780)	19,840 (18,540-21,180)
	Chum	1,410 (1,030-1,880)	1,170 (910-1,480)	1,240 (980-15630)	260 (210-330)	4,080 (3,510-4,710)
	Sockeye	6,280 (5,360-7,320)	5,690 (5,090-64930)	9,110 (8,000-10,340)	1,910 (1,630-2,210)	22,990 (21,370-24,720)
	Total	13,510 (11,910-15,240)	11,890 (10,960-12,930)	17,730 (16,150-19,410)	3,790 (3,400-4,190)	46,920 (44,380-49,520)

¹Geographic strata: A = below Johnson River, B = Johnson River to Napaskiak, C = Napaskiak to Akiachak, D = Akiachak to Akiak

Table 6. Salmon harvests from set gillnets by subsistence opening, species, and geographic stratum in 2021. Numbers within parentheses are 95% confidence limits.

Opener	Species	Geographic Stratum ¹				Total
		A	B	C	D	
6/2/2021	Chinook	0 (0-0)	0 (0-0)	20 (10-30)	10 (0-10)	30 (10-40)
	Chum	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)
	Sockeye	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)
	Total	0 (0-0)	0 (0-0)	20 (10-30)	10 (0-10)	30 (10-40)
6/5/2021	Chinook	0 (0-0)	70 (20-130)	170 (70-340)	60 (20-120)	300 (120-590)
	Chum	0 (0-0)	0 (0-10)	10 (0-20)	0 (0-10)	10 (0-40)
	Sockeye	0 (0-0)	10 (0-20)	30 (10-50)	10 (0-20)	40 (10-80)
	Total	0 (0-0)	80 (30-150)	200 (90-380)	70 (30-130)	360 (150-660)
6/9/2021	Chinook	0 (0-0)	30 (20-30)	270 (200-340)	90 (70-120)	390 (290-490)
	Chum	0 (0-0)	0 (0-0)	0 (0-10)	0 (0-0)	0 (0-10)
	Sockeye	0 (0-0)	0 (0-0)	20 (10-30)	10 (0-10)	20 (10-40)
	Total	0 (0-0)	30 (20-30)	280 (220-360)	100 (80-130)	410 (310-520)
6/12/2021	Chinook	10 (0-10)	20 (0-30)	100 (30-190)	20 (10-40)	140 (50-270)
	Chum	0 (0-0)	0 (0-0)	10 (0-20)	0 (0-0)	10 (0-20)
	Sockeye	0 (0-0)	0 (0-0)	10 (0-30)	0 (0-10)	20 (0-40)
	Total	10 (0-10)	20 (10-40)	120 (40-220)	30 (10-50)	170 (60-320)
6/15/2021	Chinook	30 (10-40)	60 (30-90)	310 (140-470)	90 (40-130)	480 (230-230)
	Chum	0 (0-0)	0 (0-10)	20 (0-40)	0 (0-10)	30 (0-70)
	Sockeye	0 (0-10)	10 (0-10)	40 (0-80)	10 (0-20)	60 (0-120)
	Total	30 (20-60)	70 (30-110)	360 (150-580)	100 (40-160)	560 (240-910)

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Table 6-(Page 2 of 2).

Opener	Species	Geographic Stratum¹				Total
		A	B	C	D	
6/19/2021	Chinook	50 (20-80)	40 (20-60)	260 (130-430)	70 (40-120)	420 (220-700)
	Chum	10 (0-20)	10 (0-10)	50 (10-90)	10 (0-30)	80 (10-150)
	Sockeye	20 (10-40)	20 (10-30)	120 (60-190)	30 (20-60)	190 (90-310)
	Total	80 (40-120)	60 (30-90)	430 (230-640)	120 (70-180)	690 (380-1,040)
	6/28/2021	Chinook	0 (0-0)	0 (0-0)	10 (0-30)	20 (0-40)
	Chum	0 (0-0)	0 (0-0)	0 (0-10)	0 (0-10)	10 (0-20)
	Sockeye	0 (0-0)	0 (0-0)	60 (10-140)	70 (10-180)	130 (20-320)
	Total	0 (0-0)	0 (0-0)	70 (10-180)	90 (20-220)	160 (30-400)
7/2/2021	Insufficient data					
7/9/2021	No data					
7/16/2021	Chinook	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)
	Chum	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-10)
	Sockeye	0 (0-0)	0 (0-0)	70 (40-110)	70 (40-110)	140 (90-210)
	Total	0 (0-0)	0 (0-0)	70 (50-110)	70 (50-110)	150 (90-220)
	All Openers	Chinook	90 (60-120)	200 (140-280)	1,130 (860-1,420)	360 (280-450)
	Chum	10 (0-20)	10 (0-20)	90 (30-140)	30 (10-50)	140 (50-230)
	Sockeye	30 (20-40)	40 (20-50)	340 (240-440)	200 (130-320)	600 (430-820)
	Total	130 (80-170)	260 (180-340)	1,550 (1,210-1,890)	590 (480-720)	2,530 (1,980-3,080)

¹Geographic strata: A = below Johnson River, B = Johnson River to Napaskiak, C = Napaskiak to Akiachak, D = Akiachak to Akiak

Table 7. Key harvest characteristics of 12-hour openers on June 12 in all years where inseason harvest was rigorously monitored. These numbers correspond only to the mainstem Kuskokwim River between and including the villages of Tuntutuliak and Akiak.

	2016	2017	2018	2019	2020	2021	Average
Drift Effort	524	523	466	446	406	383	458
Total salmon Harvest	5,100	5,420	6,500	8,650	3,820	3,680	5,528
Total salmon/Boat	9.7	10.4	13.9	19.4	9.4	9.6	12.1
Chinook Harvest	4,290	2,240	4,590	8,040	3,240	3,260	4,277
Chinook/Boat	8.2	4.3	9.8	18.0	8.0	8.5	9.5
Chum/Sockeye Harvest	810	3,180	1,910	600	590	420	1,252
Chum/Sockeye/Boat	1.5	6.1	4.1	1.3	1.5	1.1	2.6
Species Ratio	0.2	1.4	0.4	0.1	0.2	0.1	0.4

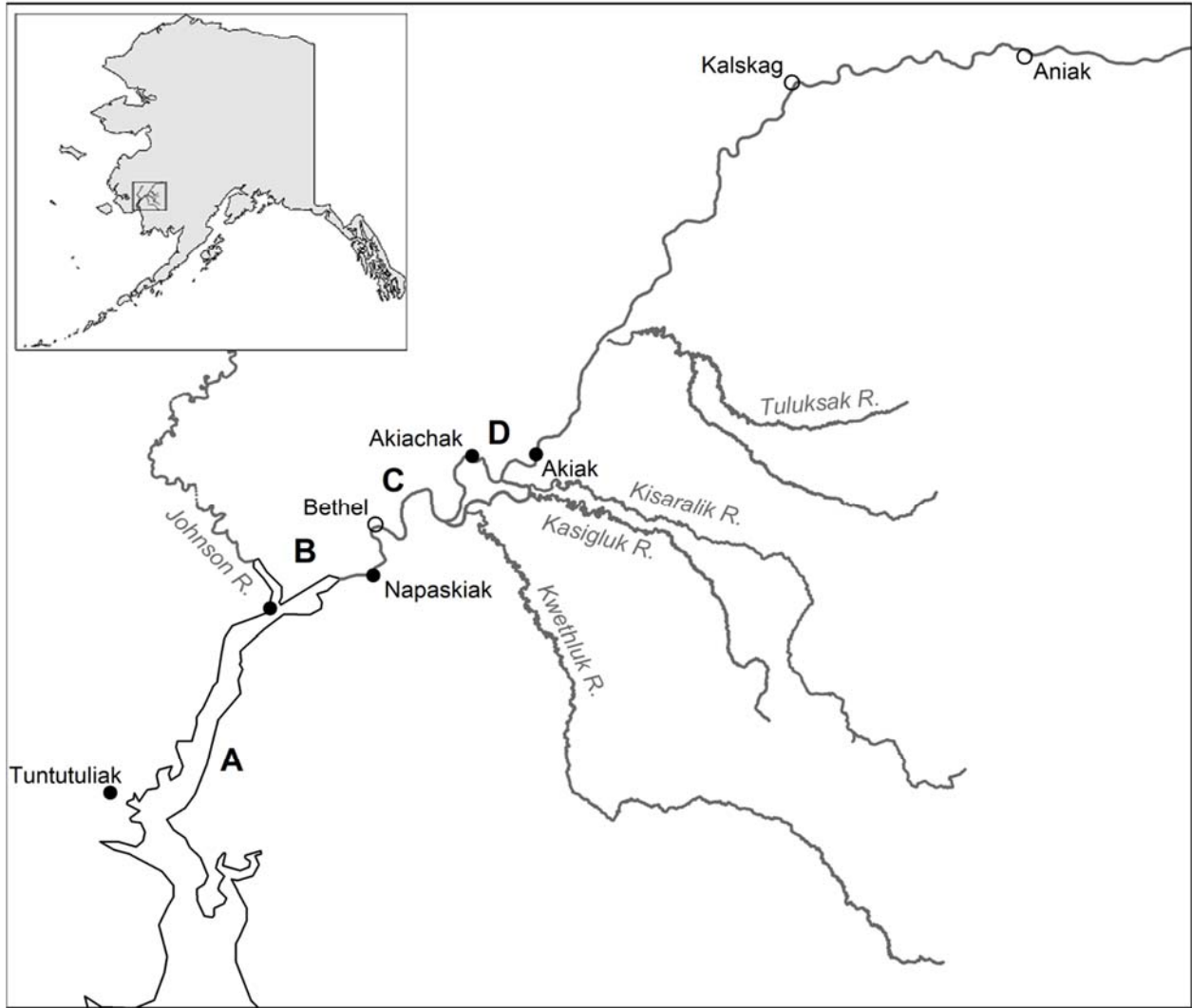


Figure 1. Map of the Yukon Delta National Wildlife Refuge waters that compose the survey area with geographic strata noted (A – D). Solid circles indicate strata boundaries; hollow circles indicate other points of interest.

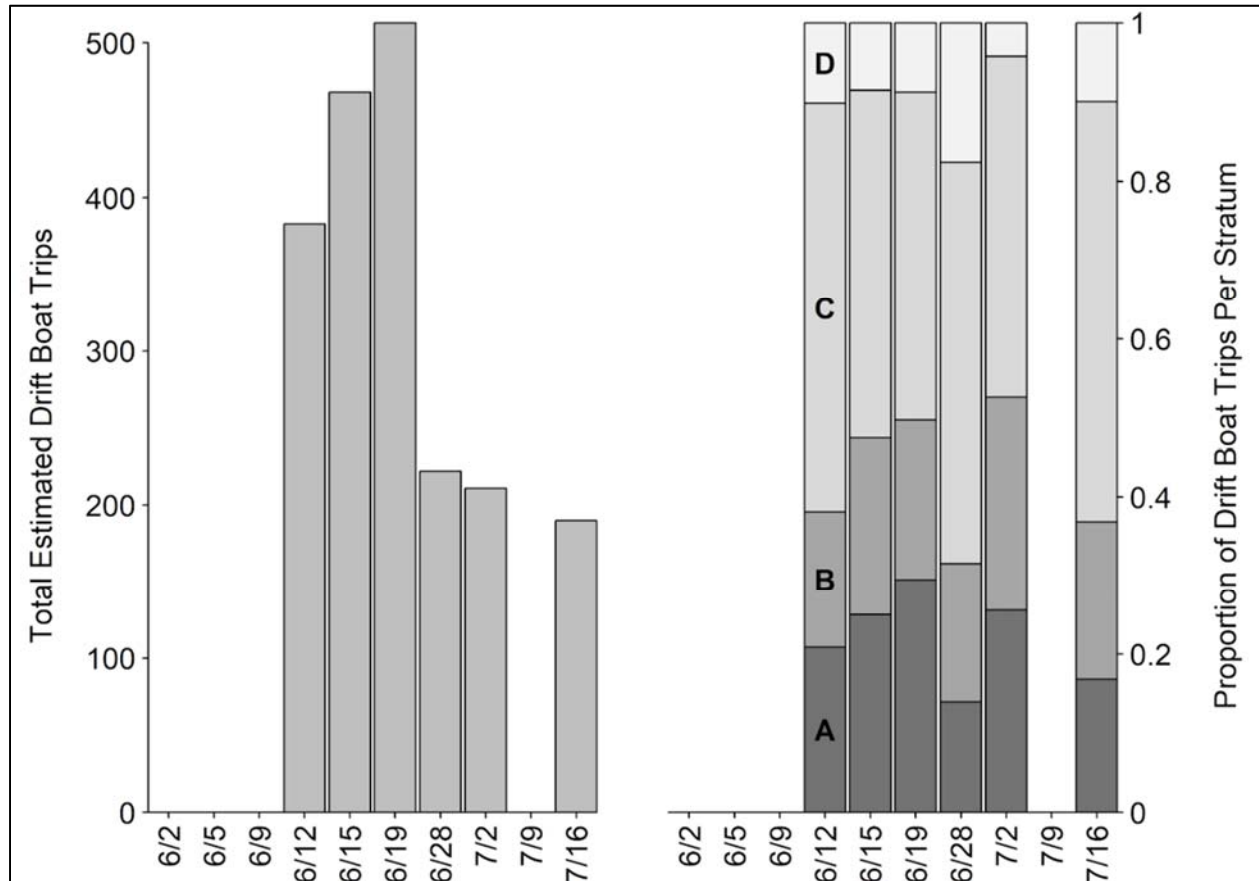


Figure 2. *Left:* Total estimated drift boat trips by opener. *Right:* the proportion of all estimated trips that occurred in each geographic stratum by opener. *Note:* Opportunities before June 12 were for set gillnets only. Drift net effort is not shown for 7/9/21 due to flight cancellation for weather. The 7/10/21 - 7/11/21 and 7/17/21 - 7/18/21 openers are not included due to being set gillnet opportunities and no data were collected. Geographic strata are: A = below Johnson River, B = Johnson River to Napaskiak, C = Napaskiak to Akiachak, and D = Akiachak to Akiak

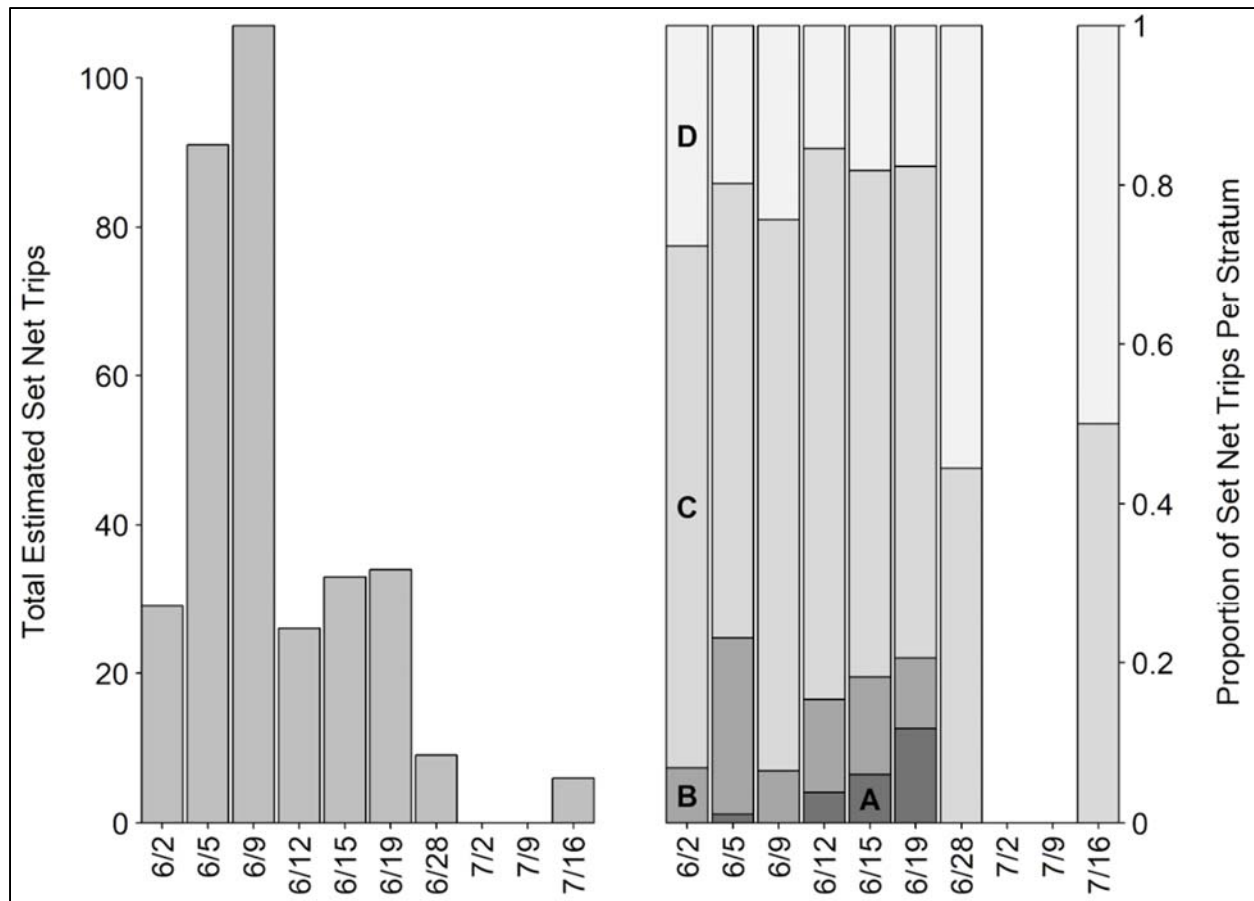


Figure 3. *Left:* Total estimated set net trips by opener. *Right:* The proportion of all estimated set net trips that occurred in each geographic stratum¹ by opener. Set net effort is not shown for 7/9/21 due to insufficient data. Set net effort is not shown for 7/9/21 due to flight cancellation for weather. The 7/10/21 - 7/11/21 and 7/17/21 - 7/18/21 openers are not included due to no data collection. Geographic strata are: A = below Johnson River, B = Johnson River to Napaskiak, C = Napaskiak to Akiachak, and D = Akiachak to Akiak.

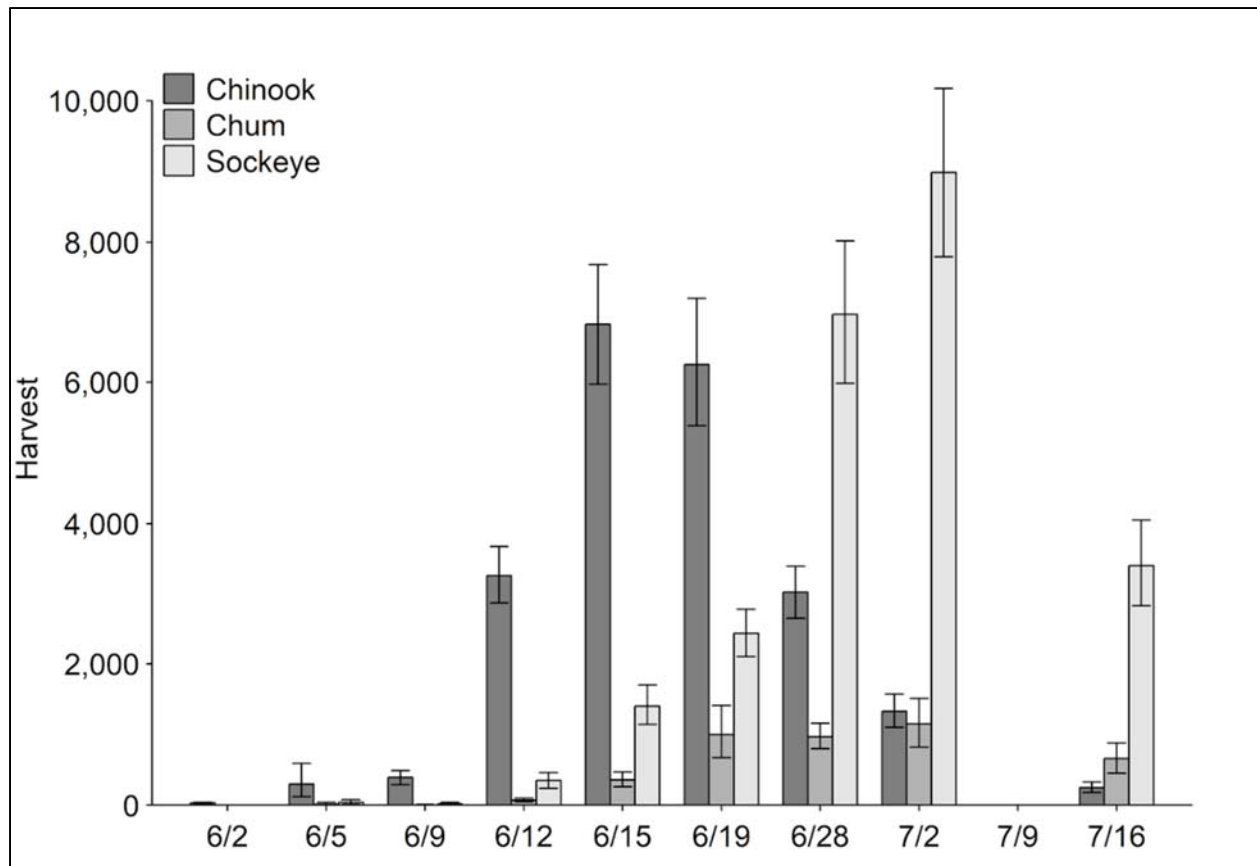


Figure 4. Estimated salmon harvest by species in the openers where data were collected. Estimates include harvest from both drift nets (when available) and set nets. This figure does not show data for 7/9/21 due to flight cancellation which resulted in no harvest estimate produced. The 7/10 - 7/11 and 7/17 - 7/18 openers are not included as no data were collected.

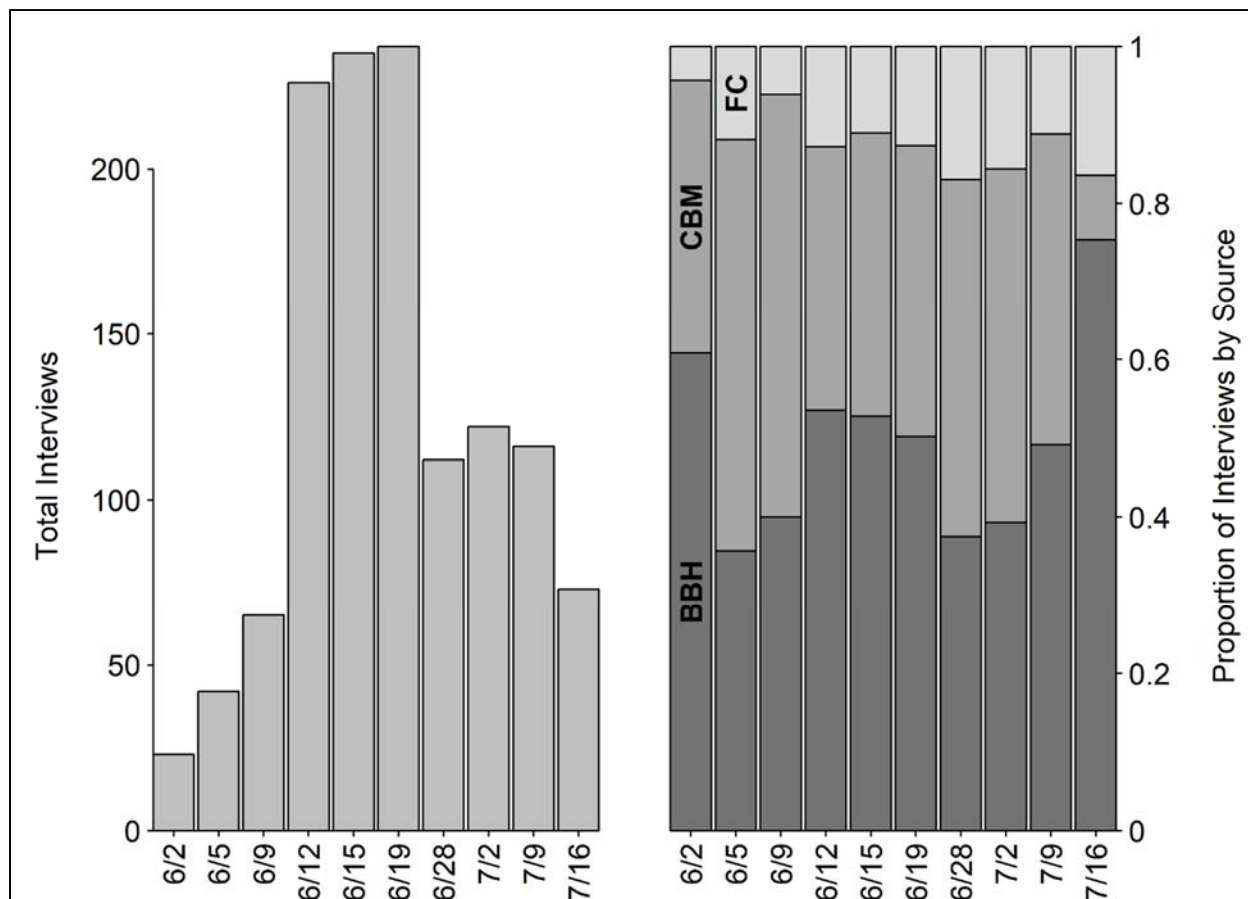


Figure 5. *Left:* Total number of interviews used to inform the harvest estimates from each opener. *Right:* The proportion of all interviews that came from each source by opener. Data sources were: BBH = Bethel boat harbor (ONC), FC = Bethel area fish camps (ONC), and CBM = community-based monitoring (KRITFC)

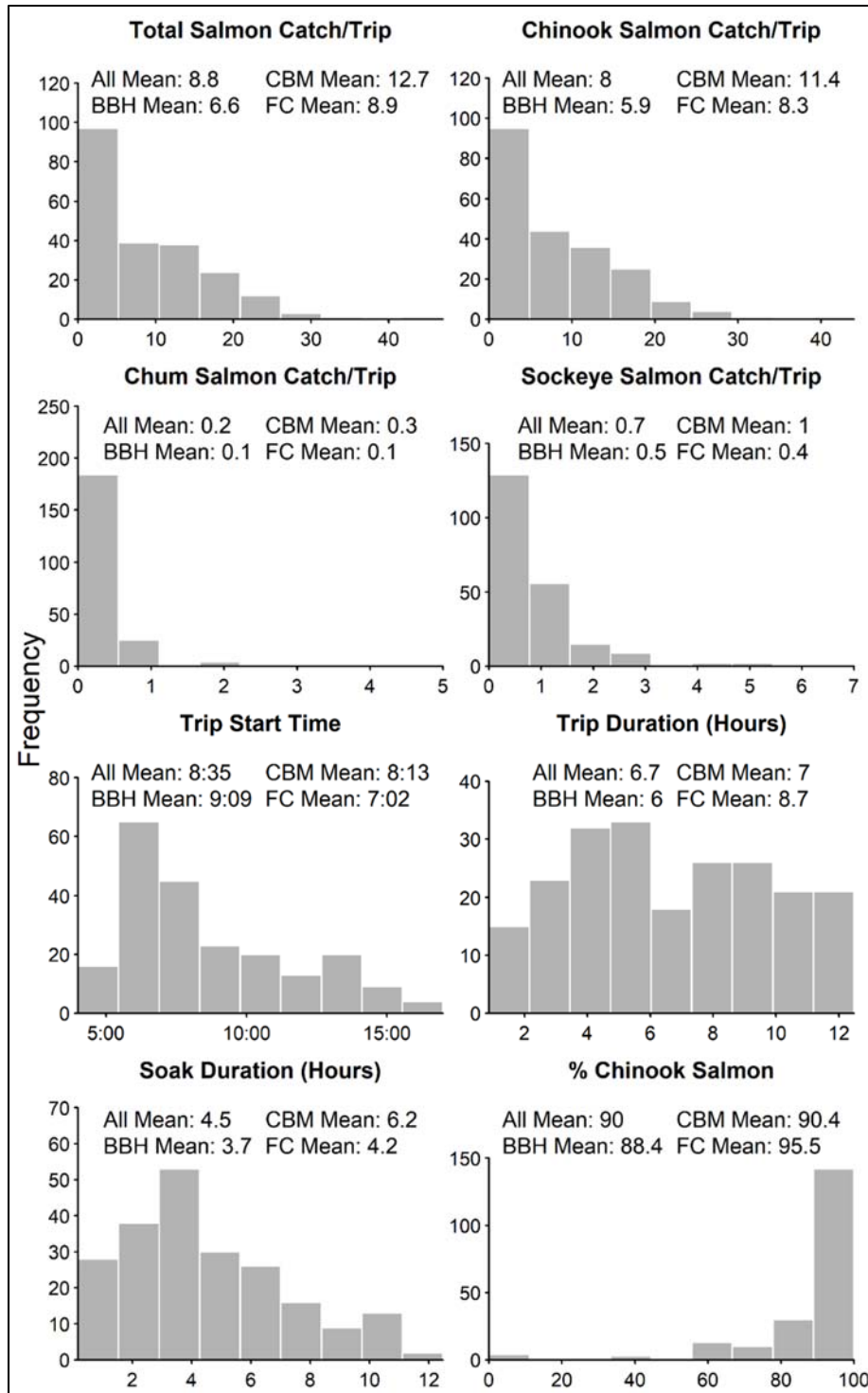


Figure 6. Distribution of relevant quantities from completed drift boat trip interviews during the first drift gillnet opener (6/12/2021), with means for all available interviews and by data source. Data sources were: BBH = Bethel boat harbor (ONC), FC = Bethel area fish camps (ONC), and CBM = community-based monitoring (KRITFC).

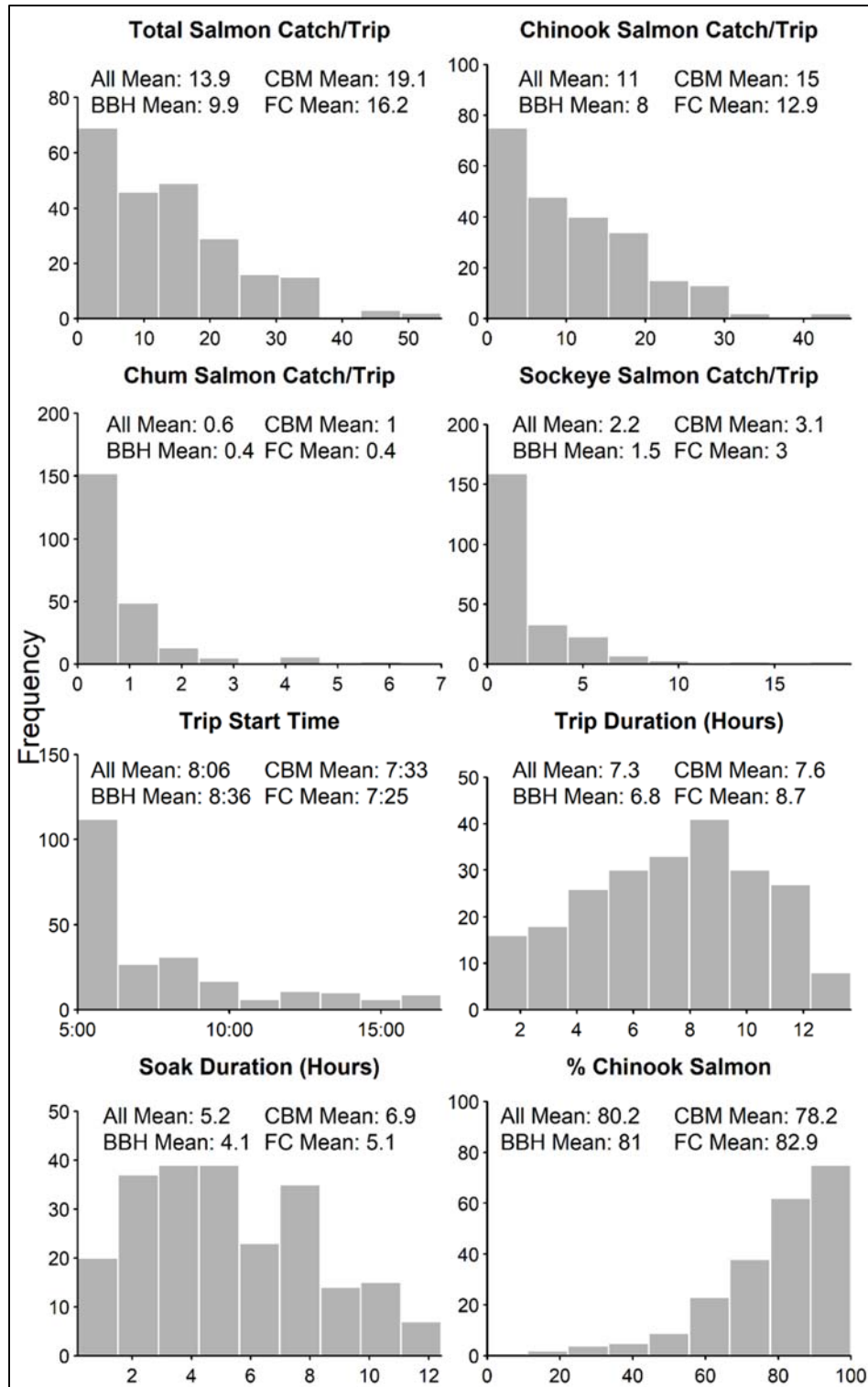


Figure 7. Distribution of relevant quantities from completed drift boat trip interviews during the second drift gillnet opener (6/15/2021), with means for all available interviews and by data source. Data sources were: BBH = Bethel boat harbor (ONC), FC = Bethel area fish camps (ONC), and CBM = community-based monitoring (KRITFC).

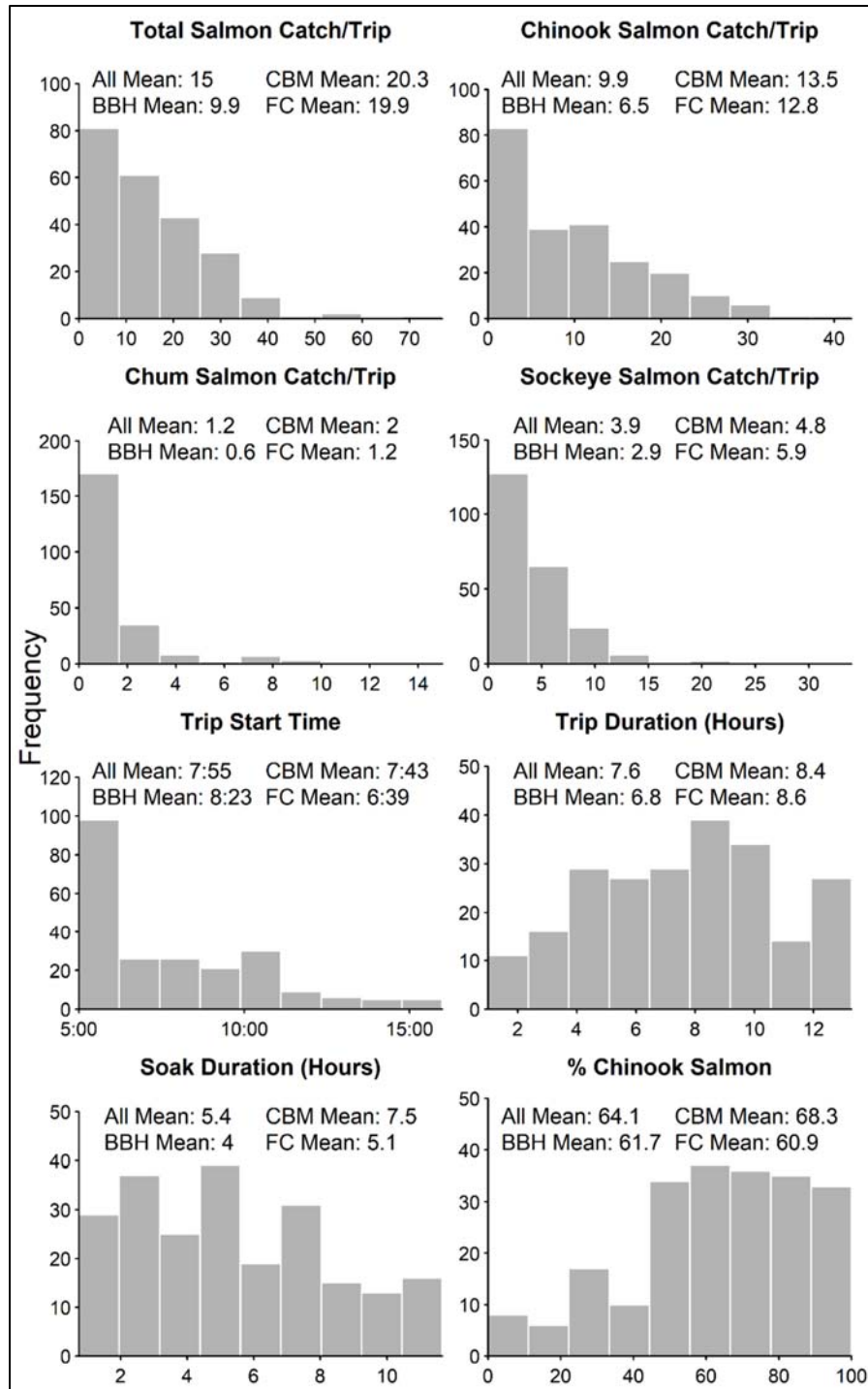


Figure 8. Distribution of relevant quantities from completed drift boat trip interviews during the third drift gillnet opener (6/19/2021), with means for all available interviews and by data source. Data sources were: BBH = Bethel boat harbor (ONC), FC = Bethel area fish camps (ONC), and CBM = community-based monitoring (KRITFC).

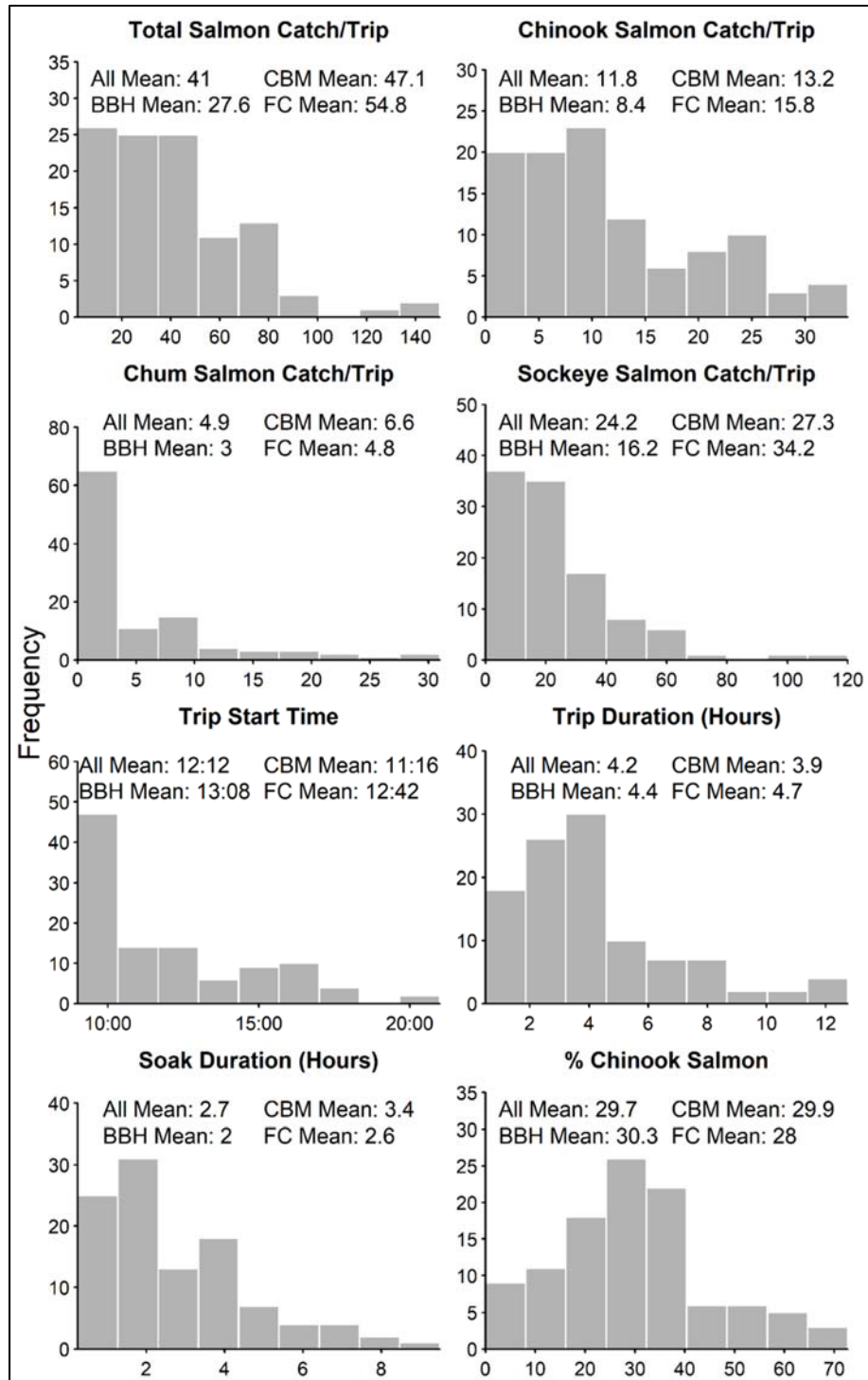


Figure 9. Distribution of relevant quantities from completed drift boat trip interviews during the fourth drift gillnet opener (6/28/2021), with means for all available interviews and by data source. Data sources were: BBH = Bethel boat harbor (ONC), FC = Bethel area fish camps (ONC), and CBM = community-based monitoring (KRITFC).

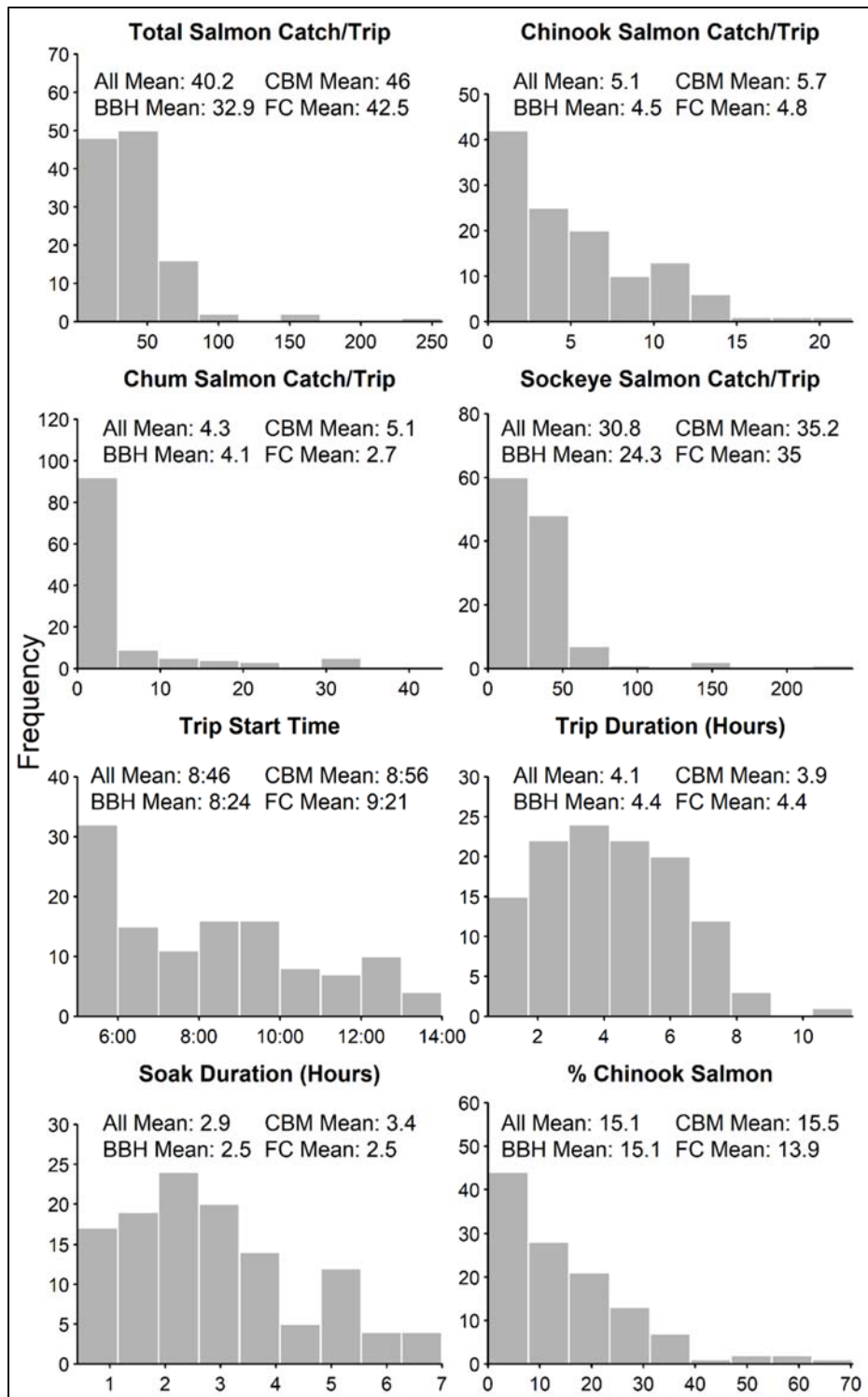


Figure 10. Distribution of relevant quantities from completed drift boat trip interviews during the fifth drift gillnet opener (7/2/2021), with means for all available interviews and by data source. Data sources were: BBH = Bethel boat harbor (ONC), FC = Bethel area fish camps (ONC), and CBM = community-based monitoring (KRITFC).

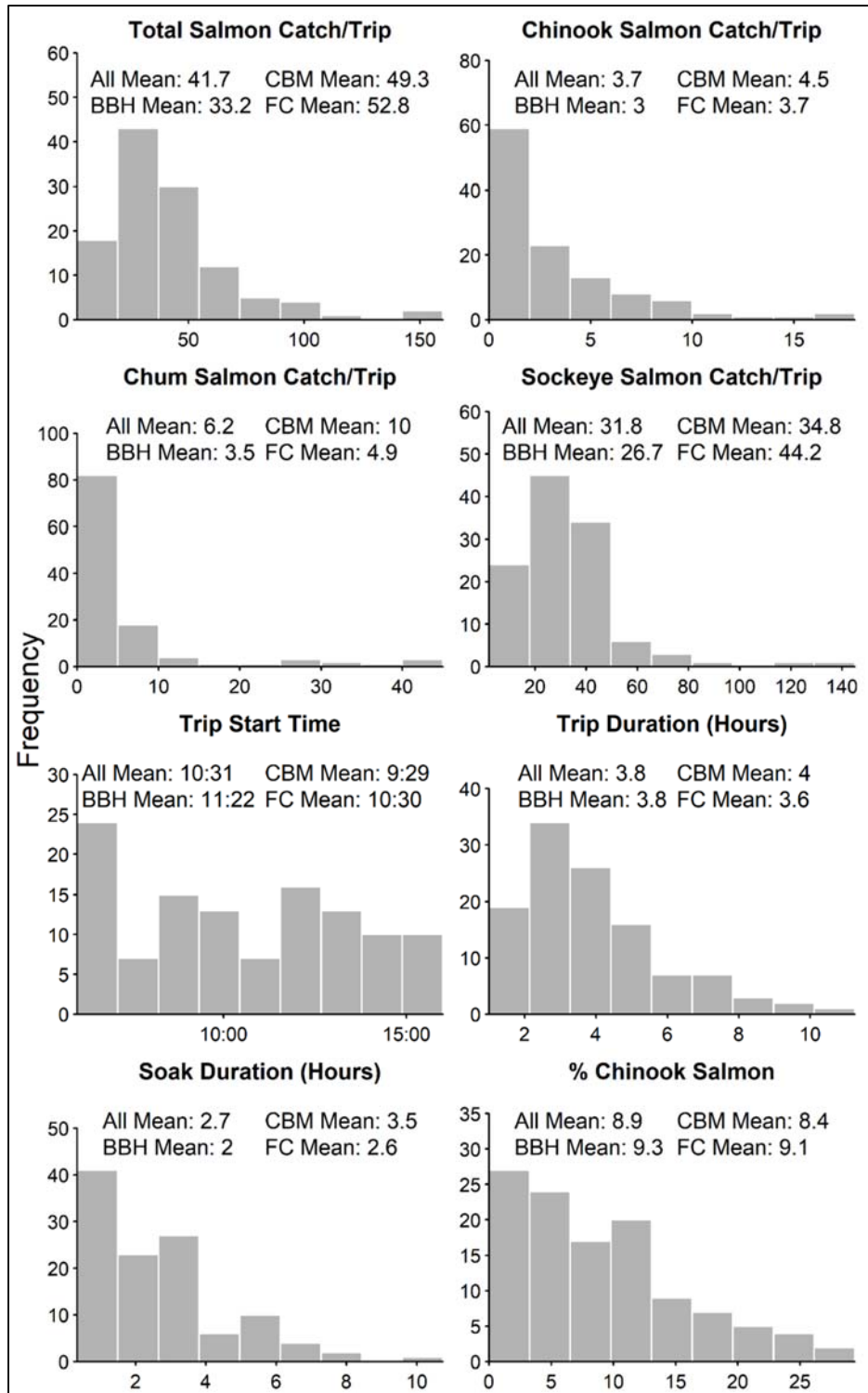


Figure 11. Distribution of relevant quantities from completed drift boat trip interviews during the fifth drift gillnet opener (7/9/2021), with means for all available interviews and by data source. Data sources were: BBH = Bethel boat harbor (ONC), FC = Bethel area fish camps (ONC), and CBM = community-based monitoring (KRITFC).

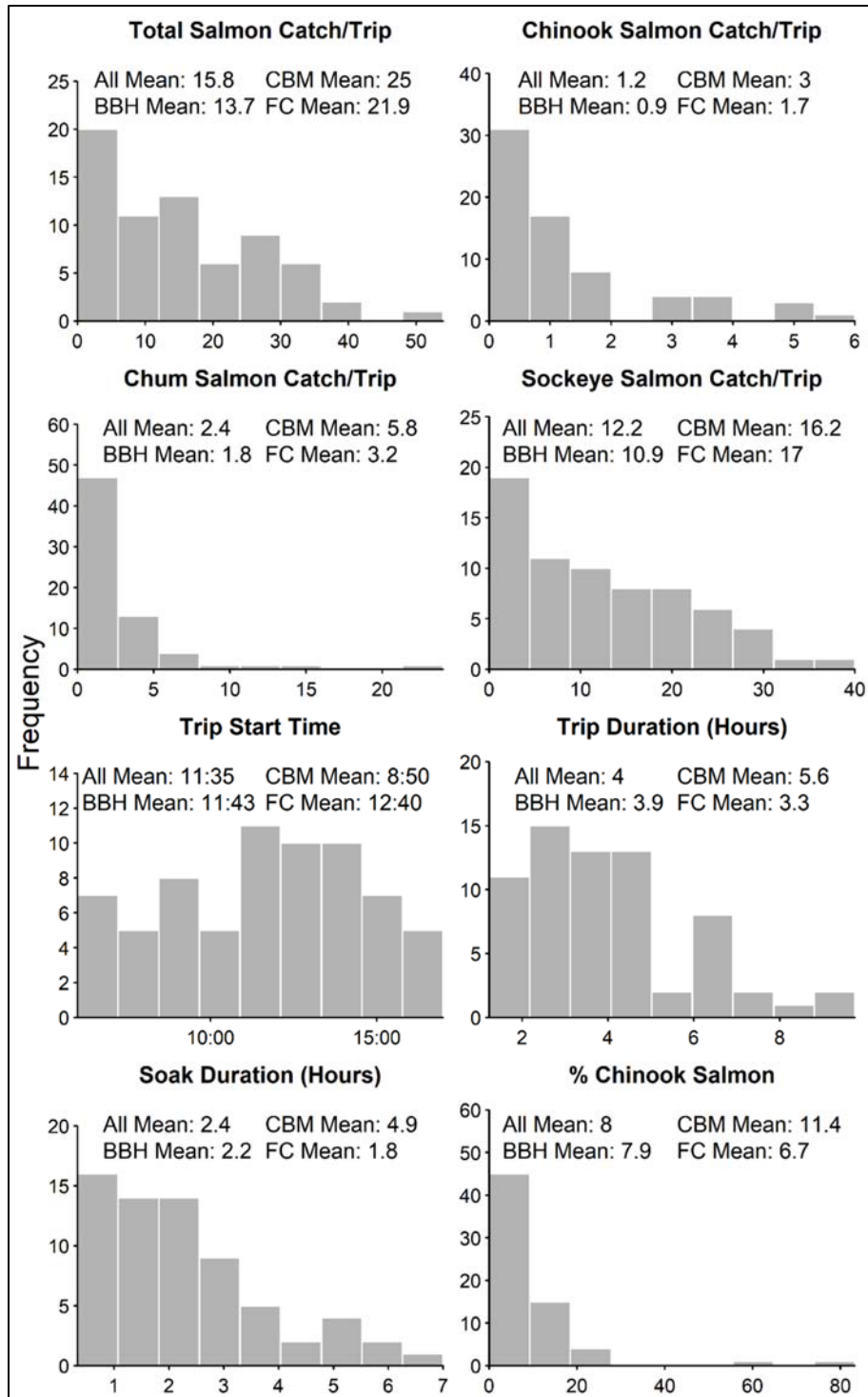


Figure 12. Distribution of relevant quantities from completed drift boat trip interviews during the sixth drift gillnet opener (7/16/2021), with means for all available interviews and by data source. Data sources were: BBH = Bethel boat harbor (ONC), FC = Bethel area fish camps (ONC), and CBM = community-based monitoring (KRITFC).

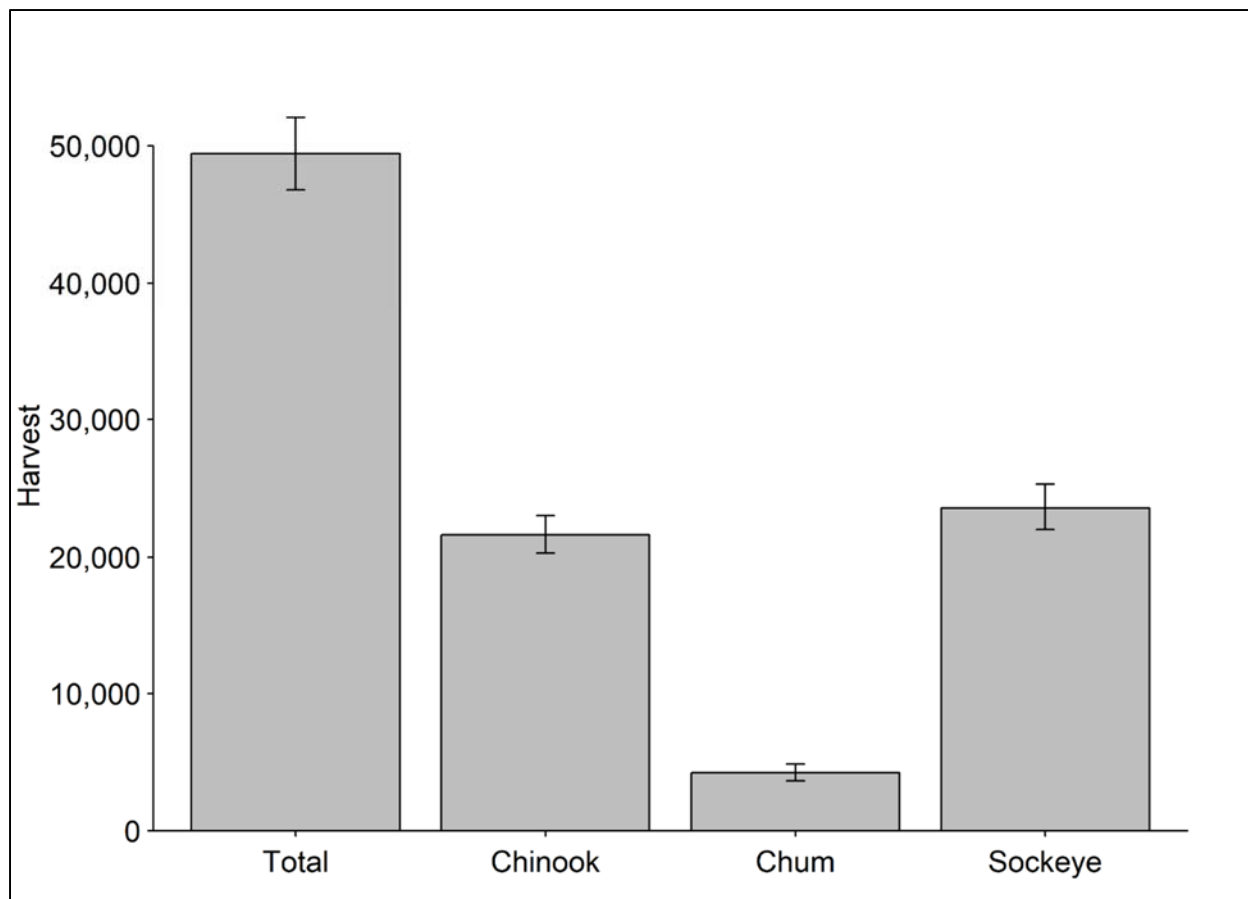


Figure 13. Total salmon harvest by species across all the nine openers for which harvest estimates were produced (all openers except 7/9/21, 7/10/21, and 7/17/21) combined between drift nets and set nets.

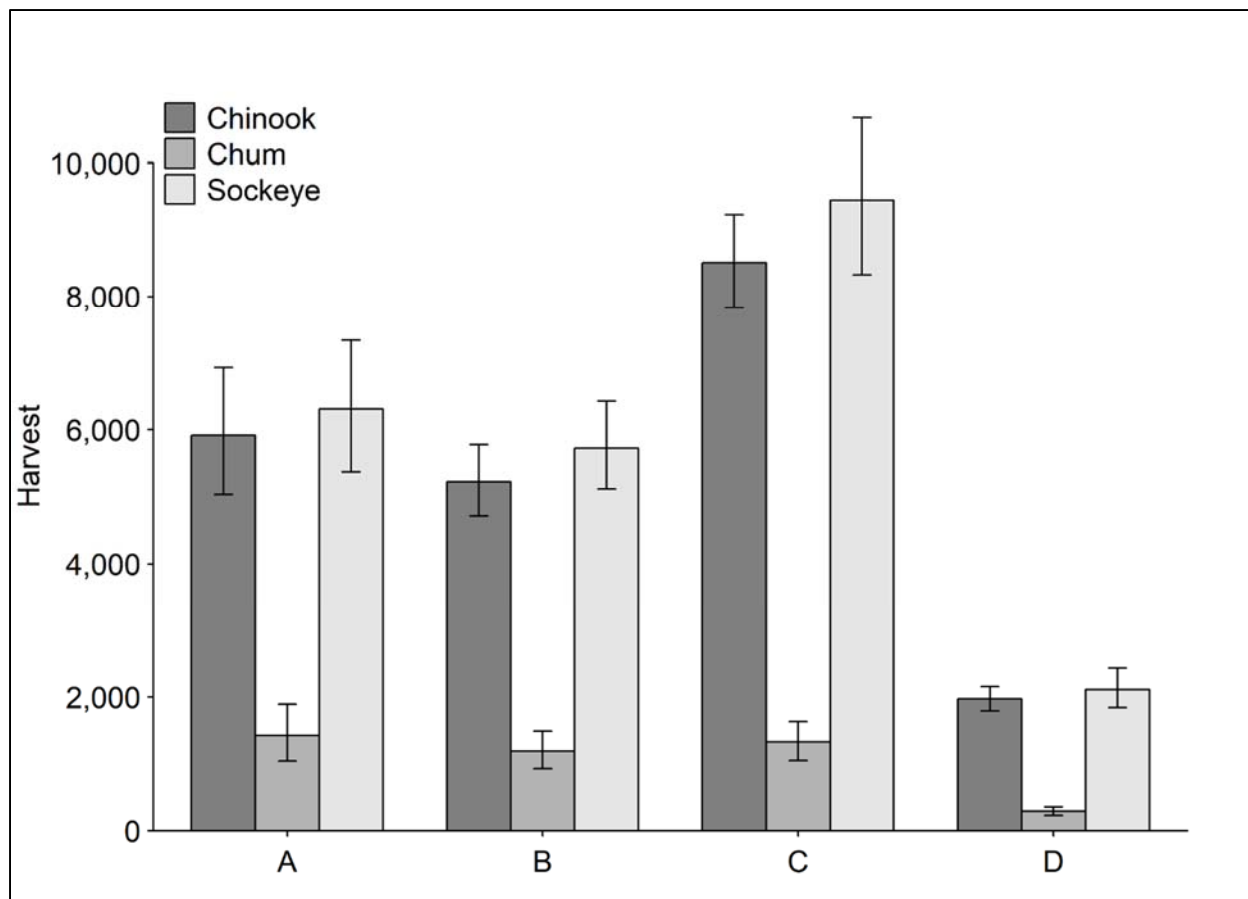


Figure 14. Total estimated salmon harvest by species and geographic stratum across all nine openers for which harvest estimates were produced (all openers except 7/9/21, 7/10/21, and 7/17/21) combined between drift nets and set nets. Geographic strata are: A = below Johnson River, B = Johnson River to Napaskiak, C = Napaskiak to Akiachak, and D = Akiachak to Akiak.