Alaskan Harvest of BC Salmon: State of Knowledge

Part 7: Steelhead Trout

Version 1

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Preface

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

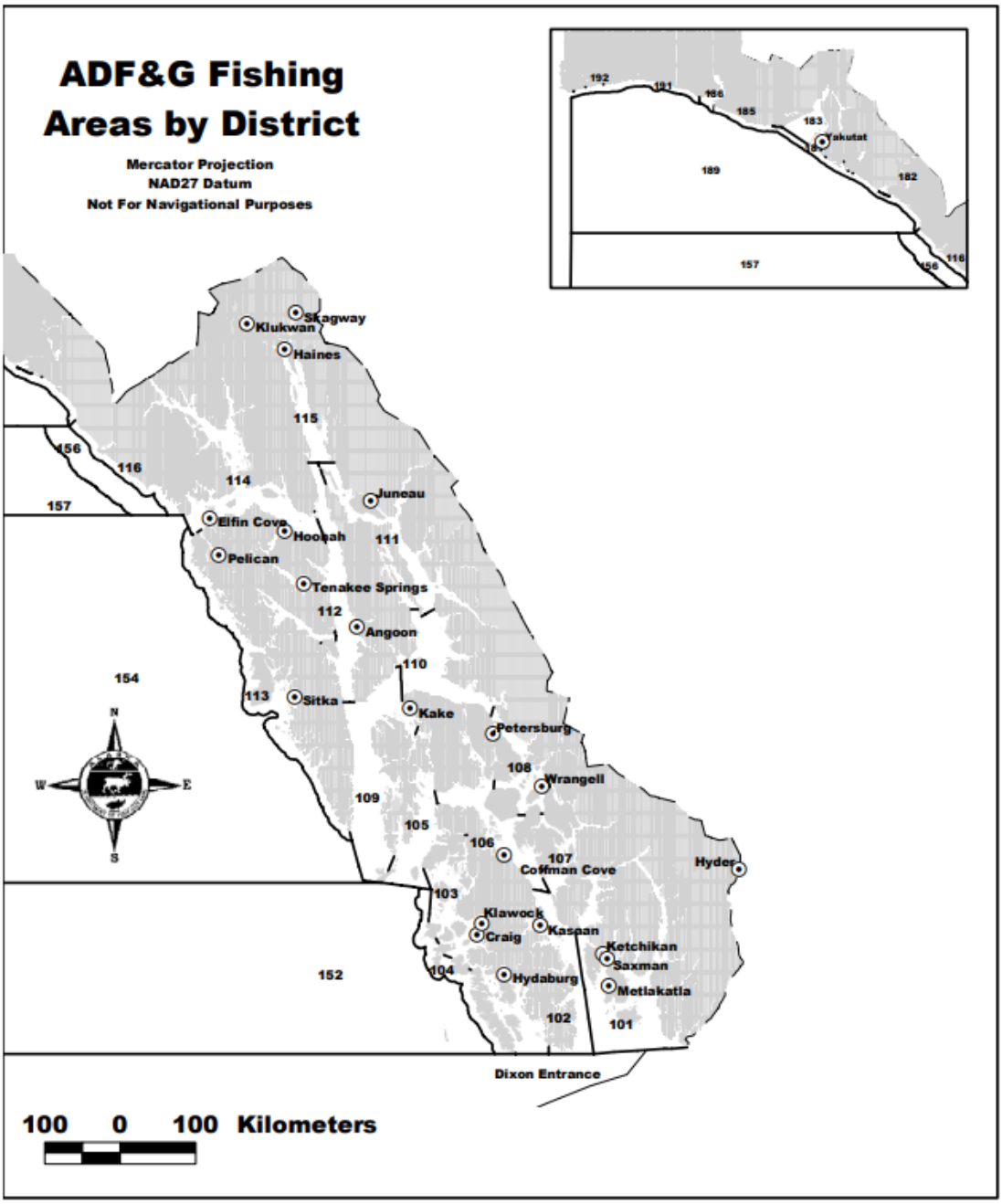
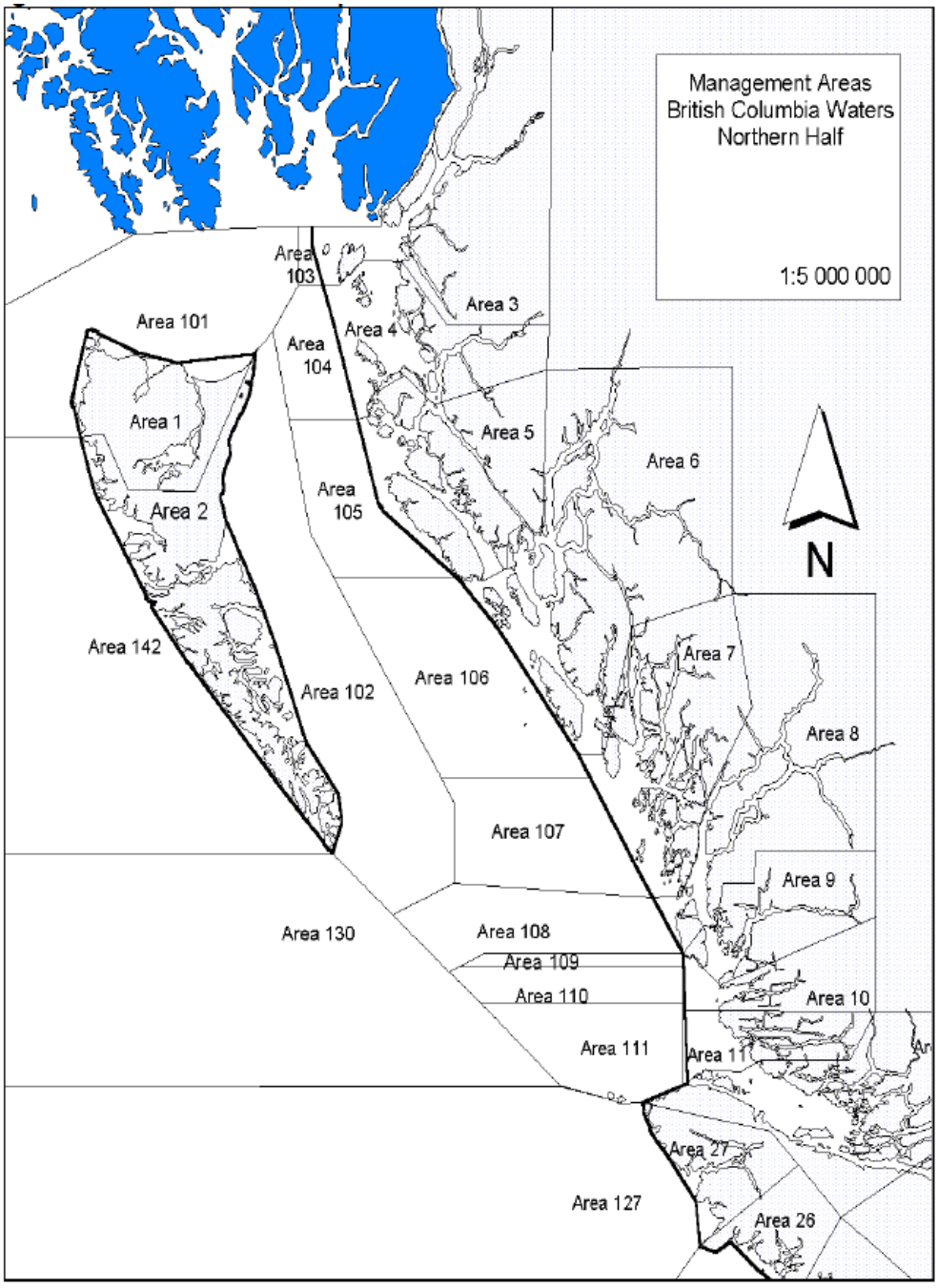


Figure 1: Map of Southeast Alaska Fishing Areas by District.



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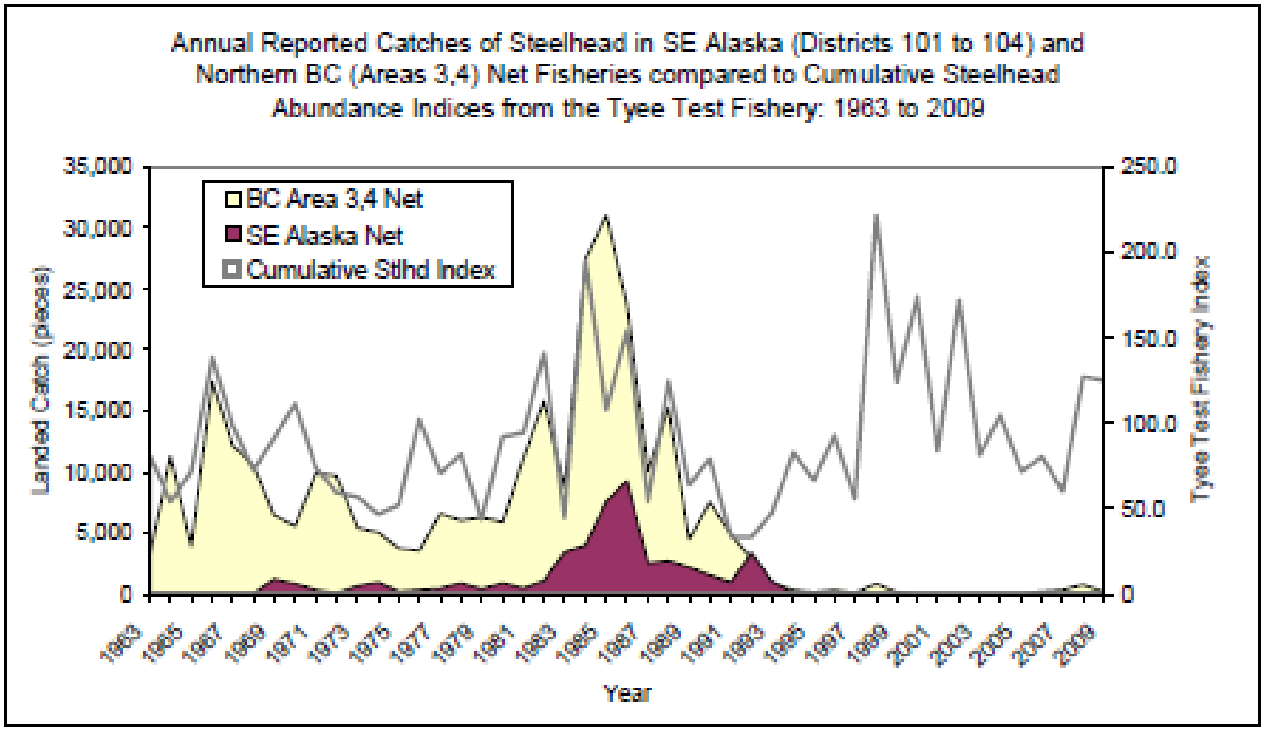

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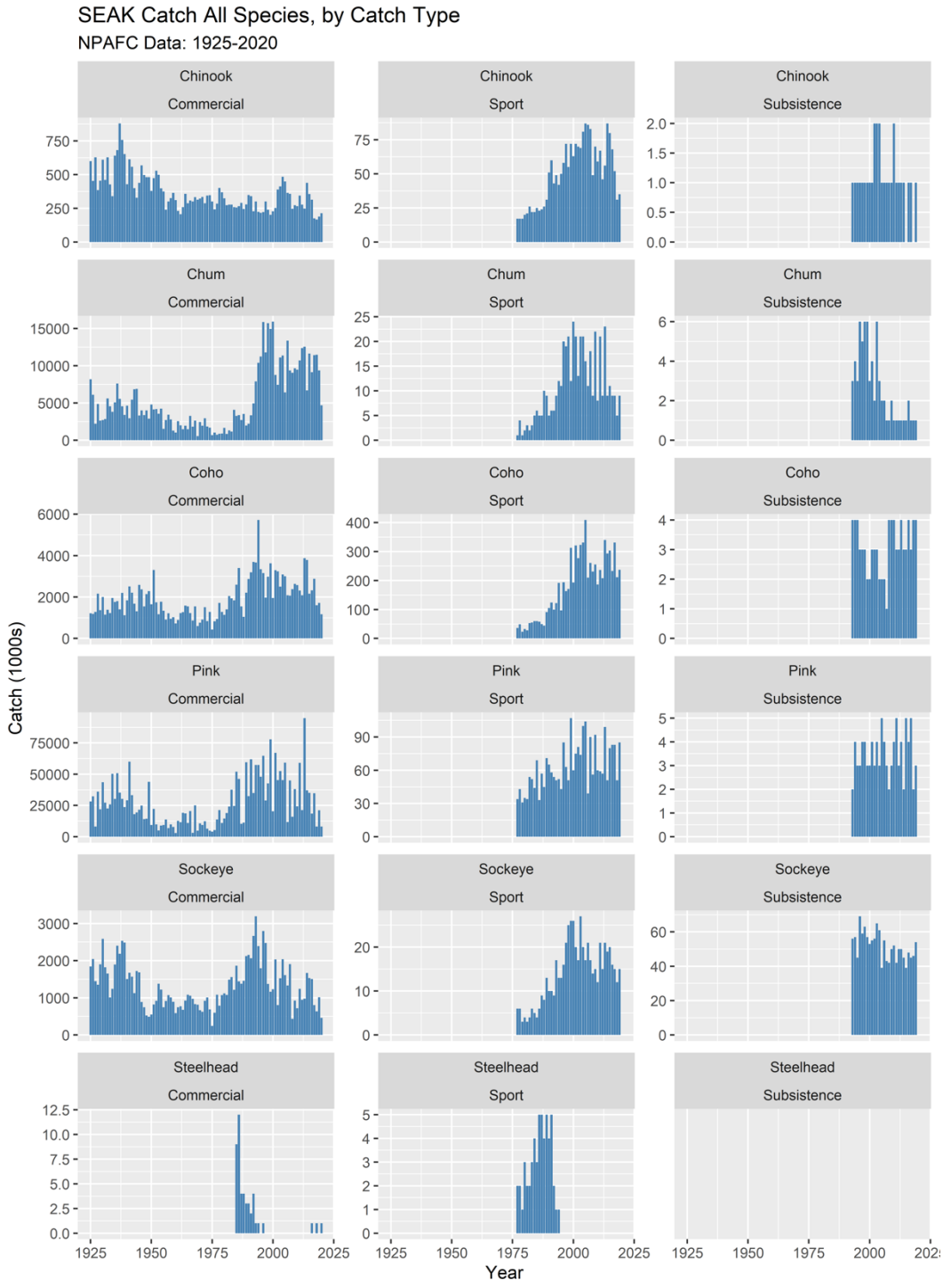

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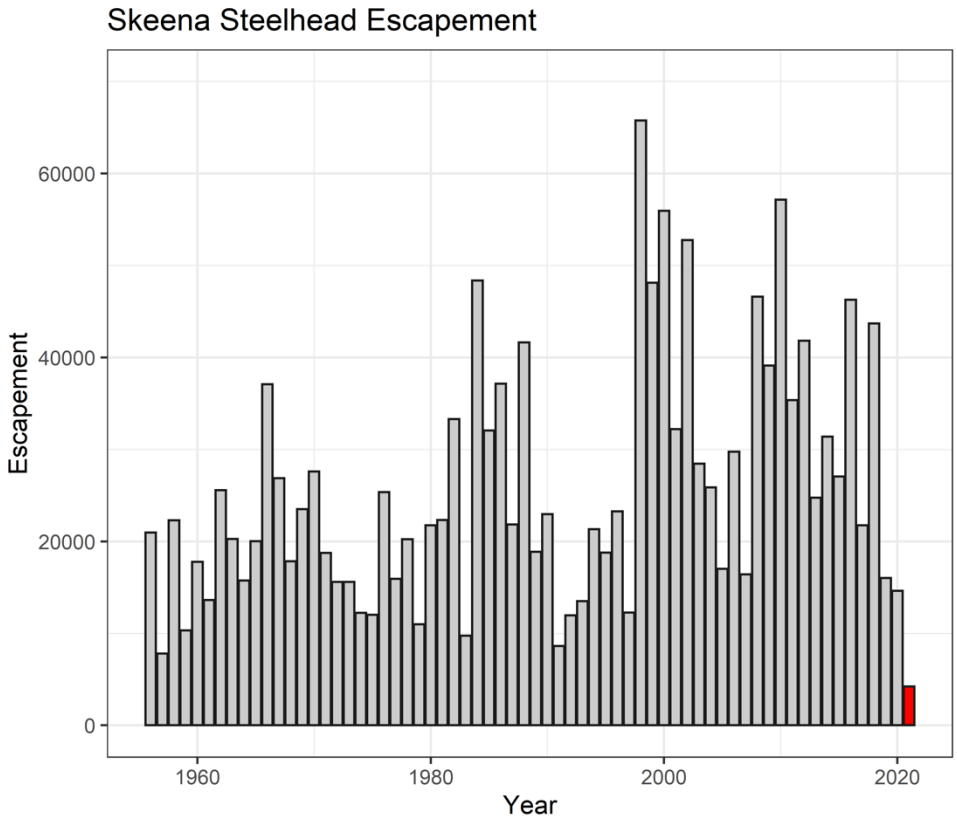

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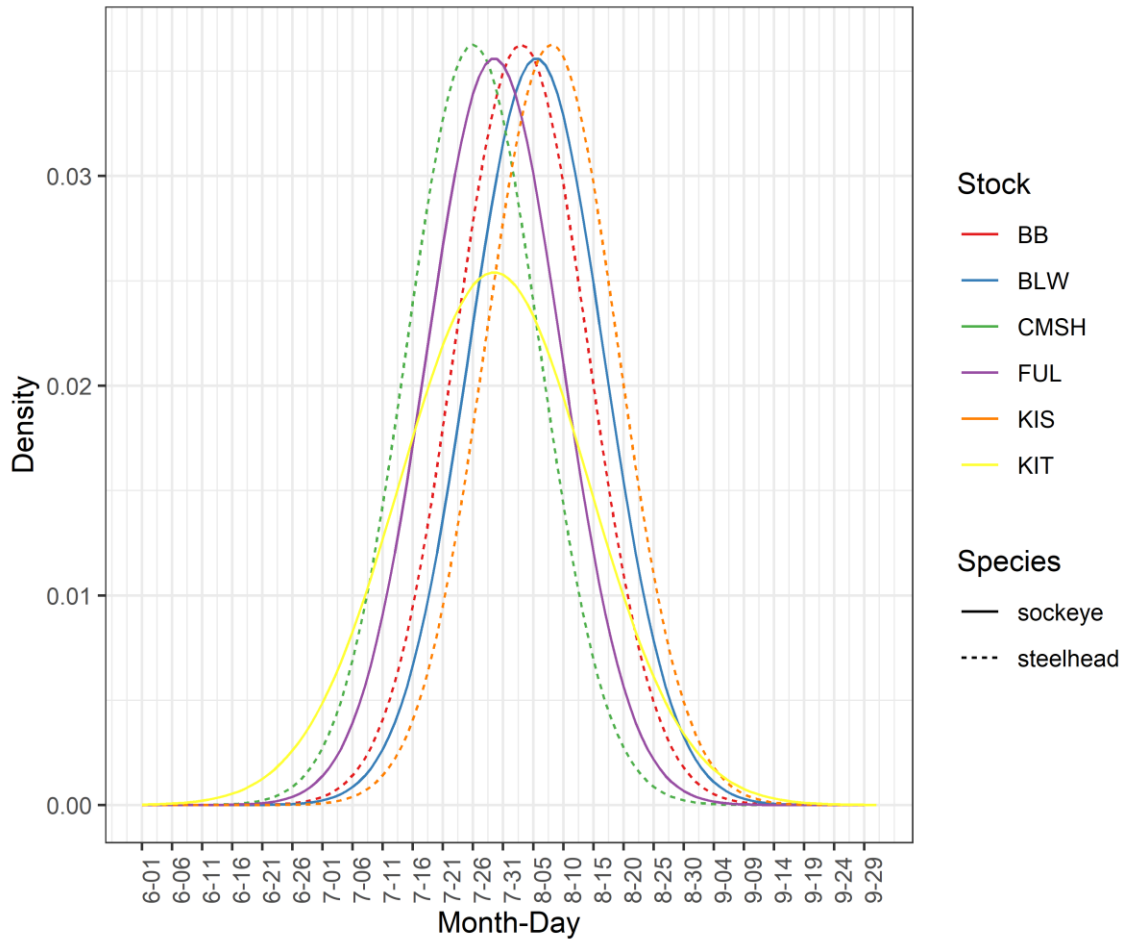

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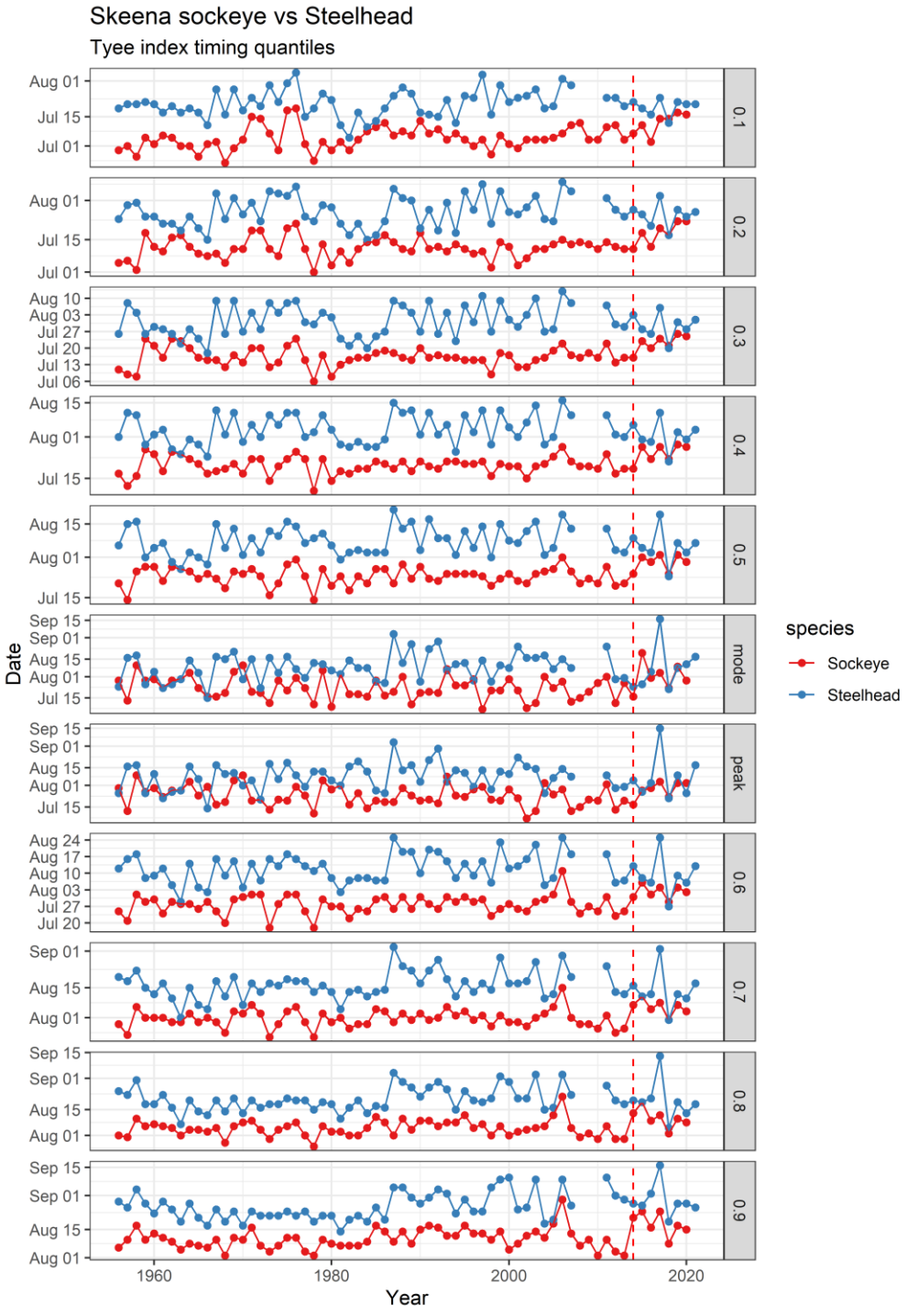

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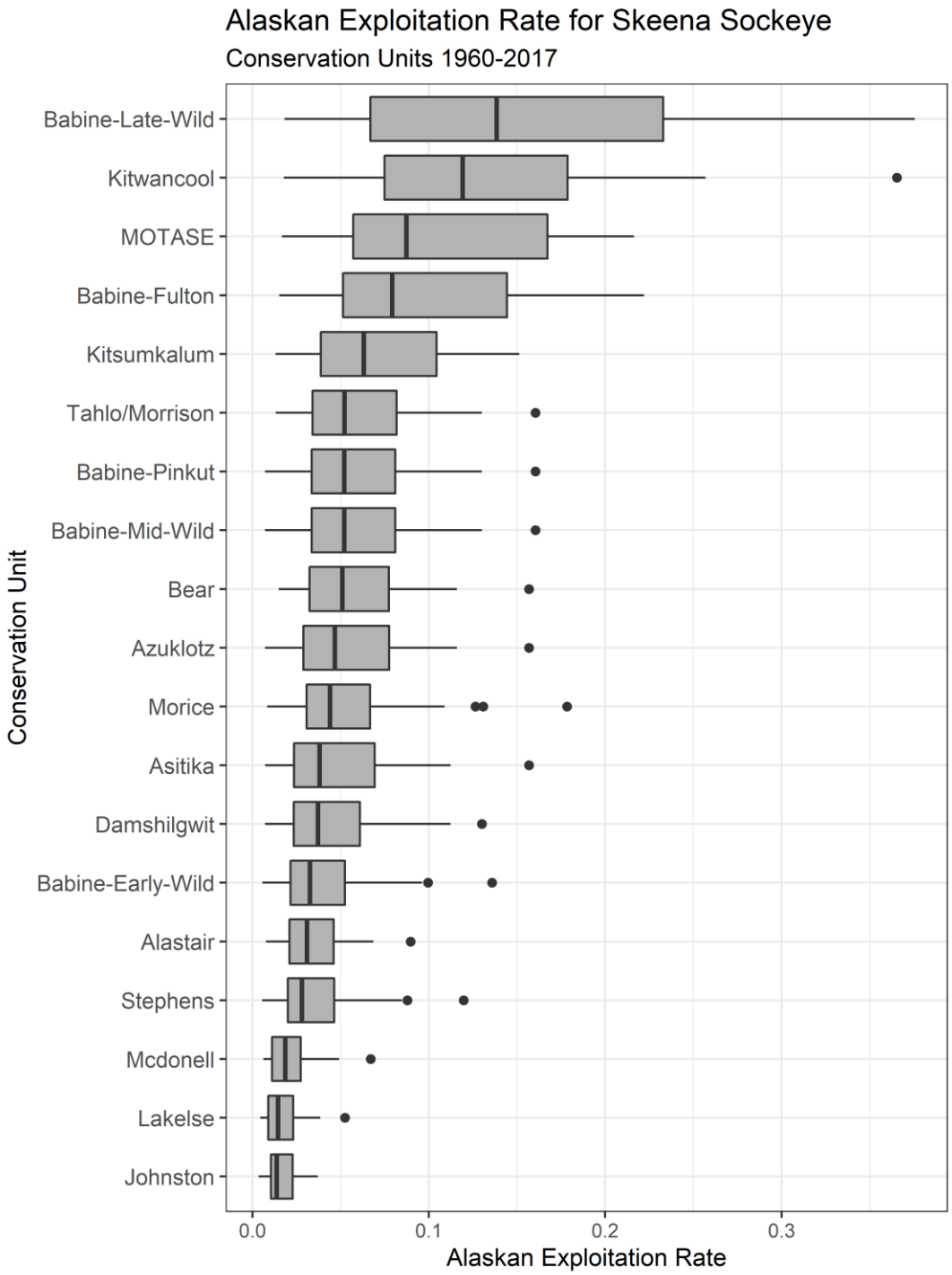

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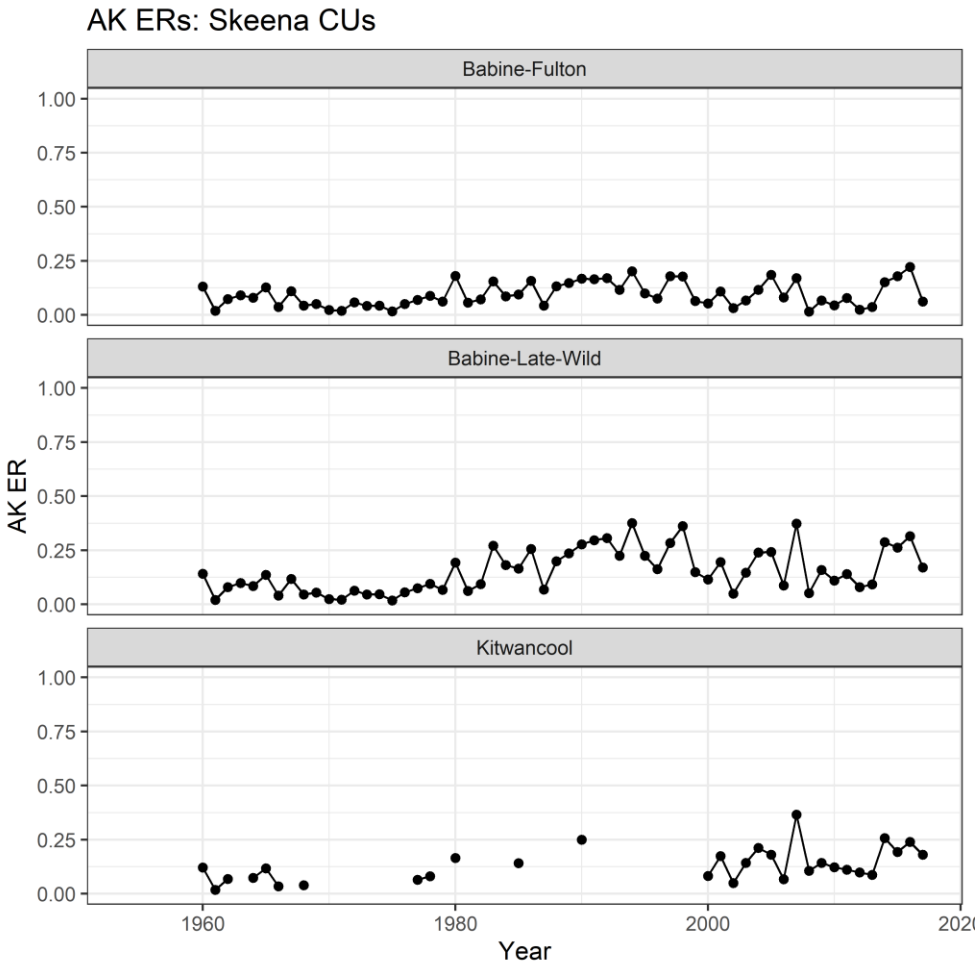

Figure 9: Total Alaskan exploitation rate on the Babine Late-Wild, Babine-Fulton and Kitwanga (Kitwancool) Conservation Units (1960-2017) over time. Source: PSF 2021.

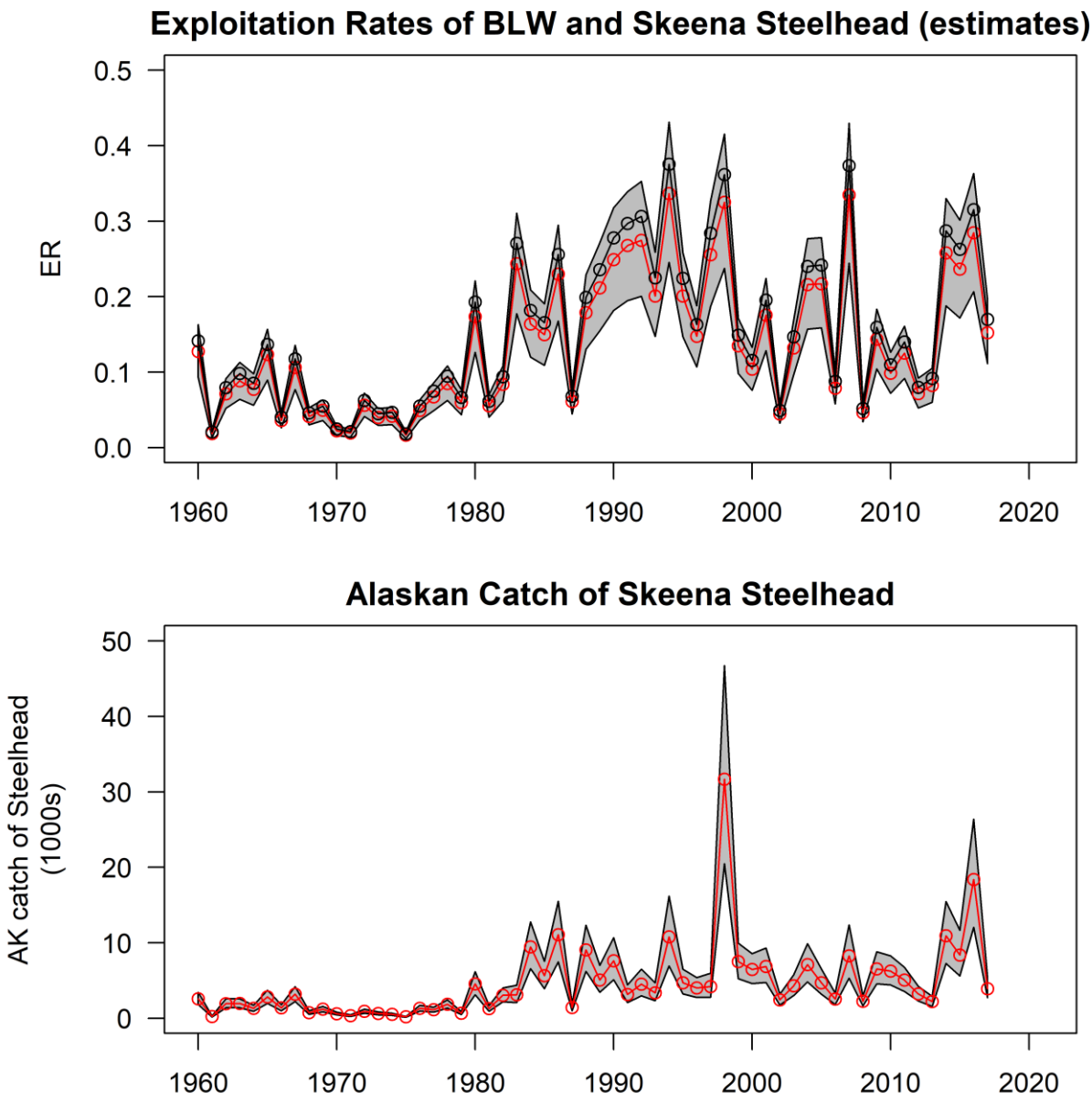

Figure 10: Median (red points) exploitation rates of Babine Late Wild sockeye and estimated exploitation rates on Skeena steelhead with 95 percent confidence intervals shown in grey (top panel) and estimated catch of Skeena steelhead with 95% CIs (bottom panel).

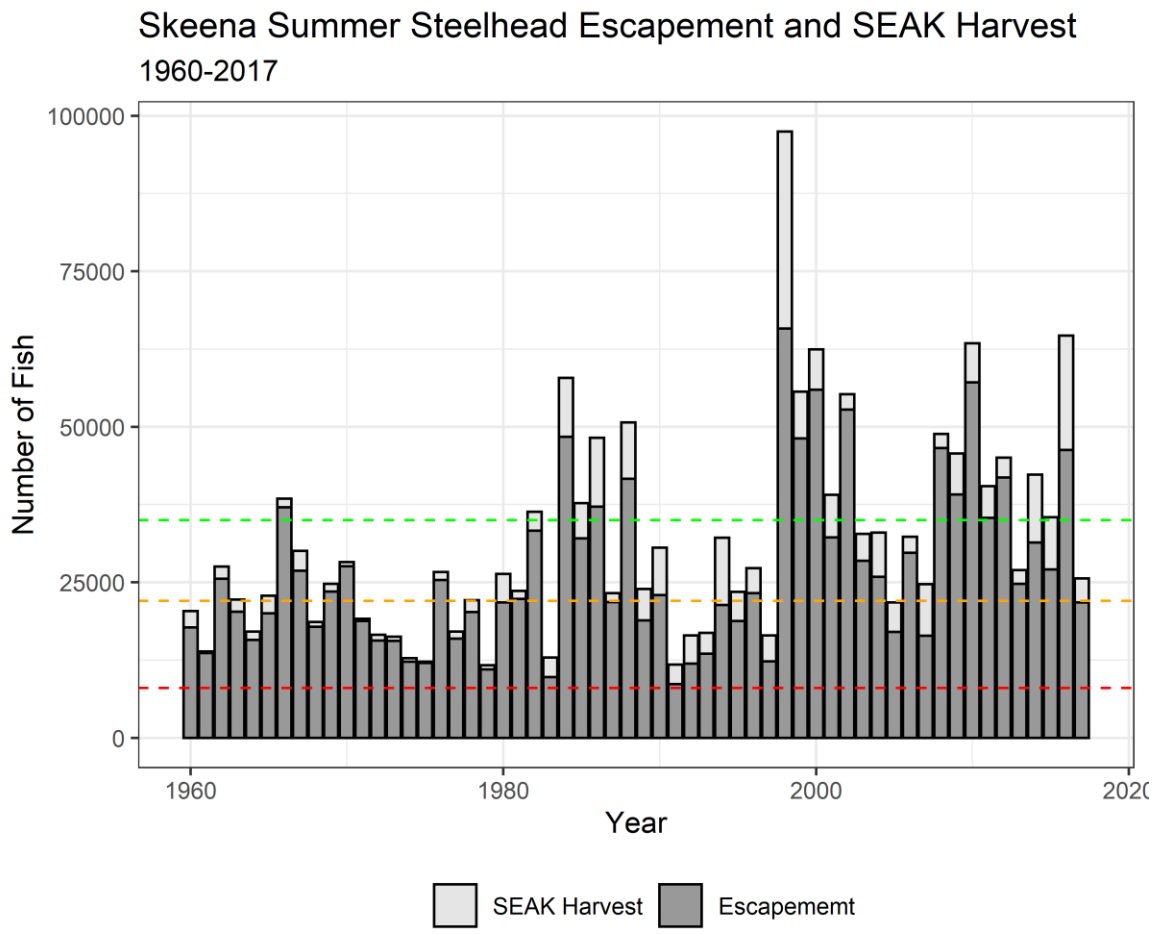

Figure 11: Escapement and Alaskan catch of Skeena River summer steelhead versus management reference points. The green dashed line represents the PSARC MSY (~35,000), the yellow dashed line represents the PSARC Escapement Minimum Critical Conservation Zone (~ 23,000), and the red dashed line represents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

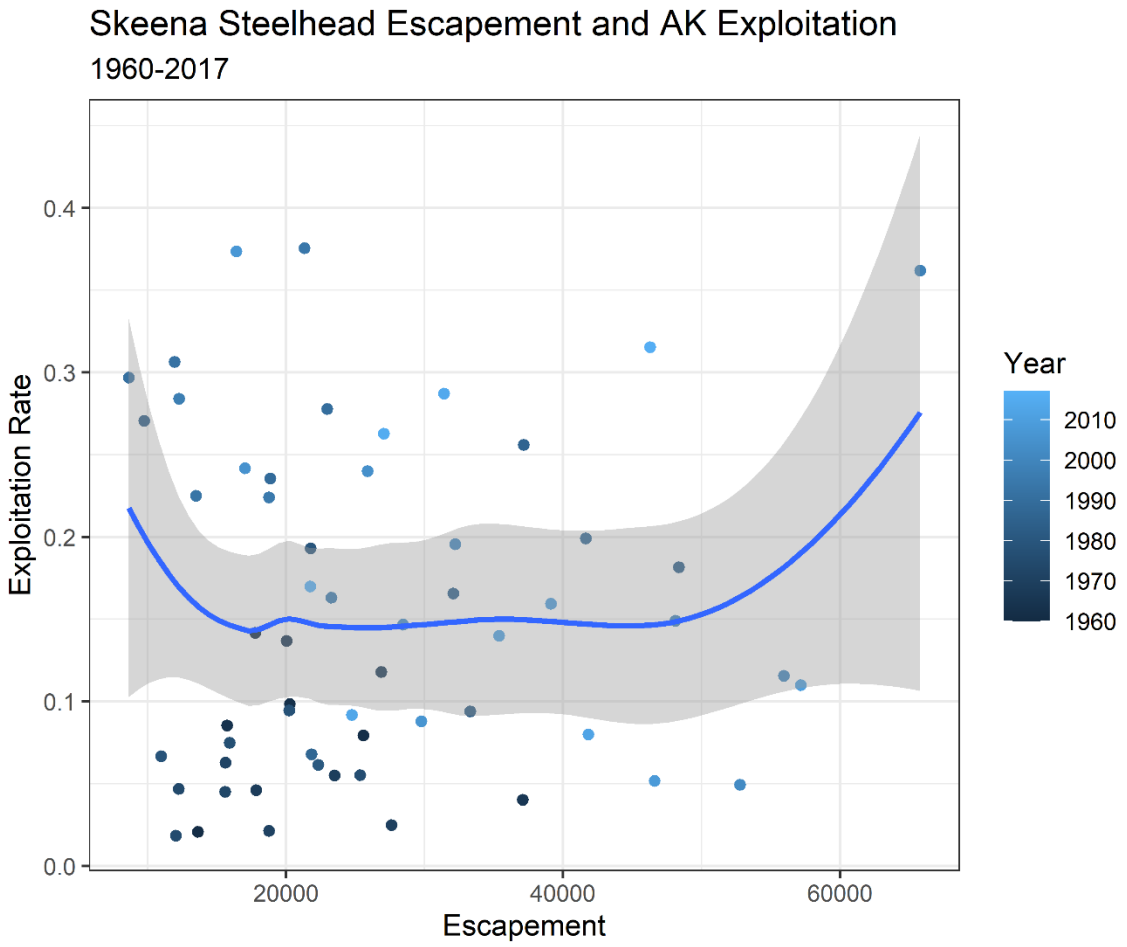

Figure 12: Escapement versus Alaskan exploitation rate for Skeena steelhead 1960-2017. Lighter blue points are more recent years. The blue line shows the LOESS fit with 5th/95th confidence intervals.