

Alaskan Harvest of BC Salmon: State of Knowledge

Part 5: Chum Salmon

Version 1

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Preface

This report is part of a series of reports on the ‘State of Knowledge’ of Alaskan interception of south migrating BC salmon. This report series is a summary of existing information that was compiled from a number of sources. We also provide information on 2021 catch in Southern Southeast Alaska. The intent of this report series is to promote discussion, identify knowledge gaps, attempt to collect, and make available, all relevant data, and provide recommendations to improve our understanding of Alaskan interceptions of Canadian salmon. To that end, we encourage feedback and discussion on the content, and welcome additional information that we may have missed. As such, it should be considered a ‘living document’. Future versions will include clarifications, edits, and likely additional content. Changes will be tracked and recorded for transparency and collaborative purposes. Please reach out to either of the authors for further information or to provide feedback or additional content.

To complete this ‘State of Knowledge’ report series, we procured, compiled, and surveyed data from numerous sources (e.g., Pacific Salmon Commission website and reports, Fisheries and Oceans Canada, Alaska Department of Fish and Game, Pacific Salmon Foundation, LGL Limited). Estimates of Alaskan capture of BC salmon were from multiple sources and required an extensive effort to compile, including numerous discussions with staff from DFO (NC, WCVI, ECVI, ISC and Fraser regions), LGL Limited, the Pacific Salmon Commission, the Pacific Salmon Foundation, and Alaska Department of Fish and Game.

The objectives of the reports in this series were to:

1. Identify and compile data sources on Southeast Alaska (SEAK) catch of BC salmon, with a focus on South Southeast Alaska (SSEAK);
2. Summarize information on recent and historical SSEAK catch at the regional, stock aggregate, DFO Statistical Area and Conservation Unit (CU) level where possible, including proportions of SEAK catch;
3. Provide details on information specific to District 104 fisheries (Noyes and Dall Island), where possible;
4. Provide context and/or estimates for SSEAK catch of BC salmon in the 2021 fishing season;
5. Identify gaps in knowledge and provide high-level recommendations to stimulate discussion.

While we limited our review and summary to SSEAK salmon fisheries, we do include other areas and fisheries where information was available.

The following points should be considered for context when reading this report series:

- Many of the populations of Canadian salmon that are caught in SSEAK are at depressed or extremely depressed levels of abundance (e.g., North and Central Coast BC chum, some Fraser sockeye Conservation Units (CUs) and have had few, or severely curtailed, Canadian fisheries in recent years.
- There are numerous assumptions and uncertainties in much of the information presented here that simply could not be detailed fully; however, we have tried to identify reference materials and resources that may provide further details should the reader be interested.
- Some of the information presented is based on studies that were completed 35+ years ago.
- There have been recent shifts in terminal run-timing that may influence where and when salmon are present in SSEAK fisheries.

- Climate change and associated marine conditions (e.g., sea surface temperatures, marine heat waves) may be influencing migration routes and migration timing relative to the tagging studies completed in the early 1980's that are used to underpin many of the migration and run-timing assumptions currently employed.
- The effects of climate change in freshwater and marine environments are compounded by natural and human-caused landscape change. These marine and freshwater ecosystem changes are impacting Pacific salmon at every stage of their life-cycle. The changing conditions already observed likely will continue, and possibly accelerate, warranting expanded efforts to understand and address uncertainties in exploitation in both SSEAK and BC.

The Report Series includes:

- Summary
- Part 1: Southeast Alaska Harvest and Pink Salmon Escapement
- Part 2: Southeast Alaskan Harvest of BC Sockeye Salmon
- Part 3: Southeast Alaskan Harvest of BC Chinook Salmon
- Part 4: Southeast Alaskan Harvest of BC Coho Salmon
- Part 5: Southeast Alaskan Harvest of BC Chum Salmon
- Part 6: Southeast Alaskan Harvest of BC Pink Salmon
- Part 7: Southeast Alaskan Harvest of BC Steelhead Trout

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Glossary

ADFG: Alaska Department of Fish and Game.

Bycatch: Catch of a species that is not targeted.

CC: Central Coast (DFO Statistical Management Areas 7-10).

Conservation Unit: A CU is a group of wild salmon sufficiently isolated from other groups that, if extirpated is very unlikely to recolonize naturally within an acceptable timeframe, such as a human lifetime or a specified number of salmon generations.

CWT: Coded Wire Tag. Passive tags implanted in juvenile salmon that are used to identify where and when fish were either released (hatcheries) or tagged (wild systems).

DFO: Department of Fisheries and Oceans.

District: Refers to Alaskan fisheries management areas.

ECVI: East Coast Vancouver Island (Vancouver Island sections of DFO Statistical Management Areas 11-19, 28)

Encounters: All the fish (kept/retained + released) that are encountered in a fishery. Estimates of encounters may include estimates of drop-off (fish that are on/in gear but escape before they are brought on board).

Escapement: Escapement refers to the number of spawners that return to a stream/area/system (fish that have escaped being captured in fisheries). Inter-changeable in this report with spawners or spawner abundance.

Exploitation Rate: Exploitation rate is the amount of catch as a proportion of the total run. We try to present all data in this report as exploitation rates.

FSC: First Nations Section 35(1) Food, Social, and Ceremonial use harvest.

Fraser: Fraser River (DFO Statistical Management Area 29).

FRIM (Fisheries Related Incidental Mortality): FRIM accounts for mortality that occurs prior to capture (e.g., depredation and drop-out mortality), during handling (i.e., on-board mortality), and after release (i.e., post-release mortality). It is added to kept/retained catch/mortalities to estimate total fishing-related mortalities.

Harvest Rate: Harvest rate refers to the proportion of fish caught versus those available to be caught. E.g., for Skeena sockeye, the harvest rate in the marine commercial fishery is the catch divided by the Total Return to Canada, not the Total Run.

ISC: Inner South Coast Areas (Mainland BC sections of DFO Statistical Areas 11-18, 28)

Kept: Fish that are kept in fisheries. Also retained catch.

NC: North Coast (DFO Statistical Management Areas 1-6).

Released: Fish that are caught and then released (live or dead) from a fishery.

Retained: Fish that are kept in fisheries. Also kept catch.

Statistical Area: Refers to DFO Pacific Fisheries Management Areas, or Statistical Area. Haida Gwaii is areas 1 and 2, Nass is area 3, Skeena is area 4, Central Coast is areas 6-10, Johnstone Strait and Strait of Georgia is areas 11-18, Juan de Fuca is areas 19-20, West Coast Vancouver Island is areas 21-27, Howe Sound is area 28, and the Fraser River is area 29.

Total Mortalities: Total mortality includes all natural and fishing-related causes. The latter is composed of retained catch, plus any incidental mortalities associated with fishing activities.

Total Run: Total run (or total abundance) refers to the total return of fish in a given year (total catch + escapement).

WCVI: West Coast Vancouver Island (DFO Statistical Management Areas 20-27).

1 Introduction and Methods

Information on SEAK catch of BC chum salmon was compiled from a very limited number of sources including the Pacific Salmon Foundation Salmon Explorer and LGL Limited. We drew predominantly on the Pacific Salmon Explorer for Conservation Unit level data (PSF 2021) and LGL’s North and Central Coast Run Reconstruction website for Statistical Area level data (LGL 2021). Background on the methodology for estimating SEAK catch of Area 3, 4 and 5 chum salmon is provided in Challenger et al. (2018) and English et al. (2018). Pink salmon exploitation rates for SEAK are used to estimate chum exploitation rates for Areas 3, 4 and 5. As such, many additional details on methodology and background on pink salmon estimates are contained in Part 6: Pink Salmon of this report series. Other than these data sources, we were unable to identify any information on BC chum salmon stock contributions to SEAK fisheries, or any information for SEAK catch of chum salmon originating outside of BC north coast Areas 3,4 and 5. This includes Fraser and other south-migrating pink salmon (e.g., Strait of Georgia, Central Coast, WCVI).

We provide some background information on SEAK and SSEAK harvest of chum salmon historically and in 2021, as well as information on catch information and timing of catch in District 104. SEAK exploitation rates and proportion of total catch are summarised for BC Areas 3, 4, and 5, along with associated Conservation Units.

Table 1 provides a summary of the types of data used, the data source and the years the data covers. Figure 1 and Figure 2 provide maps of Southeast Alaska fishing Districts and North Coast BC DFO Statistical Areas respectively.

All figures and statistical analyses were completed using R statistical software (R core team 2020).

Table 1: Types of data, sources, and year range used in this report for chum salmon by region.

| <i>Species</i> | <i>Region/Area</i> | <i>Type of Data</i> | <i>Data Source</i> | <i>Year</i> |
|--------------------|---|---|--|-------------|
| <i>Chum salmon</i> | BC NC/CC Areas 1-10, by Statistical Area | Escapement, harvest and exploitation rates from run reconstructions | LGL 2021 (North and Central Coast Run Reconstructions) | Various |
| | BC NC/CC Areas 1-10, by Conservation Unit | Escapement, harvest and exploitation rates from run reconstructions | PSF 2021 (Pacific Salmon Explorer) | Various |
| | WCVI | Data deficient | | |
| | Fraser | Data deficient | | |
| | Strait of Georgia | Data deficient | | |

2 SEAK Harvest

Summary information on chum salmon harvest in SEAK (historically and for 2021) is provided in this report for context. SEAK catch and value (1979-2020) were downloaded from the ADFG website (ADFG 2021a). “Blue Sheet” commercial data from 1980-2020 were provided by ADFG (ADFG 2021b). Preliminary chum salmon harvest information for commercial SEAK harvest in 2021 by fishery type (“Blue Sheet Data”) was downloaded from the ADFG website (ADFG 2021c). District and gear level

catch data from 1985-2020 and weekly District 104 catch by gear were also provided by ADFG (2021d and 2021e respectively).

- Total chum salmon catch in SEAK between 1979 and 2021 ramped up in the early 90s following investments in large scale enhancement in Alaska, has averaged nearly 10 million since (Figure 3). Since 2010, catches have averaged just under ~ 10 million chum per year. Total SEAK catch of chum in 2021 was over 7 million chum, below the recent and long-term averages.
- Chum salmon catch is divided between a number of fisheries (Figure 4). Most chum salmon (~ 60%) are caught in terminal hatchery fisheries, however, a large number are also caught in northern and southern (~13.5%) purse seine fisheries. Median catch from 1979-2021 in the southern purse seine fisheries is just over 1 million.
- Median total catch (all gears) of chum salmon in SSEAK Districts 101-106 shows that chum catch is highest in District 101, followed by Districts 102, 104 and 106. District 101 contributes about 44% over the entire time series, with Districts 102 (29%) and 104 (12%) contributing smaller catches on average (Figure 5).
- Total catches (all gears) in District 101 is highly variable has declined and since 2000 has ranged from ~ 100,000 to nearly 2 million (Figure 6). The last few years have seen relatively low catches. The District 104 fishery has remained relatively constant and low since the 2000s.
- The proportion of total District 101-106 catch of chum salmon for each district over time is shown in Figure 7. The proportion of chum salmon caught in District 101 has declined over time, and has been between 25% and 50% since 2000. District 102 catch proportion has increased over the same time period and also ranges between 25 and 50%. District 104 proportion of catch has remained low (< 25%) in most years.
- In 2021, total SEAK catch of chum salmon (including Yakutat) was over 7 million. SSEAK Districts 101-106 accounted for only about 1.2 million of that. As in most years, most catch was taken in terminal hatchery fisheries or cost recovery programs (~ 61%) with just over 1 million caught in southern seine fisheries and almost 600,000 in summer troll fisheries (Figure 8).
- District 104 only catch of chum salmon in seine fisheries in 2021 was ~217,000, with only 467 fish reported from power trolls. Weekly catch in purse seine fisheries was highest in Week 31 and 32 (Figure 9). 2021 data is preliminary.
- There are no hatchery release sites or cost recovery fisheries in District 104.
- We were unable to find information on the proportions of wild and hatchery chum salmon catch in District 104.

3 SEAK Catch of BC Origin Salmon

This section of the report provides a summary of the limited information on SSEAK exploitation rates on BC chum salmon that we could identify, as well as proportions of SSEAK exploitation by Statistical Area and Conservation Unit for Areas 3, 4 and 5.

It is important to note that these exploitation rate estimates for Area 3, 4 and 5 chum are based on historical tagging studies on pink salmon in transboundary fisheries in 1982, 84 and 85 and reconstruction methods detailed in Gazey and English (2000). Few or no chum were tagged. There have been major shifts in oceanographic conditions since the 80s, as well as dramatic shifts in equipment (e.g., boats). There are a number of assumptions to these models which are listed in the papers that detail the methodology (Challenger et al. 2018; English et al. 2018: Appendix E). As such, there is even more uncertainty in estimates for chum salmon than for pink salmon as there are additional assumptions about chum vulnerability to fisheries being similar to that of pink salmon. Estimates of SEAK exploitation rates

on Area 3, 4 and 5 chum salmon prior to 1982 are likely especially uncertain, however, this is the best information that we currently have. Estimates at the Area (LGL 2021) and Conservation Unit (PSF 2021) level were only available until 2017 at the time of writing.

3.1 North Coast – Skeena River, Nass River and Area 5

Estimates of SEAK exploitation rates on Area 3 (Nass), 4 (Skeena) and 5 chum salmon are the same as pink salmon exploitation rates (English et al. 2018). Estimates of SSEAK exploitation rates on Area 3 (Nass), 4 (Skeena) and 5 pink salmon from 1954-1981 and 1996-2017) are derived from a Pink Effort-Harvest Rate model based on historical harvest rates from 1982-95 run reconstructions (Gazey and English 2000, English 2019). For 1954-1981, the average exploitation rate over 1982-1995 period for pink salmon is used for both Area 3 and Area 4 chum salmon (and Area 5 which is the same as Area 4). Further details on the application of pink salmon exploitation rates to chum salmon are given Challenger et al. (2018) and English et al. (2018). Area 3 SSEAK exploitation rates for 1982-1995 are estimated in the Area 3 Inside Pink salmon Run Reconstructions (Gazey and English 2000). For Area 4, SSEAK exploitation rates are estimates in the Skeena Pink salmon Run Reconstruction (Gazey and English 2000). Area 5 SEAK exploitation rates are assumed to be the same as in Area 4 (English et al. 2018).

3.1.1 Statistical Areas 3, 4 and 5

- SSEAK and Canadian exploitation rates for north and central coast BC even year chum salmon are shown in Figure 10. Exploitation rates from SSEAK are only estimated for Areas 3, 4 and 5 (see above). Canadian exploitation rates are highly variable and have recently declined to much lower levels than in the historical time period in most Areas (except Area 9 and 10 where recent estimates are not available), and especially in Areas 3, 4 and 5. Following pink salmon exploitation rates, estimated SSEAK exploitation rates on chum salmon have declined slightly since the 80s, but in the last 20 years have averaged around 12% in Areas 3,4 and 5.
- The proportion of exploitation attributed to SEAK fisheries for chum salmon from Areas 3, 4 and 5 is shown in Figure 11. Canadian exploitation rates include both Section 35(1) FSC catches and any sport catches, where as SEAK exploitation rates are based on commercial fisheries only¹. SSEAK percent of exploitation has increased for all Areas for chum salmon starting in the mid-90s/early, and in recent years (up to 2017) ranges from about 50-100%.

3.1.2 Area 3, 4 and 5 Conservation Units

Derivation of estimates of SSEAK exploitation rates on chum salmon CUs are detailed in Table 4 of English et al. (2018). Only CUs that are in, or partially in Areas 3, 4 and 5 have estimates of SEAK exploitation rates.

- Distribution of SSEAK exploitation rates by CU are shown in Figure 12. Nass and Skeena CUs have similar median and range of exploitation rates, with median rates at ~ 0.185 and ranging upwards of 0.3 in some years. The only other CU with SSEAK exploitation rate estimates is the Hecate Lowlands CU. Exploitation rates are much lower as explained in English et al. 2018 as they are an average of Areas 3-7, and only Areas 3-5 have estimates of SSEAK exploitation rates.
- SSEAK exploitation rates are shown for north and central coast CUs by year for chum salmon in Figure 13. Similar to the Area specific exploitation rates these are estimated from, SSEAK

¹ This may lead to some bias, however the proportion of SEAK exploitation commercial only catch would be higher if CDN FSC and sport were not included. Unfortunately, estimates of CDN FSC and sport exploitation rates were not available at the time of report writing, but will be investigated further.

exploitation rates decline starting around 1990 in most CUs. Recent year CUs range from ~ 10-15% for most CUs, and ~ 7.5% for the Hecate Lowlands CU.

3.1.3 Areas outside north coast Areas 3, 4 and 5

We have been unable to find any specific information on SSEAK exploitation rates on chum salmon returning outside of the Skeena, Nass and Area 5. Results from pink salmon tagging studies in the early 80s were confounded by incomplete surveys in fisheries and escapements in central coast and southern areas. However, Pella et al. (1993) note that in some years tagged pink salmon were recovered in central coast areas and as far south as WCVI and Johnstone Strait. It is reasonable to assume that central coast and further south returning chum would also be caught in SSEAK fisheries, especially in mixed-stock outside fisheries.

In our discussions with ADFG, chum otolith sampling programs by the SEAK Aquaculture Association were identified as possible sources of information on Canadian hatchery marked chum. However, at the time of writing we were not able to locate any data to explore. Information on the Southern Southeast Alaska Aquaculture Association and Northern Southeast Alaska Aquaculture Association can be found online². The authors are reaching out to the associations at the time of writing.

3.2 2021 Estimates

2021 estimates of SSEAK exploitation rates on Area 3, 4 and 5 chum salmon will not be available until after the Pink Run Reconstructions have been updated to include 2021, and then can be applied to chum salmon. There is usually a lag of a few years before the information is updated. Based on recent trends, it would be expected that estimates of SSEAK exploitation rates on Area 3, 4 and 5 chum salmon would follow recent trends (~ 10-15%) in most areas, and slightly lower in the Hecate Lowlands CU. Chum catches in Districts 101 to 106 were not significantly higher than recent years, which may imply that harvest rates on BC chum salmon would remain at similar levels. However pink catches and effort, which determine chum salmon exploitation rates according to the methods used, were higher in some areas in 2021.

We currently have no information on estimates of SSEAK exploitation on Fraser or other south coast chum salmon stocks in 2021.

4 Information Gaps

- 1) We were unable to find any information on SSEAK catch or exploitation rates of WCVI, central coast (other than in the Hecate Lowland CU), Fraser or Strait of Georgia chum salmon populations, despite numerous discussions with DFO stock assessment staff and other experts. Given the findings in Pella et al. (1993) regarding pink salmon, it is likely that some of these populations are present in some years when SSEAK fisheries are being prosecuted. Recent advances in genetic stock ID methods may provide insight into stock compositions in SSEAK fisheries, however we recognize that there would be significant logistical and financial challenges if sampling program be designed given catch numbers. However, stratified step-wise catch sampling for hatchery marked fish and/or genetic stock ID in fisheries which are known mixed-stock areas for other species (e.g., District 104, 101) are likely warranted given the stock status of BC chum.
- 2) Then international transboundary tagging studies on pink salmon (that chum salmon exploitation rates are derived from) were completed in 1982, 84 and 85, 35+ years ago.

² Southern www.ssraa.org; Northern www.nsraa.org

- i) Pella et al. (1993) raise the point that migration routes of stocks are possibly affected by annual changes in oceanographic conditions, and that large -scale climactic events such as El Nino may influence stock compositions and timing. This in turn would influence inferences that are based on average stock compositions, for example. Since the 80s, there have been fundamental shifts in oceanographic conditions in the Northwest Pacific Ocean including marine heatwaves (aka the Blobs) and sustained changes in average sea surface temperatures. While it is likely that these events have had major effects on the migration routes of all salmon species, we have not found any specific information on pink and/or chum salmon and the potential implications on estimates of SSEAK exploitation rates.
 - ii) There have been significant changes to the fishing fleet since the 1980s. Exploitation rates are based on Effort-Harvest relationships that have changed along with fishing gear and efficiencies.
- 3) The PSRR and Pink and Chum models only use information from SSEAK catches. While it is unlikely that there is much, if any, catch of BC pink salmon in other areas of Alaska, we could not identify any information to confirm this.
 - 4) We could not find any information on the proportions of wild and hatchery produced chum in common property catches by fishing District.

5 References

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6 Figures

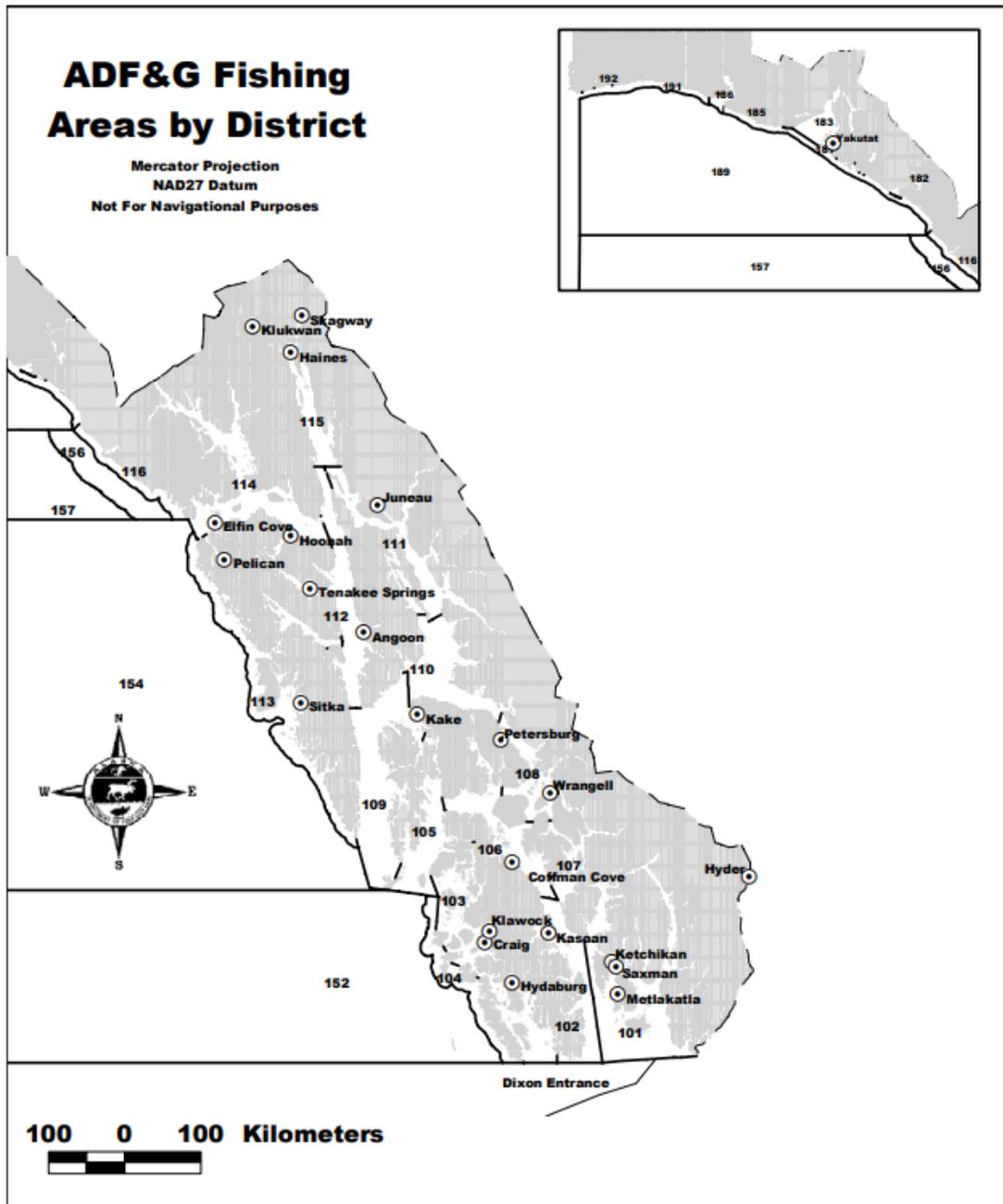


Figure 1: Map of Southeast Alaska Fishing Areas by District.

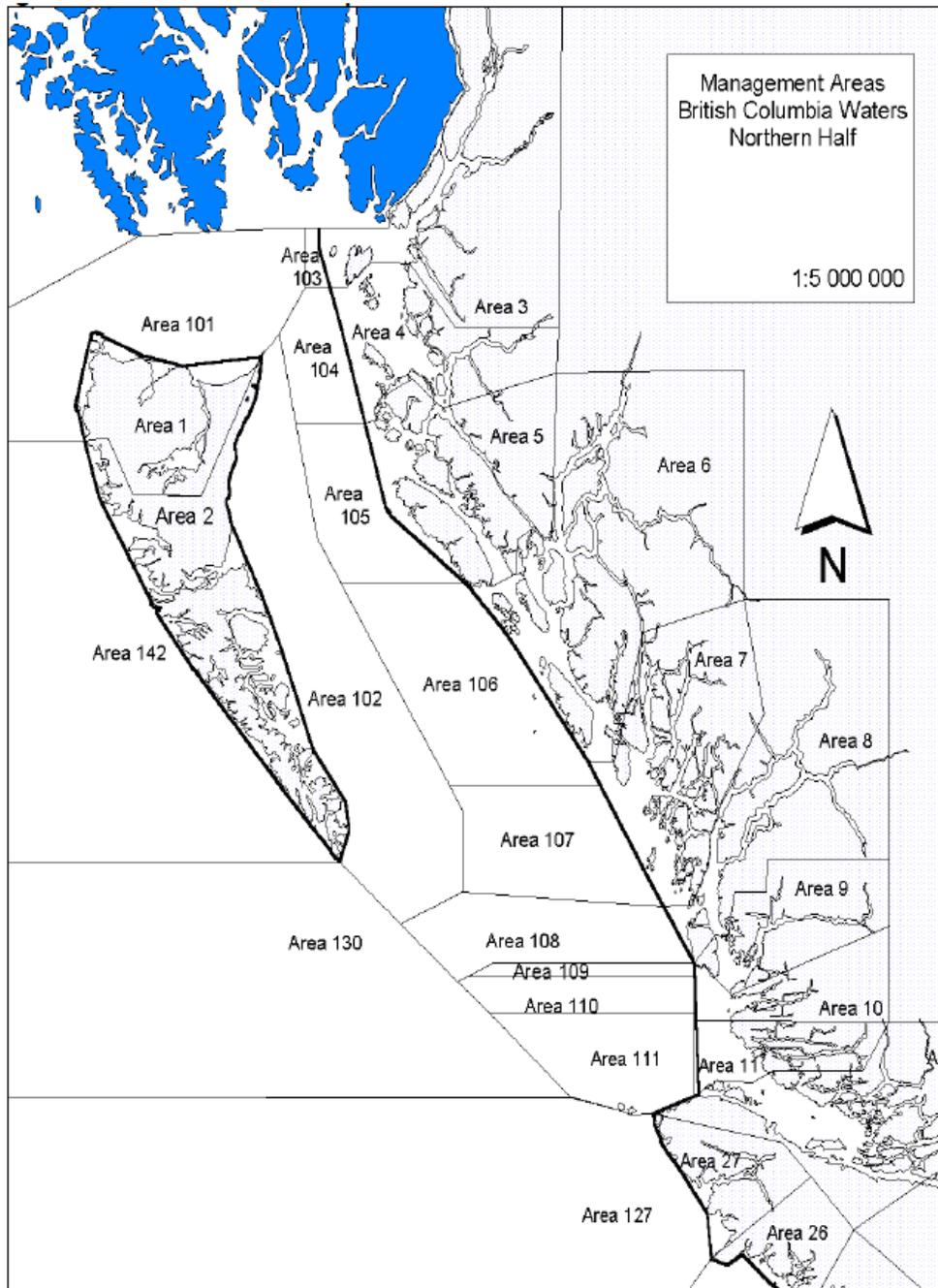


Figure 2. Map of DFO Statistical Areas in the North and Central Coast Areas.

SEAK Harvest: Chum Salmon (1979-2021)

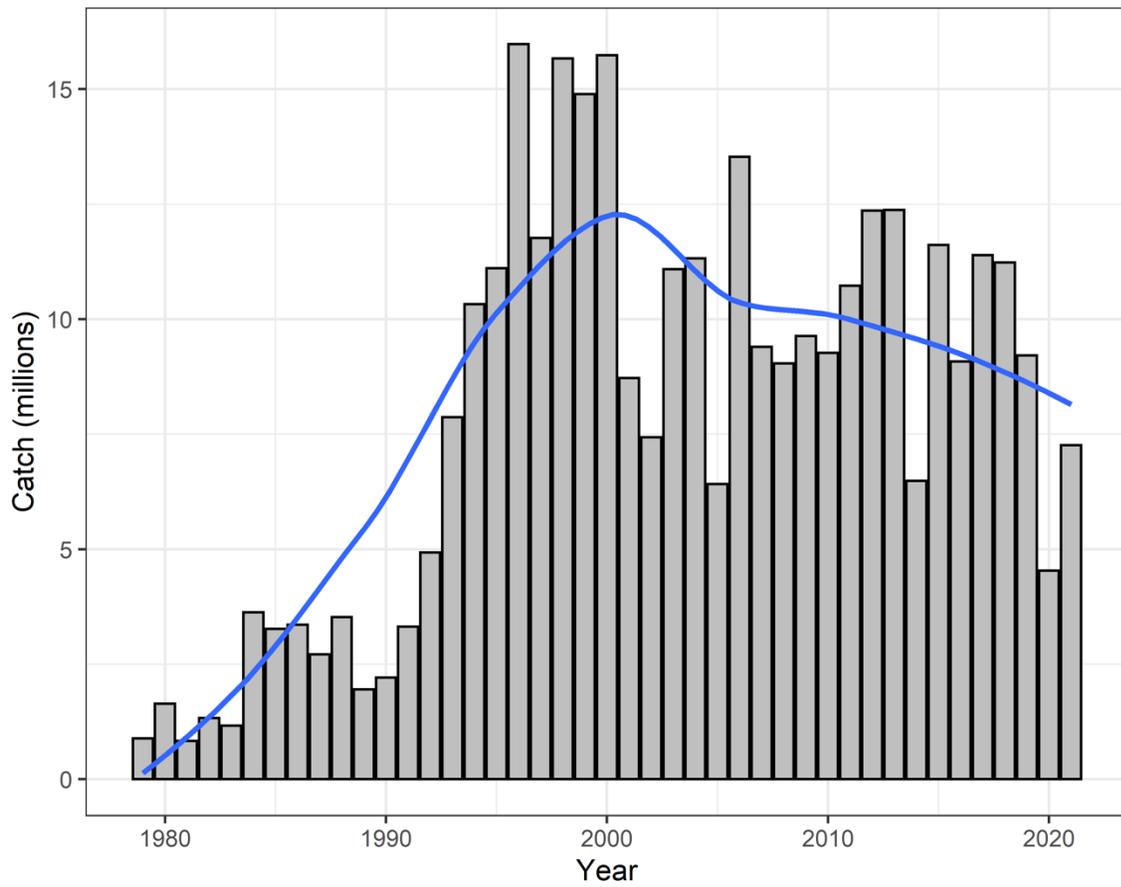


Figure 3: Total SEAK harvest (millions of fish) of chum salmon from 1979-2021. Blue line is fit using LOESS.
Source: ADFG 2021a (1979-2020), ADFG 2021b (2021).

SEAK Catch of Chum Salmon by Fishery Blue Sheet Fisheries (1980-2020)

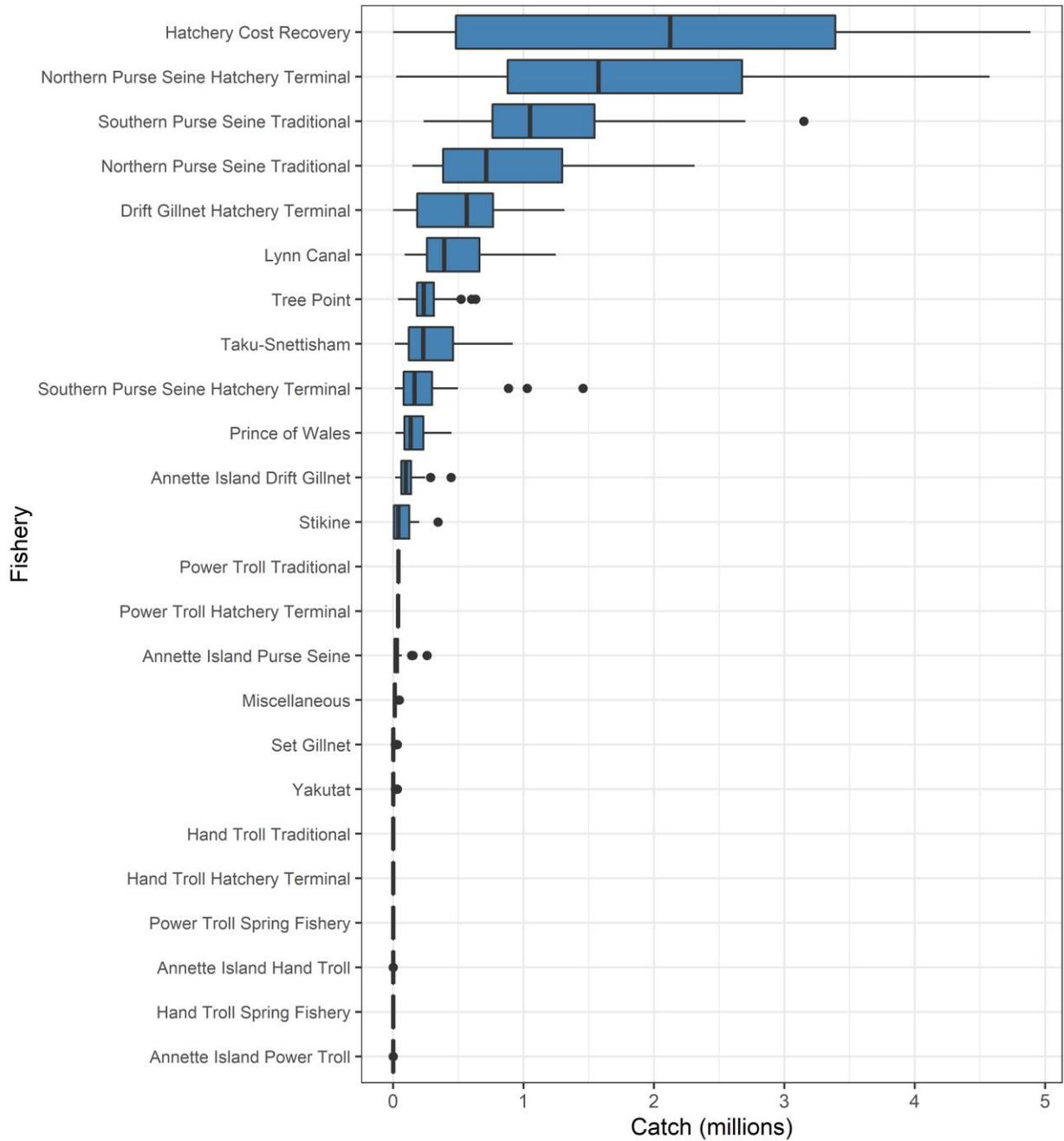


Figure 4: Distribution of total chum salmon commercial catch in SEAK “Blue Sheet” fisheries 1980-2021. Fisheries are ordered from highest catch to lowest catch. The thick black line is the median value, the box in indicates the interquartile range (25th to 75th percentiles – or middle 50% of the data), whiskers are 1.5x the interquartile range and dots are outliers (< 5th or > 95th percentile). Source: ADFG 2021c.

Total SSEAK Catch All Gear by District (101-106)
Chum Salmon (1985-2021)

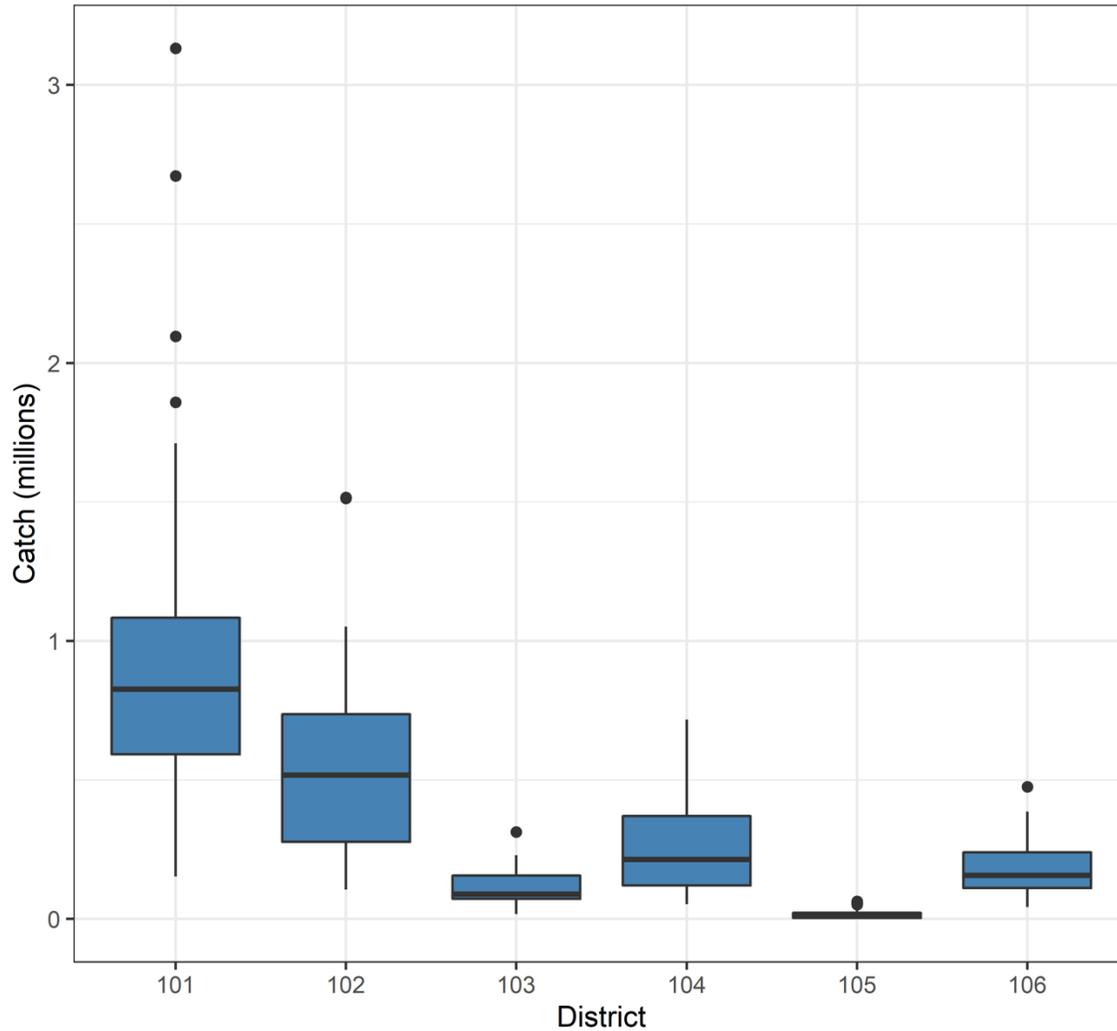


Figure 5: Median catch of chum salmon from all gears in SSEAK fisheries by district (districts 101-106) from 1985-2021. The thick black line is the median value, the box indicates the interquartile range (25th to 75th percentiles – or middle 50% of the data), whiskers are 1.5x the interquartile range and dots are outliers (< 5th or > 95th percentile). Source: ADFG 2021d.

SSEAK Catch All Gear by District (101-106)
 Chum Salmon (1985-2021)

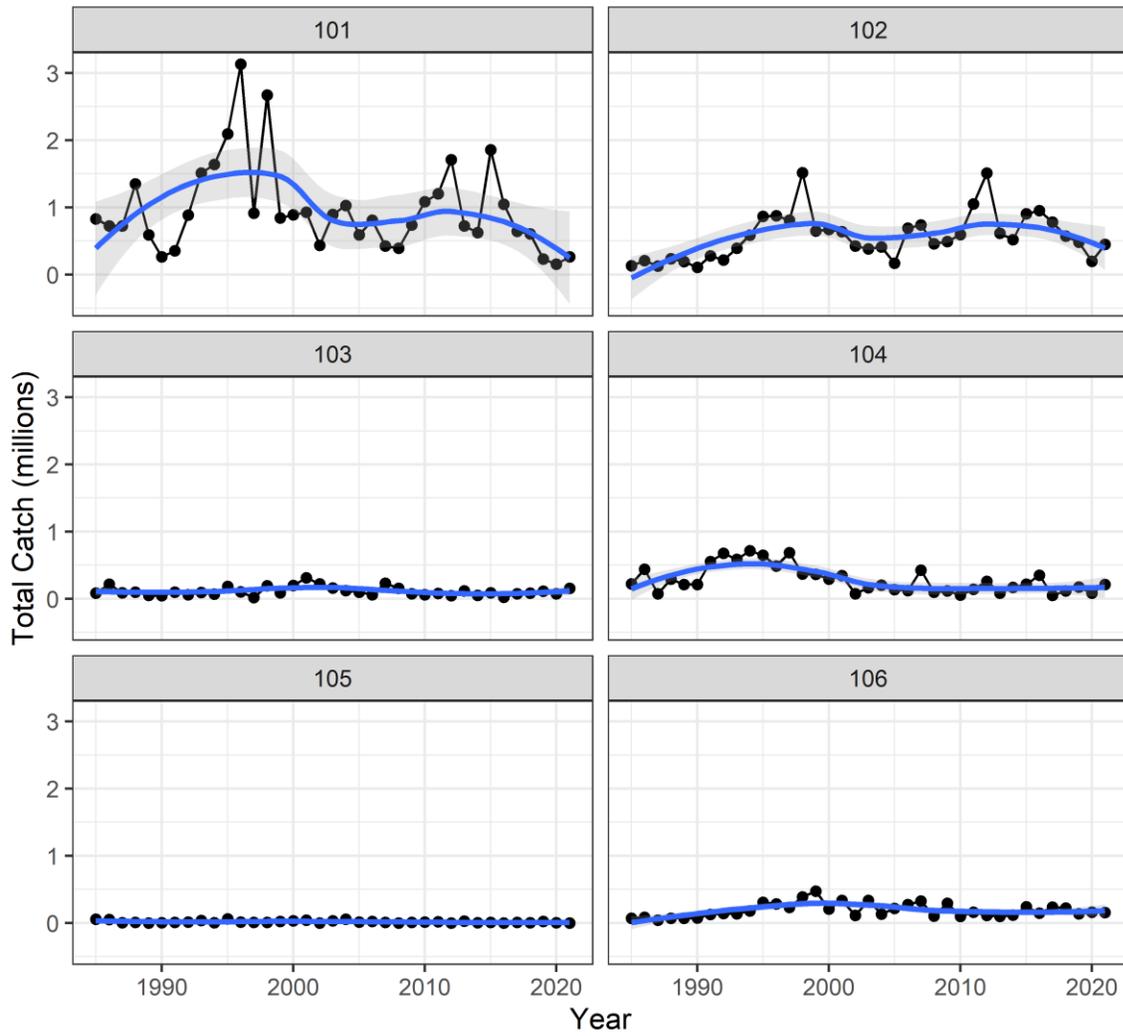


Figure 6: Total catch of chum salmon by year for SSEAK Districts 101-106 (1985-2021). Smoothed lines are derived by LOESS with standard errors shown in grey. Source: ADFG 2021d.

Proportion of Total D101-106 Catch
Chum Salmon (1985-2021)

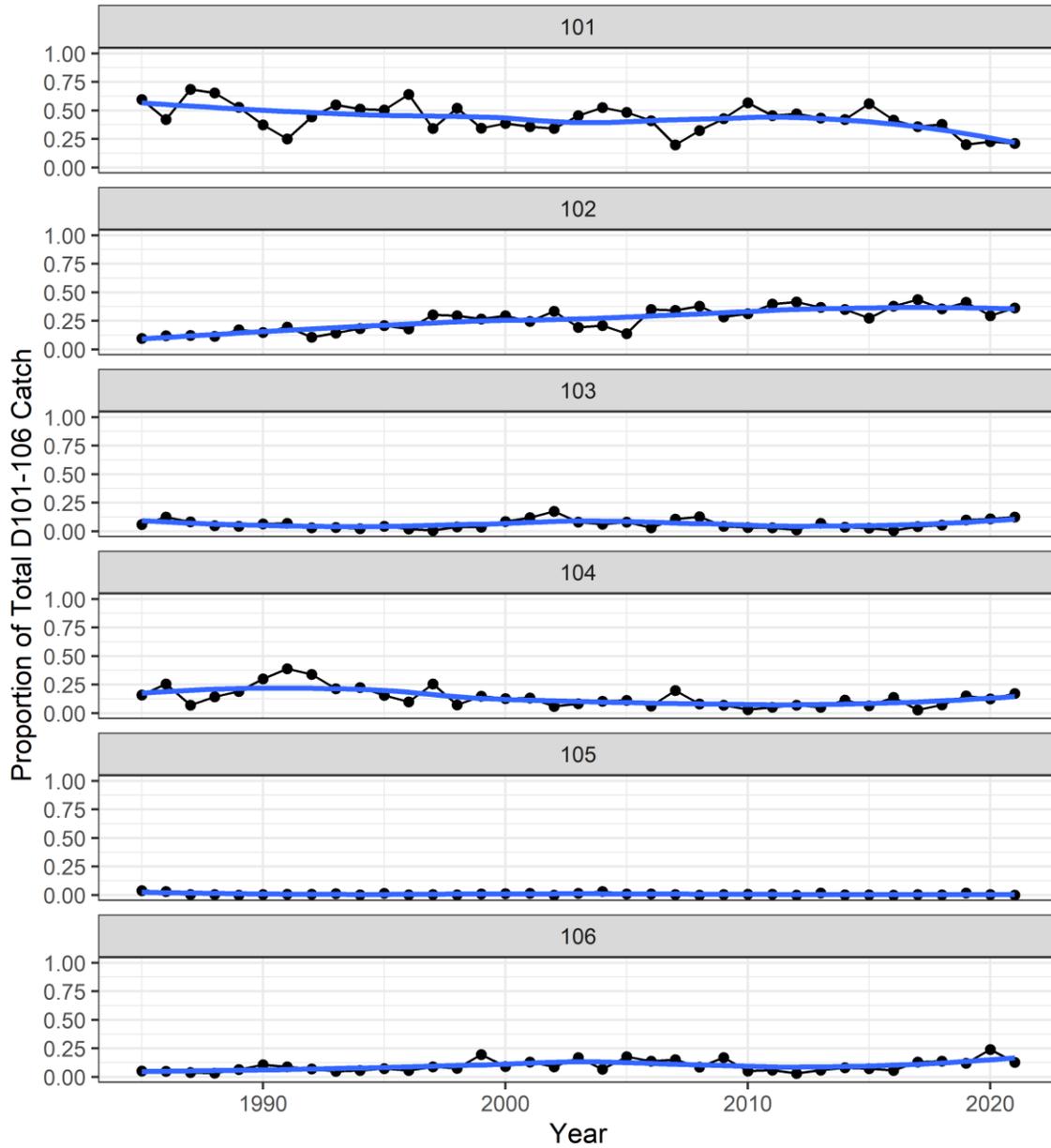


Figure 7: Proportion of total SSEAK District 101-106 chum salmon catch (all gears) by year for 1985-2021. Blue lines are estimated by LOESS fits. Source: ADFG 2021d.

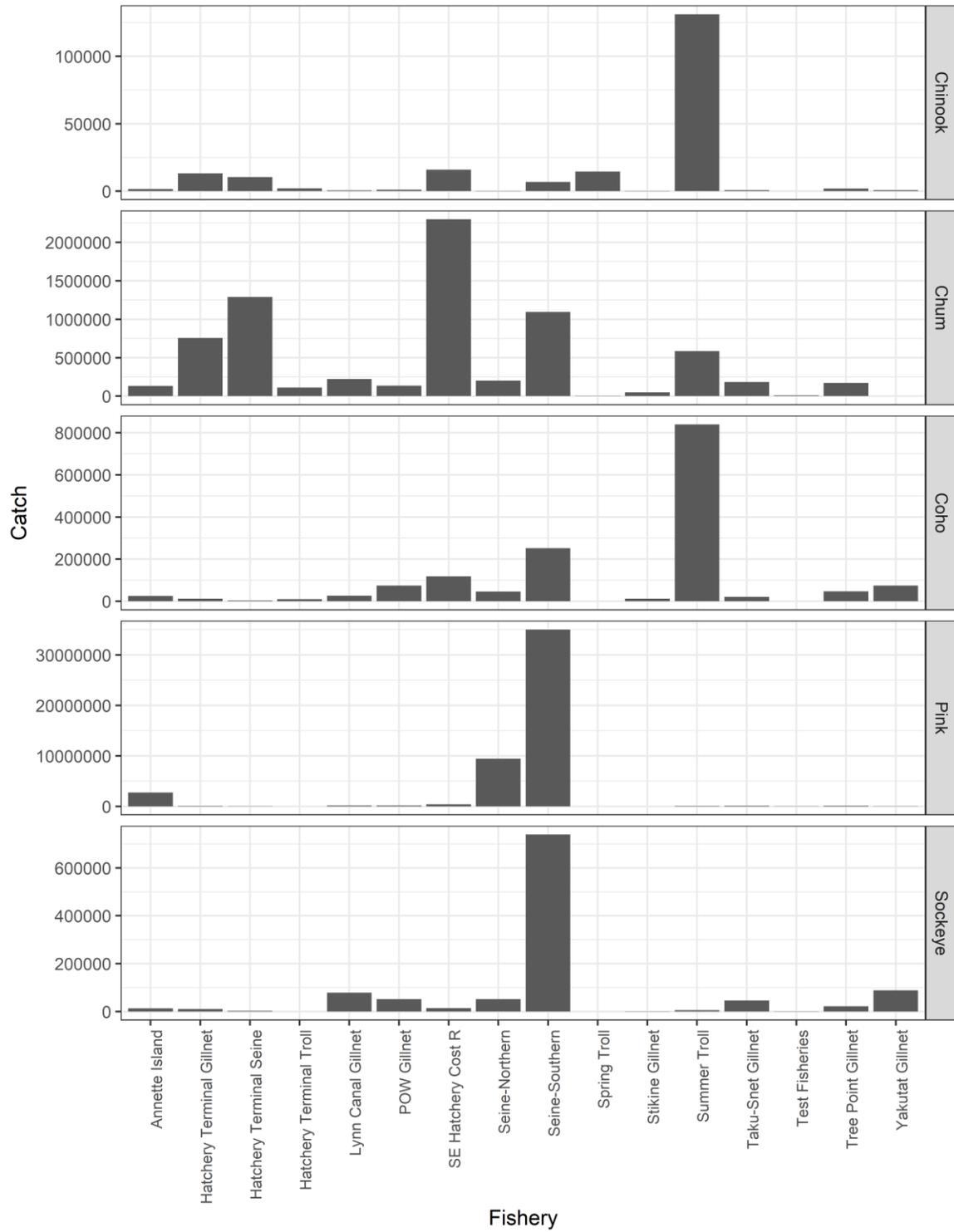


Figure 8: Harvest of all salmon species in SEAK “Blue Sheet” commercial fisheries in 2021. Source: ADFG 2021b.

Weekly Harvest of Chum Salmon by Gear Type District 104: 2021

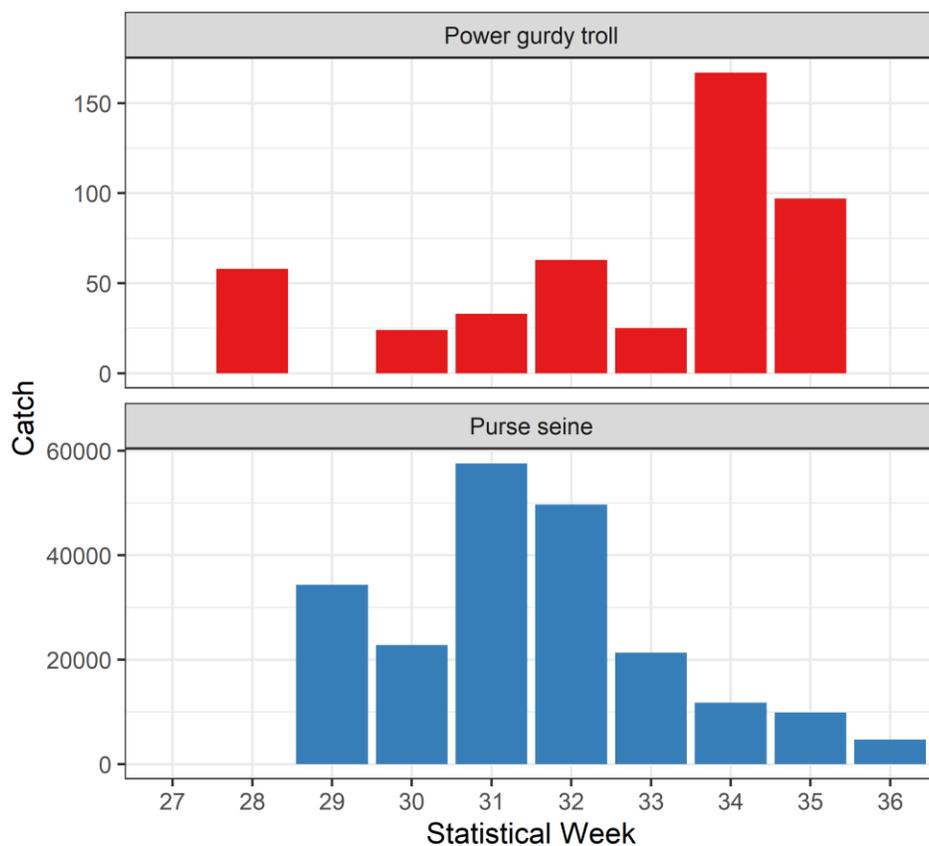


Figure 9: Weekly catch of chum salmon in District 104 fisheries by gear type for 2021. Note y-axis scales are not the same between panels. Source: ADFG 2021e.

SEAK and CDN Exploitation Rates

Chum (1954-2017)

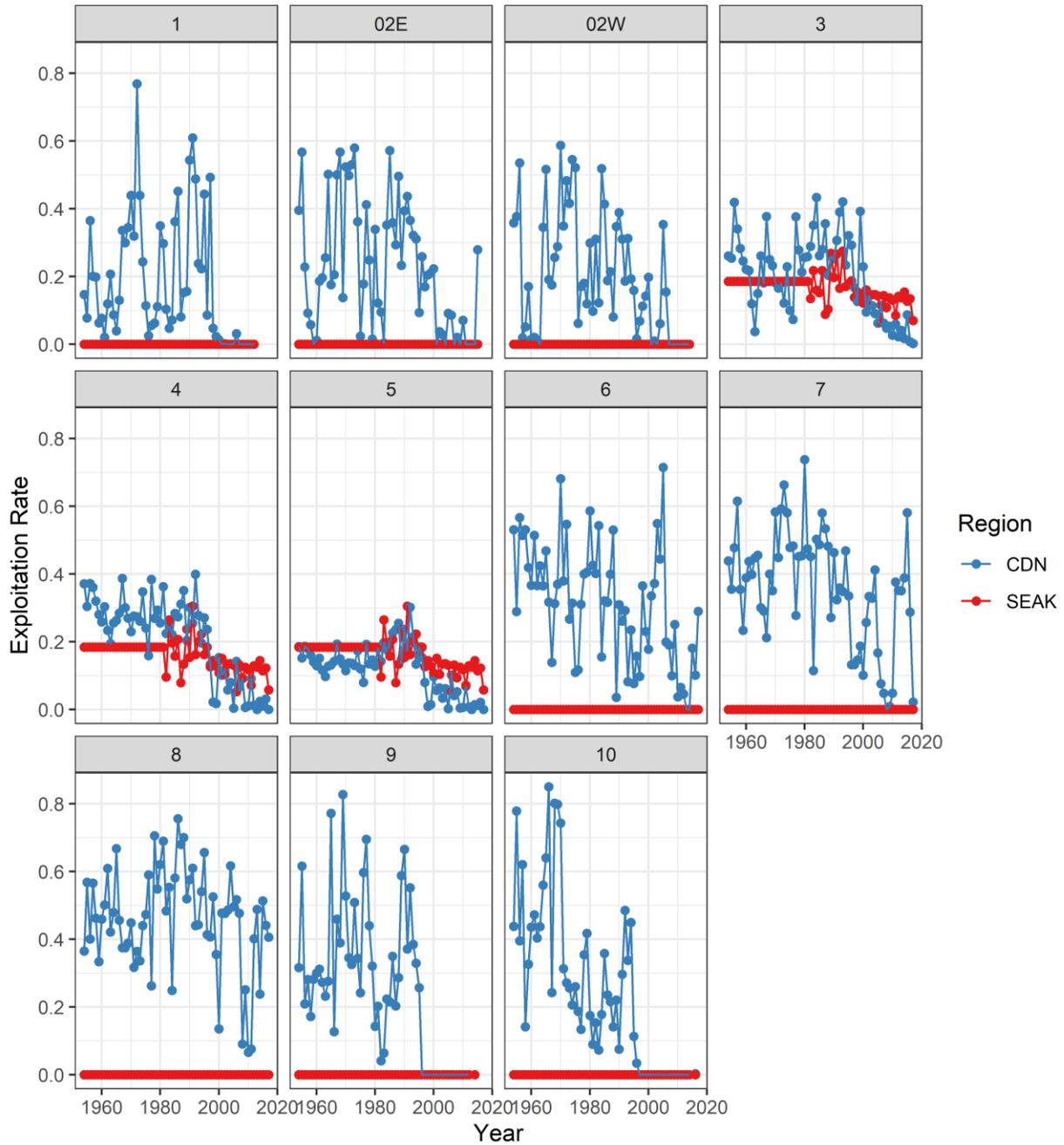


Figure 10: SEAK (red) and Canadian (blue) exploitation rates by year for north and central coast (Statistical Areas 1-10) chum salmon from 1954-2017. Source: PSF 2021.

SEAK Percent of Total Exploitation Chum Salmon (1954-2017)

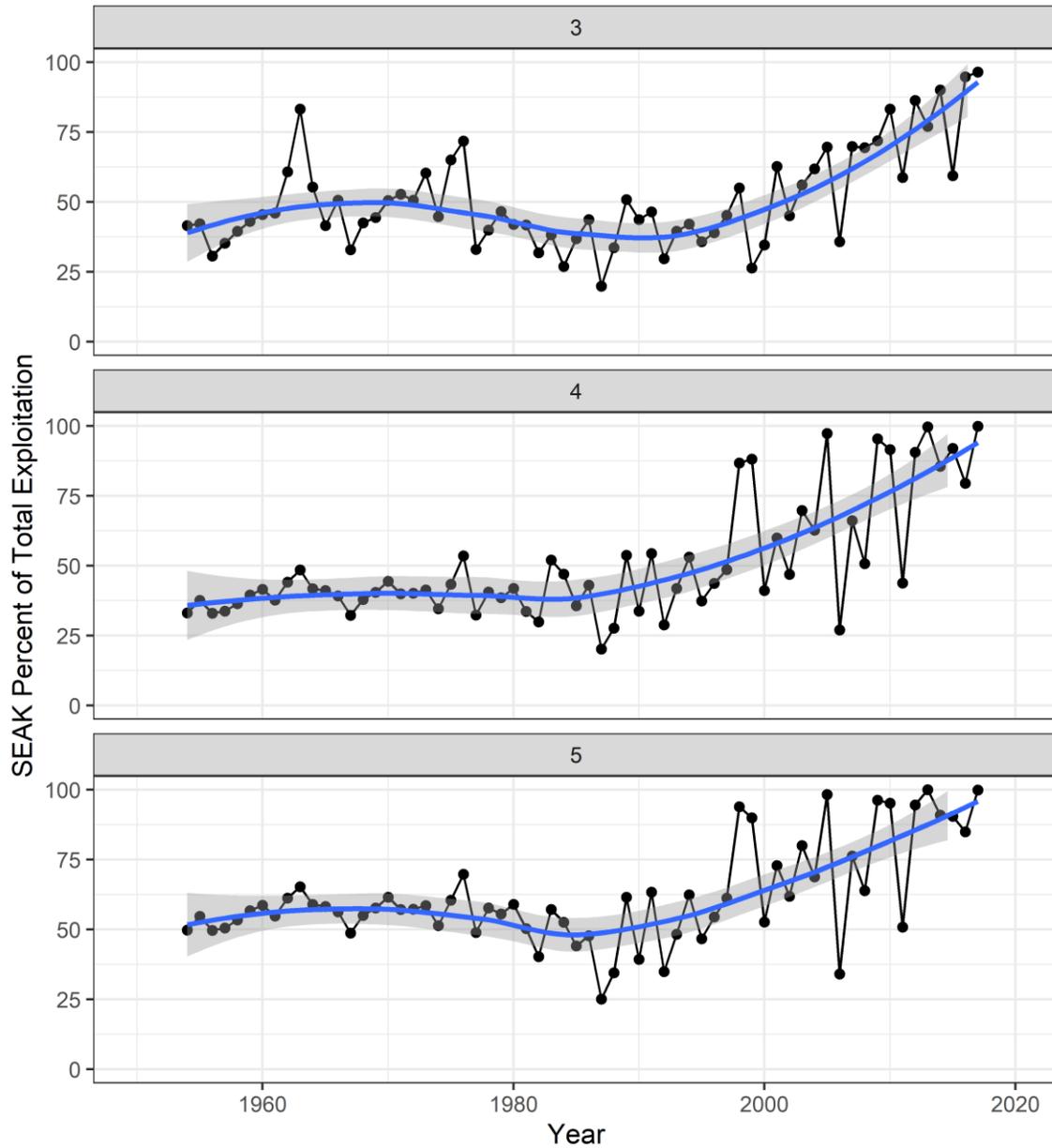


Figure 11: Percent of exploitation attributed to SEAK for even and odd year pink salmon from Areas 3,4, and 5 from 1954-2017. Trend lines and SEs were derived using LOESS in R. Source: LGL 2021.

SEAK Exploitation Rate by Conservation Unit Chum Salmon (1954-2017)

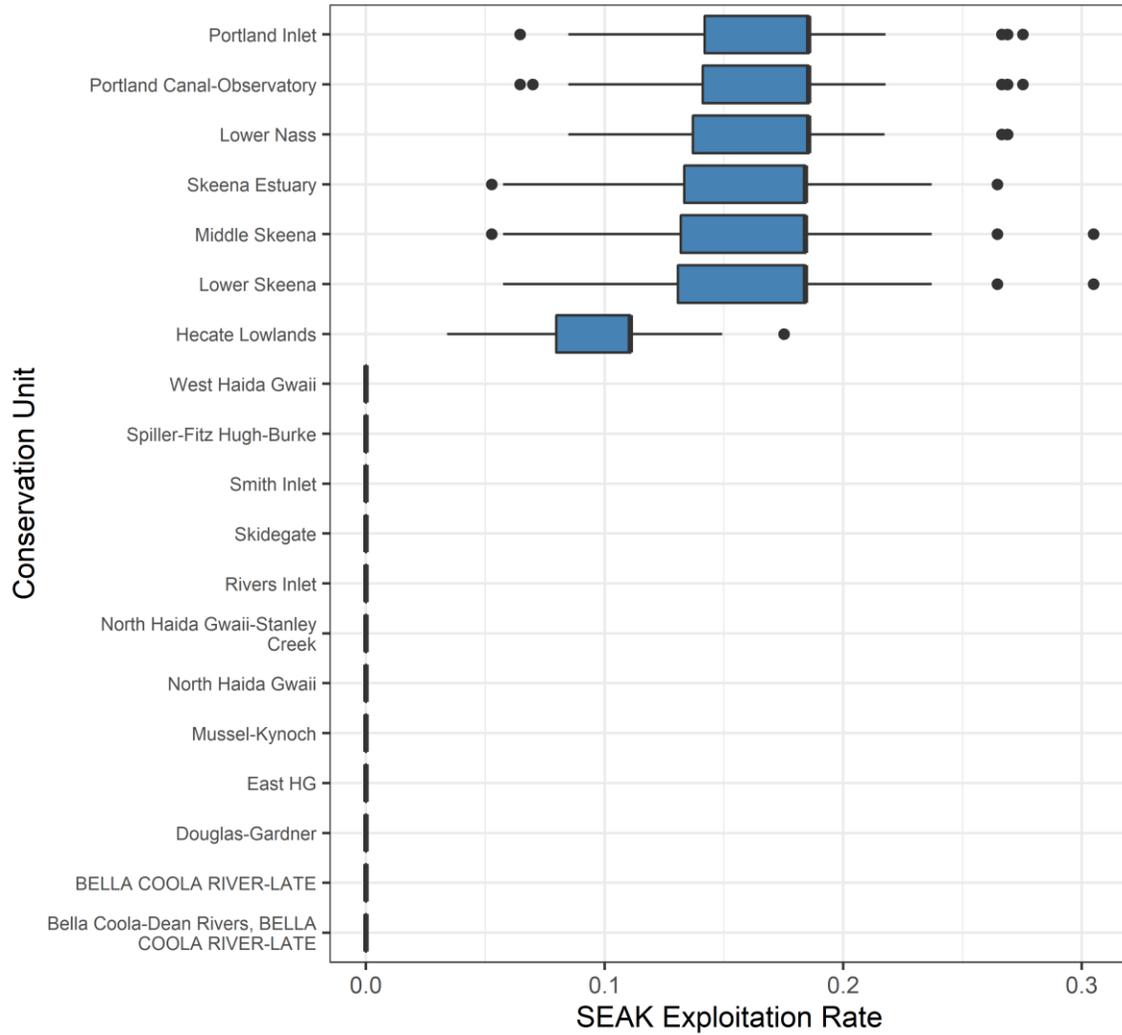


Figure 12: Boxplot of SEAK exploitation rates on chum North and Central Coast BC Conservation Units for 1954 to 2017. CUs are ordered from highest median exploitation rate to lowest. Source: PSF 2021.

SEAK Exploitation Rate by Conservation Unit Chum Salmon (1954-2017)

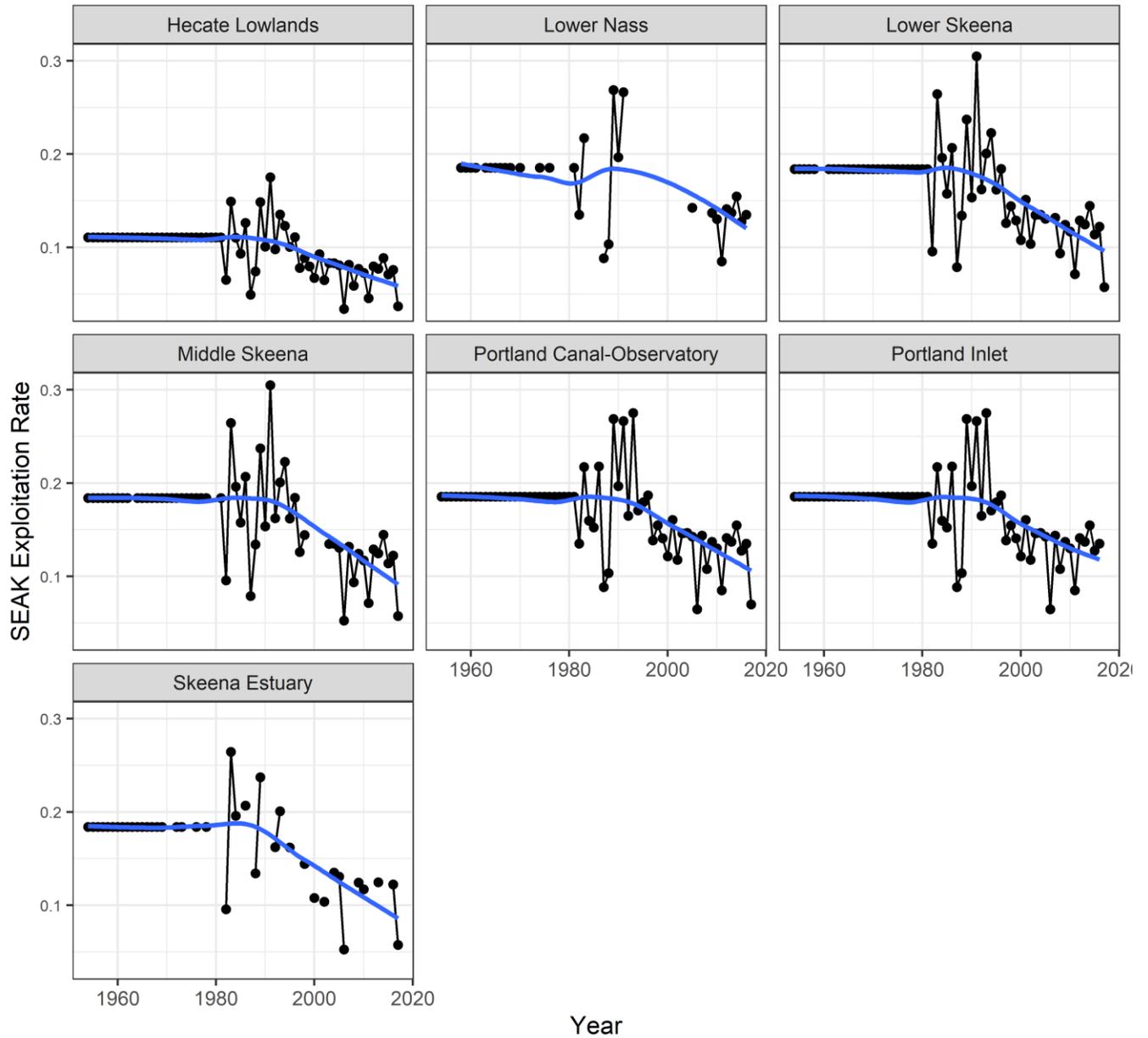


Figure 13: SEAK exploitation rates for chum salmon from north and central coast Conservation Units from 1954-2017. Trend lines derived using LOESS in R. Source: PSF 2021.