

# Alaskan Harvest of BC Salmon: State of Knowledge

## Part 6: Pink 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 salmon was compiled from a 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). Detailed background on the methodology for estimating SSEAK catch of Area 3, 4 and 5 pink salmon is provided in a number of reports (Gazey and English 2000; Challenger et al. 2018; English et al. 2018). Pella et al. (1993) provides a summary of the international pink and sockeye salmon tagging studies in 1982, 1984 and 1985, which provide some insight into pink salmon stock composition in SSSEAK fisheries in the early 80s. Other than that, we were unable to identify any more recent information on pink salmon stock composition in SSEAK fisheries, or any information for SSEAK catch of pink 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 pink salmon historically and in 2021, as well as information on harvest timing in SSEAK and District 104. SSEAK exploitation rates and proportion of total catch are summarized for BC Areas 3, 4, and 5, along with associated Conservation Units. Results from Pella et al. (1993) are discussed briefly. We are also in the process of digitizing the original manuscript reports from these tagging studies (in collaboration with LGL), although the current relationship to migration timing and routes with changing marine conditions is discussed in the Information Gaps Section below.

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 pink salmon by region.

<i>Species</i>	<i>Region/Area</i>	<i>Type of Data</i>	<i>Data Source</i>	<i>Year</i>
<i>Pink salmon</i>	BC NC/CC Areas 1-10, by Statistical Area	Escapement, harvest and exploitation rates from run reconstructions	LGL 2021a. 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 Strait of Georgia	Data deficient Data deficient		

## 2 SEAK Harvest

Summary information on pink salmon harvest in SEAK and SSEAK (historically and for 2021) is provided in this report for context. SSEAK 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 pink salmon harvest information for commercial SSEAK 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). More detailed information on SSEAK harvests (e.g., magnitude, timing etc.) is provided in Part 1 of this report series.

- Total pink salmon catch in SEAK between 1979 and 2021 peaked in the mid-90s, averaging ~ 37 million (Figure 3). Since 2010, catches have averaged ~ 32.5 million.

*Most pink salmon are caught in purse seine fisheries. with some in northern areas (*

- Figure 4). Median annual catch in southern purse seine fisheries is ~ 20 million pinks, and northern purse seine fisheries have a median catch of just over 10 million.
- Median total catch (all gears) of pink salmon in SSEAK Districts 101-106 shows that District 101 and 104 each contribute about 30% over the entire time series, Districts 102 and 103 each contribute about 18%, and Districts 105 and 106 contribute only small catches in most years (Figure 5).
- Total catches (all gears) in District 104 in most years has declined since the 90s to an average catch of around 5 million per year in the 2000s (Figure 6). The other Districts have remained variable with no major trends over time.

*The proportion of total District 101-106 catch for each district over time is shown in*

- Figure 7. The proportion of pinks caught in District 104 has declined over time, and has been around 25% since 2000. Districts 102 and 103 catch proportion has increased slightly over time, so that they contribute about 25% in recent years.

*In 2021, total SEAK catch of pink salmon (including Yakutat) was ~ 48 million. SSEAK (Districts 101-106) accounted for about 34 million of that. As in most years, 91% of the total catch was from the southern (72%) and northern (19%) seine fisheries (*

- Figure 8).
- District 104 only catch of pink salmon in seine fisheries in 2021 was ~10.7 million, with only 10 fish reported from power trolls; one of the highest catches since 1996. Weekly catch followed the normal annual pattern peaking in Week 32, followed by Week 31 and 33 (Figure 9).

### 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 pink 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 exploitation rate estimates in recent years continue to be 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). 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 likely considerable uncertainty in these estimates, especially prior to 1982 and in recent years, 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 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 is used for both Area 3 and Area 4 pink salmon (and Area 5 which is the same as Area 4). Further details are given Challenger 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 SSEAK exploitation rates are assumed to be the same as in Area 4 (English et al. 2018).

Pink salmon are typically separated into even and odd years as separate cohorts, since the vast majority of fish return 1.5 years after emergence as fry in a single age class. As such, we present information by Statistical Area and Conservation Unit by even and odd year pink cohorts, and compare even versus odd year exploitation rates.

#### **3.1.1 Statistical Areas 3, 4 and 5**

- SSEAK and Canadian exploitation rates for north and central coast BC even year pink salmon are shown in Figure 10. Exploitation rates from SSEAK are only estimated for Areas 3, 4 and 5 (see above). Canadian exploitation rates have declined to much lower levels than in historical time period in all Areas (except Area 9 and 10 where recent estimates are not available). SSEAK exploitation rates have declined slightly since the 80s, but in the last 20 years have averaged around 12% in Areas 3,4 and 5.
- SSEAK and Canadian exploitation rates for north and central coast BC odd year pink salmon are shown in Figure 11. Exploitation rates from SSEAK are only estimated for Areas 3, 4 and 5 (see above). Similar to even year pink salmon, Canadian exploitation rates have declined to much lower levels than in historical time period in all Areas (except Area 9 and 10 where recent estimates are not available). SSEAK exploitation rates have declined slightly since the 80s, but in the last 20 years have averaged around 10% in Areas 3,4 and 5.

*The proportion of exploitation attributed to SSEAK fisheries for even and odd year pink salmon from Areas 3, 4 and 5 is shown in*

- Figure 12. Canadian exploitation rates include both Section 35(1) FSC catches and any sport catches, where as SSEAK exploitation rates are based on commercial fisheries only.<sup>1</sup> SSEAK percent of exploitation has increased for all Areas for both even and odd year pink salmon since the late 90s/early 2000s, and in recent years (up to 2017) ranges from about 50-75%.

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<sup>1</sup> This may lead to some bias, however the proportion of SSEAK 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.

### **3.1.2 Area 3, 4 and 5 Conservation Units**

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

- Distribution of SSEAK exploitation rates by CU are shown in Figure 13. 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 CUs with SSEAK exploitation rate estimates are Hecate Strait-Lowlands (odd-year) and Hecate Lowlands (even-year). These are much lower as explained in English et al. 2018 as they are an average of Area 5-10 and 6-10 respectively.
- SSEAK exploitation rates are shown for north and central coast CUs by year for even and odd year pink salmon in Figure 14. Similar to the Area specific exploitation rates these are estimated from, SSEAK exploitation rates decline starting around 1990 in most CUs. Recent year CUs range from ~ 10-15% for most CUs, and ~ 2.5% for the even-year Hecate Lowlands and odd-year Hecate Strait-Lowlands CUs.

### **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 pink 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.

## **3.2 2021 Estimates**

2021 estimates of SSEAK exploitation rates on Area 3, 4 and 5 pink salmon will not be available until after the Pink Run Reconstructions have been updated to include 2021. 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 pink salmon would follow recent trends (~ 10-15%) in most areas, and much lower in the Hecate Strait CUs. Catches in District 101 in 2021 were 2 to 10-fold greater than in the last 10 years, which may imply that harvest rates on Area 3 pink salmon may also be higher than average. Pink salmon production in SSEAK is much larger than in northern BC, however, since there is no way to target SSEAK pink salmon versus Canadian salmon in mixed-stock areas, high harvest rates on prevalent SSEAK pink salmon may result in high harvest rates on co-migrating Canadian populations.

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

## **4 Information Gaps**

- 1) We were unable to find any information on SSEAK catch or exploitation rates of West Coast Vancouver Island (WCVI), central coast (other than in Hecate Strait CUs), Fraser or Strait of Georgia pink salmon populations, despite numerous discussions with DFO stock assessment staff and other experts.
- 2) Given the findings in Pella et al. (1993), it is likely that some of these populations are present in some years when SSEAK fisheries are being prosecuted. Both the 1984 and 1985 tagging years (the 1982 tagging year did not survey areas below Area 4) saw recoveries of tags south of Area 4. Tags were found as far south as Johnstone Straits in 1985. However, poor surveys of both fisheries and escapements south of Area 4 in 1984 and 1985 mean that no estimates of stock composition of central and southern BC pink salmon could be generated.

- 3) Pella et al. (1993) estimated that up to 10% (depending on week with the proportion of Canadian pink salmon increasing through August) of the pinks harvested in D104 were from Northern BC. Considering 10 million pink salmon were caught in D104 in 2021, there could have been a substantial number of Canadian origin pink salmon caught in the fishery.
- 4) International transboundary tagging studies on pink salmon were completed in 1982, 84 and 85, 35+ years ago.
  - 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 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.
  - iii) Recent advances in genetic stock ID methods may provide insight into stock compositions in SSEAK fisheries, however we recognize that the sheer volume of pink salmon catch presents significant logistical and financial challenges were a sampling program be designed.
- 5) 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.

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## 6 Figures

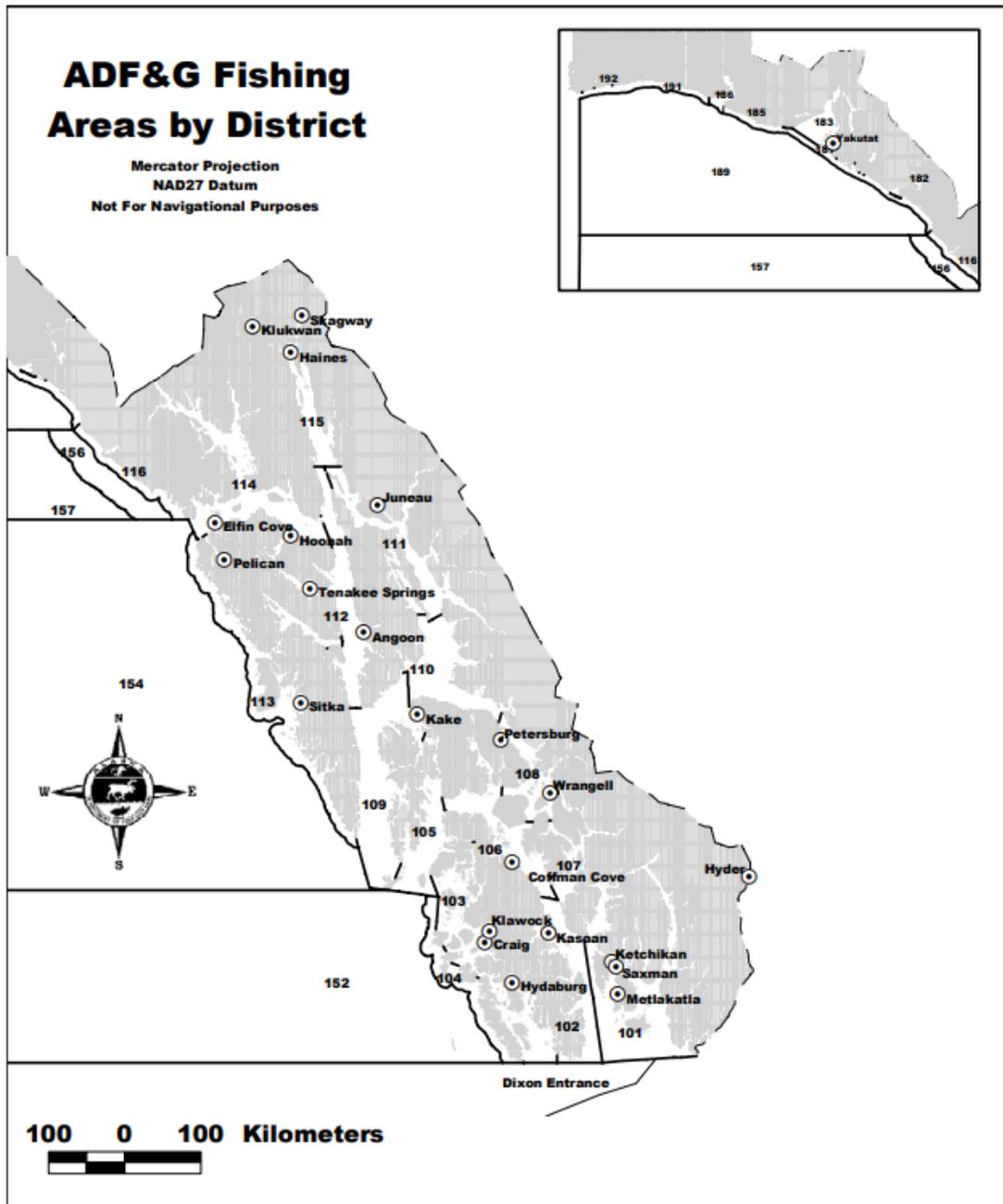


Figure 1: Map of Southeast Alaska Fishing Areas by District.

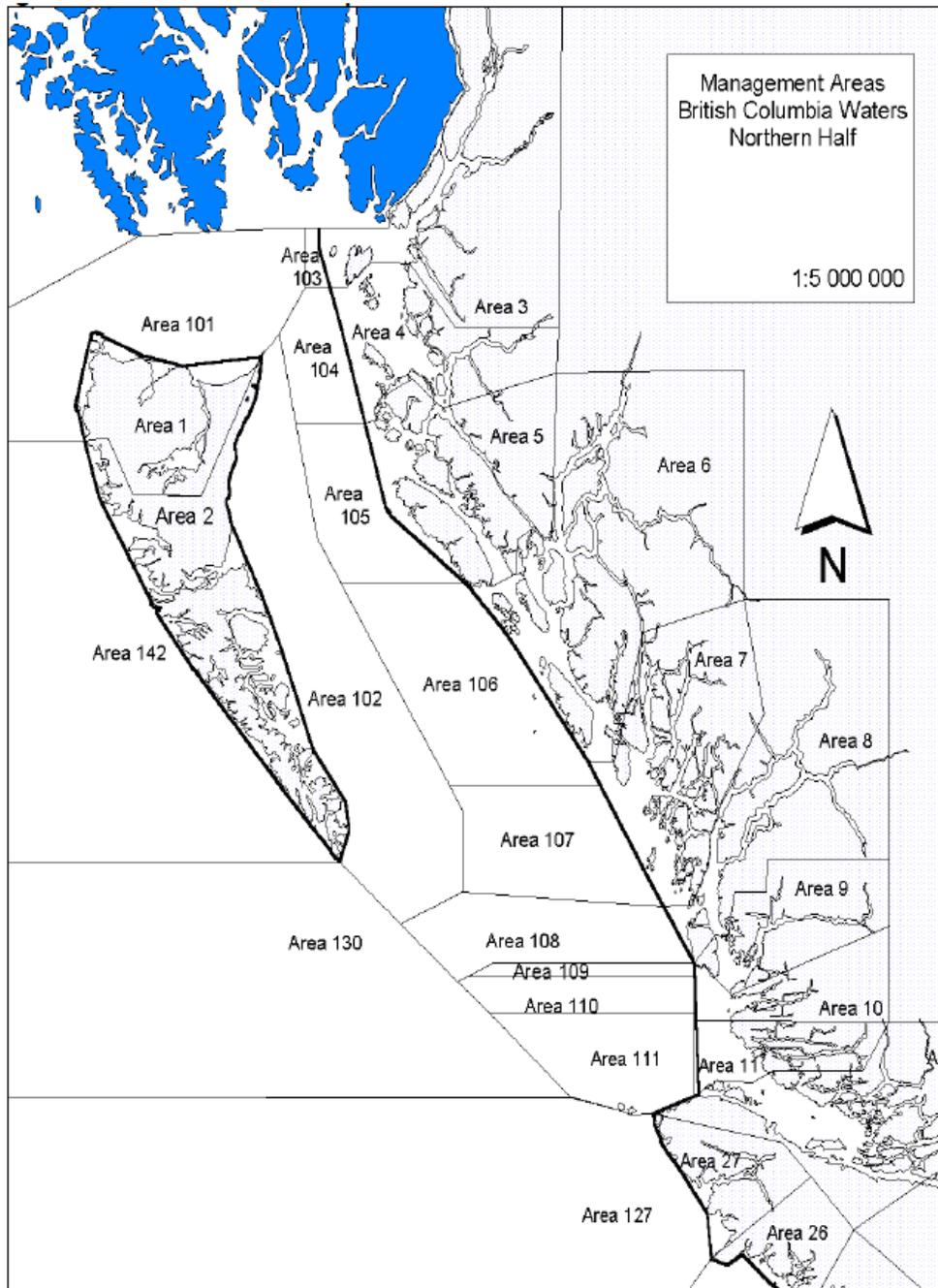


Figure 2. Map of DFO Statistical Areas in the North and Central Coast Areas.

### SEAK Harvest: Pink Salmon (1979-2021)

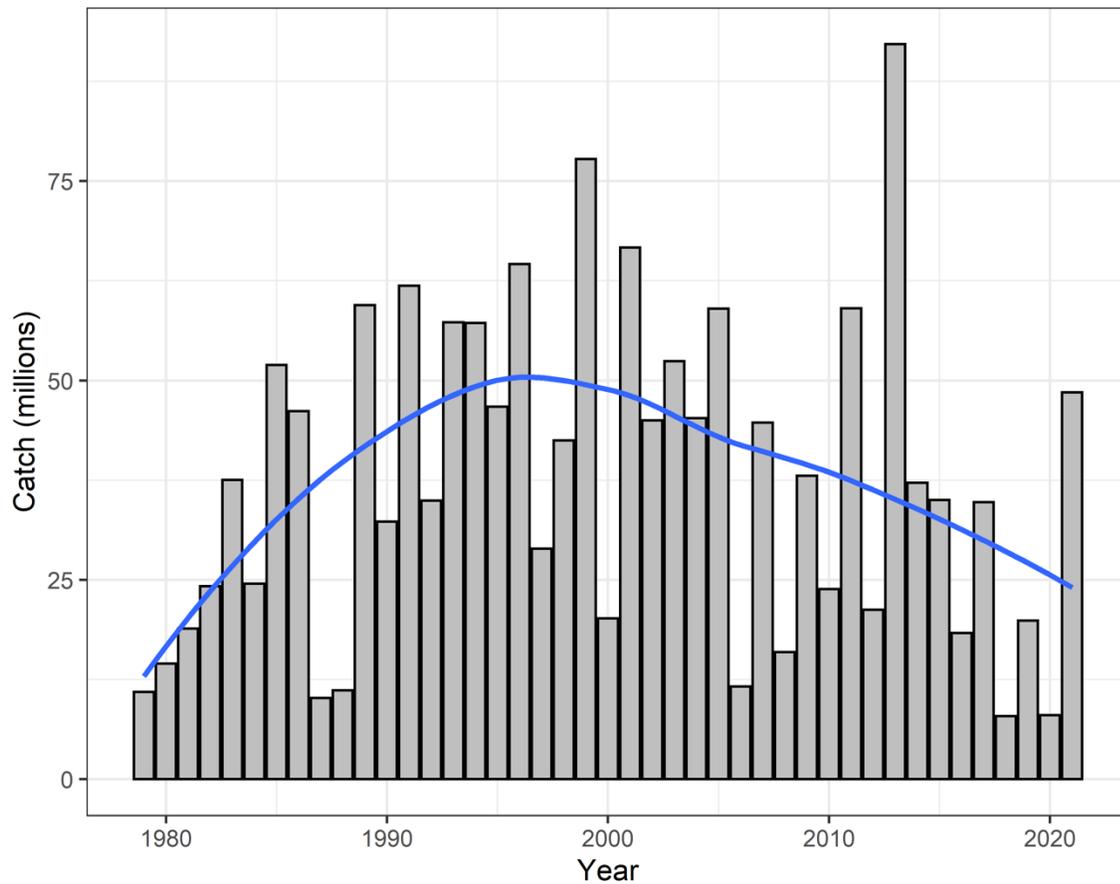


Figure 3: SEAK catch (millions of fish) of pink salmon from 1979-2021. Blue line is fit using LOESS. Source: ADFG 2021a (1979-2020), ADFG 2021b (2021).

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

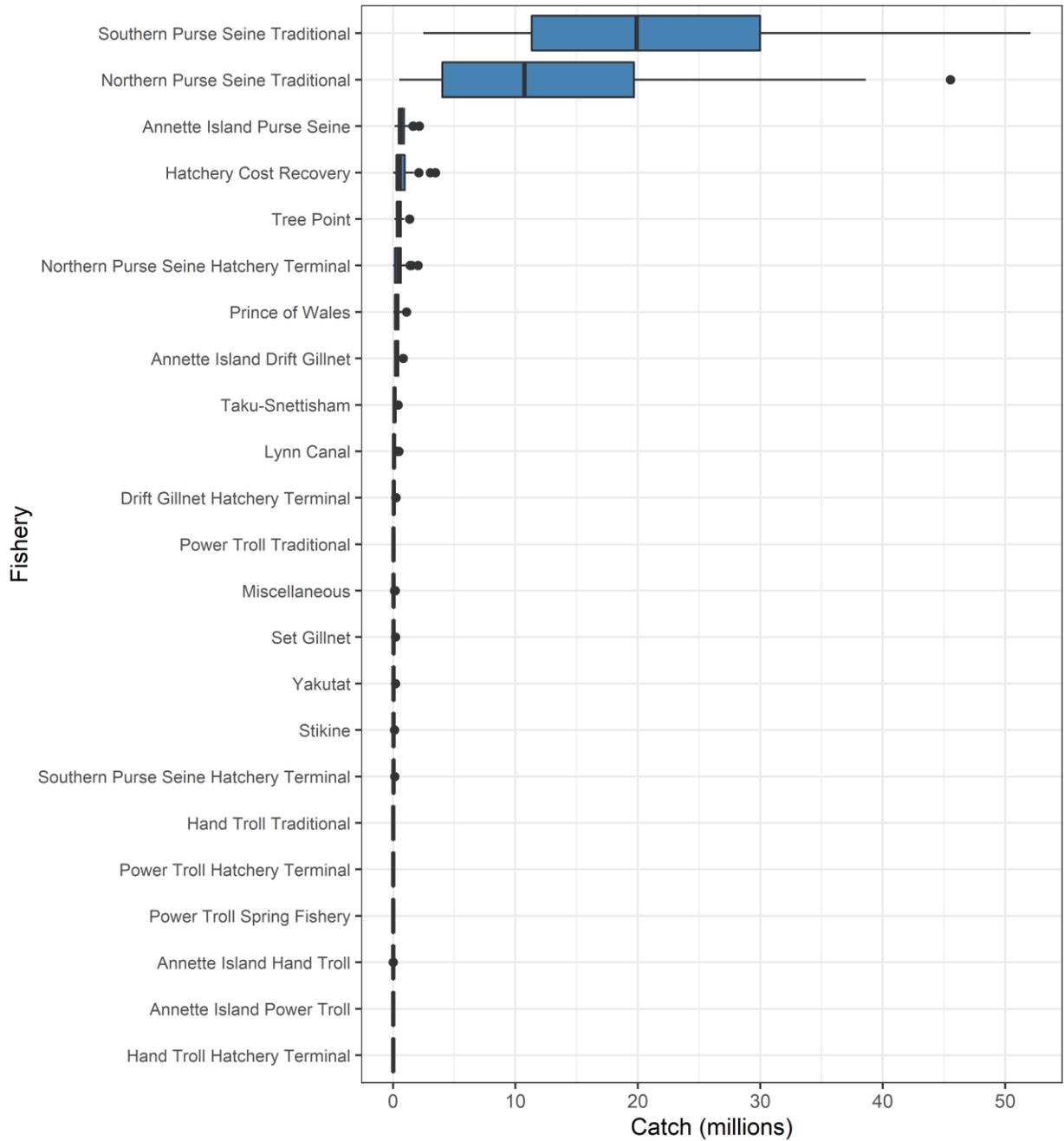


Figure 4: Distribution of total pink salmon commercial catch in SEAK “Blue Sheet” fisheries 1980-2021. Fisheries are ordered from highest catch to lowest catch. The thick black line is the median value, the box in indicates the interquartile range (25<sup>th</sup> to 75<sup>th</sup> percentiles – or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

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

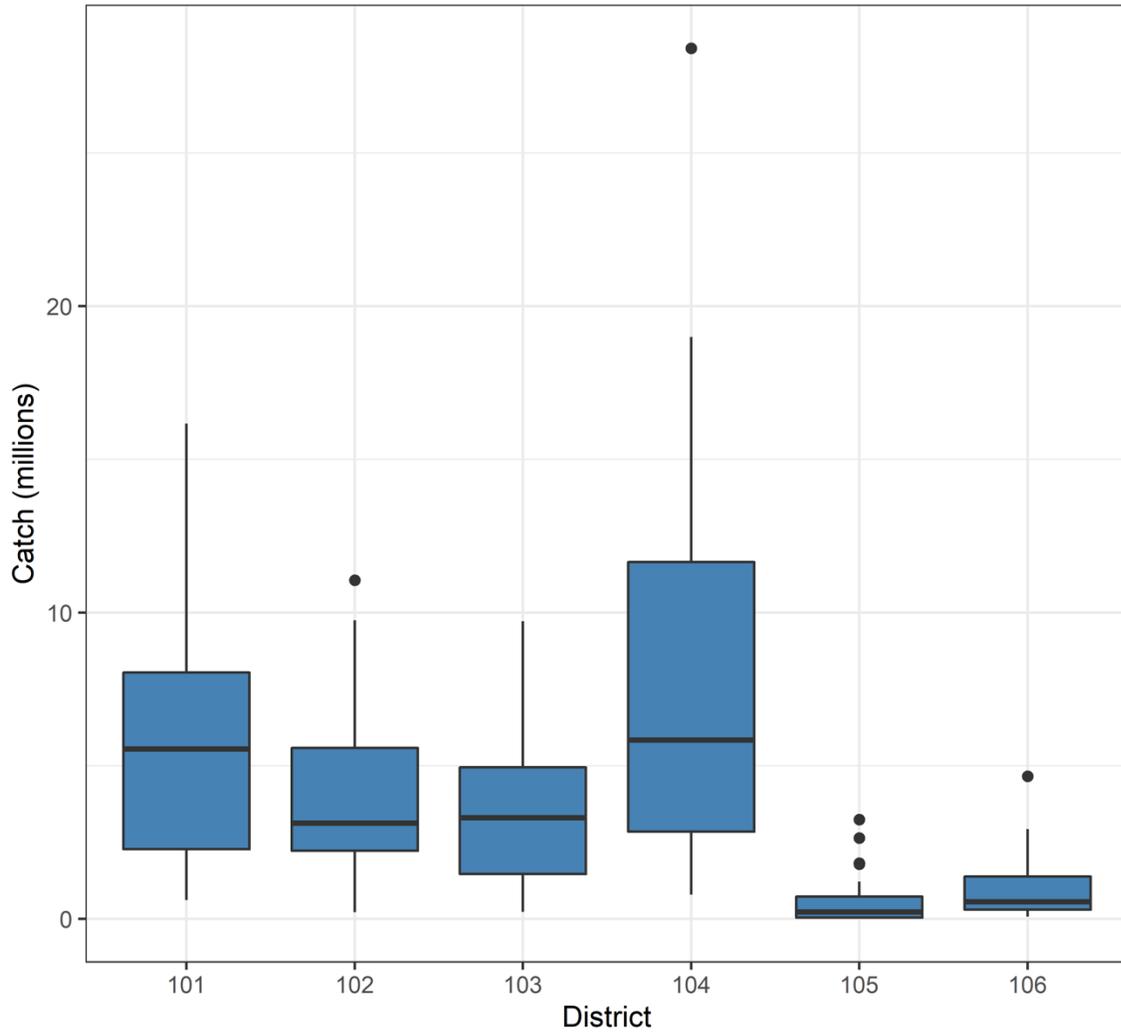


Figure 5: Median catch of pink salmon from all gears in SSEAK fisheries by district (districts 101-106) from 1985-2021. The thick black line is the median value, the box indicates the interquartile range (25<sup>th</sup> to 75<sup>th</sup> percentiles – or middle 50% of the data), whiskers are 1.5x the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

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

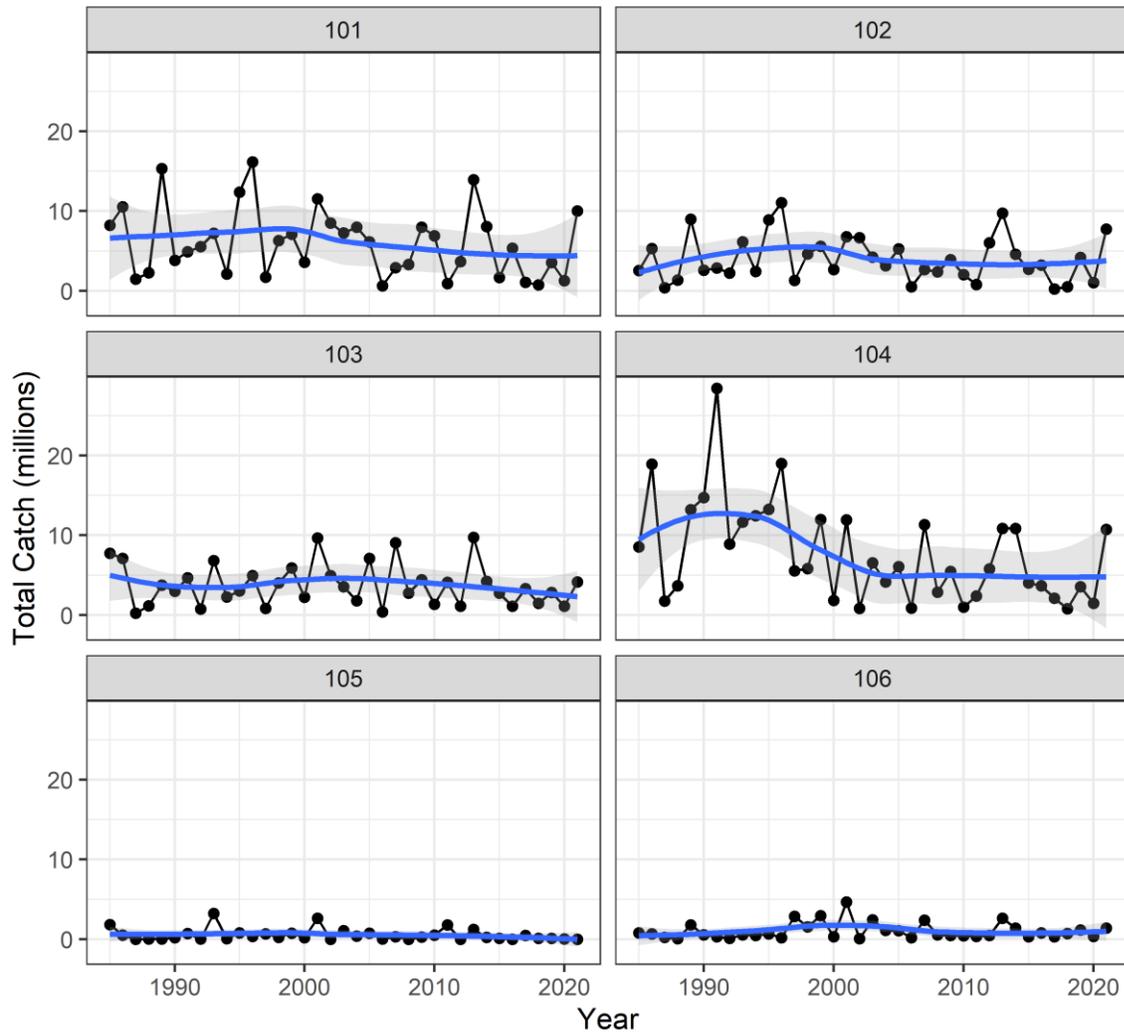


Figure 6: Total catch of pink salmon by year for SSEAK Districts 101-106 (1985-2021). Smoothed lines are derived by LOESS with standard errors shown in grey. Source: ADFG 2021d.

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

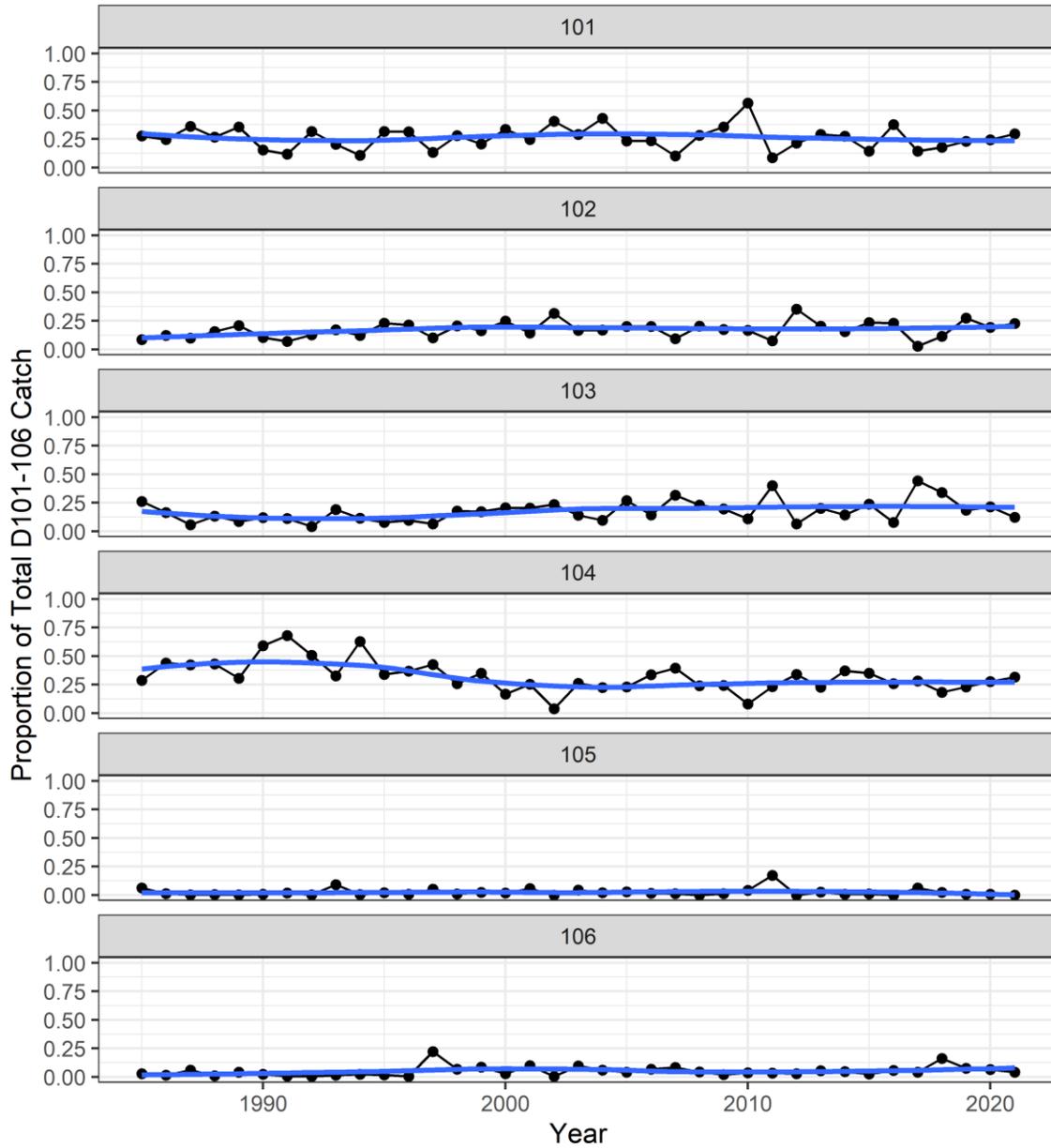


Figure 7: Proportion of total SSEAK District 101-106 pink salmon catch (all gears) by year for 1985-2021. Blue lines are estimated by LOESS fits. Source: ADFG 2021d.

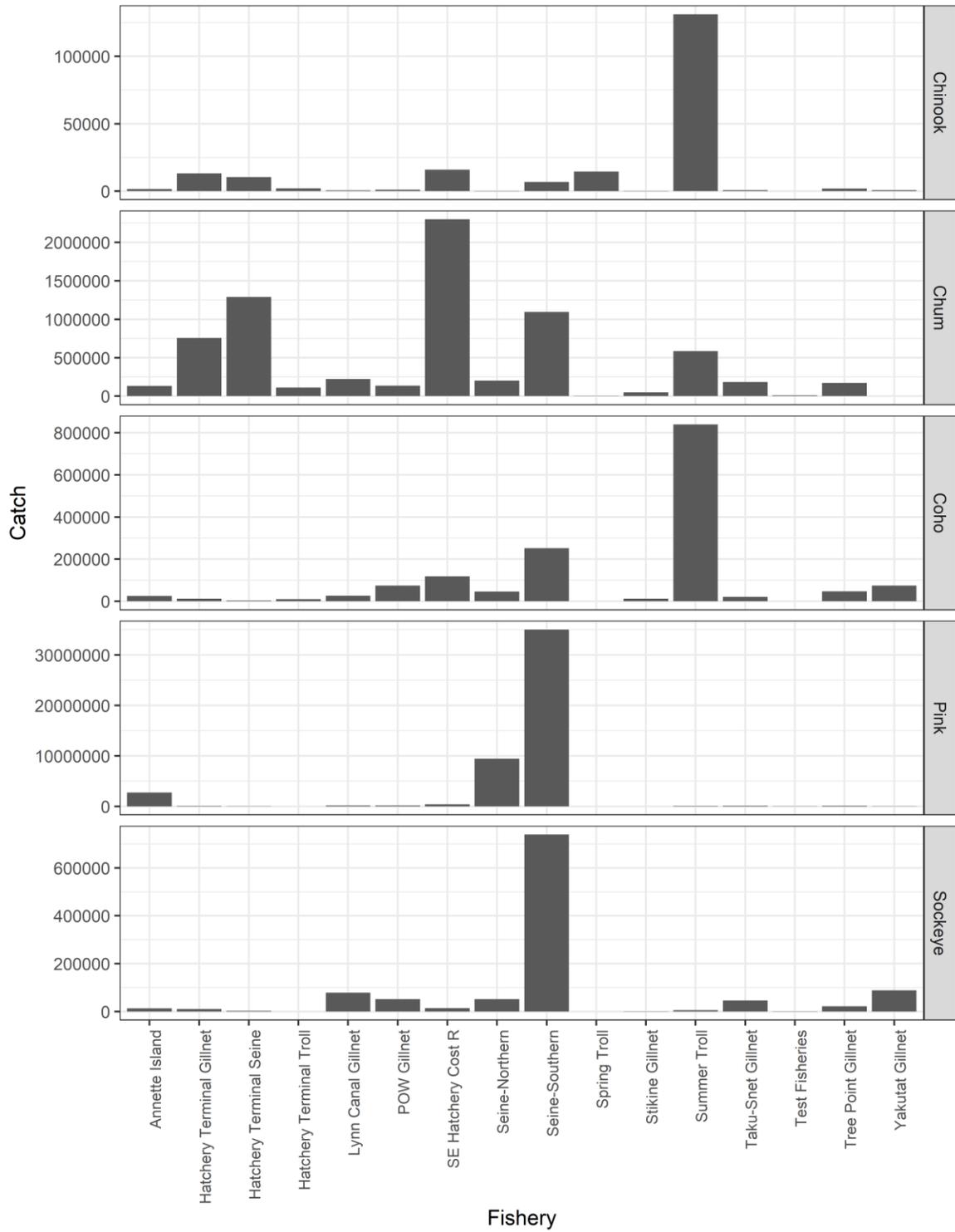


Figure 8: Harvest of all salmon species in SEAK “Blue Sheet” commercial fisheries in 2021. Source: ADFG 2021b.

### Weekly Harvest of Pink Salmon by Gear Type District 104: 2021

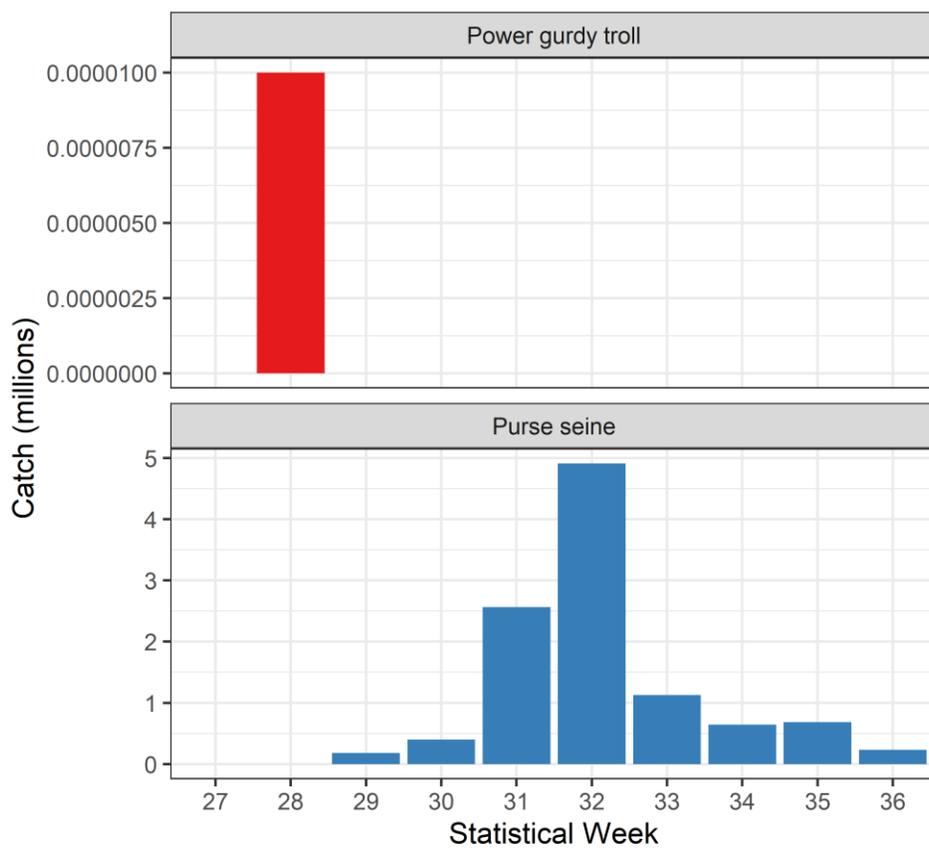


Figure 9: Weekly catch of pink salmon (millions) in District 104 fisheries by gear type for 2021. Note y-axis scales are not the same between panels. Source: ADFG 2021e.

## SEAK and CDN Exploitation Rates

PinkEven (1954-2017)

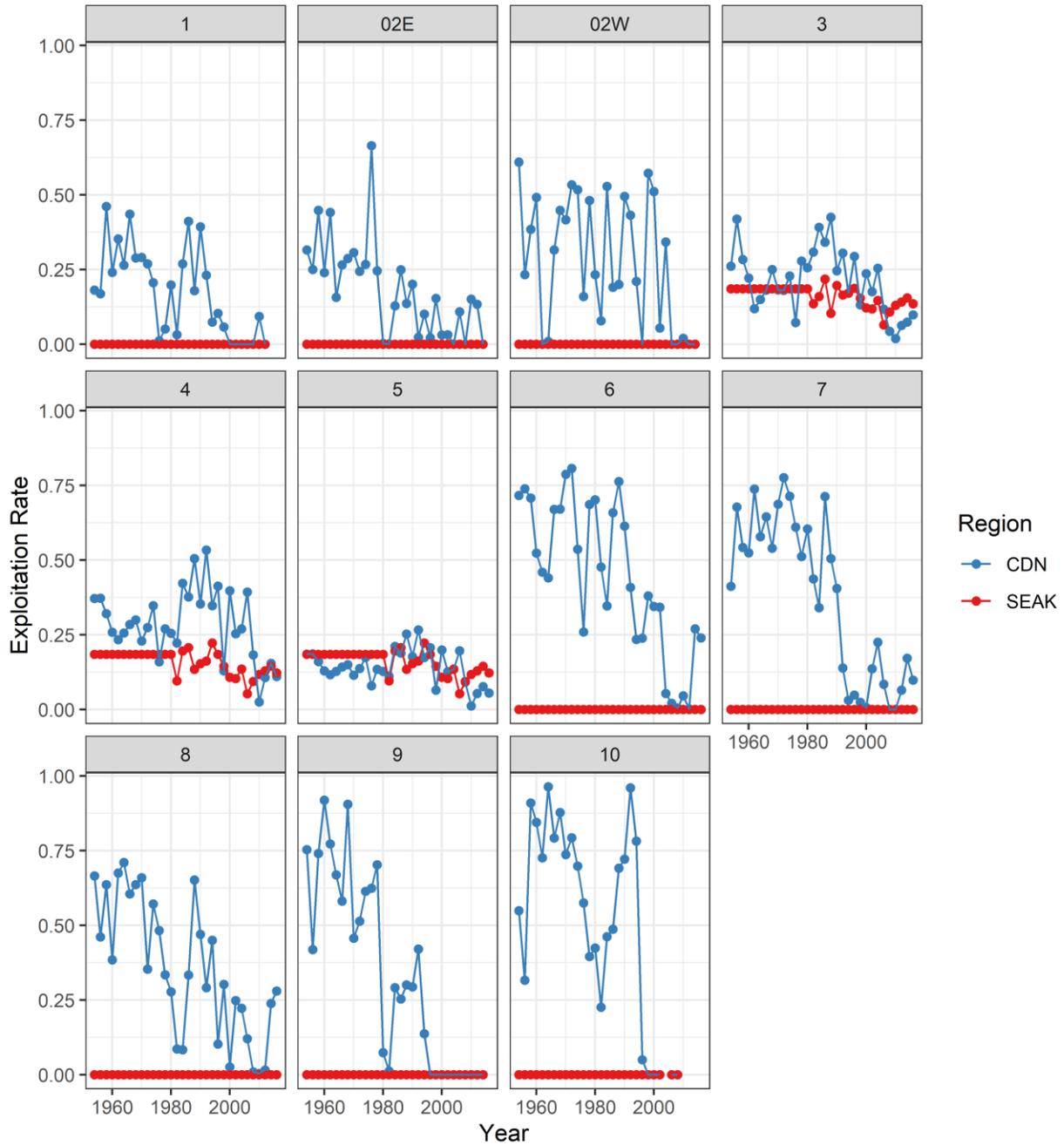


Figure 10: SSEAK (red) and Canadian (blue) exploitation rates by year for north and central coast (Statistical Areas 1-10) even-year pink salmon from 1954-2017. Source: PSF 2021.

## SEAK and CDN Exploitation Rates

PinkOdd (1955-2017)

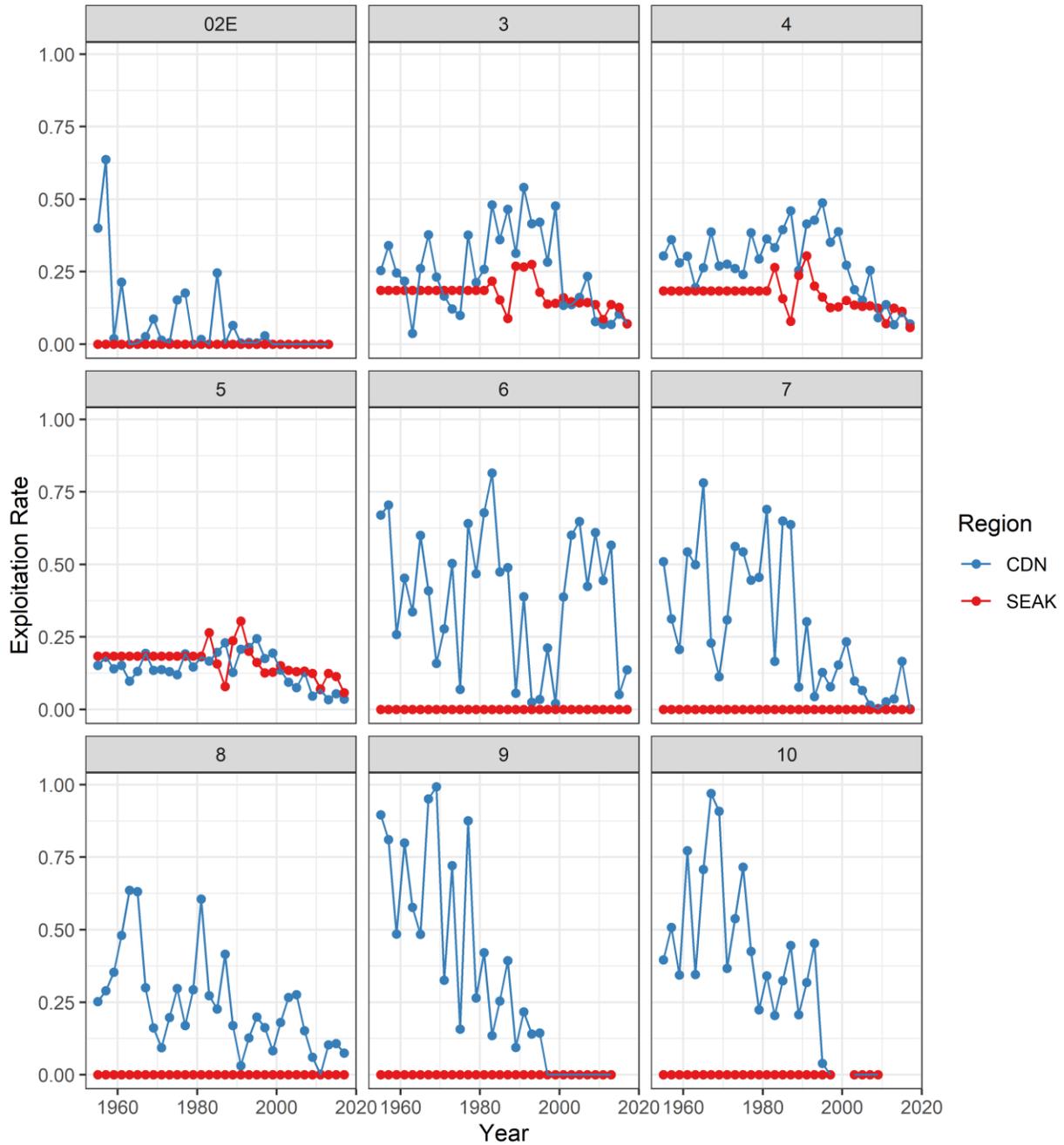


Figure 11: SSEAK (red) and Canadian (blue) exploitation rates by year for north and central coast (Statistical Areas 1-10) odd-year pink salmon from 1954-2017. Source: PSF 2021.

## SEAK Percent of Total Harvest Pink Salmon (1954-2017)

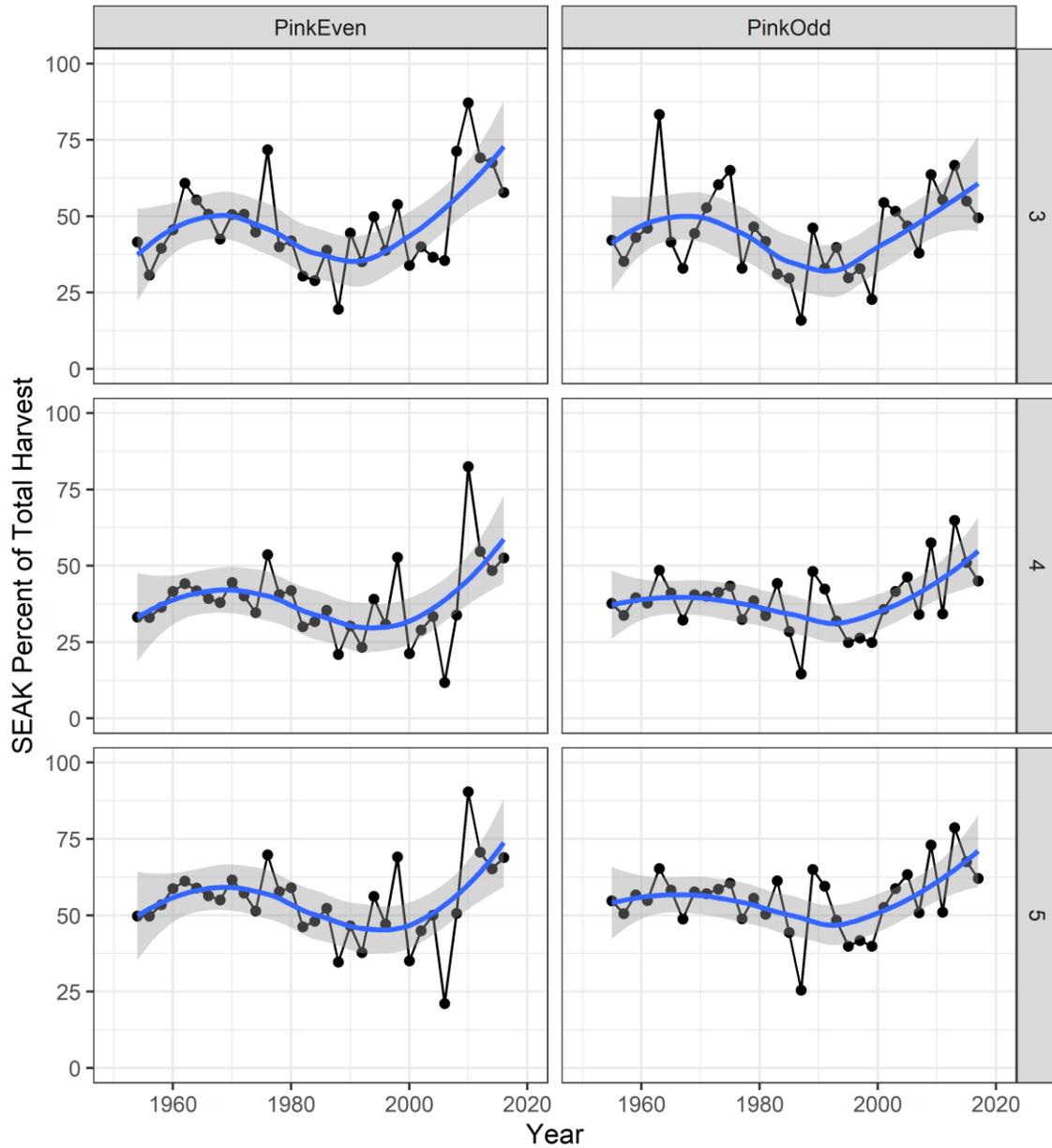


Figure 12: Percent of exploitation attributed to SSEAK for even and odd year pink salmon from Areas 3,4, and 5 from 1954-2017. Trend lines and SEs were derived using LOESS in R. Source: LGL 2021.

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

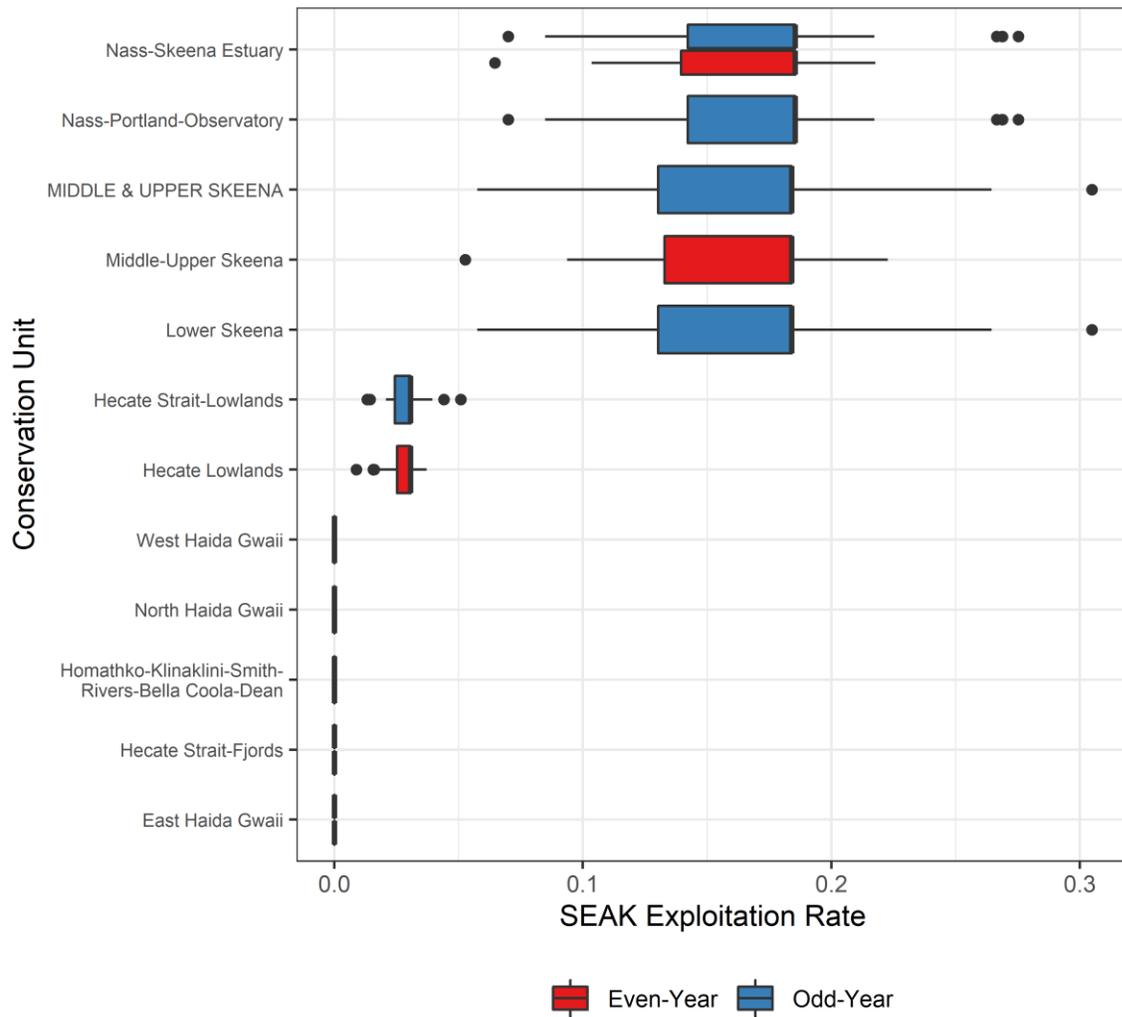


Figure 13: Boxplot of SSEAK exploitation rates on even- (red) and odd (blue)-year pink salmon North and Central Coast BC Conservation Units for 1954 to 2017. CUs are ordered from highest median exploitation rate to lowest. Source: PSF 2021.

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

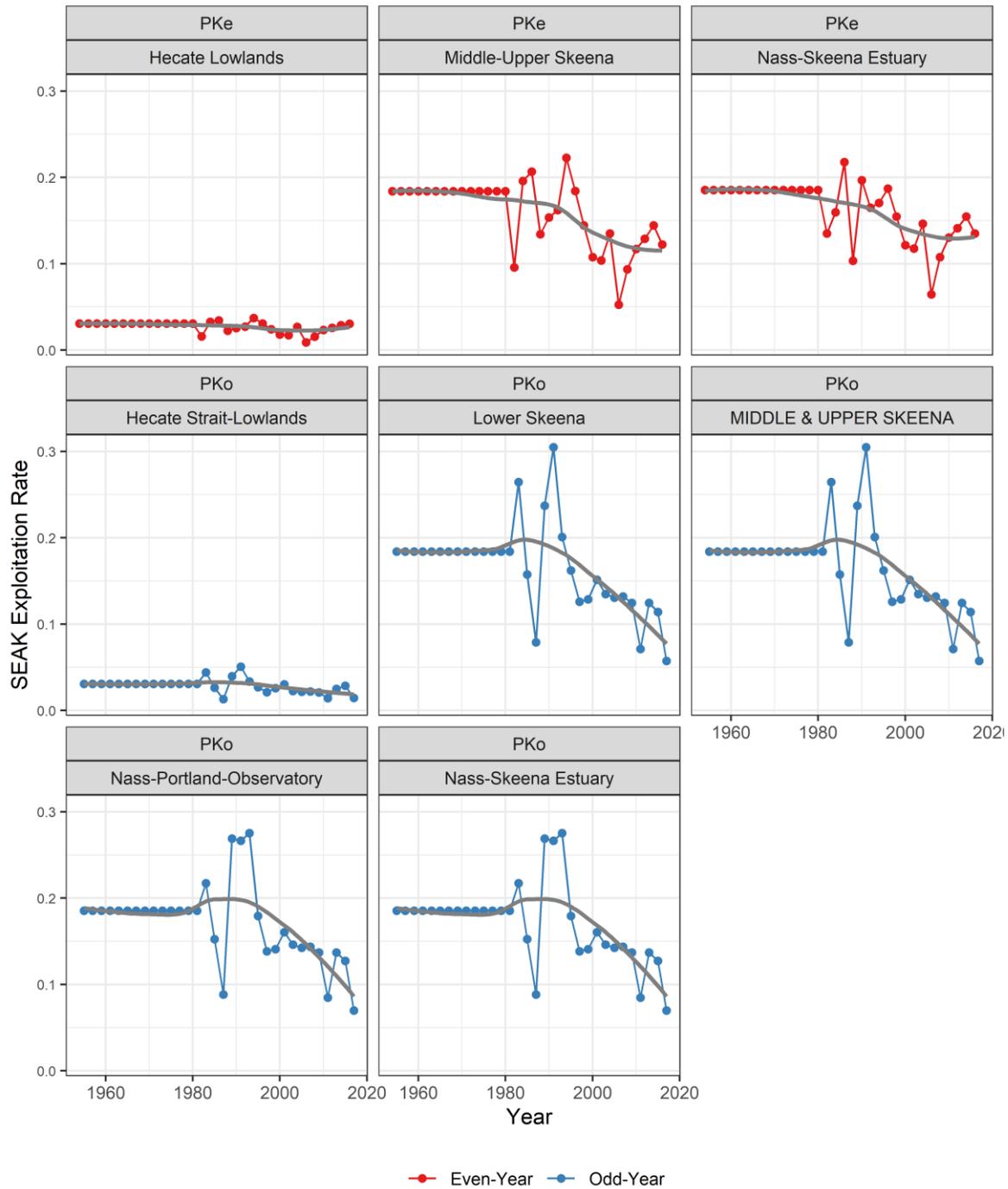


Figure 14: SSEAK exploitation rates for even (red points) and odd (blue points) year pink salmon from north and central coast Conservation Units from 1954-2017. Trend lines derived using LOESS in R. Source: PSF 2021.