Alaskan Interceptions of BC Salmon: State of Knowledge

Report Series Summary

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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

Abstract

Alaskan fisheries intercept and catch salmon of all species from British Columbia (BC) in Southeast Alaska (SEAK). There is growing concern that as Canadian salmon abundance declines, and Canada closes or restricts its fisheries, Alaskan catch continues to have an impact on Canadian salmon and steelhead populations. Information gaps regarding the assessment of stock and species composition, and catch reporting in Alaskan fisheries, are increasing the risk to Canadian salmon caught in these fisheries. Fisheries located in southern Southeast Alaska (SSEAK, Alaskan Fishing Districts 101-106) are where most BC salmon (excluding Transboundary Rivers) are caught. While fisheries intercepting BC salmon populations occur throughout SEAK, this report focuses mostly on southern Southeast Alaska (SSEAK) and District 104.

In 2021, SSEAK net fisheries from Districts 101-106 caught over 50,000 Chinook (net only), over 1.2 million chum, ~540,000 coho, 34 million pink, and ~800,000 sockeye. The District 104 fishery - located on the outside of the Alaskan panhandle - is where the largest proportion of Canadian salmon and steelhead are caught. The total salmon catch in District 104 during 2021 was ~20,000 Chinook (power troll and seine combined), over 212,000 chum, ~130,000 coho, ~10.7 million pink, and ~495,000 sockeye. The proportion of Canadian salmon in the catch, and the certainty of the estimates, varies by species.

We provide a 'State of Knowledge' on SSEAK catch of BC salmon and steelhead that compiles and summarizes historical and recent information. Information on SSEAK catch (either information or data) were obtained through discussions with staff from Department of Oceans and Fisheries (DFO), Alaska Department of Fisheries and Game (ADF&G), and LGL Limited, and other agencies, and many additional resources were found online through the Pacific Salmon Commission Technical Committee websites, the Pacific Salmon Foundation Pacific Salmon Explorer, LGL Limited, and published literature and reports. Products of this work include the following technical summary, 100+ page data report, and R-code for figures and data summaries.

This report provides information that indicates significant Alaskan exploitation on many BC stocks, such as Area 3 (Nass), 4 (Skeena), and 5 (coastal streams south of the Skeena), coho, chum and pink salmon, other North and Central Coast Chinook and coho, Fraser River sockeye, and Chinook from Vancouver Island, Strait of Georgia, and some Fraser River populations. Importantly, these impacts continue despite declines in abundance of many species in BC. Additionally, catch of Canadian-bound salmon in most recent years is highest in Alaska. Data quality and quantity vary between species and regions. While several models provide estimates of catch based on previous tagging studies, historical effort/catch relationships, stock composition (known or inferred), and migration timing, these models are based on assumptions that generate considerable uncertainties.

While the inclusion of details for all data sources, expansions, and models is beyond our scope, we provide citations for many reports where further details are included. Rather than thoroughly review specific methodology, we collate and present available information, and highlight important considerations for further discussion.

Given the current depressed status of many wild populations across BC, and in the context of changing marine and freshwater environments due to various threats such as land use, forestry practices, and climate change, further examination of SSEAK impacts on BC salmon appears warranted.

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).

Summary

Alaskan fisheries intercept and catch salmon of all species from British Columbia (BC) in Southeast Alaska (SEAK). There is growing concern that as Canadian salmon abundance declines and Canada further restricts its fisheries, the relative impact of Alaskan catch of Canadian salmon and steelhead populations may be increasing. There are further concerns that information gaps are increasing the risk to many BC populations given their depressed state.

While fisheries intercepting BC salmon populations occur throughout SEAK and other areas of Alaska, this report focuses mostly on salmon directed fisheries in southern Southeast Alaska (SSEAK). The objective of our report is to provide a 'State of Knowledge' on SSEAK catch of BC salmon and steelhead trout, including historical and recent estimates of catch and exploitation for populations where information exists. Furthermore, we provide more detailed information in some 'data-rich' areas on the location and timing of these fisheries. Background information on Alaskan catch and pink salmon abundance is included for additional context. Concerns regarding assumptions and information gaps in current assessment methods are identified, with recommendations to guide further discussion.

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) to complete this 'State of Knowledge', and reviewed current assessment methodologies (e.g., Northern Boundary Sockeye Run Reconstruction Model). Some analyses were completed to explore potential exploitation of steelhead in Alaskan fisheries using information from sockeye, and the potential mortalities of BC Chinook in District 104 seine fisheries.

Estimates of Alaskan catch of BC salmon were quantified from multiple sources, and required an extensive effort to compile, including numerous discussions with staff from DFO Stock Assessment (North and Central Coast, West Coast Vancouver Island Strait of Georgia, and Fraser regions), LGL Limited, the Pacific Salmon Commission, the Pacific Salmon Foundation, and Alaska Department of Fish and Game. Much information was found online through the Pacific Salmon Commission Technical Committee website and reports, as well as other publications from various agencies, and in the primary literature. To aid in future discussions, we will be compiling all available information into a data package, including a code package to re-produce figures from this report.

First, we outline several contextual comments for the reader to better understand the scope and nature of our report:

1. This is a preliminary summary of information, with some basic analysis, which is not meant serve as a complete and definitive report. Rather, we hope that it will serve to continue and expand discussions so that a complete set of reports can be developed to hold all available information on US (beyond just SSEAK) interceptions of BC salmon in a publicly available and accessible manner. We invite feedback and welcome additional information that may have been missed.
2. While the scope of our report is limited to SSEAK catch of BC salmon, we aim to expand to transboundary and other fisheries that catch BC salmon (e.g., Alaskan trawl, Fraser sockeye, chum and pink, etc.).
3. Many of the stocks/populations of salmon that are caught in SSEAK are at depressed or highly depressed levels of abundance (e.g., North and Central Coast BC chum, some Skeena and Fraser sockeye populations).

4. Canadian fisheries (subsistence, recreational, and commercial) have been severely reduced in recent years due to low abundance for some population in some years; SSEAK often has the largest commercial catch of BC salmon.
5. There are numerous assumptions and uncertainties in the information presented here that simply could not be detailed in full (e.g., expansions of Coded-Wire Tag information, etc.); however, we try to identify reference materials (e.g., PSC Chinook Technical Committee reports, etc.) that may provide further details for the reader.
6. Some of the information presented is based on studies that were completed 35+ years ago.
7. There have been recent shifts in terminal run-timing that suggest there could be changes in where and when salmon are present in SEAK fisheries.
8. 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.
9. 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 (Grant et al., 2019)[1].
10. Commitments by the Canadian government to protect, recover, and sustainably manage BC salmon and steelhead in the recently announced Pacific Salmon Strategy Initiative (PSSI) warrant expanded efforts to understand and address uncertainties in exploitation in both SEAK and BC fisheries.

Key findings

SSEAK Harvest

- Southern Southeast Alaskan catch of salmon is significant, typically in the tens of millions, and dominated numerically by pink salmon.
- Chinook and coho are caught predominantly in troll fisheries, with some catch in seine fisheries, and limited catch in gillnet fisheries.
- Most pink salmon are caught in seine fisheries, and most chum are caught in seine fisheries and terminal-hatchery fisheries.
- Most sockeye are caught in southern purse seine fisheries, with some caught in gillnet fisheries.
- In 2021, SSEAK (Districts 101-106) commercial fisheries caught over 50,000 Chinook, over 1.2 million chum, ~540,000 coho, 34 million pink, and ~800,000 sockeye.
- In 2021, the District 104 fishery alone (power troll and seine combined) caught ~20,000 Chinook (see comments on seine fisheries below), over 200,000 chum, over 130,000 coho, over 10 million pink, and ~500,000 sockeye salmon.

[1] Grant, S.C.H., MacDonald, B.L., and Winston, M.L. 2019. State of Canadian Pacific Salmon: Responses to Changing Climate and Habitats. Can. Tech. Rep. Fish. Aquat. Sci. 3332. ix + 50 p.

SSEAK Pink and Chum Production

- SSEAK pink salmon production is predominantly 'wild' and returns to inside SSEAK systems. There are no index systems and little production from the District 104 area located on the outside of the Alaskan panhandle.
- The situation is similar for SSEAK wild chum salmon production, there are no index streams and little production in the District 104 area.
- We could find little information on the proportion of wild and enhanced chum in common property seine fisheries by District.

SSEAK interceptions of BC Salmon

There is significant catch of all species of BC salmon in SSEAK fisheries; however, exploitation, information quantity and quality, and certainty in estimates vary substantially between species and Districts. Estimates of BC salmon caught in SSEAK in 2021 are limited, with preliminary information available for some species and areas, but not most. The following provides a summary of key findings by species.

Sockeye Salmon

- In 2021, SSEAK fisheries caught a total of ~800,000 sockeye salmon, mostly in seine fisheries. Sockeye (~21,000) also were caught in the Tree Point gillnet fishery.
- SSEAK catch of Skeena, Nass, and Area 5 sockeye has been significant in recent years. The Alaskan commercial marine catch has exceeded the Canadian commercial marine catch in 7 of the last 10 years (Skeena) and 5 of the last 6 years (Nass), based on Northern Boundary Sockeye Run Reconstruction (NBSRR) model outputs.
- BC sockeye from areas other than the Fraser, Skeena and Nass Rivers are present in these fisheries in most years.
- SSEAK exploitation of some depressed Skeena sockeye Conservation Units has been high (e.g., Babine Late-Wild and Kitwanga), relative to the Skeena aggregate.
- The District 104 seine fishery captures 50% to 75% of all Skeena sockeye caught in SSEAK, and between ~10% and 50% of all Nass sockeye.
- Fraser sockeye are also caught in SSEAK fisheries, and can constitute more than 50% of the total sockeye catch in District 104 in the latter part of August.
- SSEAK catch of Fraser sockeye exceeded Canadian catch in 2019, and likely will do so again in 2021.
- Although formal estimates of SSEAK catch of BC sockeye are not yet available for 2021, preliminary information suggests significant catch of both Nass (~101,000) and Skeena (~280,000) sockeye in SSEAK fisheries (predominantly in District 104). There was no Canadian commercial catch of sockeye in the Skeena and Nass in 2021. This represents an SSEAK exploitation rate for both stocks of ~ 20%.
- The 2021 commercial catch of sockeye salmon in north and central BC was limited, with little marine commercial catch, and only limited treaty catch in Area 3 (~40,000).
- There is evidence of a shift to later run-timing for Skeena and Nass sockeye which may mean that provisions in the Pacific Salmon Treaty that limit the number and duration of D104 seine fisheries prior to Week 31 (end of July) may be less effective than intended.

Chinook Salmon

- In 2021, SSEAK fisheries caught ~51,000 Chinook, mostly (66%) in the summer troll fishery. Chinook non-retention was required for most 2021 SSEAK seine fisheries.
- Unlike Canadian seine fisheries, Alaskan fishers are not required to sort their catch, release non-target species with the least possible harm, record bycatch in logbooks, or have independent monitoring of their fisheries.
- Historical and current estimates of SEAK exploitation of BC Chinook are largely derived from Coded Wire Tag (CWT) information from indicator stocks. However, Genetic Stock ID (GSI) methods have also been used more recently to estimate stock composition in SEAK troll and sport fisheries.
- Information from the PSC Chinook Technical Committee (mortality distribution tables) from CTC indicator populations indicate that BC Chinook are caught predominantly in SSEAK troll fisheries, where exploitation rates are typically 10-20% for many stocks (and higher in some years). North migrating stocks with high exploitation rates include West Coast Vancouver Island (Robertson), East Vancouver Island (Big Qualicum, Puntledge, Quinsam, and Phillips), north and central coast (Atnarko and Kitsumkalum), and some Fraser River populations (Middle and Lower Shuswap).
- Estimates of SEAK exploitation on Cowichan, Nicola, Harrison, Chilliwack, and Dome (limited to 1990-2007) and Nanaimo (1990-2007) are very low (< 1%).
- Terminal SEAK fisheries catch very few north and south coast BC Chinook; however, Transboundary Alsek, Taku, and Stikine stocks are harvested in SEAK in directed abundance-based SEAK fisheries (including gillnet), as well as incidentally in terminal sockeye gillnet, sport, and personal-use fisheries. Stikine Chinook also are harvested in SEAK non-terminal sport and troll fisheries.
- Of the stocks where SEAK exploitation rates are greater than ~5% in most years, almost all show trends towards lower SEAK exploitation rates in recent years (with the exception of Puntledge).
- Coded Wire Tags (CWT) are analyzed by removing the tags from salmon heads recovered from troll, net, and recreational fisheries. A higher proportion of heads, and therefore tags, is recovered in Alaskan fisheries head recoveries from than from BC fisheries (mainly FSC and recreational), leading ADF&G to suggest that CWT analyses may be biased.
- While Chinook are targeted in troll fisheries, they are considered bycatch in seine fisheries. SSEAK seine fisheries do not permit the retention of chinook for sale for most of the season. Estimates of legal and sub-legal encounters and incidental mortalities are provided in Pacific Salmon Commission Chinook Technical Committee (CTC) reports by gear (e.g., purse seine); however, information on individual fisheries/areas are not provided, nor are methodologies for how estimates of Chinook total mortalities are derived.
- In 2021, approximately 5,800 Chinook were retained in District 104 seine fisheries during one period of retention (~2 days). We do not have estimates of encounters or incidental mortality for 2021; however, there were significant numbers of legal releases as well as sub-legal releases in 2020 and 2019, and corresponding incidental mortality.
- We were not able to determine if releases were sampled for either CWT or GSI to derive stock composition estimates, or if releases were available at a District or even fishery level. Moreover, regulations allow fishers to retain, but not report, certain sizes of Chinook, further complicating the issue.

- Reports completed in 1987 and 1988 surveyed fishers on numbers of Chinook released, retained for personal use, or retained for sale. The reports estimated that total mortalities of Chinook were many times higher than what was reported on sales slips. We could not find similar reports for recent years.
- Formal estimates of SEAK exploitation on BC Chinook salmon in 2021 will be produced by the PSC Chinook Technical Committee, and will not be available until late 2022/early 2023. However, it is reasonable to assume that there was similar exploitation of north-migrating Chinook populations as in recent years.
- In 2021 BC fisheries caught ~ 64,000 chinook were caught in Area 1-10 (north and central coast) mixed-stock troll fisheries (predominantly south coast stocks), with another 36,000 caught in sport fisheries in Areas 1, 2W, and 3/4. In southern BC, there were terminal seine and gillnet fisheries on WCVI Chinook targeting Somass Chinook, and large recreational fisheries both on the WCVI and ECVI. Final catch numbers are not available, and will be reviewed by the PSC CTC over the next year.
- In addition, because most BC fisheries – other than terminal ones – employ non-retention, final estimates of total mortalities can be much higher than catch estimates.

Coho Salmon

- In 2021, SSEAK fisheries caught over 540,000 coho.
- In 2021, ~130,000 coho were caught in District 104, with 73% (~97,000) caught in the purse seine fishery.
- Estimates of SEAK exploitation of BC coho are largely derived from CWT information from indicator populations and modelling.
- Information from north coast (Skeena and Nass) coho indicators indicates that SSEAK exploitation is typically 2.5- to 5-fold higher than Canadian exploitation (Nass), with SSEAK exploitation on Nass coho ranging from ~20% to 60%, and ~30% to 50% on Skeena coho. Much like Chinook indicator stocks, this information is stock specific, but is used as an indicator for surrounding populations.
- SSEAK catch represents ~75% of the total catch in most years for both Skeena and Nass coho.
- There are no CWT exploitation rate indicator stocks on the central coast, so estimates of SSEAK catch and exploitation are derived from Area 3 and 4.
- A soon to be released report from the Pacific Salmon Commission on north and central coast coho may contain updated estimates of SEAK exploitation of coho salmon, and our report will be updated upon review of the PSC report.
- SSEAK exploitation of South coast coho is likely very low (~1%), based on Coded Wire CWT recoveries and modelling (FRAM model) completed by the PSC Coho Technical Committee.
- Estimates of SSEAK exploitation of BC coho are not yet available for 2021, however recent information suggests that SEAK coho exploitation will likely remain high on north coast (Skeena and Nass ~20-40%) and very low on the south coast.
- In 2021, ~200,000 coho were caught in north and central BC, primarily in mixed stock troll and Area 1 and 3/4 sport fisheries.

Pink Salmon

- In 2021, SSEAK fisheries caught over 34 million pink salmon.
- In 2021, approximately 10.7 million pink salmon were caught in the District 104 purse seine fishery.

- Recent estimates of SSEAK exploitation of north coast pink salmon are based on an Effort-Harvest Rate model (Area 3, 4, 5 Pink and Chum Exploitation Rate Model produced for the Pacific Salmon Foundation by LGL Limited). The model is based on tagging studies completed in the 1980s and historical effort-catch relationships from the late 1980s/early 1990s when BC's seine fleet was many times larger than today and fished under much less restrictive regulations.
- The only areas in BC for which SSEAK exploitation of BC pink salmon is estimated is on the north coast: Areas 3, 4 and 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. In some years tagged pink salmon were recovered in central coast areas and as far south as WCVI and Johnstone Strait. Considering Canadian stock compositions by week in D104 (in excess of 10% in some periods) from tagging studies relative to the 10 million pink salmon pink salmon caught in D104 in 2021, the catch of Canadian origin pink salmon may have been significant depending on numbers available to the fishery and their vulnerability.
- We were unable to find any information on Alaskan catch of southern BC pink salmon other than described in the NOAA report summarising the 80s tagging studies.
- Estimated exploitation rates in SSEAK on pink salmon from Areas 3, 4, and 5 range from 10-30% in most years, with very little difference between odd and even years.
- There is little information on SSEAK exploitation rates of pink salmon from other north and central coast Areas, including many places in the Great Bear Rainforest and other areas of BC's central coast, although the results of the tagging studies in 1984 and 1985 indicate that central and southern B.C. pinks are caught in SSEAK pink fisheries
- Since 1980, both Canadian and SSEAK pink salmon exploitation rates have been declining, however, Canadian exploitation rates have declined much more than SEAK exploitation rates.
- Formal estimates of exploitation rates on BC pink salmon using the current Effort-Harvest model are not available yet for 2021; however, if exploitation rates remain similar to the most recent years, then exploitation rates of approximately 10% would be expected. There were no pink salmon fisheries during the summer in Areas 3 -10 in BC in 2021. However, there was a fishery in Area 1 on Haida Gwai in late August that caught 270,000 pink salmon.
- Over the long term, SSEAK exploitation has comprised ~50% of the total SSEAK and Canadian exploitation (CDN includes all catch: commercial, Food, Social, and Ceremonial, and sport); however, that proportion has increased in recent years (since the early 2000s), likely due to declines in abundance of BC pink salmon.
- SSEAK pink salmon production is much larger than Canadian pink production, so even modest catch in Alaska that targets Alaskan pink salmon could have significant impacts on Canadian pink salmon.
- Alaska does not assess pink salmon stock composition in District 104 fisheries. The abundance of Alaskan relative to Canadian pink salmon in District 104, and limitations in fine scale genetic resolution for pink salmon, may make the use of GSI techniques too challenging and expensive.

Chum Salmon

- In 2021, SSEAK fisheries caught over 1.2 million chum salmon.
- In 2021, just over 200,000 chum salmon were caught in the District 104 purse seine fishery.
- There are no direct estimates of SEAK exploitation of north coast chum salmon. Current estimates are based on pink salmon SEAK exploitation rates derived by the Effort-Harvest rate model described above.

- Very few chums were tagged in the tagging studies completed in the early 1980's.
- The only areas where SSEAK exploitation of BC chum salmon is estimated on the north coast is Areas 3, 4, and 5.
- As for pink salmon, there is little information on SSEAK exploitation on chum salmon returning to Haida Gwaii, areas of the Great Bear Rainforest other than Areas 3, 4, and 5, and BC's central coast.
- We were unable to find any information on Alaskan interceptions of southern BC chum salmon, including WCVI, ECVI, ISC, and Fraser areas. The later run-timing of southern BC chum salmon suggests interceptions would be minimal.
- Estimated exploitation rates in SSEAK on chum salmon from Areas 3, 4, and 5 are typically less than 20%, though some years are 30%. There is no difference in odd versus even year catch rates. These are likely near, or possibly above, the total allowable exploitation rates for unproductive or depressed chum populations.
- Since 1980, both Canadian and SSEAK exploitation rates on BC Areas 3, 4, and 5 chum salmon have been declining; however, Canadian exploitation rates have declined much more than SSEAK exploitation rates, with Canadian exploitation rates near zero in most years since 2010 in Areas 4 and 5, and Area 3 below 10% since ~2000.
- Historically, SEAK exploitation has accounted for ~50% of total exploitation (Canadian includes all catch: commercial, FSC, and sport); however, in recent years (since the early 2000s), that proportion has increased dramatically concurrently with the decline in Canadian catch, and in recent years has accounted for nearly all catch.
- Formal estimates of exploitation on BC chum salmon are not yet available for 2021; however, exploitation rates of approximately 10% would be expected if exploitation remains similar to recent years.
- There were extremely low catches of chum salmon in Areas 1-10 in BC in 2021, with most areas closed and only limited opportunities for Food, Social, and Ceremonial fisheries. Because Canada has not developed benchmarks or reference points for its north/central coast chum stocks, it is not possible to comment on current exploitation rates relative to stock status.

Steelhead Trout

- We were unable to find any information on current SSEAK exploitation of BC north or south coast steelhead trout, either in terms of reported catch in SSEAK fisheries or data on exploitation rates. It is unknown how many steelhead were encountered in the District 104 fisheries.
- Since 1997, steelhead may only be retained for personal use in SEAK fisheries, and are not required to be recorded or reported. The North Pacific Anadromous Fish Commission database does not contain any steelhead catch estimates since 1997 for SEAK.
- In 2021, the Skeena River steelhead return was the lowest on record (~5,400 to September 29), and far below the Extreme Conservation Concern Zone.
- In 2021, an unknown number of BC steelhead were encountered in SSEAK fisheries; however, there likely was a significant impact on Skeena River steelhead in SSEAK fisheries given that terminal run-timing is similar to late-timed Skeena River sockeye stocks, there is similar vulnerability to fisheries, and high release mortality.

Uncertainties and Recommendations:

1. Estimates of SSEAK exploitation of BC chum are inferred from pink salmon exploitation rates using an Effort-Harvest model based on tagging studies from the 1980s, and effort-catch relationships from the late 1980s and early 1990s. Given the current biological status of BC chum, especially on the north and central coast where SSEAK exploitation is likely to be highest, we recommend sampling chum in SEAK non-terminal net and troll fisheries (otolith, then GSI) to estimate stock composition, focussed on Districts 104 and 101.
2. Estimates of SSEAK exploitation of BC pink salmon are made using an Effort-Harvest model (see above) based on tagging studies from the early 1980s and effort /harvest relationships from the late 1980's and early 1990's when BC's seine fleet was many times larger than today and fished under much less restrictive regulations.
3. In that the tagging studies completed in 1984 and 1985 identified that pink salmon caught in SSEAK were recovered as far south as WCVI and Johnstone Straits, and given the current status of BC pink salmon and limited catch in BC in recent years, we recommend sampling (for GSI) pink salmon in SSEAK seine fisheries to provide estimates of the number of BC salmon caught and, where possible, their stock composition. We recognize that given the ratio of abundance (Alaskan pink production is much greater than BC), there could be considerable logistical constraints to this. Preliminary information from recent work on pink Single Nucleotide polymorphism (SNP) baselines in Alaska suggest that there is still low small-scale resolution, and pink salmon only separate out at large regional levels. However, this may be enough information should BC regional groups separate out from Alaskan and Southern US groups.
4. We were unable to find much information on SSEAK interception of BC steelhead. Since 1997, Alaskan regulations prohibit sale of steelhead, and allow retention only for personal use with no reporting requirements. Quantification of steelhead caught and retained for personal use, and quantification of steelhead released from net and troll fisheries - especially in non-terminal south SEAK fisheries - should be discussed. Given the current critical biological status in many steelhead populations in BC, this work would be both timely and a priority in the context of recovering populations.
5. It is difficult to provide an estimate of total Chinook mortalities or stock composition associated with the seine fishery without improved monitoring and assessment of releases and retention for personal use.
6. It may be useful to survey other Alaskan commercial mixed-stock fisheries, similar to the D104 seine fishery, to determine what strategies Alaskan managers employ to decrease risks to salmon stocks or species of conservation concern caught as bycatch to the target species, and ensure management objectives for both the target and bycatch species are achieved.
7. There is limited information that aligns with the scale of Canada's Wild Salmon Policy in terms of Conservation Units. In some instances (e.g., some years, some species), sub-aggregate estimates are made through modelling (e.g., Skeena sockeye) or GSI (Fraser sockeye). We recommend that DFO and ADFG review existing, and design new, assessment programs that can provide opportunities to improve our understanding of exploitation at the sub-aggregate/Conservation Unit level.

Alaskan Harvest of BC Salmon: State of Knowledge

Part 1:

Southeast Alaska Catch of Salmon and Southeast Alaska Pink Salmon Escapements

Version 1

Prepared by:

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Prepared for:

Watershed Watch Salmon Society

Skeena Wild Conservation Trust

January 2022

Preface

This report is part of a series of reports on the 'State of Knowledge' of Alaskan interception of 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 Chinook 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

This report provides background information on catch of salmon and steelhead in SEAK fisheries, as well as information on SEAK pink salmon escapements. Information on Southeast Alaska (SEAK) catch and pink salmon escapement information was compiled from a number of sources. Catch data was available online or provided by Alaska Department of Fish and Game staff. Pink salmon escapement information was extracted from Pison (2021). Table 1 provides a summary of information used in this report.

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

Table 1: Types of data, sources, and year ranges used in this report for SEAK salmon and steelhead catches and pink salmon escapements.

Species	*Region/Area*	*Type of Data*	*Data Source*	*Year*
All	SEAK	Gross earnings and landed catch by Area	ADFG 2021a	1979-2021
	SEAK	Commercial "Blue Sheet" data	ADFG 2021b	1980-2020
	SEAK	Commercial "Blue Sheet" data	ADFG 2021c	2021
	SEAK	SEAK landings by District and Gear	ADFG 2021d	1985-present
	SEAK	District 104 salmon landings by stat week, gear type and species	ADFG 2021e	1985-present
Pink Salmon	District 104	District 104 catch	Piston 2021	1960-2018
	Various	Pink salmon escapements	Piston 2021	1960-2018
Sockeye Salmon	District 104	District 104 sockeye catch	Piston 2021	1960-2018

2 Southeast Alaskan Harvest

This section provides a background on harvest of sockeye, Chinook, chum, pink, and coho salmon in Southeast Alaska (SEAK). It provides important context for discussions of SEAK harvest of BC salmon.

- Figure 1 shows Southeast Alaskan fisheries management areas. Note the location of the District 104 (Noyes and Dall Island) and District 101 (Tree Point) areas.
- Total catch of all species in SEAK commercial fisheries has ranged from ~15 million to ~105 million (Figure 3). Pink salmon dominate catch numbers. Chum salmon are the second most caught, with increases in numbers since the 1980s.
- Harvest value from commercial fisheries from 1979 to 2021 has ranged from approximately 50 million USD to nearly 250 million USD in 2013 (Figure 4). Pink and chum salmon make up ~30% of the overall value, with coho at ~ 18%, and Chinook and sockeye at ~11%.
- Figure 5 shows the harvest and harvest value of all salmon species in SEAK from 1979-2021. Catch of chum salmon increased dramatically in the early 1990s. Catches of Chinook and coho salmon are trending down in recent years. Pink salmon catch is highly variable, with a discernable odd year/even year pattern (odd years being higher). Sockeye catches peaked in the mid-90s and have trended down since. Value is influenced by both the number of fish caught and the price per pound in any given year. Chum salmon now contribute the most value in SEAK fisheries.

- Figure 6 shows the harvest of pacific salmon in SEAK commercial fisheries by species in even and odd years. For all species except pink, there is no difference in median catch between even and odd years. For pink salmon, odd year median catch is significantly higher.
- ADFG "Blue Sheet" harvest data for SEAK commercial fisheries was requested and provided from ADFG for 1979-2020.
    - Figure 7 (Chinook), Figure 8 (chum), Figure 9 (pink), Figure 10 (coho) and Figure 11 (sockeye) show the harvest of salmon by SEAK fishery for 1979-2020. Note that the Troll fishery data was incorrect in the original data provided, and we added data manually for Troll fisheries from 2004 to 2020 using data provided in the annual Run Forecasts and Harvest Projections from the ADFG website.[1]
    - Chinook and coho salmon are caught predominantly in troll fisheries, with some catch in northern and southern purse seine fisheries.
    - Pink salmon are predominantly caught in seine fisheries, but many are also caught in the hatchery cost recovery and hatchery terminal fisheries.
    - Chum salmon are predominantly caught in the hatchery cost recovery fisheries (since hatchery production ramped up in the 1990s) and terminal hatchery fisheries, with many being caught in the southern and northern purse seine fisheries.
    - Sockeye salmon are primarily caught in the southern purse seine fisheries, while also being caught in the Lynn Canal, Yakutat and set gillnet fisheries, with some also being caught in the Tree Point fishery.
- Weekly proportion of pink salmon catch in the District 104 seine fishery from 1960-2018 is shown in Figure 12 (Piston 2021). Most years show the same profile with harvest peaking in weeks 32-33.
- Catch of pink and sockeye salmon in District 104 (1960-2018) by subdistrict (104-10 to 104-50) is shown in Figure 13. Note that the peak weeks for pink catch is generally weeks 32 and 33, however, sockeye catches peak in weeks 31 and 32 (or approximately 1 week earlier). Also note that most of the catch of both pink and sockeye salmon is from subdistricts 104-10, 20, and 40.
- 2021 catch by fishery in SEAK varies by species (Figure 14). Pink (91%) and sockeye (70%) salmon were predominantly caught in the northern and southern seine fisheries with only a small proportion of sockeye caught in the Tree Point gillnet fishery (8%), coho (53%) and Chinook (65%) salmon were caught predominantly in the Summer Troll fishery, with some coho caught in the northern and southern seine fisheries (20%). Chum salmon were caught mostly in terminal hatchery fisheries (61%), however a significant portion were caught in the northern and southern seine (18%) and summer troll (8%) fisheries.
- Figure 15 shows the catch of Chinook, pink and sockeye salmon from Southeast Alaska districts 101, 102, 103, 104, and 106 in 2021, for seines and gillnets.
    - Note that the pattern of harvest is similar to that in other years, with sockeye harvest peaking in the D104 fishery slightly before the peak in pink harvest. In 2021, pink harvest was highest in D104 and D101, with the vast majority of sockeye harvest from D104.
    - Chinook was non-retention in the purse seine fisheries through almost all of 2021, however in one day of opening ~ 6,000 Chinook were kept in D104.

Data Sources:

[1] https://www.adfg.alaska.gov/sf/publications/: select "Title" in field and enter "Run forecasts and harvest projections" in the Search String field.

3 Southeast Alaska Pink Salmon Escapement

Pink salmon return to many systems in Alaska, and sometimes in great abundance. This section provides a summary of pink index escapement information from Piston (2021) to provide background information on pink salmon escapement and the locations of the major populations.

- Figure 16 show the locations of pink salmon stock groups and index streams. Note that there are no index streams or stock groups located in the District 104 area on the west side of Noyes and Dall Island.
- Total South SEAK pink salmon index escapement is shown in Figure 17. Pink salmon escapements have increased since 1960 and since ~ 1980 have ranged from approximately 5 million to nearly 15 million.
- South SEAK pink salmon index escapement by District is shown in Figure 18. Escapements have increased since the 60s especially in D101, D102 and D103. D105, 6, and 7 have increased, but are more variable. In recent years, the majority of pink salmon returns have been to D101, 102 and D103 (southern Districts). Note that D104 is not included in this figure as there are no pink salmon escapement index streams there.

4 References

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5 Figures

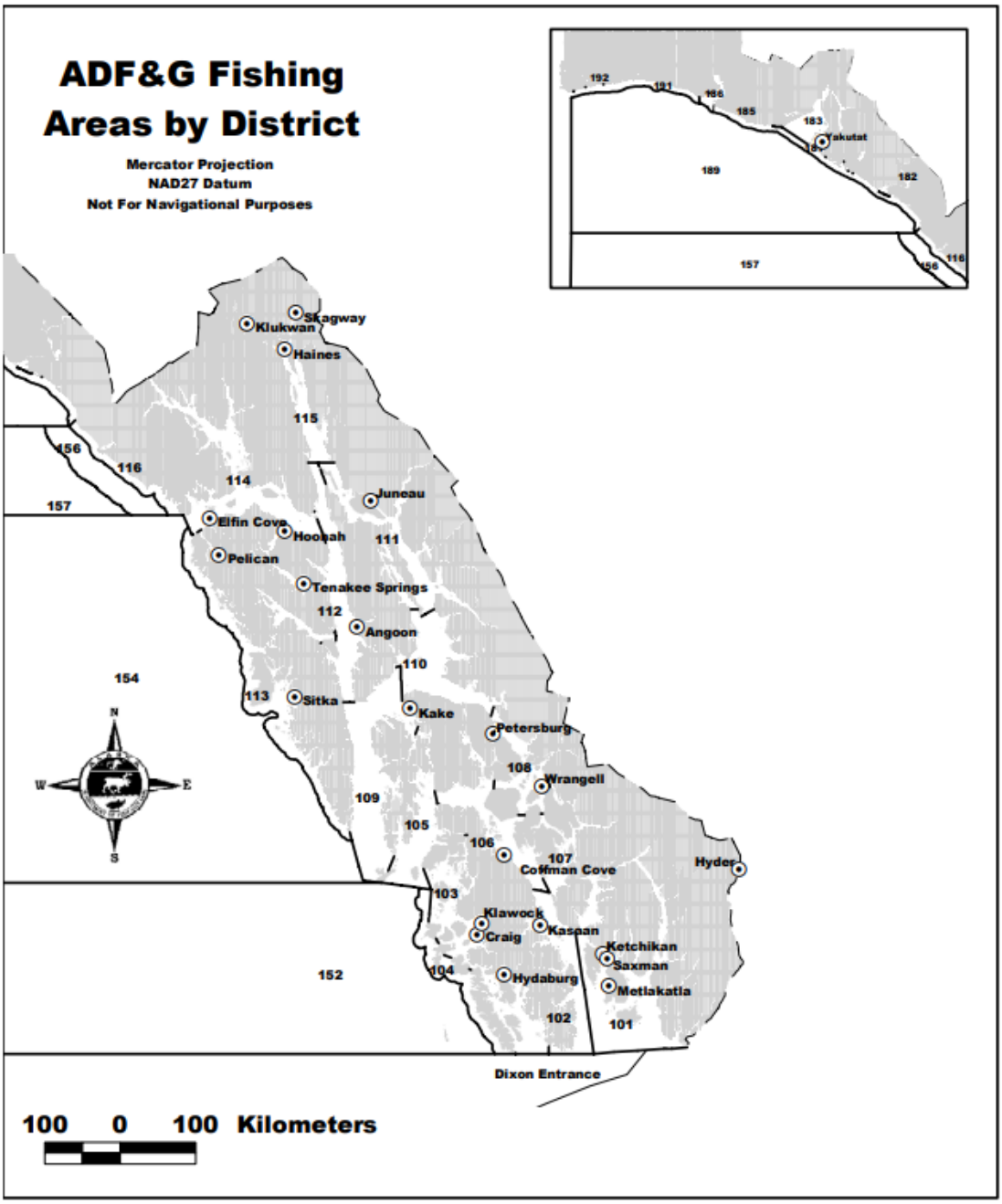

Figure 1: Map of Southeast Alaska Fishing Areas by District.

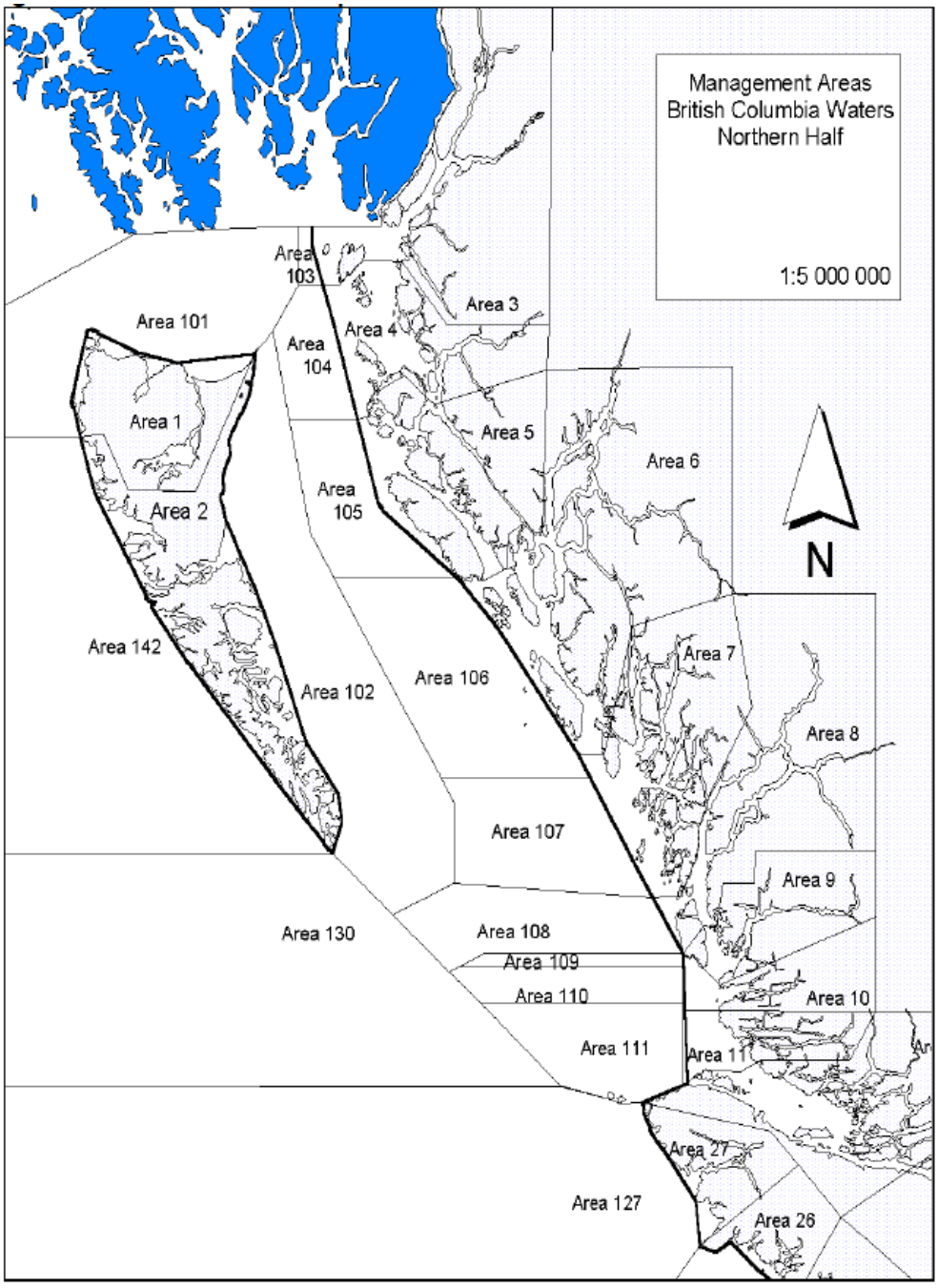

Figure 2.Map of DFO Statistical Areas in the North and Central Coast Areas.

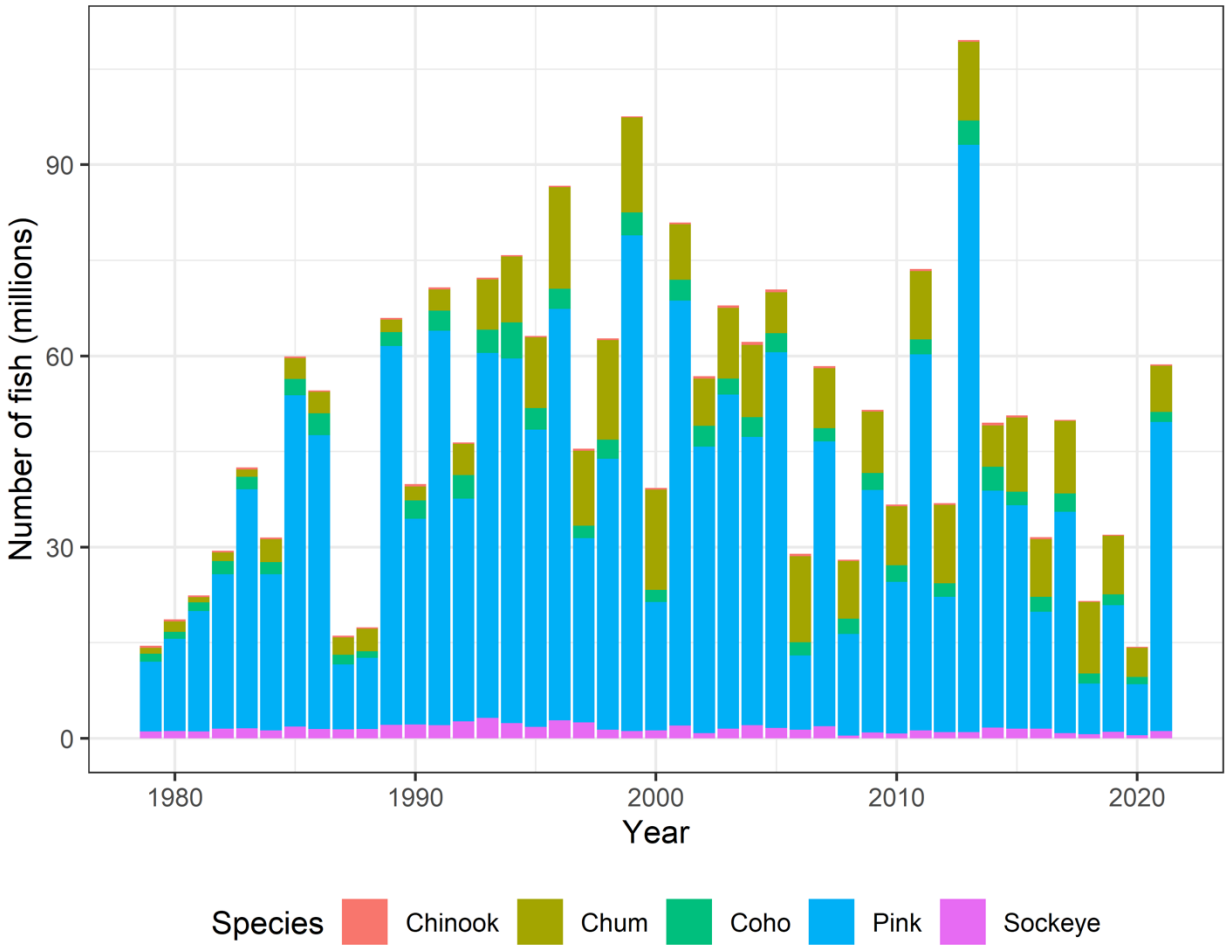

Figure 3: Southeast Alaska, US (SEAK) harvest in million number of fish by species over time for 1979-2021. Harvest is shown for Chinook (red), Chum (olive), Coho (green), Pink (blue), and Sockeye (pink) Salmon. Overall column height shows the total harvest by year. 2021 data are preliminary.

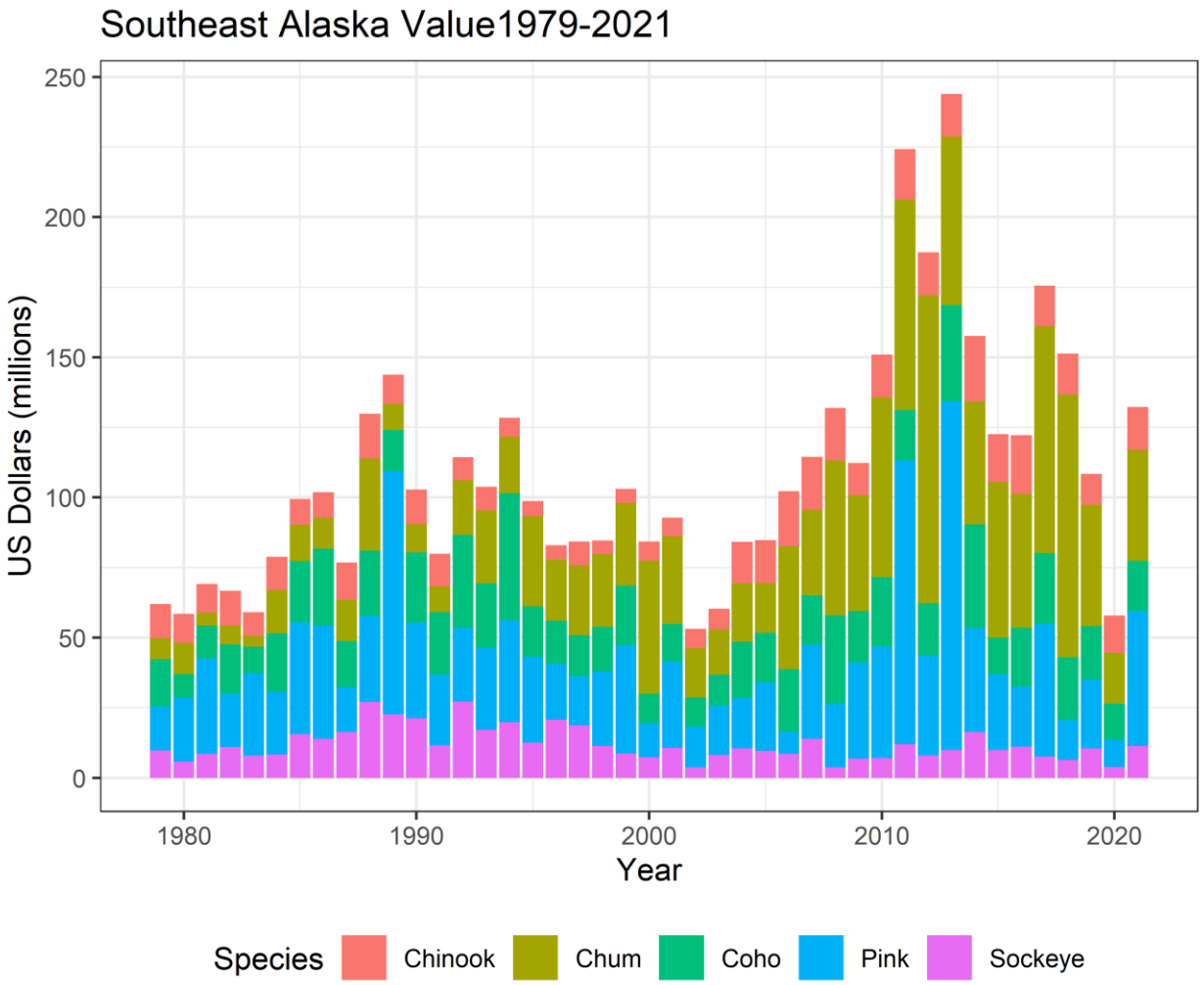

Figure 4: Southeast Alaska, US (SEAK) harvest value in millions of US Dollars from 1979-2021. Harvest value is shown by species Chinook (red), Chum (olive), Coho (green), Pink (blue), and Sockeye (pink). Overall column height shows the total harvest value by year. 2021 data are preliminary.

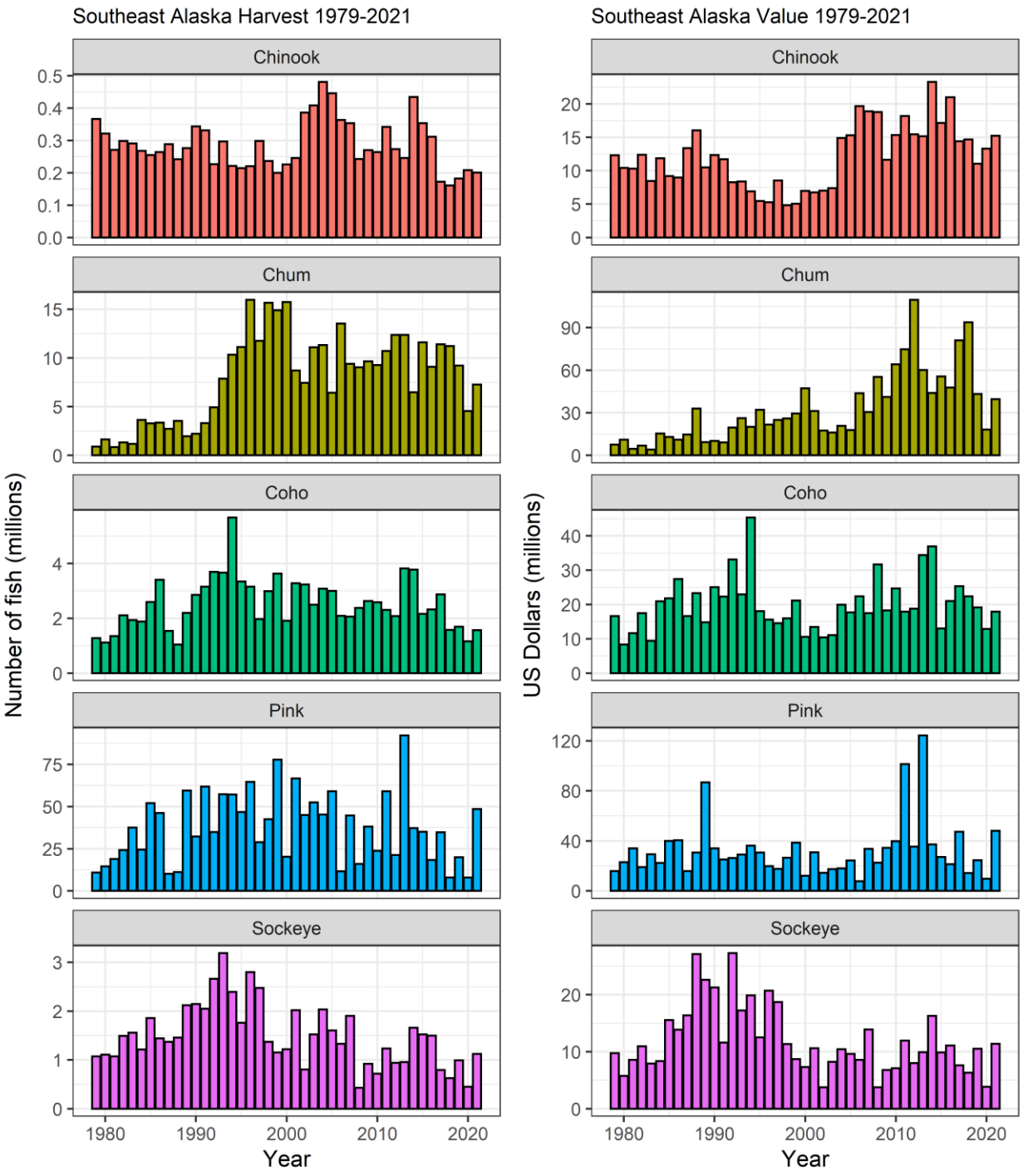

Figure 5: Southeast Alaska, US (SEAK) harvest (millions of fish) and value (millions of US Dollars) by species from 1979-2021. 2021 data are preliminary.

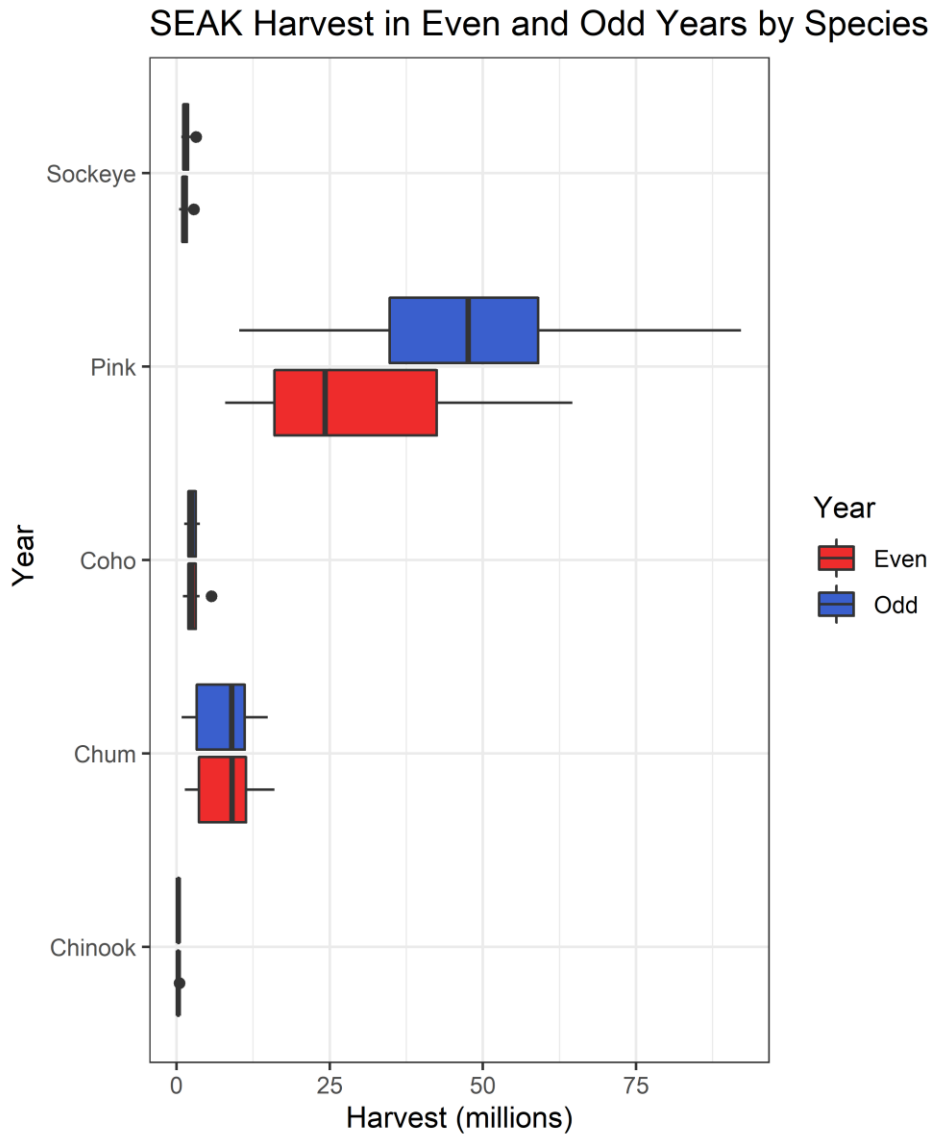

Figure 6: Southeast Alaska, US (SEAK) harvest in million of fish in even and odd years from 1979-2021. Even years are shown by the blue bars, and odd are red. The thick black line is the median value, the box in indicates the interquartile range (25th to 75th percentiles – or middle 50% of the data), whiskers are 1.5x the interquartile range and dots are outliers (< 5th or > 95th percentile).

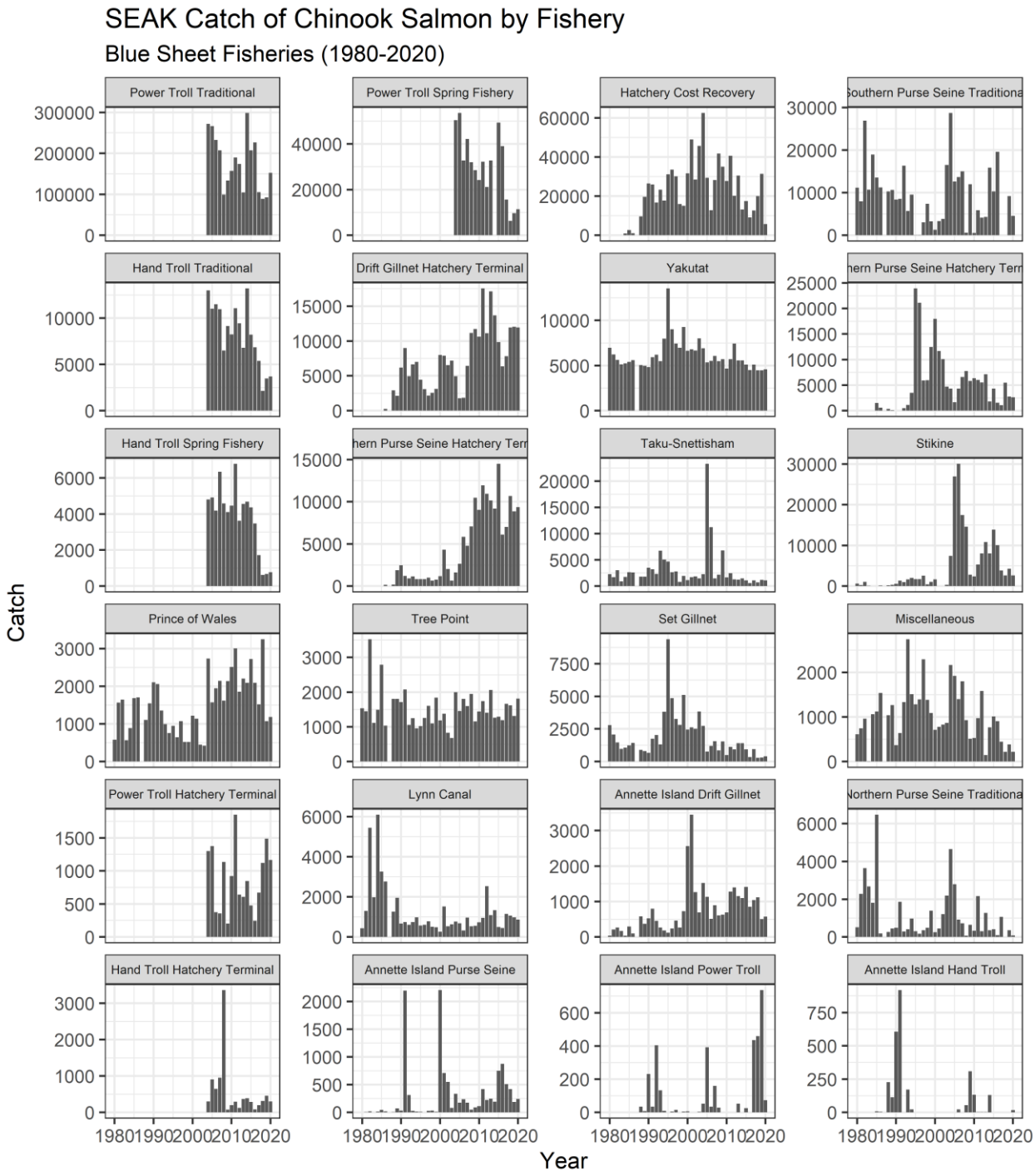

Figure 7: Southeast Alaska, US (SEAK) harvest of Chinook by fishery between 1980 and 2020. Note that the y-axis scales are scaled by individual facet. Facets are arranged in order of greatest to smallest total catch over all years.

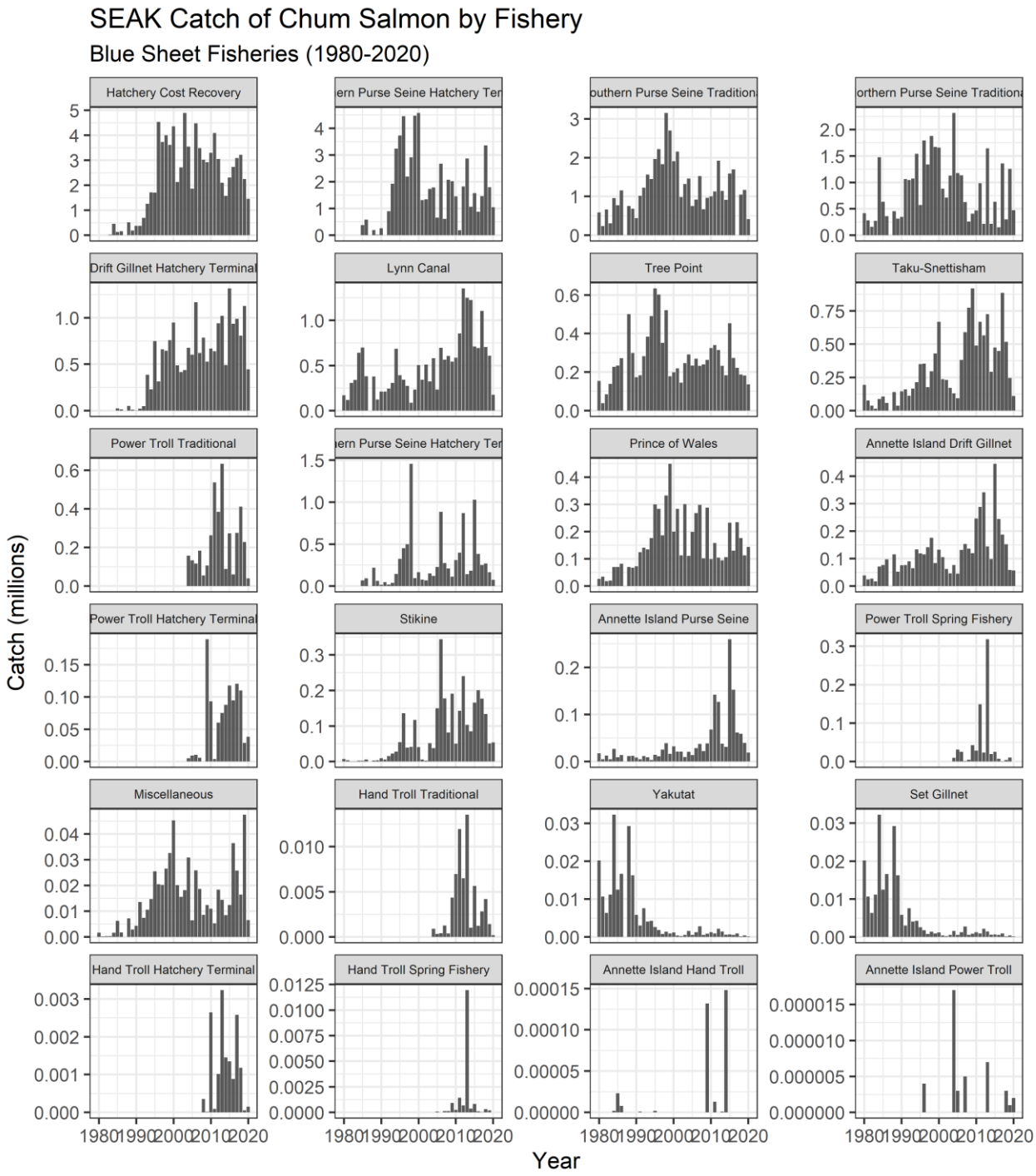

Figure 8: Southeast Alaska, US (SEAK) harvest of chum by fishery between 1980 and 2020. Note that the y-axis scales are scaled by individual facet.

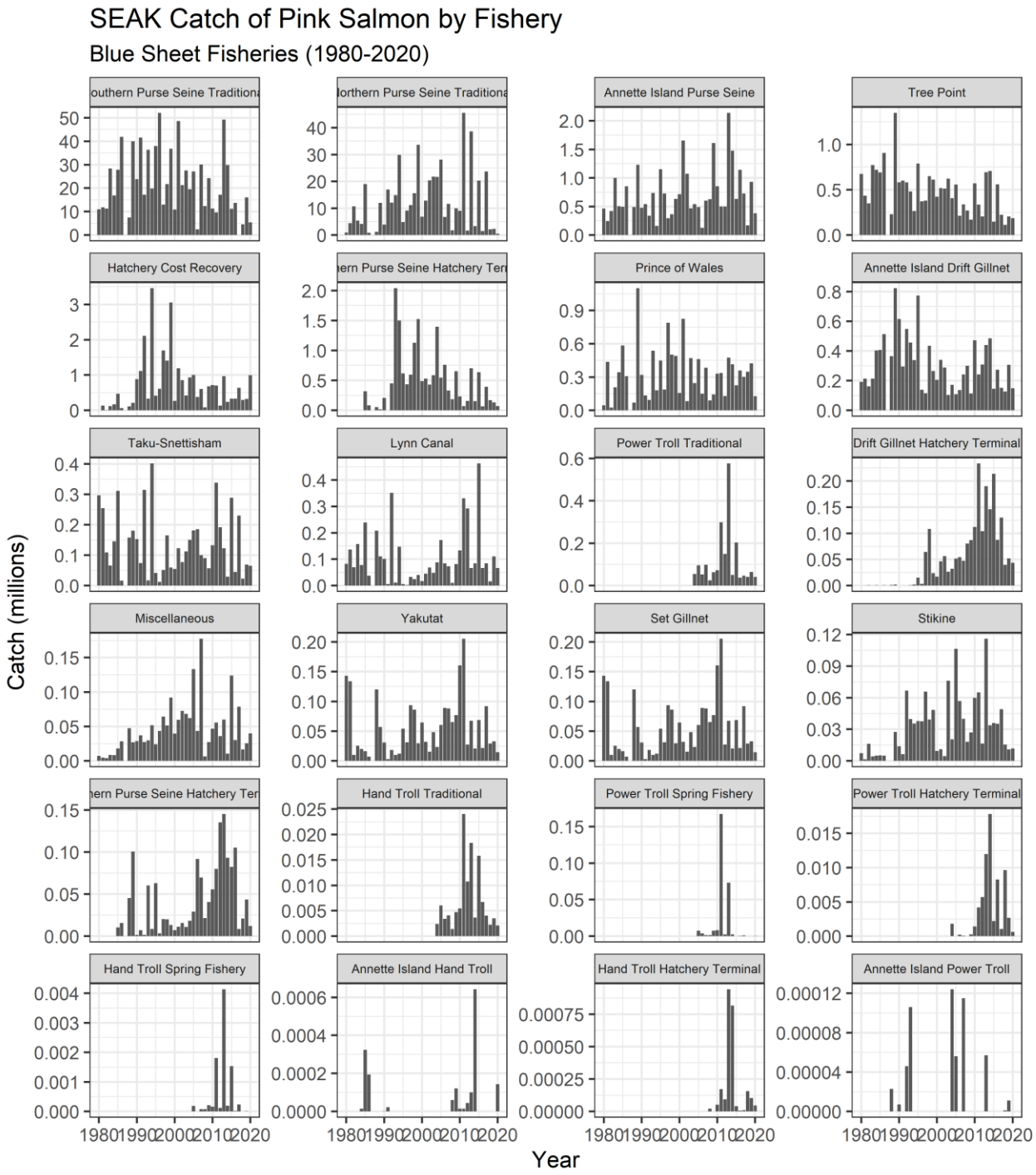

Figure 9: Southeast Alaska, US (SEAK) harvest of pink by region between 1979 and 2020. Note that the y-axis scales are scaled by individual facet.

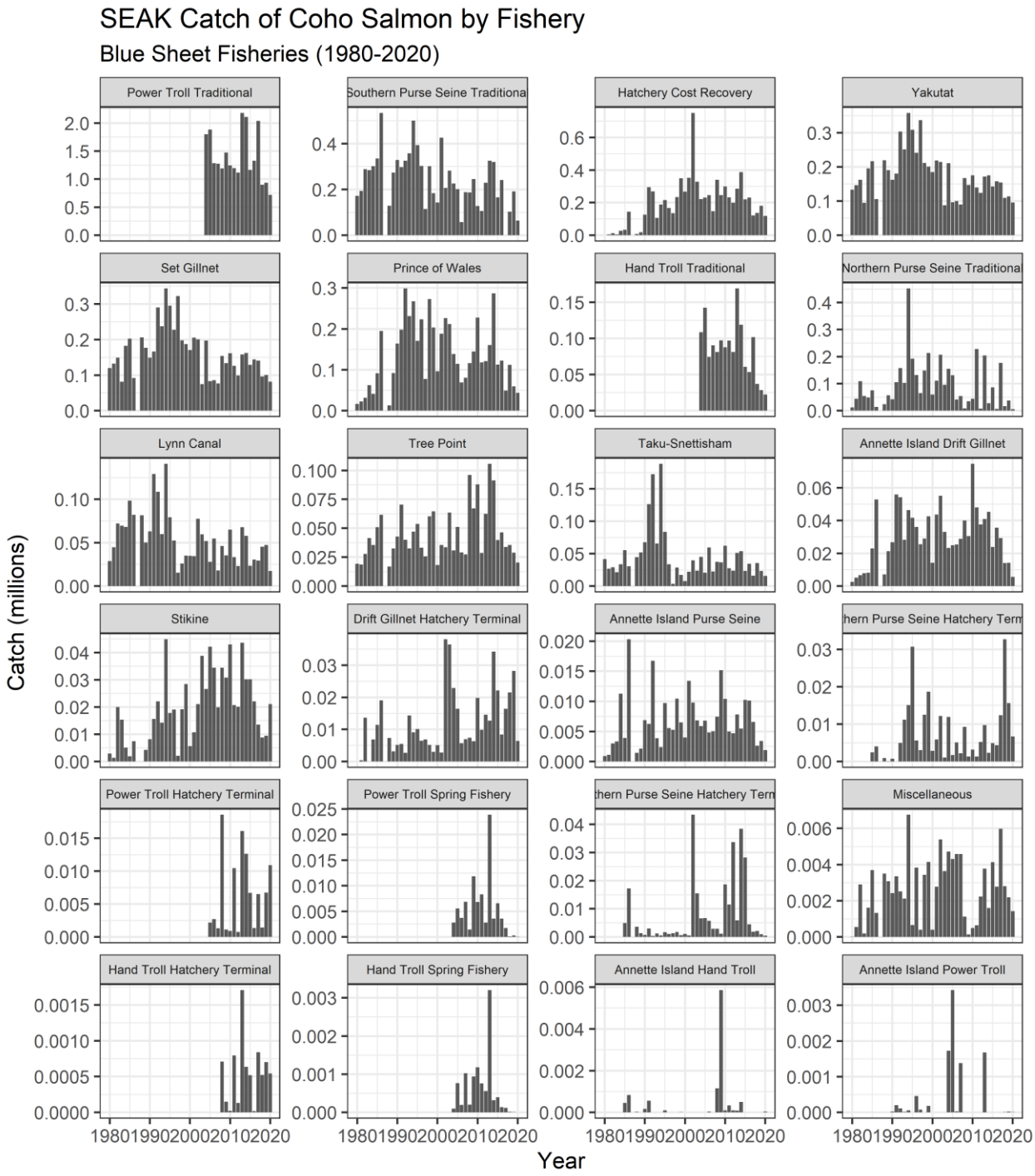

Figure 10: Southeast Alaska, US (SEAK) harvest of coho by fishery between 1980 and 2020. Note that the y-axis scales are scaled by individual facet.

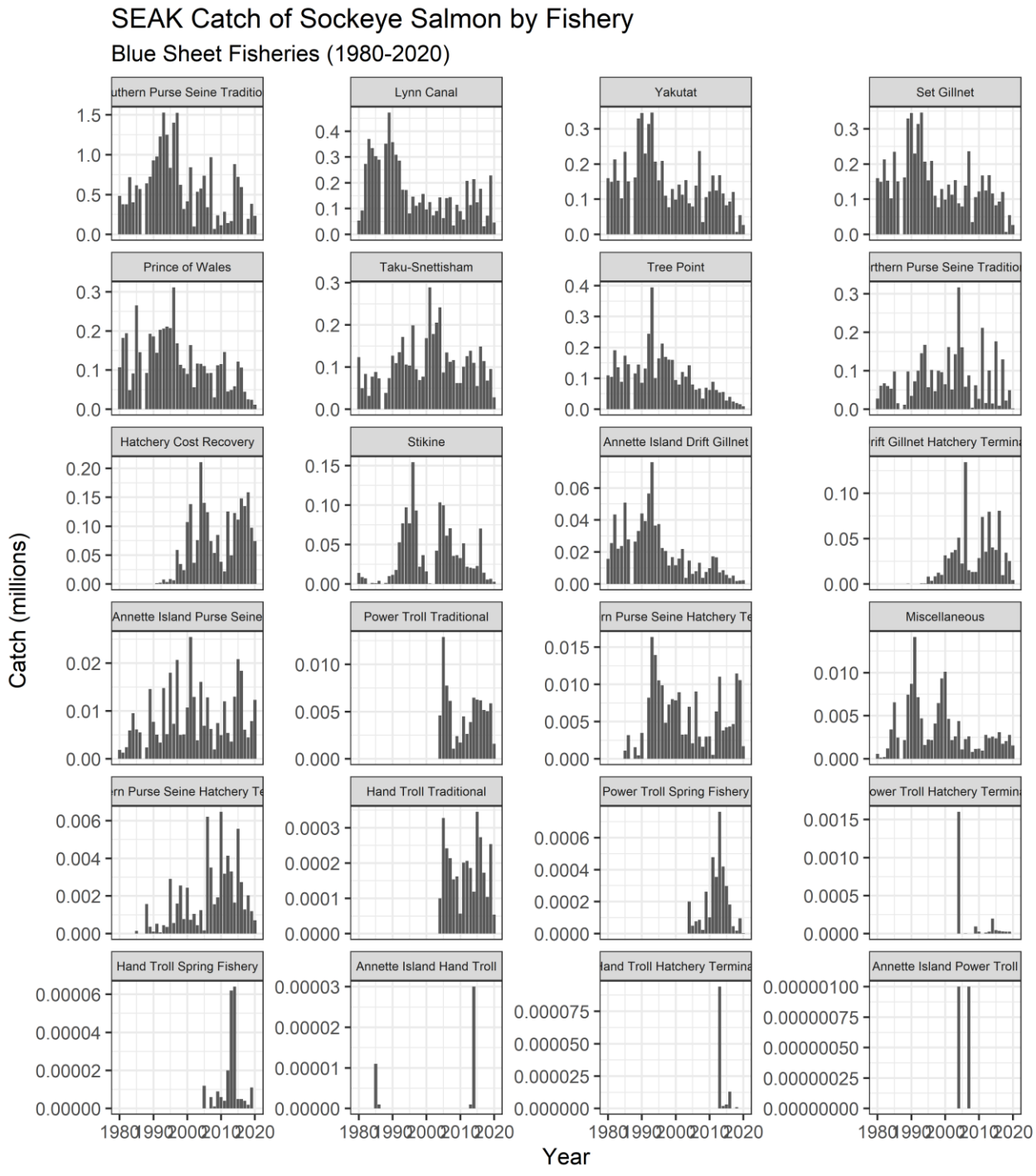

Figure 11: Southeast Alaska, US (SEAK) harvest of sockeye by fishery between 1980 and 2020. Note that the y-axis scales are scaled by individual facet.

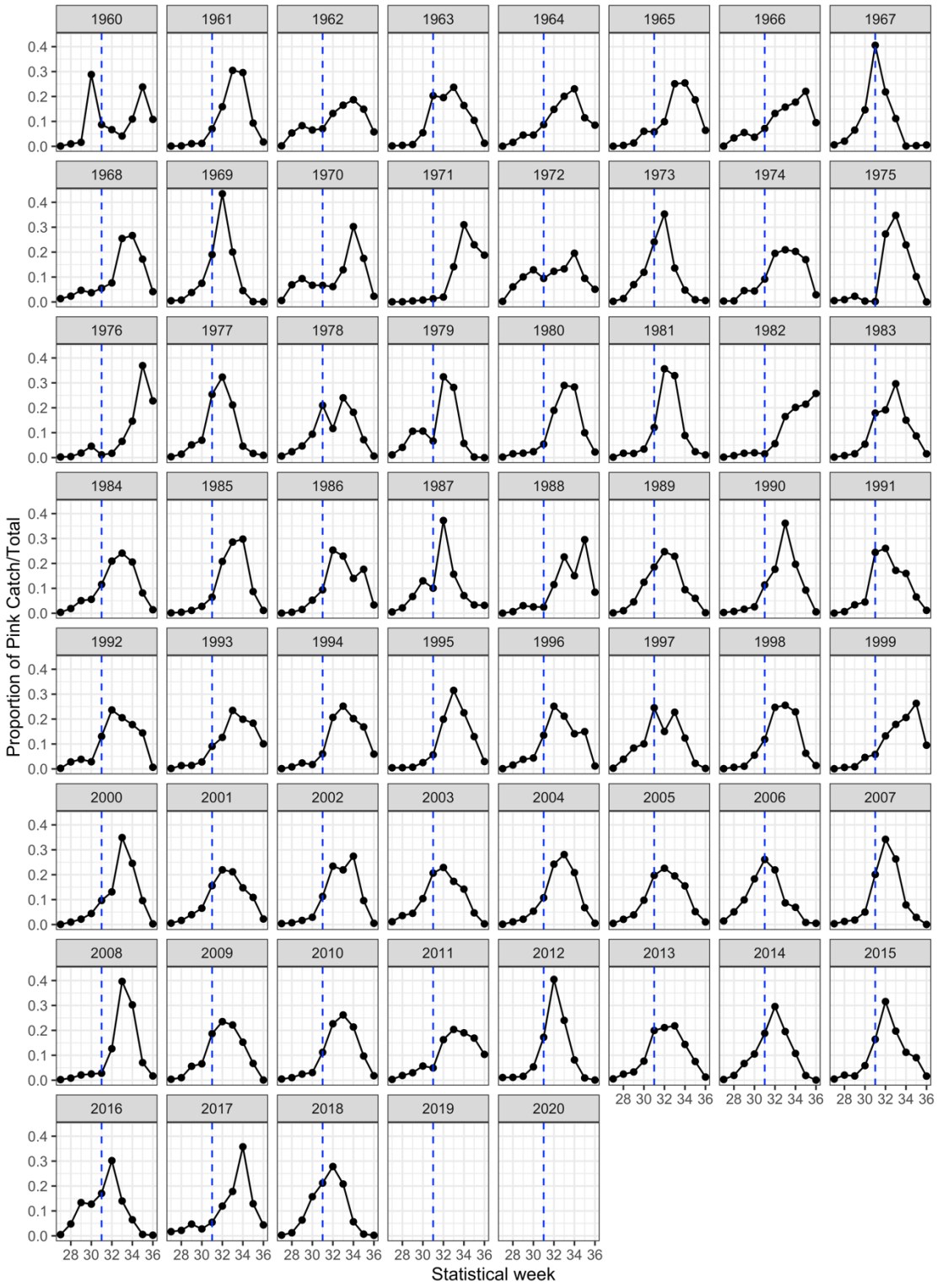

Figure 12: Weekly catch of pink salmon in the District 104 seine fishery from 1960-2018. The blue dotted line represents statistical week 31. Data from Piston,2021.

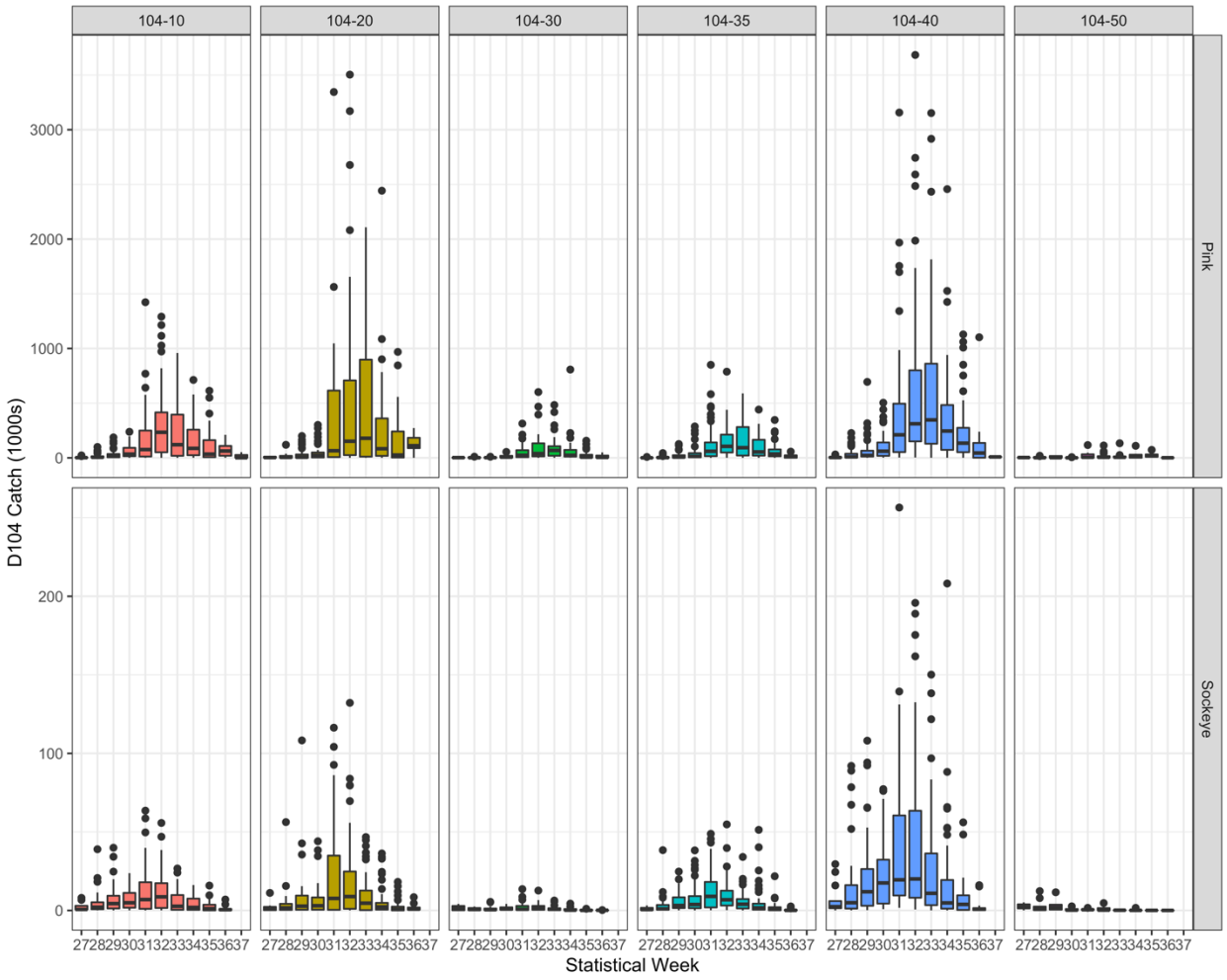

Figure 13: Southeast Alaska, US (SEAK) Pink and Sockeye Salmon catch in District 104 sub-areas by statistical week. This figure shows the distribution of Catch in thousands in District 104 sub-areas 104-10 to 104-50 of Pink (top) and Sockeye (bottom) Salmon by SEAK for statistical weeks 27-36 for years 1960-2018. 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). Data from Piston (2021).

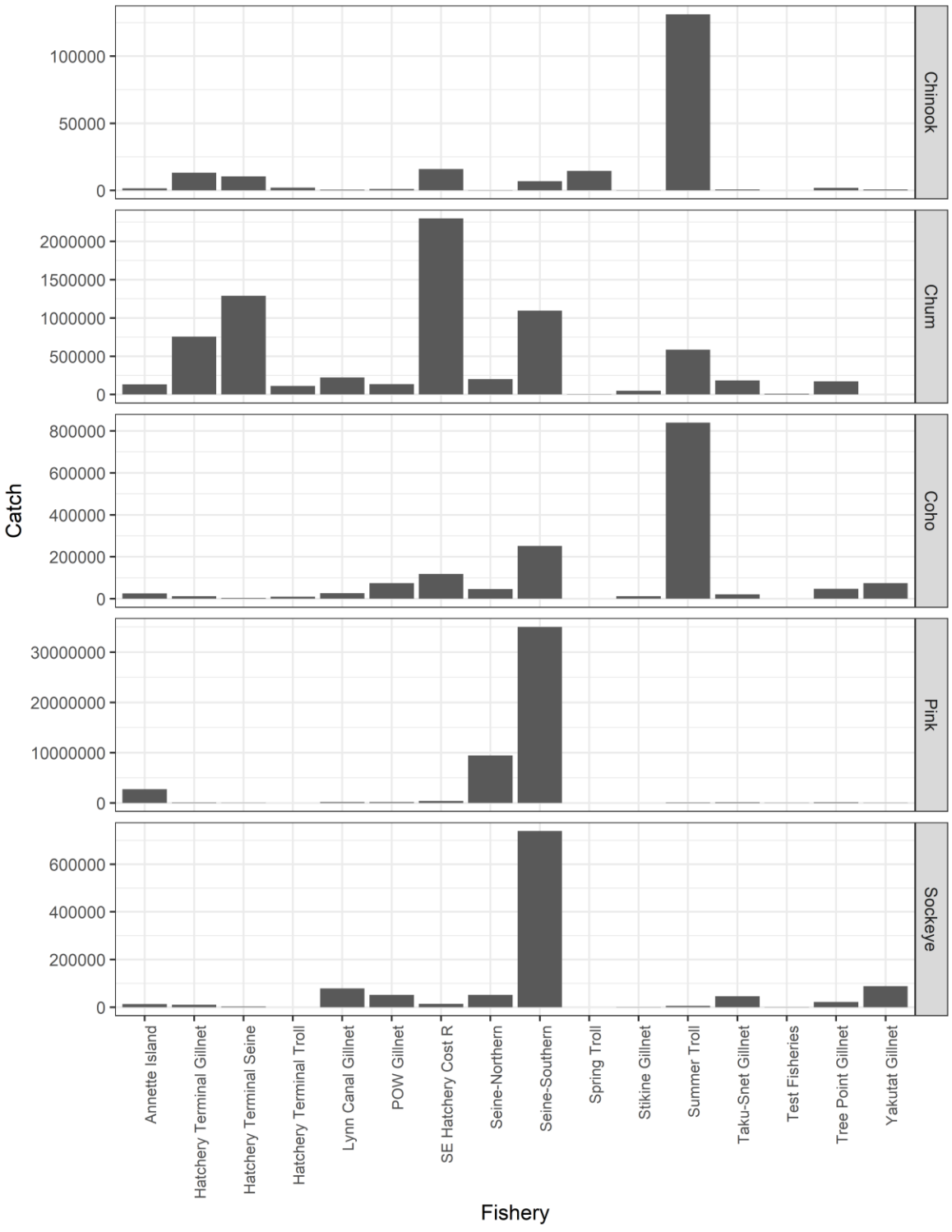

Figure 14: Harvest of all salmon species in SEAK fisheries in 2021. Source: ADFG Blue Sheet data 2021.

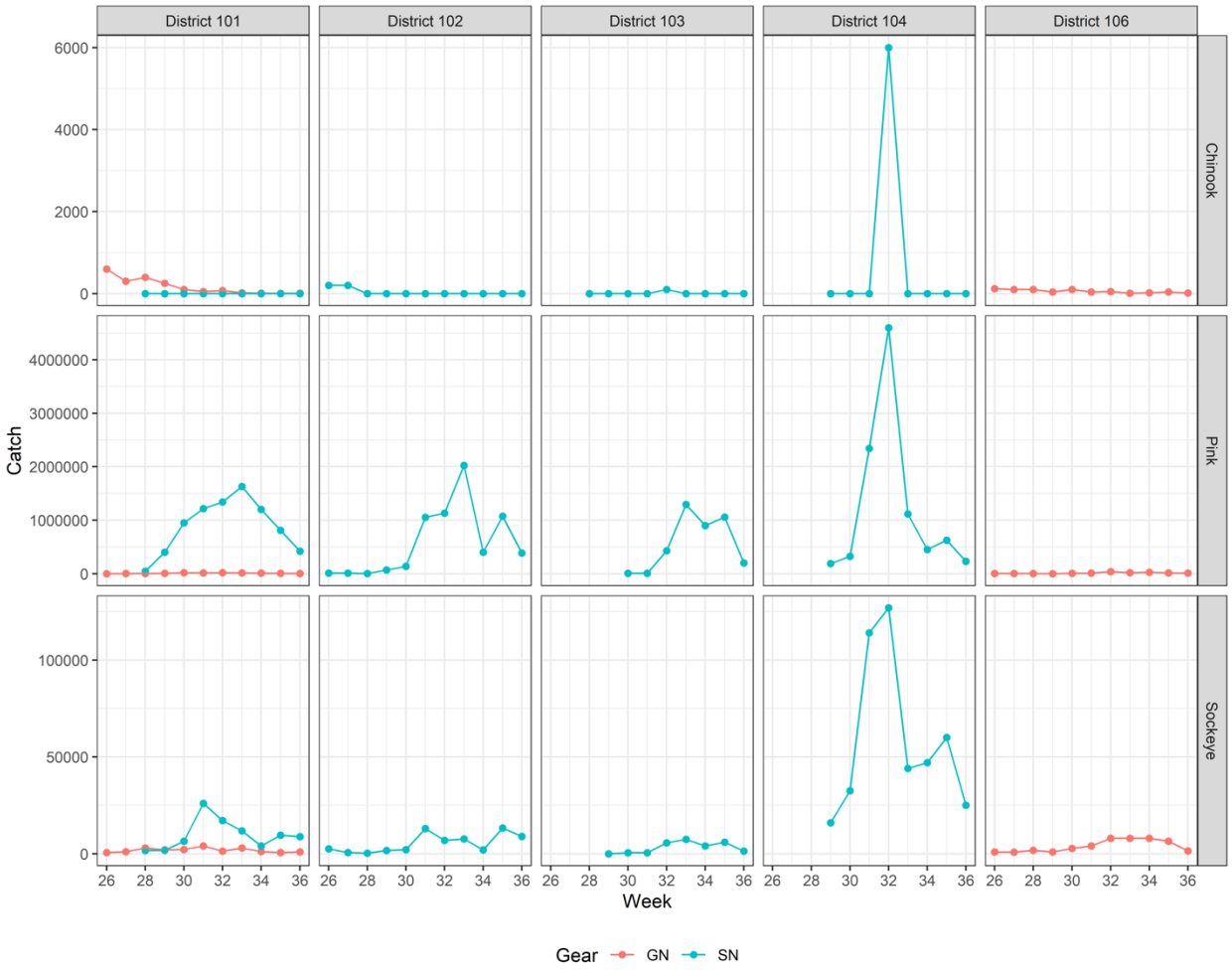

Figure 15: Southeast Alaska, US (SEAK) Chinook, Pink and Sockeye Salmon catch in 2021 by gear type, district, and statistical week. This figure shows the distribution of Catch by Gill Net (red) and Seine Net (blue) for Districts 101- 104 and 106 of Chinook (top), Pink (middle) and Sockeye (bottom) Salmon by SEAK for statistical weeks 26-36. Data from ADFG website and weekly Fishery Advisory Notices.

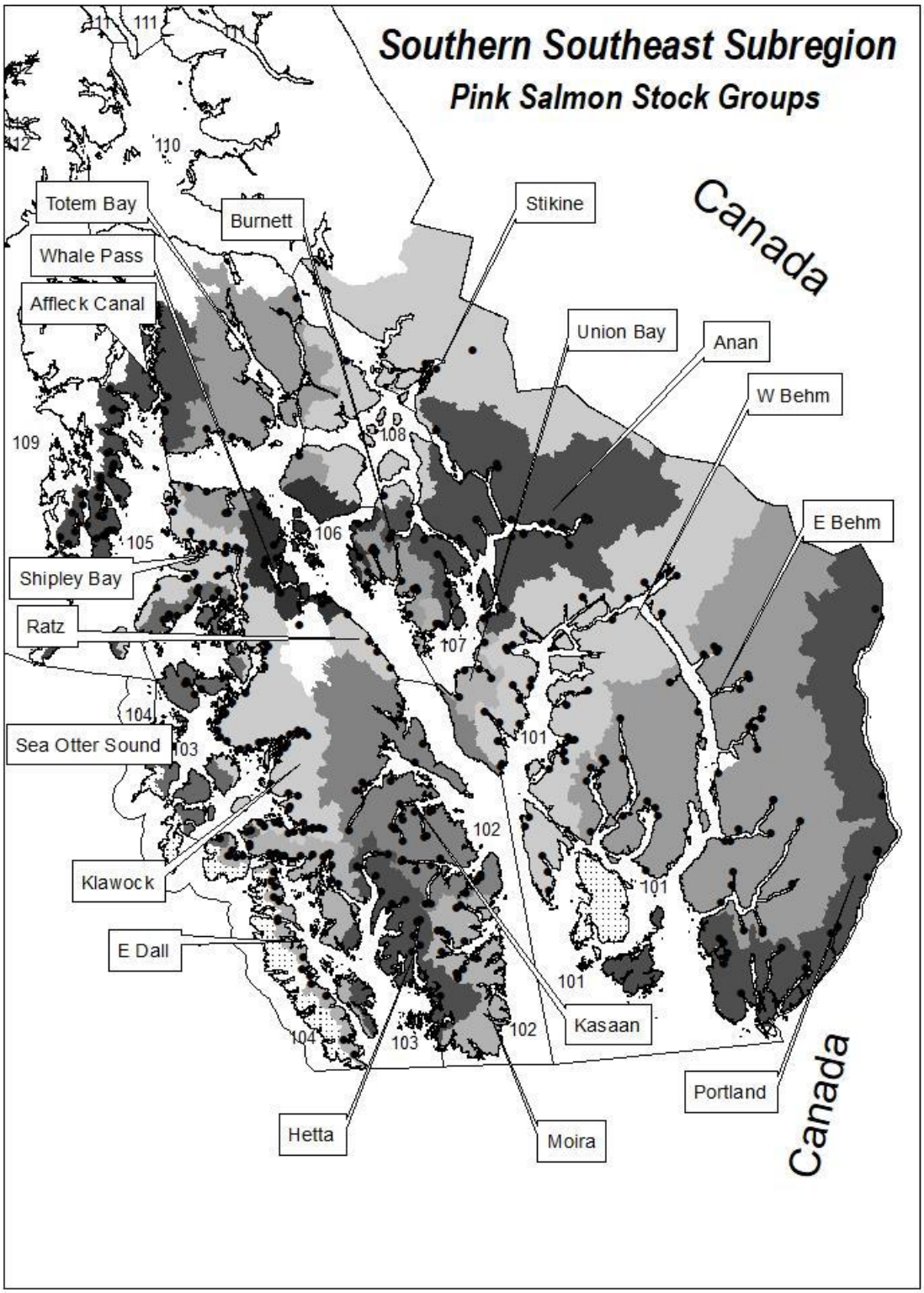

Figure 16: Map of Southern Southeast Alaska subregion showing location of major pink spawning groups. Black points show 'indicator' populations. Figure from Piston (2021).

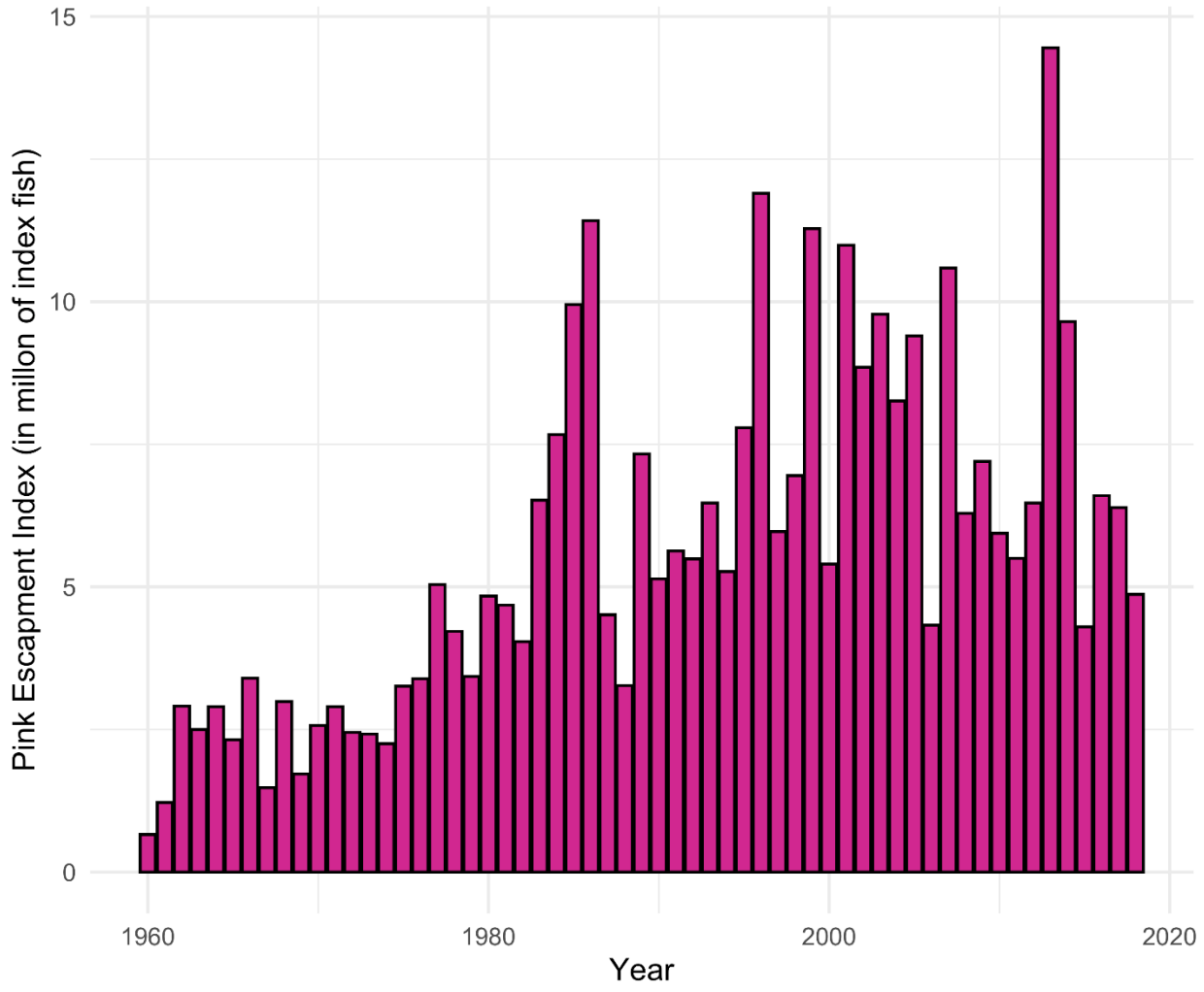

Figure 17: Southern Southeast Alaska, US (SSEAK) pink salmon escapement index in millions of index fish for years 1960-2018. Data from Piston (2021).

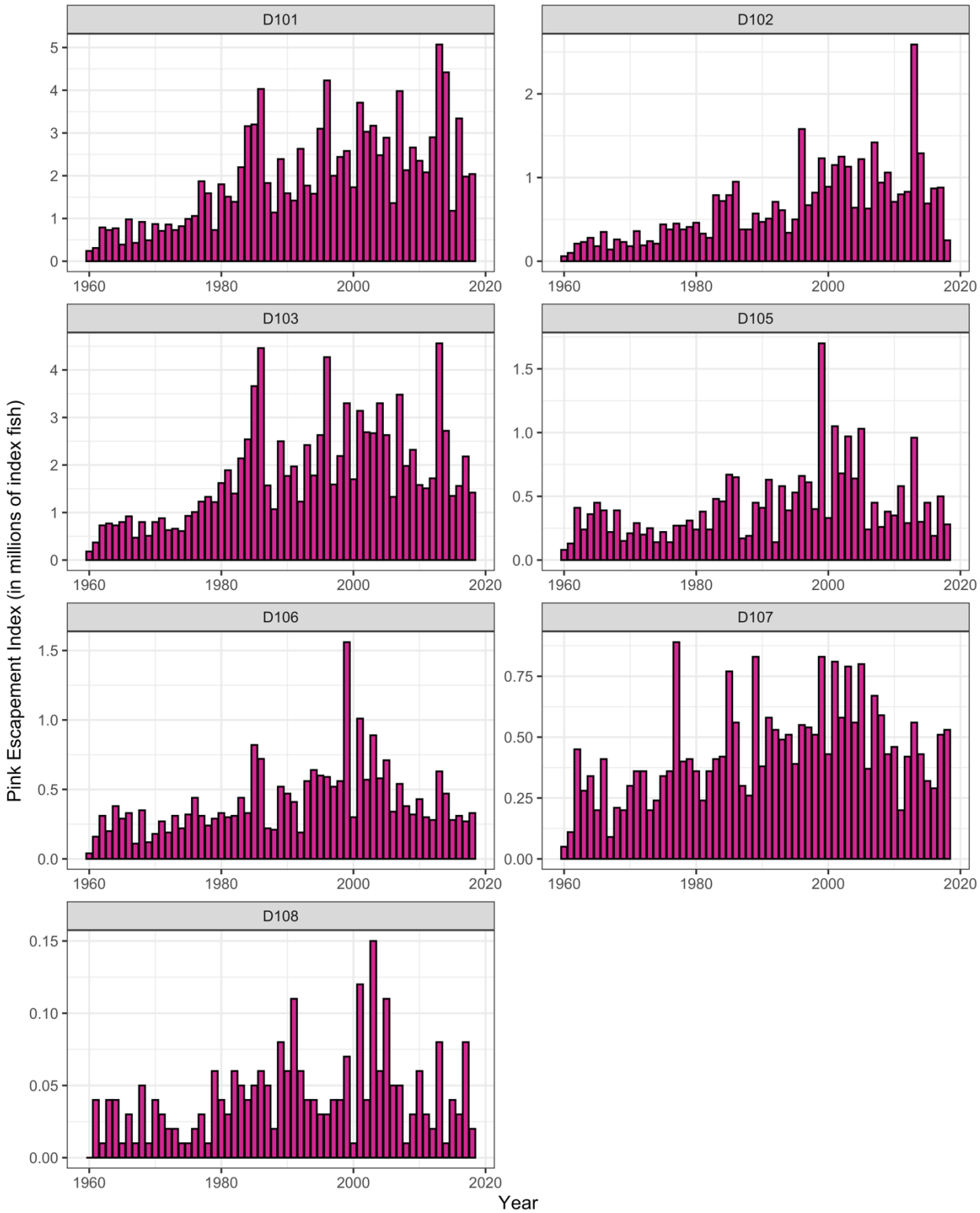

Figure 18: Southern Southeast Alaska, US (SSEAK) pink Salmon escapement index in million of index fish by district D101-D108 for years 1960-2018. Data from Piston (2021).

Alaskan Harvest of BC Salmon: State of Knowledge

Part 2: Sockeye

Version 1

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January 2022

Preface

This report is part of a series of reports on the 'State of Knowledge' of Alaskan interceptions 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 Southern Southeast Alaska Districts 101-104, 106 (SSEAK) catch of BC salmon;
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.

NBSRR: Northern Boundary Sockeye Run Reconstruction model.

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

For sockeye, information was compiled from a number of sources including the Pacific Salmon Foundation Salmon Explorer, LGL Limited, the Pacific Salmon Commission (PSC) website and data department, and through discussion with staff from the above organizations. We drew predominantly on the Pacific Salmon Explorer for Conservation Unit level data, LGL's North and Central Coast Run Reconstruction website for Statistical Area level data, outputs from the Northern Boundary Sockeye Run Reconstruction Model (NBSRR) for specific fishing area level data (e.g. Noyes, Dall etc.) for Skeena and Nass sockeye, reports found on the Pacific Salmon Commission Fund webpages for genetic stock composition in District 101 and 104 fisheries and information provided from the PSC for Fraser sockeye. 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 (SEAK) fishing Districts and North Coast BC DFO Statistical Areas respectively.

Information on commercial SEAK harvest in 2021 was downloaded from the ADFG website or requested and provided by ADFG staff (e.g., District level catch by species and week or season "Blue Sheet data"), and while 2021 data for sockeye is presented in this report, background information on SEAK harvests in general (e.g., magnitude, timing etc.) is provided in Part 1 of this report series.

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 sockeye salmon by region.

Species	*Region/Area*	*Type of Data*	*Data Source*	*Year*
Sockeye	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
	Skeena and Nass	Escapement, total run, SEAK and Canadian harvest and ERs by sub-fishery	LGL 2021b. (Northern Boundary Sockeye Run Reconstruction Model)	1982-2020 (Skeena), 1985-2020 (Nass). 2020 preliminary data.
	Fraser sockeye	Escapement, total run, Canadian, Washington and Alaska harvest	PSC 2021	2000-2020
	All BC	Weekly genetic stock composition in D101 and D104 fisheries	Guthrie 2010-2019b	Return years 2008-2018

2 SEAK Harvest

Summary information on sockeye harvest in SEAK and SSEAK (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 sockeye 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). More detailed information on SEAK harvests (e.g., magnitude, timing etc.) is provided in Part 1 of this report series.

- Total sockeye catch in SSEAK peaked in the mid-90s and has declined since, with average harvest in the last 10 years around 1 million (Figure 3).
- Most sockeye are caught in southern purse seine fisheries, with some caught in in gillnet fisheries (Figure 4). Median catch in southern purse seine fisheries is ~ 575,000 sockeye.
- Median total catch (all gears) by SSEAK district (101-106) shows that District 104 dominates sockeye SSEAK catch in most years, followed by District 101 and District 106 (Figure 5).
- Total catches (all gears) in Districts 101 and 106 have declined since the 90s, total catch in Districts 102, 103, and 104 have remained low and District 104 total catch peaked in the 90s and declined to an average of ~ 225,000 since, with catches ranging from near 0 to almost 800,000 (Figure 6).
- In 2021, SEAK fisheries (including Yakutat) caught nearly 1.1 million sockeye, predominantly in southern seine fisheries (~ 740,000, Figure 7), with nearly 500,000 sockeye salmon being caught in District 104 alone (Figure 6).

3 SEAK Catch of BC Salmon

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

Estimates of Alaskan exploitation for Skeena River, Nass River and Area 5 sockeye are derived from the NBSRR model and assessed by the PSC Northern Boundary Technical Committee (NBTC). Details on the NBSRR can be found in Gazey and English (2000) and Alexander et al. (2008) and NBTC reports can be found online on the PSC website[1]. Fisheries in Alaska are relatively well sampled for sockeye and stock composition estimates are completed using scales and more recently (since 2012), genetic stock ID methods (see Guthrie et al. 2018, 2019a, 2019b for example). Estimates of Skeena and Nass sockeye harvest in SEAK and north coast BC fisheries are a relatively well quantified. This section of the report provides background information on Skeena and Nass sockeye abundance, and more detailed information on where Skeena and Nass sockeye are caught in SEAK fisheries as well as comparisons between SEAK and Canadian exploitation rates and harvest.

Skeena and Nass Sockeye total run and escapements from 1982-2021 are shown in Figure 8. Escapements (left panel) have remained reasonably constant due to harvest control rules that dictate harvest levels above escapement goals. However, in many years sockeye escapements to the Skeena have been below the commercial fisheries trigger of 1.05 million. Only in a few years have escapements fallen below escapement goals on the Nass. The total run of sockeye on the Skeena peaked in 80s and 90s following the development of the spawning channels at Pinkut and Fulton Rivers in the late 60s and early 70s. Since the late 90s, the total return of Skeena River sockeye has declined dramatically, to a point where

[1] https://www.psc.org/publications/technical-reports/technical-committee-reports/northern-boundary/

commercial fisheries are either not prosecuted, or severely limited in many years. Nass sockeye have followed similar trends with a decline in total run evident since the 90s.

3.1.1 Skeena and Nass River Aggregates

The following set of figures describe the commercial marine catch of Skeena and Nass sockeye in South Southeast Alaska (SSEAK) and BC, with specific information on the proportion of catch between regions and trends over time. We also provide a more detailed summary of information on specific fisheries in SSEAK (e.g. with focus on District 104 and the Noyes and Dall Island fishing areas). Data source is provided in each figure.

- Total, US and Canadian commercial catch have declined since the 80/90s for both Skeena and Nass sockeye (Figure 9).
- In the last 11 years (2011-2021 inclusive), SEAK commercial catch has exceeded Canadian commercial catch in 5 out of last 6 years for Nass sockeye, and in 7 out of the last 10 years for Skeena sockeye (Figure 10).
- SEAK and Canadian exploitation rates (ERs) have declined since the 80/90/2000s for Nass sockeye, while only Canadian ERs have declined for Skeena sockeye. US ERs on Skeena sockeye range from very low (~ 1%) to over 20%, averaging around 10% over time (Figure 11). SSEAK ERs in 3 out of the last 6 years have been nearly 20% for Skeena sockeye. In the last 10 years, SSEAK ERs on Nass sockeye have averaged ~ 12%.
- The US proportion of commercial marine catch in SEAK and Area 3/4/5 fisheries has ranged between 25 and 75% for Nass sockeye, with a shift upwards to nearly 100% in 2020 and 2021 (Figure 12 top panel and Figure 13 left panel).
- The US proportion of commercial marine catch in SSEAK and Area 3/4/5 fisheries has ranged between ~ 10% and 100% for Skeena sockeye, with 3 ‘regimes’ apparent (1982 to 1995=low, 1996-2012=moderate but variable, 2013-2020=high) (Figure 12 bottom panel and Figure 13 right panel).
- Figure 14 shows the average proportions of SSEAK and Canadian commercial harvest on Skeena and Nass sockeye for 3 time periods, 1982-1995, 1996-2011 and 2021-2020. The shift in catch proportion for Skeena sockeye over the 3 time periods is significant, with nearly 75% of catch being attributed to SEAK fisheries in the 2012-2020 time period.
- Chapter 2 of the Pacific Salmon Treaty contains a clause that limits harvest of sockeye prior to Statistical Week 31 (end of July) in the District 104 seine fishery. The proportion of catch prior to Week 31 out of the total District 104 sockeye catch for Skeena and Nass sockeye is shown in Figure 15. Although variable, the proportion of sockeye harvested before Week 31 has declined for Nass sockeye, and was very low in 2019 and 2020 for Skeena sockeye. This could be an indication of later timed runs to the Skeena and Nass.
- The District 104 area can also be divided into 2 general regions, Noyes Island in the north and Dall Island in the south (roughly corresponding to sub-districts 104-35 to 104-50 in the north and 104-10 to 140-30 in the south) (Figure 16).
- SEAK sub-area exploitation rate distributions over all years on Skeena and Nass sockeye are shown in Figure 17.
- Notably, the Noyes and Dall (District 104) fisheries have the most significant impact on Skeena sockeye, followed by the Lower Clarence (southern District 102) and Tree Point fisheries (District 101).
- For Nass sockeye, the Tree Point fishery has the most significant impact, followed by the Noyes, Dall, and Lower Clarence fisheries. This highlights the different migration routes of Skeena and

Nass fisheries, where Nass sockeye are much more susceptible to harvest in District 101. Exploitation rates on Skeena and Nass sockeye by year in these three fishery areas are shown in Figure 18. The Dall area (southern District 104) has shown a significant decrease in exploitation since the 80s and 90s, whereas the Noyes area (northern District 104) has remained variable over time. The Tree Point area (District 101) has also shown a decline over time for Nass and Skeena sockeye exploitation.

- Total District 104 (Noyes and Dall areas combined from previous bullet) account for near 0 to almost 30% exploitation of Nass sockeye, and between near 0 and ~ 17% of Skeena sockeye (Figure 19).
- District 104 catch of sockeye accounts for between ~ 2% to almost 75% of Nass sockeye caught in south SEAK fisheries, and between ~ 10% and 90% of Skeena sockeye (Figure 20). Mean percent over all years is 31.6 ± 15.8% for Nass sockeye, and 66.9 ± 16.5% for Skeena sockeye.

3.1.2 Skeena and Nass Conservation Units

Exploitation rate data is available from the Pacific Salmon Explorer (PSF 2021) for 19 Skeena sockeye Conservation Units (CUs), and 3 Nass sockeye CUs. Alaskan exploitation for Area 3 and 4 sockeye are derived from the NBSRR (1982-2017) and for Area 4, historical Skeena estimates provided by DFO North Coast Stock Assessment (English et al. 2018). Alaskan exploitation for Area 3 and 4 CUs are also derived from the NBSRR and Skeena aggregates using CU specific run-timing (English et al. 2018). The following section provides information on CU specific Alaskan exploitation rates for Nass and Skeena sockeye.

- Median Alaskan exploitation rates on Skeena CUs range from ~ 14% for Babine Late-Wild sockeye, to just ~1-2% for early timed populations such as Lakelse and Johnstone (Figure 21). SSEAK exploitation rates are highest on late- and mid-timed CUs such as Babine Late-Wild, Kitwancool (or Kitwanga), Motase and Babine-Fulton.
- Exploitation rates have been extremely variable over time for all Skeena CUs (Figure 22). For some CUs, such as Babine Late-Wild, SSEAK ERs have increased since the 1960s and 70s. ERs of Babine Late-Wild sockeye have ranged from ~ 10% to nearly 40% since the 1980s.
- Figure 23 illustrates the shift in SSEAK exploitation rates using an arbitrarily set time period comparison between 1960-1999 and 2000-2017. Median exploitation of late- and mid-timed CUs Babine Late-Wild and Kitwancool increased, while exploitation rates for all other CUs decreased in recent years. This may reflect shifts in effort in pink seine fisheries to later in the year.
- There is a disproportionate impact of SSEAK fisheries on Babine Late-Wild sockeye, as shown in Figure 24. Babine-Fulton sockeye comprise the majority (~ 60%) of both total SSEAK Skeena sockeye catch and the Skeena total sockeye run. However, Babine Late-Wild comprise ~ 30% of the total SEAK Skeena sockeye catch, and only ~ 10% of the total run. Babine-Pinkut (an early-mid timed group), show an opposite pattern. Percent values are median values from 1960-2017.
- Median Alaskan exploitation in Nass CUs ranges from ~ 28% for Damdochax/Winimasik sockeye, to ~ 23% for Fred Wright sockeye (Figure 25).
- Exploitation rates in these CUs have ranged from ~ 10 and 50% between 1982 and 2017, with a trend to lower ERs in recent years (Figure 26).
- The absence of peer reviewed biological benchmarks and reference points for most Canadian salmon populations, including Skeena sockeye, makes it difficult to comment on exploitation rates relative to stock status or management objectives.

3.1.3 DFO Statistical Area 5 and Conservation Units

Area 5 covers from just south of the Skeena River to the south end of Banks and Pitt Island and along a portion of the west side of Douglas Channel (Figure 2). The DFO escapement database, NuSEDs, identifies 24 lake-type sockeye Conservation Units (CUs) and 2 river-type CUs in Area 5. Although relatively small, these Conservation Units are important to local First Nations. Of these, only 8 lake-type CUs and 1 river-type CUs have escapement data and US exploitation rates in the PSF Pacific Salmon Explorer downloadable database. Alaskan exploitation for Area 5 is derived from the NBRR estimates for Lakelse sockeye on the Skeena (Table 1, English et al. 2018). As such, Alaskan exploitation on Area 5 sockeye CUs is estimated using the NBSRR derived estimates for Lakelse (English et al. 2018: Table 2). The following section illustrates Alaskan exploitation of Area 5 and associated CUs for sockeye.

- Escapement and Total Return of sockeye to Area 5 has been variable, but with no major trends (Figure 27).
- Estimated Canadian ERs averaged around 15% in the 60s-80s, peaked in the 90s at around 30% and have since declined dramatically to between 0 and 8% in the last 10 years (Figure 28). Alaskan ERs have remained relatively constant between 0 and 5%.
- Figure 29 shows Alaskan ERs over time for the 8 lake-type and 1 river-type sockeye CUs in Area 5. Note that not all CUs have ERs in all years (some years are missing escapement and exploitation rate data). The exploitation rate data does exist, however in years where there are no escapement estimates the exploitation rate is dropped from the database as well. This explains the variation in median ER in Figure 30, which shows the distribution of ERs for the CUs.
- Note that the river-type sockeye CU, Northern Coastal Fjords, spans Areas 5-8, and the Alaskan exploitation rate indicator for that CU is Areas 6, 7 and 8, which have zero Alaskan ER in the database.

3.1.4 DFO Statistical Areas 1, 2 and 6-10

We have been unable to find any specific information on SSEAK exploitation rates on sockeye returning outside of the Skeena, Nass and Area 5, other than those provided in English et al. (2018, Table 1). English et al. (2018) set all Alaskan ERs in these areas to zero.

Stock composition reports for some SSEAK sockeye fisheries in Districts 101-104, 104, 106, 108, and 111 are available on the PSC Northern Fund final report webpage[2]. We downloaded and reviewed many of these reports, however we did not undertake a comprehensive review of each report. These reports provide stock composition estimates by regional reporting groups based on genetic analyses of fisheries samples. We extracted stock composition data for District 101 commercial gillnet fishery and the District 104 commercial purse seine fisheries from the three most recent years available (Guthrie et al. 2018, 2019a, 2019b). Weekly stock compositions are shown in

Figure 31. This shows that while Skeena and Nass (and Alaska) sockeye dominate catches in these 3 years in both fisheries, there is a small portion of catch attributed to the South Migrating reporting group separate from Fraser River sockeye. It is important to note that the reporting groups were condensed in fishery year 2016, so that those reports previous to 2016 showed a greater resolution of south migrating stocks and showed Central Coast BC and Queen Charlotte Island reporting groups (Guthrie et al. 2010, 2011, 2012, 2013, 2014, 2015a, 2015b, 2016, 2017). While these reporting groups were only present in fisheries in small proportions, sample size and power to detect low abundance populations may have been an issue. In summary, BC sockeye from areas other than the Fraser, Skeena and Nass Rivers are likely present in these fisheries in most years.

[2] https://www.psc.org/publications/fund-backgrounders-final-reports/#60-418-2016-fund-projects

3.1.5 Additional Information: Skeena and Nass sockeye run-timing

Both Skeena and Nass sockeye are showing trends of later run-timing in recent years. The median or 50th percentile (mid-point) of the Skeena sockeye run shows a shift of approximately 1 week later since 2015 (Figure 32) using Tyee test fishery daily index data (note that it would be better to use the total reconstructed daily TRTC since marine fisheries remove sockeye at various times and quantities before the Tyee test fishery, however that data was not made available by DFO). The late-timing shift is echoed by the near-start of the run (10th quantile) and near-end of the run (90th quantile), but was less clear for the peak of the run (most numerous 5 days).

Nass sockeye run-timing has also shifted later by ~ 1 week on average in the 2010-2019 period versus 1982-1989 (Figure 33).

Shifts towards later run-timing may have implications for marine catch of Skeena and Nass sockeye in SSEAK fisheries, especially those governed by PSC Treaty provisions such as the Week 31 guidance in District 104 and 101 fisheries. PSC harvest restrictions are in place for Skeena sockeye caught in D104 fisheries up until Week 31 (the end of July). Beginning Week 31 there are no harvest restrictions on Skeena sockeye.

3.2 Fraser Sockeye

Information on Alaskan interceptions of Fraser sockeye by Canadian, Washington and Alaskan fisheries from 2000-2020 were provided by the Pacific Salmon Commission (PSC 2021a) and DFO (Les Jantz and Jamie Scroggie, personal communication, 2021). Additional information at the Conservation Unit/Stock level was provided in Latham and Samarasin (2018), which is a draft report summarizing the results of genetic analysis using Single Nucleotide Polymorphisms (SNPs) from sockeye samples collected during the 2018 fishing season from Alaskan District 104 seine fisheries.

- For a general idea of the magnitude of catch by region, Alaskan catch of Fraser sockeye averaged ~ 60,000 from 2000 to 2020 (Figure 34, top panel). Canadian catch averaged ~ 2.2 million and Washington catch averaged ~ 320,000 over the same period. However, due to the cyclic nature of Fraser sockeye catch, average catch may not be an appropriate indicator of each fishery's relative impact in a given year.
- Alaskan exploitation is typically estimated to be very low (< 5%), with only 2 years 10% or higher (Figure 34, middle panel).
- The percent of total Fraser sockeye catch attributed to Alaskan fisheries is typically low, however there are a number of years where the proportion of Alaskan catch has been near to or much greater than the Canadian proportion ((Figure 34, bottom panel). This can likely be attributed to abundance-based management in PSC Fraser Panel waters, where in low abundance years Washington and BC fisheries targeting Fraser sockeye would be severely curtailed, whereas Alaskan fisheries are independent of Fraser sockeye abundance.
- In 2018, Alaskan catch of Fraser sockeye was estimated to be ~ 53,000 (PSC 2021). Of this, Shuswap Lake sockeye dominated the catch (57%), followed by Quesnel (22%) and Chilko (13%) sockeye (Latham and Samarasin 2018).

3.3 2021 Estimates

3.3.1 North Coast

2021 estimates of SEAK catch of Skeena and Nass sockeye are not formally available until after the PSC NBTC meetings in January. However, some preliminary information is available.

In 2021, over 739,000 sockeye were caught in SSEAK Southern Purse Seine fisheries (ADFG 2021a), with over 495,000 of those being caught in the District 104 Purse Seine fishery alone (ADFG 2021b). Approximately 21,500 sockeye were also caught in the Tree Point Gillnet fishery. Although we extracted weekly stock compositions from 3 years of PSC Northern Fund Genetic Stock Composition Reports, full weekly stock composition data from sampling in SSEAK fisheries were not available to us at the time of this report writing, so we did not directly estimate 2021 harvest Skeena and Nass sockeye.

Preliminary estimates of 2021 catch of Nass sockeye in SEAK fisheries are provided in Table 9 of the DFO Post Season Review Areas 1-6 Booklet (DFO 2021a). This indicates that SSEAK fisheries harvested approximately 101,000 sockeye, which represents a 20% exploitation rate.

Preliminary estimates of 2021 catch of Skeena sockeye in SEAK fisheries were provided at the DFO North Coast Post Season Review via handout (~ 9% which is the average exploitation rate from 2000-2020) (DFO, 2021b), however more recent preliminary estimates were provided at a recent Northern Boundary Technical Committee meeting (G. Knox, personal communication, December 2021). This estimate, while still preliminary, was ~ 280,000 Skeena sockeye, which given a Skeena sockeye Total Return of 1.4M (DFO, 2021b), represents an exploitation rate of 20%. This is similar to exploitation rates in some recent years (e.g., 2016 and 2019) (Figure 11).

For Nass and Skeena sockeye, there were no sockeye directed commercial fisheries in 2021. There were some released sockeye in Area 3 pink and chum salmon directed seine fisheries that would have incidental mortality. This would imply that the proportion of total catch in 2021 would be very close to 100% in SEAK.

No information is available for 2021 SSEAK exploitation of Area 5, however, it would be expected that 2021 exploitation would be higher than average.

3.3.2 South Coast

We currently have no information on estimates of SSEAK exploitation on Fraser or other south coast sockeye stocks in 2021. It would be expected that this information would be available in early 2022 after the PSC meetings in January.

4 Information Gaps

- SSEAK harvest of North and Central Coast sockeye other than Skeena, Nass and Area 5.
    - Annual stock composition reports from some SEAK fisheries provide information on sockeye stocks other than those included in the NBSRR model (Skeena/Nass) and Fraser sockeye. This provides evidence that these smaller stocks are present during fisheries, however, given their generally low abundance they represent small proportions of the total catch which is dominated by more abundant or local stocks.
    - We were unable to find information on exploitation rates of these stocks at any level.
    - It is our understanding that there is ongoing work to improve the BC sockeye baseline using SNPs.
    - An ongoing PSC driven project is also underway to align genetic baselines between US and Canada, which may aid in small/sub stock genetic ID.
    - Follow-up is required with DFO Stock Assessment.
- Fraser sockeye
    - We received one draft report which looked at sub-aggregate level genetic ID (Latham and Samarasin 2018), however it is unclear to us if there are more years where BC genetics

labs received samples for analysis at the sub-aggregate level for Fraser sockeye, and if those results are available.

- Strait of Georgia (SOG) and West Coast Vancouver Island (WCVI) sockeye
    - We were unable to identify information on exploitation rates for SOG and WCVI sockeye in SEAK fisheries, although WCVI sockeye are included as a reporting group in recent ADFG genetic analyses.
    - Follow-up is required with DFO Stock Assessment.

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6 Figures

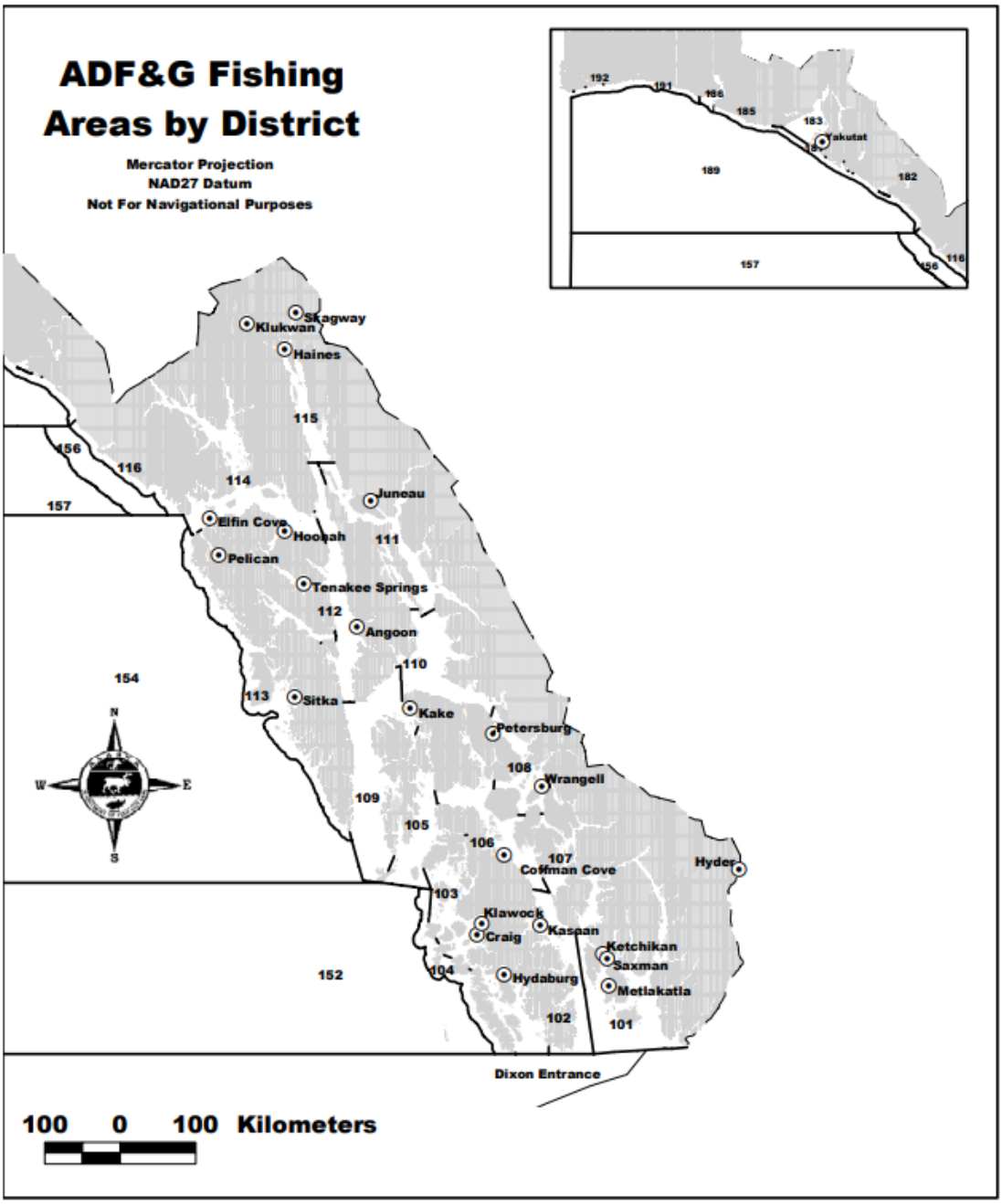
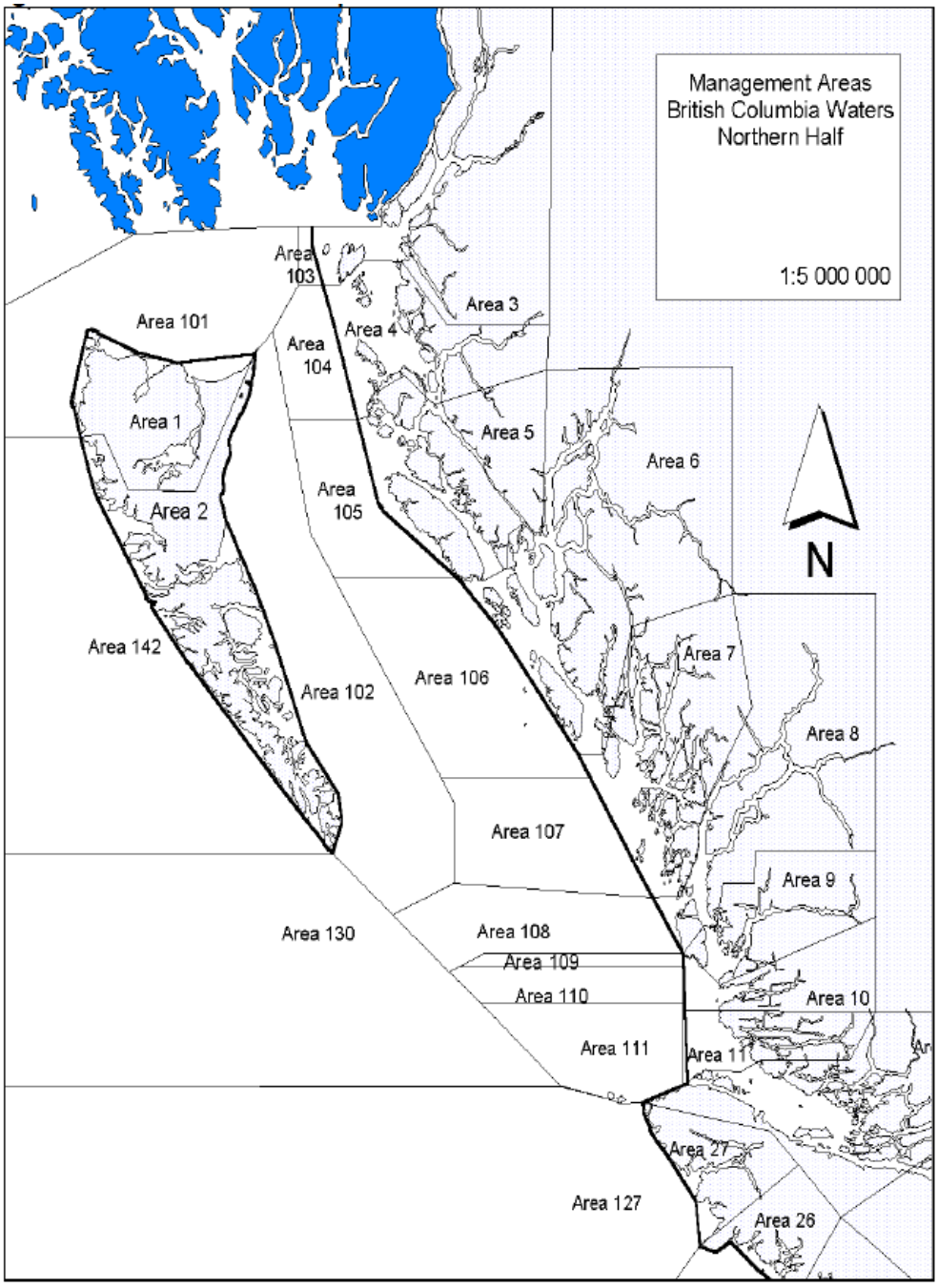


Figure 1: Map of Southeast Alaska Fishing Areas by District.



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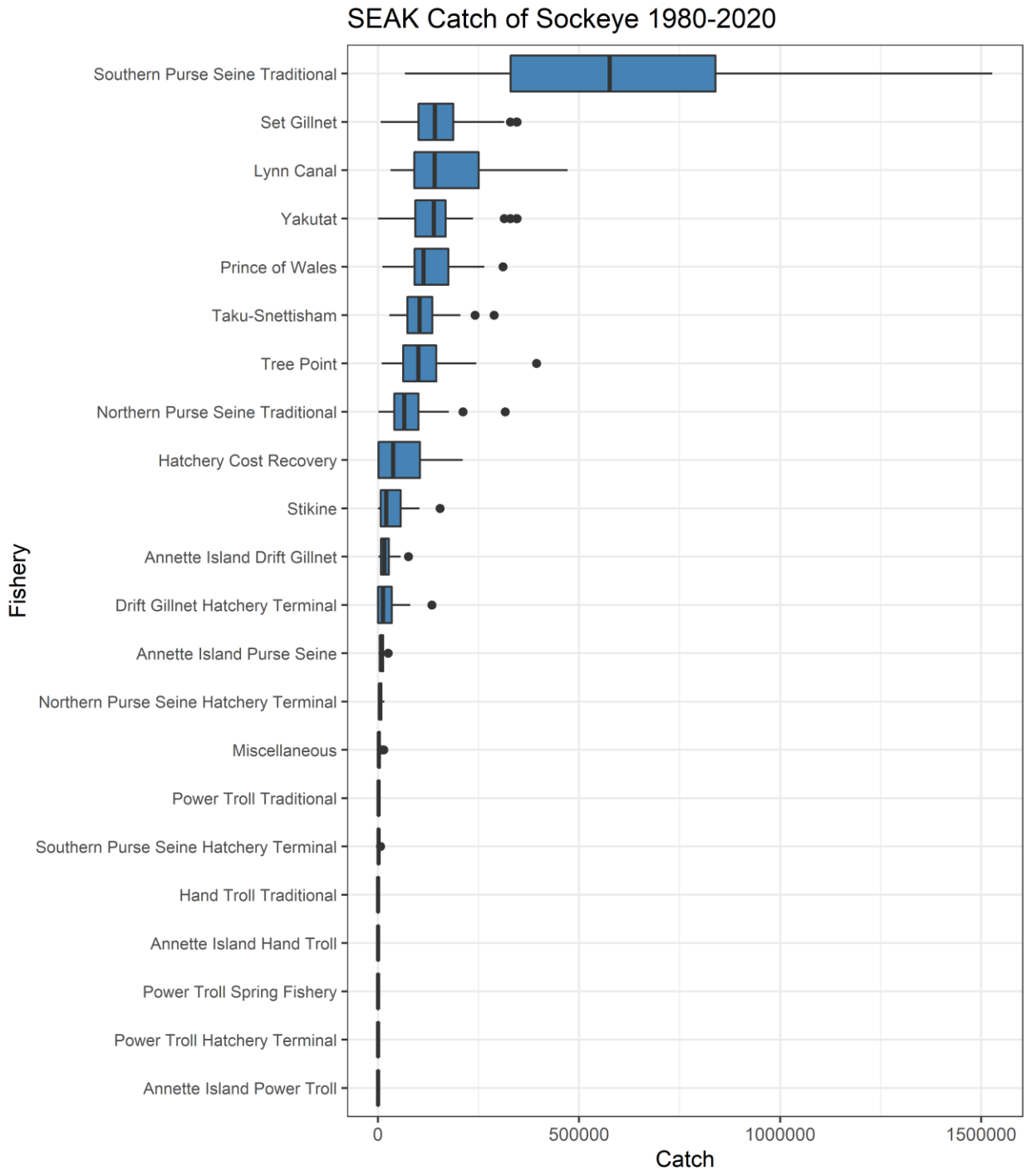
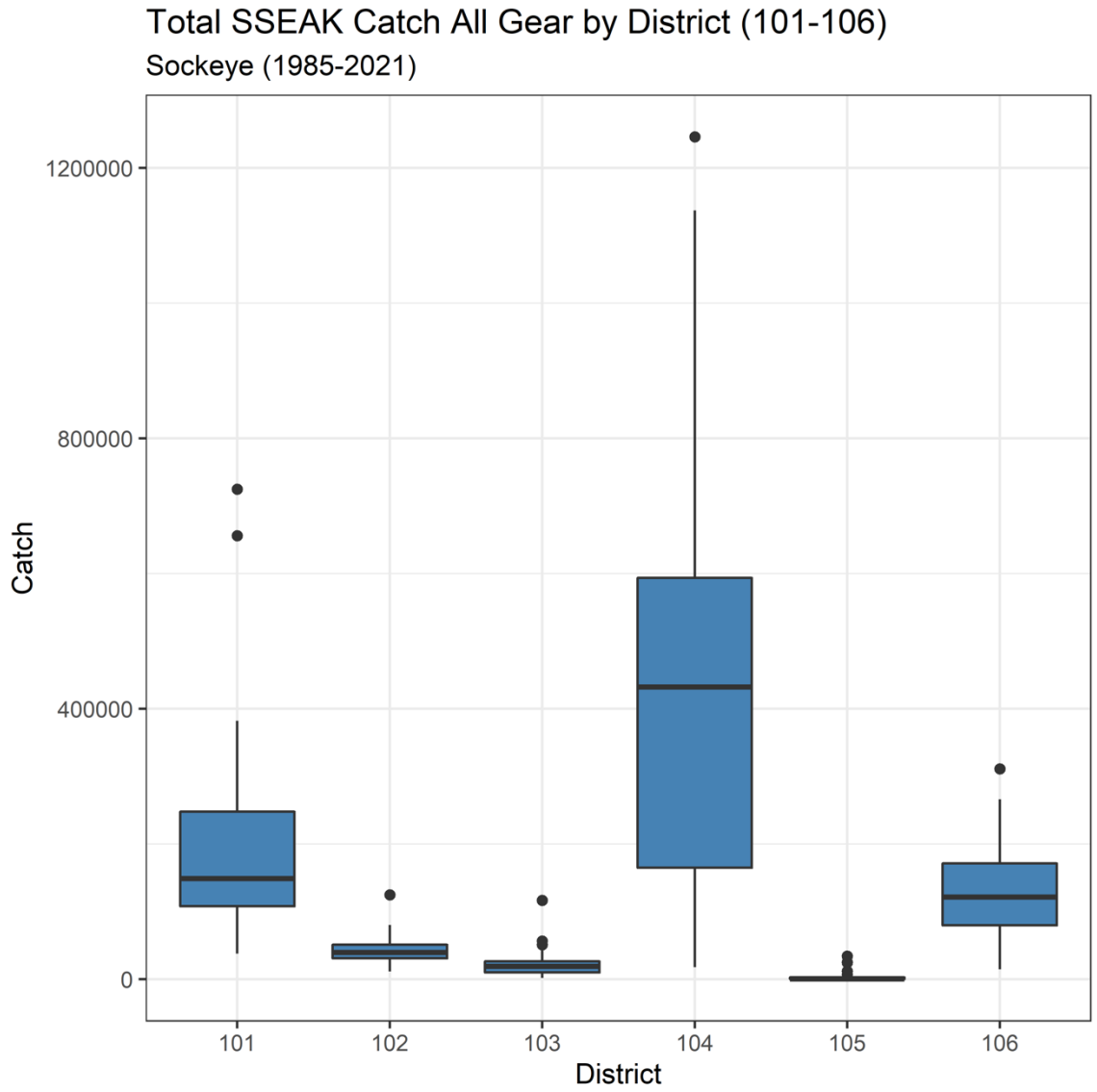


Figure 4: Distribution of total sockeye commercial catch in SEAK "Blue Sheet" fisheries. Fisheries are ordered from highest catch to lowest catch. The thick black line is the median value, the box in indicates the interquartile range (25th to 75th percentiles – or middle 50% of the data), whiskers are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



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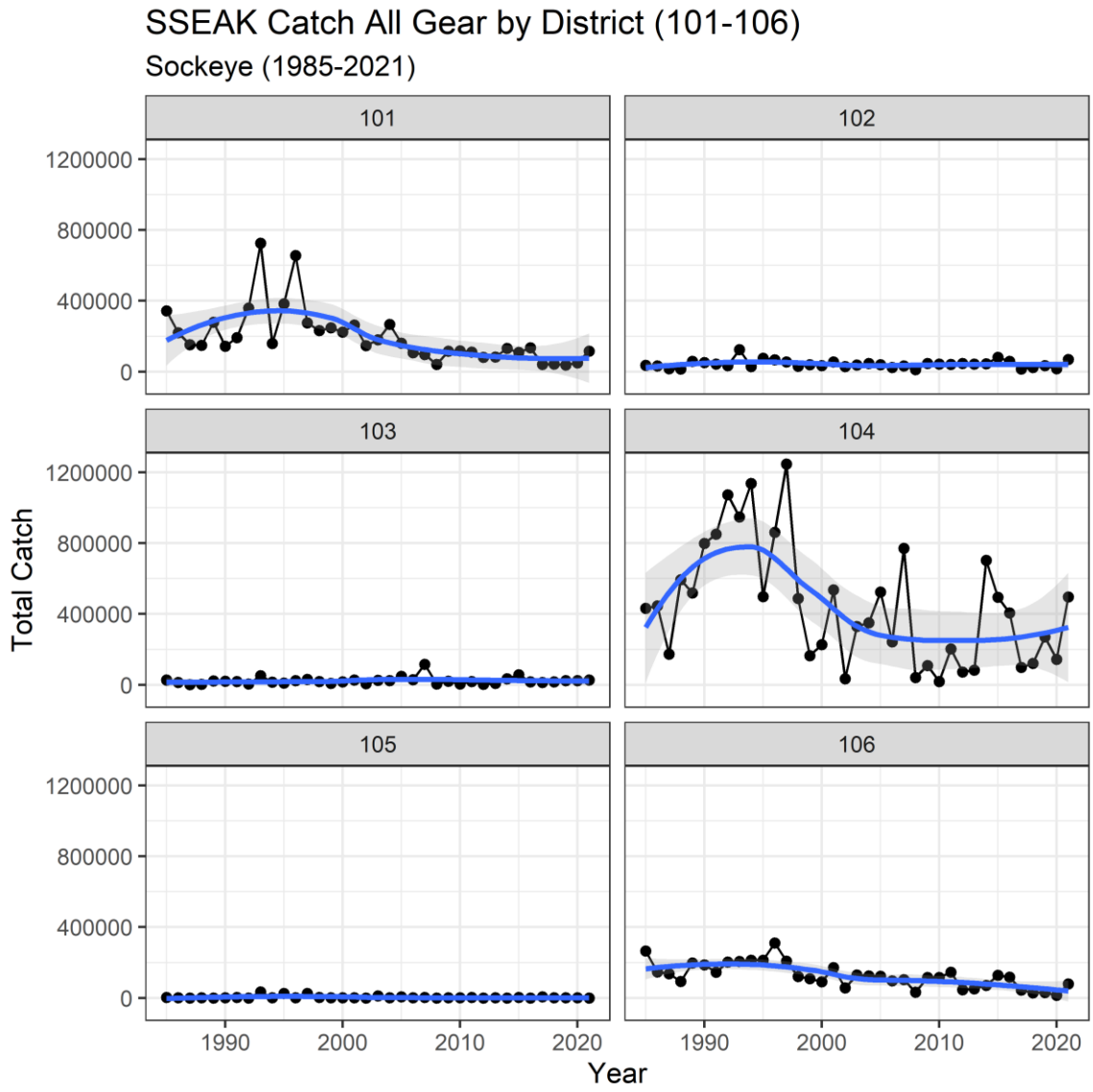

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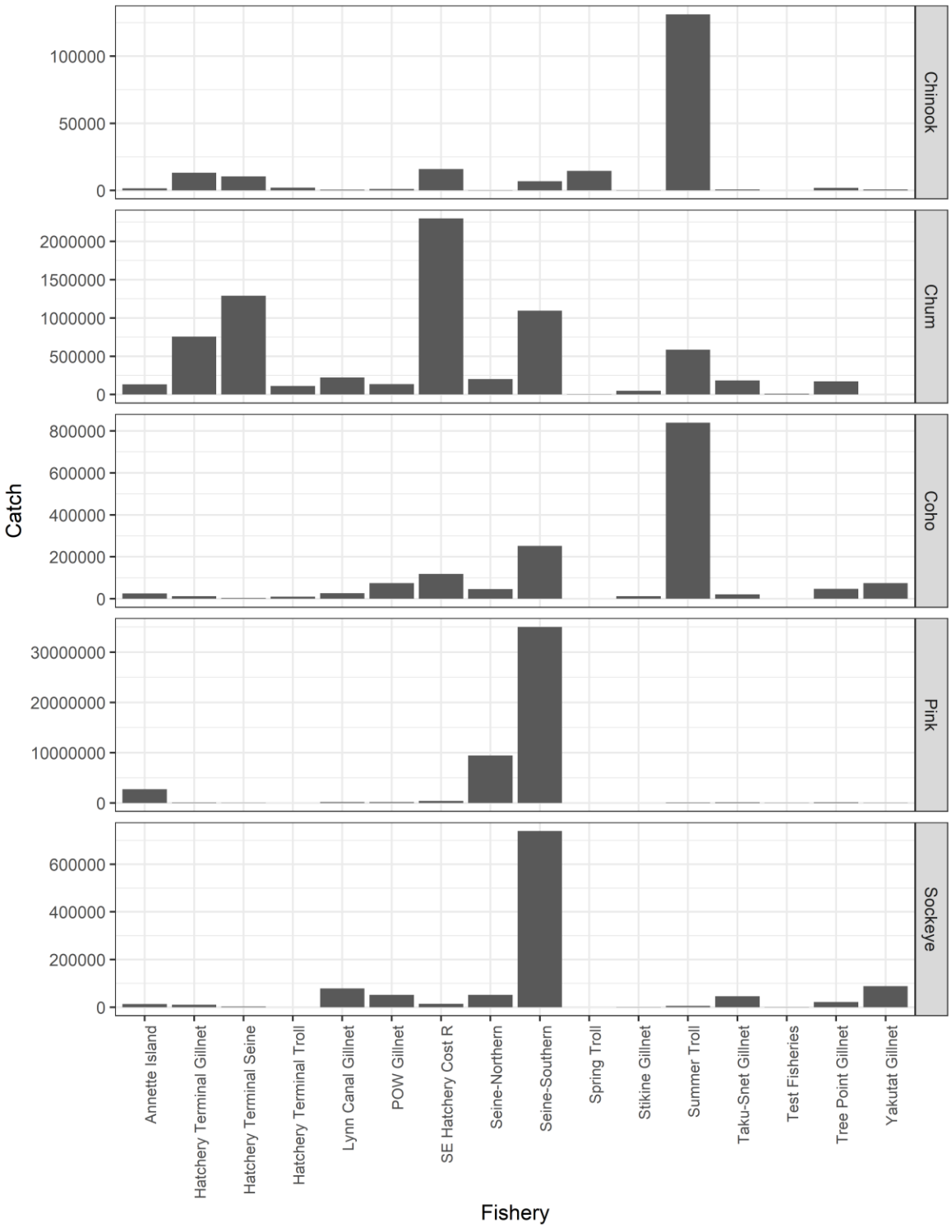

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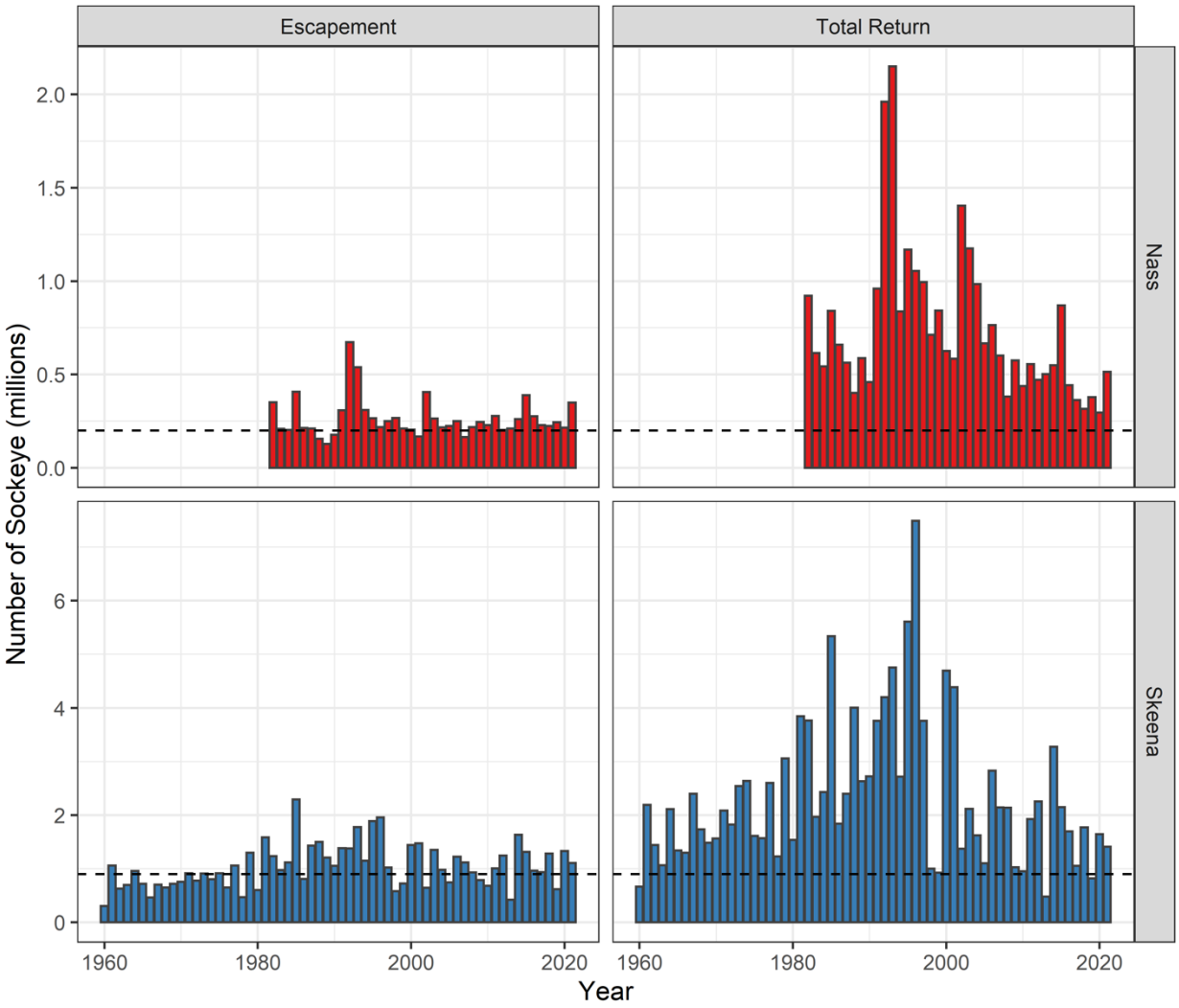

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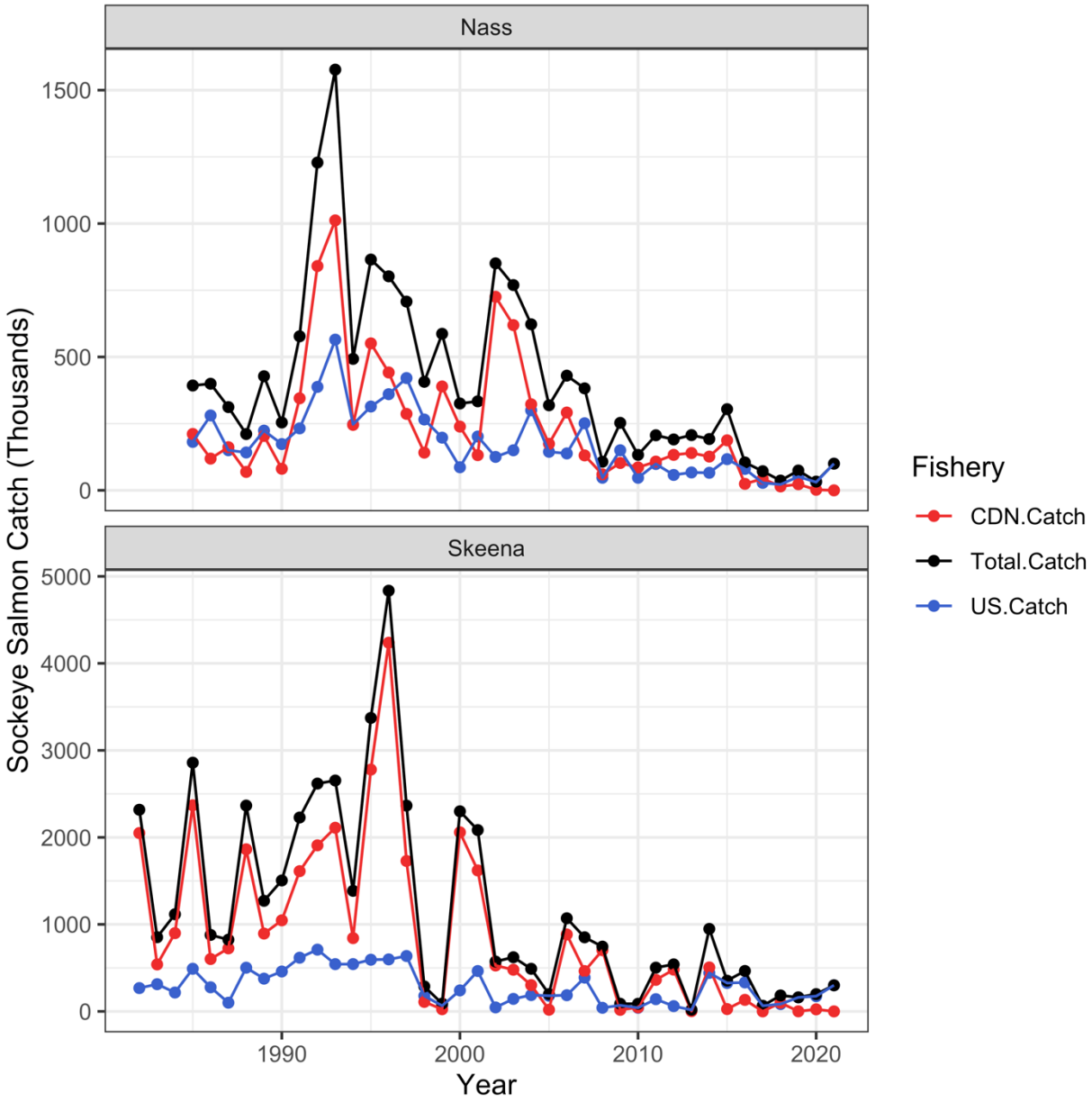

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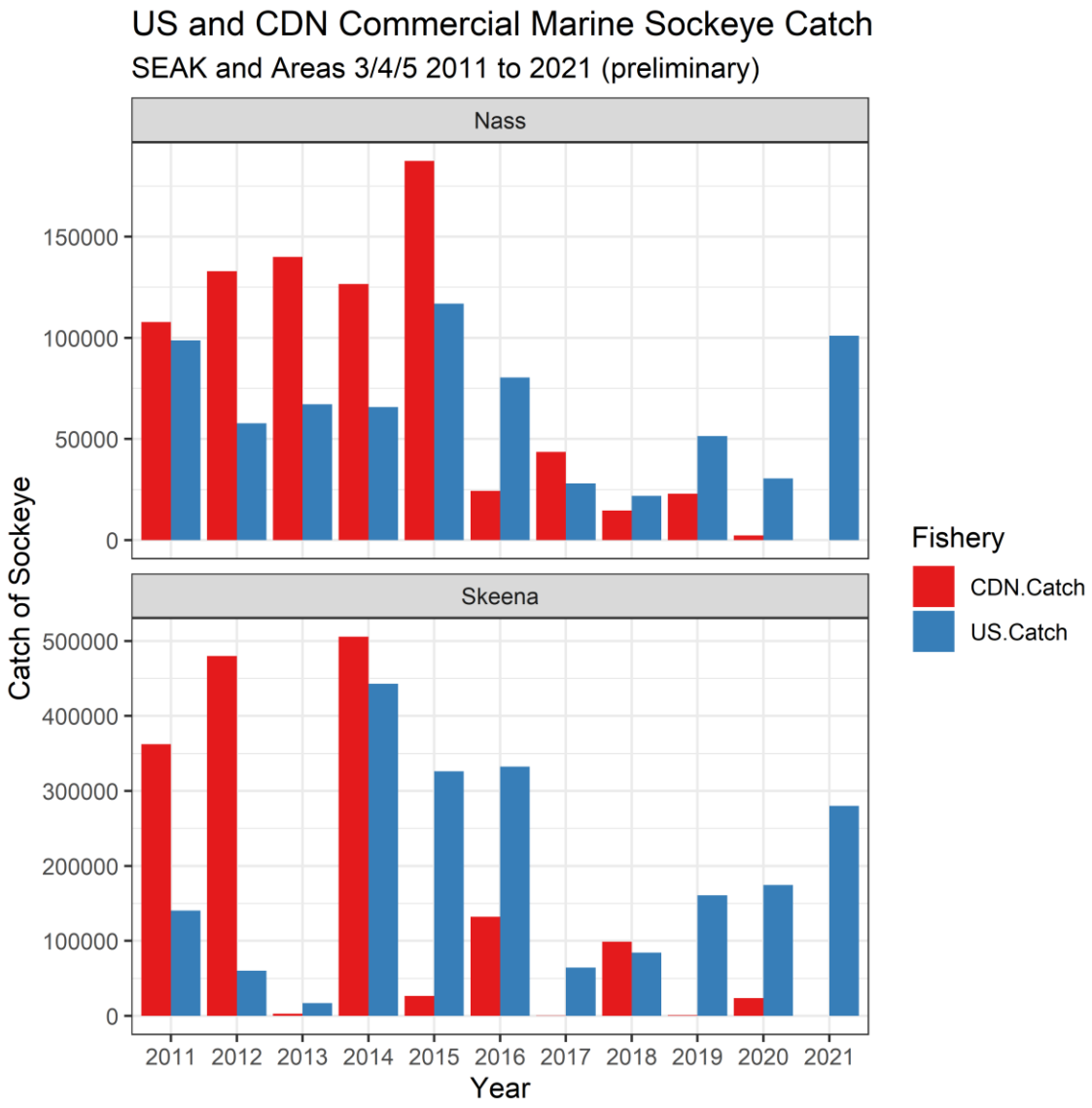

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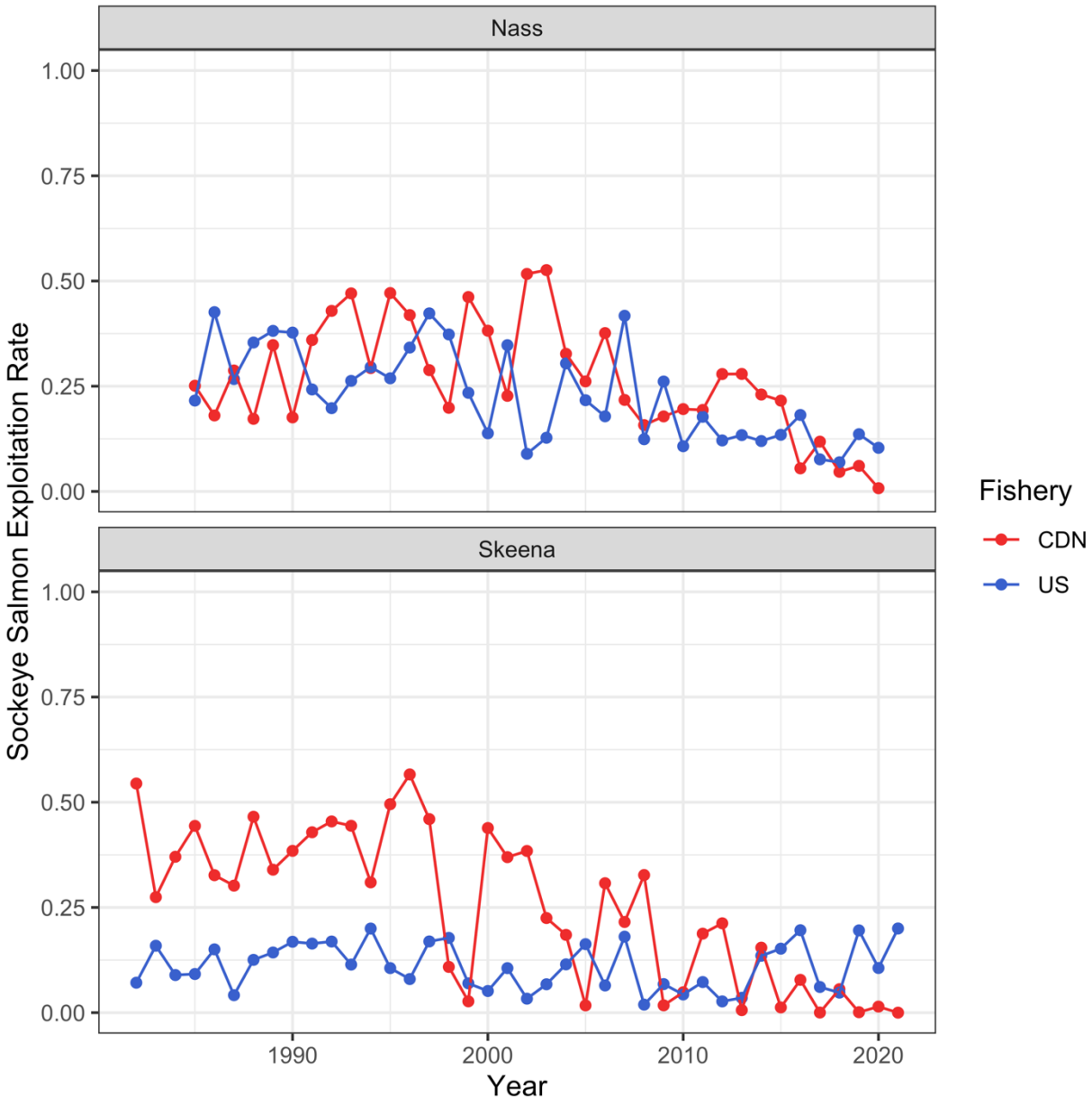

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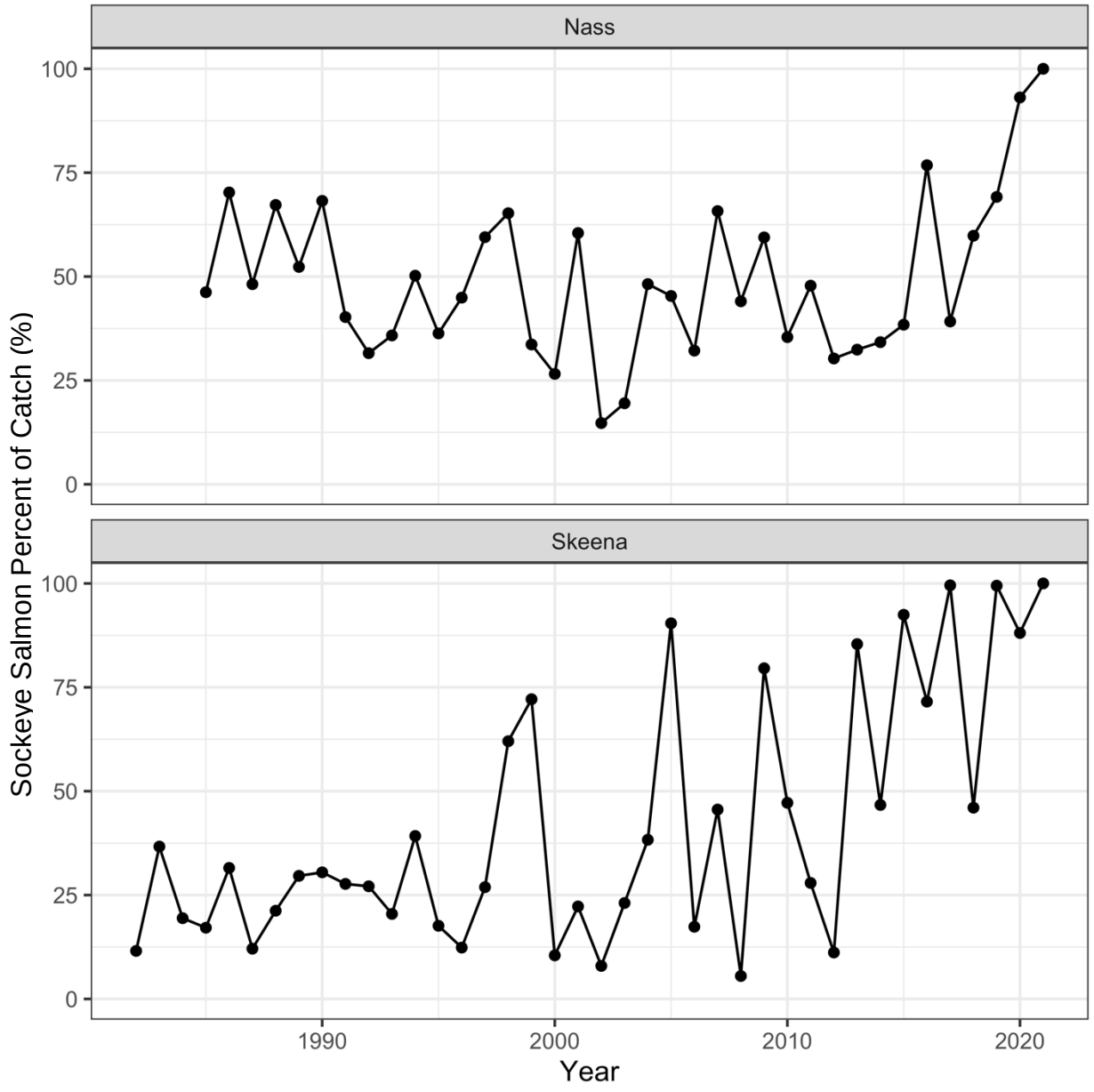

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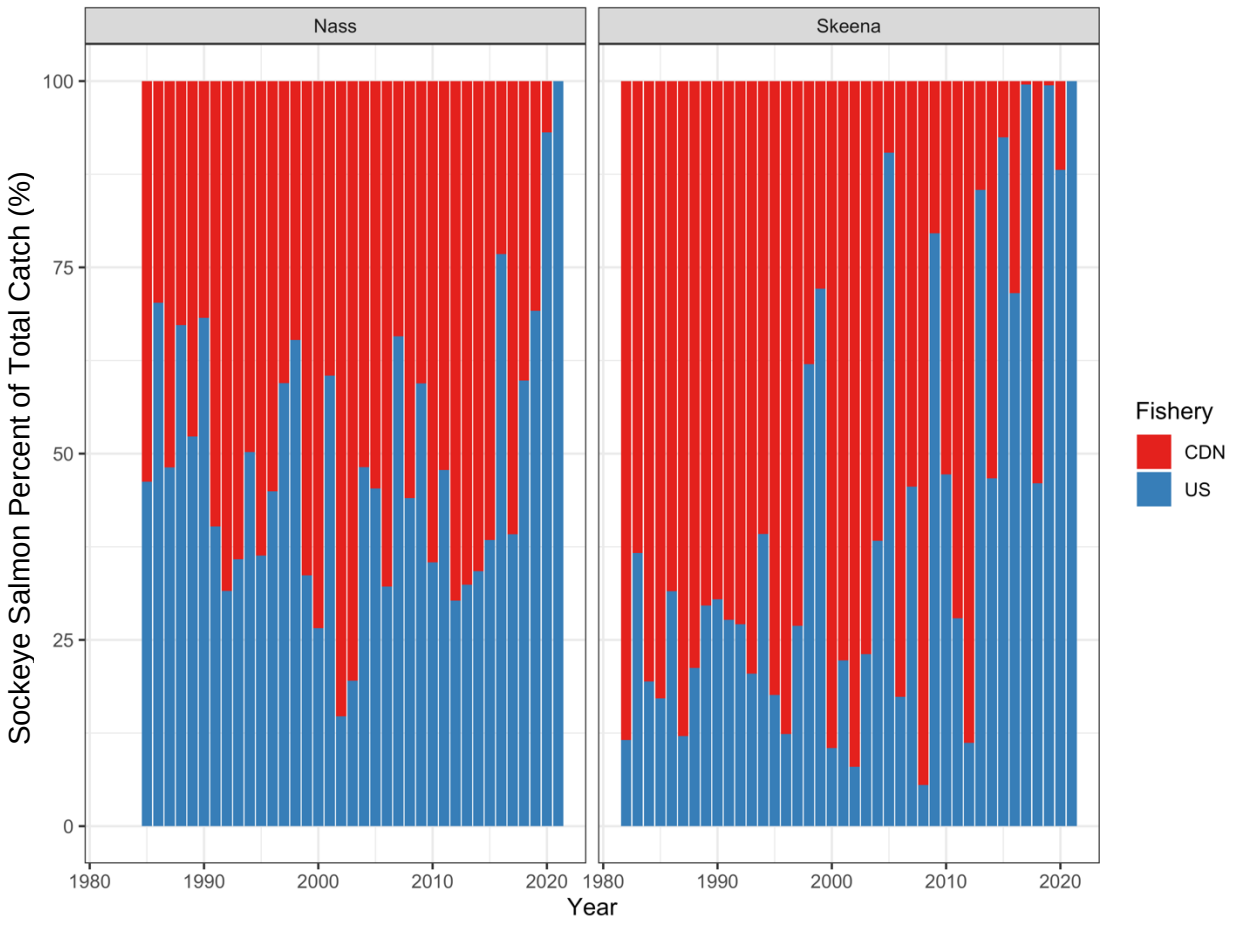

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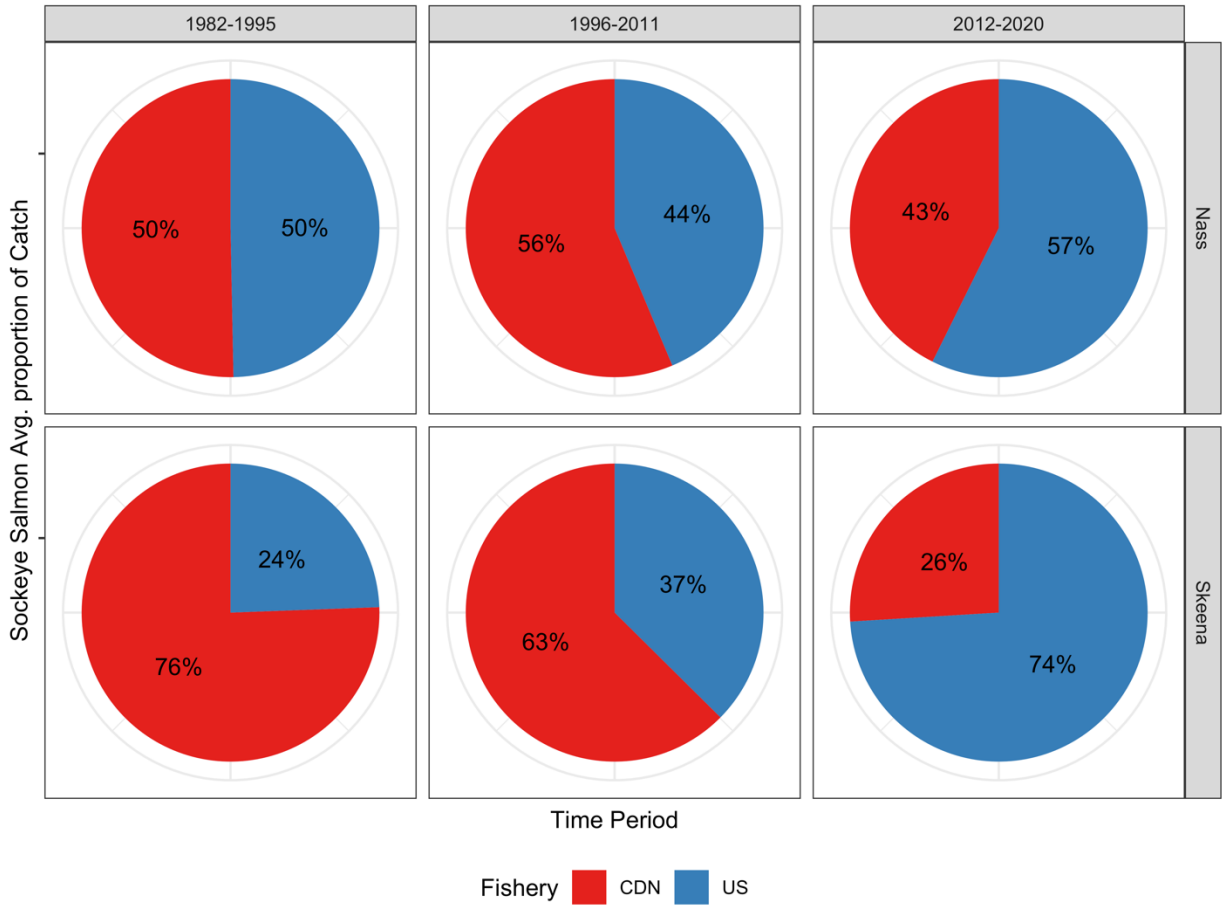

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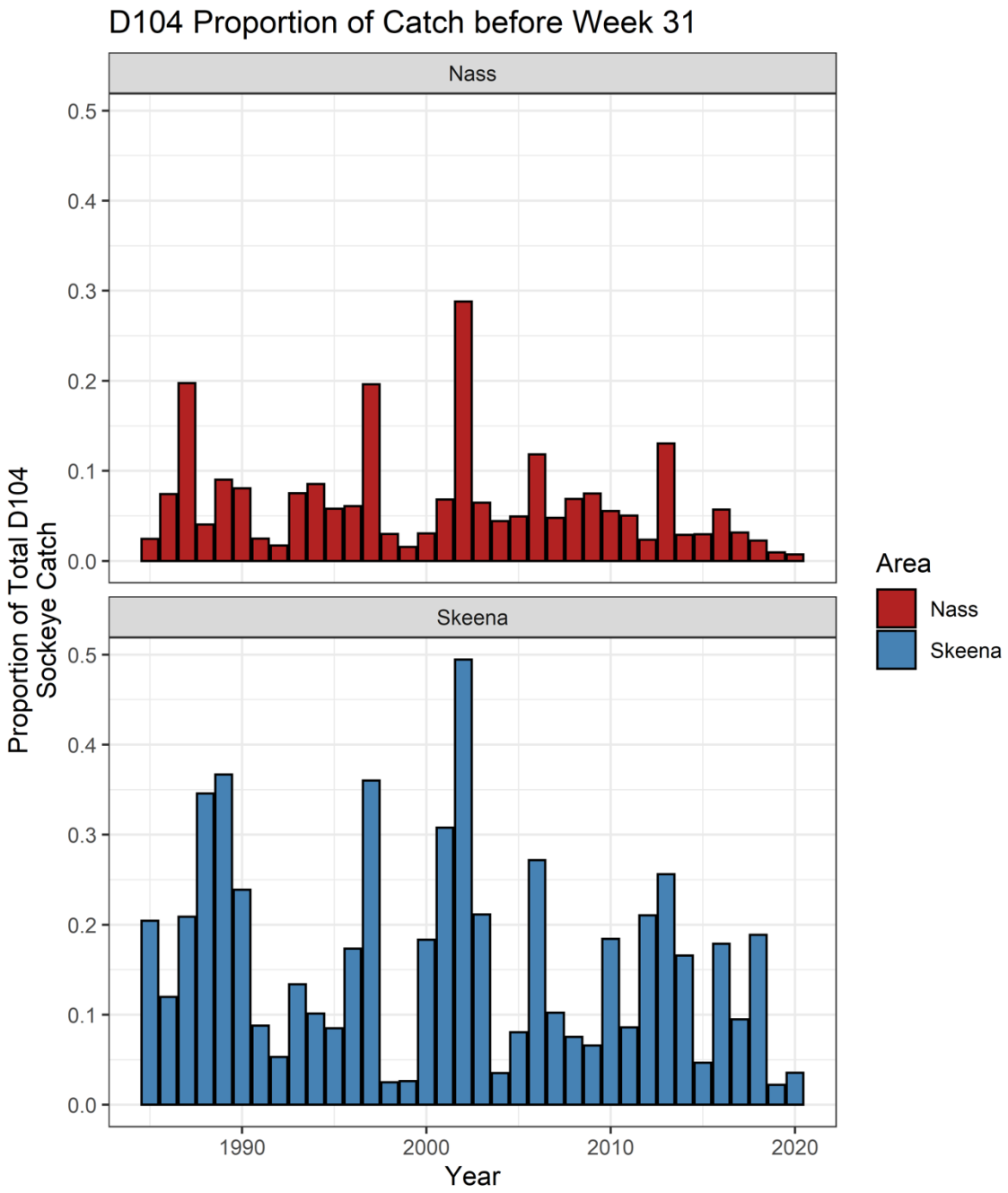

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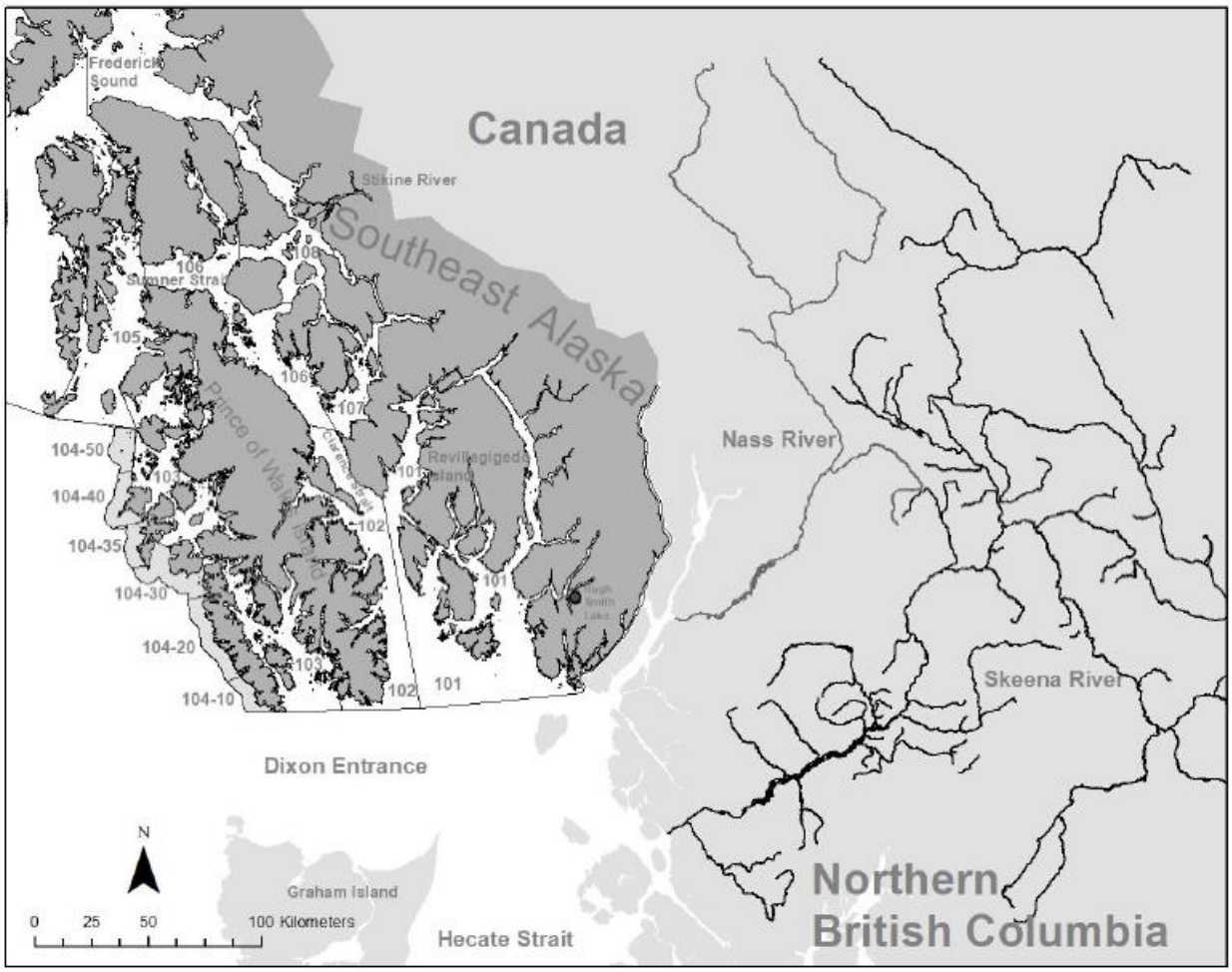

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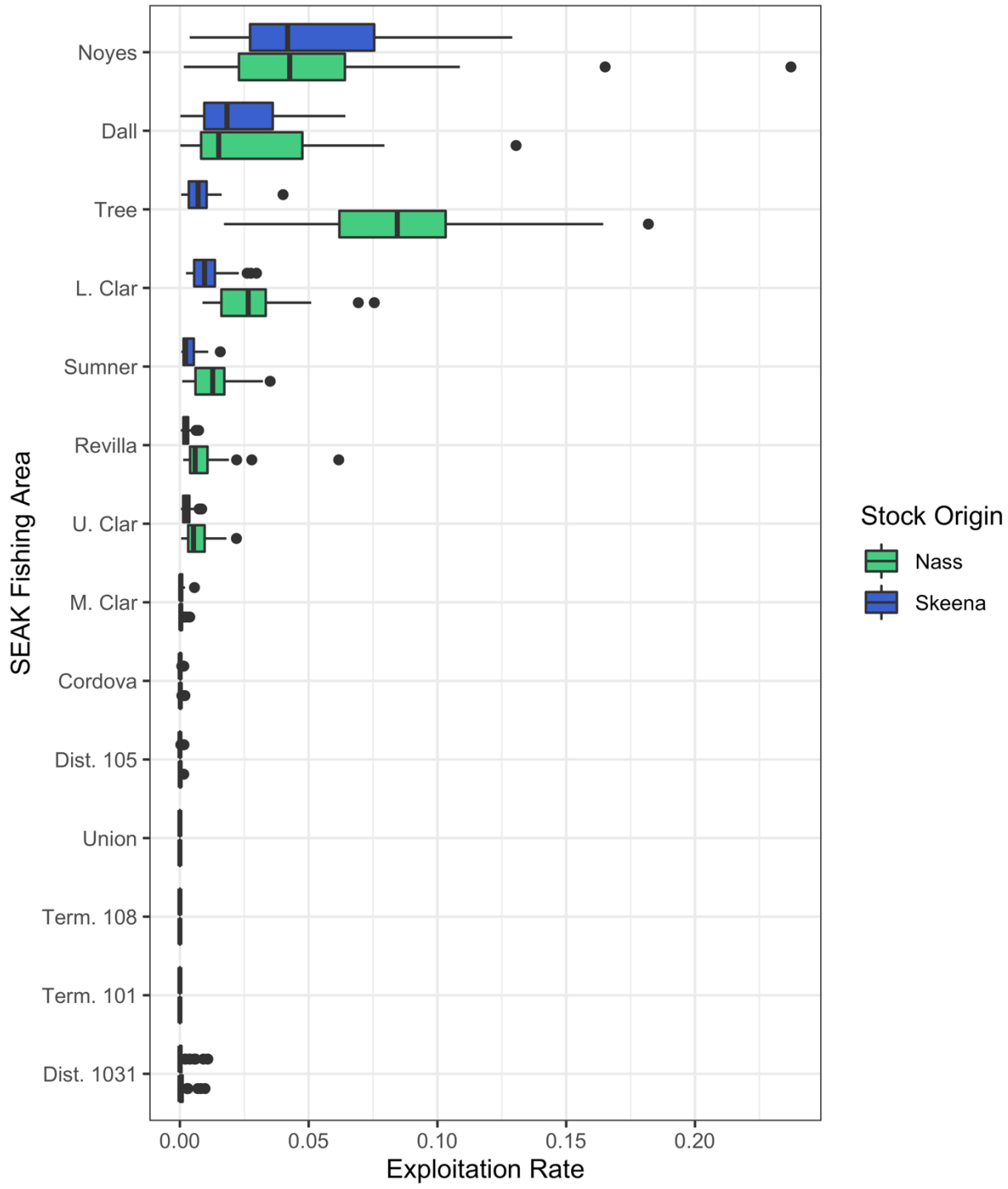

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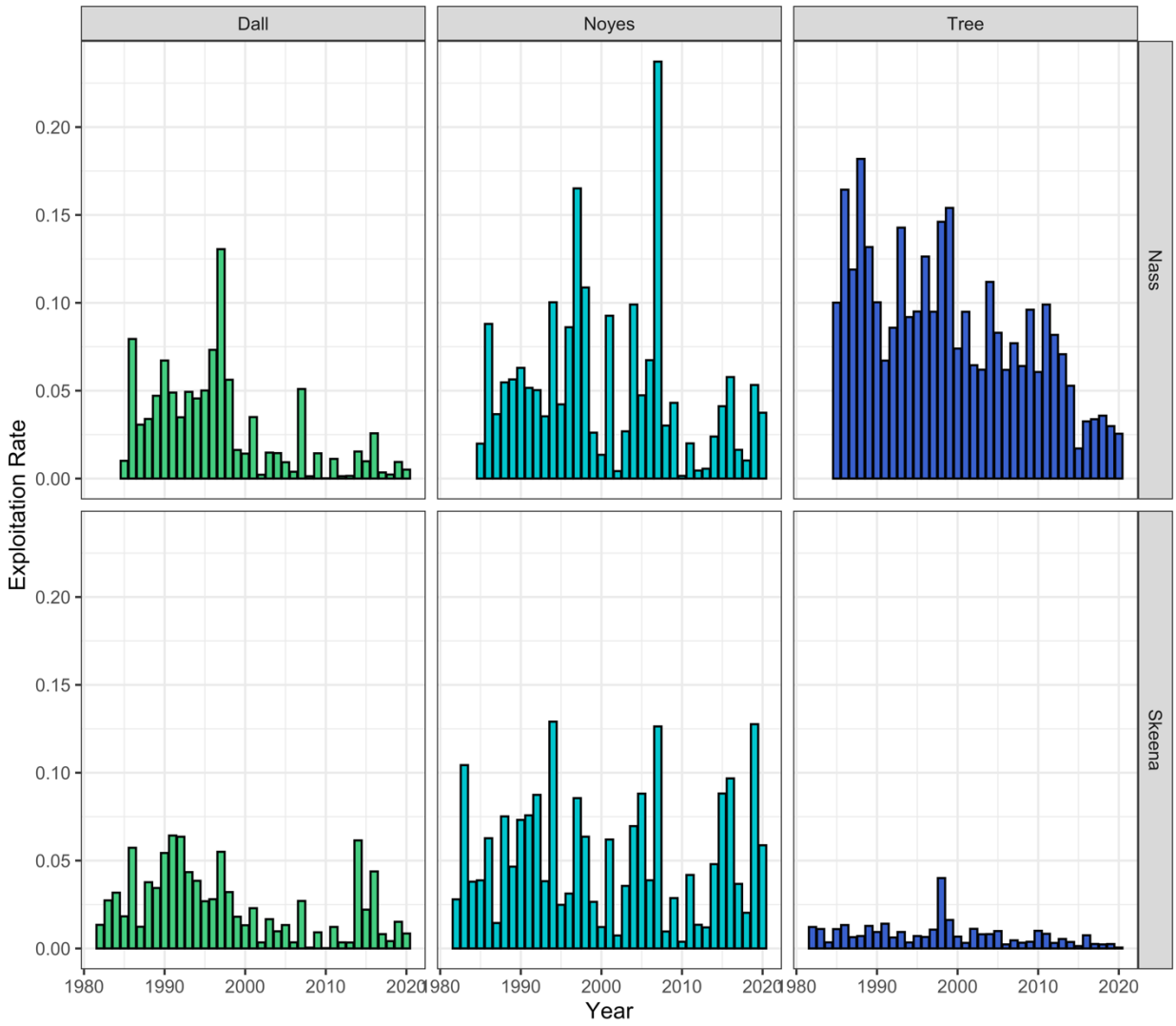

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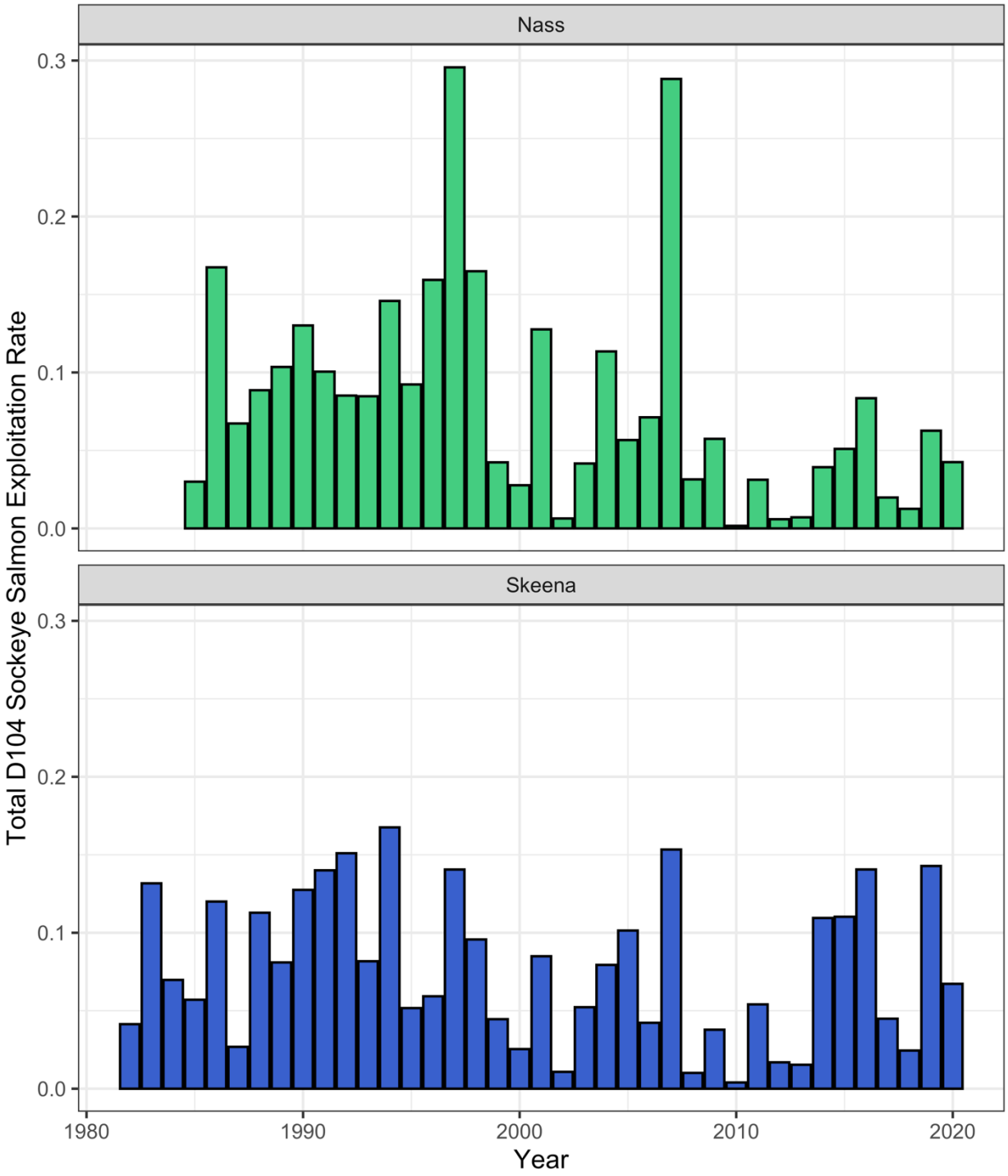

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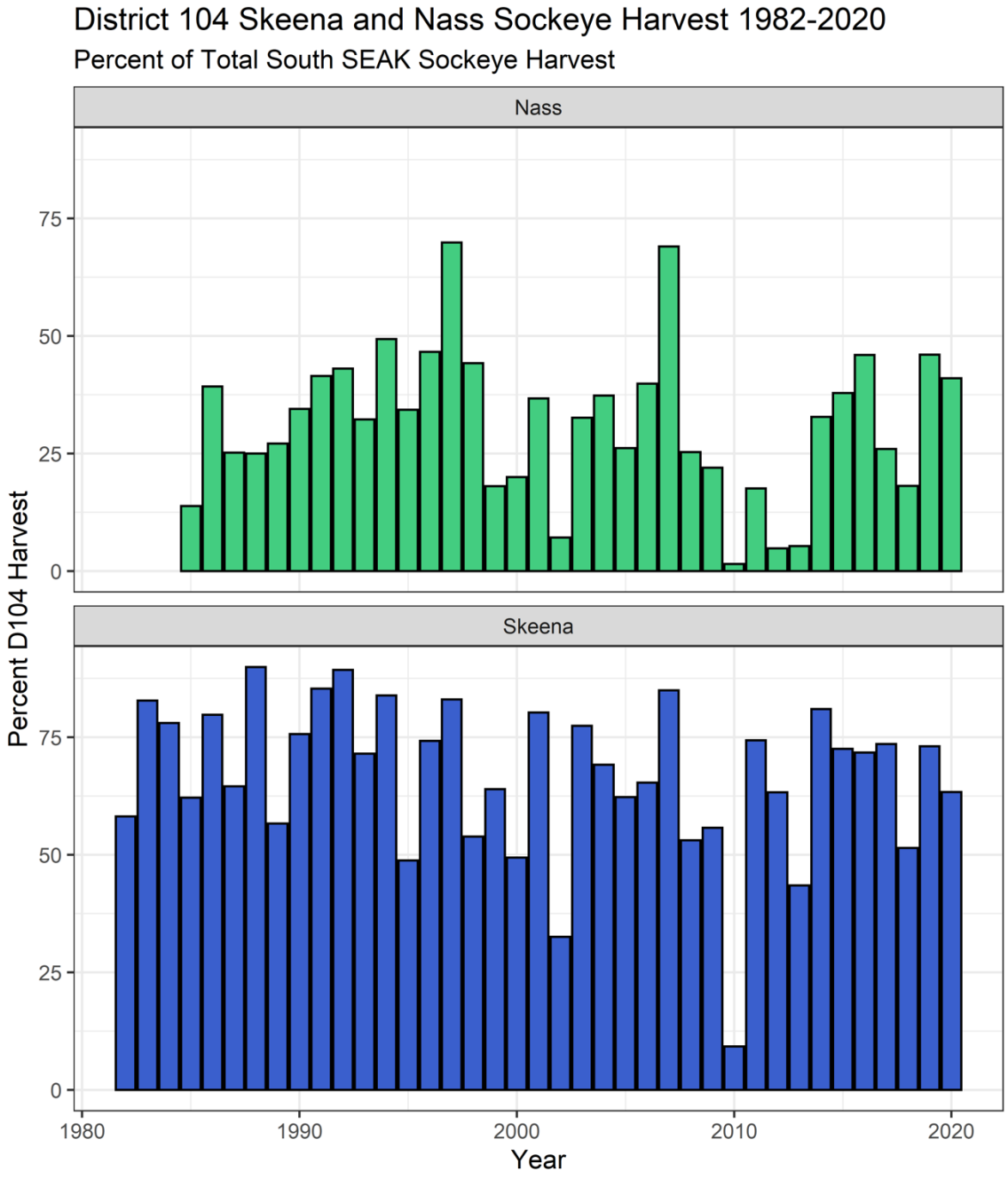

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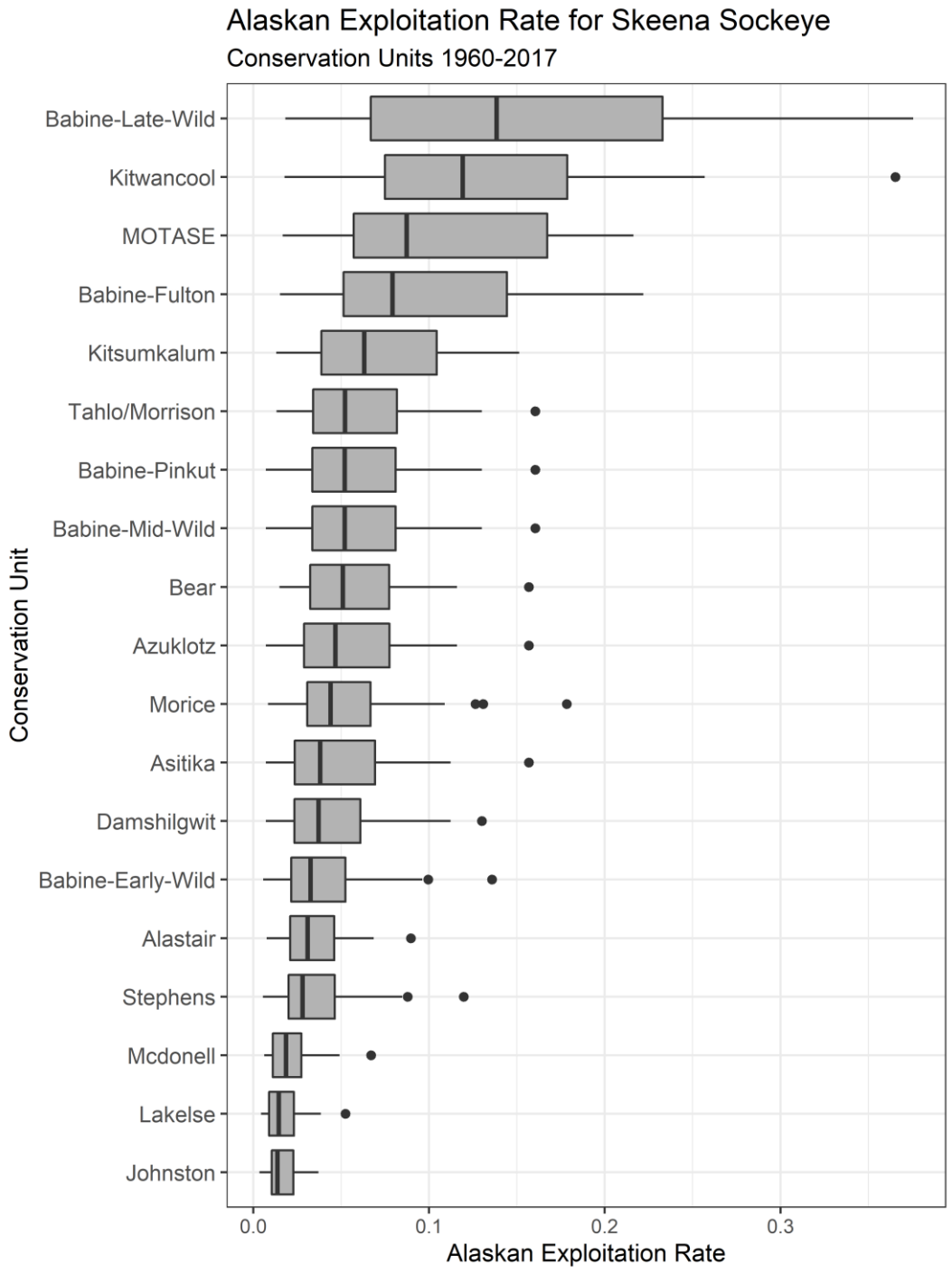

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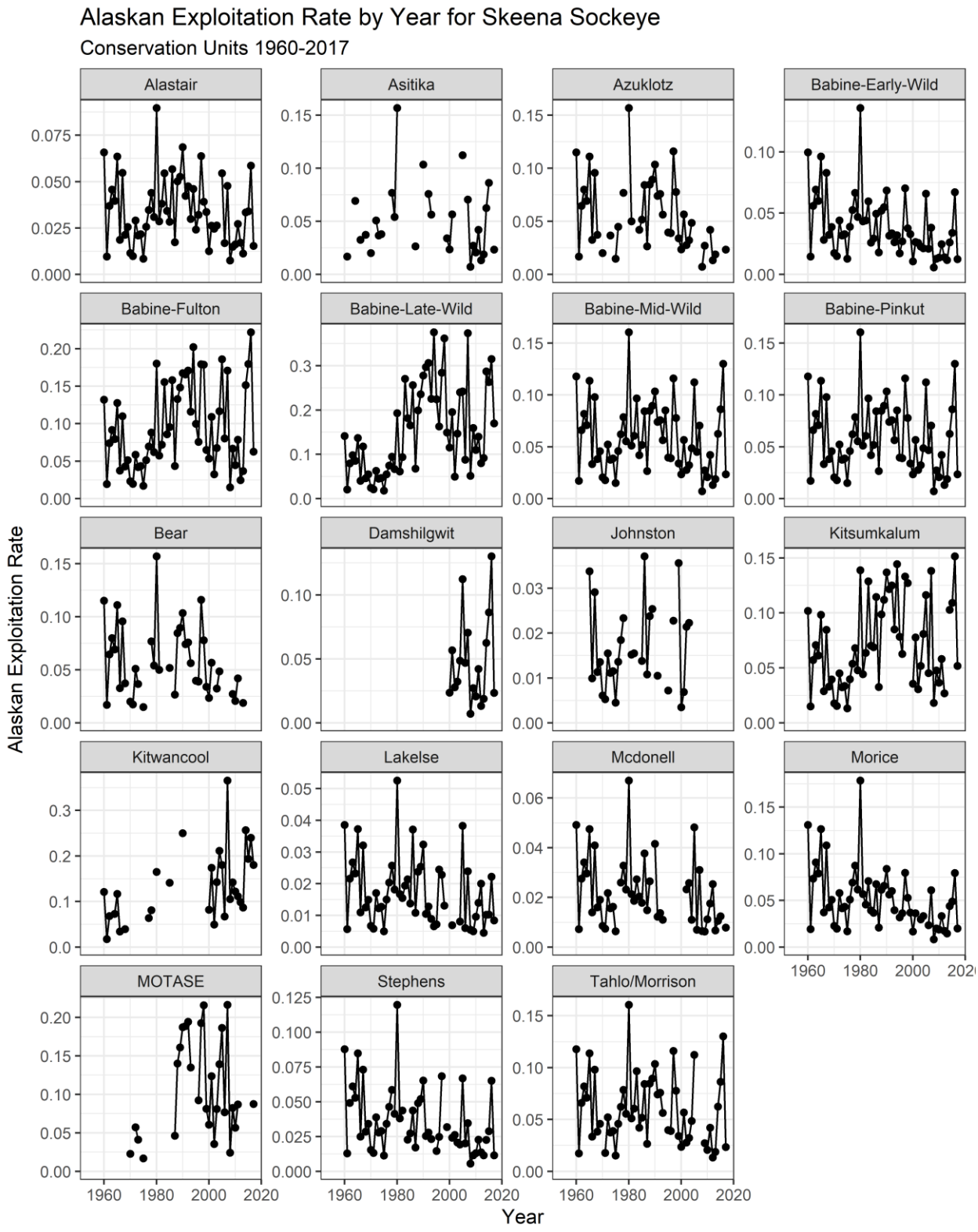

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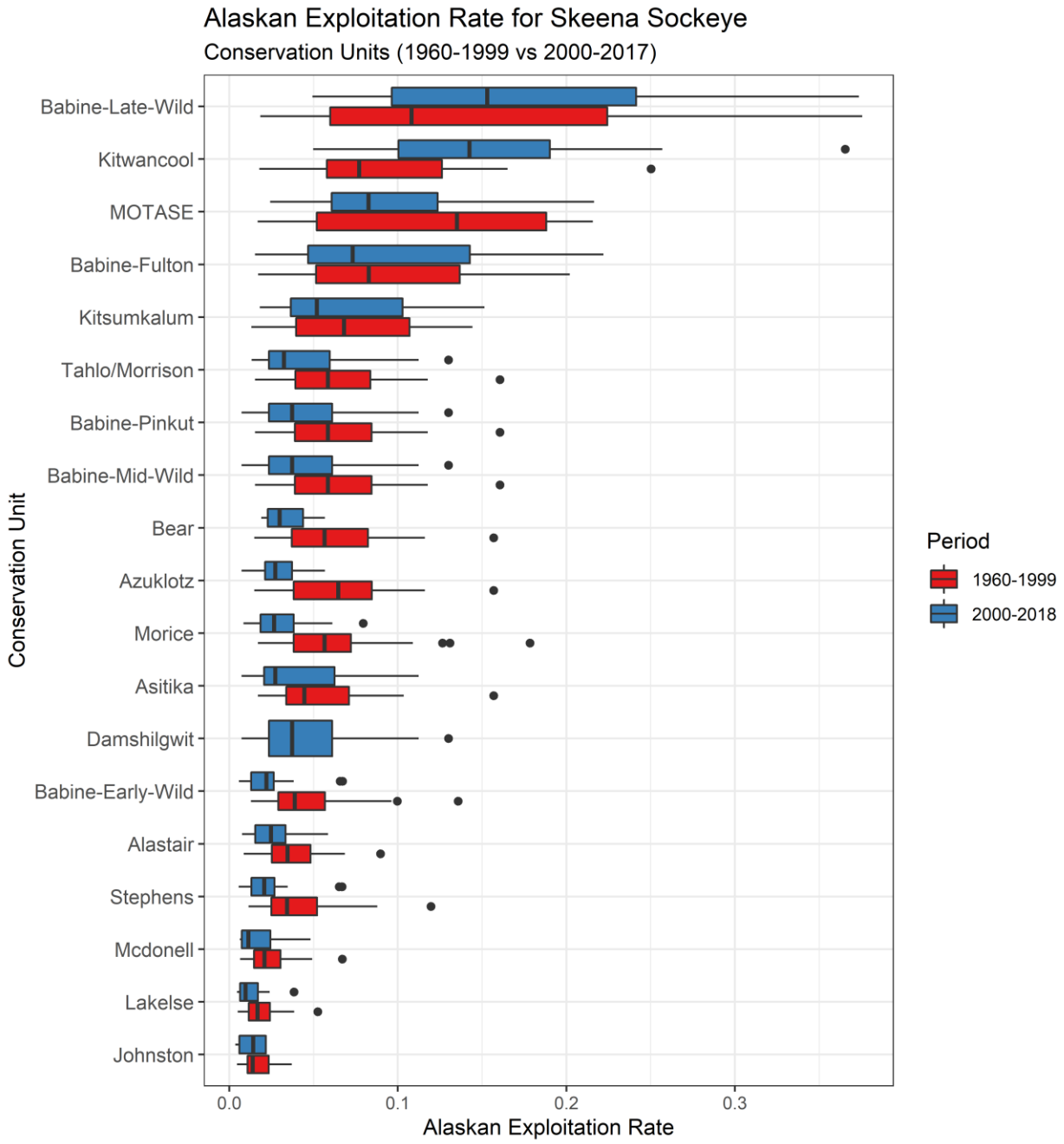

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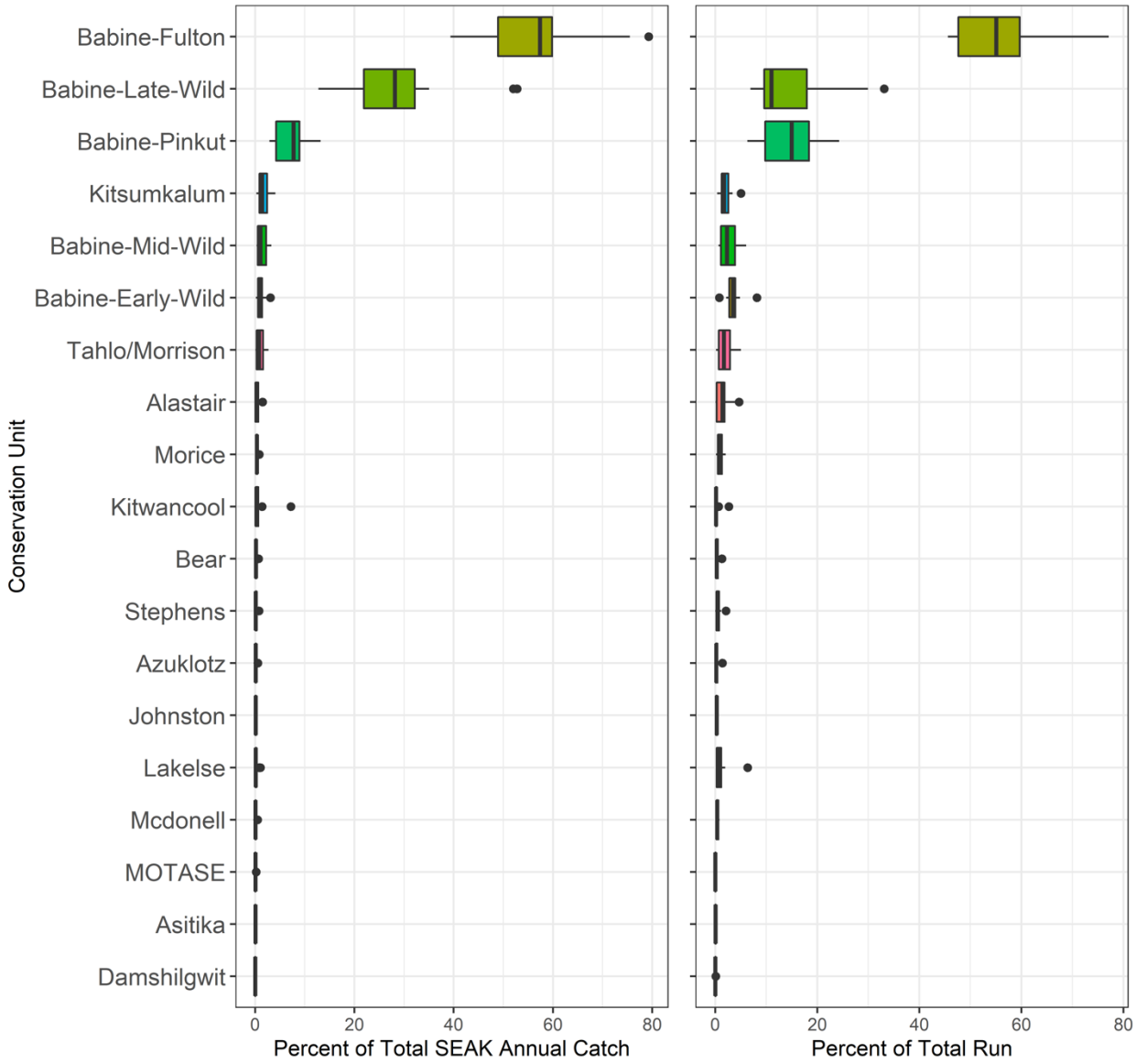

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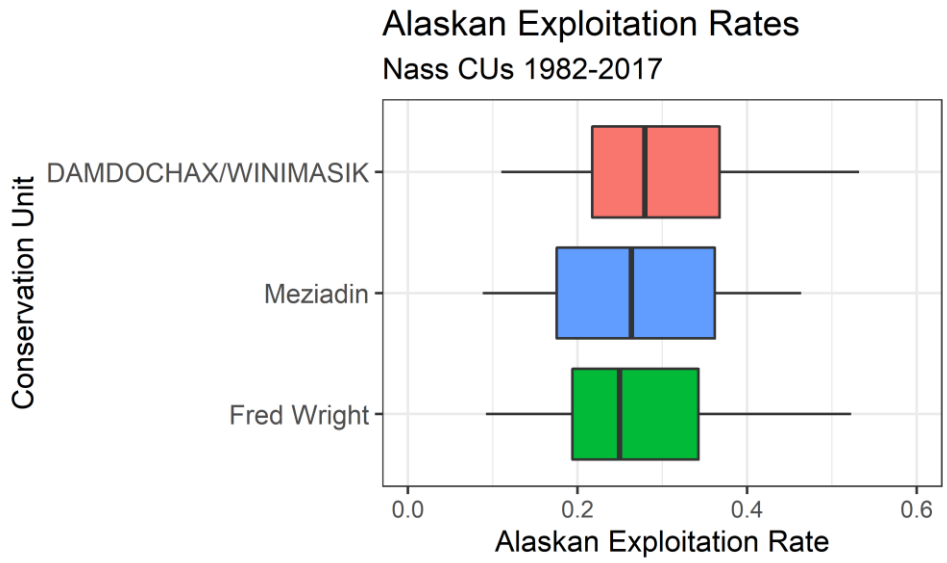

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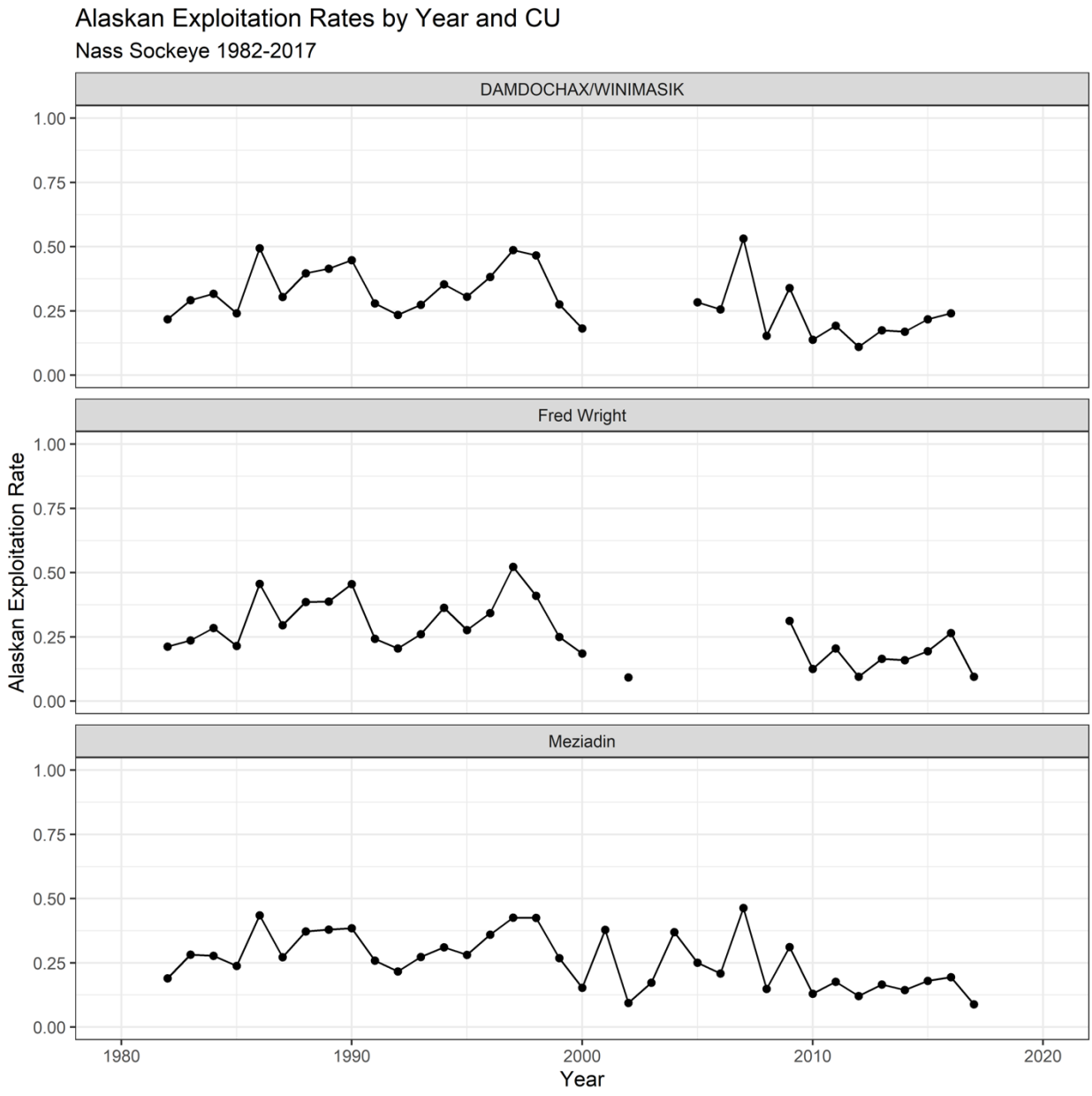

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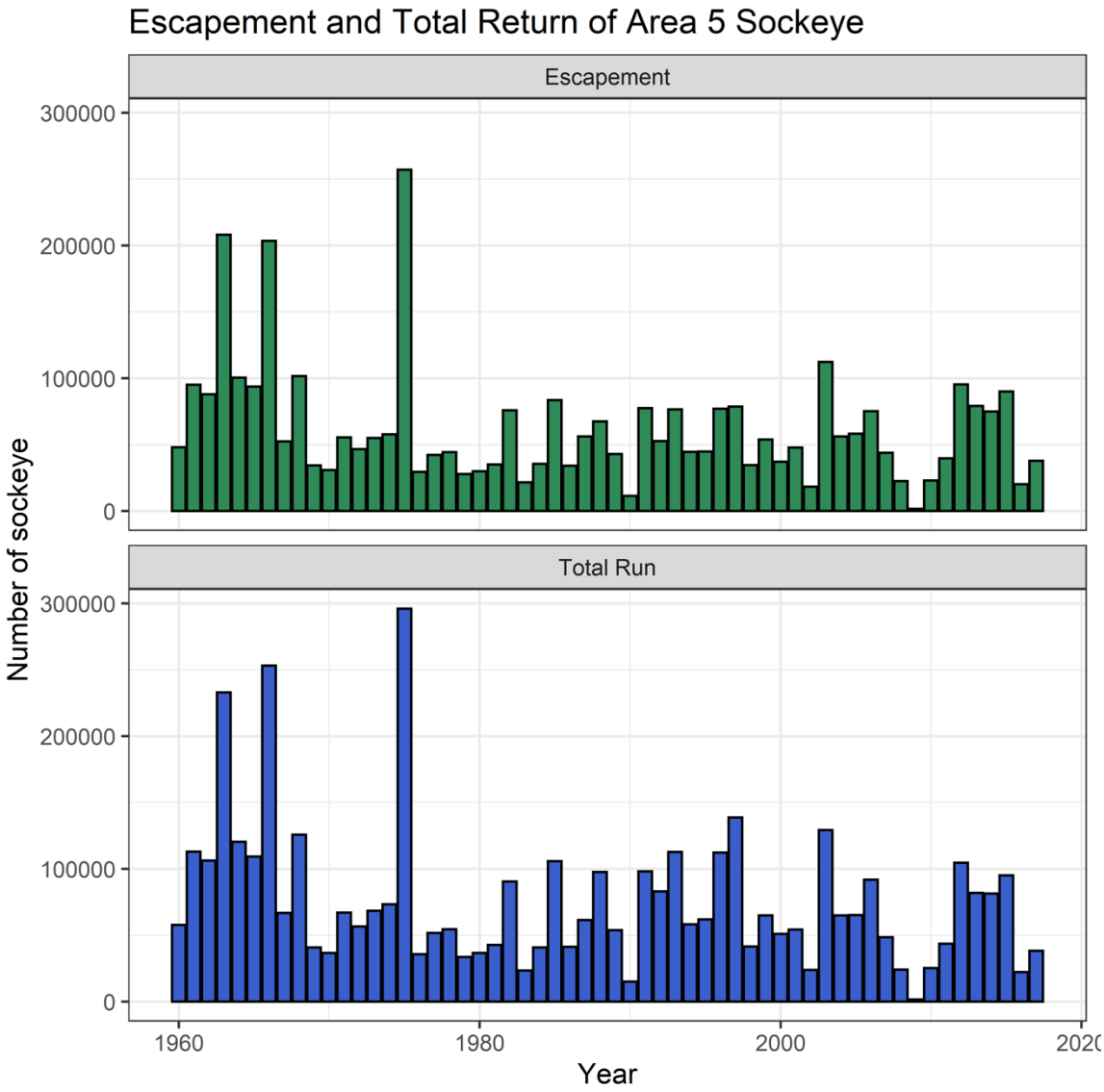

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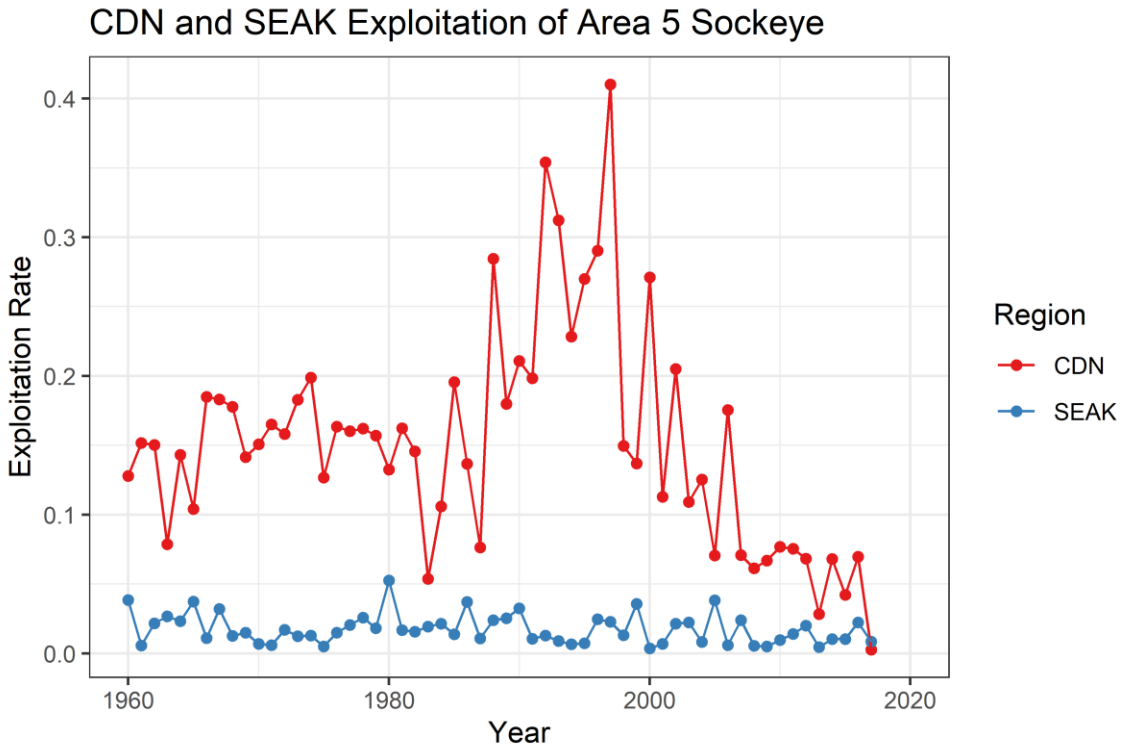

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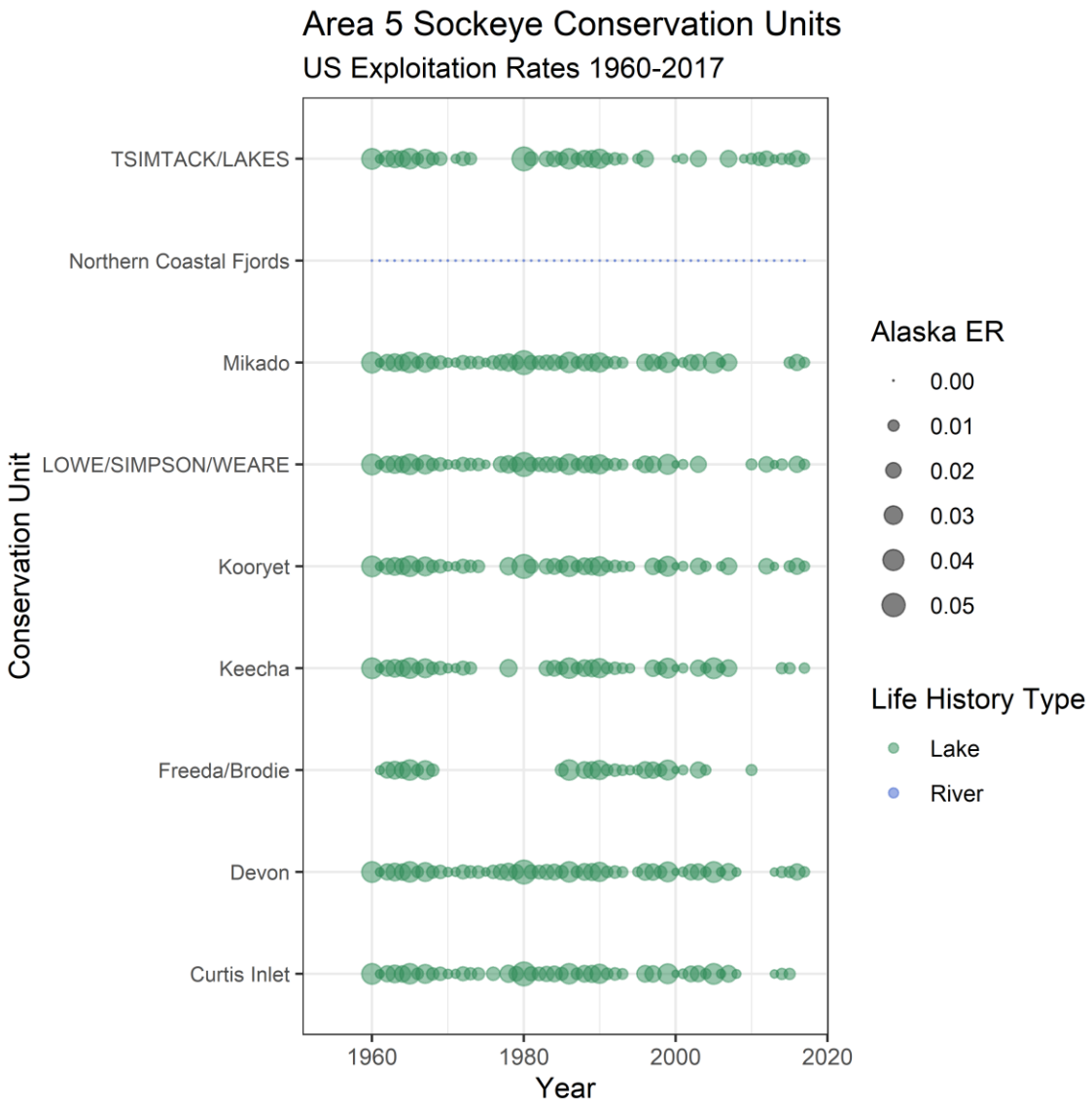

Figure 29: SEAK exploitation rates on Area 5 sockeye Conservation Units with escapement/exploitation data from 1960-2017. The size of the point shows the exploitation rate value. with escapement/exploitation data from 1960-2017. PSF 2021.

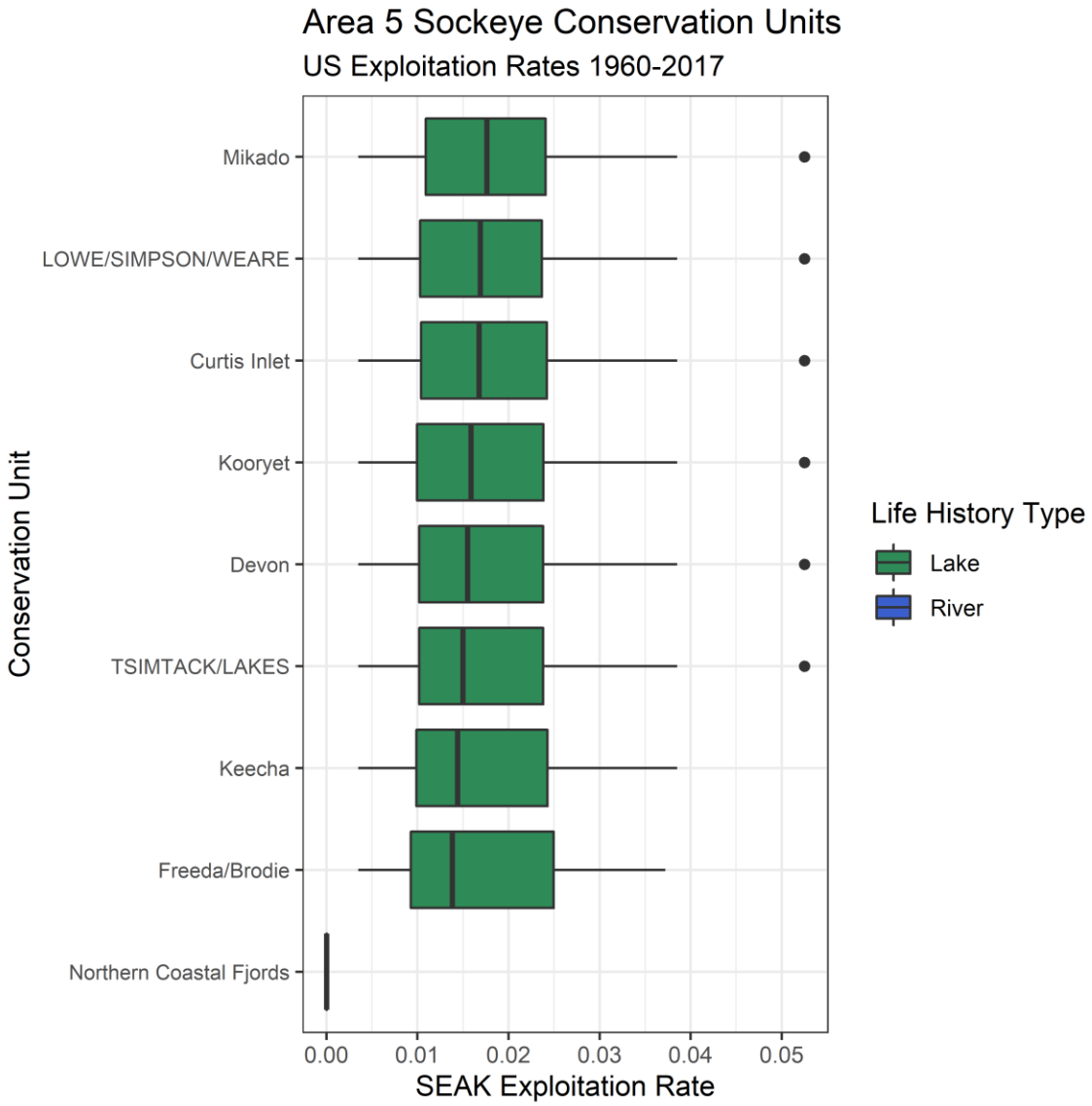

Figure 30: Distribution of SEAK exploitation rates on the 8 lake-type and 1 river-type Area 5 sockeye Conservation Units with escapement/exploitation data from 1960-2017. Note that all exploitation rates are set the same for Area 5 in each year (see English et al., 2019), however median ERs are slightly different due to different numbers of missing years in each CU. 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). PSF 2021.

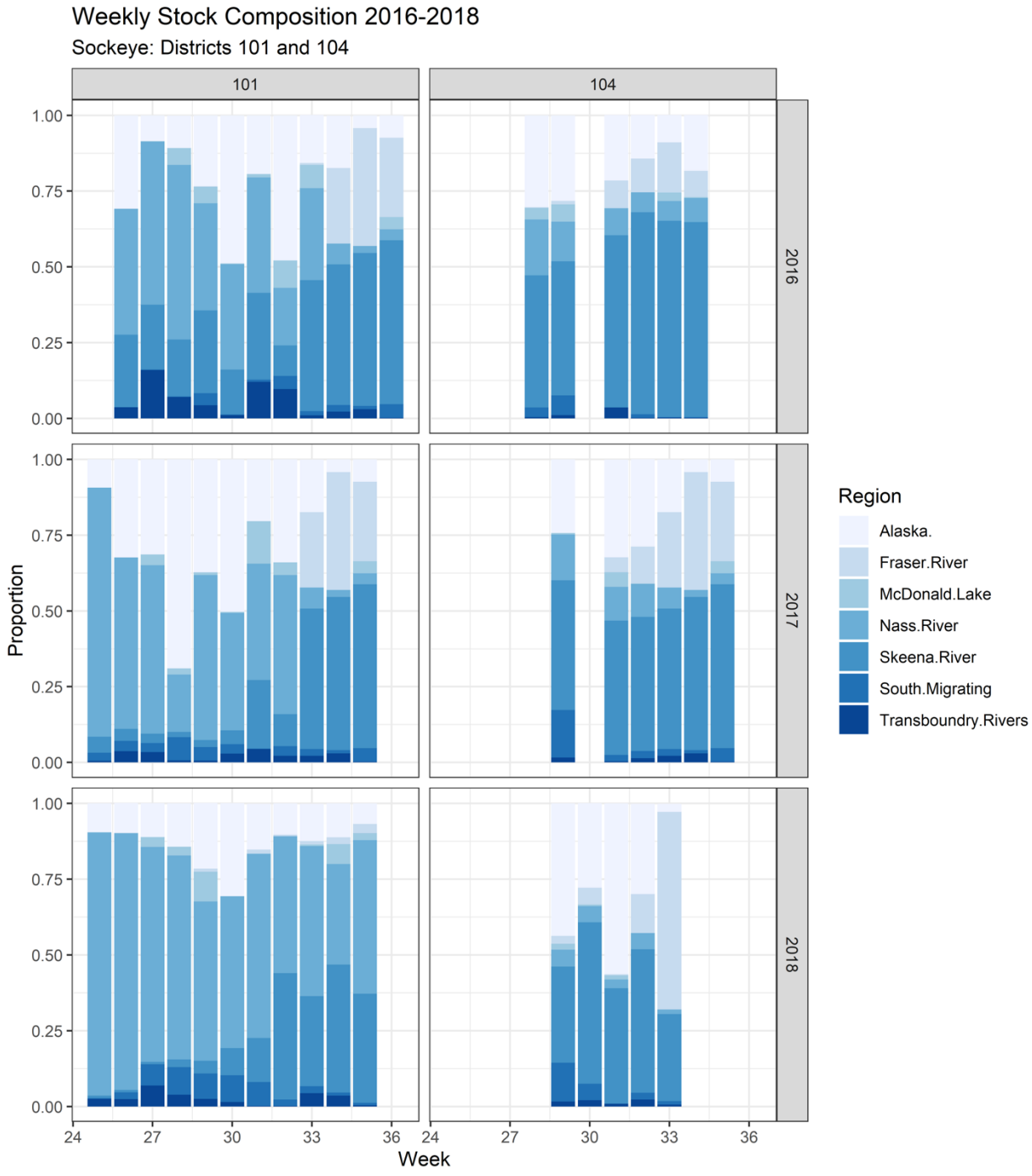

Figure 31: Weekly stock composition of sockeye in the District 101 commercial gillnet and 104 commercial purse seine fisheries for 2016-2018. Estimates are based on genetic stock ID. Source: Guthrie 2018, 2019a, 2019b.

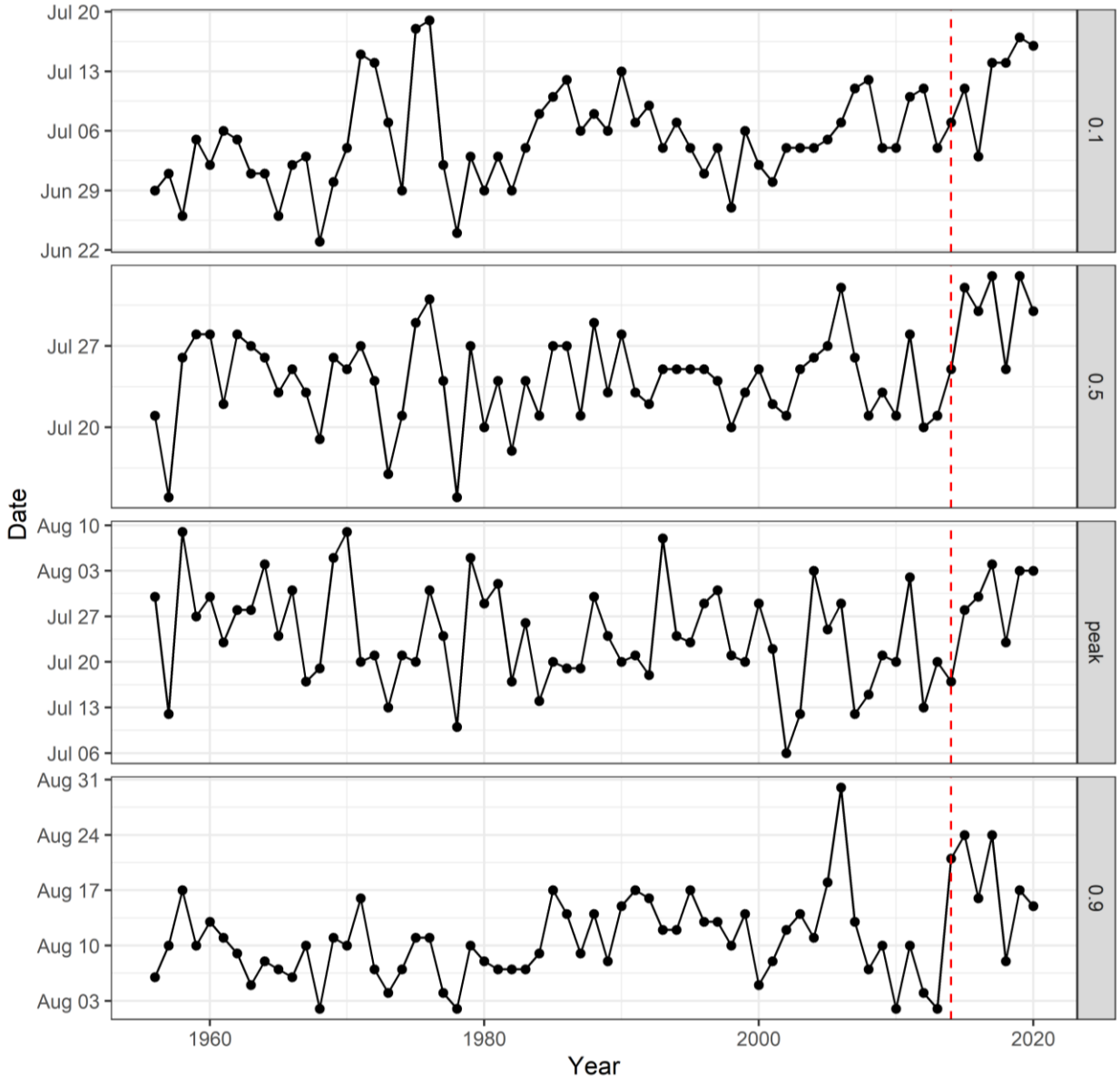

Figure 32: Skeena sockeye salmon run-timing past Tyee by date and index timing quantiles for years 1956-2020. The red vertical dashed line indicates an apparent run timing shift starting in 2014/2015. Daily index data from Tyee test fishery.

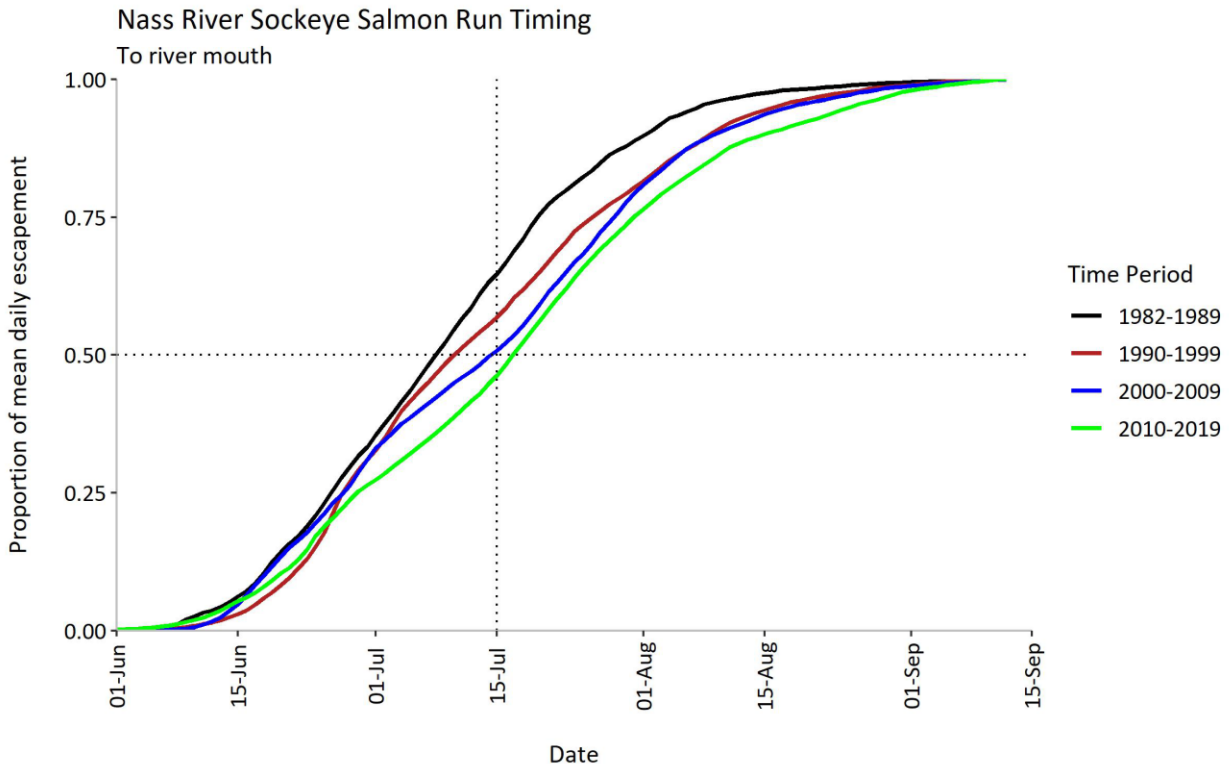

Figure 33:Nass River Sockeye salmon run timing. This figure shows the proportion of mean daily escapement by run timing for the time periods of 1982-1989 (black), 1990-1999 (red), 2000-2009 (blue), and 2010-2019 (green). LGL, personal communication.

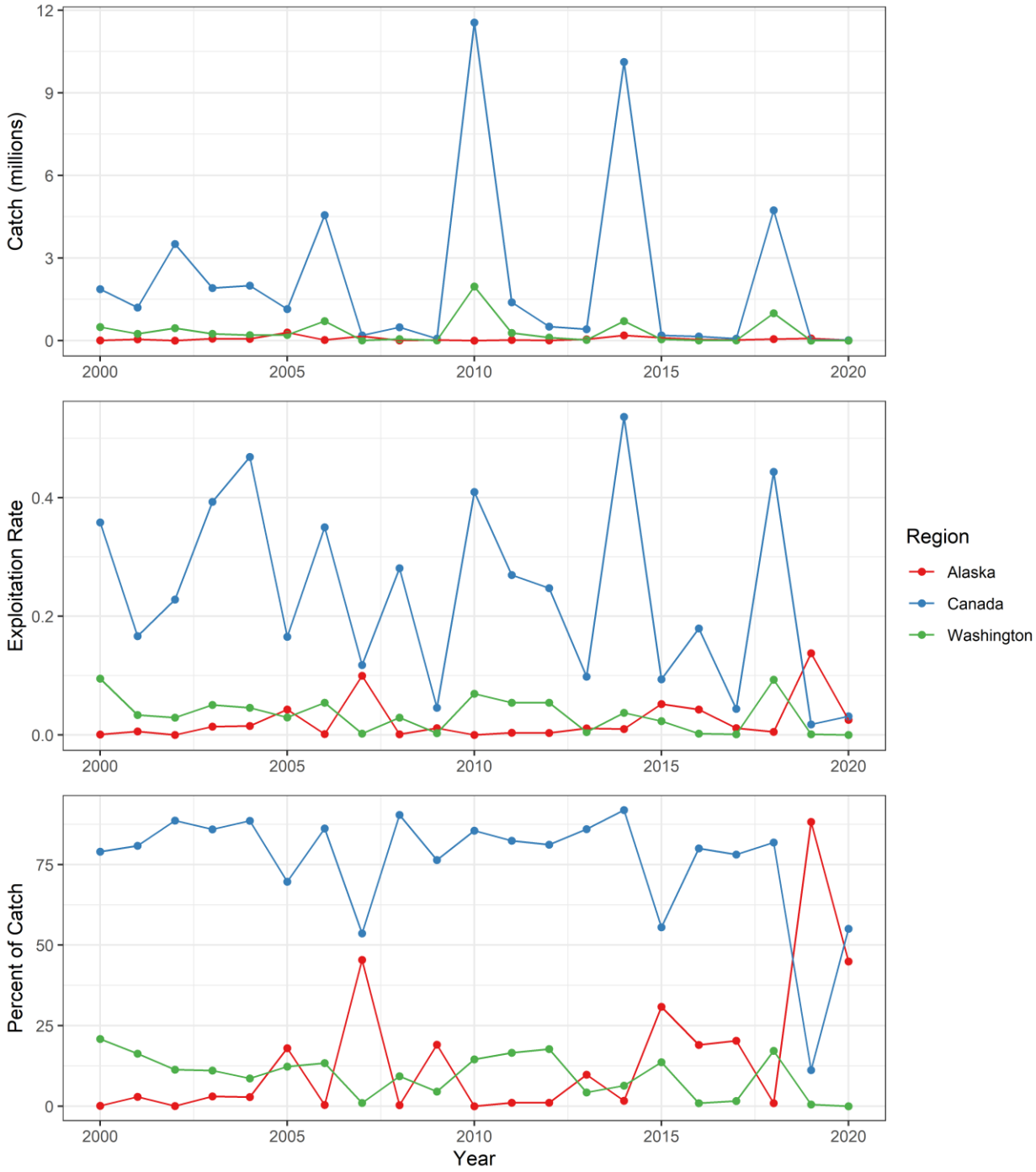

Figure 34: Canadian (green), Alaskan (red) and Washington (green) catch (top panel), exploitation rate (middle panel) and percent of catch (bottom panel) for Fraser River sockeye from 2000-2020. PSC 2021.

Alaskan Harvest of BC Salmon: State of Knowledge

Part 3: Chinook Salmon

Version 1

Prepared by:

Andrew Rosenberger[1], Victoria Chicatun[1], and Greg Taylor[2]

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Prepared for:

Watershed Watch Salmon Society

Skeena Wild Conservation Trust

January 2022

Preface

This report is part of a series of reports on the 'State of Knowledge' of Alaskan interception of 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 Chinook 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 Southeast Alaska (SEAK) catch of BC Chinook salmon was compiled from a number of sources including the Pacific Salmon Foundation Salmon Explorer, LGL Limited, PSC Chinook Technical Committee (CTC) reports and indicator stock mortality distribution tables derived from Coded Wire Tag (CWT) recovery information. We drew predominantly on the Pacific Salmon Explorer for coast wide Conservation Unit level data (PSF 2021) and LGL's North and Central Coast Run Reconstruction website for north coast Statistical Area level data (LGL 2021a). PSC CTC reports can be found online[1] as well as the most recent versions of the mortality distribution tables (PSC CTC 2021). There are also a number of reports on genetic stock composition in SEAK mixed-stock fisheries that we summarise (Crane et al. 2000; Templin et al. 2011; Gilk-Baumer et al. 2013, 2017a,b; Shedd 2020).

Background on the methodology for estimating SEAK catch of north and central coast Chinook salmon by Statistical Area and Conservation Unit is detailed in English et al. 2018 (Appendix D and Table 6).

We provide some background information on SEAK and southern Southeast Alaska (SSEAK) harvest of Chinook 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 north and central coast BC Statistical Areas and Conservation Units. We also present information on SEAK catch of Chinook using the PSC CTC mortality distribution tables based on CWT recoveries.

We do not currently have information on specific fisheries or Districts that contribute to exploitation rate estimates via CWT recoveries for Chinook, so we have used SEAK throughout this report where appropriate.

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 SEAK 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).

[1] https://www.psc.org/publications/technical-reports/technical-committee-reports/chinook/

Table 1: Types of data, sources, and year range used in this report for Chinook salmon by region. ADFG fishery data are not included in this table.

Species	*Region/Area*	*Type of Data*	*Data Source*	*Year*
Chinook salmon	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
	All areas	Mortality distribution tables	PSC CTC 2021	Various
	BC	SEAK Fishery Genetic Stock Composition	Crane et al. 2000; Templin et al. 2011; Gilk-Baumer et al. 2013, 2017a,b; Shedd 2020	Various

2 SEAK Catch Of Chinook Salmon

Summary information on Chinook salmon harvest in SEAK and SSEAK (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 Chinook 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 Chinook salmon catch in SEAK from 1979 to 2021 (2021 preliminary) is shown in Figure 3 and averaged 286,000 (median 271,000). Catch peaked in the mid-2000s, and since 2010 catches have averaged just under ~ 260,000 Chinook per year. Total SEAK catch of Chinook in 2021 was just over 200,000, below the recent and long-term averages.
- Chinook salmon catch in SEAK is historically dominated by power troll traditional (60%) and spring (11%) fisheries, with smaller contributions (< 25,000 median catch) from other fisheries (e.g., southern purse seine, hatchery cost recovery, etc.) (Figure 4). Median catch from 1979-2021 in the southern purse seine fisheries is just under 10,000, but in some years can be much higher (20-30,000). The total 2021 catch in Southern Purse Seine fisheries was 6,836 (ADFG 2021c), lower than the median catch at the ~ 35th percentile of all years.
- Figure 5 shows the catch over time by SEAK "Blue Sheet" fishery. Notably catches in the Power Troll Traditional Fishery are highly variable between years, and there is no major trend. The second most abundant fishery, Power Troll Spring Fishery, follows the same trend. Other fisheries show mixed trends. All fisheries catches are likely confounded by fishing regulations (e.g., non-retention periods) and local/regional Chinook abundance.

- Median total catch (all gears) of Chinook salmon in SSEAK Districts 101-106 shows that the median catch of Chinook catch is highest in District 104, followed by District 101. District 102, 103, 105 and 106 median catch is substantially lower. District 104 contributes about 43% over the entire time series, followed by District 101 at ~ 24% (Figure 6).
- Total catches (all gears) in District 104 is highly variable but has declined substantially since around 2000 (Figure 7). The last few years have seen relatively low catches at less than or around 20,000. District 101 catch has remained relatively constant since increasing in the 90s. Catch in District 104 was higher than in the last 4 years in 2021.
- The proportion of total District 101-106 catch of Chinook salmon for each district over time is shown in Figure 8. The proportion of Chinook salmon caught in District 104 has declined over time, and now represents between 25% and 40% in most years. District 101 proportion has increased to about the same, and Districts 102,105 and 106 have remained relatively constant at low levels. The District 103 proportion was much higher than in previous recent years in 2020 and 2021. These shifts may have important implications related to harvest of specific stocks, if stock composition varies by District.
- In 2021, total SEAK catch of Chinook salmon (including Yakutat at 577 fish) was just over 200,000. SSEAK Districts 101-106 accounted for only about 50,000 of that. As in most years, most catch was taken in the summer troll fishery (~ 61% or 131,000) (Figure 9).
- District 104 only catch of Chinook salmon in 2021 was ~20,000, split between power troll (~13,500) and seine (~6,000) fisheries. In 2021, the Chinook retention period in the District 104 seine fishery retention was only ~ 2 days, suggesting that there were many more releases that we do not currently have information on. This means that total mortalities were likely much higher than the 6,000 recorded kept catch. Weekly catch in purse seine fisheries shows the catch during the retention period in Week 32, with catch in the power troll fishery highest in Weeks 27 and 28. was highest in Week 31 and 32, with a significant catch later on in Week 36 (Figure 10). 2021 data is preliminary.

3 SEAK Catch of BC Origin Chinook

This section of the report provides a summary of information on SEAK exploitation rates on BC Chinook salmon, as well as proportions of SEAK exploitation by Statistical Area and Conservation Unit for north and central coast BC (Areas 1-10).

3.1 North Coast and Central Coast Exploitation Rates

3.1.1 Statistical Areas

Estimates of SEAK exploitation rates on north and central coast Chinook salmon from 1985 to 2017 are derived using various methods as detailed in Appendix D of English et al. (2018). It is beyond the scope of this report to provide all the details for each statistical area, but they are largely derived from CWT indicator stocks from Kitsumkalum River Chinook (Area 4-Skeena) and Atnarko River Chinook (Area 8-Central Coast), or genetic data (e.g., Area 3 Chinook). Numerous assumptions are made for years missing data to infill missing years or infer exploitation rates from one area to another (see Appendix E, English et al. 2018).

Canadian exploitation rates for north and central coast BC Chinook Areas with data are shown in Figure 11. Area 9S refers to Area 9 Summer Chinook, and Area 9W refers to Wannock Chinook.

- Canadian exploitation rates have been variable, but in general have remained relatively constant (Areas 3, 6, 9W, and 9S), increased (Area 8) or decreased (Area 10) (Figure 11). There is little

recent data for Areas 10, and Area 8 ERs are likely driven by catch of enhanced Atnarko River Chinook.

- SEAK ERs have increased (9W and 9S), averaged about the same (Areas 3, 4, and 6), or decreased (Areas 8 and 10). over time. Area 4 ERs were historically the highest, averaging around ~40-50%, dropped in the late 90s and in recent years have averaged between 10 and 20%. SEAK ERs range from near 0 to close to 40% in some Areas (Area 9W and 9S in recent years).
- The proportion of exploitation attributed to SEAK fisheries for north and central coast Chinook salmon is shown in Figure 12. Canadian exploitation rates include both Section 35(1) FSC catches and any sport catches, where as SEAK exploitation rates are based on commercial fisheries only.[2] SEAK percent of exploitation ranges widely between Areas, with SEAK proportion very low in Area 3, between 20-50% in Area 4, between near 0 and 50% in Area 6, between 12 and 50% in Area 8 (but declining in recent years), between ~ 10% and 75% and increasing in recent years for Areas 9S, 9W and 10.

3.1.2 Conservation Units

Extrapolation of Statistical Area SEAK ER estimates to Chinook CUs are detailed in Table 5 of English et al. (2018). We are currently working with LGL and PSF to resolve a data issue for the Northern Coastal Streams and Dean River CUs, and will update this report with revised data once resolved. Since SEAK ERs in CUs are derived from the related Statistical Areas, the basic patterns described above for Statistical Areas hold true for CUs within their respective Areas.

- Distribution of SEAK ERs on Chinook salmon by CU are shown in Figure 13. Median SEAK ERs range from almost 20% to 2%, following the patterns for Area specific ERs. Due to information on run-timing, there are some Skeena CUs (Upper Bulkley River and Kalum-Early Timing) with much lower median ERs (10% of Kalum-Late Timing estimates). Central coast CUs median SEAK ER is around 10%, but much higher in some years (note trends in recent years above). There is some variation in the years included in median values as some CUs are missing some years that others are not.
- Figure 14 shows SEAK ERs over time by CU for north and central coast CUs. There is some variation in trends between CUs, however following Area specific SEAK ERs, there are substantial increases in SEAK ERs in recent years in Rivers Inlet and Wannock Chinook CUs. SEAK ER on Skeena CUs

3.2 South Coast Area and CU Specific Exploitation Rates

When we accessed the Pacific Salmon Explorer in October, 2021, there were no Chinook CUs in the south coast, Vancouver Island, or Fraser areas with exploitation rate information. We are currently following up with DFO Stock Assessment to determine if estimates of SEAK ERs on stocks other than CTC indicator stocks are available, and if the CTC indicator stock mortality distribution data (discussed below) can be used as a proxy for other populations and areas.

- [2] 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, separate estimates of CDN FSC and sport exploitation rates were not available at the time of report writing, but will be investigated further.

3.3 CWT Indicator Stocks

We downloaded the mortality distribution tables for all CTC indicator stocks (PSC CTC 2021), which contains exploitation rate data derived from CWT recoveries in fisheries from Alaska to California. We then extracted the information for Canadian stocks and manipulated the data for analysis in R.

The mortality distribution tables provide estimates of mortality in fisheries for CTC indicator stocks. These were converted to ERs and SEAK fishery data was compiled. Six SEAK fisheries were identified, SEAK net, troll and sport, and SEAK Terminal net, troll and sport. We did not include the Terminal fisheries for stocks that return to north and south coast BC in figures, since they have extremely low ERs on all stocks in the vast majority of years (not including Transboundary Rivers, which have much higher terminal SEAK ERs). However they are included in calculations of total SEAK ER by stock. We identified 15 stocks with information on SEAK ERs in our summary.

- Median exploitation rates in SEAK net and sport fisheries range from 0 to ~ 5%, and median ERs in SEAK troll fisheries range from 0 to 15% (Figure 15). SEAK troll fisheries have the highest median ERs for all stocks. Stocks from all regions (ECVI, Fraser, ISC, North Coast, and WCVI) have significant ERs in SEAK fisheries.
- Furthermore, 2 groups of stocks are immediately apparent; there are many stocks (Nanaimo, Cowichan, Harrison, Chilliwak, Nicola and Dome) that have very low presence in any of the SEAK fisheries. This is consistent with what we know about their life history and marine distribution patterns (see for example Riddell et al. 2013).
- Median total SEAK ERs range from near 0 to 20% (Table 2, Figure 16)Table 2: Median total and fishery specific SEAK ERs for CTC indicator stocks included in this summary.. There is no consistent pattern across regions, SEAK ERs are highest on Robertson Chinook, followed by Kitsumkalum and Quinsum, and then Phillips, Lower Shuswap, Atnarko, Big Qualicum, Middle Shuswap and Puntlege.

Table 2: Median total and fishery specific SEAK ERs for CTC indicator stocks included in this summary.

						Terminal Fisheries		
Stock	Region	Total ER	SEAK.Net	SEAK.Sport	SEAK.Troll	SEAK.Net	SEAK.Sport	SEAK.Troll
Robertson	WCVI	20.51	2.55	2.03	14.20	0.00	0.00	0.00
Kitsumkalum	North Coast	20.06	0.00	3.55	13.90	0.00	0.00	0.00
Quinsum	ECVI	19.76	4.99	1.84	11.95	0.00	0.00	0.00
Phillips	ISC	15.53	4.73	1.56	9.29	0.00	0.00	0.00
Lower Shuswap	Fraser	13.54	0.01	0.88	10.43	0.00	0.00	0.00
Atnarko	North Coast	7.98	0.04	0.53	6.53	0.00	0.00	0.00
Big Qualicum	ECVI	7.66	0.81	0.00	4.93	0.00	0.00	0.00
Middle Shuswap	Fraser	4.71	0.00	0.53	4.23	0.00	0.00	0.00
Puntledge	ECVI	4.24	0.00	0.00	3.03	0.00	0.00	0.00
Nanaimo	ECVI	0.95	0.00	0.00	0.42	0.00	0.00	0.00
Cowichan	ECVI	0.53	0.00	0.00	0.30	0.00	0.00	0.00
Harrison	Fraser	0.37	0.00	0.00	0.27	0.00	0.00	0.00
Chilliwack	Fraser	0.13	0.00	0.00	0.13	0.00	0.00	0.00
Dome	Fraser	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Nicola	Fraser	0.00	0.00	0.00	0.00	0.00	0.00	0.00

- Figure 17 shows total SEAK ERs by year for Canadian CTC Chinook indicator stocks (excluding Transboundary systems). Total SEAK ERs have trended lower in recent years for most stocks, with the exception of Puntledge River, which increased slightly in the 2000s and has remained

relatively stable since. Note that the Phillips and Middle Shuswap stocks have short time series (< 10 years).

For more details on the specifics of the PSC CTC Chinook indicator and CWT programs, we refer you to the PSC CTC website and technical reports[3].

3.4 Genetic Data

We reviewed a series of Genetic Stock Identification (GSI) reports detailing stock compositions from sampling conducted in SEAK fisheries from 1998 to 2019. They are focused on the summer troll fishery in most cases, with a 2016 exception for sampling in sport fisheries.

Table 3: Summary of key findings related to Canadian Chinook caught in SEAK troll and sport fisheries based on genetic stock ID (1999-2019).

Source	*Fishery/Year*	*Key Findings*
Crane et al. 2000	Summer Troll/1998	1. WCVI (17%) and Thompson River (14%) Chinook were large contributors to legal samples. 2. Strait of Georgia Chinook (14%) were large contributors to sub-legal Chinook samples.
Templin et al. 2011	Troll fisheries (1999-2003)	WCVI, Thompson River, Central BC (CBC), Skeena and Nass River, and Strait of Georgia Chinook all contribute significant catch to troll fisheries.
Gilk-Baumer et al. 2013	Troll fisheries (2004-2009)	The Canada reporting group (CBC, WCVI, ECVI) was a prominent contributor in all troll (winter, spring, summer) in most years, although there was some variation in timing and specific contributions.
Gilk-Baumer et al. 2015	Troll fisheries/2015	North/Central BC, South Thompson and WCVI Chinook were among the most important contributors to troll fisheries.
Gilk-Baumer et al. 2017	Troll fisheries/2016	North/Central BC, South Thompson and WCVI Chinook were among the most important contributors to troll and sport fisheries.
Shedd 2019	Troll and sport fisheries/2019	South Thompson and WCVI each contributed > 10% to troll fisheries. WCVI and South Thompson contributed significantly to sport fisheries.

Results from these studies are largely in agreement with PSC CTC Chinook indicator stock mortality distributions based on CWTs and presented by region in the previous section. Although there is considerable interannual variability, Chinook stocks from WCVI, Thompson River, Central BC, Skeena and Nass, ECVI were important contributors to SEAK troll and sport fisheries. A comprehensive stock by stock and fishery by fishery review of these studies is outside the scope of this report, however the referenced reports contain many more details on timing and seasonal variation in stock composition results.

[3] https://www.psc.org/publications/technical-reports/technical-committee-reports/chinook/

3.5 1980s Release Studies

Reports completed in 1987 and 1988 (Rowse and Marshall 1988; Rowse 1989) surveyed fishers on numbers of Chinook released, retained for personal use, or retained for sale. The reports estimated that total mortalities of Chinook were many times higher than what was reported on sales slips. We could not find similar reports for recent years.

3.6 2021 Estimates

2021 estimates of SEAK ERs for Chinook salmon will not be available in the immediate future. Based on recent trends and catches in SEAK in 2021, it would be expected that estimates of SEAK ERs on north and central coast BC would follow recent trends.

4 Information Gaps

We were unable to find direct information on the number of Chinook releases (sub-legal and legal) during periods of seine retention, other than those presented in the PSC CTC Technical Reports (see PSC CTC 2020 for example). In 2021, Chinook retention was only ~ 2 days in the District 104 purse seine fishery. During that time, almost 6,000 Chinook were caught, retained and recorded. It is unknown how many releases there were during the non-retention period throughout the rest of the season. Furthermore, it is unknown if there is any catch salmon of released Chinook in non-retention periods. This makes it difficult to determine total mortalities, or stock compositions during non-retention periods.

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6 Figures

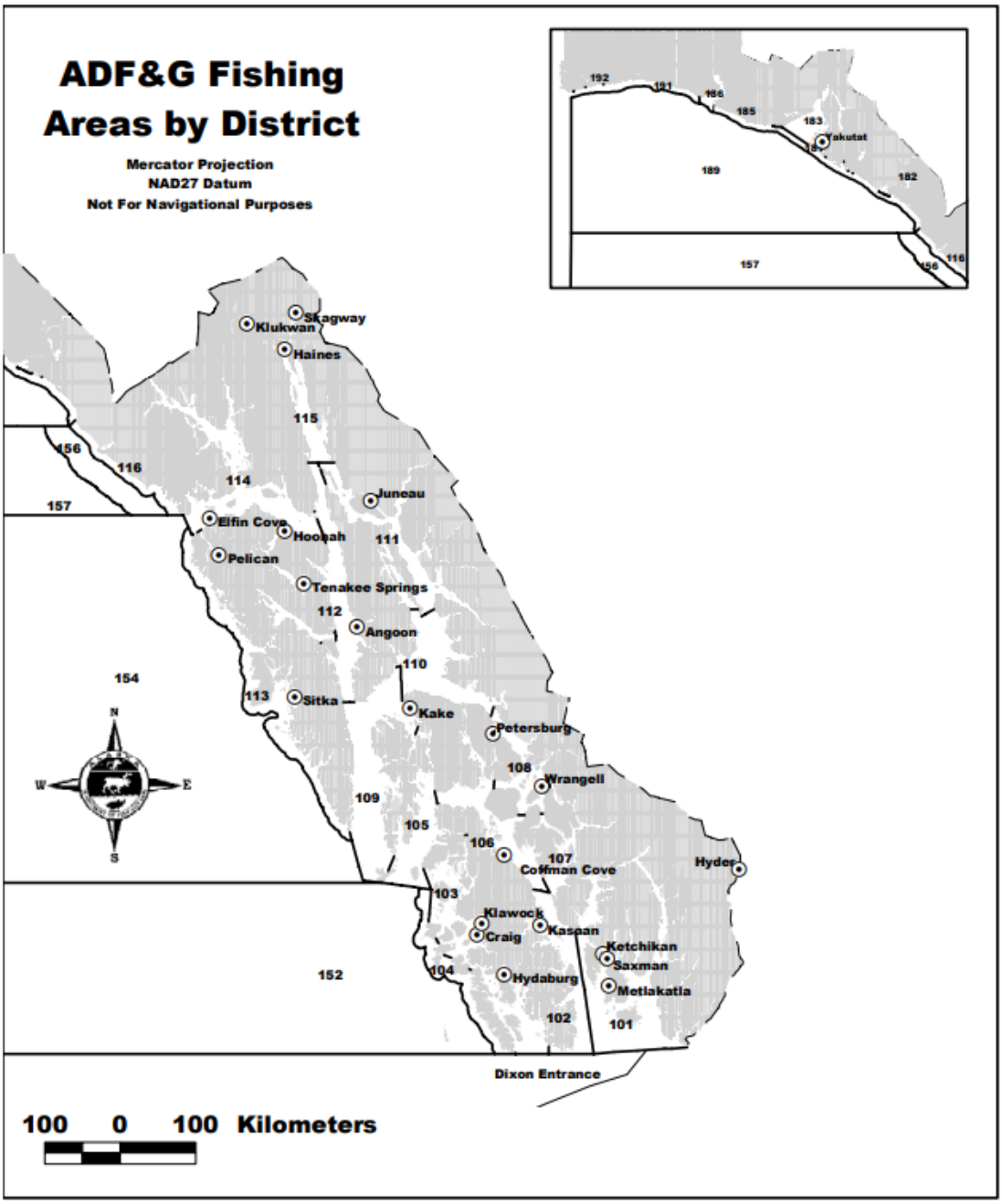


Figure 1: Map of Southeast Alaska Fishing Areas by District.

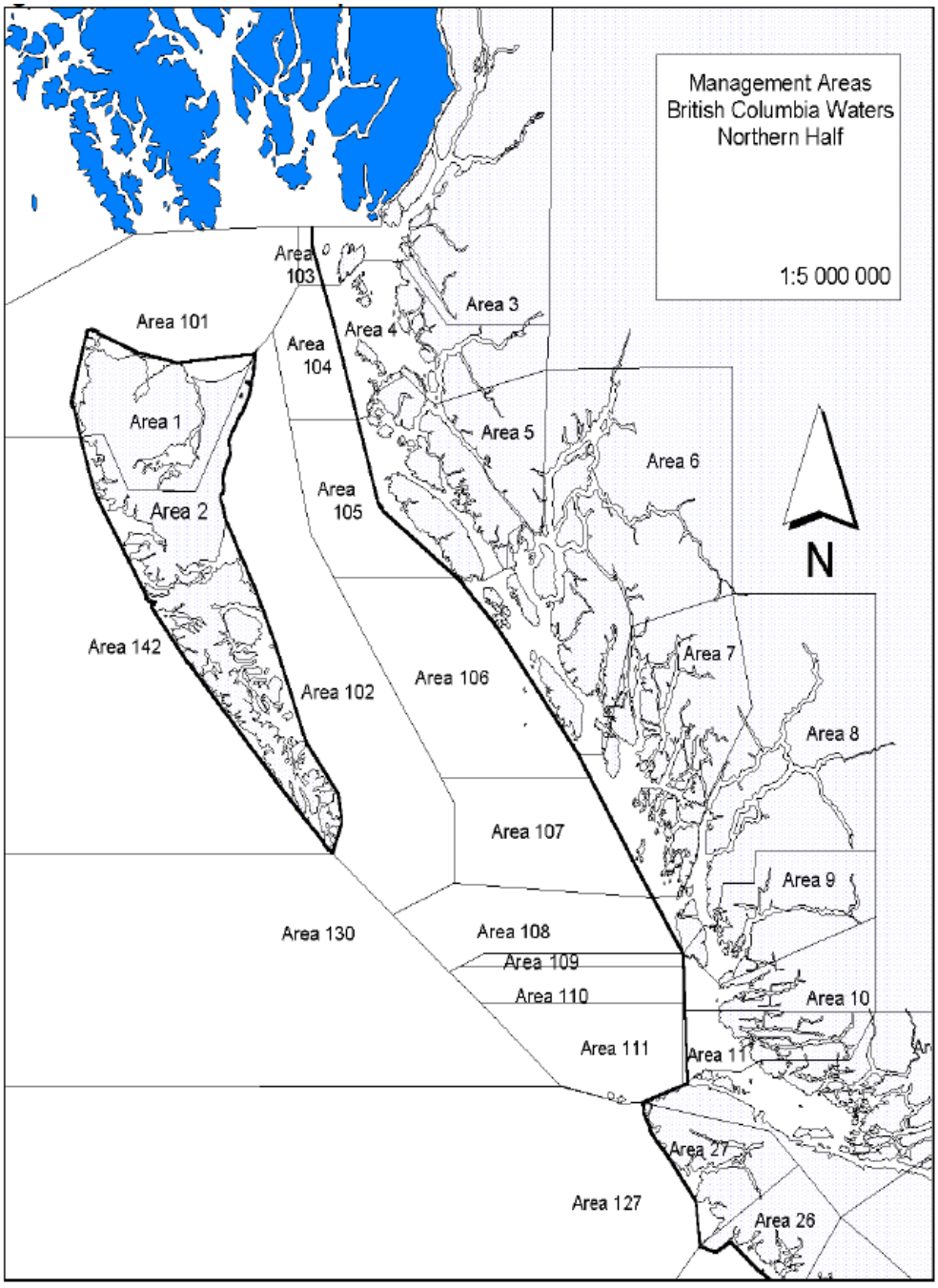


Figure 2.Map of DFO Statistical Areas in the North and Central Coast Areas.

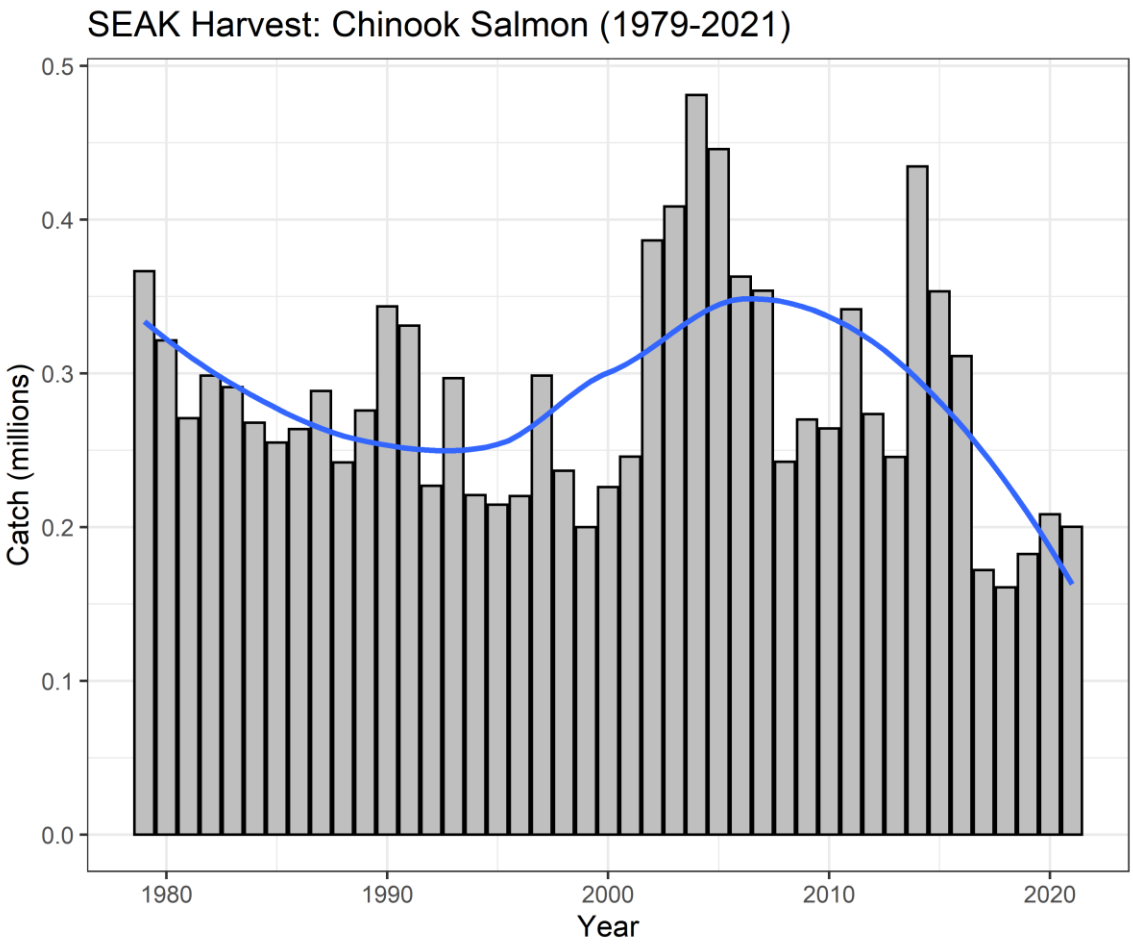


Figure 3: Total SEAK harvest (millions of fish) of Chinook salmon from 1979-2021. Blue line is fit using LOESS. Source: ADFG 2021a (1979-2020), ADFG 2021b (2021).

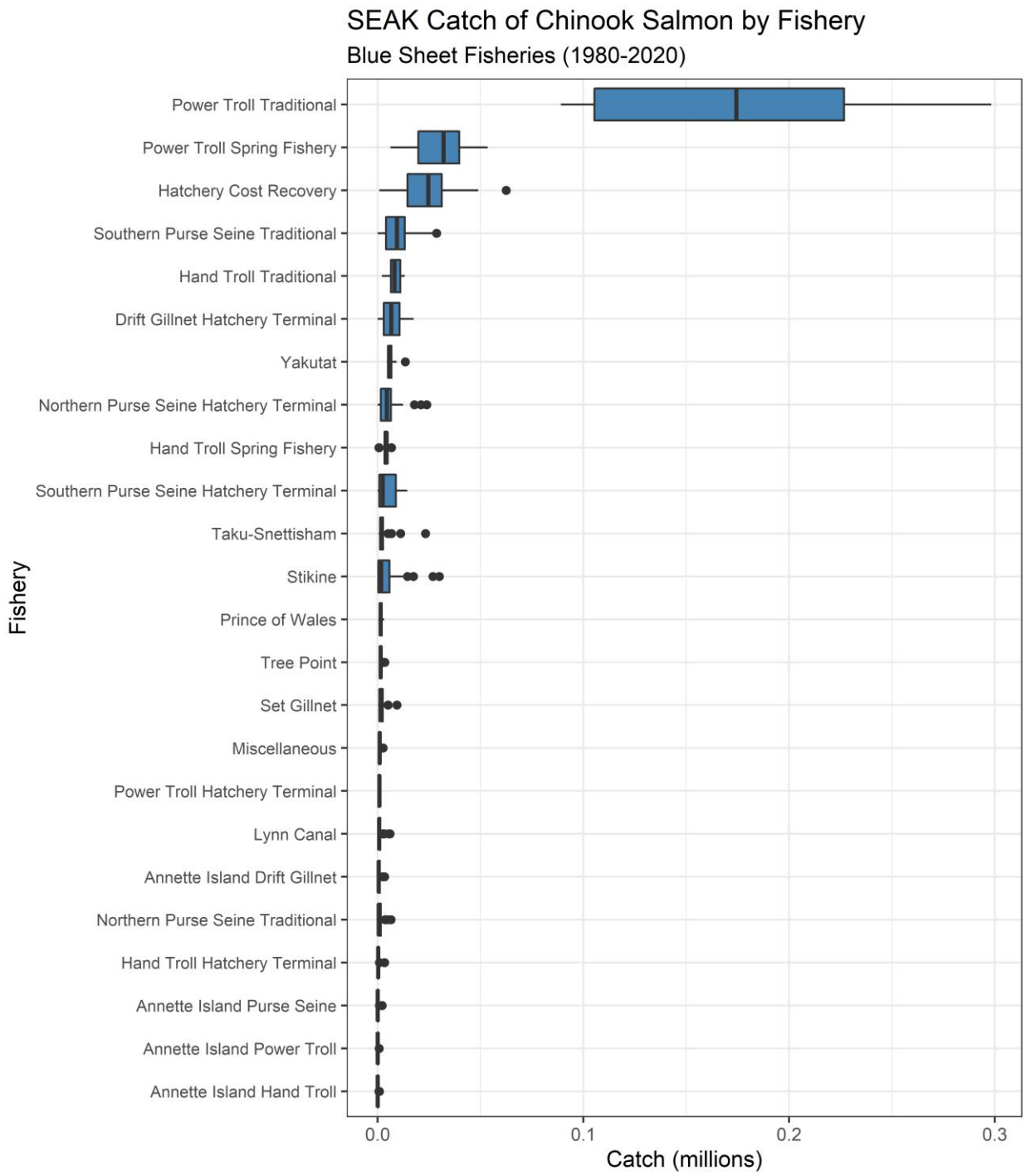


Figure 4: Distribution of total Chinook salmon commercial catch in SEAK "Blue Sheet" fisheries 1980-2021. Fisheries are ordered from highest catch to lowest catch. The thick black line is the median value, the box in indicates the interquartile range (25th to 75th percentiles – or middle 50% of the data),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

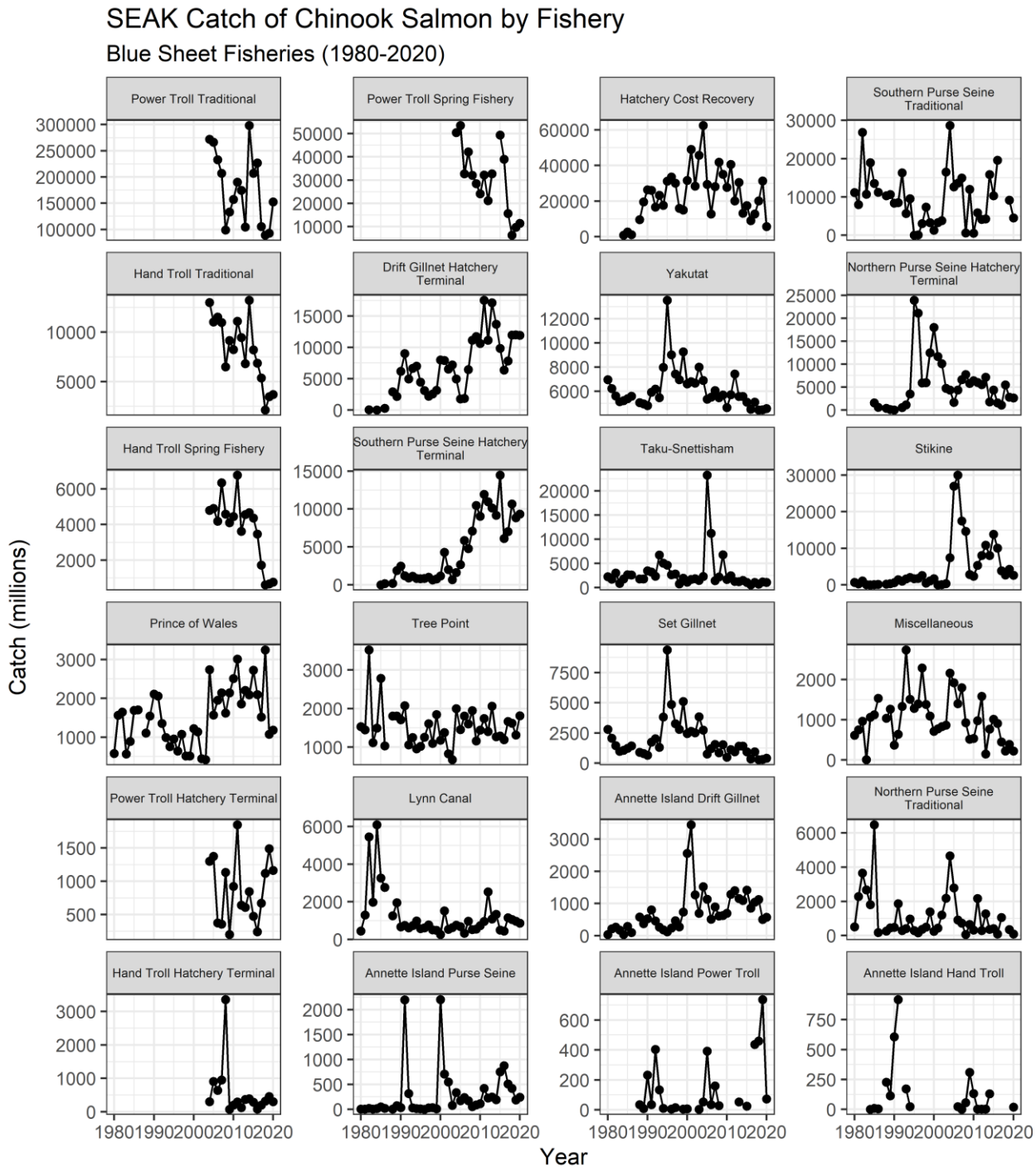


Figure 5: Total Chinook salmon commercial catch in SEAK "Blue Sheet" fisheries by year for 1980-2021. Note y-axis scales are not equal. Fisheries are ordered from highest all year median catch to lowest. The thick black line is the median value, the box in indicates the interquartile range (25th to 75th 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.

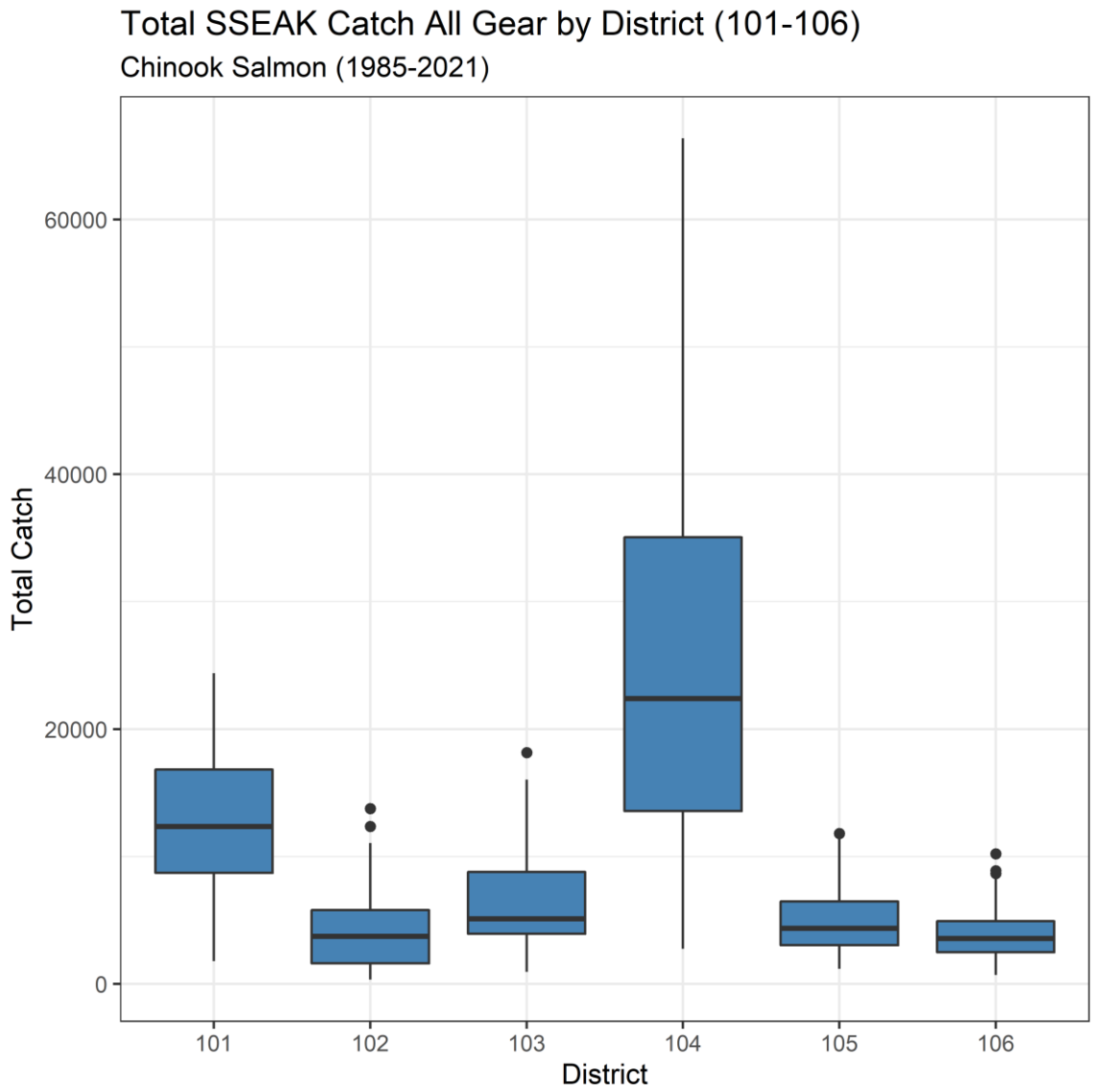
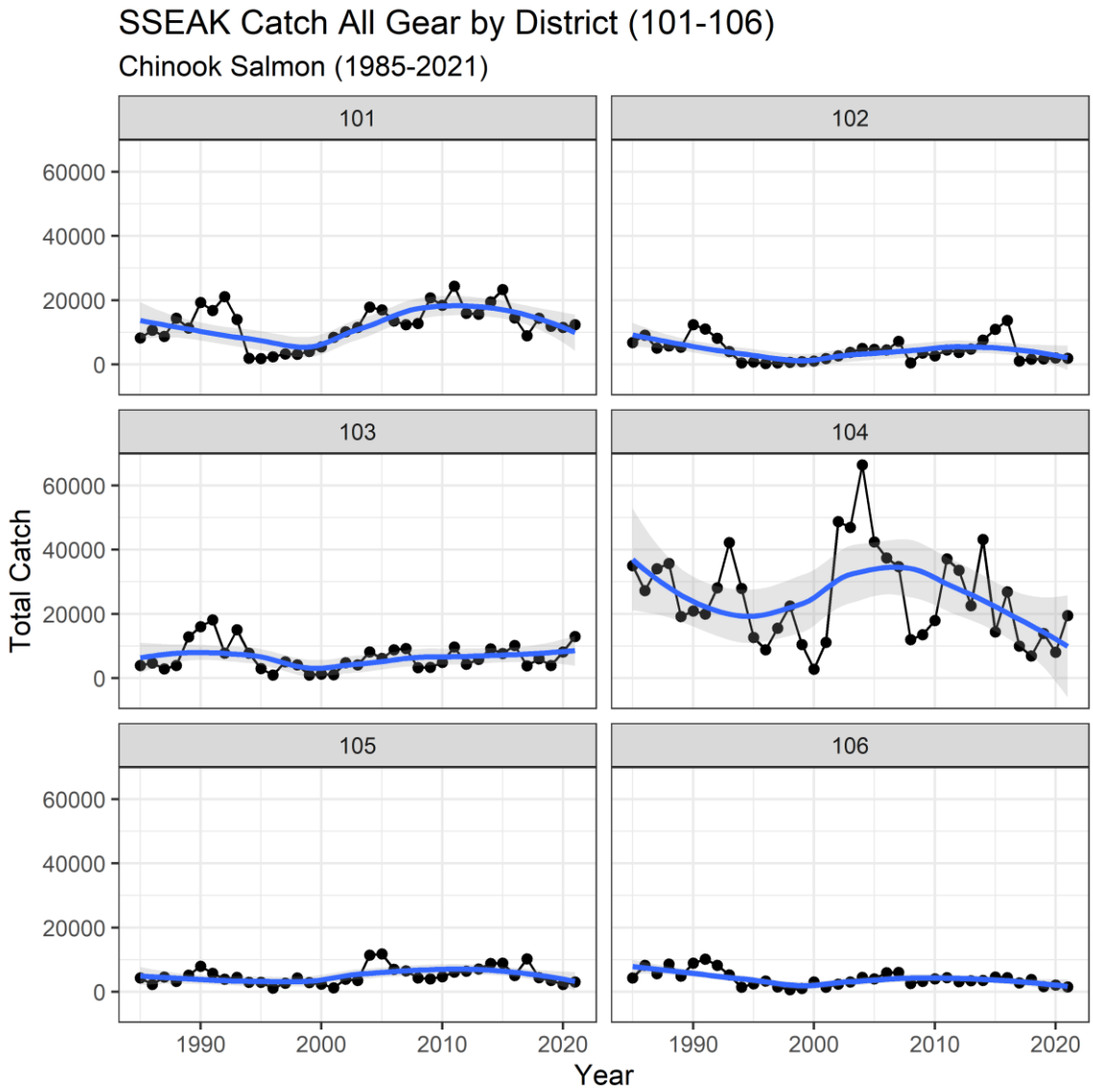


Figure 6: Median catch of Chinook salmon from all gears in SSEAK fisheries by district (districts 101-106) from 1985-2021. The thick black line is the median value, the box in indicates the interquartile range (25th to 75th percentiles – or middle 50% of the data), whiskers are 1.5x the interquartile range and dots are outliers (< 5th or > 95th percentile). Source: ADFG 2021d.



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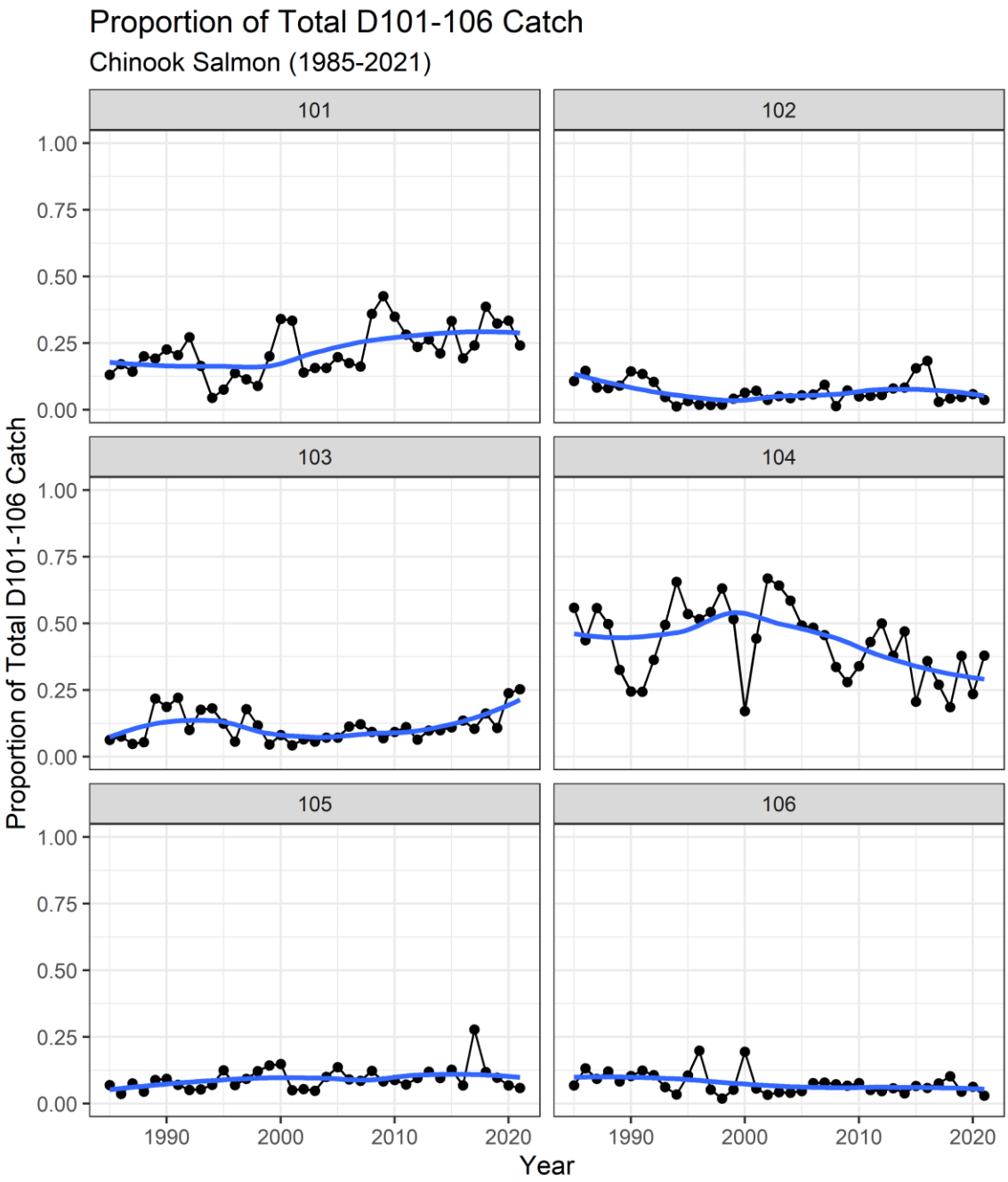


Figure 8: Proportion of total SSEAK District 101-106 Chinook salmon catch (all gears) by year for 1985-2021. Blue lines are estimated by LOESS fits. Source: ADFG 2021d.

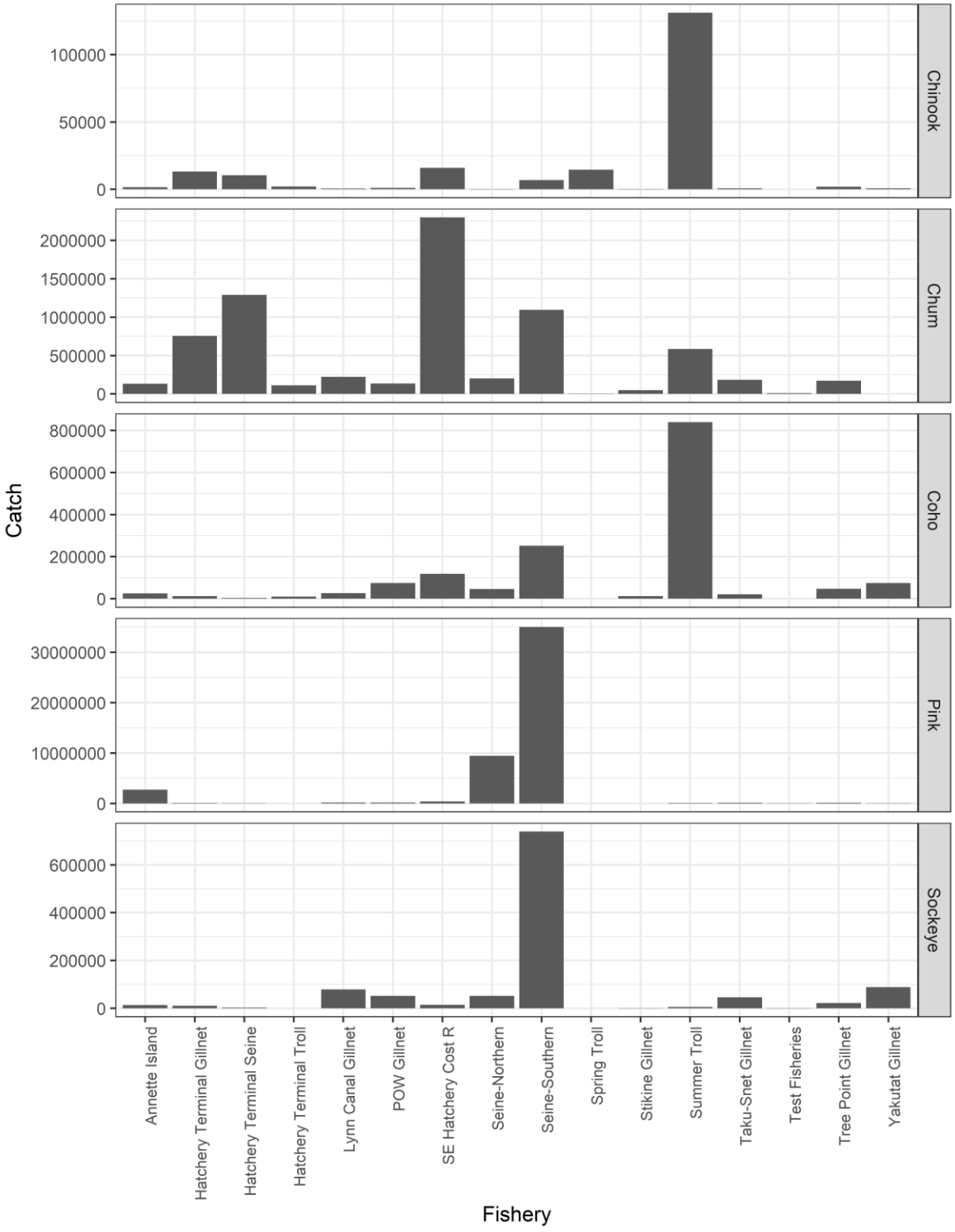


Figure 9: Harvest of all salmon species in SEAK "Blue Sheet" commercial fisheries in 2021. Source: ADFG 2021b.

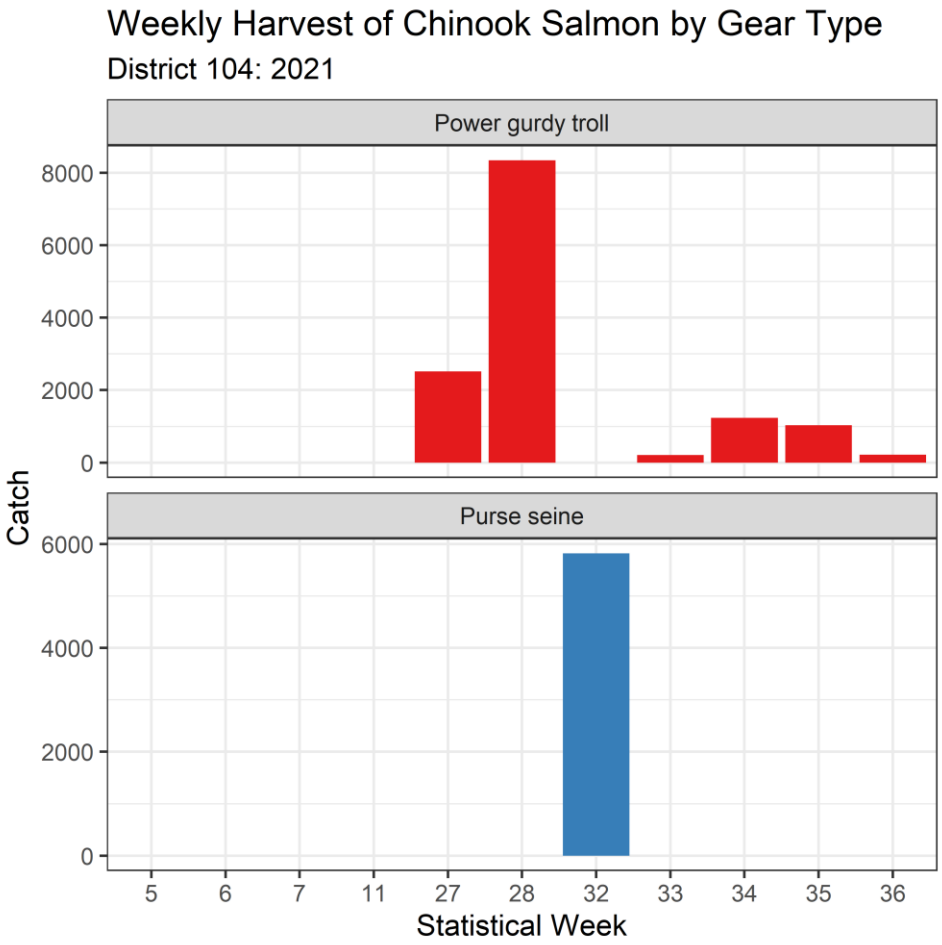


Figure 10: Weekly catch of Chinook salmon in District 104 fisheries by gear type for 2021. Note y-axis scales are not the same between panels. Source: ADFG 2021e.

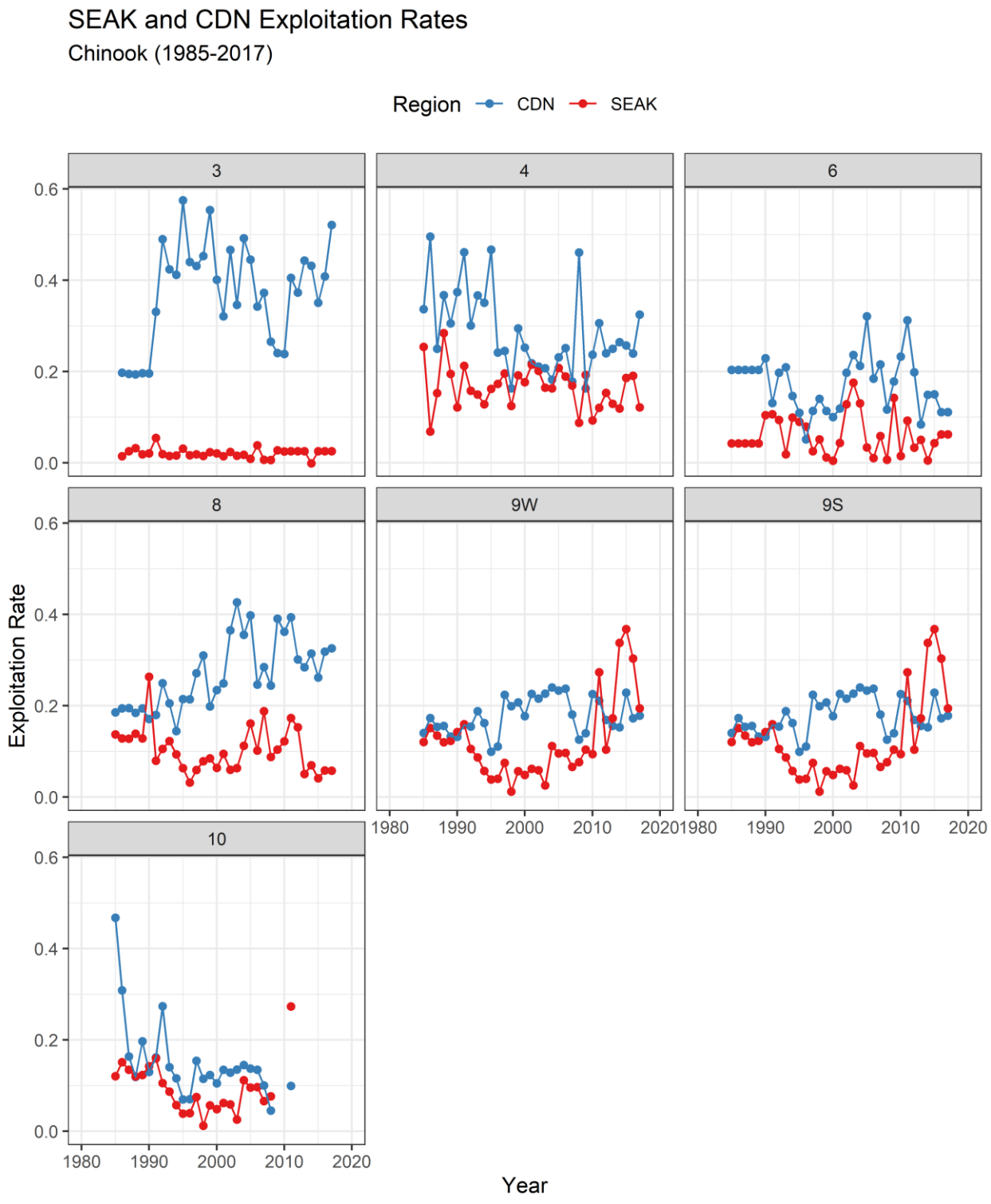


Figure 11: SEAK (red) and Canadian (blue) exploitation rates by year for north and central coast (Statistical Areas 1-10) Chinook salmon from 1985-2017. Source: LGL 2021a.

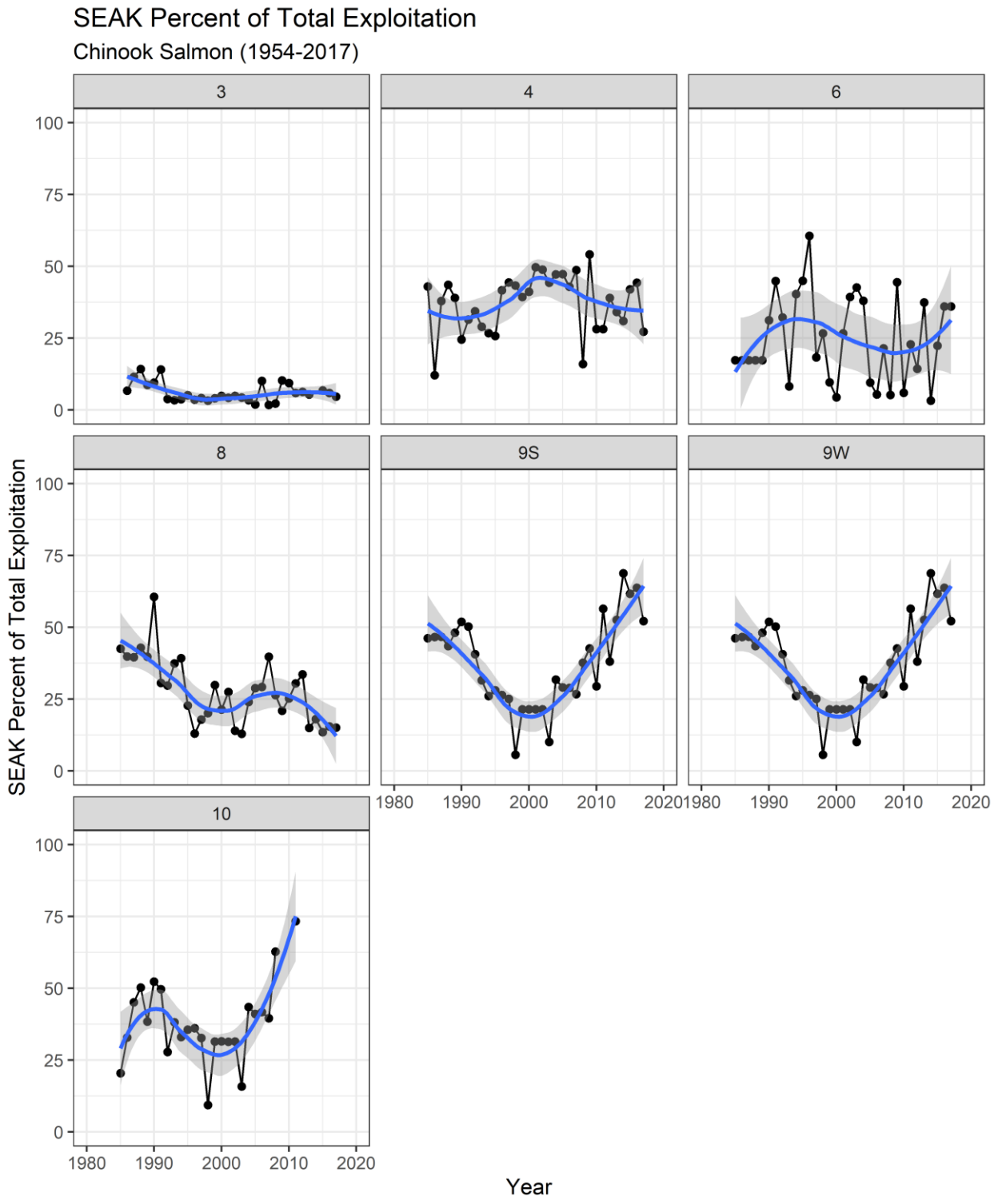


Figure 12: Percent of exploitation attributed to SEAK for Chinook salmon from north and central coast BC from 1954-2017. Trend lines and SEs were derived using LOESS in R. Source: LGL 2021.

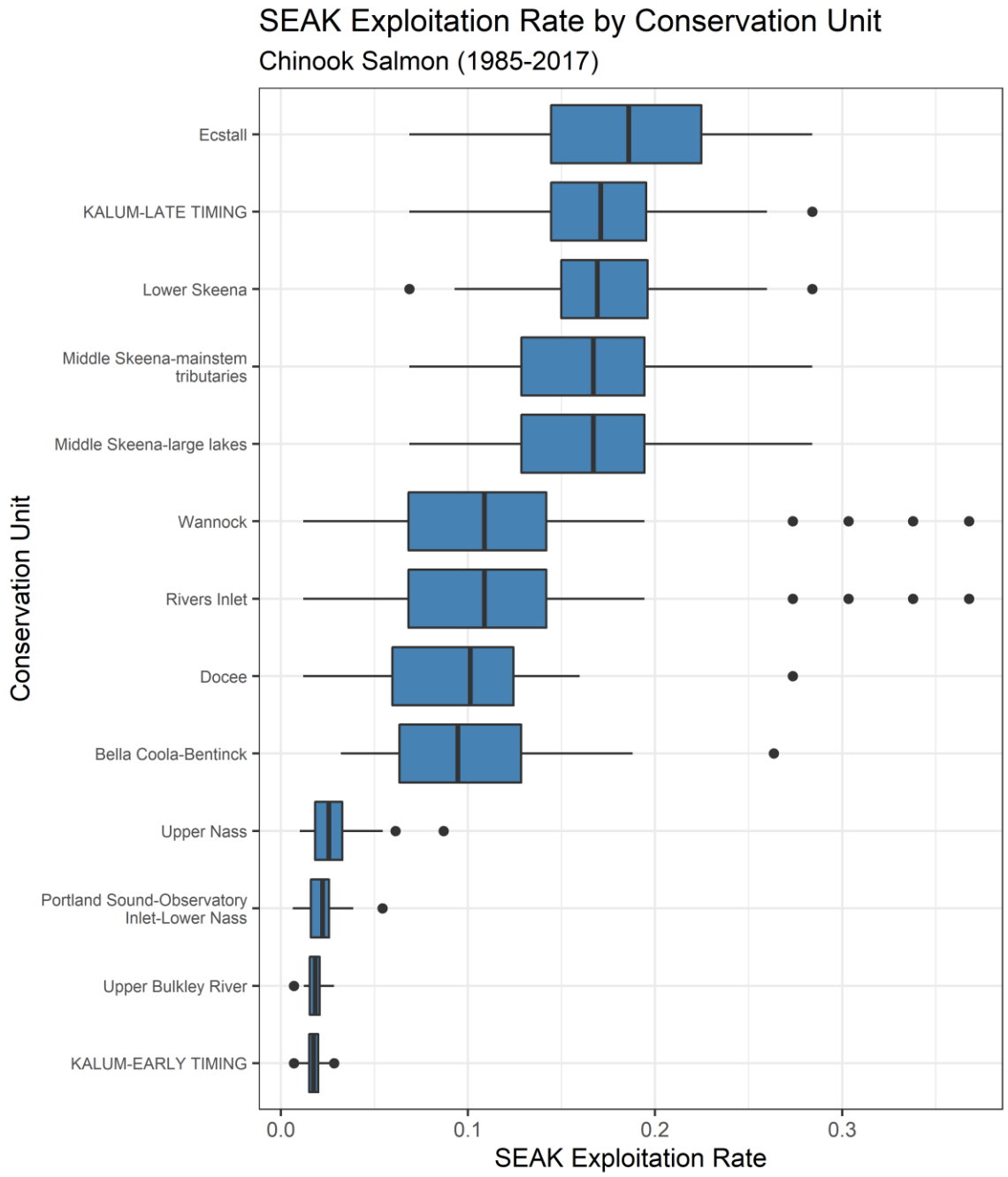


Figure 13: Boxplot of SEAK exploitation rates on Chinook north and central coast BC Conservation Units for 1954 to 2017. CUs are ordered from highest median exploitation rate to lowest. Source: PSF 2021.

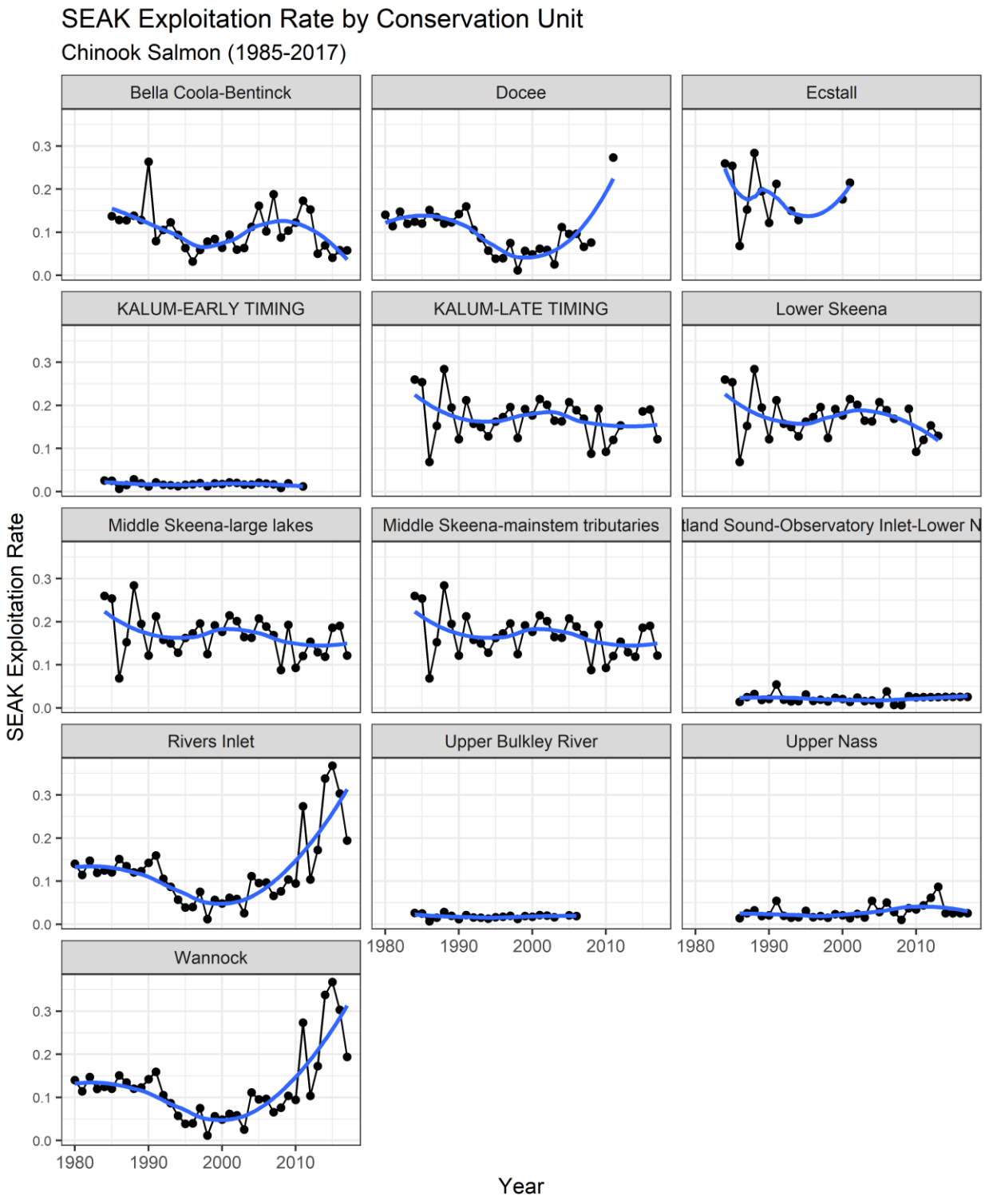


Figure 14: SEAK exploitation rates for Chinook salmon from north and central coast Conservation Units from 1954-2017. Trend lines derived using LOESS in R. Source: PSF 2021.

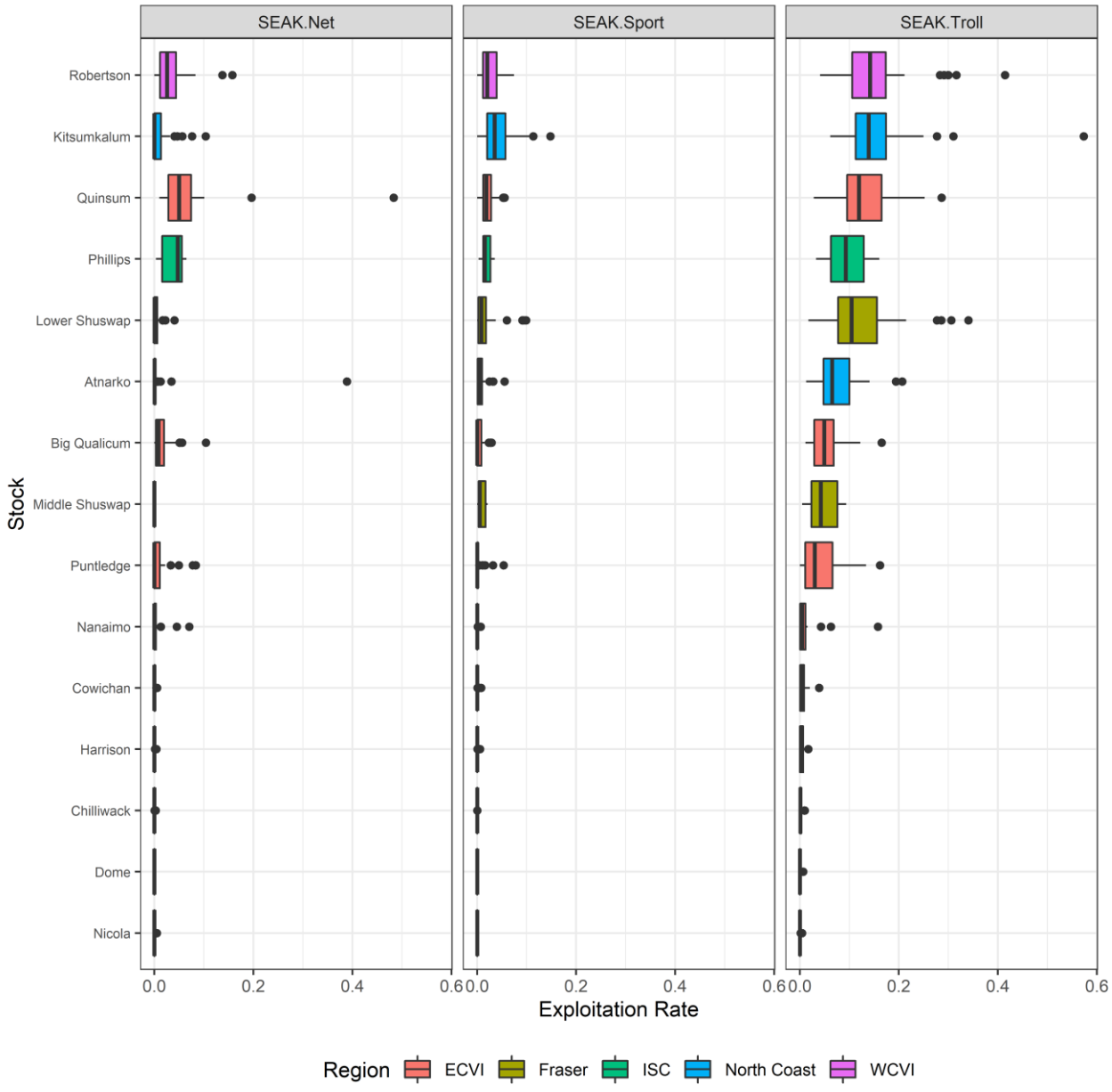
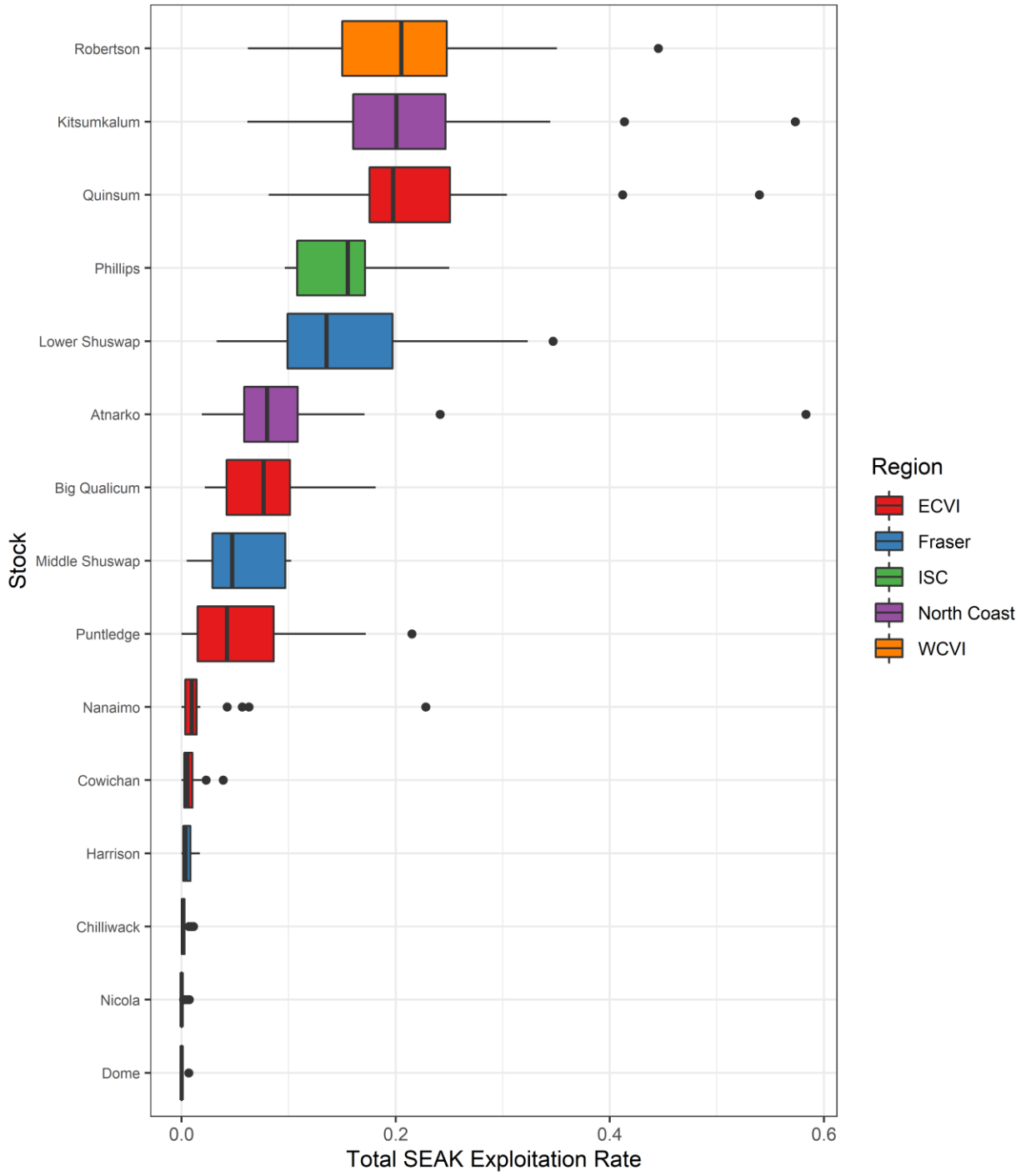


Figure 15: Median exploitation rates for Canadian (excluding Transboundary stocks) CTC indicator stocks in SEAK net, troll, and sport fisheries. Box fill indicates stock region. The thick black line is the median value, the box in indicates the interquartile range (25th to 75th percentiles – or middle 50% of the data), whiskers are 1.5x the interquartile range and dots are outliers (< 5th or > 95th percentile). Source: PSC CTC 2021.



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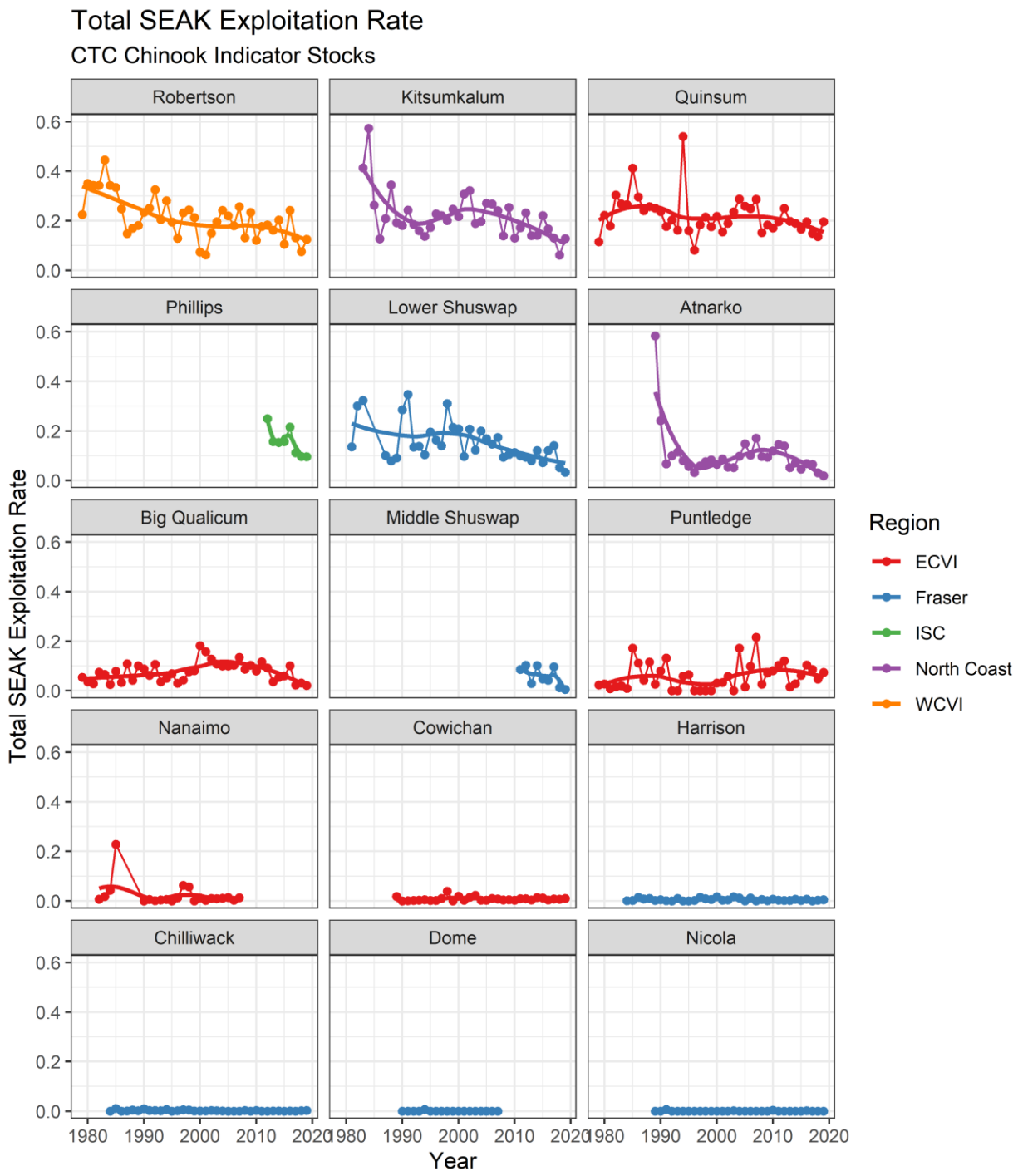

Figure 17: Total SEAK exploitation rates for Canadian (excluding Transboundary stocks) CTC indicator stocks by year (1979-2019). Trend lines derived using LOESS in R. Source: PSC CTC 2021.

Alaskan Harvest of BC Salmon: State of Knowledge

Part 4: Coho Salmon

Version 1

Prepared by:

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Prepared for:

Watershed Watch Salmon Society

Skeena Wild Conservation Trust

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Preface

This report is part of a series of reports on the 'State of Knowledge' of Alaskan interception of 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 Southeast Alaska (SEAK) catch of BC coho salmon was compiled from a number of sources including the Pacific Salmon Foundation Salmon Explorer, LGL Limited, PSC Coho Technical Committee FRAM modeling, and Coded Wire Tag (CWT) recovery information. We drew predominantly on the Pacific Salmon Explorer for coast wide Conservation Unit level data (PSF 2021) and LGL's North and Central Coast Run Reconstruction website for north coast Statistical Area level data (LGL 2021a). Information on Zolzap coho specifically was provided by and in a draft report (Noble et al. 2020, LGL 2021b). Information for Interior Fraser River coho from 2012-2019 were provided by DFO Stock Assessment (O'Brian and Sawada, 2021) and background information on the FRAM model and SEAK ERs on south coast MUs is given in the 1986-2009 periodic report (PSC JCTC 2013).

Background on the methodology for estimating SEAK catch of north and central coast coho salmon by Statistical Area and Conservation Unit is provided in English et al. (2018: Table 5 and Appendix C).

We provide some background information on SEAK and southern Southeast Alaska (SSEAK) harvest of coho 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 north and central coast BC Statistical Areas and Conservation Units. We also present information on SEAK catch of south coast coho MUs.

We do not currently have information on specific fisheries or Districts that contribute to exploitation rate estimates via CWT recoveries for coho, so we have used SEAK throughout this report where appropriate, but recognize that is likely that the vast majority of recoveries in SEAK are likely in SSEAK fisheries.

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 SEAK 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 coho salmon by region.

Species	*Region/Area*	*Type of Data*	*Data Source*	*Year*
Coho salmon	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	Marine distribution patterns	Weitkamp and Neely 2011	Various
	Fraser and Strait of Georgia	FRAM model outputs, total US and CDN ERs, SEAK ERs	PSC JCTC 2013. PSC JCTC 2019. O'Brien and Sawada 2021.	ERs provided for SC MUs for 1986-1997, 2004 to 2009. ERs for IFR coho for 2012-2019.

2 SEAK Harvest Of Coho Salmon

Summary information on coho salmon harvest in SEAK and SSEAK (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 coho 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 coho salmon catch in SEAK peaked in the 90s, declined and has remained relatively constant since, averaging around 2.5 million (Figure 3). Since 2010, catches have averaged just under ~ 2.4 million coho per year. Total SEAK catch of coho in 2021 was over 1.5 million, well below the recent and long-term averages.
- Coho salmon catch in SEAK is historically dominated by power troll fisheries, followed by the southern purse seine fishery, hatchery cost recovery programs, Yakutat, set gillnets, the Prince of Wales and northern purse seine fisheries (Figure 4). Most coho salmon (~ 50%) are caught in the power troll fisheries, with around 10% in southern purse seine fisheries. Median catch from 1979-2021 in the southern purse seine fisheries is just over 241,000, but in some years can be as high as 500,000.
- Median total catch (all gears) of coho salmon in SSEAK Districts 101-106 shows that the net catch of coho catch is highest in District 104, followed by Districts 101, 103 and 106. District 104 contributes about 25% over the entire time series, with Districts 101, 103, and 106 each contributing smaller catches on average (~ 20%) (Figure 5).

- Total catches (all gears) in District 104 is highly variable but has declined slightly since around 2000 (Figure 6). The last few years have seen relatively low catches at less than 100,000. Districts 101 and 106 have also been low in recent years. Catches in both Districts were higher in 2021.
- The proportion of total District 101-106 catch of coho salmon for each district over time is shown in Figure 7. The proportion of coho salmon caught in District 104 has declined over time, and now represents between 15 and 25% in most years. District 103 proportion has increased, and the other Districts have remained relatively constant.
- In 2021, total SEAK catch of coho salmon (including Yakutat at ~ 75,000) was over 1.5 million. SSEAK Districts 101-106 accounted for only about 514,000 of that. As in most years, most catch was taken in the summer troll fishery (~ 55% or ~ 820,000) with about 250,000 caught in southern seine fisheries (Figure 8).
- District 104 only catch of coho salmon in 2021 was ~132,000, split between power troll (~36,000) and seine (~97,000) fisheries. Note that this is distribution of catch is not the same as in other areas or in SEAK overall, where troll catches dominate other fisheries. Weekly catch in purse seine fisheries was highest in Week 31 and 32, with a significant catch later on in Week 36 (Figure 9). 2021 data is preliminary.

3 SEAK Catch of BC Origin Coho Salmon

This section of the report provides a summary of information on SEAK exploitation rates on BC coho salmon, as well as proportions of SEAK exploitation by Statistical Area and Conservation Unit for north and central coast BC (Areas 1-10). We did not, at the time of writing, extract data or provide figures for south coast BC coho Management Units, as FRAM model outputs and base period ER analysis provide considerable evidence that SEAK catch of the coho is very minimal. This is discussed in further detail in Section 3.2 below.

3.1 North Coast and Central Coast BC

Beyond our summary, the PSC has requested a report on north and central coast BC coho status. This report was prepared by north coast DFO Stock Assessment staff, is in review, and will be released shortly. We will review the final report, and provide any updates in future versions of this report.

3.1.1 Statistical Areas

Estimates of SEAK exploitation rates on north and central coast coho salmon from 1954 to 2017 are derived using various methods as detailed in Appendix C of English et al. (2018). It is beyond the scope of this report to provide all the details for each statistical area, but they are largely derived from CWT information from Zolzap Creek coho (Area 3-Nass) and Toboggan Creek coho (Area 4-Middle Skeena), as well as Deena coho (Area 2E and 2W-Haida Gwaii). SEAK ERs on other north and central coast Areas are derived from Area 4 ERs at various levels (e.g. Area 6 =100% Area 4 ER, Area 6-8 and Area 8 are 60% Area 4 ER, Area 4-9 is 40% Area 4 and Areas 9-10 are 20% Area 4).

- Canadian exploitation rates for north and central coast BC coho are shown in Figure 10. In Areas 5-10, Canadian exploitation rates have dropped dramatically in the late 90s following decreased marine survival and the coho crisis which severely curtailed most fisheries. For Areas 2E, 2W, and 3, Canadian ERs dropped in the late 90s, but appear to be close to historical levels in some recent years (~20%). Area 4 ERs were historically the highest, averaging around ~40-50%, dropped in the late 90s and in recent years have averaged between 10 and 20%.
- Figure 10 also shows SEAK exploitation rates on north and central coast coho by Statistical Unit. SEAK ERs are estimated to be highest for Area 3 coho production (averaging around 30-40% with some years over 50%), slightly lower in Area 4 and Area 6 (same ER as Area 4), and much

lower for the rest of the areas. SEAK ERs on Haida Gwaii (Areas 2E and 2W) are very low, averaging around 2-4%)

- The proportion of exploitation attributed to SEAK fisheries for north and central coast coho salmon 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 only.[1] SEAK percent of exploitation ranges widely between Areas, with SEAK proportion around 75% in most years since 1996 in Area 3, 50-75% in Area 4-8, and much lower in Areas 2E and 2W.

3.1.2 Conservation Units

Interpolation of Statistical Area SEAK ER estimates to coho CUs are detailed in Table 5 of English et al. (2018). The lack of central coast and southern north coast indicator streams requires estimating SEAK ERs from Skeena stocks in this approach, however while this is highly uncertain, it may be the best information we have until more coho indicator stocks are started, or genetic stock compositions are sampled for in non-terminal SEAK coho fisheries.

Since SEAK ERs in CUs are derived from the related Statistical Areas, the basic patterns described above for Statistical Areas hold true for CUs.

- Distribution of SEAK exploitation rates on coho salmon by CU are shown in Figure 12. The Nass and Skeena Estuary CUs have similar median and range of exploitation rates, with median rates at 35-40%, but as low as 20% and more than 50% in some years. Lower Skeena, Middle Skeena, Upper Skeena, Babine, and Douglas Gardner CUs follow with median SEAK ERs of just over 20%. There is some variation as some CUs are missing some years that others are not. Median SEAK ERs decreases in more southern CUs. This follows with information on south coast coho Management Units which have very low ERs in SEAK.
- Figure 13 shows SEAK ERs over time by CU for north and central coast CUs. There is some variation in trends between CUs, but CUs show stable, slightly increasing, or slightly decreasing SEAK ERs in recent years.
- SEAK ERs for north and central coast CUs follow the same patterns as their respective indicator estimates, therefore the proportion of catch attributed to SEAK fisheries is high for Skeena and Nass CUs, and moderate for central coast CUs. This means that these estimates suggest that SEAK catch has been higher in recent years than Canadian catch, and some times by 3-fold (Nass).

3.1.3 Zolzap Creek

Information on Canadian and SEAK catch specifically of Zolzap Creek coho for 1992-2005 and 2010-2018 was provided by LGL (2021b) and in a draft report (Noble et al. 2020). This is similar to the Area 3 data as the Zolzap system is the indicator system for the Area 3 (Nass). This was the only system level data we were able to procure before the writing of this report. SEAK ERs range from over 60% to less than 20%, but average around 40% over the time series, much higher than Canadian ERs (Figure 14). The proportion of total ER attributed to SEAK ranges from ~ 60% in 2018 to 100% in 1997, but averages around 75%.

- [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, separate estimates of CDN FSC and sport exploitation rates were not available at the time of report writing, but will be investigated further.

We are in the process of looking for other system specific data (e.g., for Toboggan Creek), and will update this report as we receive it.

3.2 South Coast

Information on SEAK exploitation rates are provided in PSC JCTC reports, for some south coast management units (Lower Fraser, Interior Fraser (including Thompson), Strait of Georgia Mainland and Strait of Georgia Vancouver Island) (PSC JCTC 2013, 2019). Exploitation rates are estimated using the FRAM model. For more details on FRAM modeling and some of the assumptions and concerns around applying base period (1986-1992) information in recent years, given changes in harvest rates, survivals, marine distributions, and implementation of mark selective fisheries, see PSC JCTC (2013). However, both the 2013 report and the 2019 post-season analysis suggest that SEAK ERs on the southern coho MUs are extremely low, and less than 1%. ERs from both Canada and US have been severely diminished since 1997 in response to the coho crisis. Total US exploitation rates on SC coho MUs from 2004-2009 were generally less than 15%, with SEAK ER in most years < 1%. Periodic Report Comparisons from 2010-2018 confirm that in all years SEAK ERs on south coast MUs were extremely low (PSC JCTC 2010-2018).

When we accessed the Pacific Salmon Explorer in October, 2021, there were unfortunately no coho CUs in the south coast, Vancouver Island, or Fraser areas with exploitation rate information.

Other than a paper on marine distribution patterns (discussed below), we were not able to locate any information specific to SEAK catch of south coast coho on the West Coast of Vancouver Island. Further exploration is needed.

Weitkamp and Neely (2011) provide an excellent analysis of ocean migration patterns from CWT recoveries of hatchery and wild coho from Alaska to California. Figure 15 (Figure 2 from Weitkamp and Neely 2011), provides an overview of the recovery patterns for tagged coho. Key findings of this analysis, which are likely still relevant today, are that north BC coast CWT coho are recovered in approximately equal numbers in north and south SEAK fisheries and north BC coast and Haida Gwaii fisheries. There are no central coast hatcheries. Haida Gwaii origin fish are mostly recovered in north BC and Haida Gwaii, and there are very few recoveries of WCVI, ECVI, south mainland, lower or upper Fraser coho in SEAK. This provides support for both the high SEAK ERs in north coast coho, and the low SEAK ERs for southern stocks. Weitkamp and Neely (2011) also determine that CWT'd tagged wild coho follow relatively similar patterns of marine distribution as their specific regional hatchery indicators, suggesting that SEAK ERs would be similar for wild coho as hatchery indicators.

There are also some wild coho indicators in the south coast Vancouver Island area which may provide additional information (e.g., Black Creek coho), and some central coast coho indicators are in development (e.g., Quaye). There may also be additional information from other systems such as the Zymachord Creek and Kitwanga River programs for Lower and mid-Skeena coho. We are in the process of procuring this data to add to the report.

3.3 2021 Estimates

2021 estimates of SEAK ERs for coho salmon will not be available in the immediate future. Based on recent trends and catches in SEAK in 2021, it would be expected that estimates of SEAK ERs on north and central coast BC would follow recent trends with high ERs on Nass coho, moderate ERs on Skeena and Area 6 coho, and lower ERs on central coast coho. ERs on southern Management Units would be expected to be very low.

4 Information Gaps

1) We were unable to find any direct information on SEAK catch or exploitation rates specifically for WCVI and central coast coho. SEAK ERs for central coast coho are estimated as described above, however there is likely considerable uncertainty in this approach. Apart from Weitkamp and Neely (2011), we did not find any direct information on WCVI coho. We have heard that there are efforts underway for central coast coho indicator stocks, which would confirm or refine current estimates.
2) We were unable to locate any references to stock composition studies based on genetic stock ID in Alaskan fisheries (other than a few from Upper Cook Inlet), and we could not find any specific information for SSEAK. We will be following up with DFO and ADFG to see if District level recovery information is available. With the improvement in genetic baselines for central and north coast BC, genetic sampling of coho caught in outside mixed-stock fisheries (e.g., the District 104 purse seine and troll fisheries) may add valuable information to the CWT recovery programs.

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6 Figures

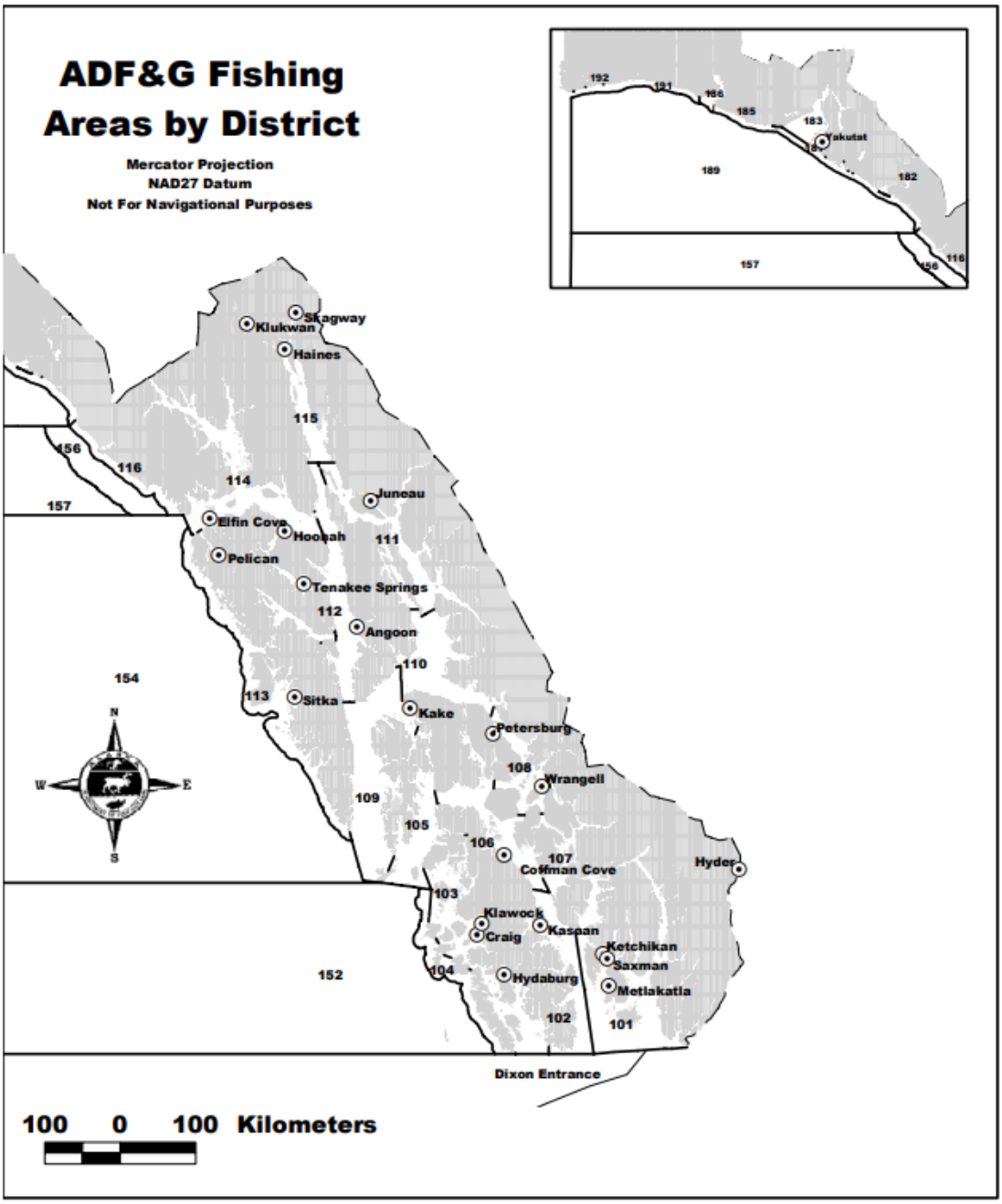
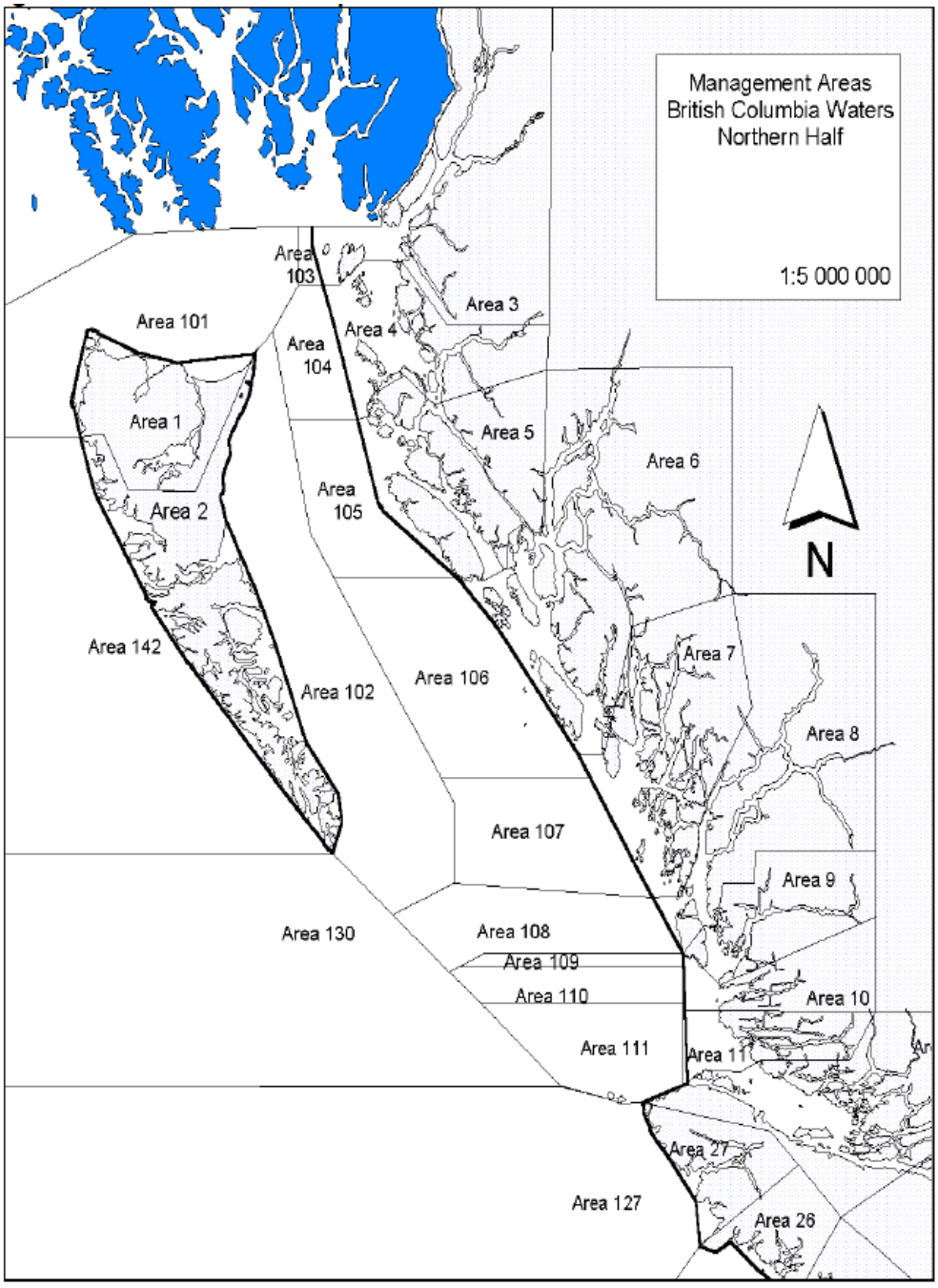


Figure 1: Map of Southeast Alaska Fishing Areas by District.



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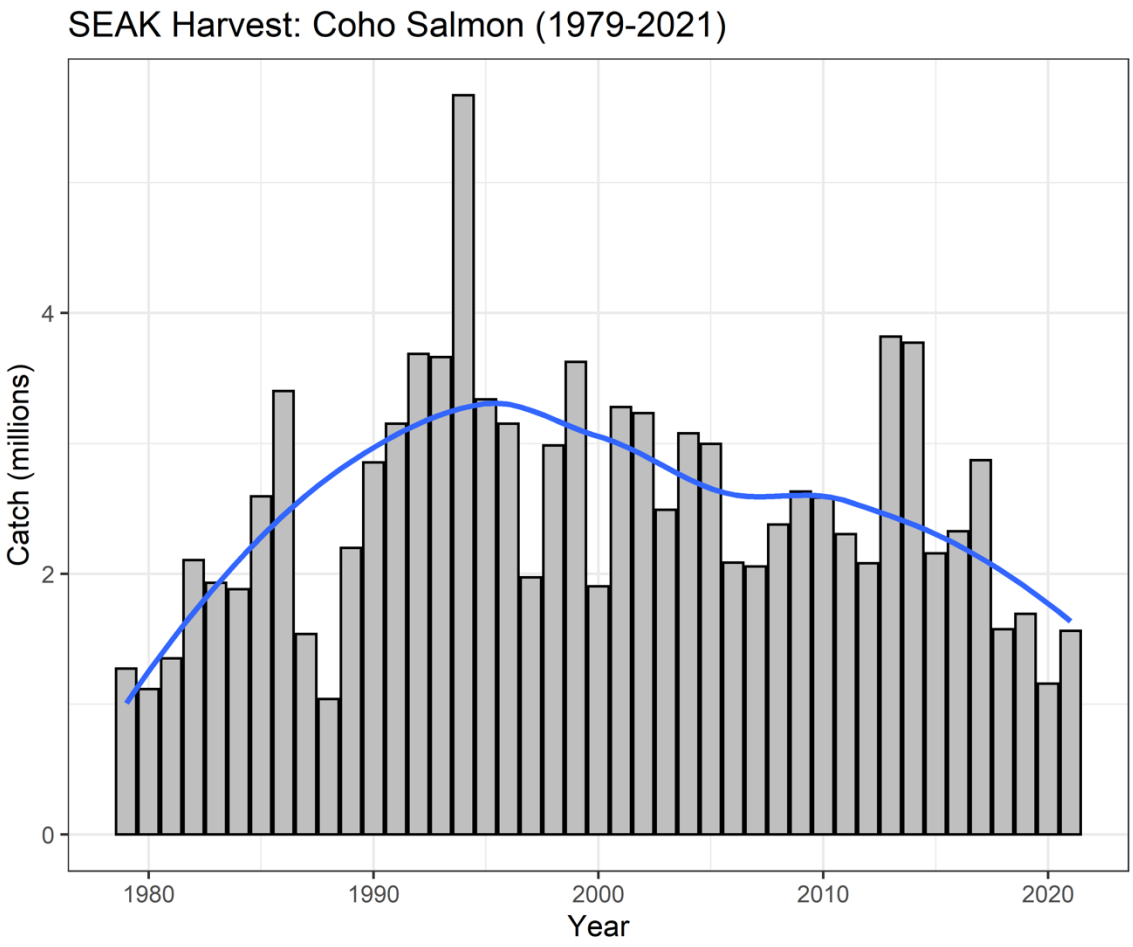


Figure 3: Total SEAK harvest (millions of fish) of coho salmon from 1979-2021. Blue line is fit using LOESS. Source: ADFG 2021a (1979-2020), ADFG 2021b (2021).

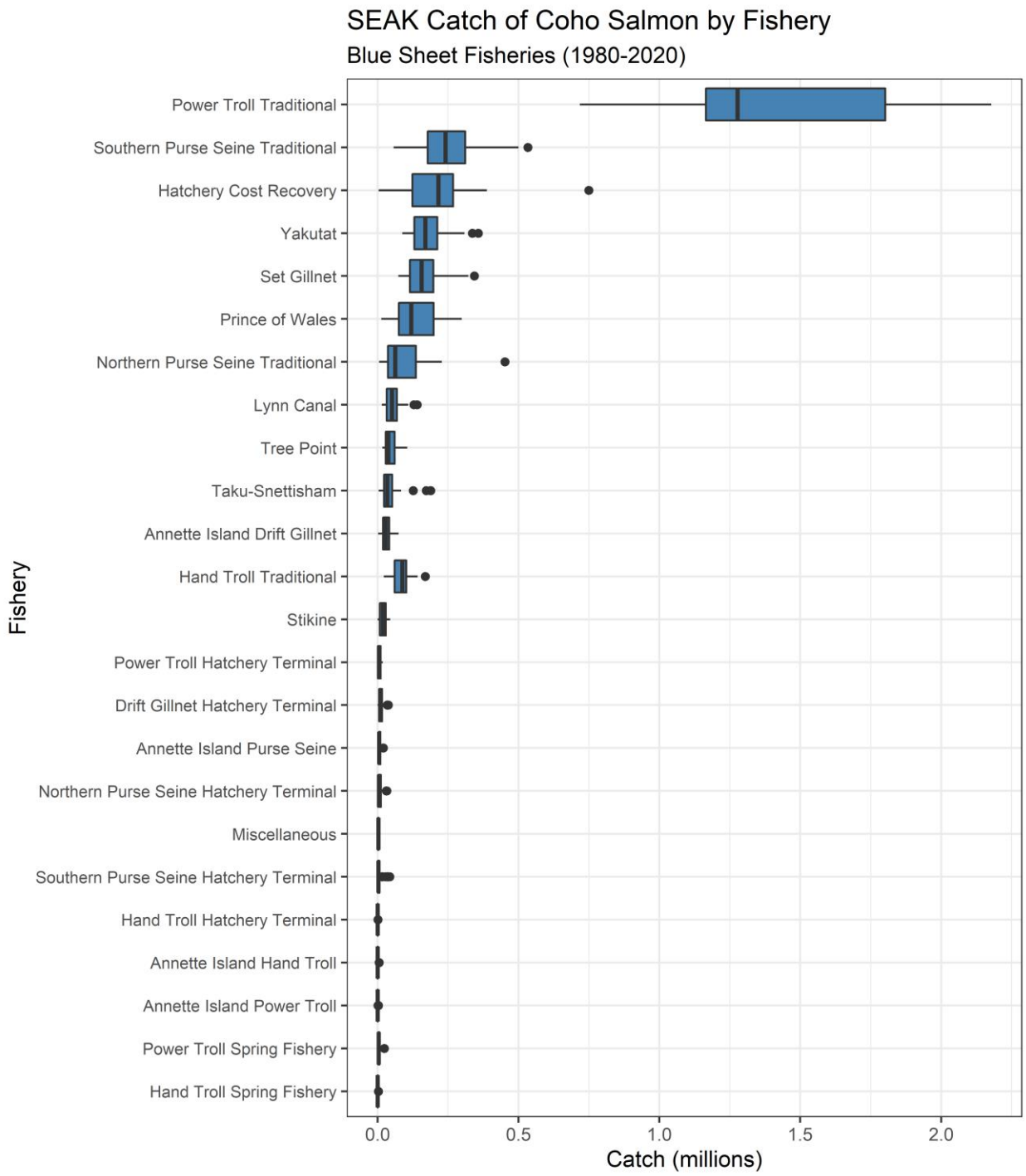
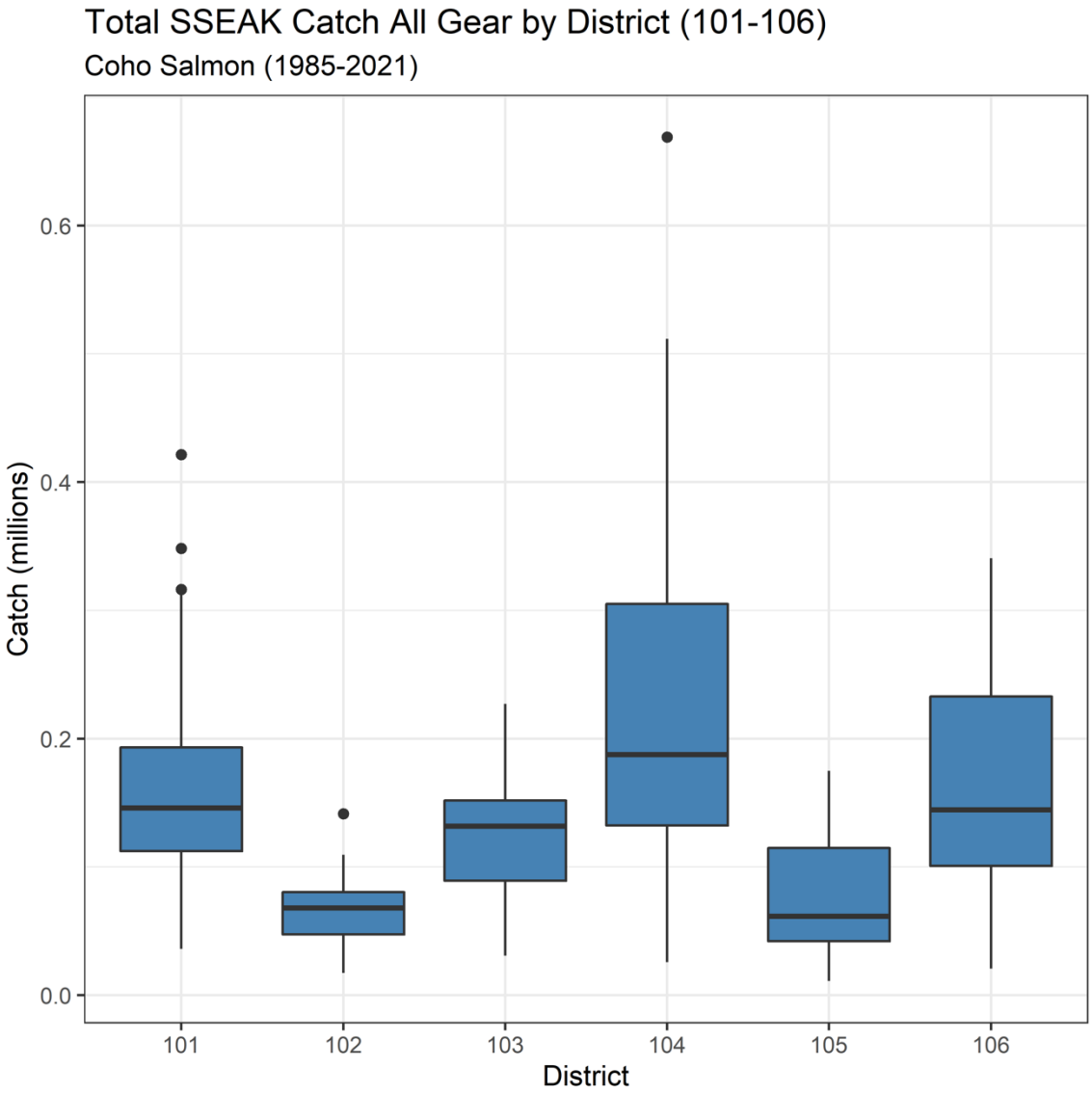


Figure 4: Distribution of total coho salmon commercial catch in SEAK "Blue Sheet" fisheries 1980-2021. Fisheries are ordered from highest catch to lowest catch. The thick black line is the median value, the box in indicates the interquartile range (25th to 75th percentiles – or middle 50% of the data),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



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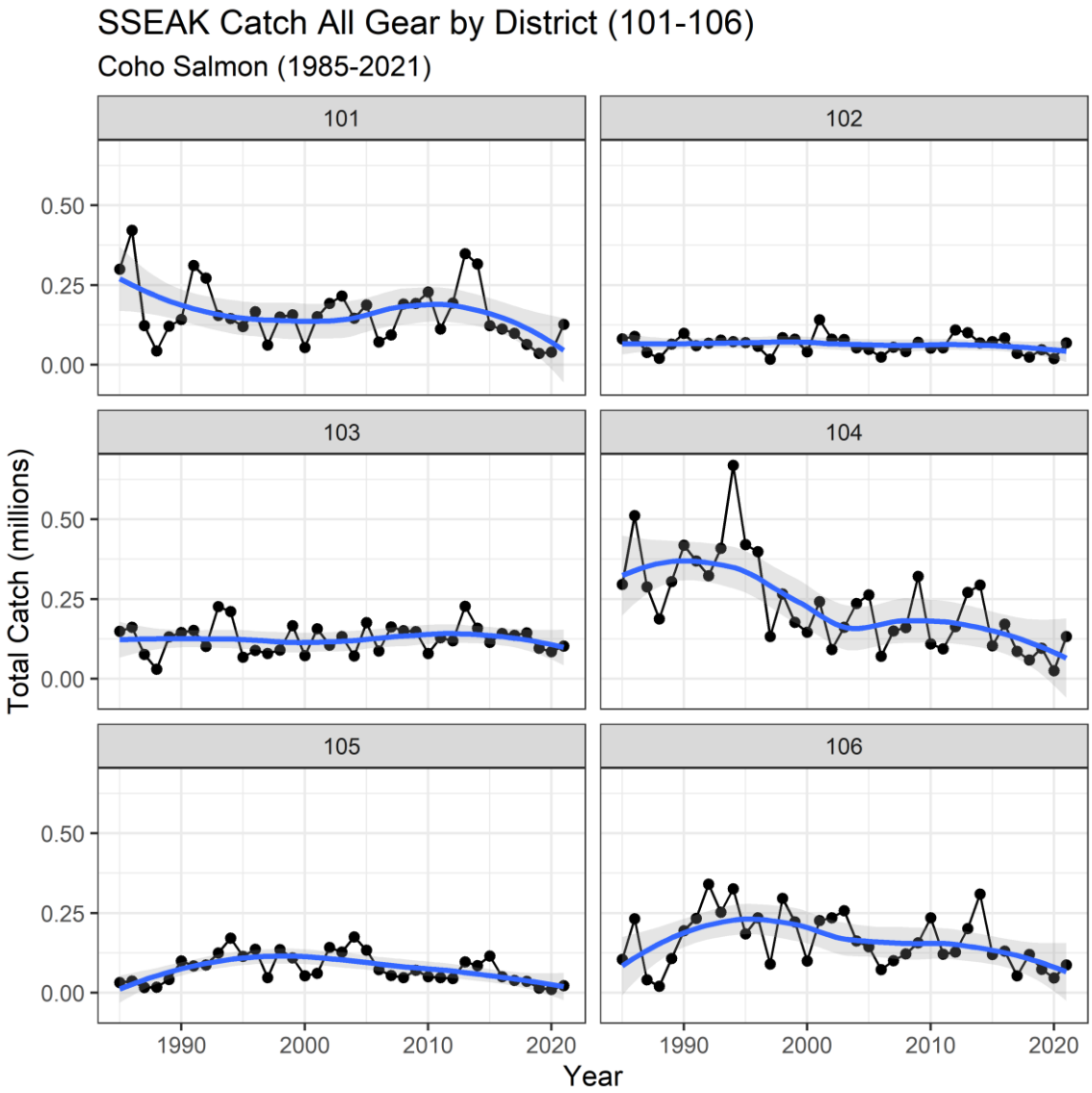

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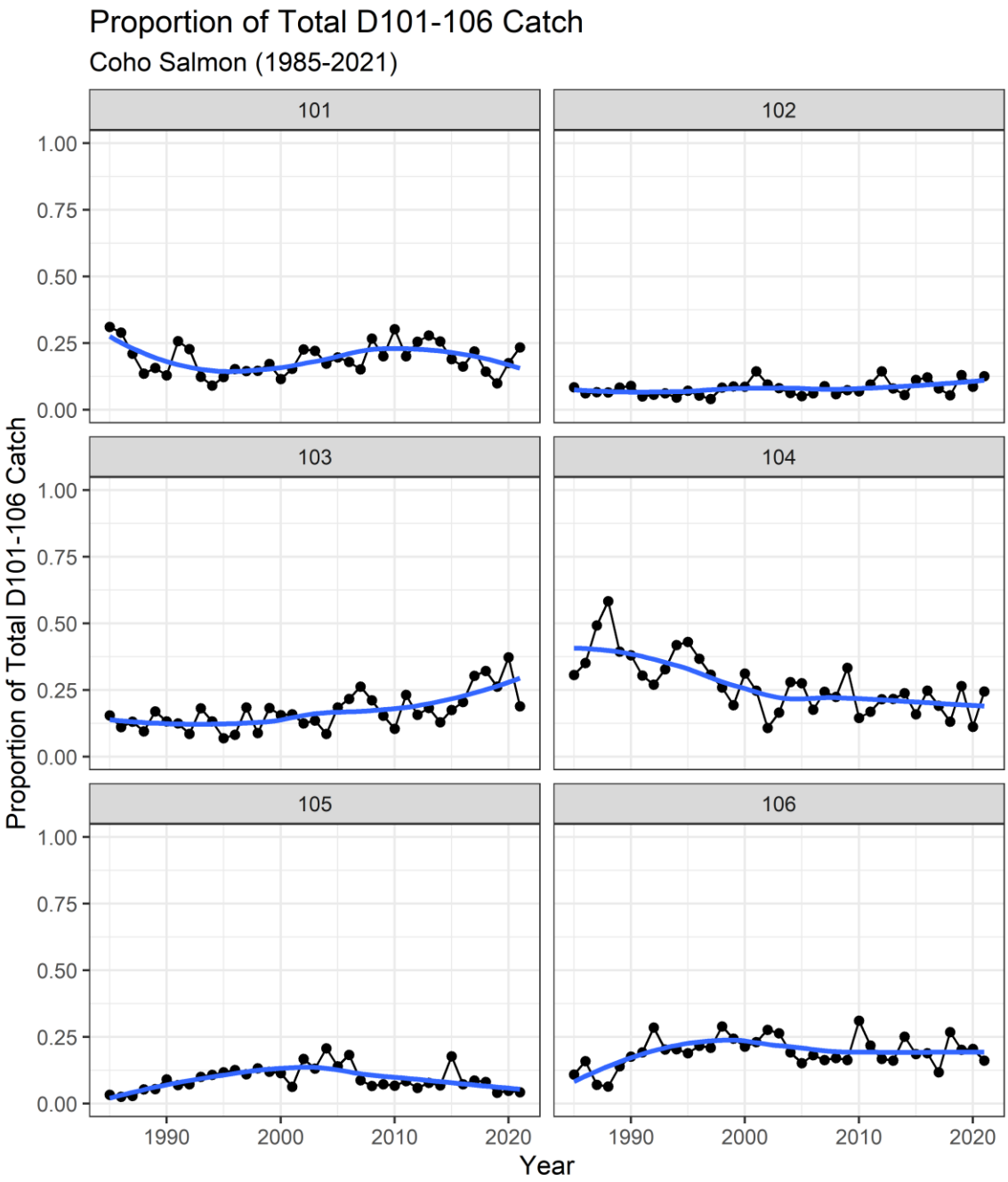


Figure 7: Proportion of total SSEAK District 101-106 coho salmon catch (all gears) by year for 1985-2021. Blue lines are estimated by LOESS fits. Source: ADFG 2021d.

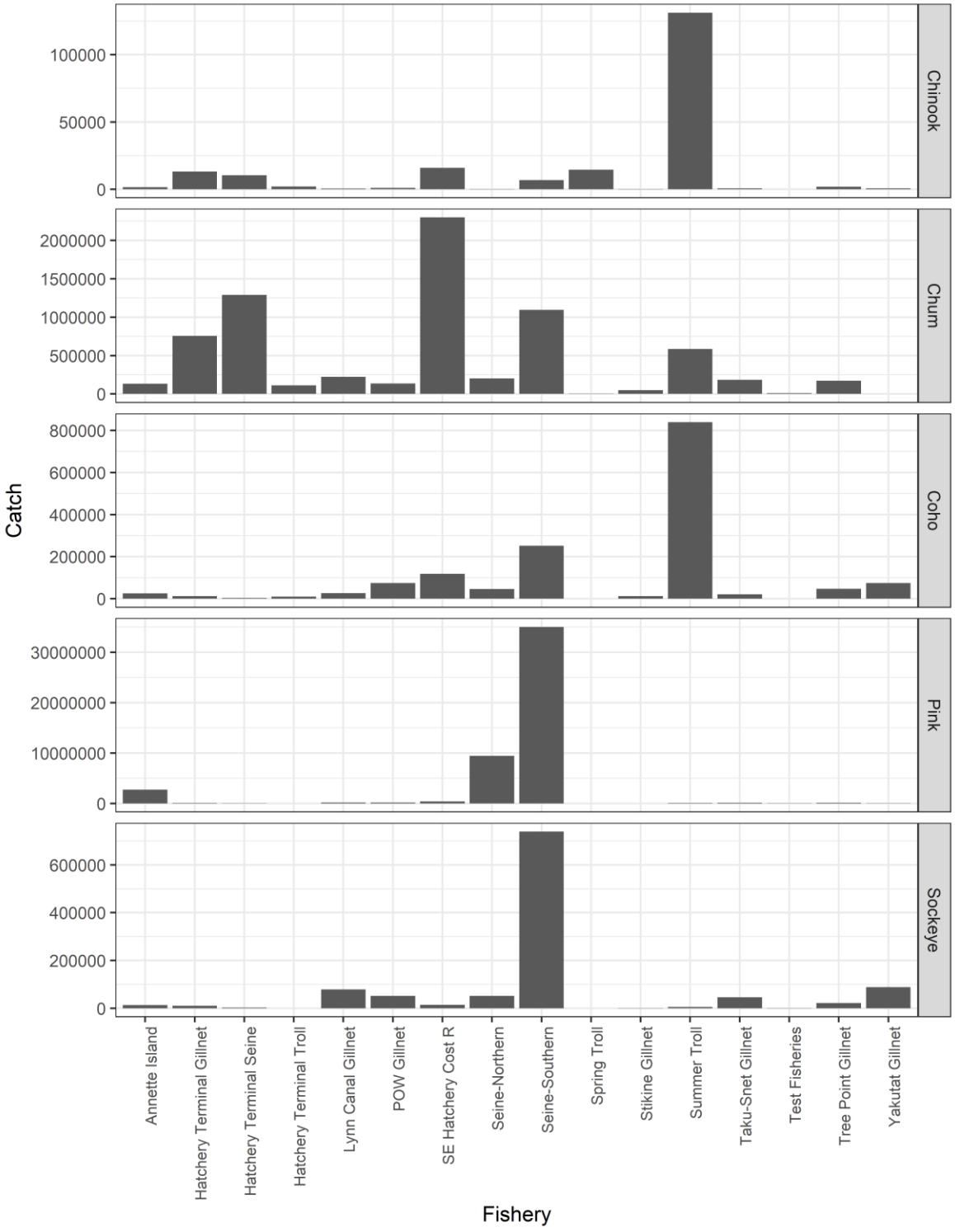


Figure 8: Harvest of all salmon species in SEAK "Blue Sheet" commercial fisheries in 2021. Source: ADFG 2021b.

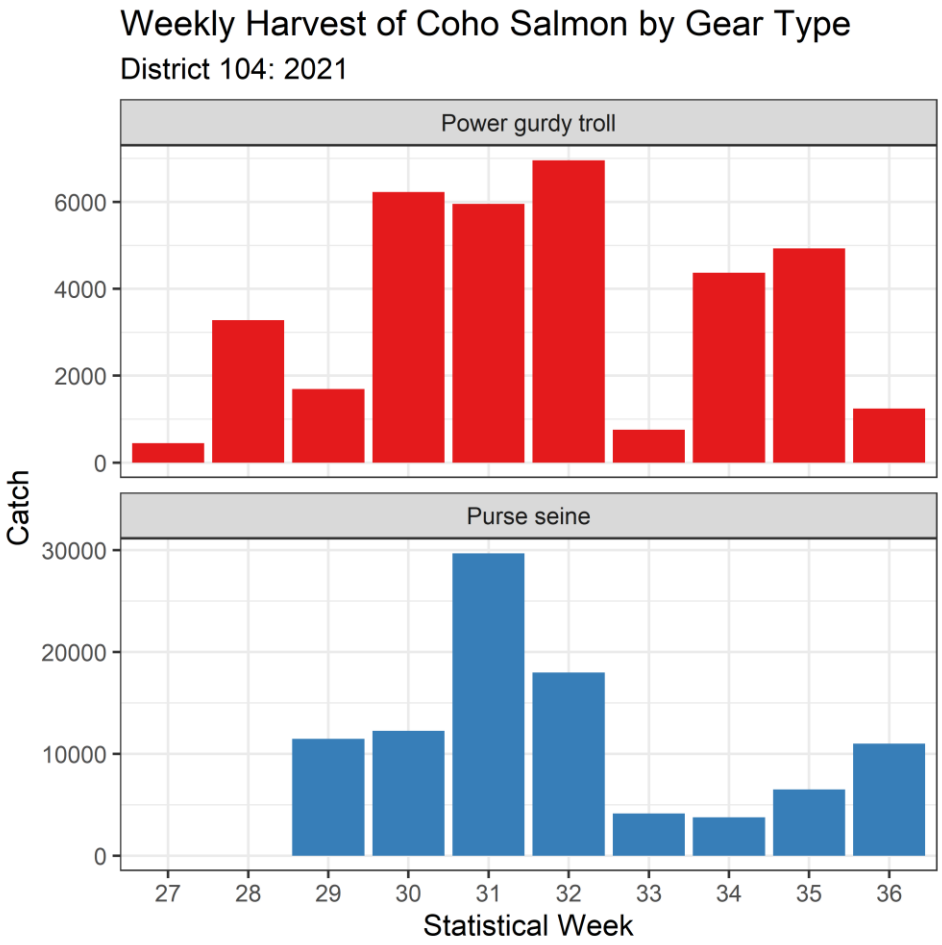
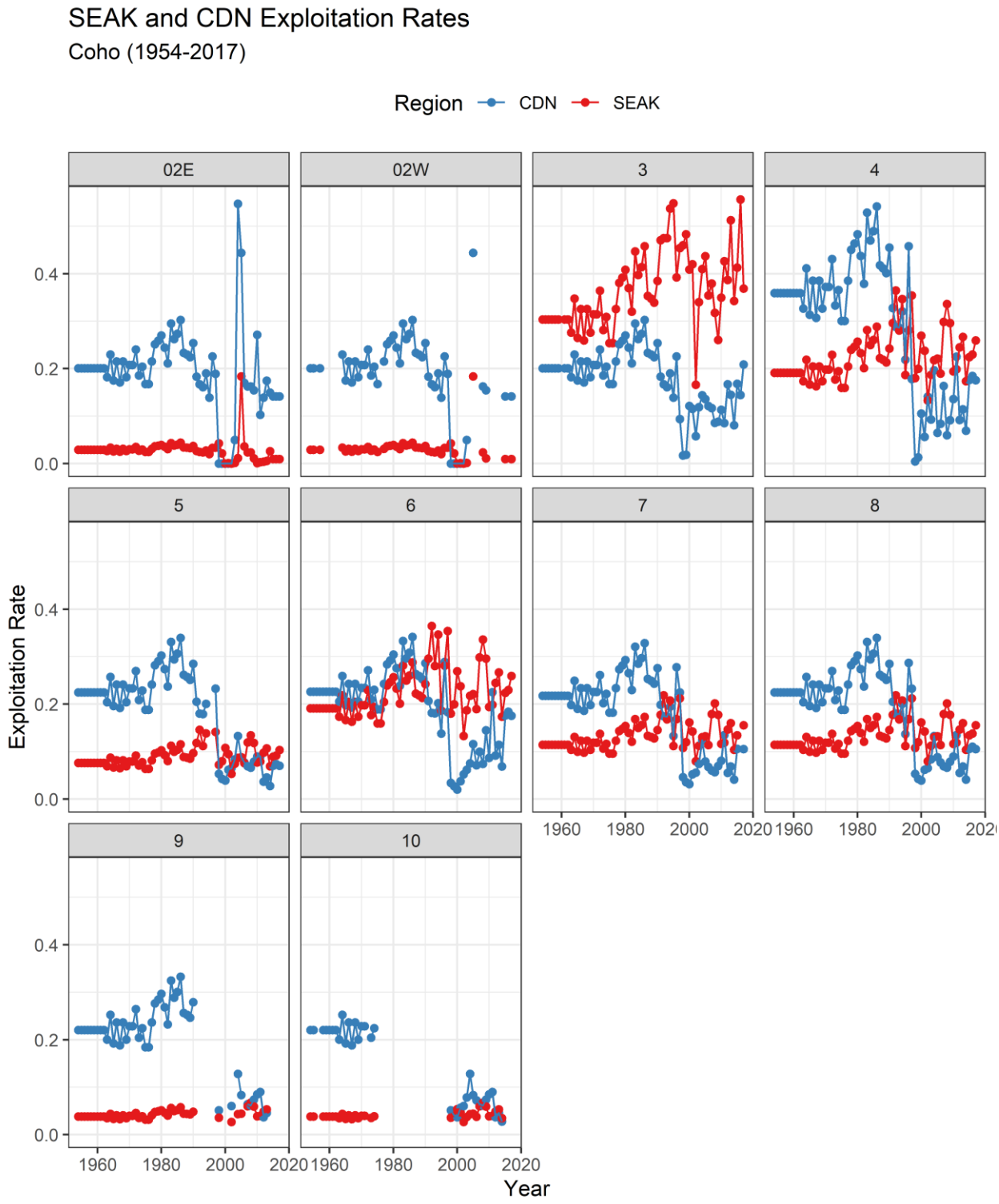


Figure 9: Weekly catch of coho salmon in District 104 fisheries by gear type for 2021. Note y-axis scales are not the same between panels. Source: ADFG 2021e.



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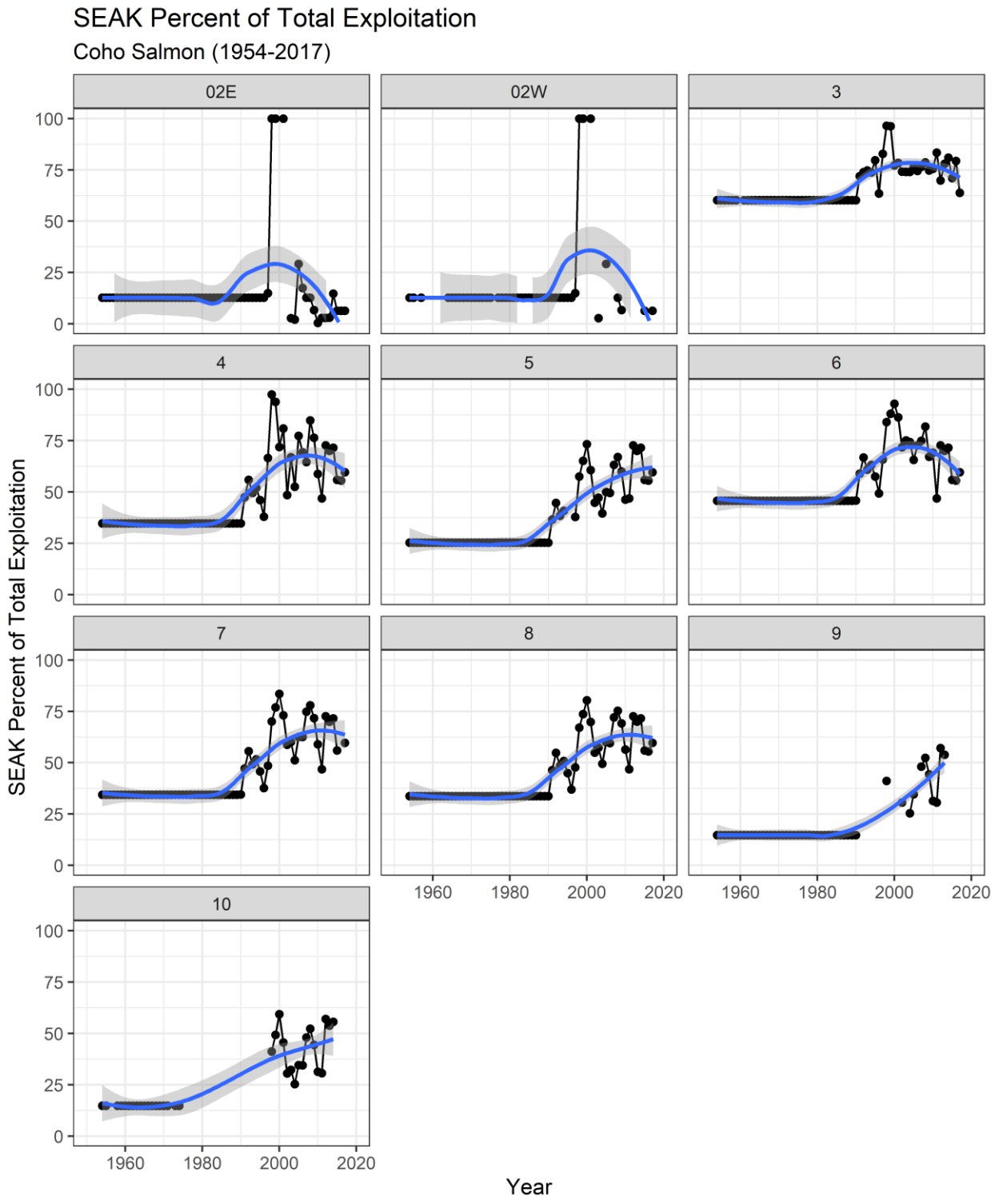


Figure 11: Percent of exploitation attributed to SEAK for coho salmon from north and central coast BC from 1954-2017. Trend lines and SEs were derived using LOESS in R. Source: LGL 2021.

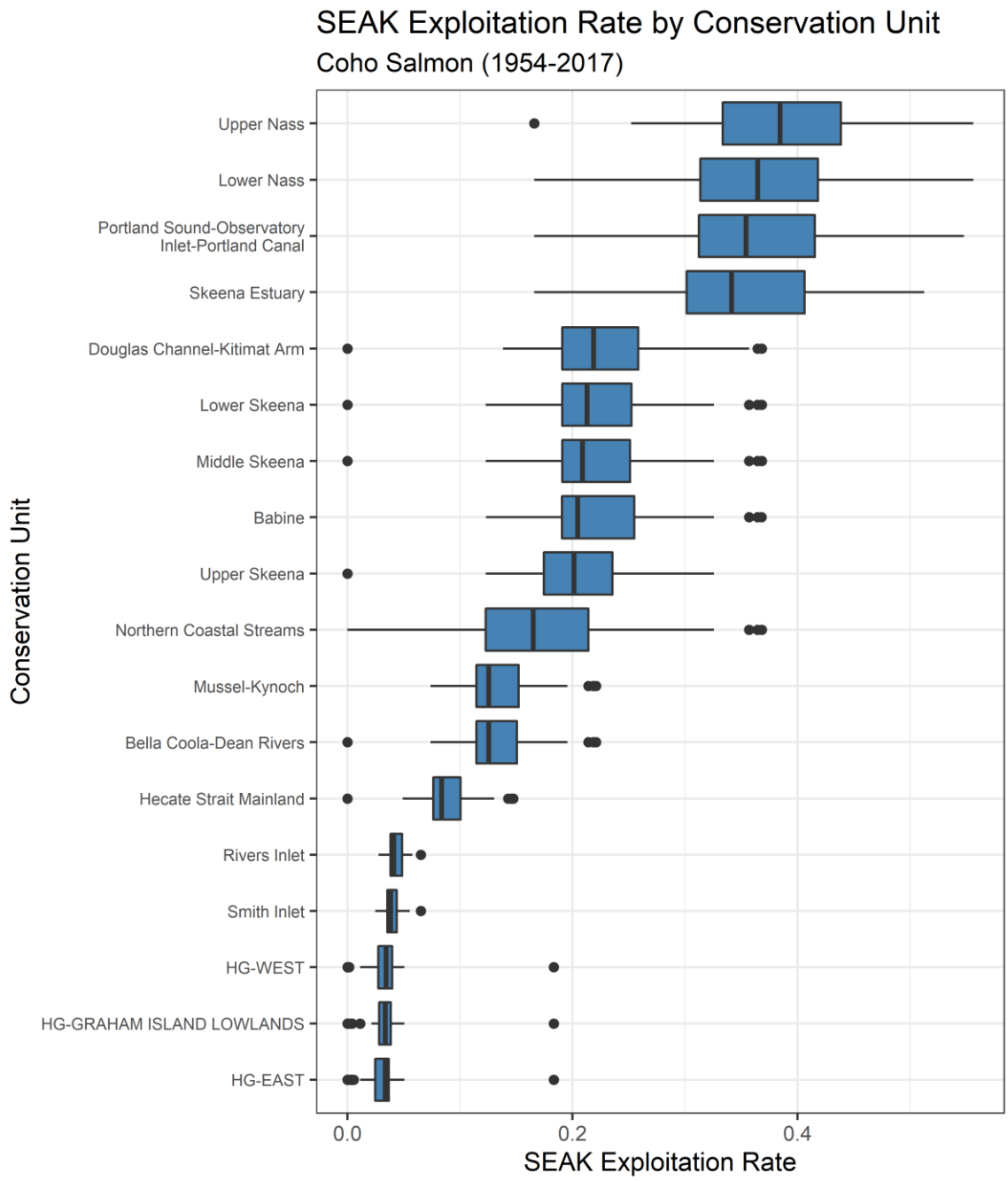


Figure 12: Boxplot of SEAK exploitation rates on coho north and central coast BC Conservation Units for 1954 to 2017. CUs are ordered from highest median exploitation rate to lowest. Source: PSF 2021.

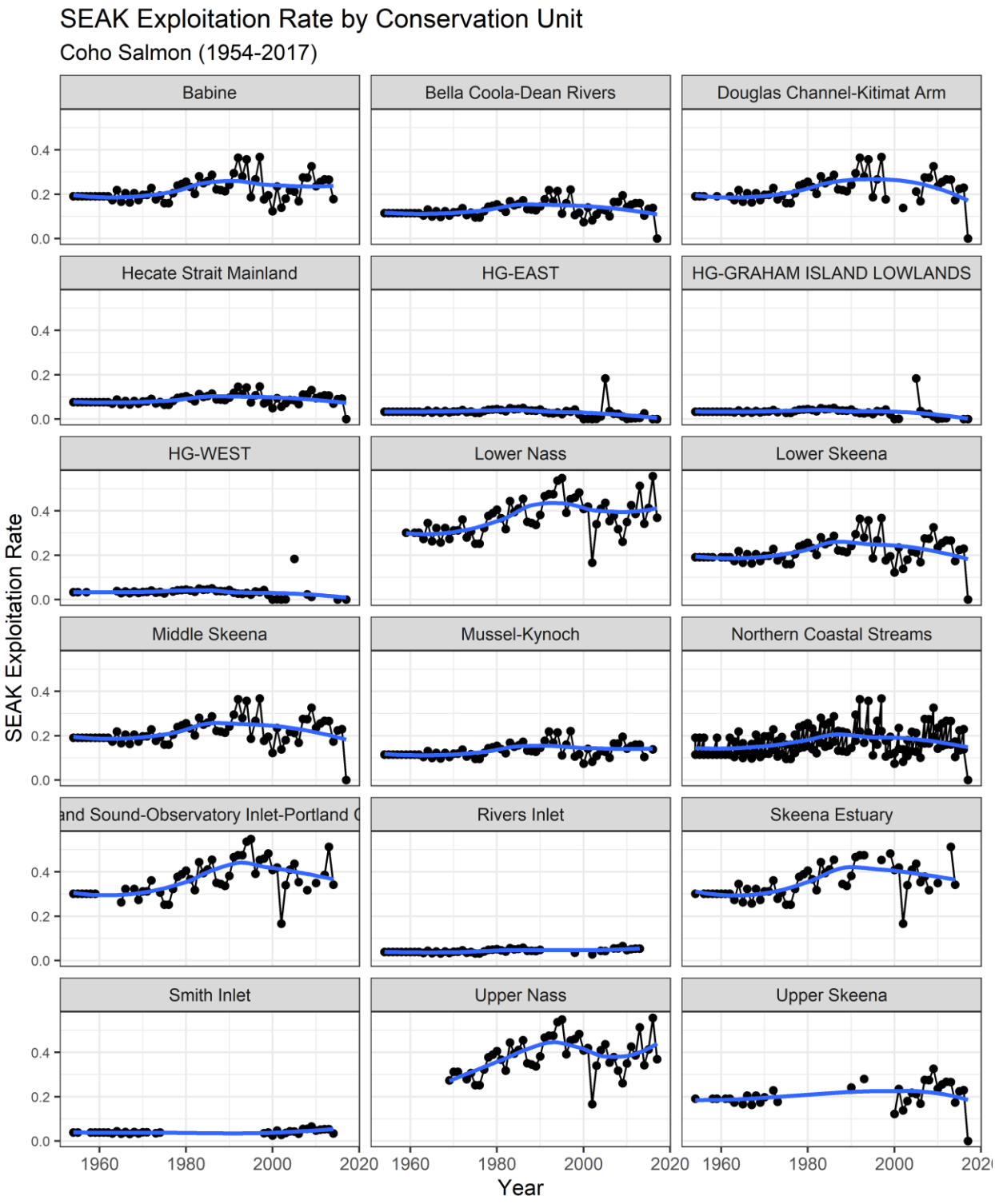
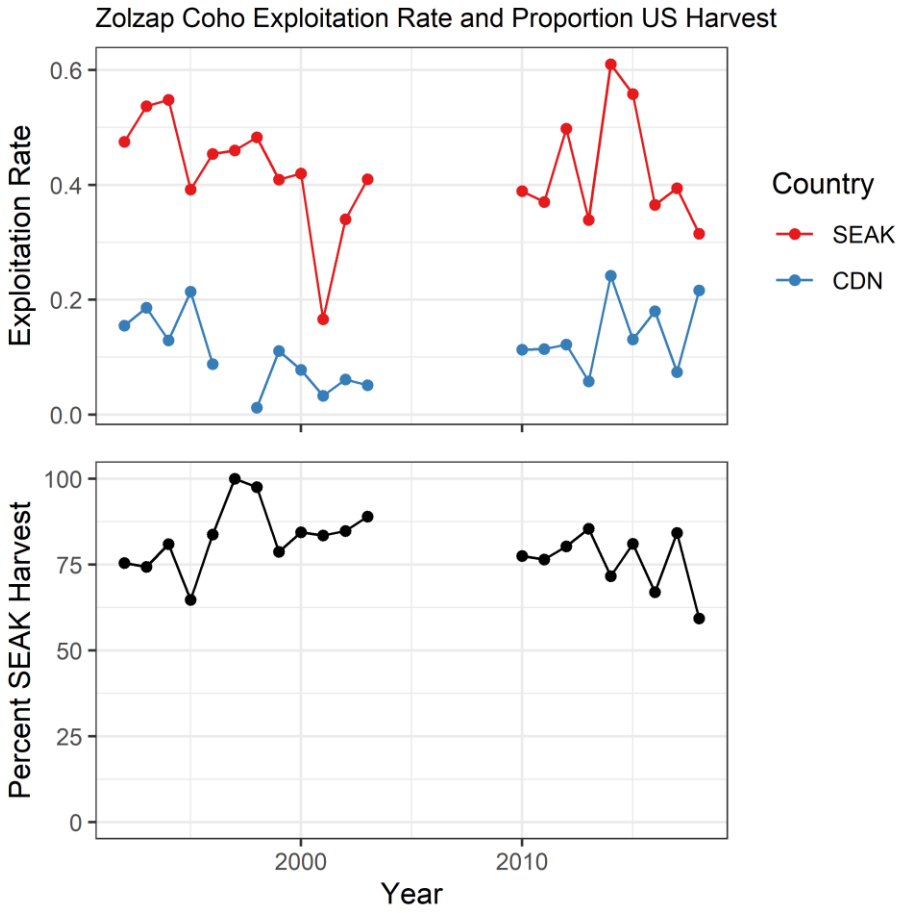


Figure 13: SEAK exploitation rates for coho salmon from north and central coast Conservation Units from 1954-2017. Trend lines derived using LOESS in R. Source: PSF 2021.



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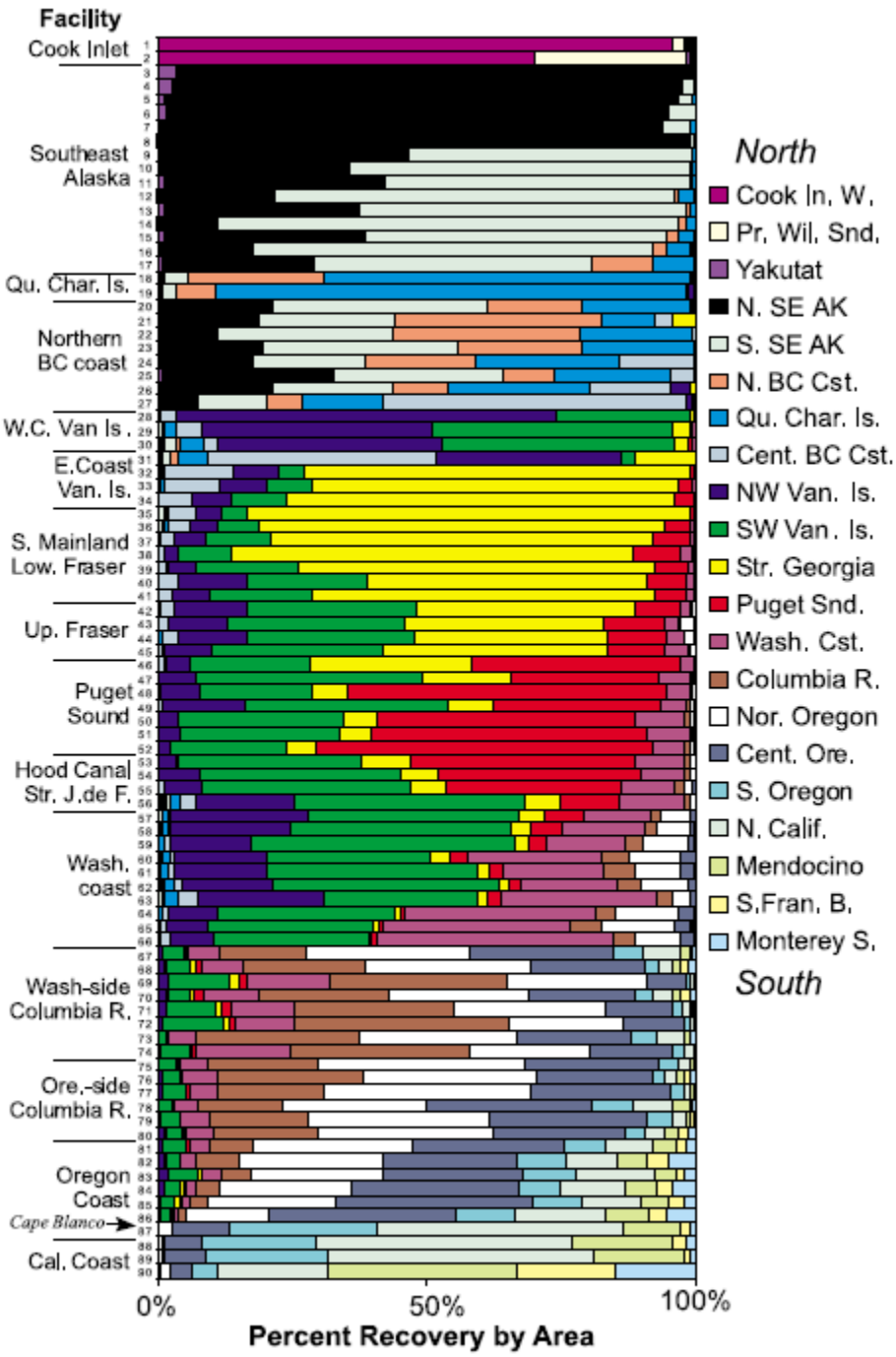

Figure 15: Recovery patterns of coded-wire tagged coho salmon (Oncorhynchus kisutch) by hatchery. Each bar provides the percent of recoveries in the 21 recovery areas for a single hatchery. The geographic region of hatcheries is indicated. Source: Weitkamp and Neely (2011).

Alaskan Harvest of BC Salmon: State of Knowledge

Part 5: Chum Salmon

Version 1

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Prepared for:

Watershed Watch Salmon Society

Skeena Wild Conservation Trust

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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.

Species	*Region/Area*	*Type of Data*	*Data Source*	*Year*
Chum salmon	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 only[1]. 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 online[2]. 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.

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6 Figures

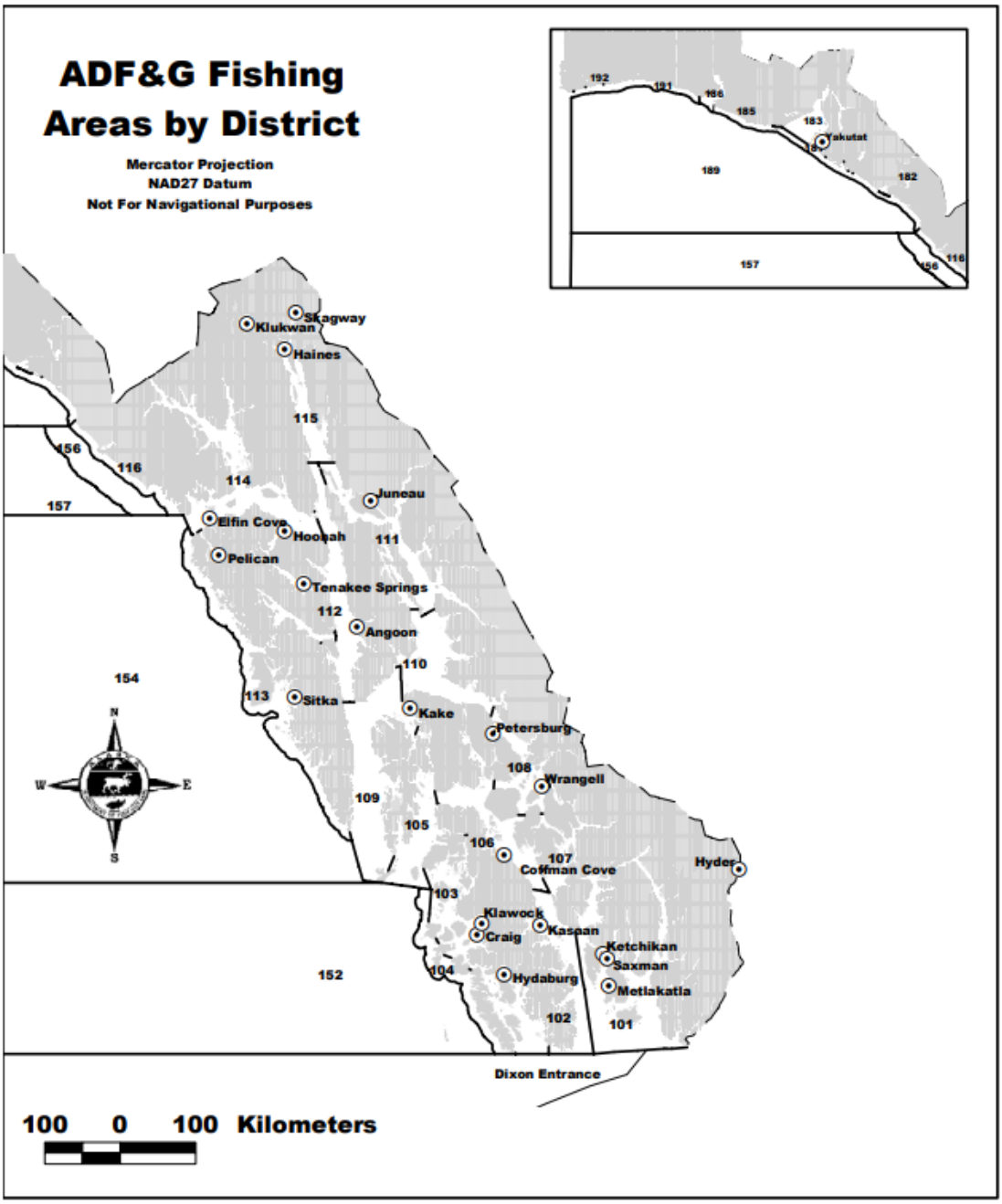

Figure 1: Map of Southeast Alaska Fishing Areas by District.

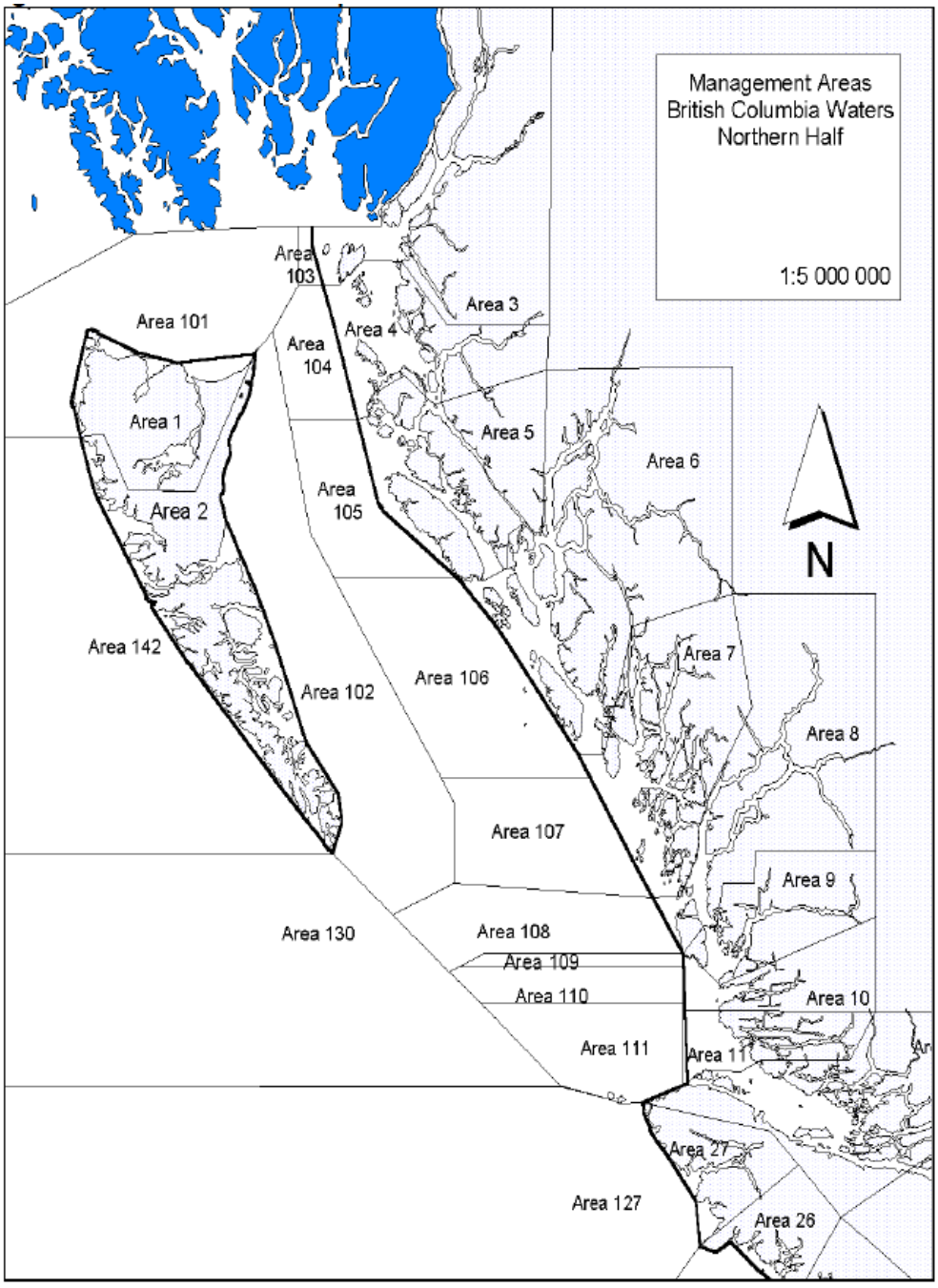

Figure 2.Map of DFO Statistical Areas in the North and Central Coast Areas.

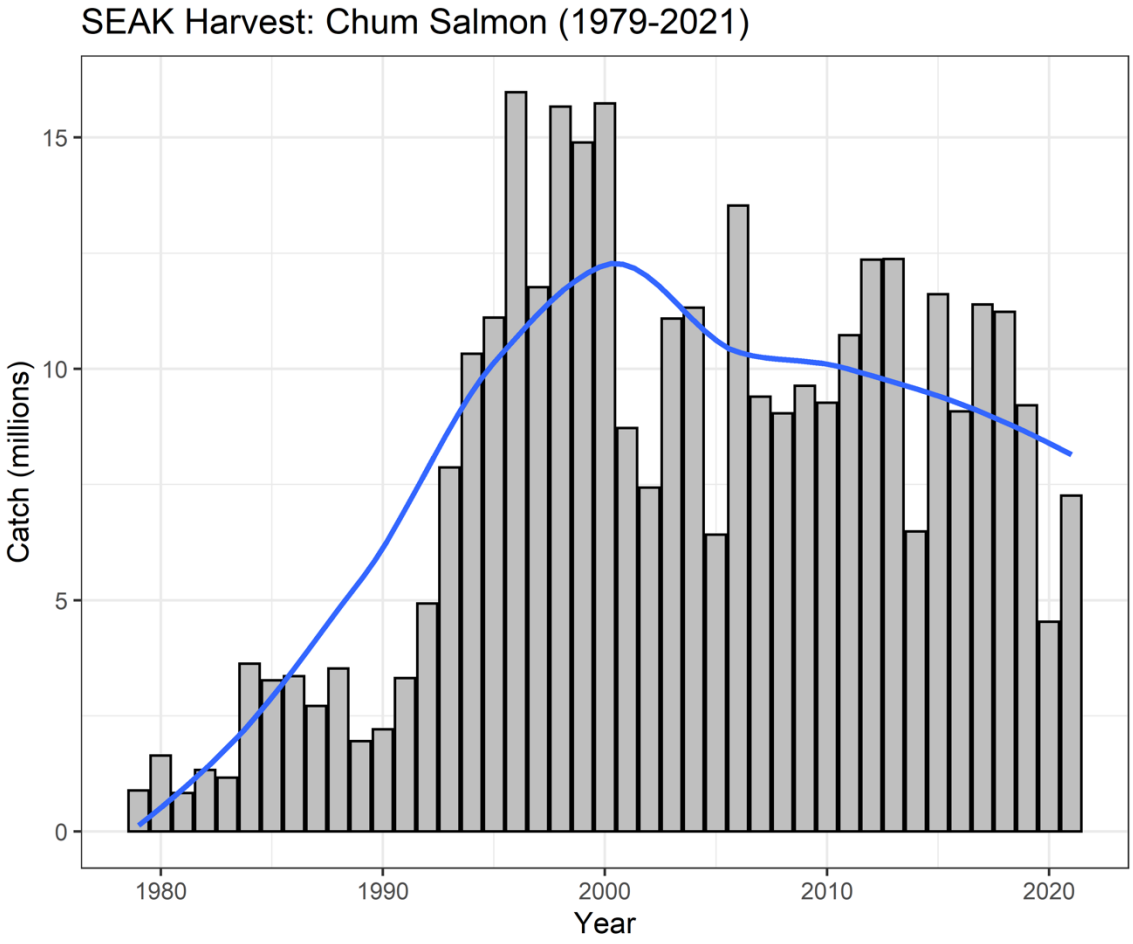

Figure 3: Total SEAK harvest (millions of fish) of chum salmon from 1979-2021. Blue line is fit using LOESS. Source: ADFG 2021a (1979-2020), ADFG 2021b (2021).

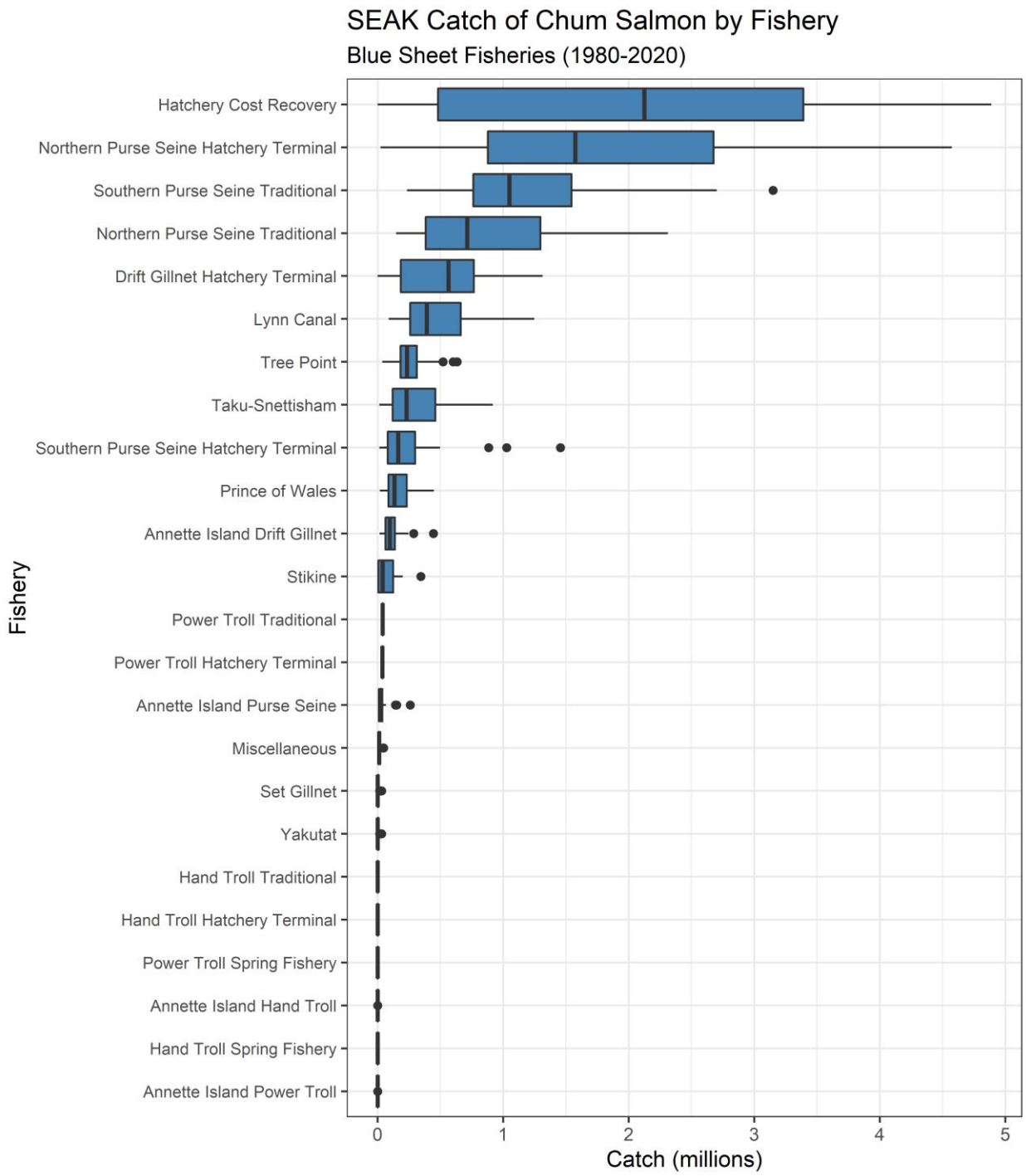

Figure 4: Distribution of total chum salmon commercial catch in SEAK "Blue Sheet" fisheries 1980-2021. Fisheries are ordered from highest catch to lowest catch. The thick black line is the median value, the box in indicates the interquartile range (25th to 75th percentiles – or middle 50% of the data),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

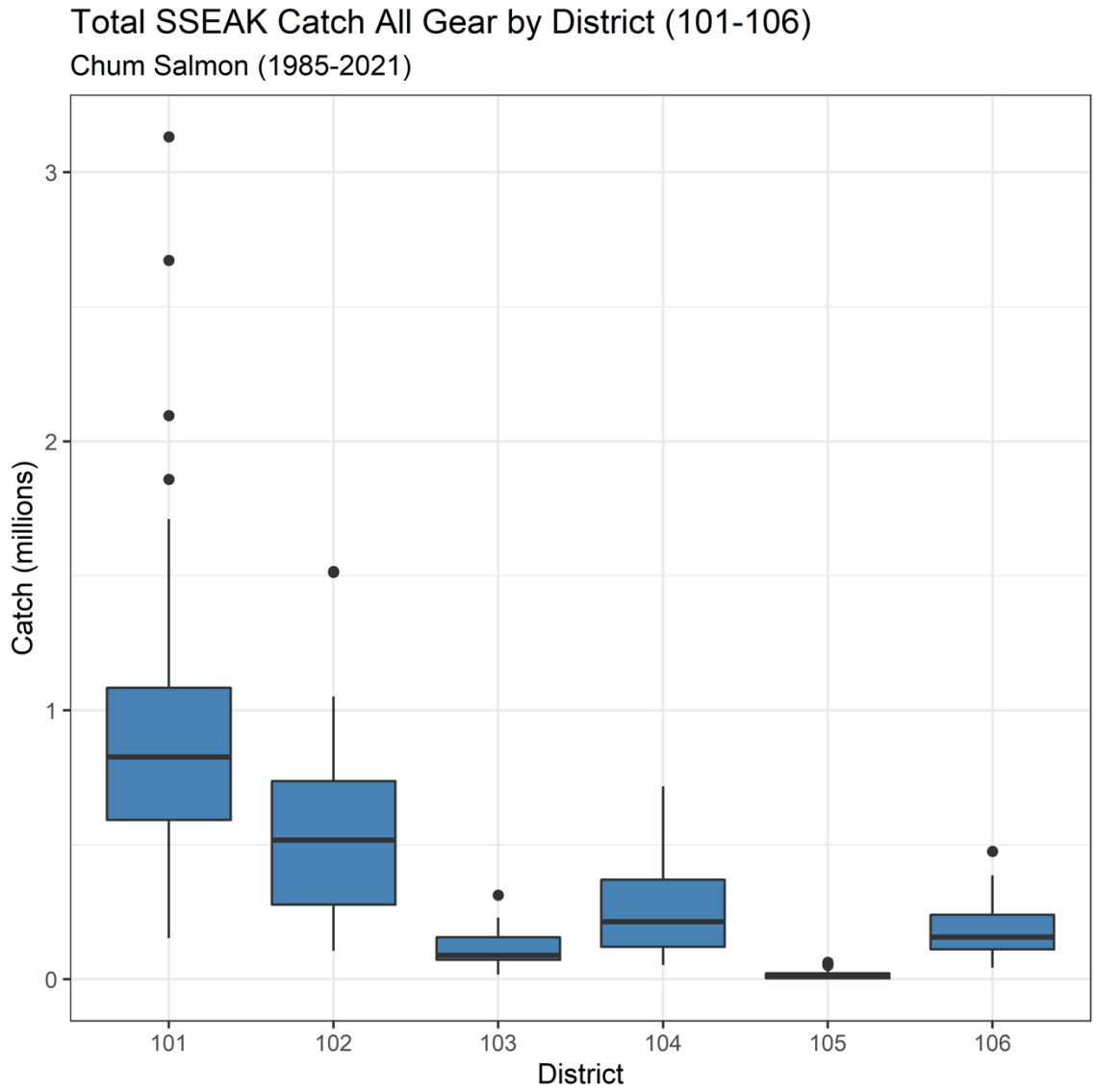

Figure 5: Median catch of chum salmon from all gears in SSEAK fisheries by district (districts 101-106) from 1985-2021. The thick black line is the median value, the box in indicates the interquartile range (25th to 75th percentiles – or middle 50% of the data), whiskers are 1.5x the interquartile range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

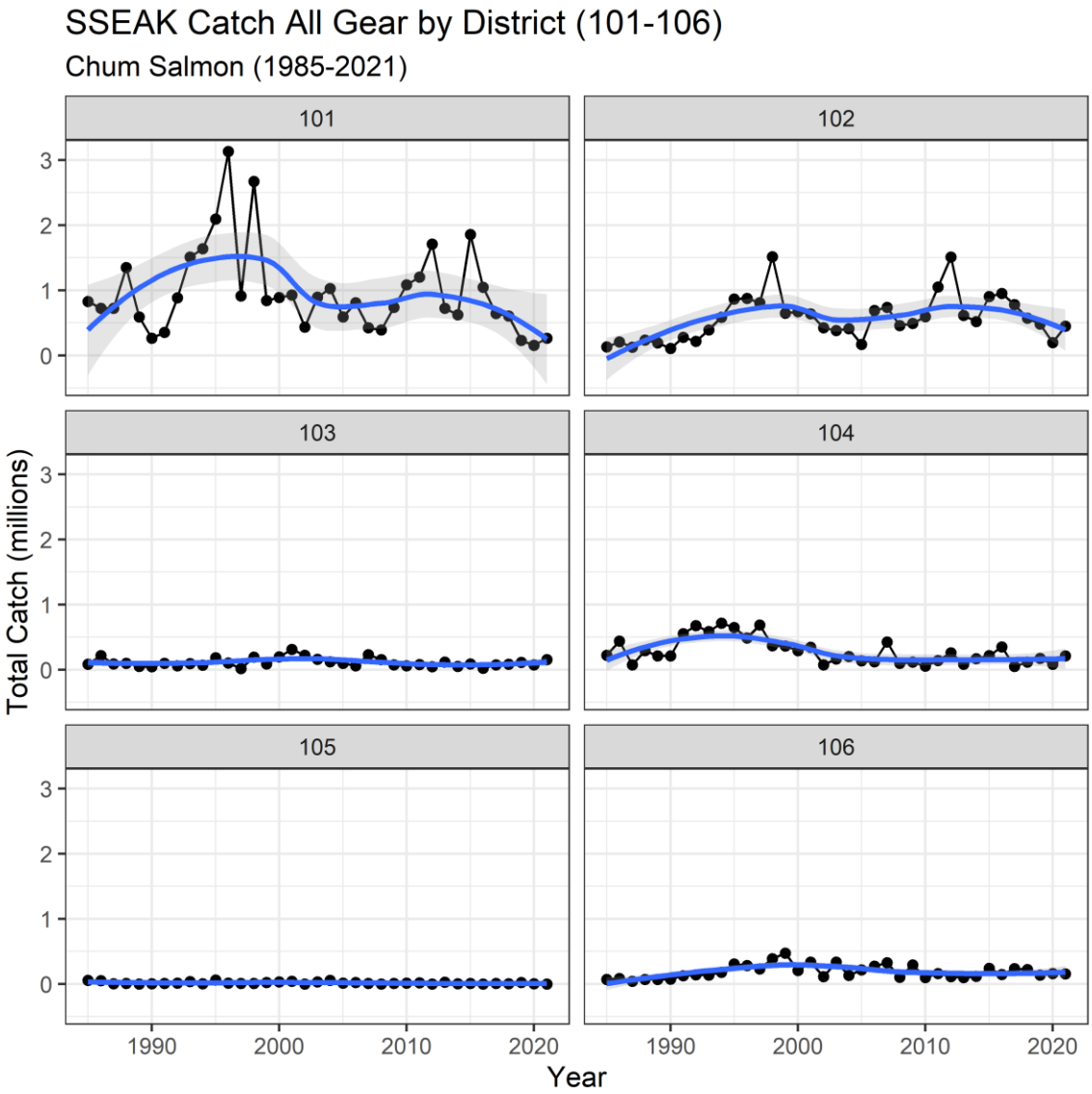

Figure 6: Total catch of chum salmon by year for SSEAK Districts 101-106 (1985-2021). Smoothed lines are derived by LOESS with standard errors shown in grey. Source: ADFG 2021d.

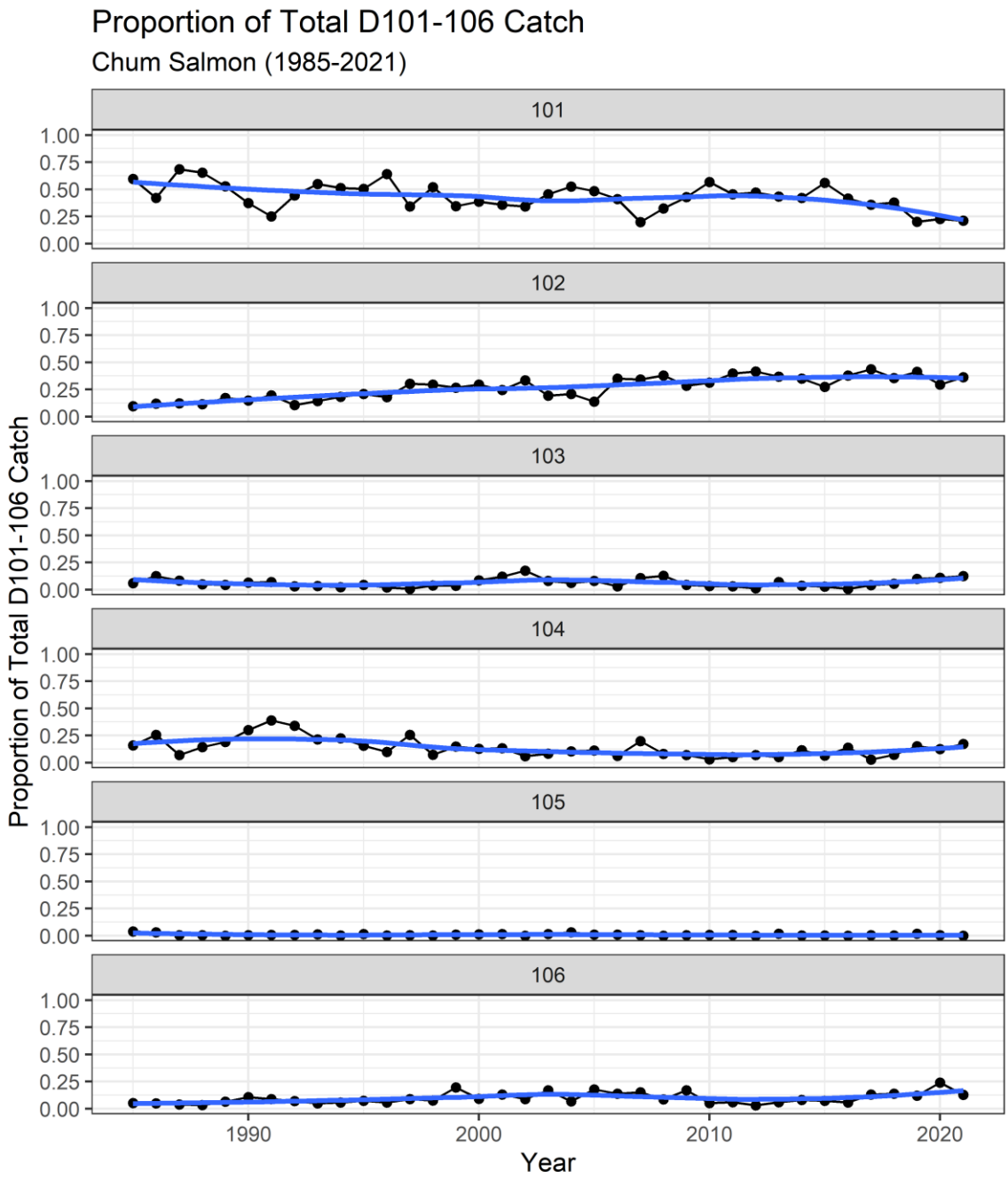

Figure 7: Proportion of total SSEAK District 101-106 chum salmon catch (all gears) by year for 1985-2021. Blue lines are estimated by LOESS fits. Source: ADFG 2021d.

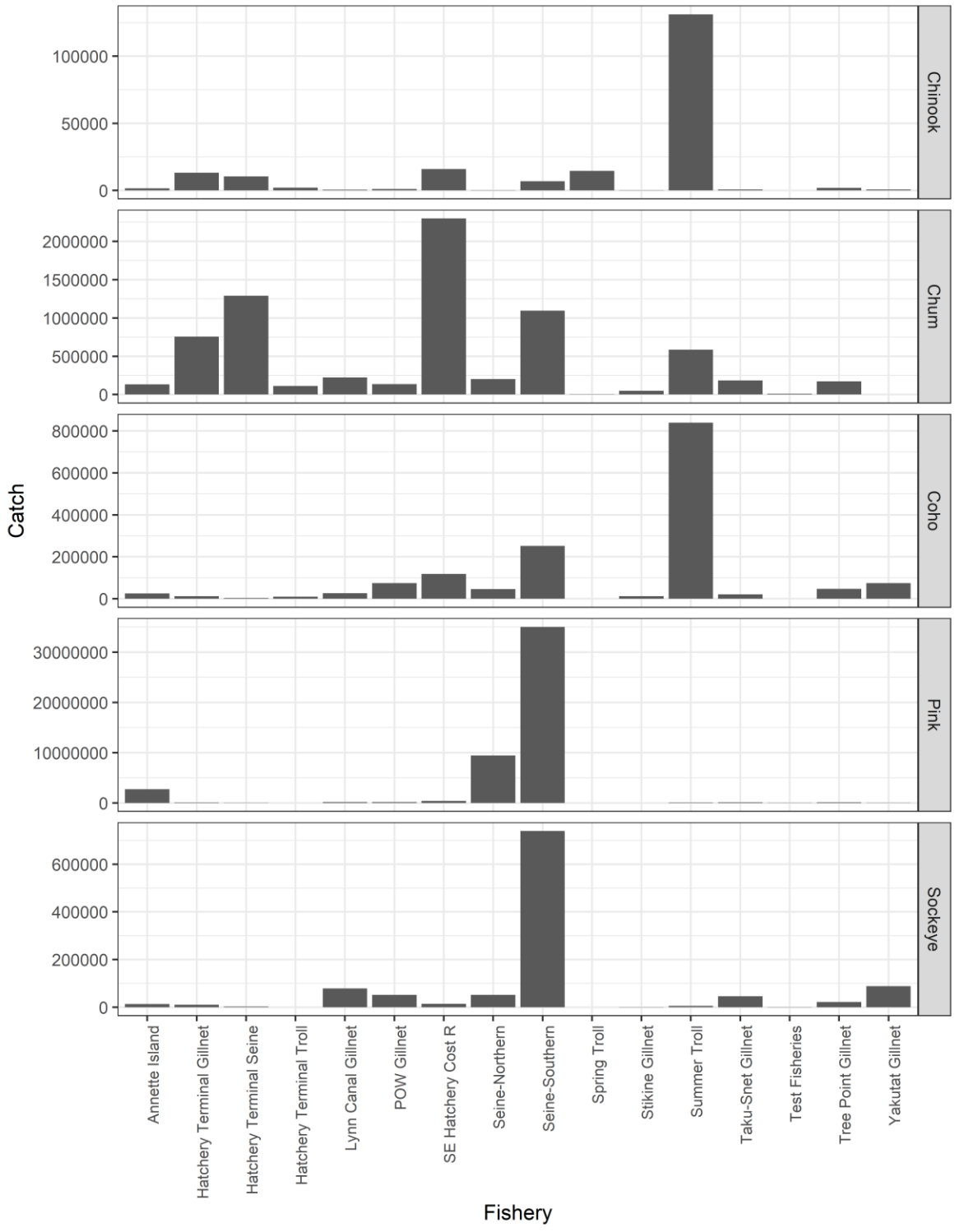

Figure 8: Harvest of all salmon species in SEAK "Blue Sheet" commercial fisheries in 2021. Source: ADFG 2021b.

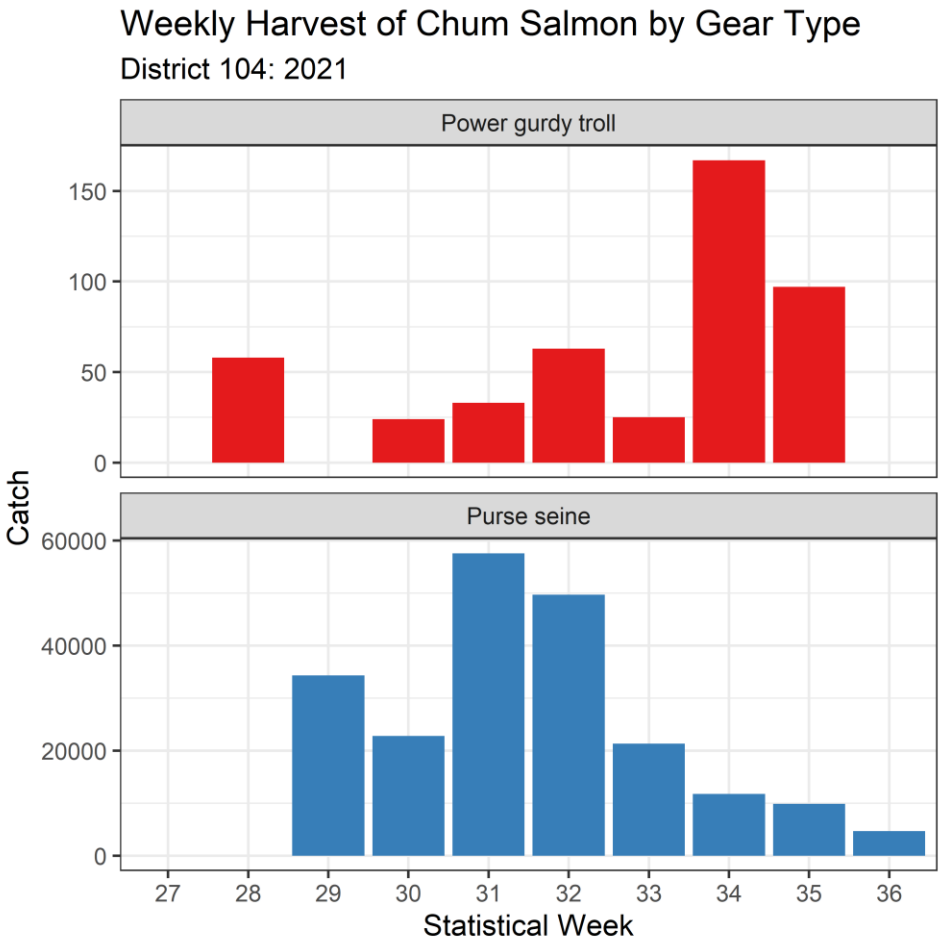

Figure 9: Weekly catch of chum salmon in District 104 fisheries by gear type for 2021. Note y-axis scales are not the same between panels. Source: ADFG 2021e.

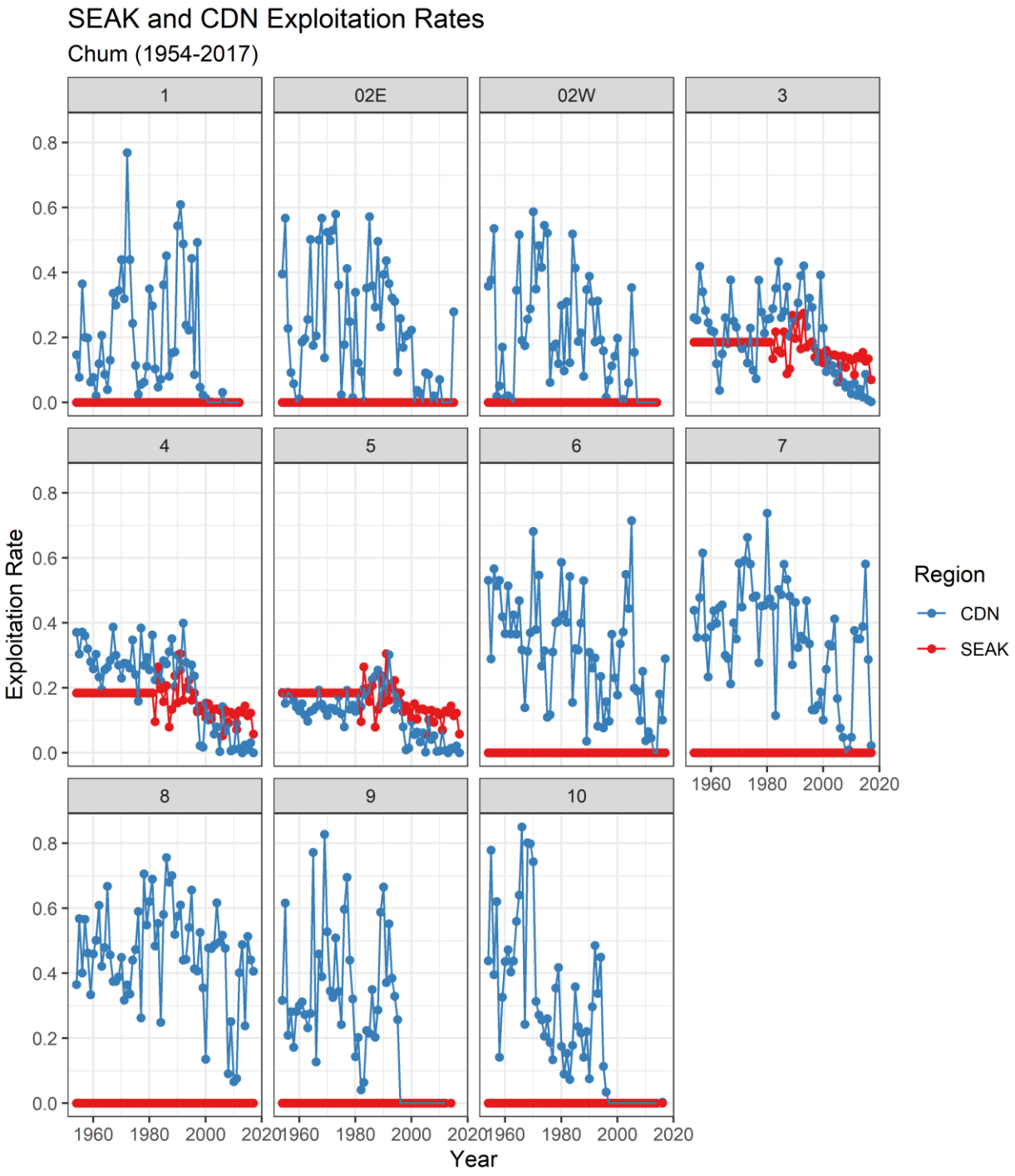

Figure 10: SEAK (red) and Canadian (blue) exploitation rates by year for north and central coast (Statistical Areas 1-10) chum salmon from 1954-2017. Source: PSF 2021.

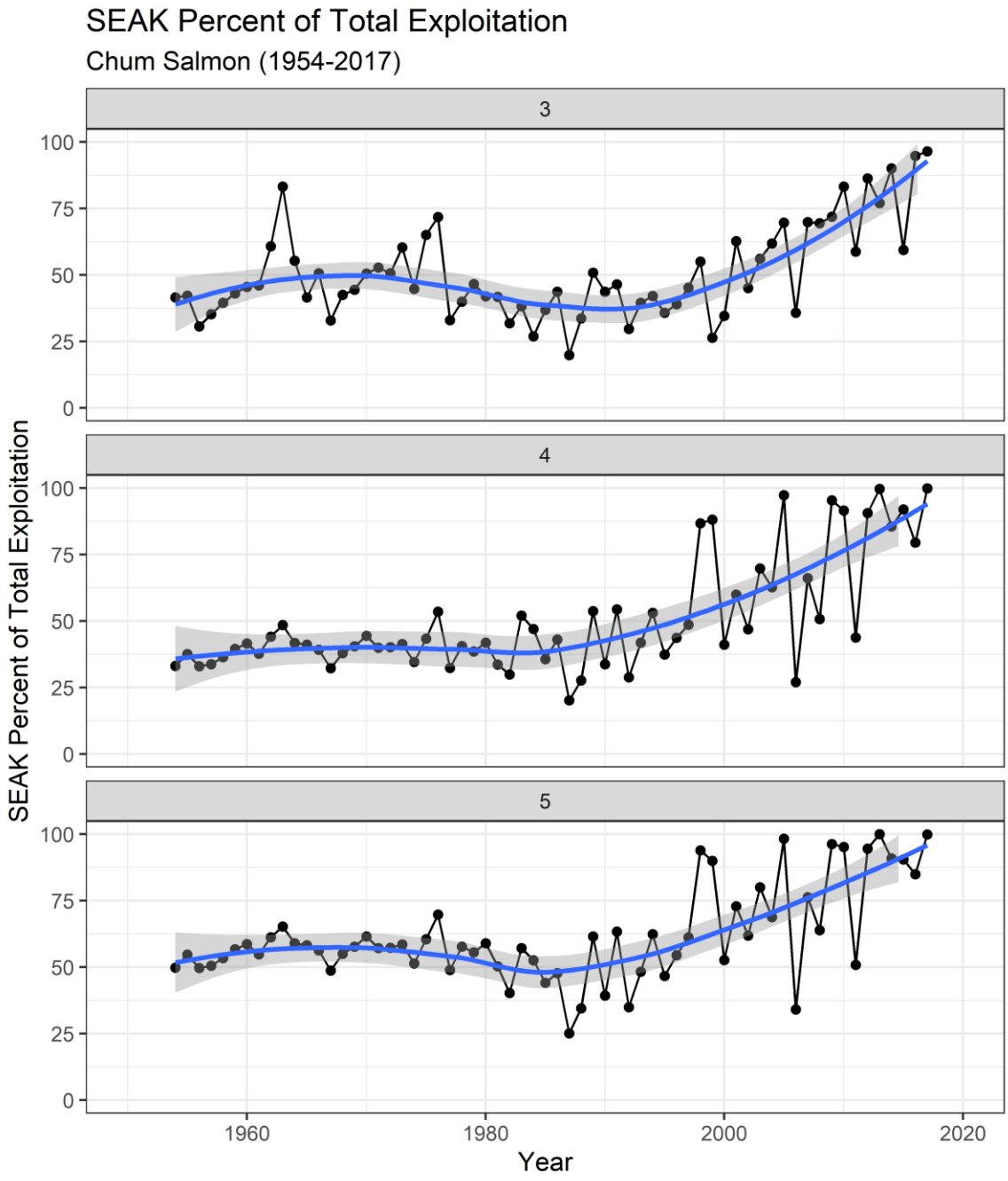

Figure 11: Percent of exploitation attributed to SEAK for even and odd year pink salmon from Areas 3,4, and 5 from 1954-2017. Trend lines and SEs were derived using LOESS in R. Source: LGL 2021.

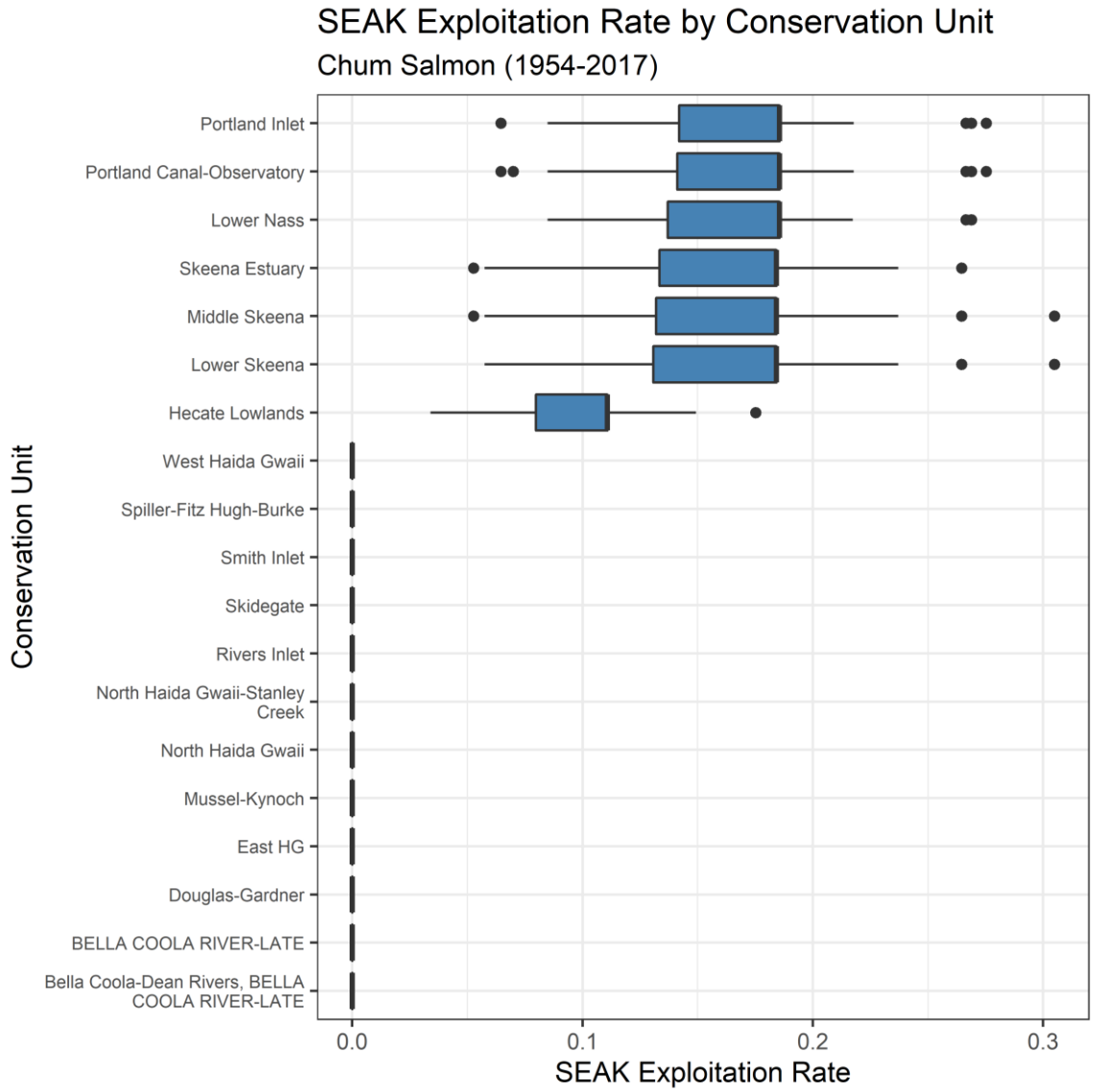

Figure 12: Boxplot of SEAK exploitation rates on chum North and Central Coast BC Conservation Units for 1954 to 2017. CUs are ordered from highest median exploitation rate to lowest. Source: PSF 2021.

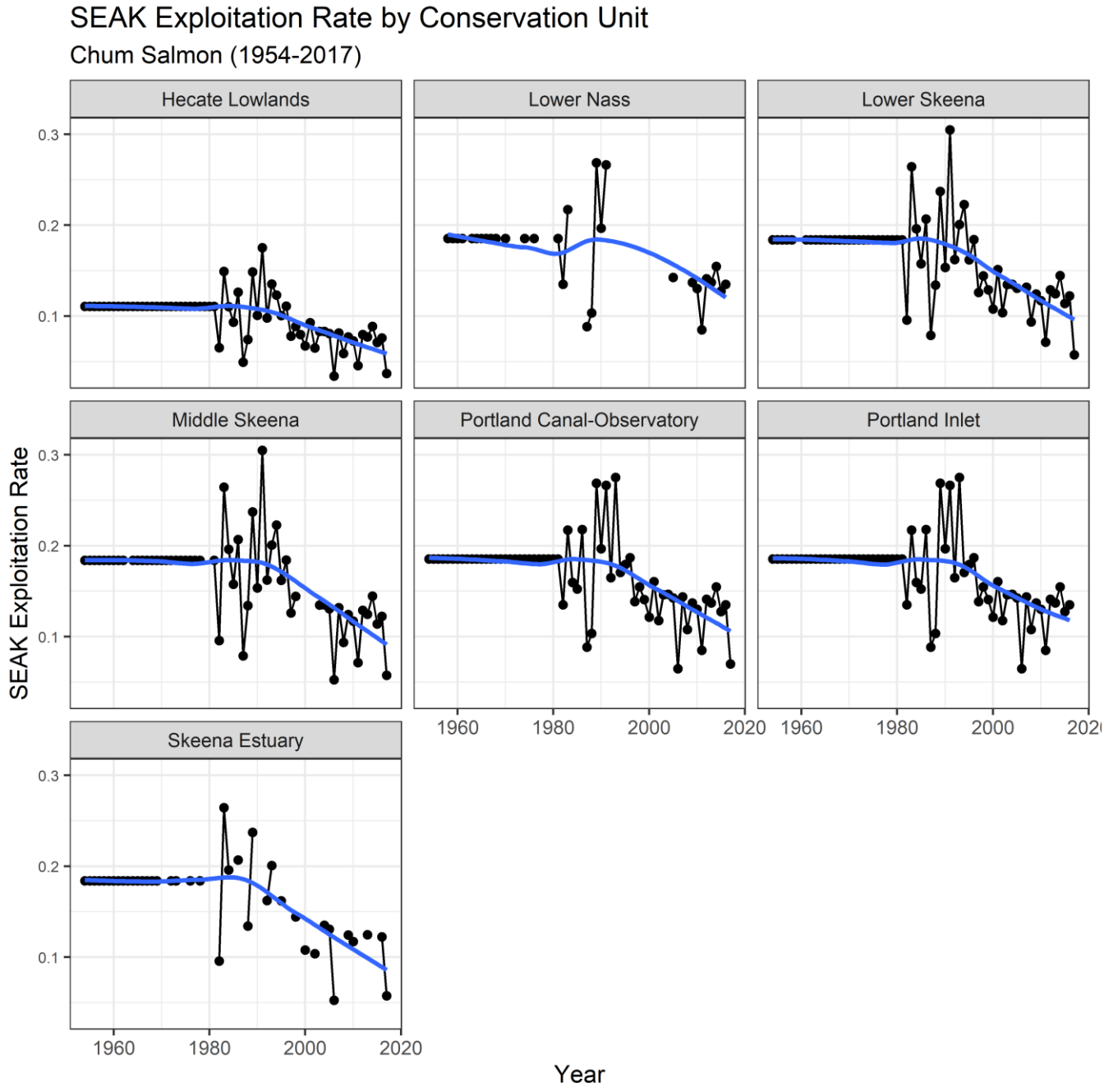

Figure 13: SEAK exploitation rates for chum salmon from north and central coast Conservation Units from 1954-2017. Trend lines derived using LOESS in R. Source: PSF 2021.

Alaskan Harvest of BC Salmon: State of Knowledge

Part 6: Pink Salmon

Version 1

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Prepared for:

Watershed Watch Salmon Society

Skeena Wild Conservation Trust

January 2022

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.

Species	*Region/Area*	*Type of Data*	*Data Source*	*Year*
Pink salmon	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	Data deficient		
	Strait of Georgia	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.[1] 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%.

- [1] 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 that 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

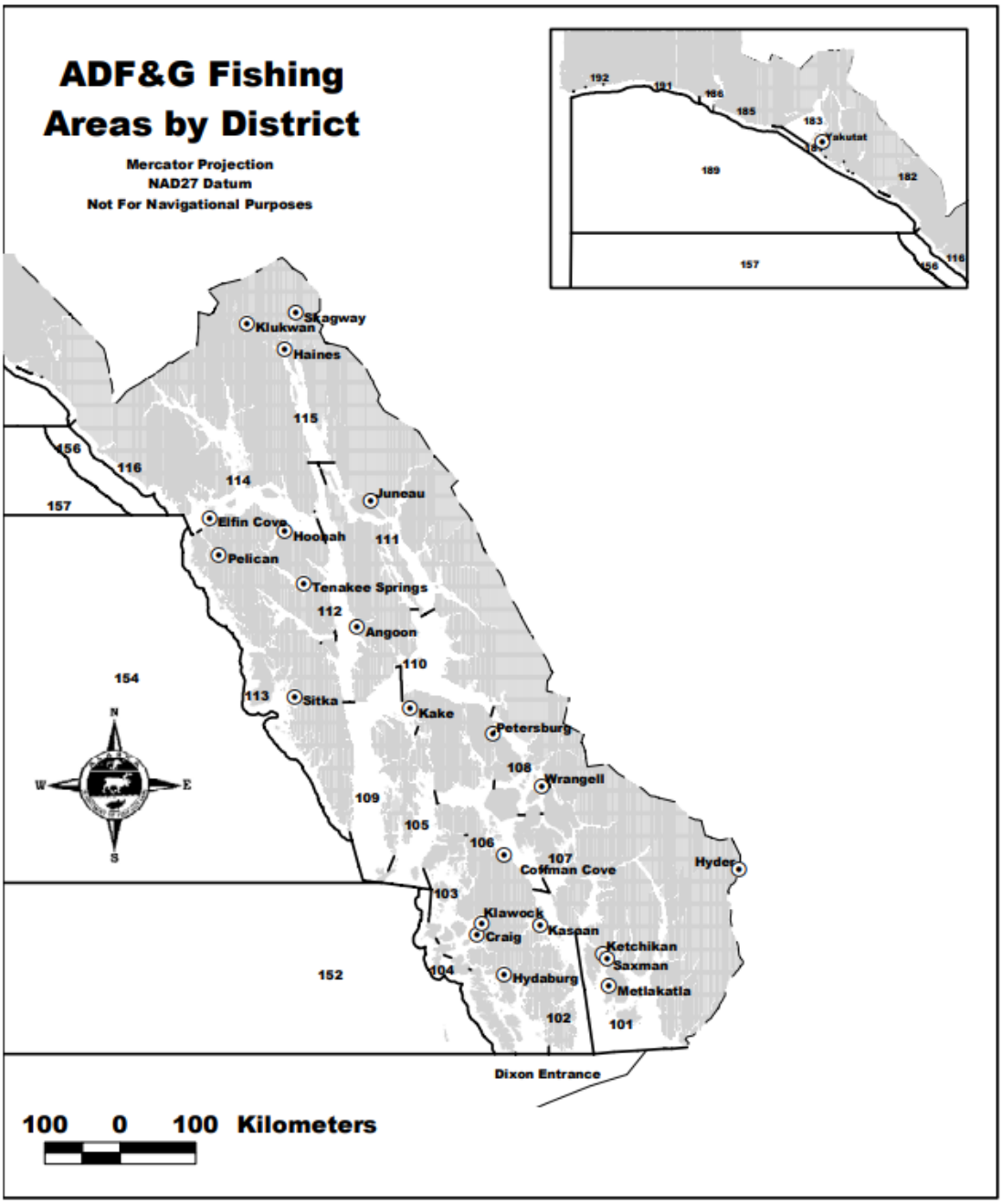

Figure 1: Map of Southeast Alaska Fishing Areas by District.

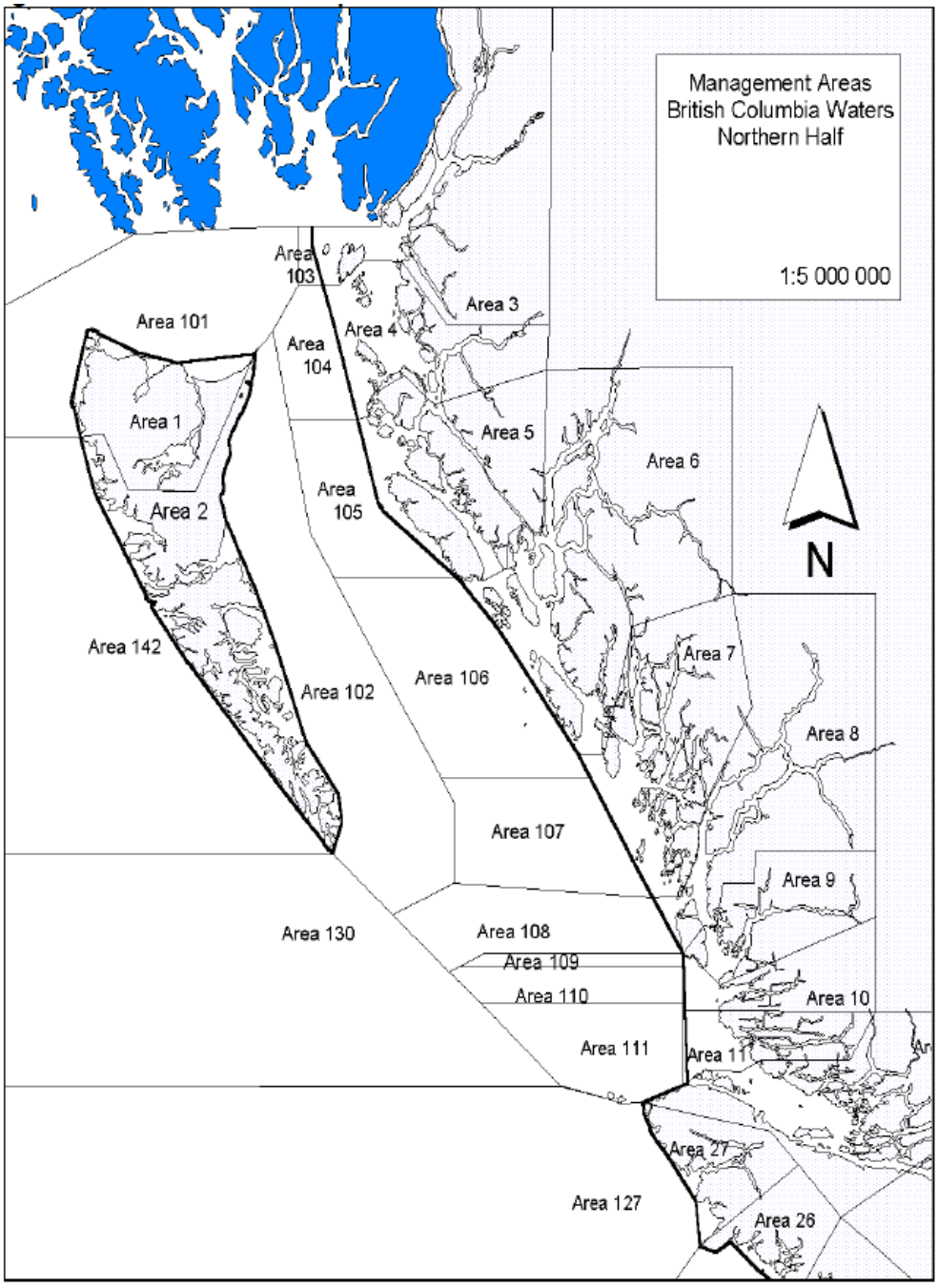

Figure 2.Map of DFO Statistical Areas in the North and Central Coast Areas.

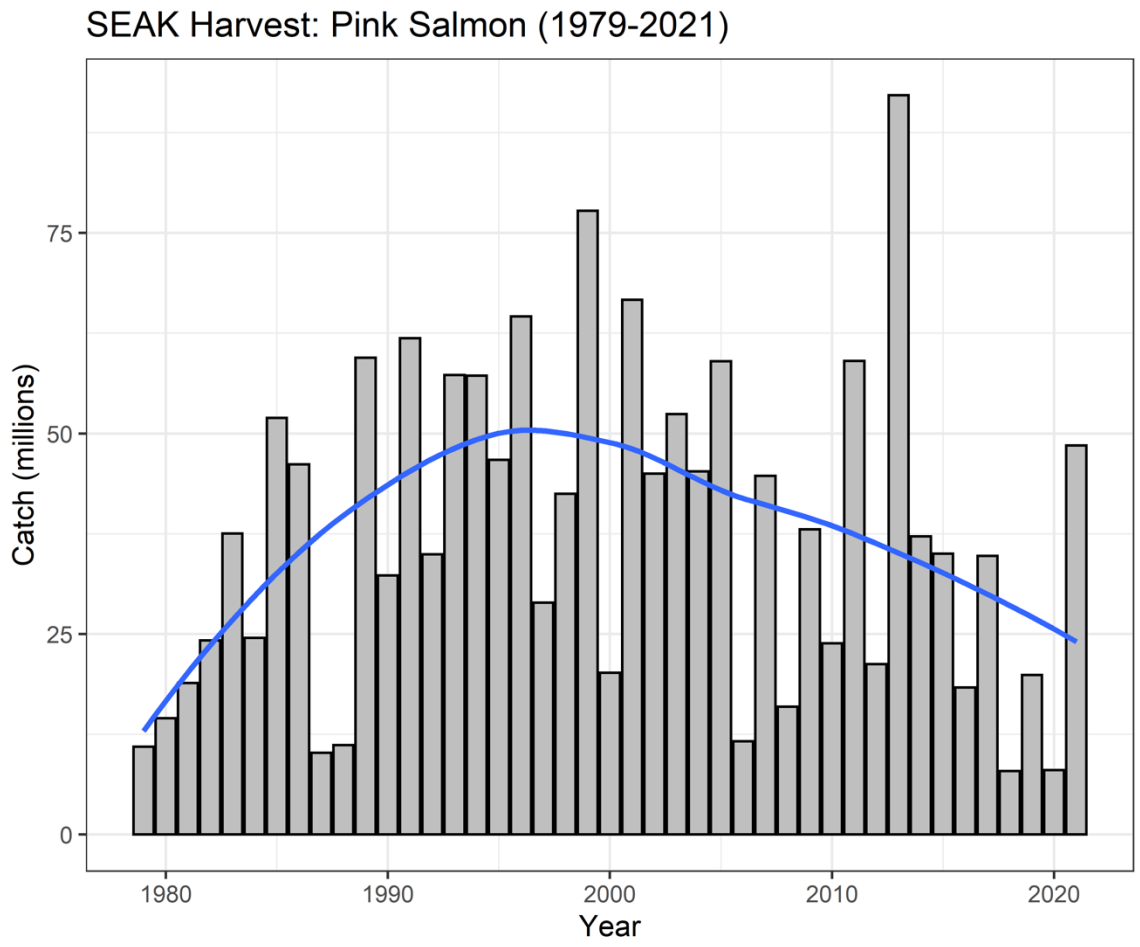

Figure 3:SEAK catch (millions of fish) of pink salmon from 1979-2021. Blue line is fit using LOESS. Source: ADFG 2021a (1979-2020), ADFG 2021b (2021).

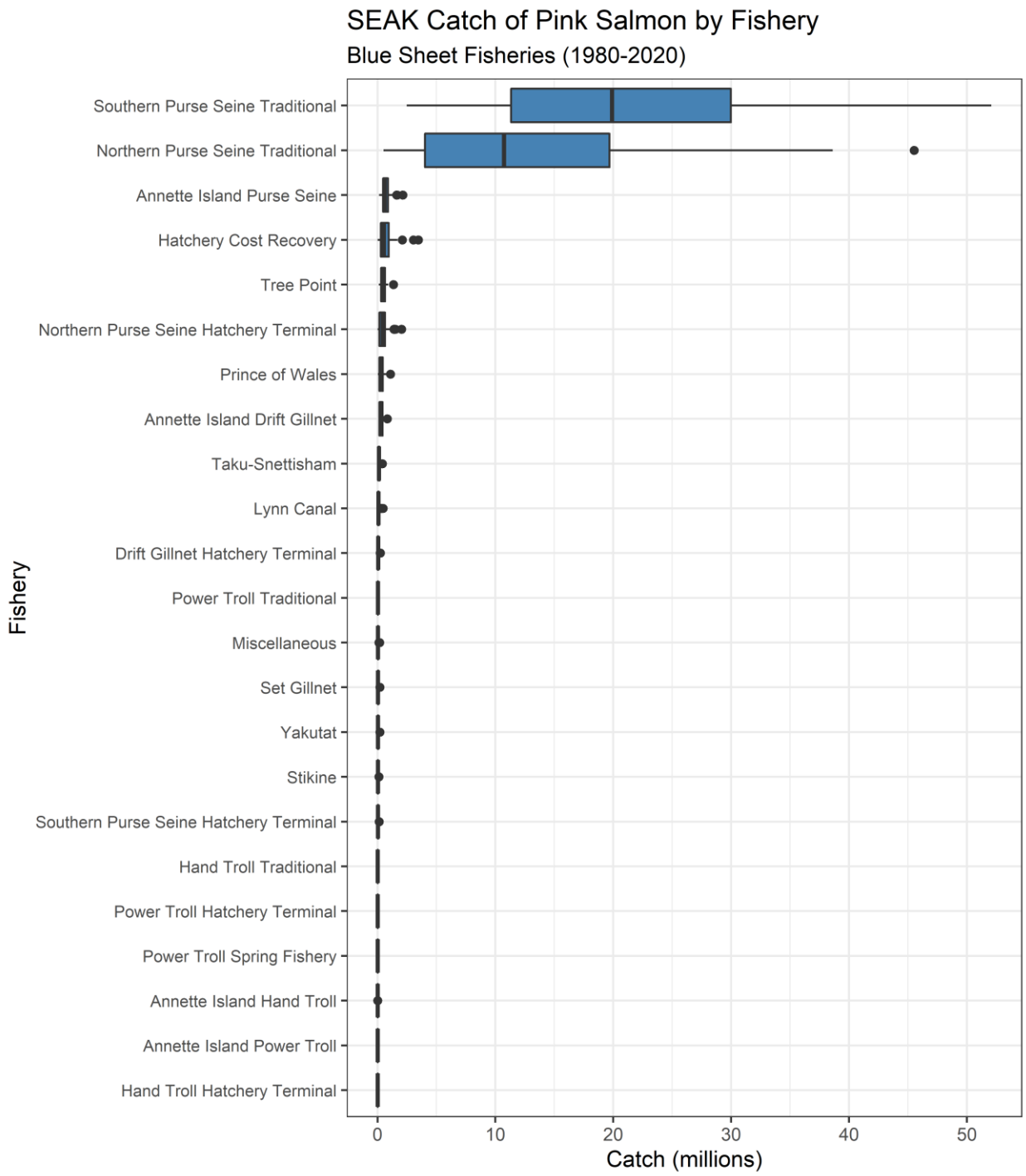

Figure 4: Distribution of total pink salmon commercial catch in SEAK "Blue Sheet" fisheries 1980-2021. Fisheries are ordered from highest catch to lowest catch. The thick black line is the median value, the box in indicates the interquartile range (25th to 75th percentiles – or middle 50% of the data),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

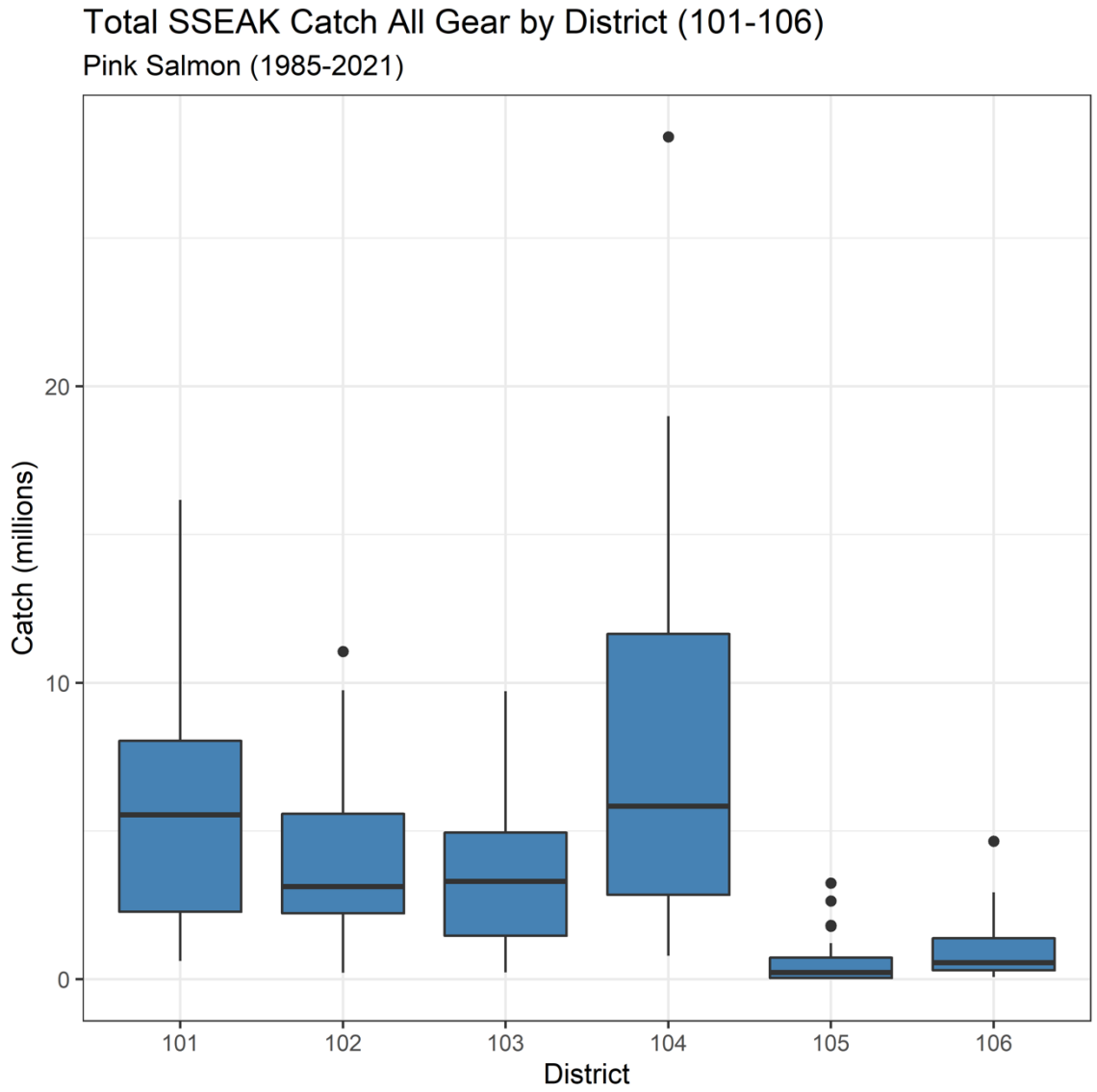

Figure 5: Median catch of pink salmon from all gears in SSEAK fisheries by district (districts 101-106) from 1985-2021. The thick black line is the median value, the box in indicates the interquartile range (25th to 75th percentiles – or middle 50% of the data), whiskers are 1.5x the interquartile range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

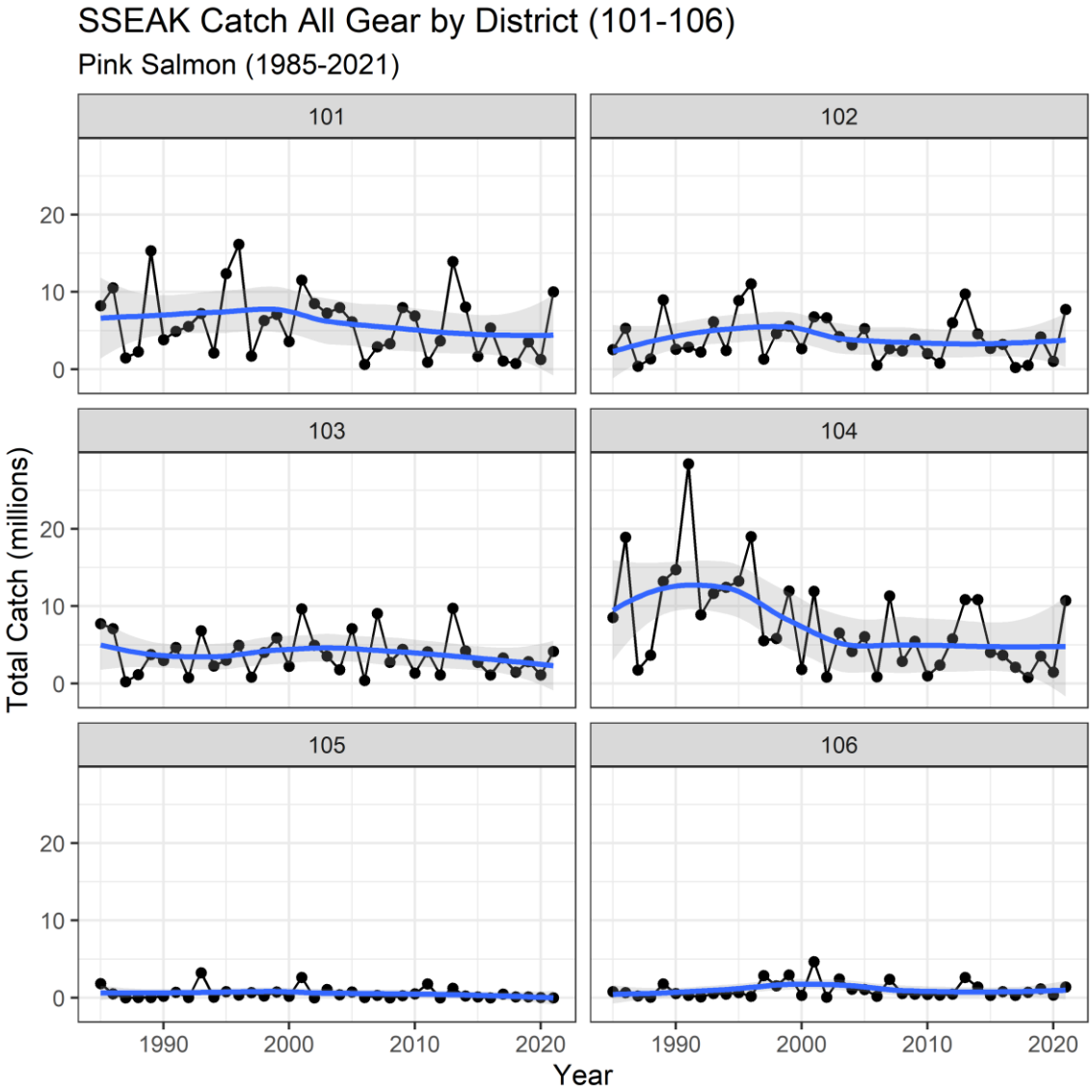

Figure 6: Total catch of pink salmon by year for SSEAK Districts 101-106 (1985-2021). Smoothed lines are derived by LOESS with standard errors shown in grey. Source: ADFG 2021d.

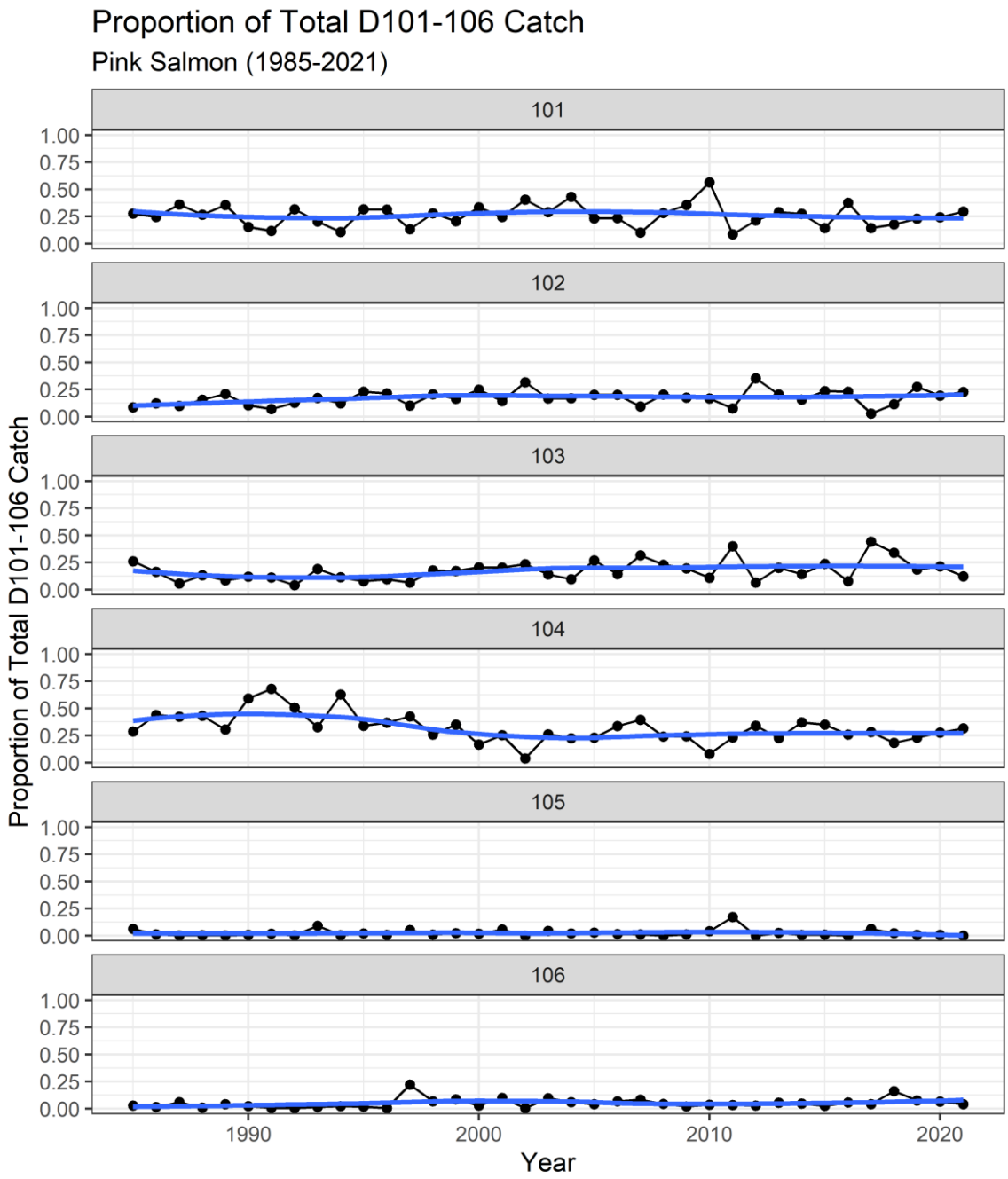

Figure 7: Proportion of total SSEAK District 101-106 pink salmon catch (all gears) by year for 1985-2021. Blue lines are estimated by LOESS fits. Source: ADFG 2021d.

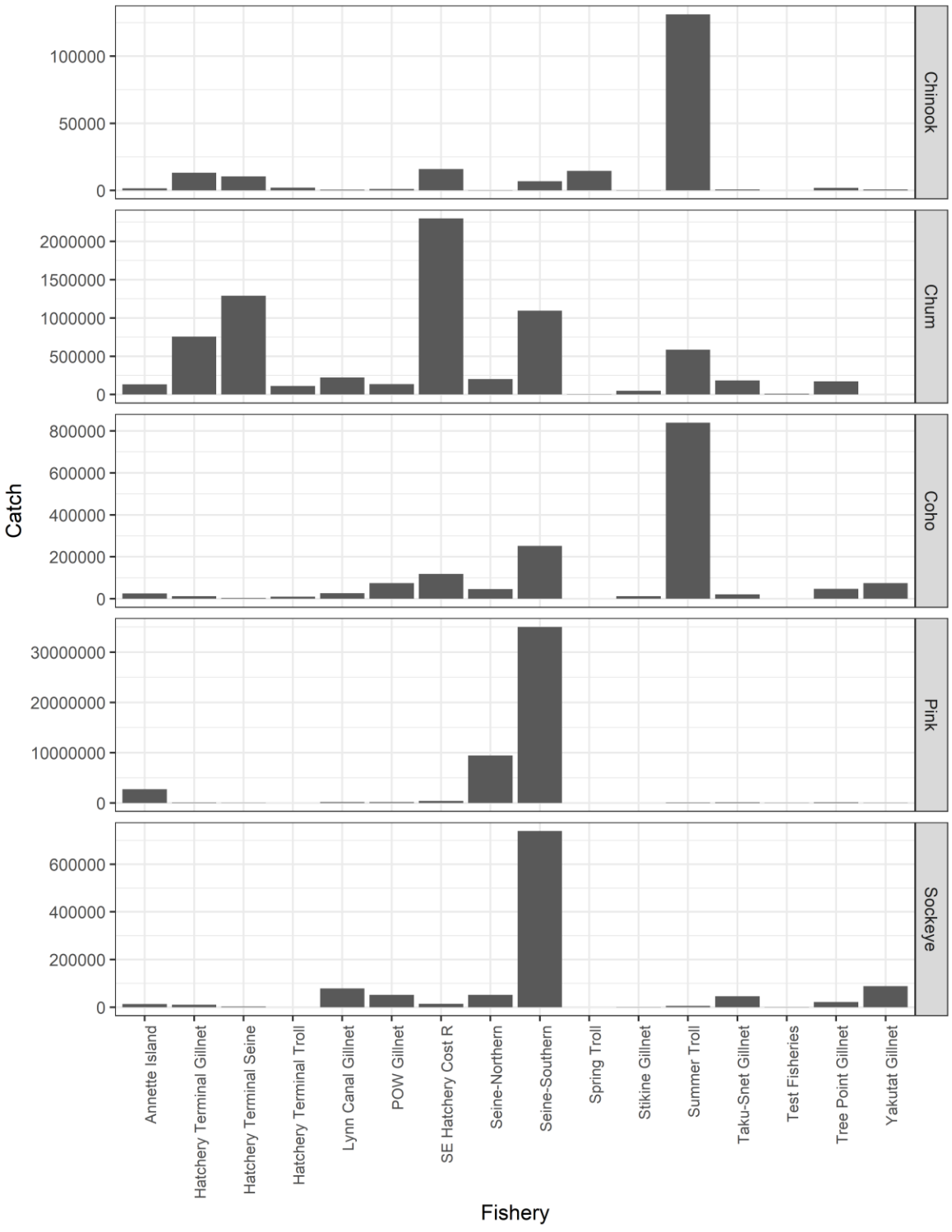

Figure 8: Harvest of all salmon species in SEAK "Blue Sheet" commercial fisheries in 2021. Source: ADFG 2021b.

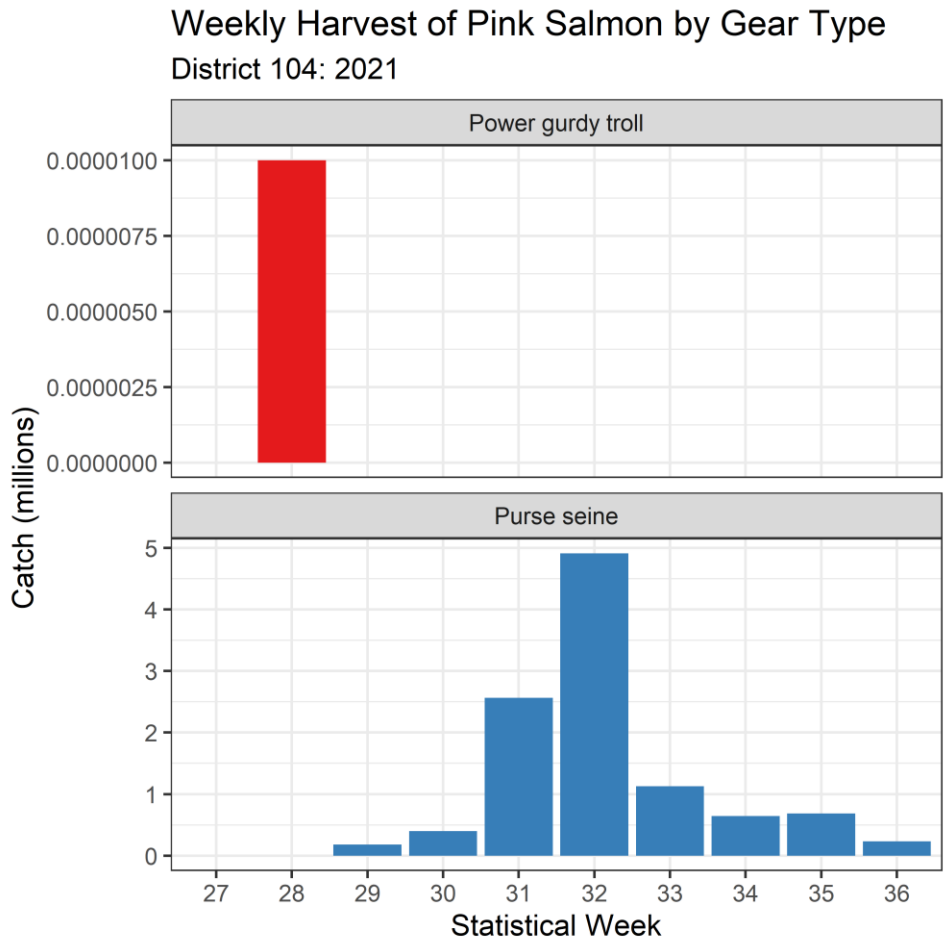

Figure 9: Weekly catch of pink salmon (millions) in District 104 fisheries by gear type for 2021. Note y-axis scales are not the same between panels. Source: ADFG 2021e.

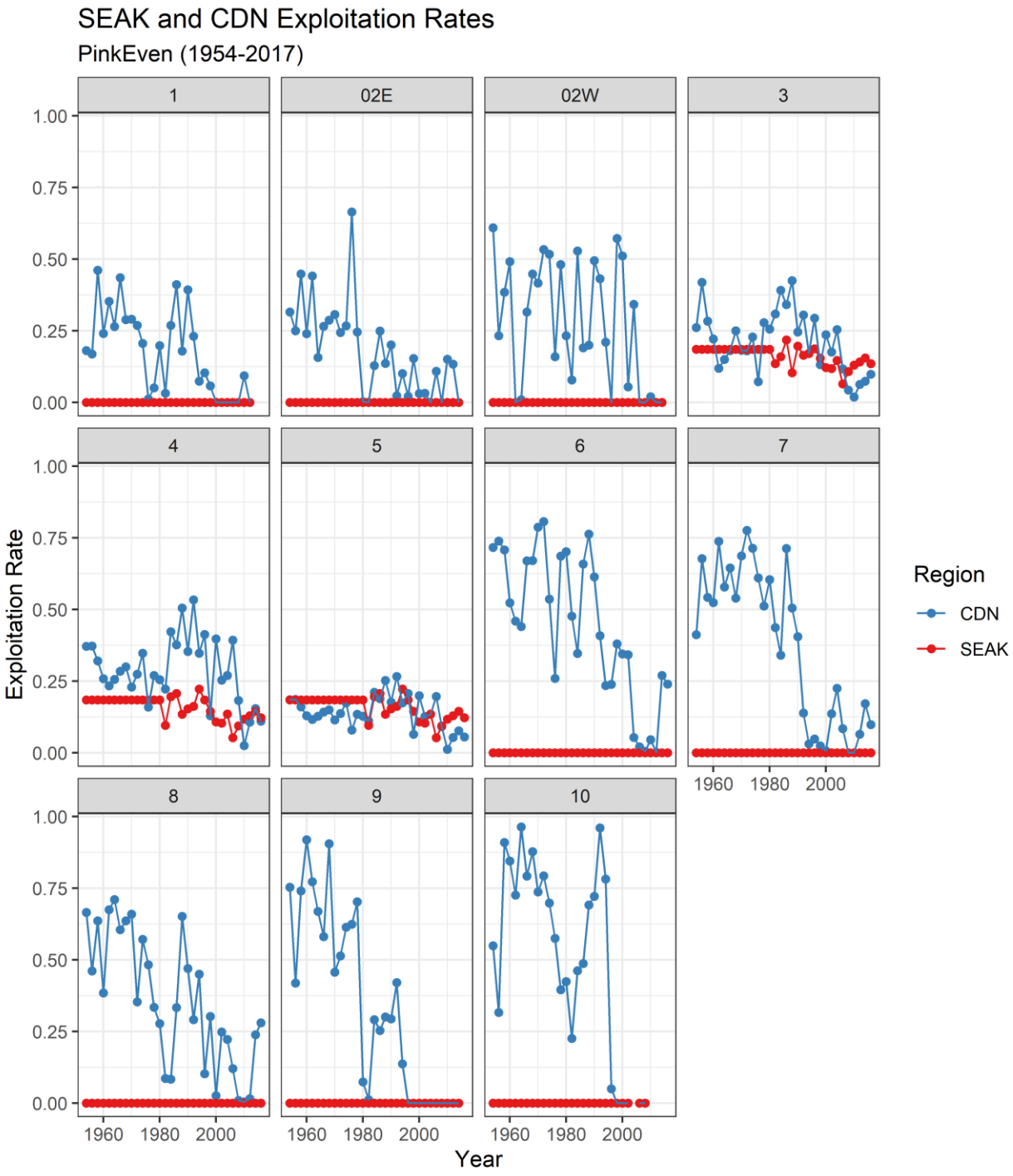

Figure 10: SSEAK (red) and Canadian (blue) exploitation rates by year for north and central coast (Statistical Areas 1-10) even-year pink salmon from 1954-2017. Source: PSF 2021.

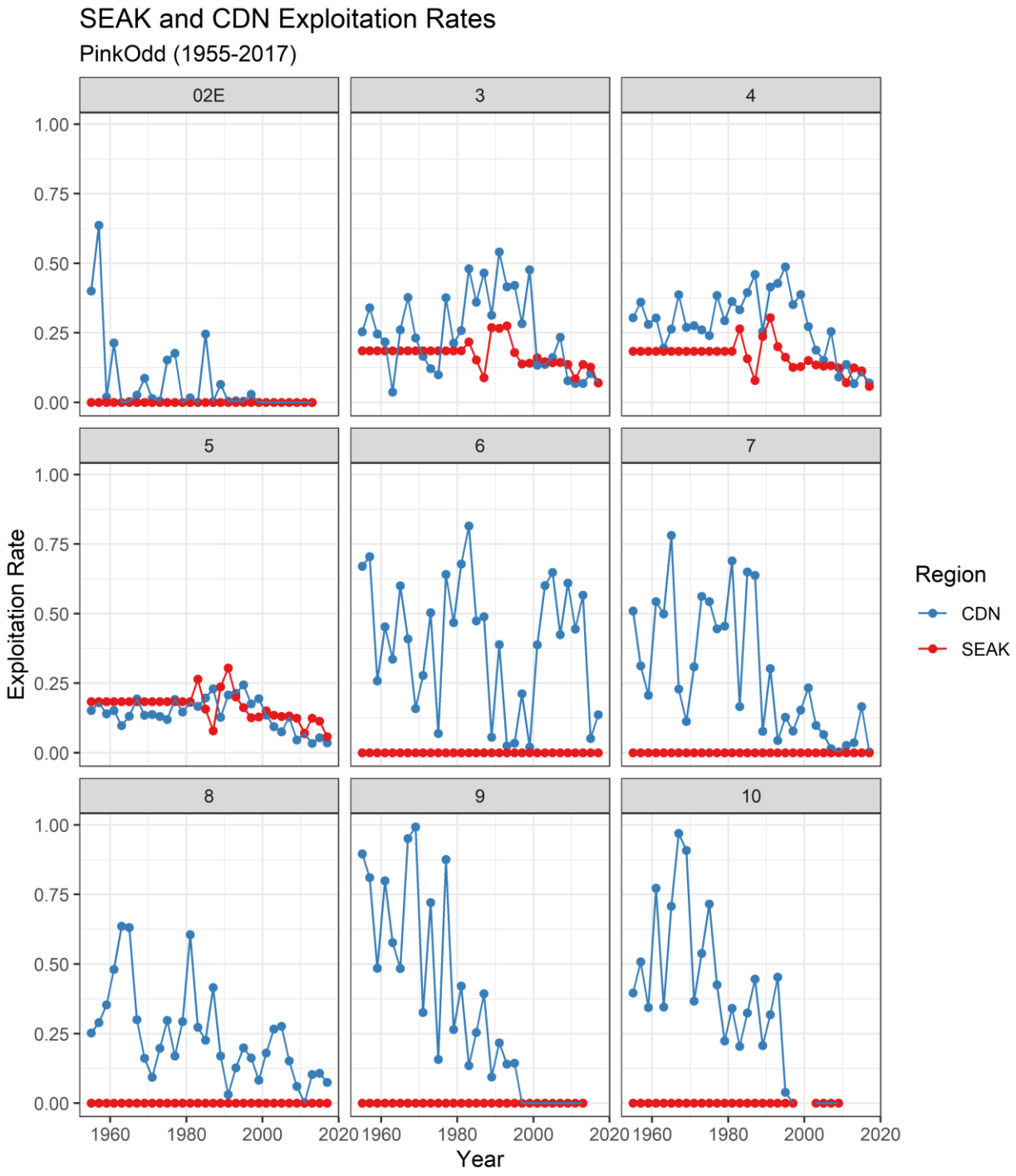

Figure 11: SSEAK (red) and Canadian (blue) exploitation rates by year for north and central coast (Statistical Areas 1-10) odd-year pink salmon from 1954-2017. Source: PSF 2021.

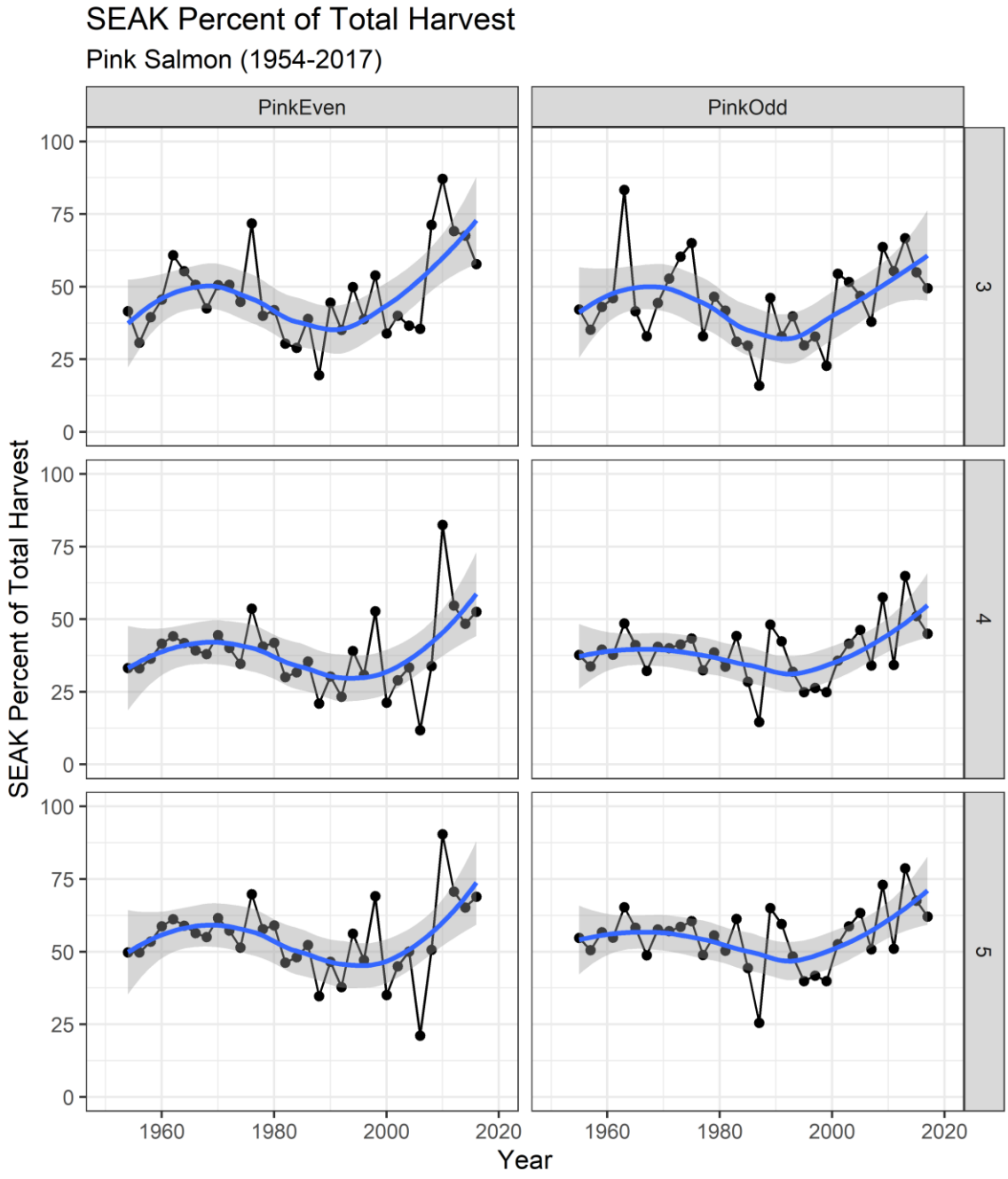

Figure 12: Percent of exploitation attributed to SSEAK for even and odd year pink salmon from Areas 3,4, and 5 from 1954-2017. Trend lines and SEs were derived using LOESS in R. Source: LGL 2021.

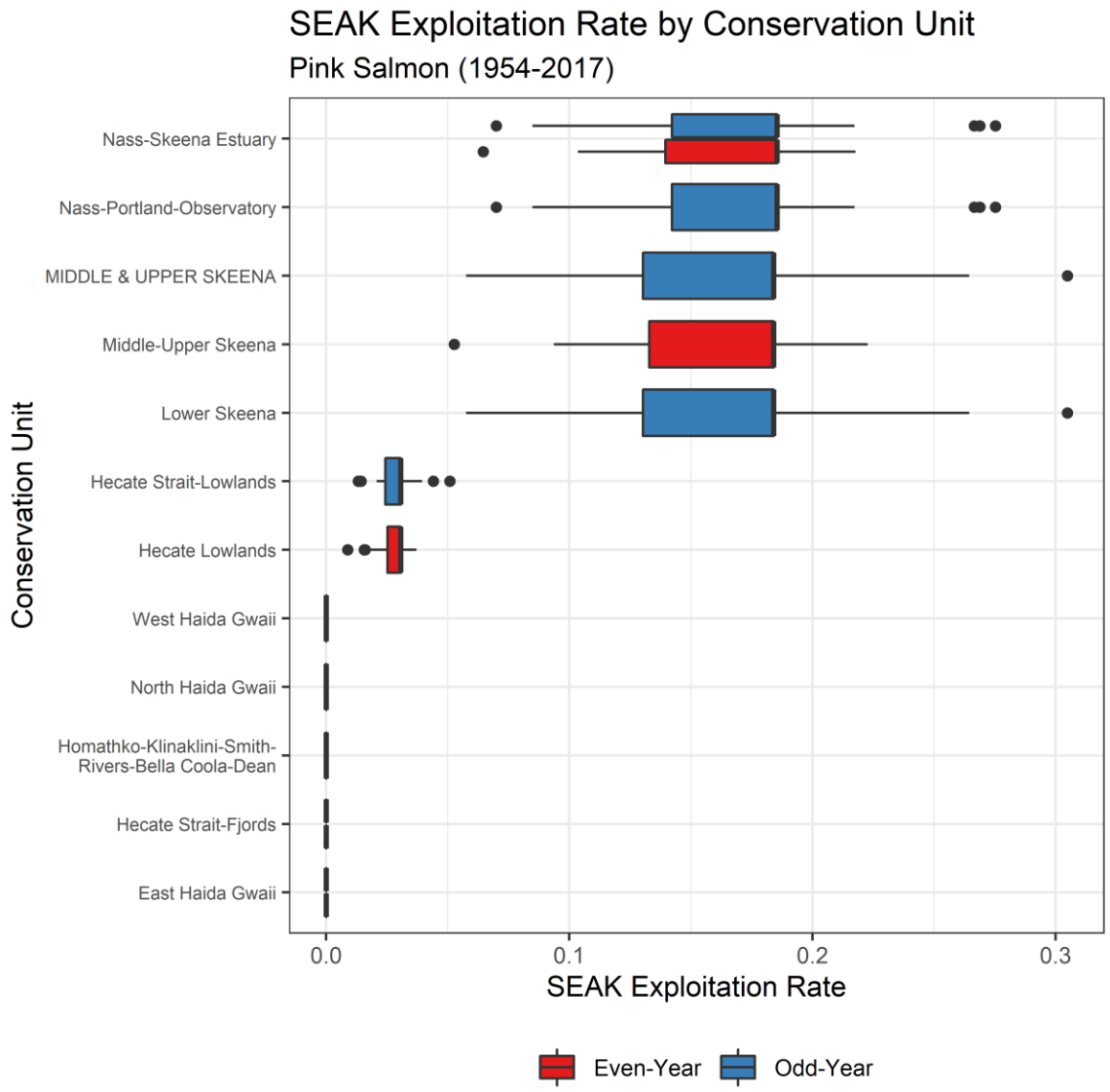

Figure 13: Boxplot of SSEAK exploitation rates on even- (red) and odd (blue)-year pink salmon North and Central Coast BC Conservation Units for 1954 to 2017. CUs are ordered from highest median exploitation rate to lowest. Source: PSF 2021.

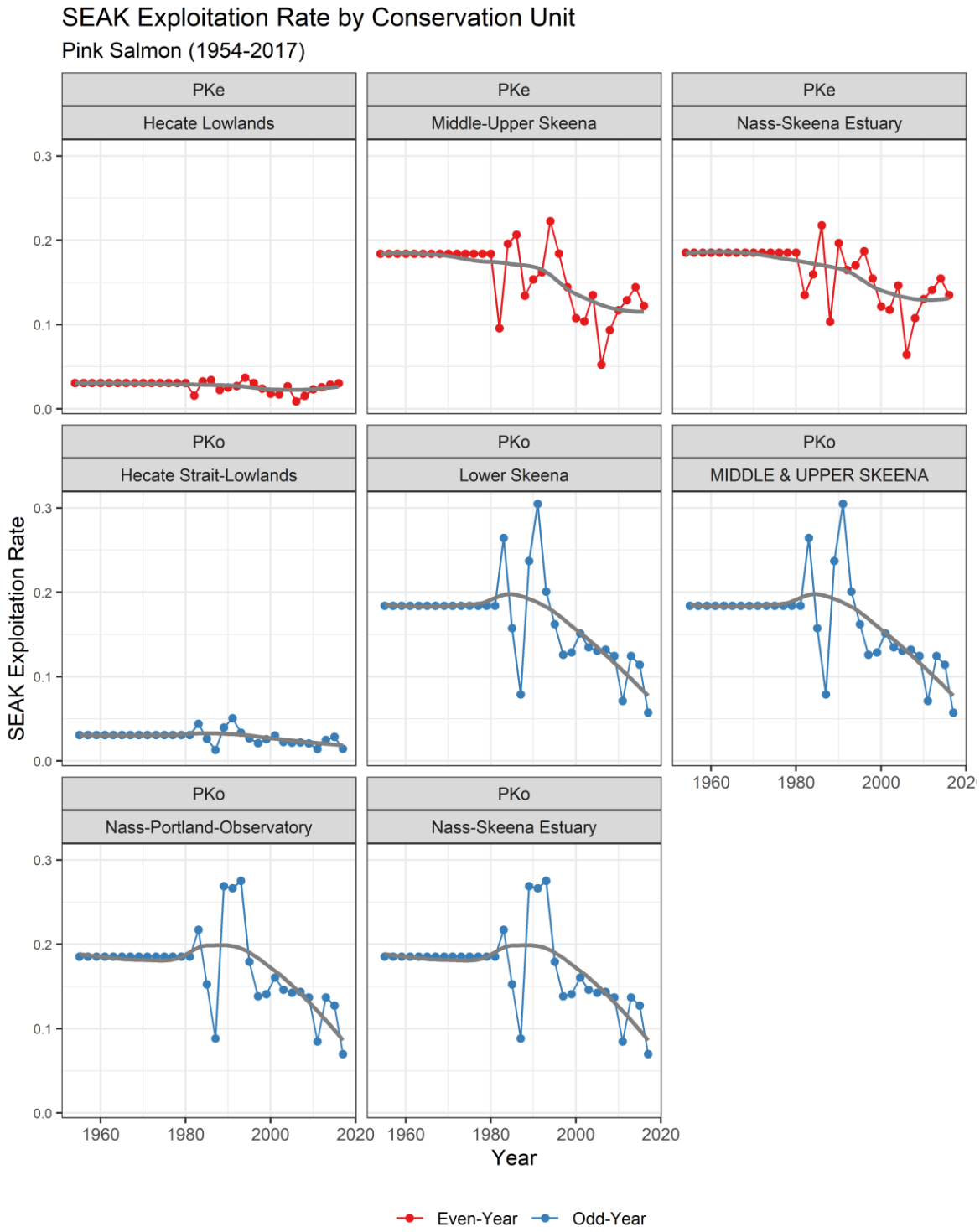

Figure 14: SSEAK exploitation rates for even (red points) and odd (blue points) year pink salmon from north and central coast Conservation Units from 1954-2017. Trend lines derived using LOESS in R. Source: PSF 2021.

Alaskan Harvest of BC Salmon: State of Knowledge

Part 7: Steelhead Trout

Version 1

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Prepared for:

Watershed Watch Salmon Society

Skeena Wild Conservation Trust

January 2022

Preface

This report is part of a series of reports on the 'State of Knowledge' of Alaskan interception of 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 Chinook 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: Steelhead Trout

This report provides background information on what we know about the catch of BC steelhead in Southeast Alaska (SEAK) fisheries. Figure 1 and Figure 2 provide maps of SEAK fishing Districts and North Coast BC DFO Statistical Areas respectively. In this report, Skeena steelhead refers to Skeena summer steelhead.

We were unable to find any information specific to SEAK catch of BC steelhead, including catch or exploitation rate estimates. One report based on observer data in BC presents a figure showing SEAK catch of steelhead prior to shifts in retention regulations (J.O. Thomas 2011). Steelhead catch has also been directly reported from District 104 (G. Taylor and B. Hooten, personal communication, 2022). Reported steelhead catches range from very low to a maximum of ~ 10,000 in 1987 (Figure 3). In the 90s, regulations were implemented to prohibit the sale of steelhead in Alaska. Steelhead retention is allowed for personal use, however, reporting of catch is not required. We queried the North Pacific Anadromous Commission catch database (NPAFC 2021), and while there are records of catch from commercial and sport fisheries, there was no catch in the database for steelhead after 1997 for sport fisheries and a few years with low catch numbers in the late 2010s for commercial fisheries (Figure 4). The source of the recent commercial fishery catch is not known at this time. There may be information from BC hatchery Coded-Wire Tagged steelhead recoveries in SEAK fisheries. We are following up on this potential data source.

In the Skeena Salmon Independent Science Review Panel Report (Walters et al. 2008), steelhead trout management and assessment were discussed at length, and with regards to Alaskan catch of Skeena steelhead, stated a recommendation that "The Canadian government should utilize all available mechanisms to ensure that Alaskan harvests of Skeena salmon and steelhead are reduced sufficiently to permit achievement of Canadian objectives". Within the scope of our review, it is apparent that there is no way in which to assess Alaskan harvests (either directed or as bycatch in salmon directed fisheries) of Skeena steelhead (or other BC steelhead) directly.

It is also critical to put into context the status of BC steelhead. Skeena steelhead were estimated to be at record low levels in 2021 (Figure 5) (FLNRO 2021), and below the Extreme Critical Conservation Zone of 8,000. Furthermore, Thompson and Chilcotin steelhead are at severely depressed abundance were subject to an emergency assessment in by COSEWIC in 2018 and both were assessed as Endangered[1], however marine migration routes of these steelhead may not include SEAK. Nass steelhead were also at low abundance in 2021 (DFO 2021).

In 2021, it is highly likely that there was significant catch of Skeena sockeye in SEAK fisheries based on preliminary information (~280,000 = 20% exploitation rate: G. Knox, personal communication, December 2021). However, we do not have any information on the number, distribution, or stock composition of steelhead that were caught and kept for personal use, or caught and released in SEAK fisheries. Steelhead terminal run-timing is similar to that of later-timed Skeena sockeye populations, and therefore, if Skeena steelhead follow similar migration routes (and marine timing) as sockeye, then they would be present in the same areas at the same time, and subject to exploitation in the same fisheries. Given the nature of large seine fisheries, for example, we also know that release mortality is likely high, and therefore total mortalities in the fishery could be significant even if non-retention is required.

[1] https://www.canada.ca/en/environment-climate-change/services/species-risk-public-registry/cosewic-assessments-status-reports/steelhead-trout-2018.html

This lack of information highlights the need to understand interception and mortalities of steelhead in SEAK fisheries, and specifically south SEAK fisheries that are in mixed-stock areas. Without direct information, a simple analytical approach was taken to provide an example of very coarse estimates for SEAK exploitation rates on Skeena steelhead. There are a number of assumptions that are detailed in the following section.

2 Methods

As a case study and example of simple estimation methods, a modeling approach was undertaken to estimate catch of Skeena steelhead in SEAK fisheries. We utilize SEAK exploitation rates on late-timed Babine River sockeye, and employ simple distributions for vulnerability and release mortality to attempt to capture some of the uncertainty in SEAK ER estimates for Skeena steelhead.

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

2.1 Assumptions

2.1.1 Marine run-timing of steelhead is similar to Babine Late-wild sockeye, and is constant over time.

Information on run-timing for steelhead was extracted from a model spreadsheet by S. Cox Rogers based on information in Cox-Rogers 1994 and Ward et al. 1993. Ward et al. 1993 also use sockeye run-timing to assign Alaskan harvest, and identified that Skeena steelhead were approximately 2 weeks later to peak run-timing than sockeye. Run-timing for sockeye populations is from English et al. 2017 (sockeye). This is similar to information provided on Skeena steelhead run-timing in Walters et al. 2008. Table 1 provides details on run-timing parameters that we used, and Figure 6 shows derived steelhead and sockeye run-timing curves.

Table 1: Run-timing parameters for Skeena steelhead and sockeye salmon.

Species	Stock/Conservation Unit	Peak month-week (Ordinal Date)	Std. Dev. (days)	Duration (days)
Sockeye	Babine Late-Wild	8-4 (217.5)	11.2	67
	Babine Fulton	7-29 (210.5)	11.2	67
	Kitwanga	7-29 (210.5)	15.7	94
Steelhead	Copper/Morice/ Sustut	7-26 (207)	11	66
	Babine/Bulkley	8-3 (215)	11	66
	Kispiox	8-8 (220)	11	66

Steelhead mid-point run-timing at the Tyee test fishery (based on daily index data), is later than the aggregate by 1- 2 weeks, similar to Babine Late-wild sockeye, and through all portions of the run (Figure 7). This pattern has changed over time, with sockeye and steelhead run-timing being much closer since 2014 due to the recent shift to later timing of sockeye, which violates the assumption of constant run-timing relative to sockeye. This may mean that steelhead ERs based on Babine-Late wild ERs in recent years may be biased high.

2.1.2 Steelhead are vulnerable in SEAK fisheries and have similar exploitation rates to Babine-Late wild sockeye

Steelhead were caught and recorded in SEAK commercial and net fisheries prior to 1997 (J.O. Thomas, 2011; NPAFC 2021), and are caught in marine approach fisheries in Canada based on research, tagging

and fisher independent catch reports (e.g. J.O. Thomas 2011). This indicates that they were present in SEAK fisheries, and are likely still being caught and released.

Given their later than Skeena sockeye aggregate run-timing, and overlap in run-timing with some mid-later timed Skeena sockeye populations, we used Babine Late-wild sockeye as a basis for steelhead ERs. Median SEAK ERs for Skeena CUs are shown in Figure 8 (PSF 2021). SEAK ERs for Babine Late-wild, Kitwanga, and Fulton sockeye by year are shown in Figure 9 (PSF 2021).

To capture uncertainty in vulnerability (even though they may be present, they may be shallower or deeper in the water column, may be better or worse at evading gear, etc.), we applied a simple uniform distribution between 0.7 and 1.3 to modify Babine-Late wild sockeye ERs. This could be modified further if there is evidence that it is unduly constrained or too broad.

2.1.3 Release Mortality

Based on information from SEAK fishing notices and anecdotal information about fishery practices, we set release mortality with a uniform distribution between 0.85 and 0.95. This is supported by release estimates from purse seine non-retention studies in 1988 and 1989 (Rowse 1990; Rowse and Marshall 1989), which set long-term release mortality at 70% in these fisheries. Release mortality in gill net fisheries is likely higher. In any case, with additional information the release mortality parameter can be easily adjusted.

2.2 Model

The 'model' employs Babine Late-wild sockeye ERs (1960-2017) which were modified using stochastic variation in vulnerability and release mortalities to provide estimates of SEAK catch of Skeena steelhead.

1) Random deviates were created (5,000) using uniform distributions from 0.7 to 1.3 for vulnerability, and 0.85 to 0.95 for release mortality.

2) Steelhead ERs in each year were estimated by:

$$ER_{SH,yi} = ER_{BLW,y} \times M_i \times V_i$$

Where $ER_{BLW,y}$ is the ER for Babine Late-wild, y designates the year, i designates the trial (n=5,000) M is a random deviate drawn from the uniform distribution for release mortality, and V is a random variate drawn from the uniform distribution for vulnerability. This creates a set of 5,000 steelhead ERs.

3) Steelhead Total Return was estimated by:

$$\mathrm{TR}_{SH,yi} = \mathrm{E}_{SH,y} \div (1 - ER_{SH,yi})$$

Where $\mathrm{E}_{SH,yi}$ is the escapement of Skeena steelhead in each year.

4) Steelhead catch in each year was estimated by:

$$C_{SH,yi} = \mathrm{TR}_{SH,yi} - E_{SH,y}$$

5) Plots were created using the median values and the 5^{th}/95^{th} quantiles.

3 Results and Discussion

Escapement estimates, run-timing and Skeena sockeye ERs are detailed in the assumption section above.

Median steelhead ERs ranged from ~ 10% to over 30% (Figure 10, top panel). Median steelhead catch ranged from near 0 to ~ 30,000 over the time series (Figure 10, bottom panel). Model estimated total catch of steelhead in SEAK fisheries from 2000-2017 was 111,814 (5^{th} 76,344, 95^{th} 154,489).

A number of Conservation Zones are defined for Skeena steelhead, and estimated SEAK catch downgrades the status to lower zones in number of years.

Given the results from this very simple approach, it is likely that SEAK fisheries catch a substantial number of Skeena steelhead, and that exploitation rates are independent of Skeena steelhead abundance Figure 12.

4 Uncertainties

There are a number of uncertainties that may influence the results presented above. For example, Skeena steelhead may not migrate in the marine environment following the same routes, or timing. When and if they are present in fisheries, they may be more or less vulnerable to capture. Release mortality is gear dependent, however we do not have information currently on the proportion of steelhead that would be caught and released by each fishery type that could be used to weight release mortality rates (e.g., purse seine, gill net, or troll). We used a very high release mortality rate given information on fishery operations in seine fisheries, Alaskan estimates of seine release mortality for Chinook, likely high release mortality from full length and full set time gillnets, and unknown release mortality from troll fisheries.

Additional uncertainty is presented using run-timing from escapements versus terminal run reconstructions before fisheries removals have occurred. Daily run reconstructions were not available for Skeena sockeye at this point, and may not exist for Skeena steelhead.

5 Recommendations

1) In order to assess SEAK impacts on BC steelhead, kept catch (for personal use) and release numbers by fishery and area, and sampling for genetic stock ID derived stock compositions would be required. Estimates of long-term release mortality by gear type/area/time would also be required.
2) GSI derived stock composition estimates would be useful in improving the management approach for steelhead bycatch and understanding impacts on specific populations.

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7 Figures

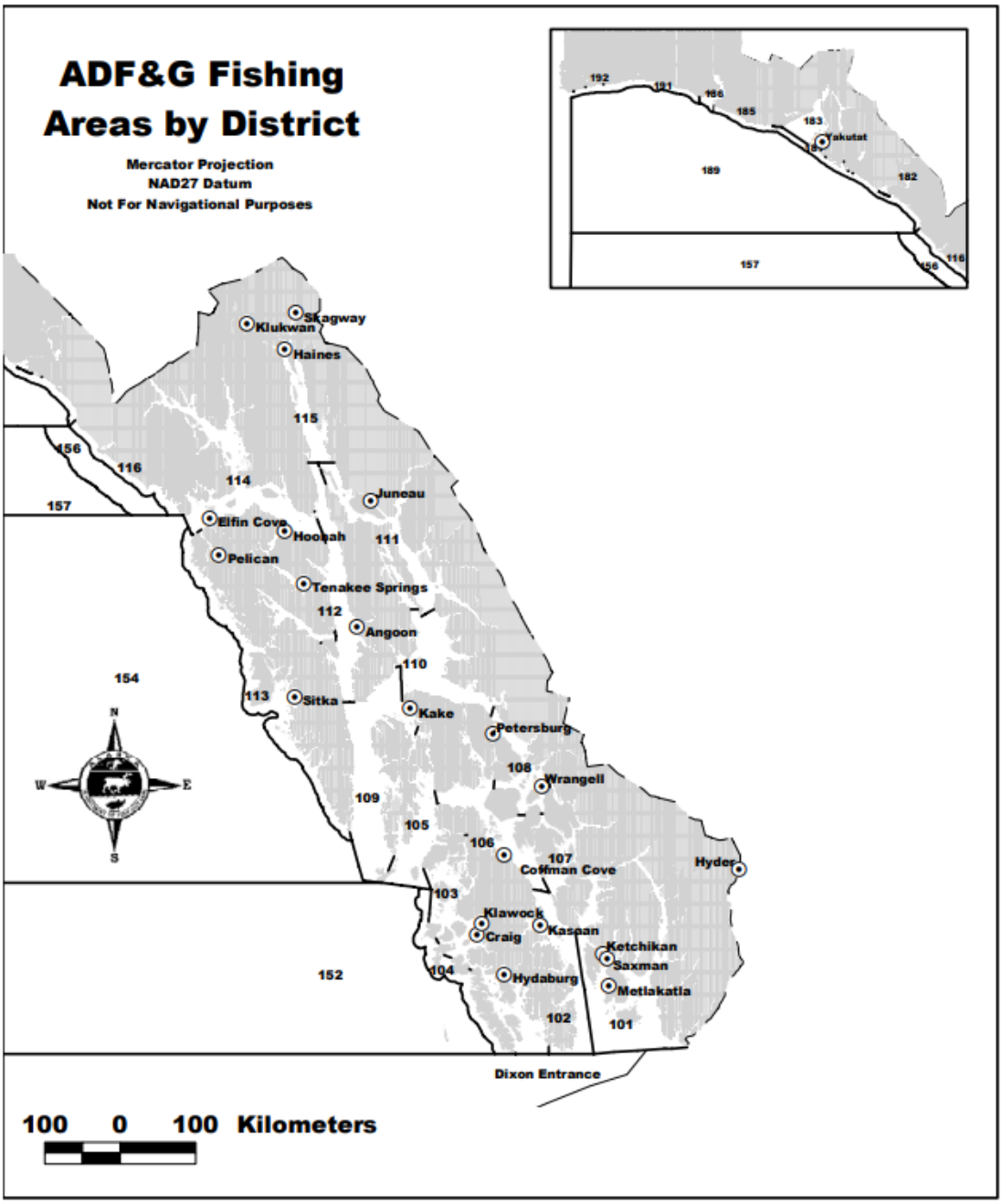

Figure 1: Map of Southeast Alaska Fishing Areas by District.

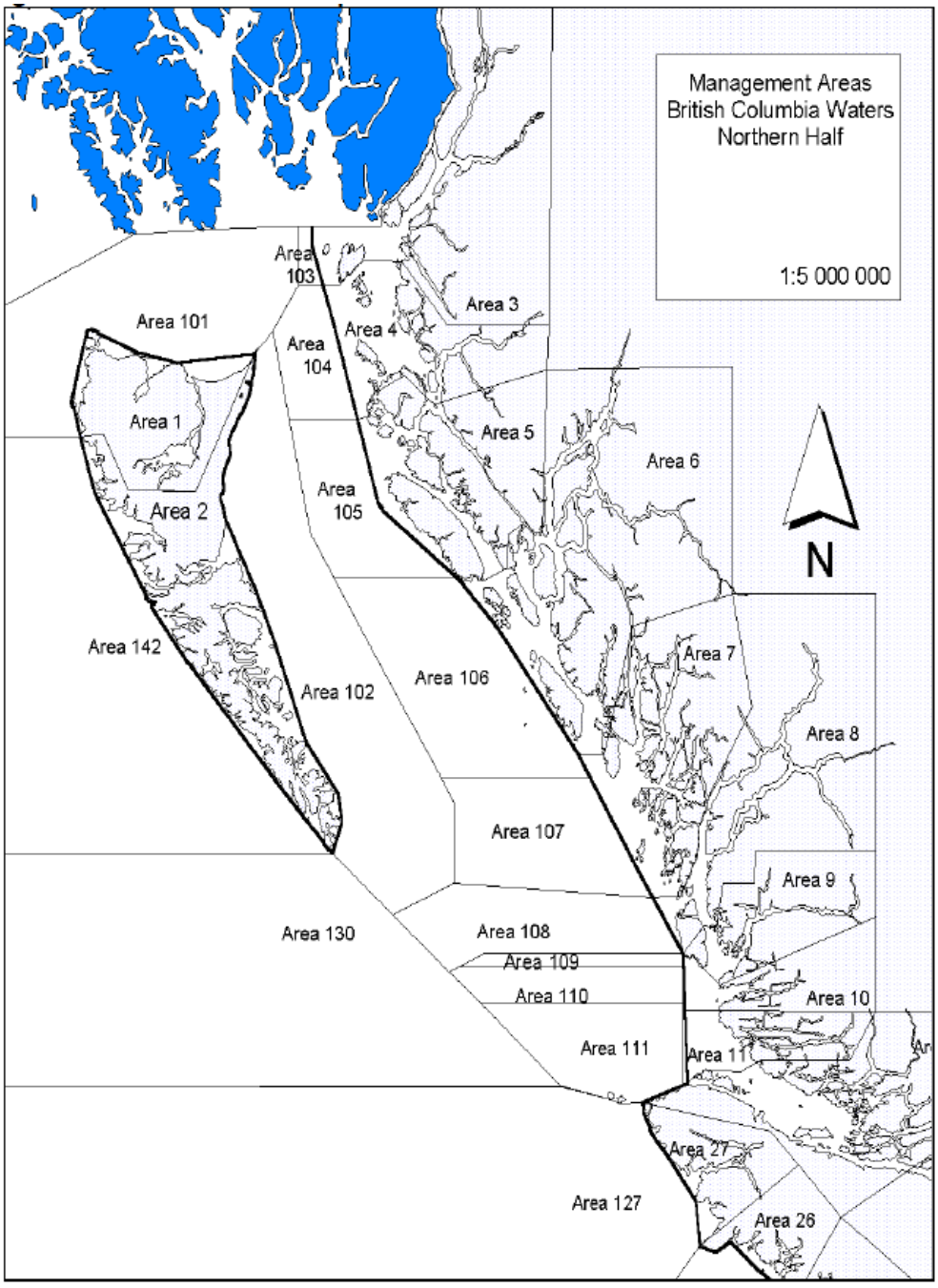

Figure 2.Map of DFO Statistical Areas in the North and Central Coast Areas.

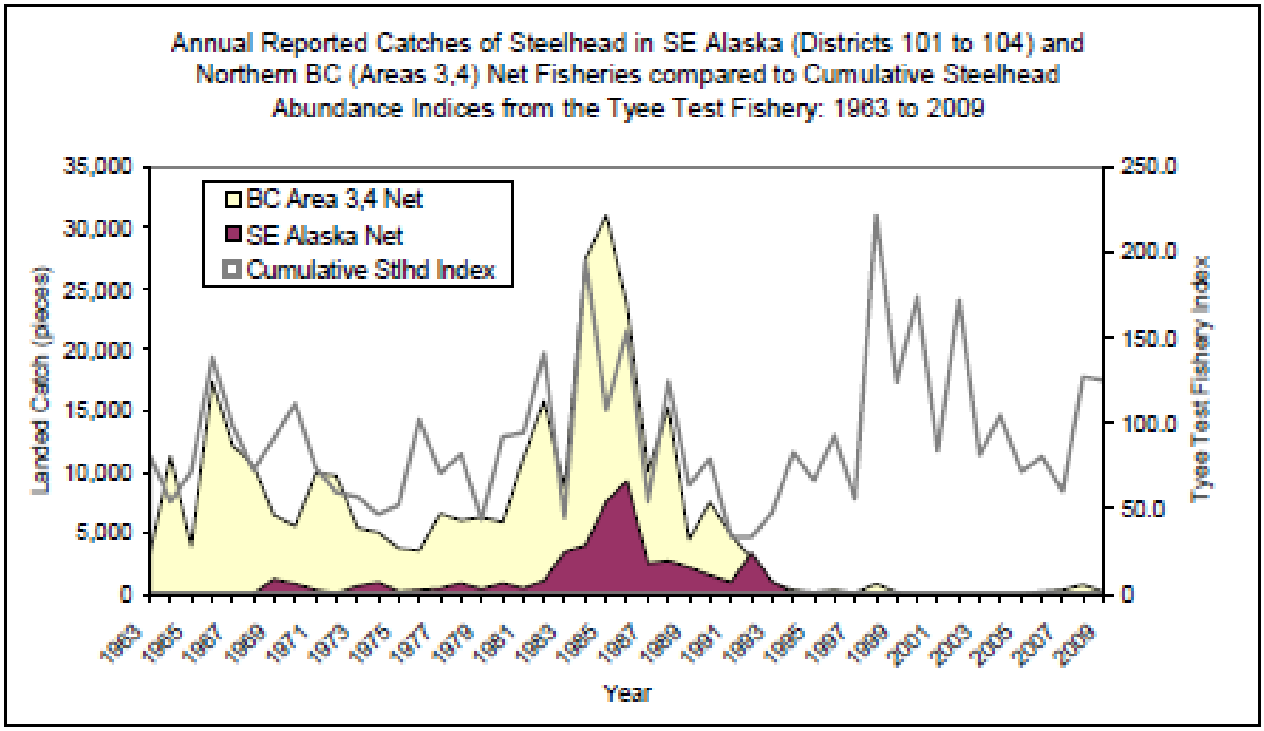

Figure 3: Annual reported catch of steelhead in Southeast Alaska (Districts 101-104) an Northern BC (Areas 3 and 4) gillnet and seine fisheries, compared to cumulative steelhead abunndance indices from the DFO Tyee Test fishery from 1963 to 2009.

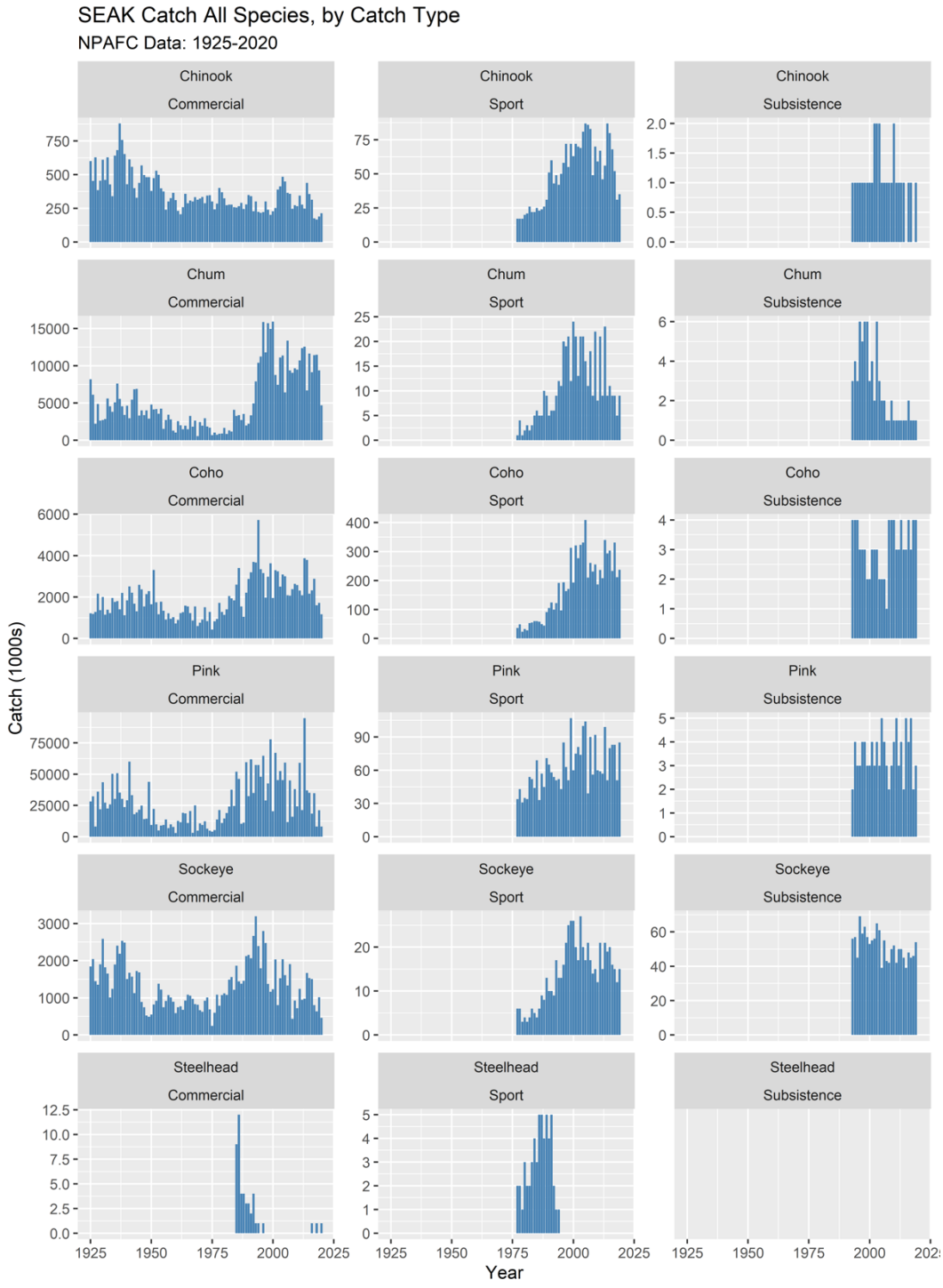

Figure 4: NPAFC catch database records for SEAK catch of all species of salmon and steelhead trout in commercial, subsistence and sport fisheries, 1925-2020.

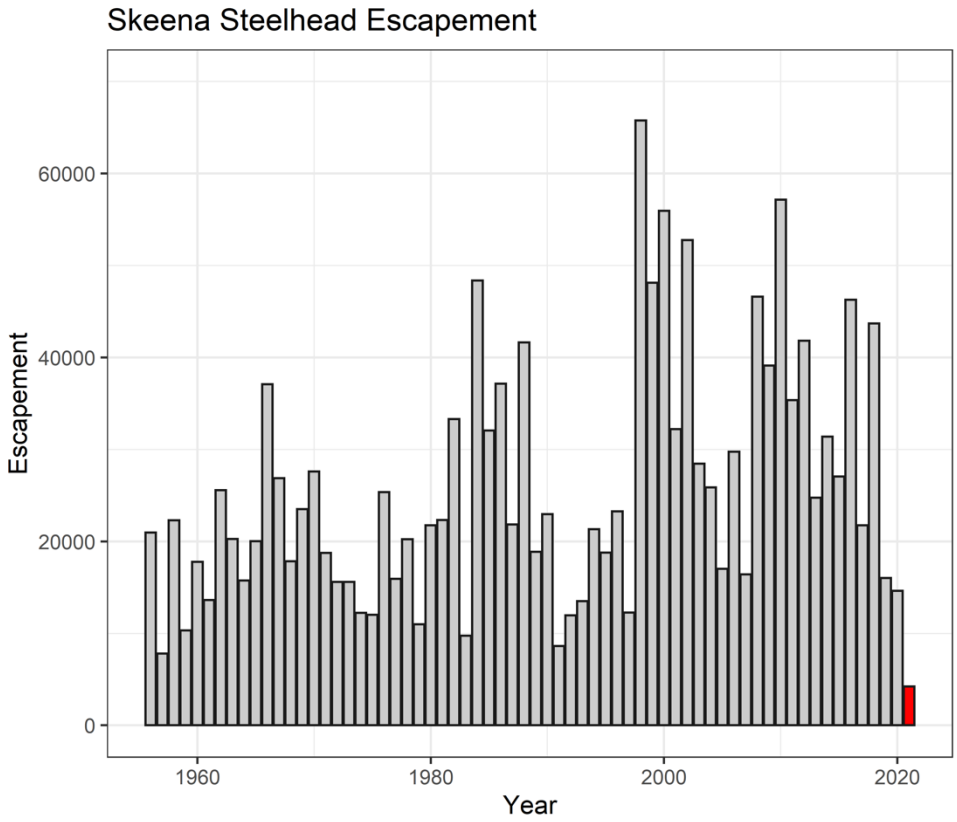

Figure 5: Estimated escapement of Skeena River steelhead from 1956 to 2021. 2021 estimated escapement is shown in red. Source: FLNRO 2021.

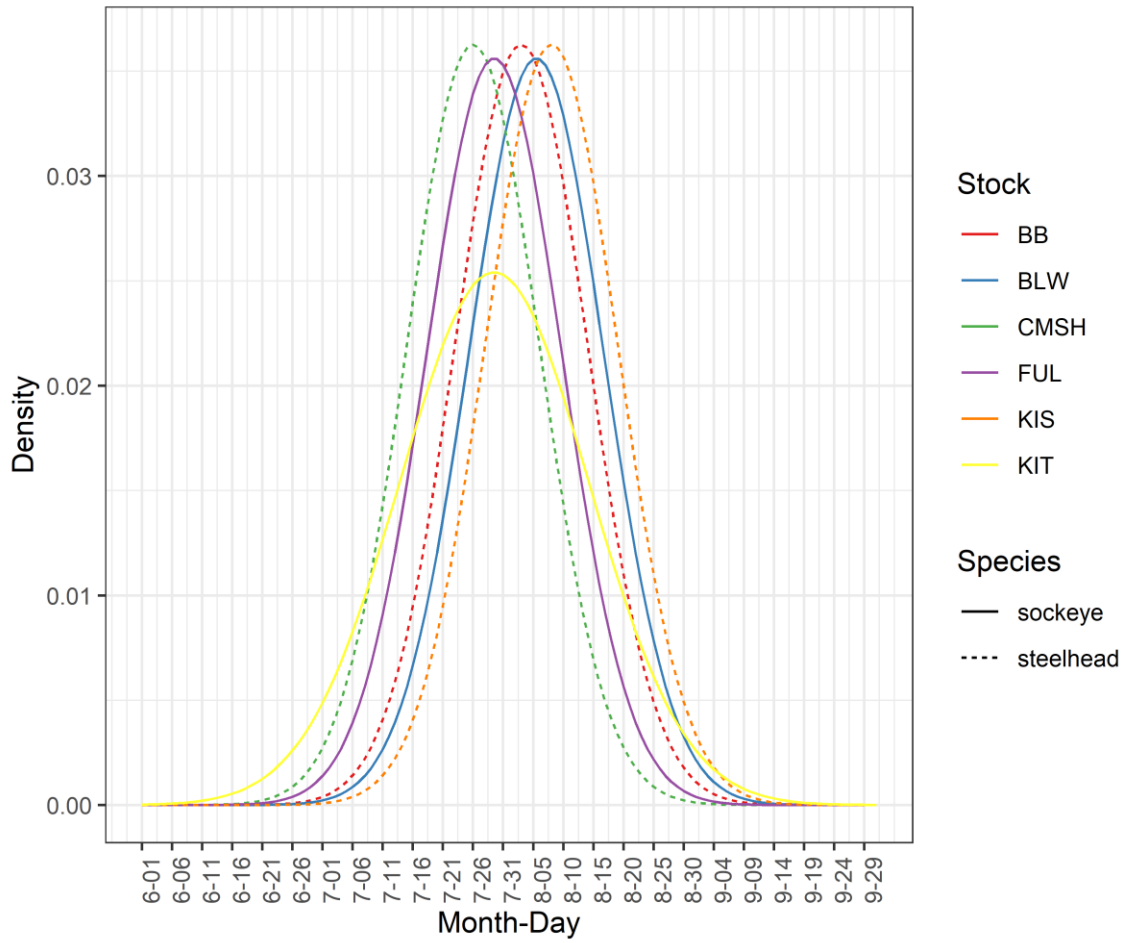

Figure 6: Estimated run-timing of Skeena steelhead and sockeye populations. Sockeye are shown by solid lines, and steelhead by dashed lines. BB=Babine/Bulkley steelhead, BLW=Babine Late-wild sockeye, CMSH=Copper/Morice steelhead, FUL=Fulton sockeye, KIS=Kispiox steelhead, KIT=Kitwanga sockeye. Source: Cox-Rogers 2000 and English et al. 2018.

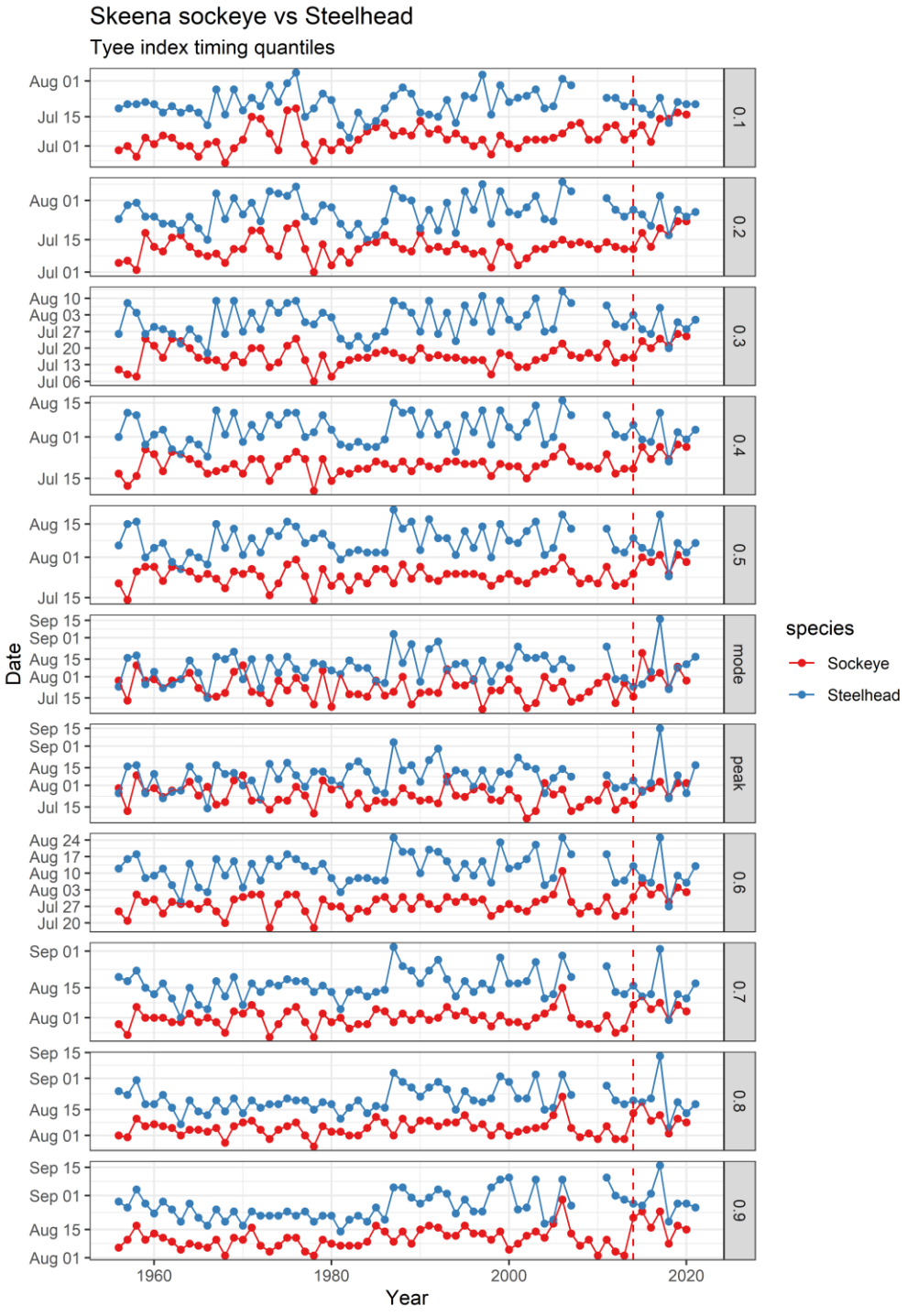

Figure 7: Run-timing of steelhead and sockeye through the Tyee test fishery. Timing data was generated through Tyee daily index values from 1956-2021. Source: Tyee test fishery data.

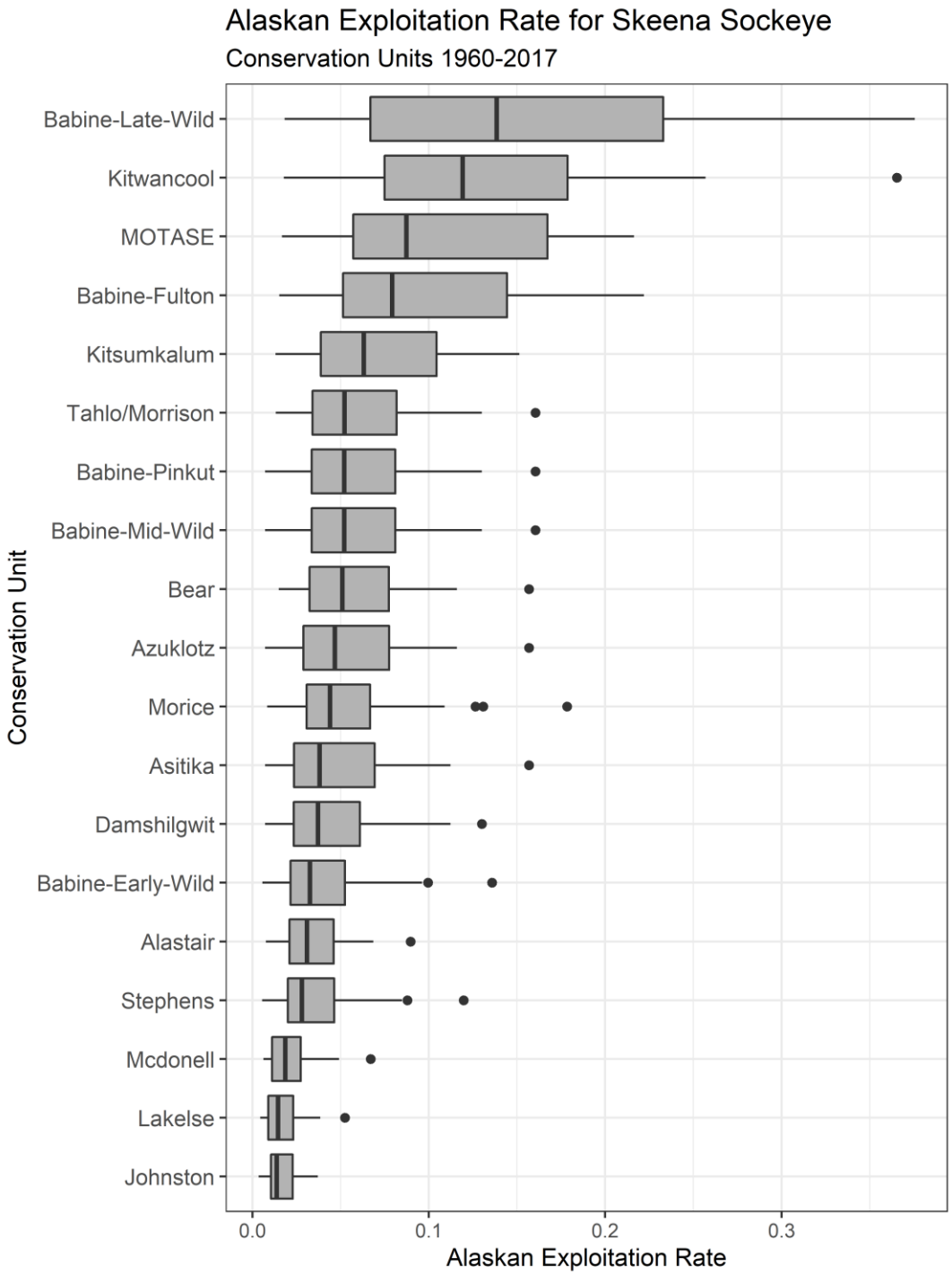

Figure 8: SEAK exploitation rates on Skeena sockeye Conservation Units. The thick black line is the median value, the box in indicates the interquartile range (25th to 75th percentiles – or middle 50% of the data), whiskers are 1.5x the interquartile range and dots are outliers (< 5th or > 95th percentile). Source: PSF 2021.

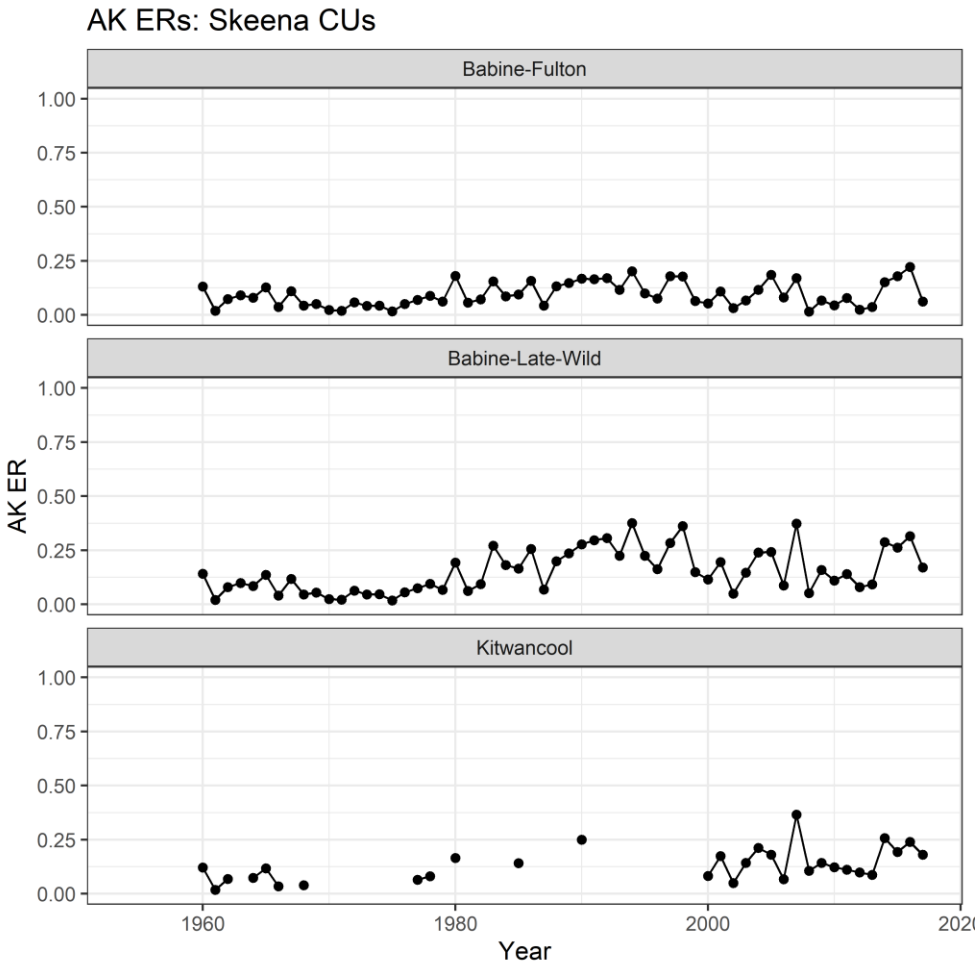

Figure 9: Total Alaskan exploitation rate on the Babine Late-Wild, Babine-Fulton and Kitwanga (Kitwancool) Conservation Units (1960-2017) over time. Source: PSF 2021.

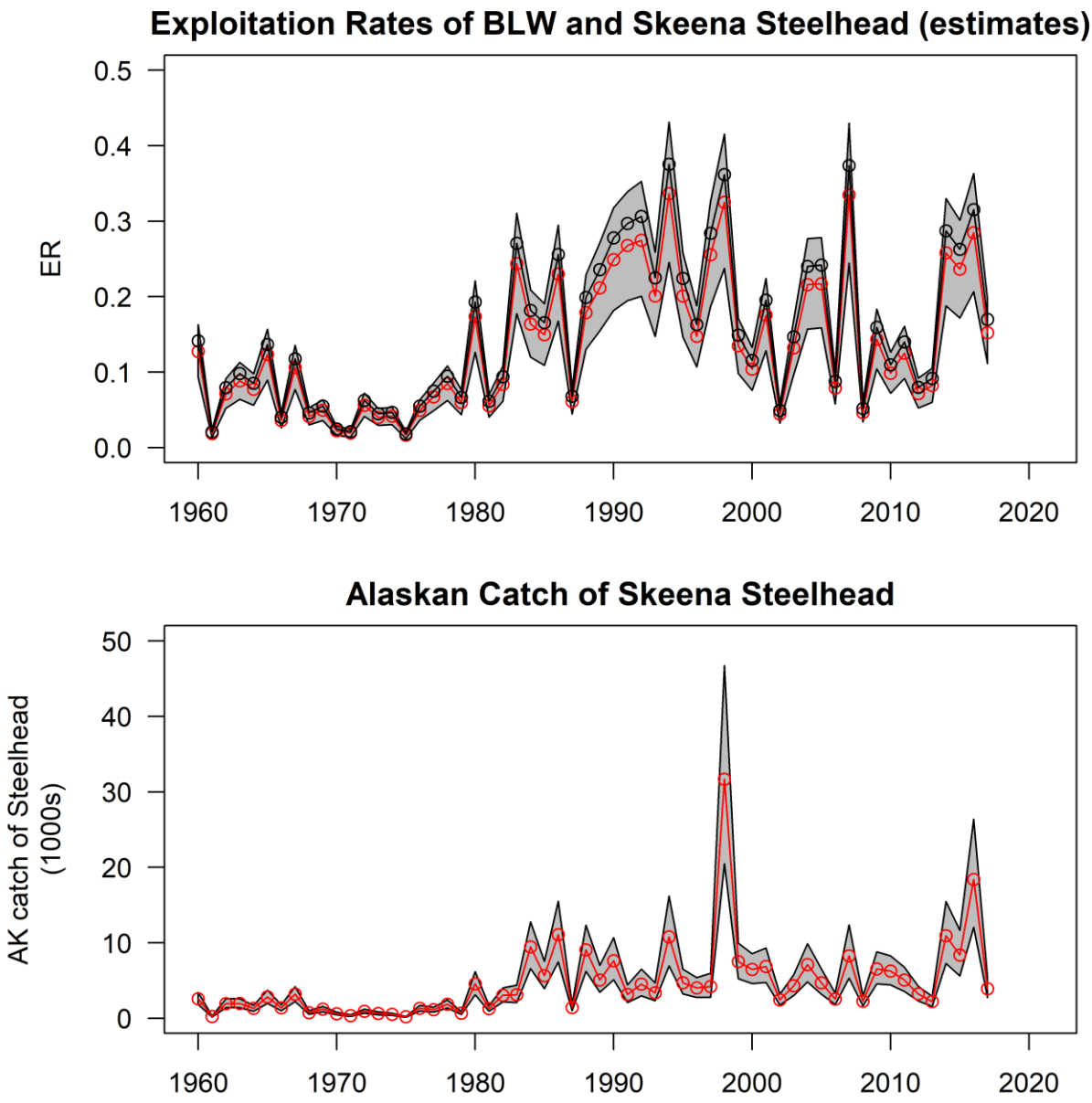

Figure 10: Median (red points) exploitation rates of Babine Late Wild sockeye and estimated exploitation rates on Skeena steelhead with 95 percent confidence intervals shown in grey (top panel) and estimated catch of Skeena steelhead with 95% CIs (bottom panel).

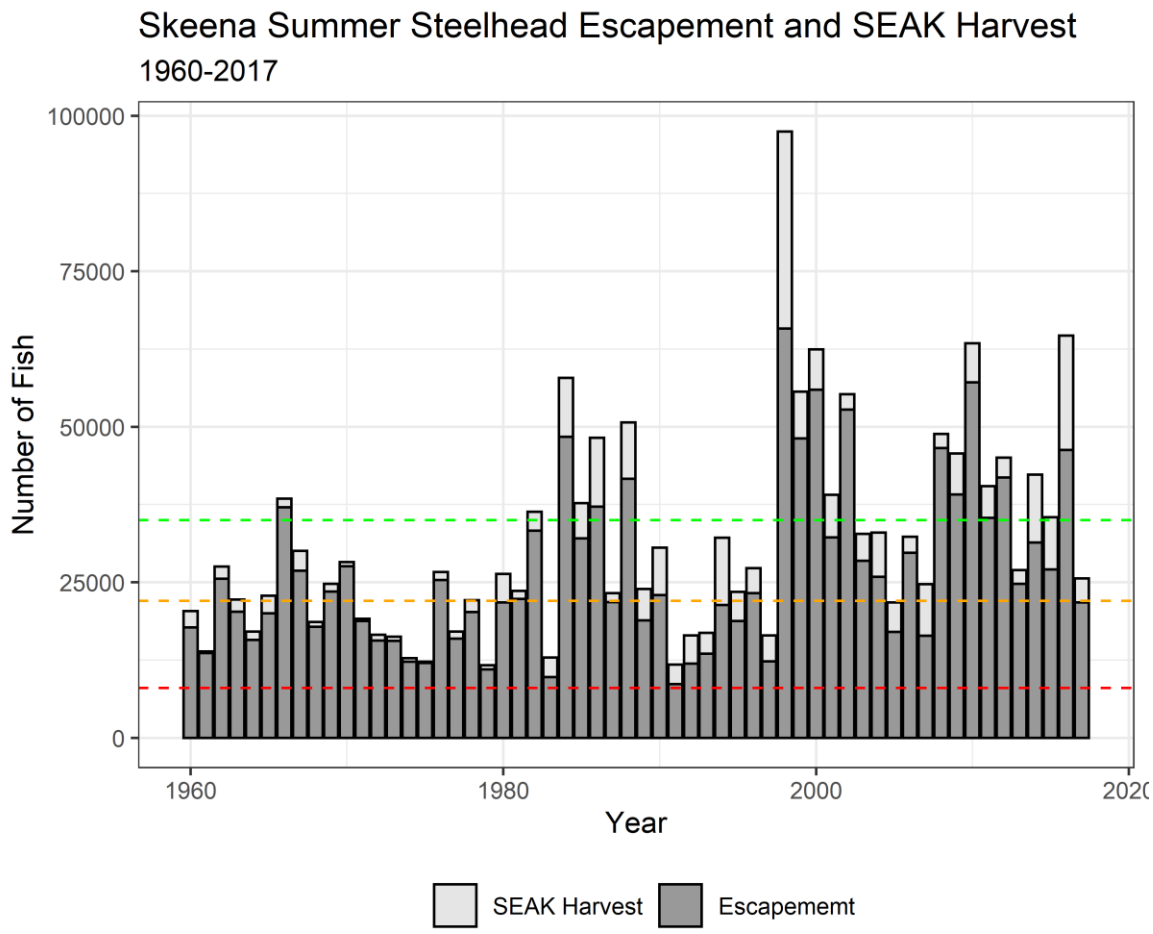

Figure 11: Escapement and Alaskan catch of Skeena River summer steelhead versus management reference points. The green dashed line represents the PSARC MSY (~35,000), the yellow dashed line represents the PSARC Escapement Minimum Critical Conservation Zone (~ 23,000), and the red dashed line represents the Extreme Critical Conservation Zone.

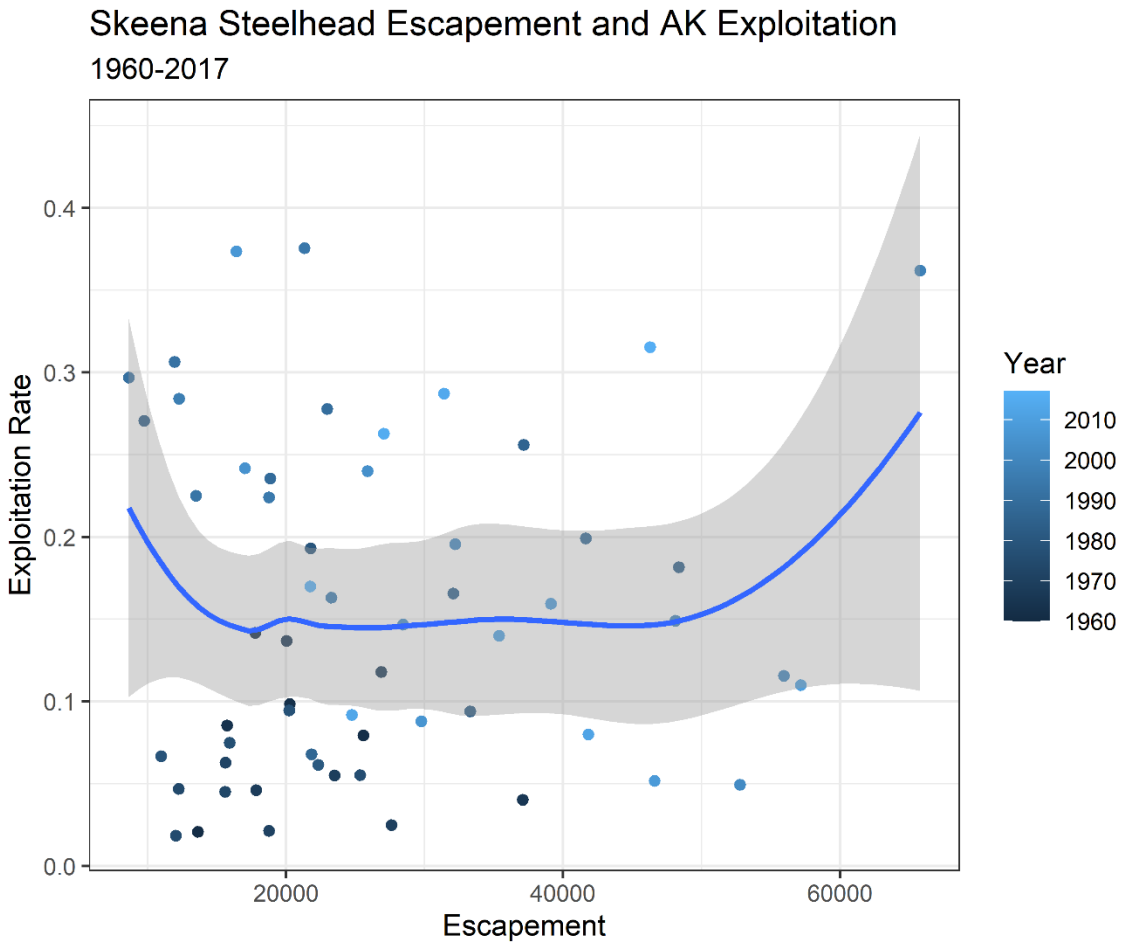

Figure 12: Escapement versus Alaskan exploitation rate for Skeena steelhead 1960-2017. Lighter blue points are more recent years. The blue line shows the LOESS fit with 5th/95th confidence intervals.