Biological Data Sets and Life History Analyses for Sablefish (*Anoplopoma fimbria*) in British Columbia in 2025

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BIOLOGICAL DATA SETS AND LIFE HISTORY ANALYSES FOR SABLEFISH (*ANOPLOPOMA FIMBRIA*) IN BRITISH COLUMBIA IN 2025

by

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ABSTRACT

Holt, K.R., Lacko, L.C., and Kronlund, A.R. 2026. Biological Data Sets and Life History Analyses for Sablefish (*Anoplopoma fimbria*) in British Columbia in 2025. Can. Tech. Rep. Fish. Aquat. Sci. 3769: ix + 52 p. https://doi.org/10.60825/43q2-qf91

This report updates biological data sets and life-history parameter estimates for British Columbia (B.C.) Sablefish (*Anoplopoma fimbria*) using an additional decade of information (2015–2024). Updated age-composition data confirm a strong 2016 cohort, which continued to dominate samples at age 8 in 2024. A revised ageing-error matrix, developed using only double-blind otolith reads, indicates slightly higher ageing imprecision than past estimates, but provides a more defensible representation of uncertainty. Life-history analyses were conducted for length-at-age (LAA), weight-length (WL), and maturity-at-age (MAA) using two different data sets. Two von Bertalanffy growth formulations were evaluated for LAA. Multiple data-model combinations produced biologically reasonable growth estimates. Both across-year and within-cohort analyses revealed declines in length-at-age over time. Previously documented differences in LAA between northern and southern regions in B.C. corresponding to the bifurcation of the North Pacific Current at an approximate latitude of 50°N were also confirmed, with cohort-specific temporal trends in LAA remaining consistent in both regions. The WL relationships were highly consistent across data sources. Temporal variation was modest and generally confined to larger size classes, suggesting limited implications for operating model performance relative to changes in growth. MAA was modeled using logistic and spline approaches. Spline functions provided better fits at young ages, whereas logistic models tended to overestimate early maturity and were sensitive to small sample sizes. The updated analyses support adopting B.C.-based life-history parameterizations for the next Sablefish operating model revision.

RÉSUMÉ

Holt, K.R., Lacko, L.C., and Kronlund, A.R. 2026. Biological Data Sets and Life History Analyses for Sablefish (*Anoplopoma fimbria*) in British Columbia in 2025. Can. Tech. Rep. Fish. Aquat. Sci. 3769: ix + 52 p. https://doi.org/10.60825/43q2-qf91

Ce rapport met à jour les données biologiques et les estimations des paramètres du cycle de vie de la morue charbonnière (Anoplopoma fimbria) de Colombie-Britannique (C.-B.) grâce à une décennie supplémentaire d'information (2015-2024). Les données actualisées sur la composition par âge confirment la présence d'une cohorte importante en 2016, qui restait dominante dans les échantillons à l'âge de 8 ans en 2024. Une matrice d'erreur de vieillissement révisée, élaborée à partir des seules lectures d'otolithes en double aveugle, indique une imprécision du vieillissement légèrement supérieure aux estimations précédentes, mais offre une représentation plus fiable de l'incertitude.

Des analyses du cycle de vie ont été réalisées pour la longueur à l'âge (LAA), le poids en fonction de la longueur (WL) et la maturité à l'âge (MAA) en utilisant deux ensembles de données différents. Deux formulations de croissance de von Bertalanffy ont été évaluées pour la LAA. Plusieurs combinaisons du modèle LAA et des données ont produit des estimations de croissance biologiquement raisonnables. Les analyses interannuelles et intra-cohortes ont révélé une diminution de la longueur à un âge donné au fil du temps, les cohortes récentes présentant des tailles prédites et des longueurs asymptotiques plus faibles. Les différences précédemment documentées dans la LAA entre les régions du nord et du sud, correspondant à la bifurcation du courant Nord-Pacifique à une latitude approximative de 50°N, ont également été confirmées, les tendances temporelles spécifiques aux cohortes dans la LAA restant cohérentes dans les deux régions. Les relations longueur-poids étaient très cohérentes entre les différentes sources de données. La variation temporelle était modeste et généralement limitée aux classes de taille les plus élevées, ce qui suggère des implications limitées sur la performance du modèle opérationnel par rapport aux variations de croissance. La maturité à l'âge (MAA) a été modélisé à l'aide d'approches logistiques et splines. Les fonctions splines ont fourni de meilleurs ajustements aux jeunes âges, tandis que les modèles logistiques avaient tendance à surestimer la maturité précoce et étaient sensibles aux petits échantillons. Les analyses mises à jour appuient l'adoption de paramétrisations du cycle de vie basées sur celles de la Colombie-Britannique pour la prochaine révision du modèle opérationnel de la morue charbonnière.

1 INTRODUCTION

Biological data for Sablefish (*Anoplopoma fimbria*) are collected from fishery-independent surveys and commercial fisheries in British Columbia (B.C.). These data are used to estimate life history parameters and provide age-composition data that are key inputs to the B.C. Sablefish operating model (OM). Harvest advice for B.C. Sablefish is informed by a Management Strategy Evaluation (MSE) process where the OM is used to generate simulated data for closed-loop feedback projections and to characterize stock status relative to reference points (Johnson et al. 2025, DFO 2025). While age composition data are updated with each revision to the Sablefish OM, life history parameters have not been updated since 2016 at which time data to the end of 2014 were used (Cox et al. 2023). The most recent updates to the Sablefish OM used the life history inputs developed in 2016 (DFO 2020, Johnson et al. 2025).

Three different life history relationships are used to describe fish growth and maturity within the OM: the length-at-age of individual fish (LAA models), the weight associated with a given length (WL models), and the proportion of fish at each age that have reached maturity (MAA models). The parameters defining these relationships are determined externally to the OM and are then input to the OM as fixed inputs. In the past, empirically derived LAA and MAA parameter estimates for B.C. Sablefish were considered unreliable, with B.C. estimates differing considerably from estimates from adjacent regions in Alaska and Washington State (Cox et al. 2023). As a result, parameter values for LAA and MAA relationships within the Sablefish OM were set at values consistent with estimates from other regions instead of being based directly on estimates derived from B.C. data (Cox et al. 2023). Only WL parameter estimates were based on empirical data from B.C.

Estimated life history relationships can be biased by the fishing gear used to collect samples. Gear types that select for larger body size tend to catch the fastest-growing fish (Kimura et al. 1993, Sullivan et al., 2024). Alaskan stock assessments have allowed for the effect of gear selectivity on estimated growth relationships by using separate LAA parameters for two different time periods (pre- and post-1996) based on the hypothesis that changes in survey gear between the two periods would affect estimates of fish growth based on survey data (Goethel et al. 2021). In B.C., Cox et al. (2023) restricted samples to those collected using longline trap gear deployed during the offshore Sablefish Stratified Random Sampling (StRS) survey to maintain consistency in gear and survey design over time. However, limiting samples to one gear type may have inherent disadvantages such as including too few fish with small body sizes because of gear selectivity.

Several other factors are also known to influence life history estimates over time and location. Observation error or bias can arise from age-determination methods and / or macroscopic maturity assignments (e.g., Rodgveller et al. 2016), while latitude, environmental conditions, and intra-specific competition have all been hypothesized to contribute to regional and temporal variation in underlying life history relationships for Sablefish (Head et al. 2014, Gertseva et al. 2017, Kapur et al. 2020, Cheng et al. 2024). Kapur et al. (2020) documented growth zonation for Sablefish based on oceanographic influences, with a boundary between northern and southern BC associated with the bifurcation of the North Pacific Current at an approximate latitude of 50°N. Sablefish north of this latitude tended to have a larger length-at-age than those to the south of it. In addition, Sablefish populations in both Alaska and off the US West coast have exhibited recent declines in growth or periods of below-average weight-at-age (Cheng et al. 2024; Wetzel et al. 2025), leading us to question whether there is similar evidence for B.C. Sablefish. In the case of Alaska, Cheng et al. (2024) hypothesized that recent declines in growth were due to increased density-dependence after several years of large recruitment events starting in 2014. Their analysis illustrated the importance of accounting for cohort effects on growth processes in Sablefish stock assessment. Such reductions in growth can also lead to changes in size- and age-at-maturity for marine fish species (Lorenzen 2008), so we consider the potential for decline in MAA as well.

In this report, we update biological data sets and estimated life history relationships for B.C. Sablefish using 10 additional years of data accumulated between 2015 and 2024. We also consider the impact of alternative data selection rules to see how data source affects the estimated life history relationships. Given the amount of new data available, we also reassess the credibility of B.C. life history parameter estimates by comparison to recent estimates from U.S. stock assessments. Finally, we look for evidence of spatial and temporal differences in life history relationships for the B.C. Sablefish population which, like the Alaskan population, experienced several large recruitment events between 2015 and 2017.

Objectives for this report include:

1. update Sablefish age-composition data and associated ageing error matrices to the end of 2024 (Section 2);
2. update Sablefish biological data sets needed for life history analyses using data up to the end of 2024 (Section 3);
3. evaluate the impact of data selection criteria on estimated life history relationships (Section 3);
4. compare parameter estimates for B.C. with those from adjacent management regions in Alaska and off the U.S. west coast (Section 3);
5. compare updated life history analyses with assumptions applied by Johnson et al. (2025);
6. investigate changes in life history relationships over time (Section 3);
7. investigate differences in life history relationships between northern and southern BC, as well as whether changes in relationships over time are consistent among both areas (Section 3); and
8. recommend parameterizations of life history models for the next revision to the Sablefish OM planned for 2026 (Section 4).

2 AGE COMPOSITION DATA

2.1 DATA SOURCES

The Sablefish OM is fit to age composition by sex from both survey and commercial fishery sources. Age composition data are derived from sampled otoliths, which are paired calcium carbonate structures extracted from inside the head of the fish. Highly trained age readers in the Sclerochronology Lab (SCL) at DFO's Pacific Biological Station (PBS) estimate Sablefish age by counting the annuli (annual rings) exposed on otoliths when following the 'break and burn' method (Chilton and Beamish 1982; Hanselman et al. 2012).

The annual Sablefish Research and Assessment Survey is a key source of age composition data (Lacko et al., 2026). This survey is conducted collaboratively by the Department of Fisheries and Oceans Canada (DFO) and the Canadian Sablefish Association (CSA) using longline trap gear. The components of the survey have evolved over time by discontinuing or adjusting some components and introducing new research (Wyeth et al. 2004, Wyeth et al. 2007, Lacko et al. 2026). The four components are:

a) StRS - offshore stratified random sampling survey indexing sets conducted in five spatial strata and three depth strata (2003–present) that also allows for randomly distributed releases of tagged Sablefish.

b) Offshore Std - offshore standardized survey indexing sets conducted at nine offshore indexing localities distributed coastwide (1988–2010),

c) Tagging - traditional tagging sets conducted at 13 offshore tagging localities that differed in location from the indexing localities used for the Offshore Std survey (1991–2007),

d) Inlet Std - standardized survey indexing sets conducted at four mainland inlet localities (1994 -present), and

In this report, we update data from the offshore StRS survey component to 2024. At the time of the 2022 OM update (Johnson et al. 2025), StRS survey age composition data were available from 2003 to 2021.

Biological samples from commercial longline fisheries, including longline trap and longline hook and line (H&L) gear, come from a voluntary commercial catch sampling program supported by the Sablefish fishing industry (Lacko et al. 2023). In 2022, age composition data from the Sablefish trap fishery were available from 1982 to 2017. We update this data set to the end of 2024. We also present age composition data for 1992 to 2024 derived from the Sablefish H&L fishery. These data have not been used to fit the Sablefish OM but will be considered in the future.

There are two additional sources of compositional data input to the OM that are not updated in 2025, and therefore, not shown in this report: historical age composition data derived from the offshore standardized survey, which ran from 1988 – 2010 (Cox et al. 2023) and length composition data from the commercial trawl fishery (1970–2019). The offshore standardized survey was suspended after 2010 and length-composition data from the trawl fishery are not available since the replacement of trawl fishery at-sea observers by at-sea electronic video monitoring in 2020 (Johnson et al. 2025).

Biological data collected by fishery-independent trawl surveys are also available for Sablefish (Nottingham et al. 2018, Williams et al. 2020, Anderson and Dunic 2025). Length, weight, and maturity observations were collected. Some otolith samples were also collected; however, these samples have not been routinely analysed for age, which limits applications to LAA and MAA analyses. These data are used in WL analyses presented below.

2.2 AGE COMPOSITION PLOTS

Annual distributions of age estimates show the progression of several strong cohorts over time from 2003 to 2024 (Figure 1 - Figure 3). During this period, dominant Sablefish cohorts usually started to appear in age composition data around age 3 or 4 and typically remained detectable for 3 to 8 years until the emergence of a new dominant year cohort. It remains to be seen how long the 2016 cohort will remain dominant. Given its estimated magnitude, it may persist as a detectable signal longer than is typical for strong cohorts.

Patterns of dominant cohorts are generally consistent between females and males in the StRS survey data, although slight deviations do occur for some years (Figure 1). Strong incoming cohorts tend to appear earlier for females than males, consistent with the larger estimated size of age-3 females and trap gear selectivity. The most recent large recruitment event emerged as age-3 fish starting in 2019 for both females and males (i.e., cohort year = 2016). This cohort continued to dominate annual age composition data through to 2024, at which time they were 8 years old.

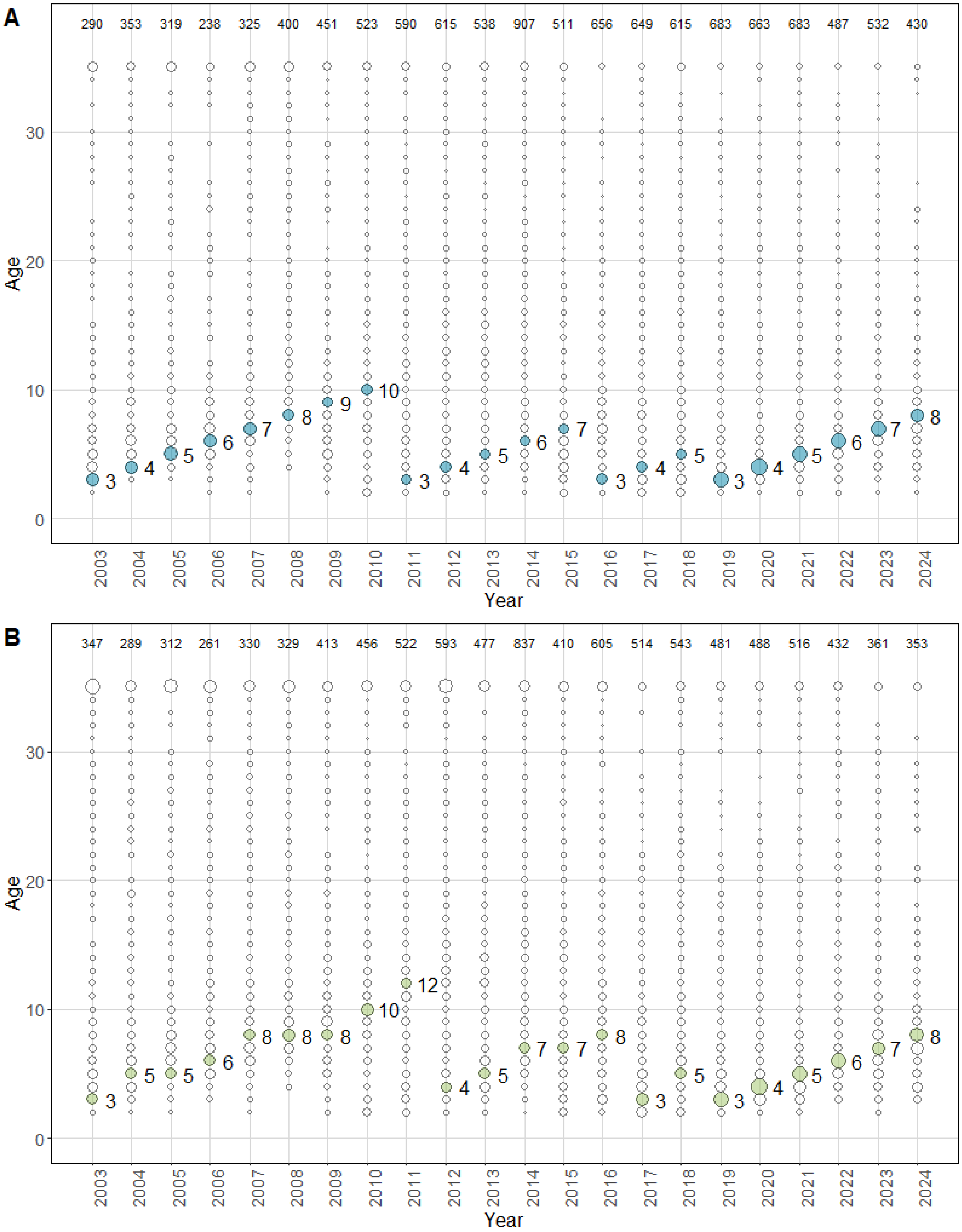

Figure 1. Bubble plot for female (A) and male (B) Sablefish ages by year from the StRS survey. The area of the circles is proportional to the number of ages. Fish age 35 and older are included in one bubble (the plus group). The total number of fish aged are listed across the top of each panel. The age with the highest frequency in a given year is printed to the right of the corresponding bubble.

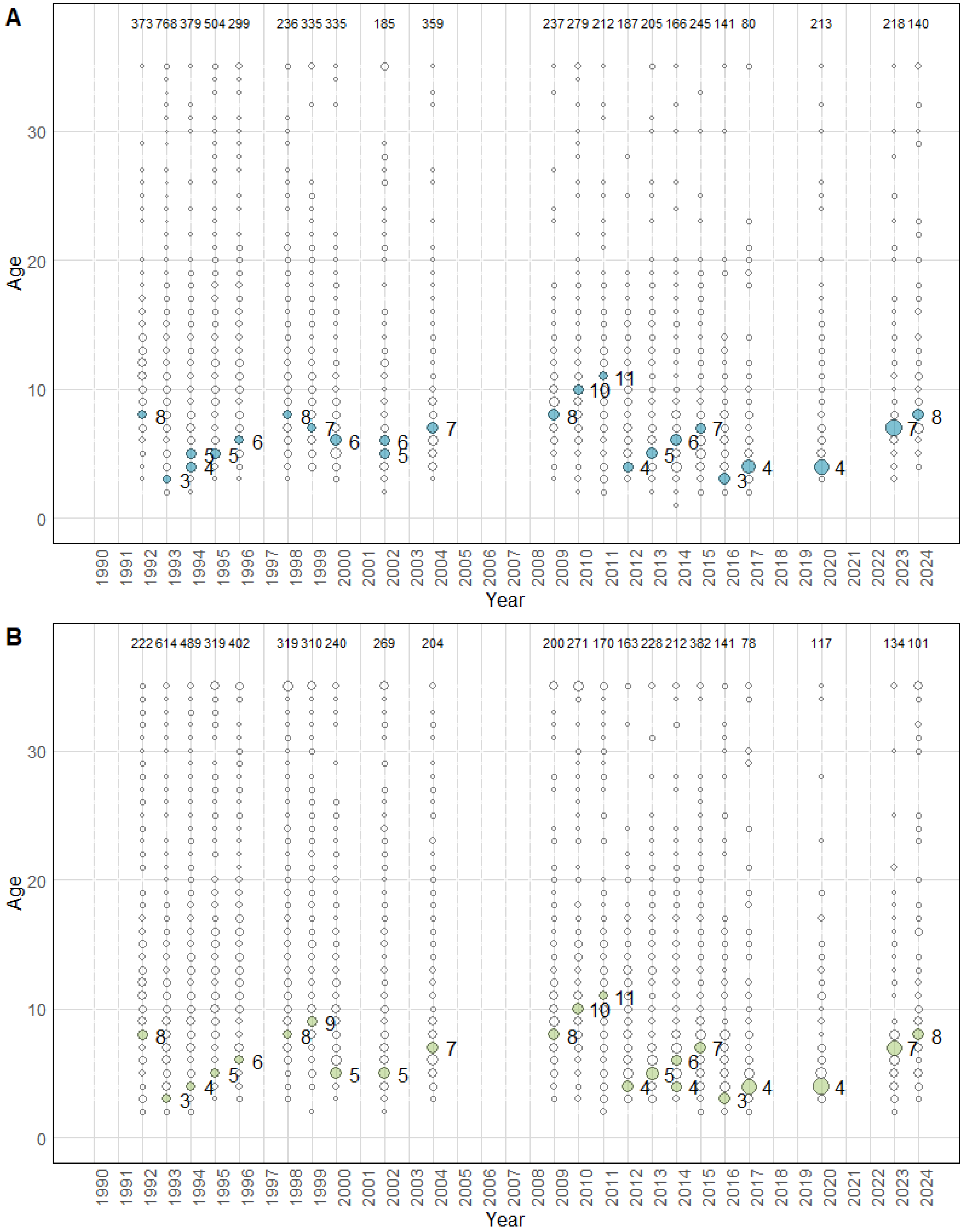

Figure 2. Bubble plot for female (A) and male (B) Sablefish ages by year from the trap fishery. The area of the circles is proportional to the number of ages. Fish age 35 and older are included in one bubble (the plus group). The total number of fish aged is listed across the top of each panel. The age with the highest frequency in a given year is printed to the right of the corresponding bubble.

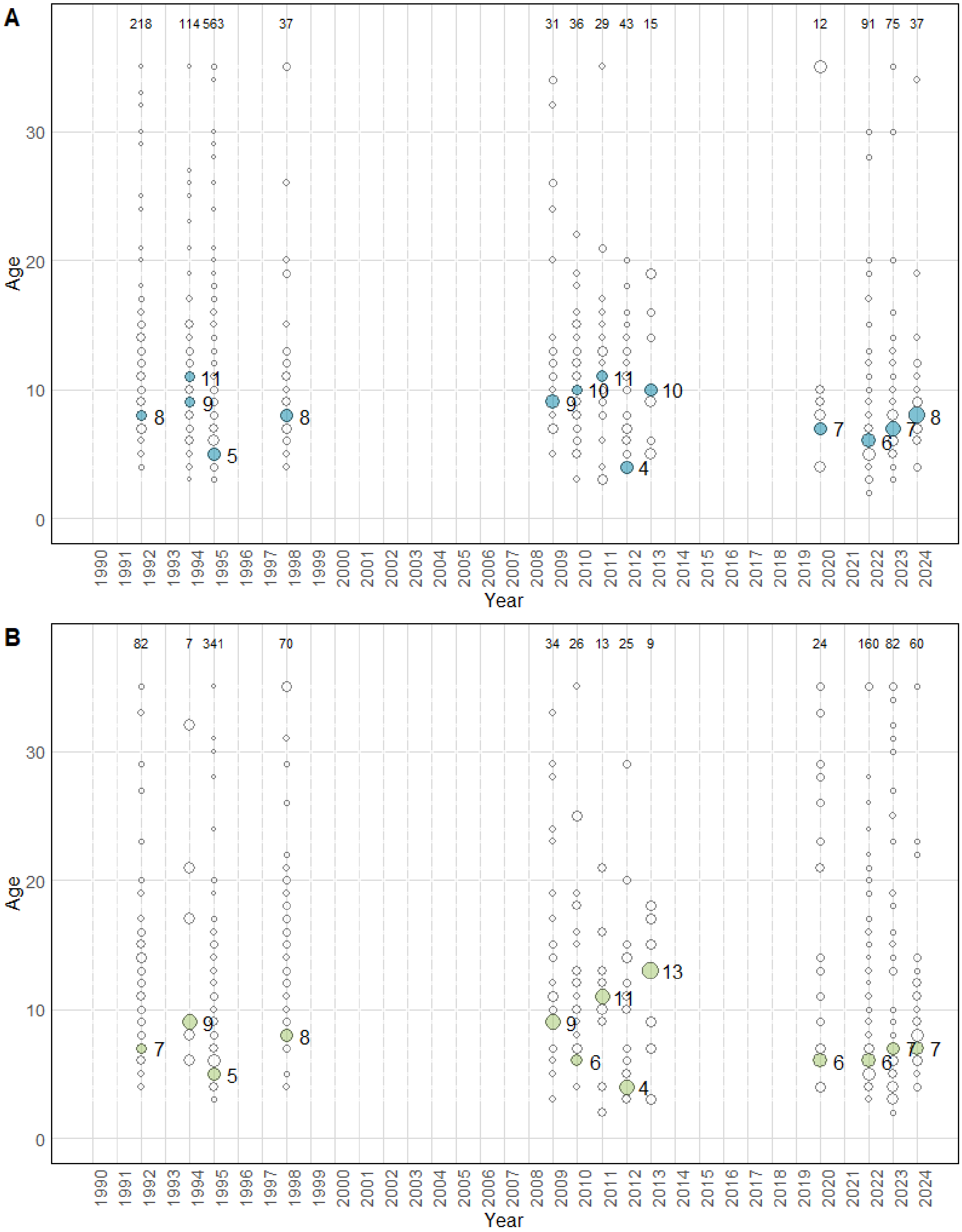

Figure 3. Bubble plot for female (A) and male (B) Sablefish ages by year from the longline hook fishery. The area of the circles is proportional to the number of ages. Fish age 35 and older are included in one bubble (the plus group). The total number of fish aged are listed across the top of each panel. The age with the highest frequency in a given year is printed to the right of the corresponding bubble.

Age composition data from the Sablefish trap fishery are available for 22 of the 33 years between 1992 and 2024 (Figure 2). The number of aged fish available in each year is greater than 100 for each sex in all but one year, and more often greater than 150–200 per sex. The number of available ages are generally higher prior to 2015 compared to recent years, due to reduction in the availability of age-reading resources rather than the availability of otoliths. The patterns of large cohorts moving through the trap fishery are synchronous with those seen in the StRS survey age composition data, but with higher variability. The increased variability is likely due to smaller sample sizes, but may also reflect differences in fishing locations and temporal variation from year-round operations. Large cohorts typically start to dominate the commercial trap catch around ages 3 or 4. Fewer observations are available for the most recent large 2016 cohort, which has only been observed in the trap fishery in 2020, 2023, and 2024 (no trap fishery otoliths were aged from 2021 or 2022).

Age composition data from the longline hook fishery are more limited than longline trap fishery data, with age composition data only available in 13 of the 33 years between 1992 and 2024 (Figure 3). Annual sex-specific numbers of aged otoliths are small in several of those years (e.g., < 45 age estimates per sex). The most recent large 2016 cohort seen in StRS survey and trap fishery age composition data appears in longline hook gear samples in 2022, 2023, and 2024.

2.3 AGEING ERROR MATRIX

The Sablefish OM uses an ageing error matrix to represent uncertainty in age composition data arising from among age-reader error (DFO 2020, Johnson et al. 2025). An ageing error matrix for B.C. Sablefish was last updated in 2019 using double-read data collected by the SCL up to 2017 (DFO 2020).

We used the same analytical methodology as DFO (2020), but with a change to data selection criteria used to extract double-read data from DFO's GFBioSQL database maintained by staff at the Pacific Biological Station, Nanaimo, B.C. Double-read otoliths are those that have been aged by two different age readers. For the current analysis, we only used double-read otoliths for which the second reader was blind to the age assigned by the first reader. Specifically, when selecting double-read estimates from the database, we required sampled specimens to have an estimate with `AGE_READING_TYPE_DESC` = 'Primary' and an estimate with `AGE_READING_TYPE_DESC` = 'Precision Test'. In contrast, the data set used by DFO (2020) was selected using the criteria `AGE_READING_TYPE_DESC` = 'Primary' and `AGE_READING_TYPE_DESC` = 'Secondary'. Only the 'Precision Test' estimates provide an independent blind read of an otolith by a second age reader. In comparison, 'Secondary' estimates are those for which the second reader is aware of the Primary age estimate and is doing a second reading for quality control (Audrey Ty, SCL, PBS, pers. comm., 2025). For cases where age estimates differ between readers, regardless of whether the second read was a 'Precision Test' or a 'Secondary' estimate, both readers confer to resolve the discrepancy and agree on a 'Final' assigned age. Final ages are recorded in GFBioSQL as `AGE_READING_TYPE_DESC` = 'Final'.

Using the updated data selection rules, 5,180 double-read Sablefish otoliths were available from fishery and research data sources between 2001 and 2024, which accounted for 14.6% of aged otoliths during this period. Both readers assigned the same age in 36% of cases, were within one year of each other for 65% of cases, and were within 2 years of each other for 80% of cases.

An updated ageing error matrix was estimated using the methods and code developed in 2019 (DFO 2020), with code provided by one of the contributors to the 2020 report (Sam Johnson, Landmark Consulting, pers. comm., 2025). The methodology is based on methods originally described in Richards et al. (1992) and Heifetz et al. (1999). We use the same equations and model notation as DFO (2020) when describing the method here.

Ageing error was characterized using a discretized normal distribution, with error assumed to be, on average, unbiased. The probability of observing an age class *a* based on a true age *b* was assumed to follow a normal distribution centered on *b*. The estimated standard deviation of the observed age for true age *b*, $\sigma(b)$, was based on three parameters, $\Phi = \{\sigma_1, \sigma_A, \alpha\}$, as follows:

$$\sigma(b) = \begin{cases} \sigma_1 + (\sigma_A - \sigma_1)\frac{1-e^{-\alpha(b-1)}}{1-e^{-\alpha(A-1)}}, & \alpha \neq 0 \\ \sigma_1 + (\sigma_A - \sigma_1)\frac{b-1}{A-1}, & \alpha = 0 \end{cases} \tag{1}$$

where, σ_1 and σ_A are the standard deviation for *b* = 1 and *b* = A, which represent the minimum and maximum ages, respectively, and the α parameter determines the degree of non-linearity of the function with $\sigma(b)$ becoming more linear as $\alpha \rightarrow 0$.

The ageing error matrix that represents the probability of mis-classifying the age of *a* fish at a given true age *b* into another age class *a* was defined as:

$$q(a|b,\Phi) = \frac{x_{ab}(\Phi)}{\sum_{a=1}^{A} x_{ab}(\Phi)}; \tag{2}$$

$$x_{ab} = \frac{1}{\sqrt{2\pi}\sigma(b)} e^{-\frac{1}{2}\left[\frac{a-b}{\sigma(b)}\right]^2}. \tag{3}$$

The likelihood $\mathcal{L}$ of observed ages *A* given true ages *B* was then defined as:

$$\mathcal{L}(A|B) = \prod_{i=1}^{I} \prod_{j=2}^{J} q\left(a_{ij}|b_i\Phi\right), \tag{4}$$

where, b_i is the assumed 'true age' of fish *i* and a_{ij} is the age assigned by reader *j* to individual fish *i*.

The true age of a fish is not known in the double-read dataset, making it necessary to assume a 'true age' when characterizing ageing error using equations 1–4. We followed DFO (2020) by considering two different approaches for assuming a true age. The first approach was to use the 'Final Age' assigned to each specimen in the GFBio database, which is the agreed upon age assigned by both readers after a discussion of any difference. The second approach was to use the 'Mean Age' of the two age estimates from each reader rounded to the nearest integer.

Maximum likelihood parameter estimates for $\Phi = \{\sigma_1, \sigma_A, \alpha\}$ are provided in Table 1, estimated standard deviation $\sigma(b)$ as a function of true age is shown in Figure 4, and the resulting probability of observed ages for each 'true age' (i.e., the ageing error matrix) is shown in Figure 5. For the case in which true age was set at the mean of the two reader ages, $\sigma(b)$ had a slight curvilinear response to true age with the ratio of $\sigma(b)$ to true age (i.e., the CV) becoming progressively smaller at higher ages (Figure 4). In contrast, when true age was set to the final age estimate, $\sigma(b)$ was more linearly related to the true age with the ratio of $\sigma(b)$ to true age relatively stable between 11-13% after age 20 (Figure 4).

Table 1. Ageing error model parameters for the 'Mean Age' and 'Final Age' cases. Parameters used to characterize ageing error include σ_1 and σ_A, which are the standard deviation for true age = 1 and true age = maximum age, respectively, and α, which determines the degree of non-linearity of the function.

Case	**True Age**	**σ_1**	**σ_A**	**α**
1	Mean Reader Age	0.38	6.87	0.0100
2	Final Age Assigned	0.66	10.12	0.0006

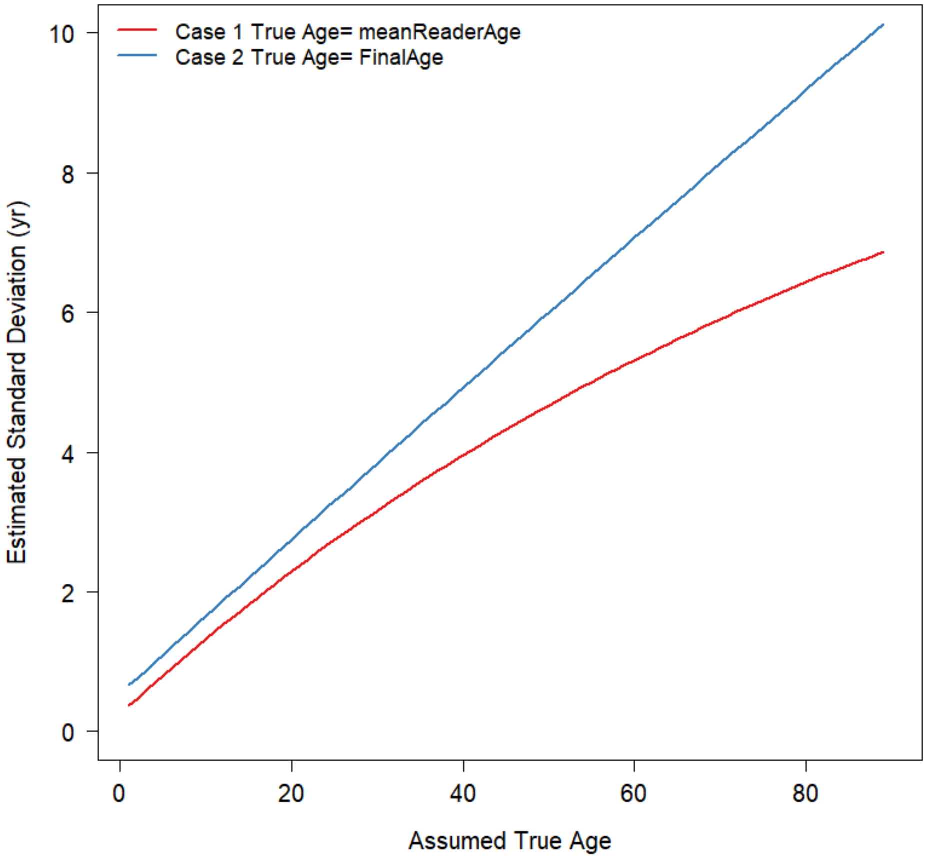

Figure 4. Estimated standard deviation of observed ages for the two age assignment cases considered when developing ageing error matrices.

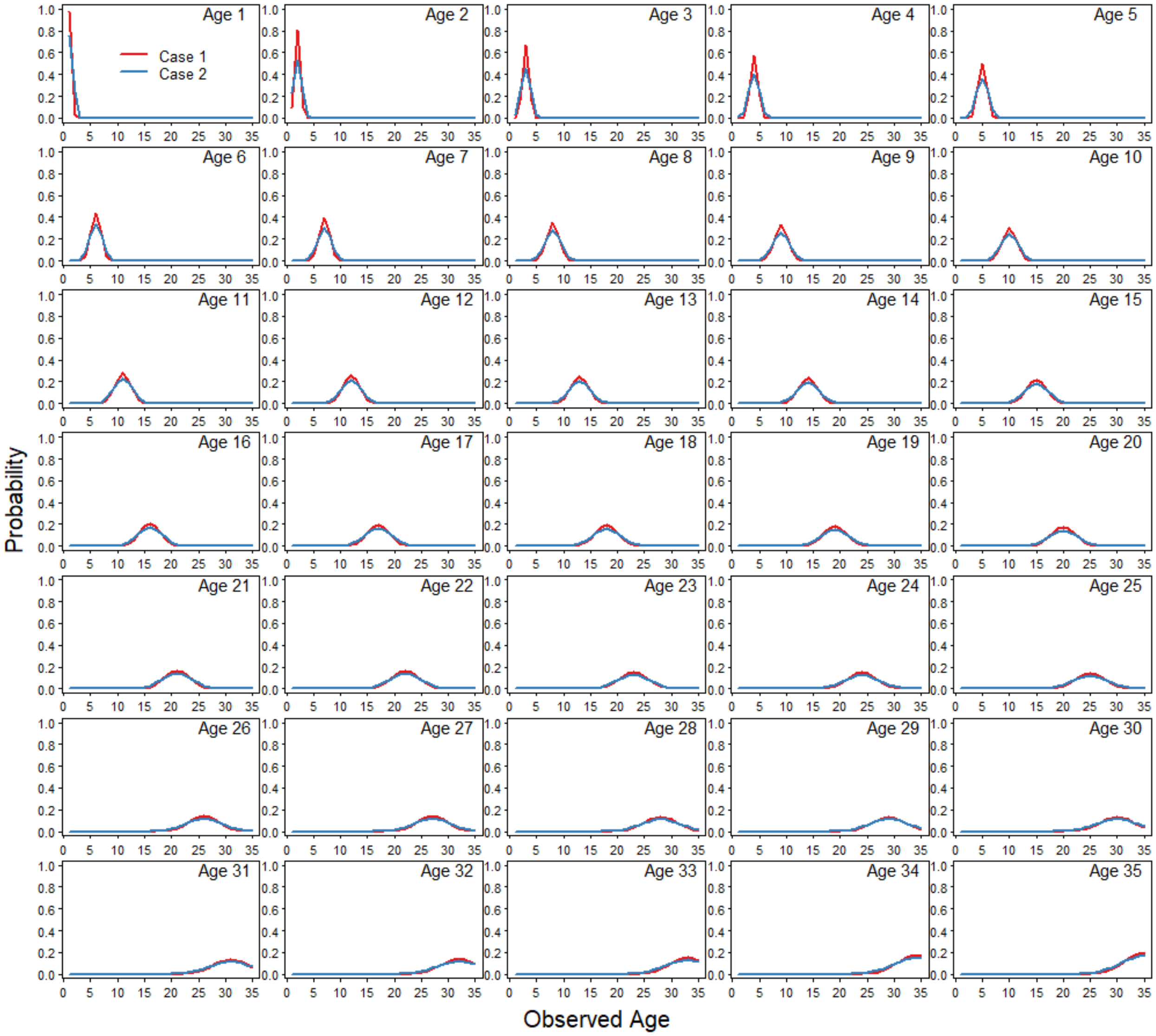

Figure 5. Probability of observed ages given the true age indicated in top right corner of each panel for the two age assignment cases considered.

3 LIFE HISTORY ANALYSES

A summary of data sources and model formulations for each of the three types of life history analyses is provided in Table 2. A detailed description of each analysis is provided below.

Table 2. Overview of life history analyses presented in this report, including model formulation and data set used, as well as indicators of whether temporal trends were examined across cohorts (i.e., by years, or multi-year bins) and / or a within cohorts (indicated with an 'X').

Type of Analysis	Model	Data source	Across Cohort	Within Cohort
Length-at-age	Standard von Bertalanffy	StRS (2003–2024)	X	X
		All Research (1978–2024)	-	-
	Fixed L1 von Bertalanffy	StRS (2003–2024)	X	X
		All Research (1978–2024)	-	-
Weight-Length	Linear regression	StRS (2003–2024)	X	X
		All Research (1978–2024)	-	-
Maturity-at-age	Logistic regression	StRS (2003–2024)	X	X
		All Research (1978–2024)	-	-
	Smoothing spline	StRS (2003–2024)	-	-
		All Research (1978–2024)	-	-

3.1 DATA SOURCES

Measurements of individual Sablefish length, weight, sex, maturity stage, and age are available from multiple fishery and research survey data sources over time (Appendix, Table A - 1 and Table A - 2). Summaries of biological characteristics (length, weight, age, sex ratio) for different data sources are listed in Table 3 and Table 4.

Only research samples were used for conducting life history analyses. Most Sablefish research samples come from the annual Sablefish Research and Assessment Program described above in Section 2.1. Limited biological samples have been collected from various multi-species research surveys undertaken by DFO over the years using a range of gear types including groundfish bottom trawl, midwater trawl, longline hook, and shrimp bottom trawl.

In this report, we use two different data selection methods when fitting life history models to research data.

1) 'StRS': Offshore StRS survey data only (2003–2024), and
2) 'All Research': Research data collected by all available gear types, including StRS data (1978–2024).

Sample sizes by year and research survey are shown in the Appendix for each of the three types of life history analyses (Table A - 3 to Table A - 5). Analyses of temporal changes in life history model fits are limited to the StRS survey data to reduce the potential for confounding effects due to different gear types being used in different years.

Table 3. Summary of sampled measurements from all research survey data sources, combined over years. Ranges shown are based on the 1st and 99th percentiles. Length is in cm and weight in in kg.

Research Data Source	Mean Age (+ Range)	Mean Length (+ Range)	Mean Weight (+ Range)	Proportion Female
Sablefish Inlet Std	5 (2, 16)	58.3 (44.2, 77.8)	2.28 (0.81, 5.71)	0.68
Sablefish Off. Std	14 (2, 55)	63.7 (48.3, 85.2)	2.85 (1.09, 6.29)	0.55
Sablefish StRS	13 (2, 62)	60.3 (45.5, 82.0)	2.63 (0.89, 6.58)	0.53
Sablefish Tagging	13 (3, 49)	62.5 (49.2, 83.2)	2.62 (1.23, 5.75)	0.48
Bottom Trawl	7 (0, 34)	48.0 (26.0, 76.0)	1.51 (0.24, 5.56)	0.40
Midwater Trawl	-	48.8 (31.4, 75.0)	0.98 (0.07, 2.64)	0.44
Shrimp Trawl	-	38.7 (27.0, 57.0)	0.53 (0.18, 1.62)	0.50
Gillnet	20 (9, 36)	70.0 (58.7, 86.8)	-	0.48
Longline	14 (3, 32)	62.9 (38.0, 89.3)	0.75 (0.33, 1.90)	0.52
Other Trap	11 (2, 39)	62.7 (44.6, 87.7)	3.0 (0.81, 7.55)	0.62

Table 4. Summary of sampled measurements from fishery data sources, combined over years. Ranges shown are based on the 1st and 99th percentiles. Length is in cm and weight in in kg.

Fishery Data Source	Mean Age (+ Range)	Mean Length (+ Range)	Mean Weight (+ Range)	Proportion Female
Sablefish Trap	12 (3, 45)	64.9 (47.0, 84.0)	2.68 (0.99, 5.63)	0.42
Hook and Line	10 (3, 40)	66.2 (49.0, 90.0)	3.01 (1.11, 7.38)	0.54
Bottom Trawl	8 (1, 52)	46.5 (25.0, 77.0)	1.11 (0.45, 2.01)	0.47
Midwater Trawl	-	49.4 (38.6, 59.8)	-	0.58

3.2 LENGTH-AT-AGE

3.2.1 Methods

Two different formulations of the von Bertalanffy LAA growth model were used to characterize sex-specific mean length-at-age. For the ‘Standard’ formulation the estimated length of a fish at age a from sex s ($\hat{L}_{a,s}$) was modelled as:

$$\hat{L}_{a,s} = L_{\infty_s}\left(1 - e^{-k_s\left(a - t_{0_s}\right)}\right) \ , \tag{5}$$

where, $L_{\infty,s}$ is the asymptotic length, k_s is the average growth rate coefficient, and t_{0_s} represents theoretical age when the average length would be zero (i.e., the x-intercept). All three von Bertalanffy parameters ($L_{\infty,s}$, k_s, t_{0_s}) were estimated by fitting this model to available length-age pairs for each sex. For each data set examined, all available pairs of length and age observations were pooled by sex; separate models were not fit by year, gear, or survey series.

Ages were adjusted by incrementing the assigned age by the fraction of the calendar year elapsed since January 1 at the time of capture. For example, a fish assigned to age 3 that was sampled on October 1 is assigned an age of 3.77 years. This approach allowed us to account for differences in the timing of sample collection among gear types. This adjustment is particularly relevant for ages drawn from the Sablefish surveys (e.g., StRS, Offshore Std. Inlet Std.) which occur in October and November after the summer growth period.

As previously noted for B.C. Sablefish, fitting the ‘Standard’ formulation to StRS survey data produced estimated lengths at age 1, L_1, that were higher than expected based on direct observations of age-1 Sablefish (Table 5, Cox et al. 2023). Consequently, we also considered the approach of Cox et al. (2023) by fixing the L_1 parameter at a specific value and applying an alternative formulation of the von Bertalanffy growth model:

$$\hat{L}_{a,s} = L_{\infty,s} + \left(L_{1,s} - L_{\infty,s}\right)e^{-k_s(a-1)} \ . \tag{6}$$

We refer to this model as the 'Fixed L_1' formulation. Only $L_{\infty,s}$ and k_s are estimated using the 'Fixed L_1' formulation; $L_{1,s}$ was set to 32.5 cm fork length for both male and female Sablefish.

The choice of $L_{1,s}$ = 32.5 cm is based on observed size of age-0+ to age-2 fish. For example, McFarlane and Beamish (1983) noted the remarkable growth of Sablefish in their first year based on observations from the large 1977 year class in B.C. Age 0+ fish from the 1977 year class averaged 28 cm fork length by the end of November and 31 to 33 cm for length by the following spring at age 1+. By September, year 1+ Sablefish from the 1977 year class averaged 37 cm fork length and averaged 40 cm fork length by November near the end of their second year of growth. Using more recent data for B.C., we found that Sablefish of age 1+ collected from our annual fall trap survey averaged 45.8 cm over the last 10 years. Because these fish were collected in October–November, they were closer in size to an age-2+ fish early in its third year of life. In comparison, age 1+ Sablefish collected from B.C. trawl surveys during summer months (June–Sept, ages 1.43–1.77) had an average size of 36.6 cm. For the US west coast trawl survey, length-at-age 1 was reported as 38.4 cm at age 1.66 in August for both sexes (Schirripa 2007). Length-at-age 1 reported in the literature for Gulf of Alaska Sablefish ranges from 31 to 39 cm fork length (Sigler et al. 2001), with fish of age 2 averaging fork lengths of 48.1 cm for males and 46.8 cm for females (Hanselman et al. 2009). Our assumption that a Sablefish would be 32.5cm at age 1.0 seems reasonable based on the above range of observations.

Both model formulations were implemented using Template Model Builder (TMB; Kristensen et al. 2016) assuming a normal log likelihood function. A coefficient of variation of length-at-age for each sex (CV_s) was also estimated during model fitting.

We looked for evidence of temporal trends in LAA relationships in two ways:

1. across cohorts: length-age observations from all sampled age classes within each year, or when necessary, by pooled years; and
2. within cohort: length-age observations selected by individual cohorts.

When fitting the Standard three parameter von Bertalanffy LAA models it was necessary to pool data over three-year time blocks instead of fitting individual years to ensure stable fits (e.g., 2004–2006, 2007–2009, etc.). When shorter or annual time periods were used, model fits appeared spurious, often with unrealistically high estimates of lengths at young ages. For the 'Fixed L_1' model, which estimates only two parameters, it was possible to fit the model to individual years (e.g., 2003, 2004, 2005, etc.).

Fitting LAA models to data from individual age cohorts was only possible for the 'Fixed L_1' model; the Standard model did not produce reliable fits when applied to individual cohorts. Since more recent cohorts are dominated by younger age classes, we used a retrospective sensitivity analysis to test the effect of maximum age on estimates of L_∞ and k for the 'Fixed L_1' LAA model. For cohorts 2000 to 2012, we fit the 'Fixed L_1' model using a series of maximum ages ranging from 8 to 20 (i.e., length-age pairs with ages greater than the maximum age were not included in the model fitting for sensitivity tests).

Our initial inspection of results for the Fixed L_1 model fit to individual cohorts showed unrealistically high estimates of the growth rate, k, for some cohorts. Estimates were greater than 0.80 for some cohorts, which is well above the long-term average estimated for B.C. as well as Sablefish in other regions (see Section 3.2.2). To test if the magnitude of changes in L_∞

over cohorts was robust to assumptions about *k*, we also fit a version of the 'Fixed L_1' model to cohort-level data in which we fixed the *k* parameter at the long-term constant value estimated using all StRS (i.e., the StRS: Fixed L_1 combination in Table 5; male *k* = 0.344, female *k* = 0.420). We refer to this version as the 'Fixed L_1+k' model.

Previous research has shown that Sablefish found north of where the North Pacific Current splits grow differently (length at age) than fish found to the south (Kapur et al. 2020). To check whether this pattern holds, we fit separate Standard and Fixed L1 growth models to length-at-age data from fish collected north and south of 50°N latitude (Figure 6), which is near where the North Pacific current bifurcates. We then assessed whether the cohort patterns observed in the coastwide analysis were similar between the northern and southern areas when the data were analysed at this finer regional scale. As in the coastwide analysis, we used only StRS survey data with the Fixed L1 model when evaluating differences among cohorts.

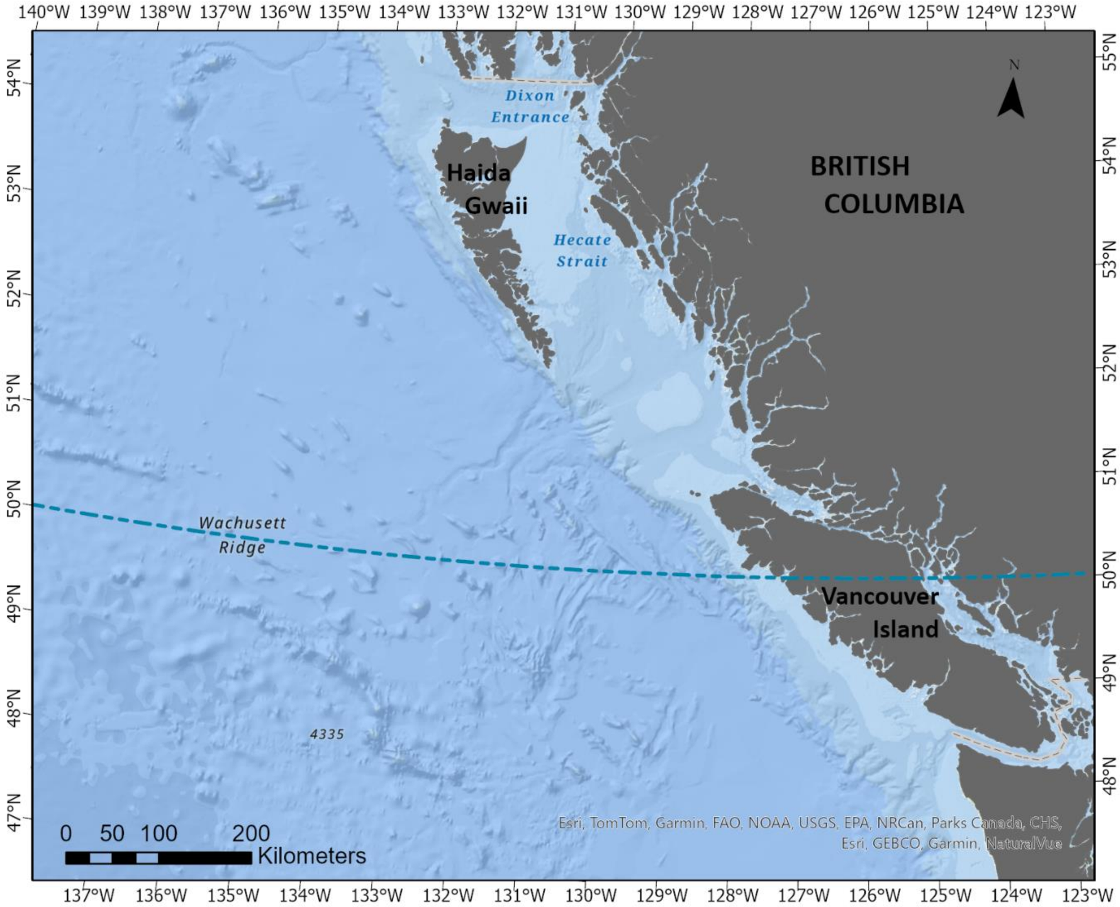

Figure 6. Map of the B.C. coast showing the location of the geographic breakpoint at 50°N used to delineate northern and southern regions when looking at spatial variation in life history relationships.

3.2.2 Results

When 'All Research' data were used, estimated LAA relationships were similar for the 'Standard' and 'Fixed L_1' models (Figure 7, Table 5). Using this data source, estimates of L_1

from the ‘Standard’ model were close to the assumed value of 32.5 cm used for the ‘Fixed L_1’ model, and sex-specific estimates of L_∞ and k are similar for both model types.

Estimated LAA relationships from Standard and Fixed L_1 models differ more from each other when only StRS survey data were used than they do when ‘All Research’ data were used. Differences are most noticeable at young ages (Figure 7, Table 5).

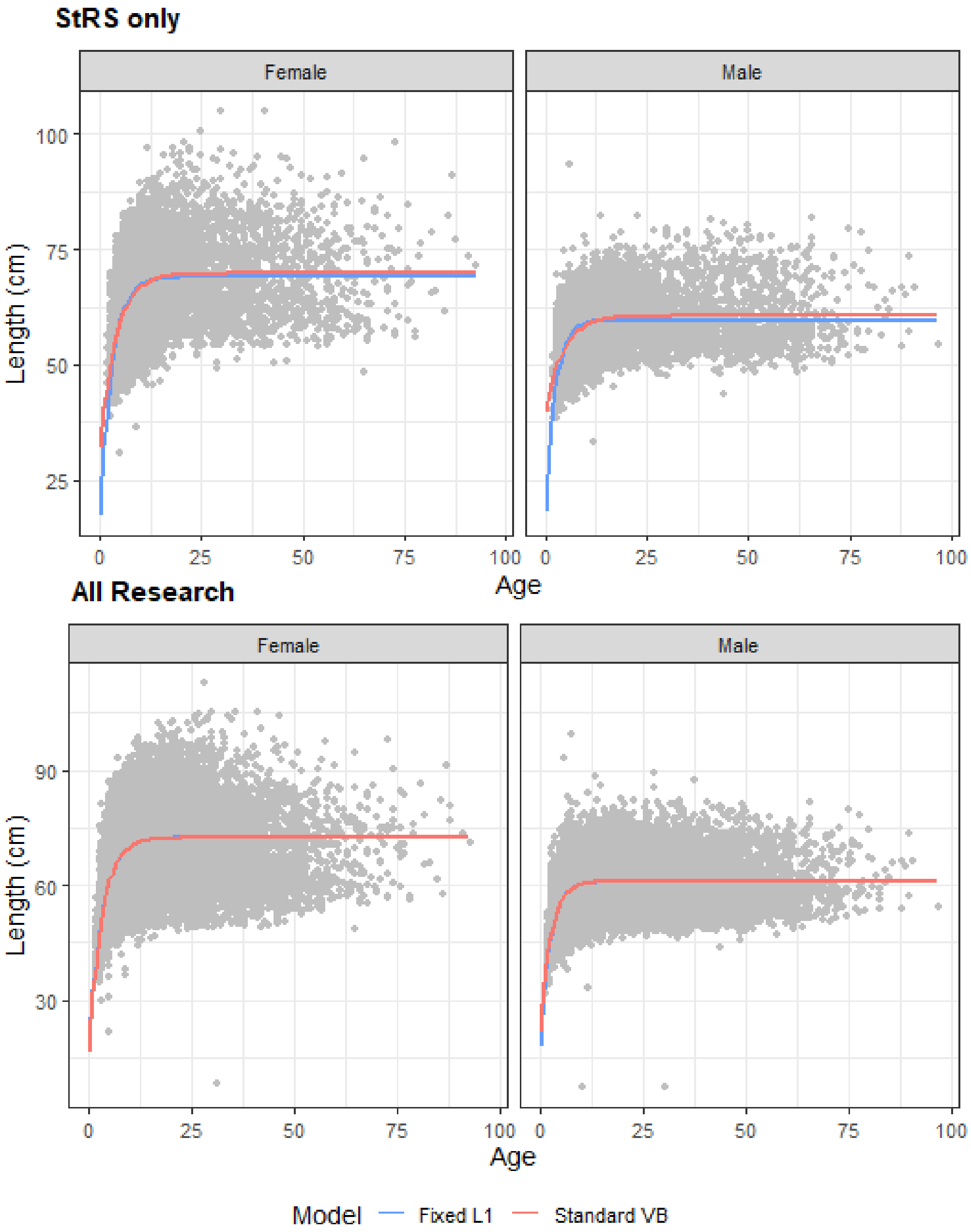

Figure 7. Estimated length-at-age relationships for Sablefish by sex (female or male), data source (StRS vs. All Research), and model formulation (Standard VonB vs. Fixed L1). Grey dots show individual observations used to fit each model.

*Table 5. Estimated parameters (and standard error) for length-at-age models, by data source, model formulation, and sex. L_∞ is the asymptotic length (cm), k is the growth rate coefficient, t_0 is the theoretical age when length is zero, and L_1 is the length at age 1 (cm). The asterisk * indicates L_1 values that were fixed. The sample size (N) and range of data years for each analysis are also shown.*

a) Male

Data Source	N	Model	Data years	L_∞	k	t_0	L_1	CV
StRS	9,859	Standard	2003–2024	60.54 (0.10)	0.235 (0.009)	-4.55 (0.31)	44.13 (0.47)	0.092 (0.0006)
		Fixed L1	2003–2024	59.69 (0.08)	0.420 (0.006)	-	32.5*	0.092 (0.0007)
All Research	28,660	Standard	1978–2024	60.99 (0.05)	0.394 (0.006)	-1.12 (0.07)	34.49 (0.44)	0.094 (00004)
		Fixed L1	1978–2024	60.95 (0.05)	0.419 (0.003)	-	32.5*	

b) Female

Data Source	N	Model	Data years	L_∞	k	t_0	L_1	CV
StRS	11,447	Standard	2003–2024	69.68 (0.15)	0.262 (0.008)	-2.34 (0.18)	40.70 (0.69)	0.115 (0.0008)
		Fixed L1	2003–2024	68.95 (0.12)	0.344 (0.004)	-	32.5*	0.115 (0.0008)
All Research	37,544	Standard	1978–2024	72.32 (0.08)	0.327 (0.004)	-0.79 (0.05)	31.98 (0.43)	0.114 (0.0004)
		Fixed L1	1978–2024	72.36 (0.07)	0.323 (0.002)	-	32.5*	0.114 (0.0004)

Table 6. Comparison of estimated length-at-age model parameters from recent stock assessments. See Table 10 for parameter definitions. Note that t_0 is not shown for B.C. assessment because the Fixed L_1 model was used with L_1 fixed at 32.5cm.

a) Male

Region	L_∞	k	t_0	Source	Notes
Alaska	67.9	0.230	3.30	Goethel et al. 2021	Used for years 1996+
B.C.	68.0	0.290	-	Cox et al. 2023	Assumed relationship, not estimated directly from data
US West Coast	57.0	0.410	0 (fixed)	Haltuch et al. 2019	

b) Female

Region	L_∞	k	t_0	Source	Notes
Alaska	81.2	0.170	3.28	Goethel et al. 2021	Used for years 1996+
B.C.	72.0	0.250	-	Cox et al. 2023	Assumed relationship, not estimated directly from data
US West Coast	64.0	0.320	0 (fixed)	Haltuch et al. 2019	

LAA parameter estimates for the ‘StRS: Fixed L_1’ combination are similar to those obtained from both the ‘All Research: Standard’ and ‘All Research: Fixed L_1‘ combinations. In contrast, the ‘StRS: Standard’ combination resulted in *k* and L_1 estimates that differed from estimated or assumed values under all other combinations (Table 5, Figure 8). The ‘StRS: Standard’ combination produced a *k* parameter estimate lower than the other three combinations, and an L_1 estimate that was > 10cm higher than the assumed value of 32.5 cm for the ‘Fixed L_1’ models (Table 5).

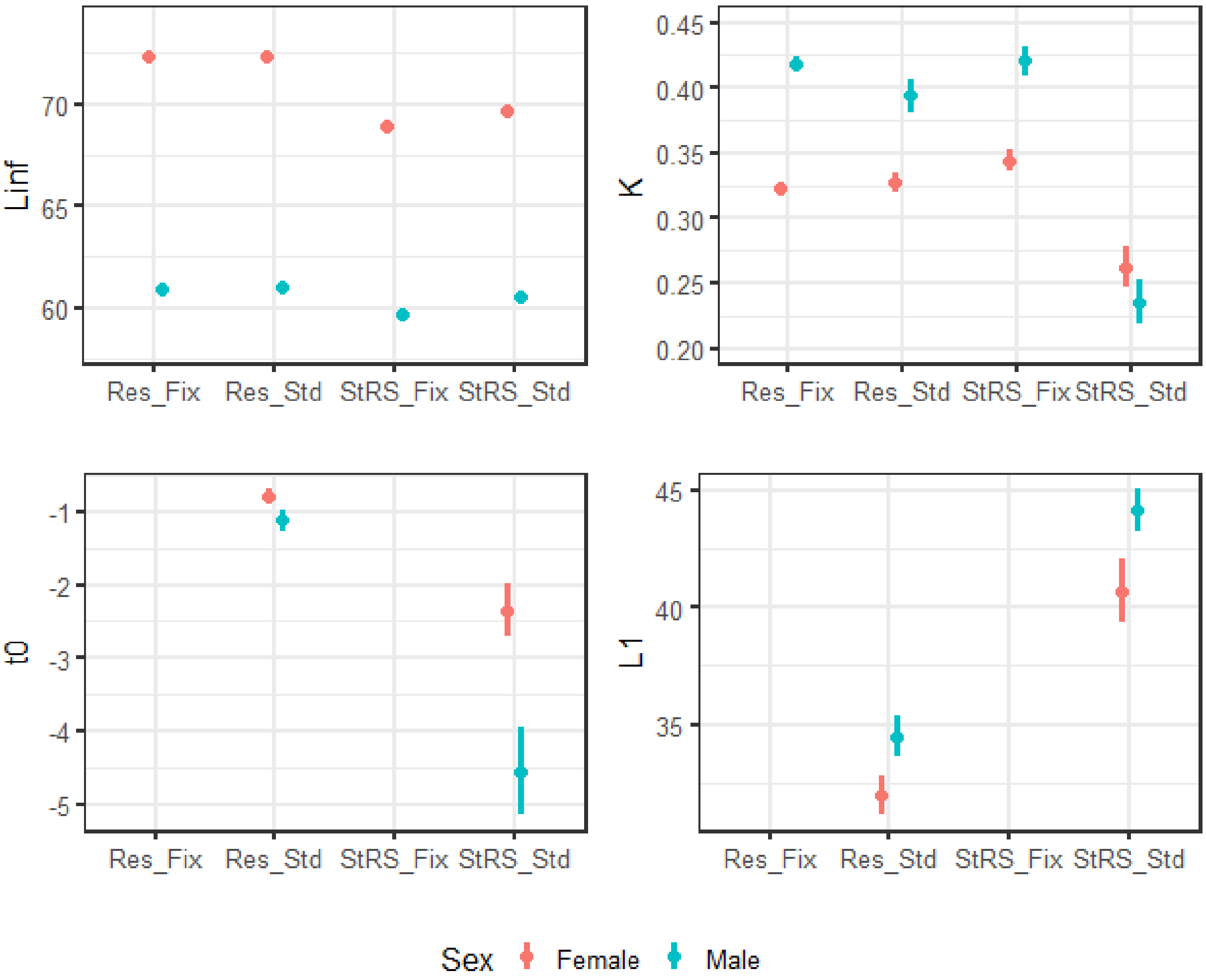

Figure 8. Comparison of estimated length-at-age parameter estimates (with 95% confidence intervals) for Sablefish, separated out by sex (male or female), data source, and model formulation. Abbreviations are as follows: Res_Fix = All Research data with Fixed L_1 model, Res_Std = All Research data with Standard model, StRS_Fix = StRS data with Fixed L_1 model, and StRS_Std = StRS data with Standard model.

Our estimates of LAA parameters fall within the range of values estimated for Alaskan and U.S. West Coast Sablefish stocks (Table 6). For both data sources and model types we considered, estimates of L_∞ were lower than those estimated in Alaska and higher than those estimated along the US West Coast for both males and females. Similarly, estimates of the growth rate *k* for both sexes in B.C. were higher than estimated *k* parameters in Alaska, and lower than or similar to estimated *k* parameters along the US West Coast. Our estimates of *k* from the ‘Fixed

L_1' model were aligned with estimates from the US West Coast model that fixed t_0 at 0 (Haltuch et al. 2019).

The temporal analysis looking at changes in LAA across all cohorts using the Standard LAA model showed a generally declining trend in LAA over time for both sexes since 2003. Sablefish over age 10 were estimated to be smaller in the two most recent time blocks (2019–2021 and 2022–2024) than in earlier time blocks (Figure 9). This change is apparent in declining estimates of *k* over time, with the largest declines happening earlier in the time series (Figure 10). Uncertainty around estimates of *k* and L_1 are highest for the first two time periods (2004–2006 and 2007–2009) compared to more recent time periods, which is consistent with lower sample sizes for these years (Appendix Table A - 3). There are 920–960 paired length-age observations for each sex in these time periods, compared to 1300–2000 observations for subsequent time periods.

The across cohort analysis for the 'StRS: Fixed L_1' combination also shows a declining trend in LAA over time. For Sablefish younger than age 10, the average LAA tends to be lower in recent years than in earlier years (Figure 11). As with the Standard model, the estimates of *k* tend to decline over time (Figure 12). For female Sablefish, estimated *k* derived using only 2023 data is lower than all other estimates over the 21-year time series, while for male Sablefish, estimated *k* in 2022 is the time series low.

The retrospective analysis aimed at examining model sensitivity to the maximum age available for a cohort showed the estimated values of L_∞ and *k* started to stabilize around a maximum age of 10–12 years (Figure 13). After 12 years of observations for a given cohort, adding additional years of observations did not have a large effect on estimates. As a result, we chose to set 12 years of length-age observations as the minimum requirement when looking at cohort-specific trends. This requirement meant that our analysis of temporal trends within cohort growth was limited to cohort years 2000 to 2012.

Cohort-specific LAA estimates derived using the 'StRS: Fixed L_1' model showed a more cyclical pattern in growth over time (Figure 14, Figure 15). Males and females followed similar patterns of increasing and decreasing estimated *k* over the 12 years of observed cohorts. Estimates of cohort-specific L_∞ showed a generally decreasing trend between the 2000 and 2012 cohorts, with occasional periods of stability between periods of decline.

When the 'Fixed L_1+k' model was fit to observations from individual cohorts between 2000 and 2012, patterns in estimated L_∞over cohorts was similar to that seen using the Fixed L_1 model. Estimates of L_∞ showed a generally decreasing pattern over the 11 observed cohorts with periods of stability occurring between declines (Figure 16, Figure 17, Table 7).

LAA tended to be larger north of the 50°N breakpoint than south of it for all combinations of sex, model, and data set (Figure 18, Figure 19). The North area had larger L_∞ and lower k than the South in all cases (Figure 20). Time-varying trends in cohort-specific LAA parameter estimates derived using the 'StRS: Fixed L_1' combination were similar in the North and South, with the same decreasing trend in L_∞ apparent between the 2000 and 2012 cohorts as was seen for the coastwide analysis (Figure 21).

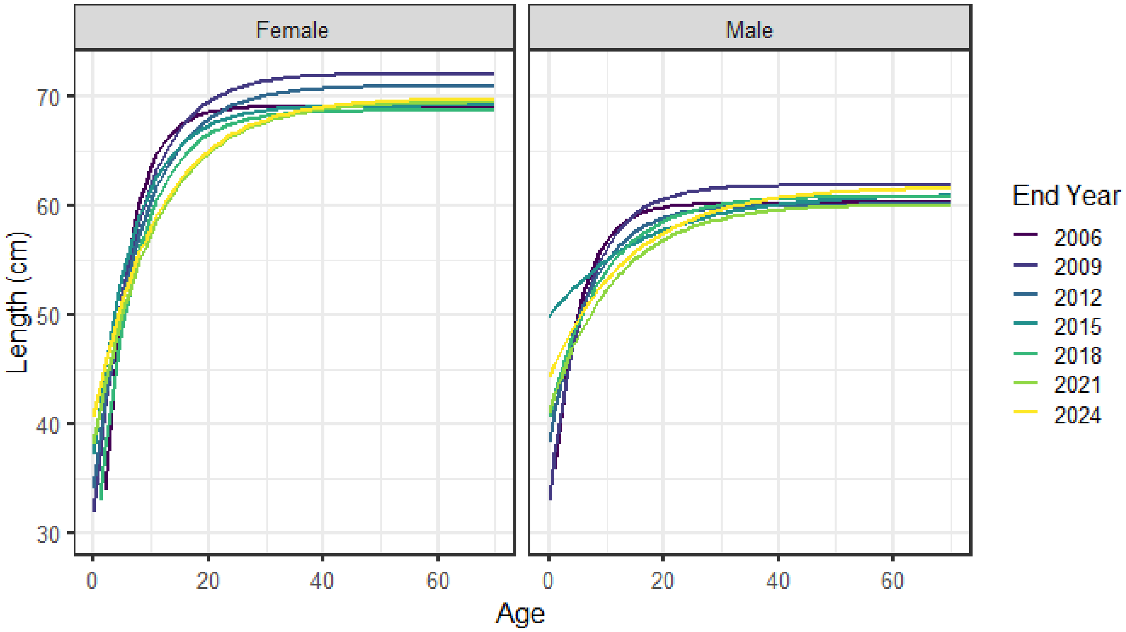

Figure 9. Estimated length-at-age relationships when fit to StRS survey data binned into 3-year time periods using the Standard von Bertalanffy model. For each period, data across all observed cohorts are included. End year indicates the last year of the 3-year time bin (e.g., 2006 includes data from 2004 – 2006).

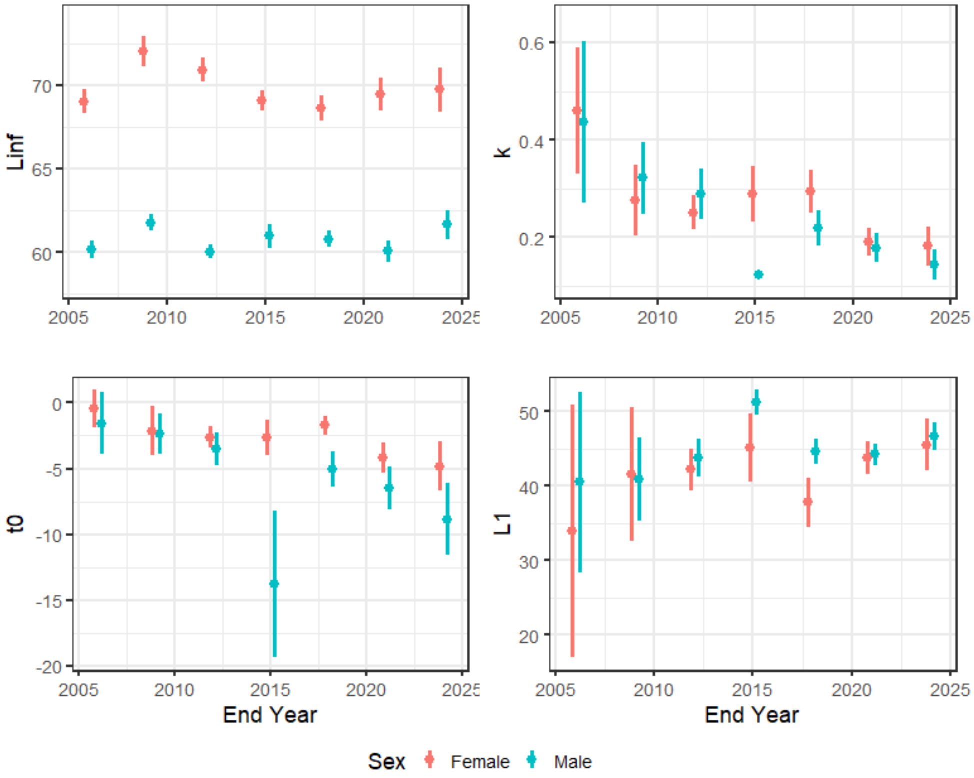

Figure 10. Changes in estimated length-at-age model parameters over time when fit to StRS survey data binned into 3-year periods using the Standard von Bertalanffy model.

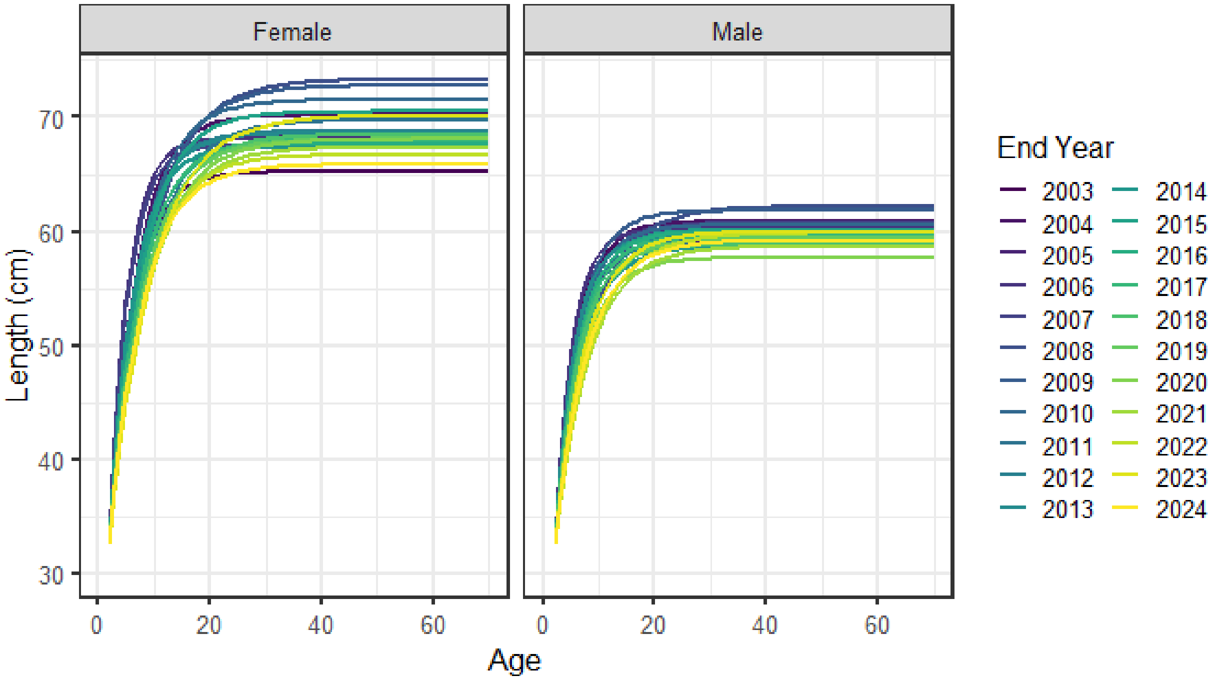

Figure 11. Estimated length-at-age relationships when fit to StRS data in each individual year using the Fixed L1 model. Data across all observed cohorts in each year are included.

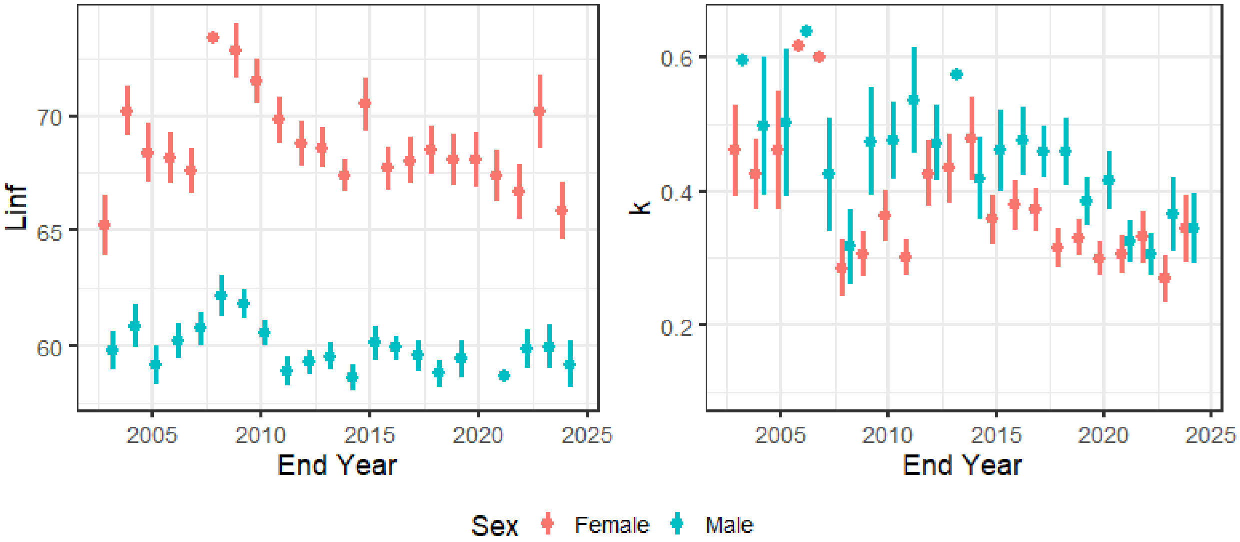

Figure 12. Changes in estimated length-at-age model parameters over time when fit to StRS data from each individual year using the Fixed L1 model.

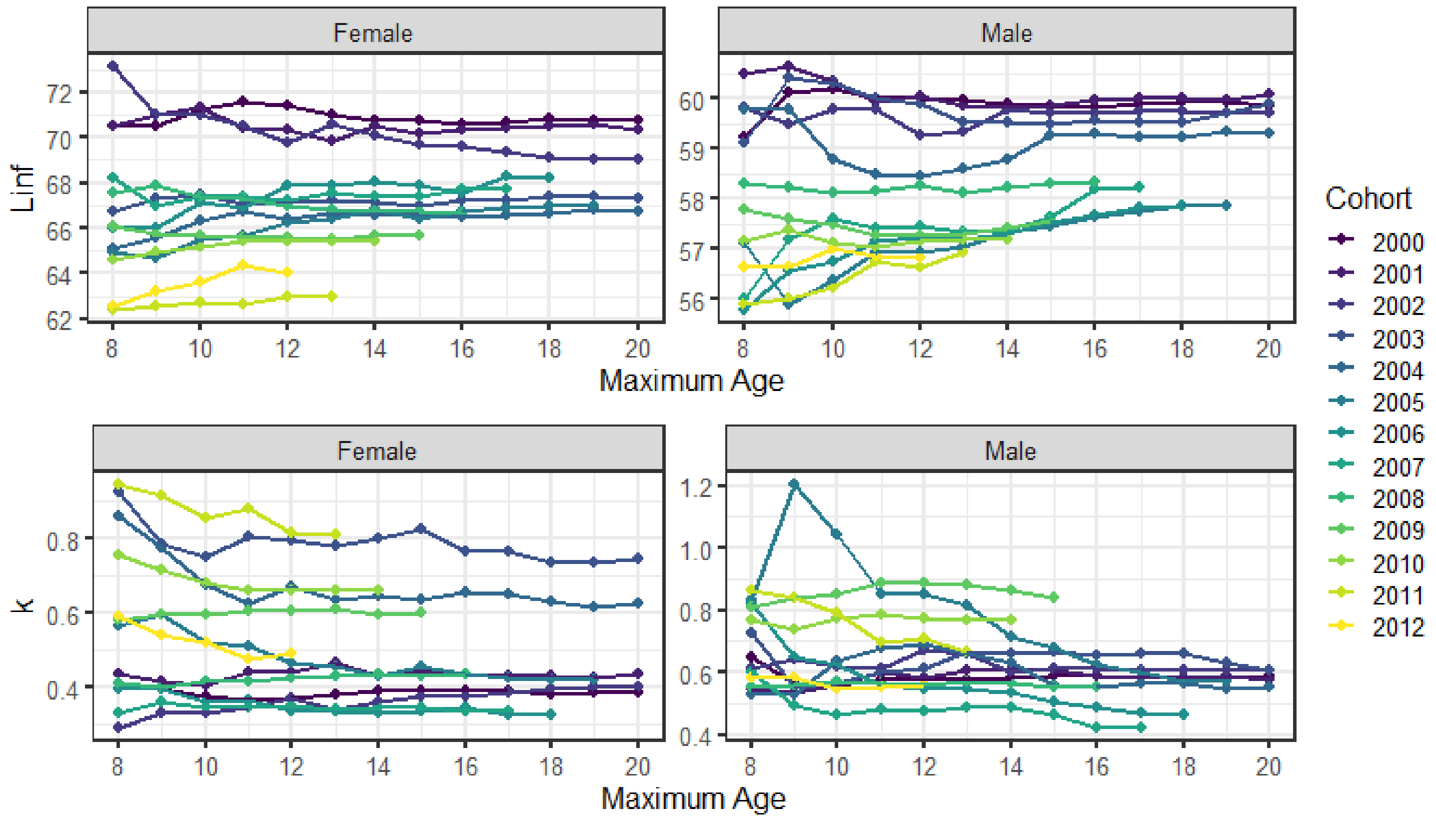

Figure 13. Retrospective sensitivity of parameter estimates (L_{inf} and k) from the Fixed L1 length-at-age model to maximum age in the data set used to fit the model to individual cohorts.

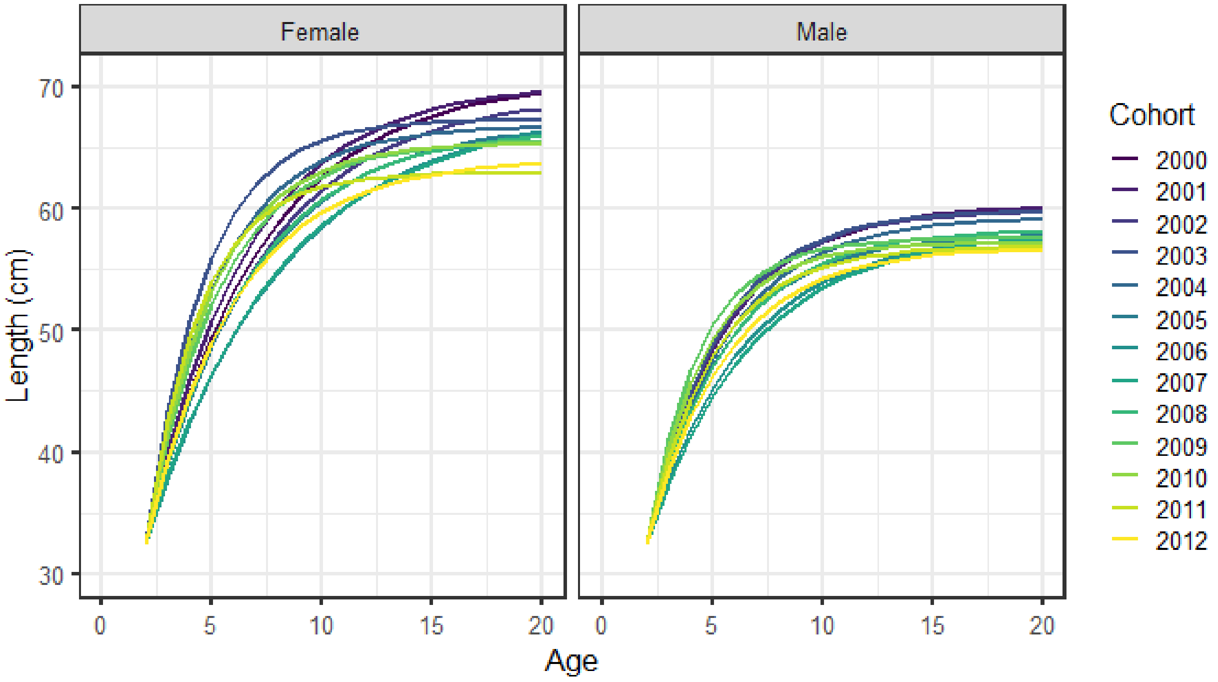

Figure 14. Estimated length-at-age relationships when fit to StRS survey data from individual cohorts using the Fixed L1 model.

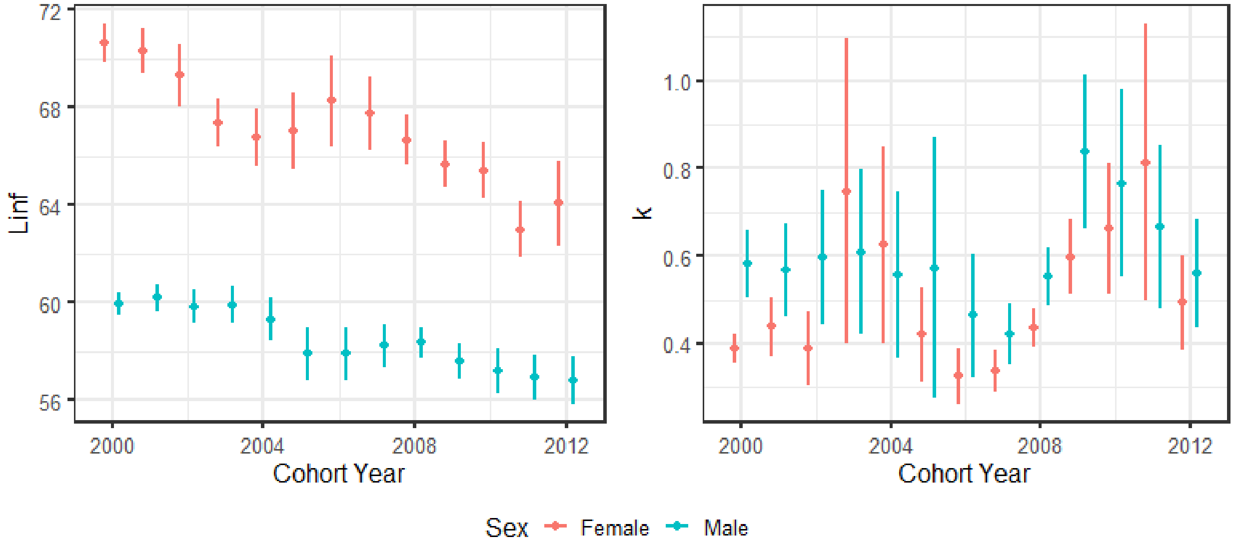

Figure 15. Changes in estimated length-at-age model parameters over time when fit to StRS survey data from each individual cohort using the Fixed L1 model.

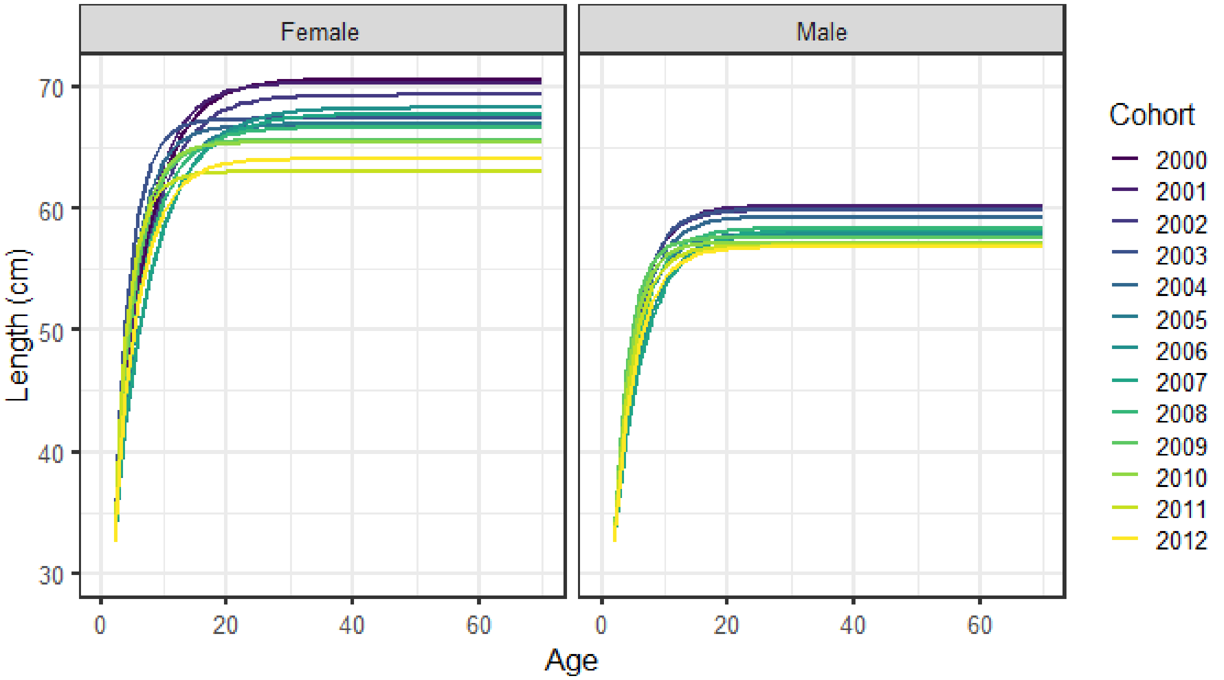

Figure 16. Estimated length-at-age relationships when fit to StRS survey data from individual cohorts using the Fixed L1 model with k parameters fixed at estimates over the entire StRS time series (female k = 0.344, male k = 0.420).

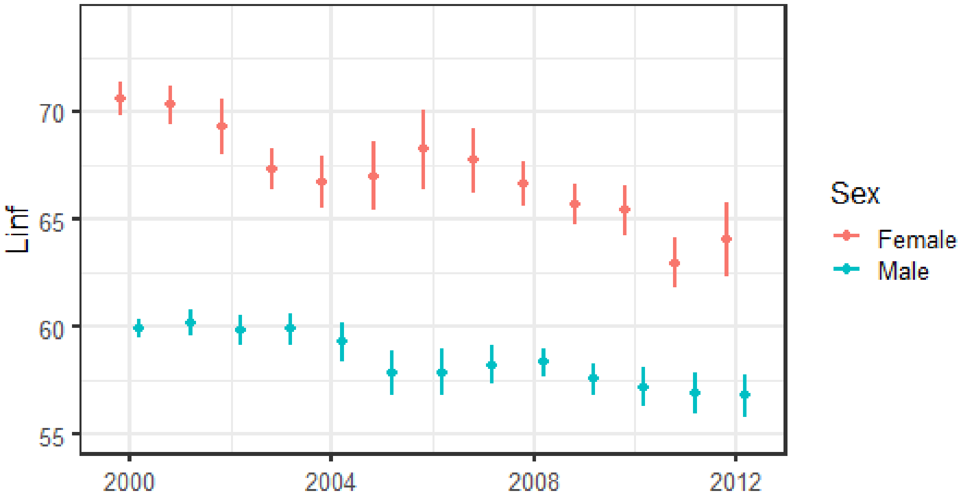

Figure 17. Changes in estimated length-at-age model parameters over cohorts when fit to StRS survey data from each individual cohort using the Fixed L1 model with k parameters fixed. For each cohort, k parameters were fixed at estimates obtained using all StRS survey data in all years (Table 5; female k = 0.344, male k = 0.420).

Table 7. Cohort-specific estimates of L_∞ (and standard error) obtained by fitting the Fixed L1 model to StRS data with k parameters held constant among years at the estimated long-term average (Table 5; female k = 0.344, male k = 0.420).

Cohort	**L_∞ males**	**L_∞ females**
2000	59.93 (0.23)	70.62 (0.39)
2001	60.18 (0.29)	70.33 (0.47)
2002	59.84 (0.35)	69.30 (0.64)
2003	59.90 (0.38)	67.34 (0.49)
2004	59.30 (0.45)	66.76 (0.61)
2005	57.88 (0.54)	67.02 (0.80)
2006	57.88 (0.55)	68.25 (0.95)
2007	58.22 (0.46)	67.74 (0.77)
2008	58.34 (0.32)	66.64 (0.51)
2009	57.58 (0.37)	65.67 (0.48)
2010	57.21 (0.47)	65.42 (0.59)
2011	56.93 (0.47)	62.98 (0.58)
2012	56.82 (0.50)	64.05 (0.89)

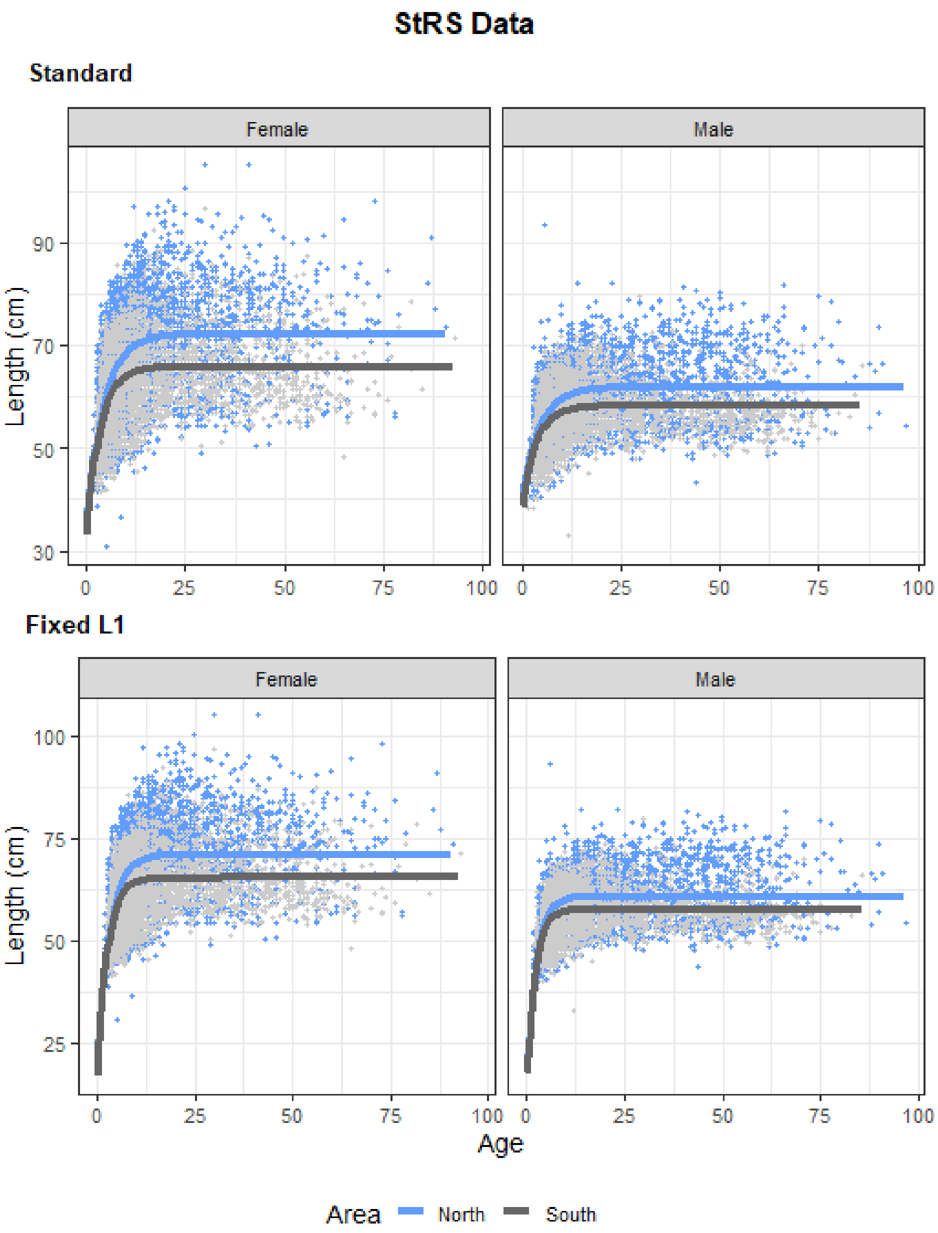

Figure 18. Estimated length-at-age relationships for Sablefish by sex (female or male), model formulation (Standard VonB vs. Fixed L1), and region (North vs. South) when fit to StRS data. Blue and grey dots show individual observations from North and South regions, respectively, used to fit each model.

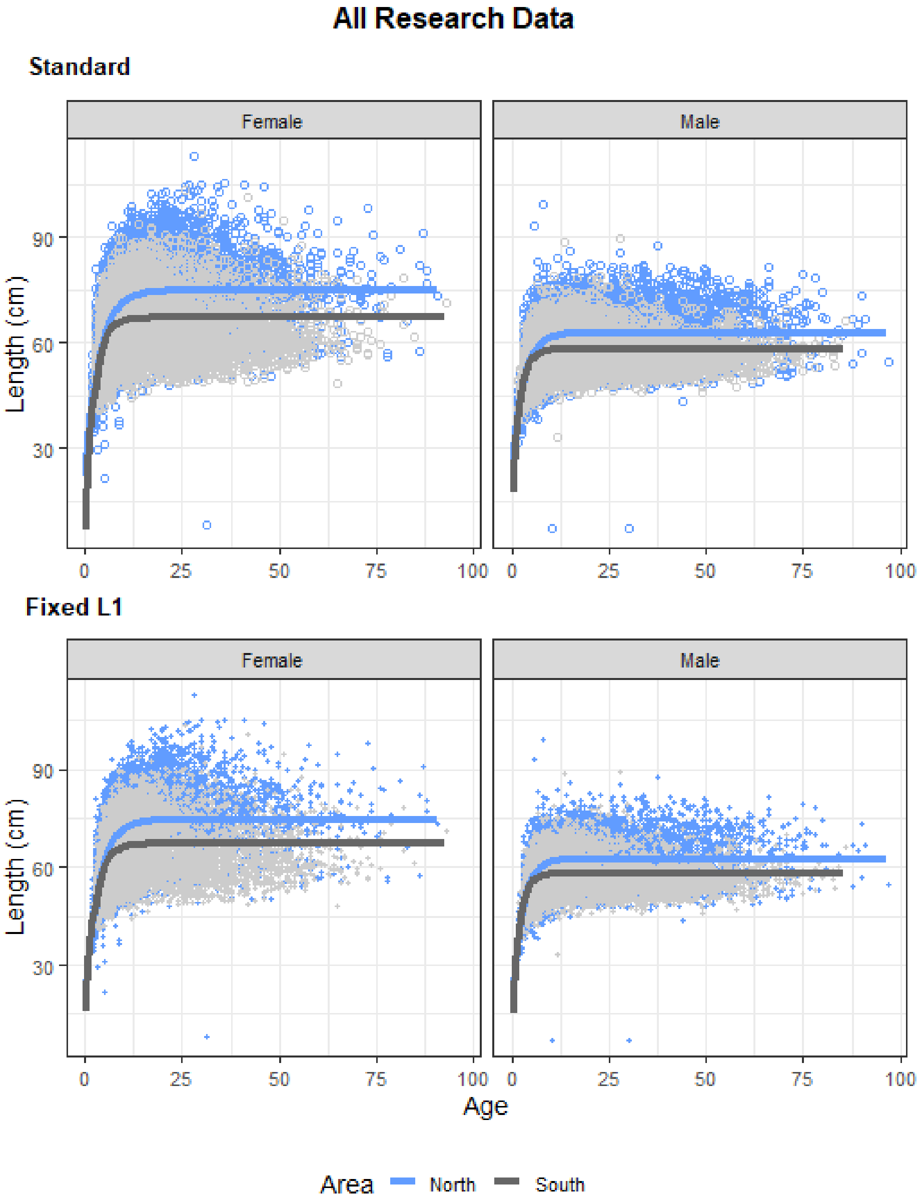

Figure 19. Estimated length-at-age relationships for Sablefish by sex (female or male), model formulation (Standard VonB vs. Fixed L1), and region (North vs. South) when fit to All Research data. Blue and grey dots show individual observations from North and South regions, respectively, used to fit each model.

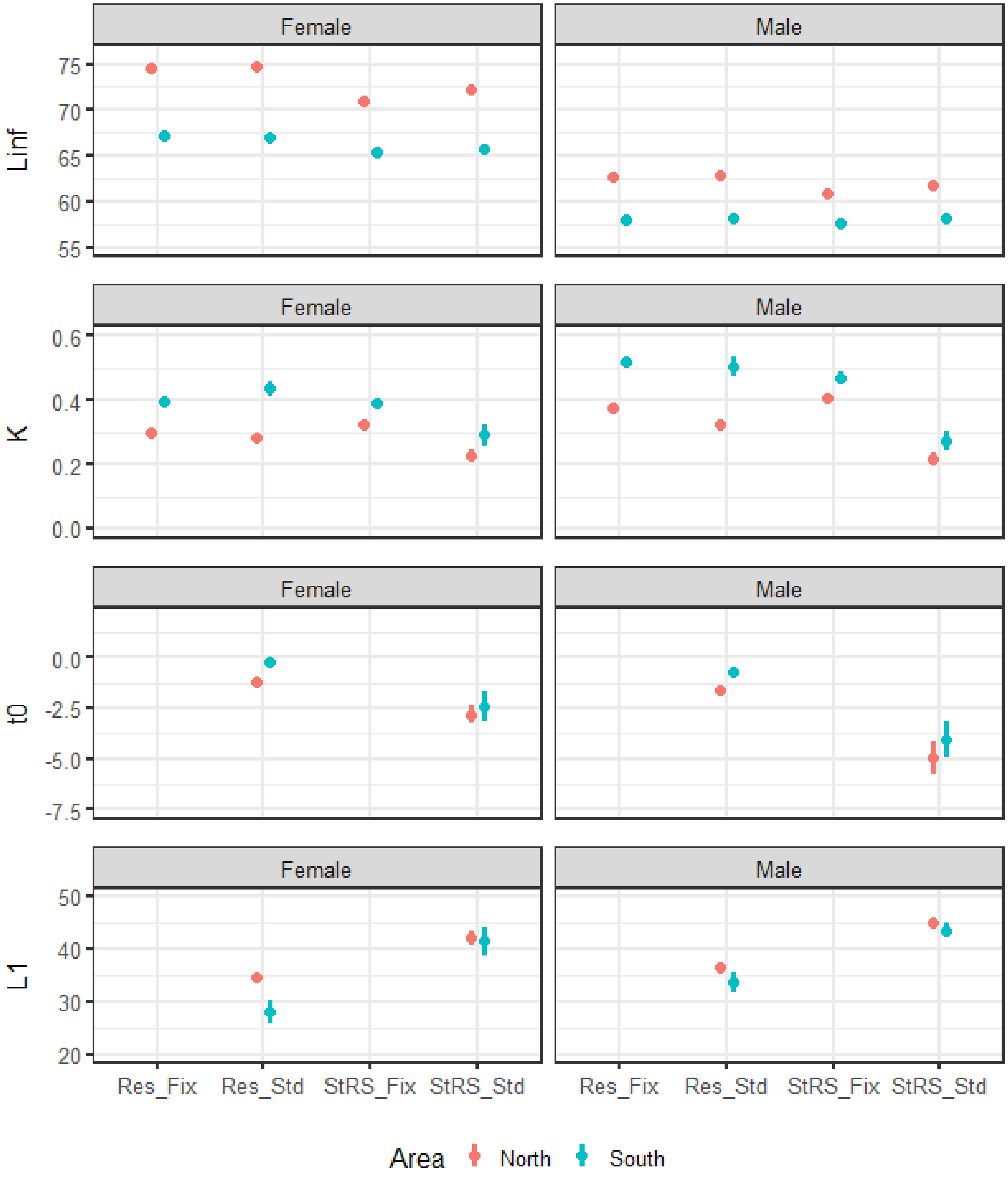

Figure 20. Comparison of estimated length-at-age parameter estimates (with 95% confidence intervals) for B.C. Sablefish, separated out by sex (female or male), data source, model formulation, and region (North vs. South). Abbreviations are as follows: Res_Fix = All Research data with Fixed L1 model, Res_Std = All Research data with Standard model, StRS_Fix = StRS data with Fixed L1 model, and StRS_Std = StRS data with Standard model.

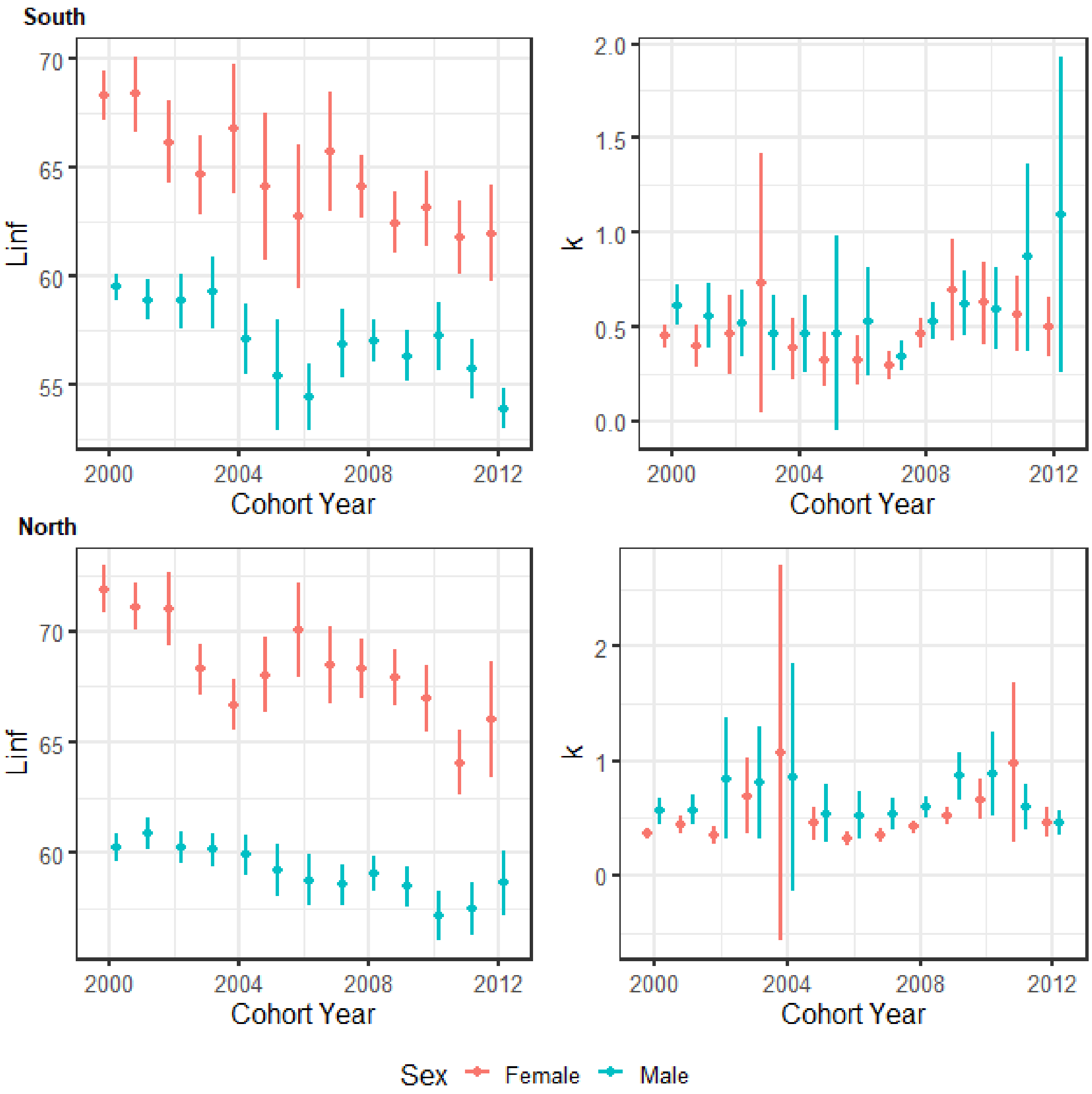

Figure 21. Changes in estimated length-at-age model parameters over time for seperate South and North regions when fit to StRS survey data from each individual cohort between 2000 and 2012 using the Fixed L1 model.

3.3 WEIGHT-LENGTH

3.3.1 Methods

Mean weight-length (WL) was estimated using the model:

$$log\left(\widehat{W}_s\right) = log(\alpha_s) + \beta_s log(L_s)\ , \tag{7}$$

where, L_s denotes the length of a fish of sex s, W_s denotes the weight of a fish of sex s, and α_s and β_s are sex-specific length-weight parameters. A standard deviation parameter was also estimated for each sex (σ_s). The linear regression model was fit to natural log length and natural log weight pairs using all available observations, without distinguishing year or survey series. Weight-length models were implemented in TMB using a normal likelihood equation.

As with LAA models, we examined temporal changes in WL in two ways. First, we fit WL models to StRS survey data by year to look at changes between years across all cohorts. Second, we fit models to StRS survey data by cohort. Finally, we looked for differences in WL north and south of 50°N latitude by fitting individual models to StRS and 'All Research' data from each area.

3.3.2 Results

Estimated WL relationships are similar for the 'StRS' and 'All Research' data sources for both sexes (Table 8, Figure 22). There is a small decrease in estimated α and corresponding increase in β for the fit to 'All Research' data compared to 'StRS' data, with this difference being more pronounced for male Sablefish than females (Table 8). Our results are similar to estimates reported for the US West Coast stock assessment (Table 9, Haltuch et al. 2019).

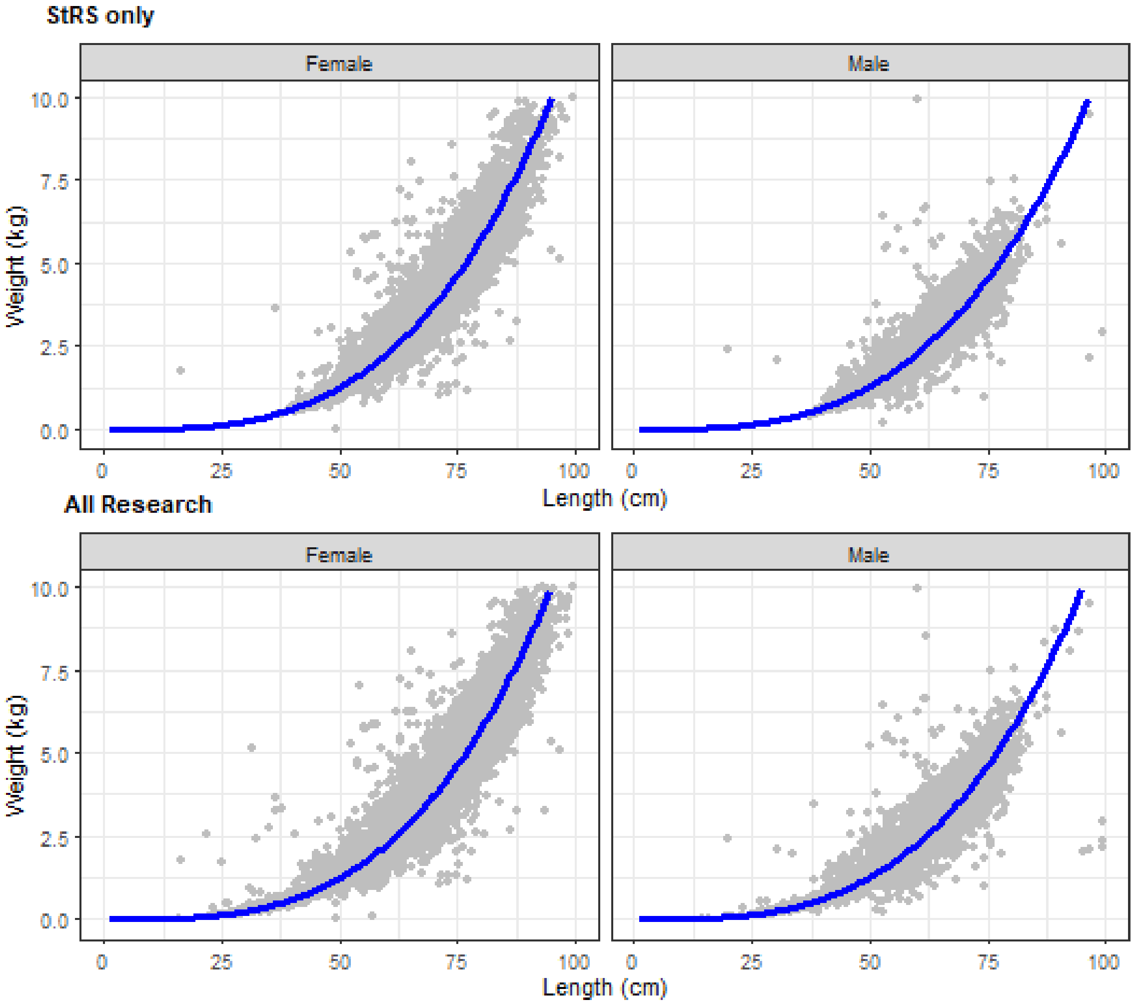

Figure 22. Estimated weight-length relationships for B.C. Sablefish, separated out by sex (male or female), and data source (StRS vs. All Research). Grey dots show individual data observations.

Table 8. Estimated parameters (and standard error) for weight-length models, by data source and sex, where α and β are length-weight parameters and 'sig' is a standard deviation parameter. The sample size (N) and range of data years for each analysis are also shown.

a) Male

Data Source	N	Data years	α	β	sig
StRS	36,936	2003–2024	6.60 e-6 (1.59 e-7)	3.112 (0.006)	0.117 (4.32 e-4)
All Research	72,444	1978–2024	4.07 e-6 (4.23 e-8)	3.229 (0.003)	0.112 (2.95 e-4)

b) Female

Data Source	N	Data years	α	β	sig
StRS	41,543	2003–2024	3.99 e-6 (7.03 e-8)	3.235 (0.004)	0.118 (4.09 e-4)
All Research	79,454	1978–2024	3.53 e-6 (2.90 e-8)	3.263 (0.002)	0.113 (2.83 e-4)

Table 9. Comparison among regions of estimated weight-length model parameters from recent stock assessments.

a) Male

Region	α	β	Source	Notes
Alaska	-	-	Goethel et al. 2021	Integrated into estimation of weight-at-age
B.C.	8.156 e-06	3.060	Cox et al. 2023	Based on 2003–2014 StRS survey data
US West Coast	3.371 e-06	3.270	Haltuch et al. 2019	

b) Female

Region	α	β	Source	Notes
Alaska	-	-	Goethel et al. 2021	Integrated into estimation of weight-at-age
B.C.	4.949 e-06	3.183	Cox et al. 2023	Based on 2003–2014 StRS survey data
US West Coast	3.315 e-06	3.273	Haltuch et al. 2019	

The temporal analysis across all cohorts showed evidence of changing WL relationships over time (Figure 23). In general, differences in estimated WL were most evident for fish with fork lengths greater than 60-75 cm. Estimated α and β parameters show a somewhat cyclical pattern, with periods of high α often coinciding with periods of low β (Figure 24). While periods of high or low estimated α / β often agree between fits to male and female data (e.g., 2017-2020), there are some years when patterns differed between the sexes.

The analysis by cohort showed similar results, but with more defined cyclic trends and more alignment between estimates for males and females (Figure 25, Figure 26). Differences in estimated WL were generally small, especially for smaller lengths (Figure 25).

No notable differences in WL were observed between North and South regions (results not shown).

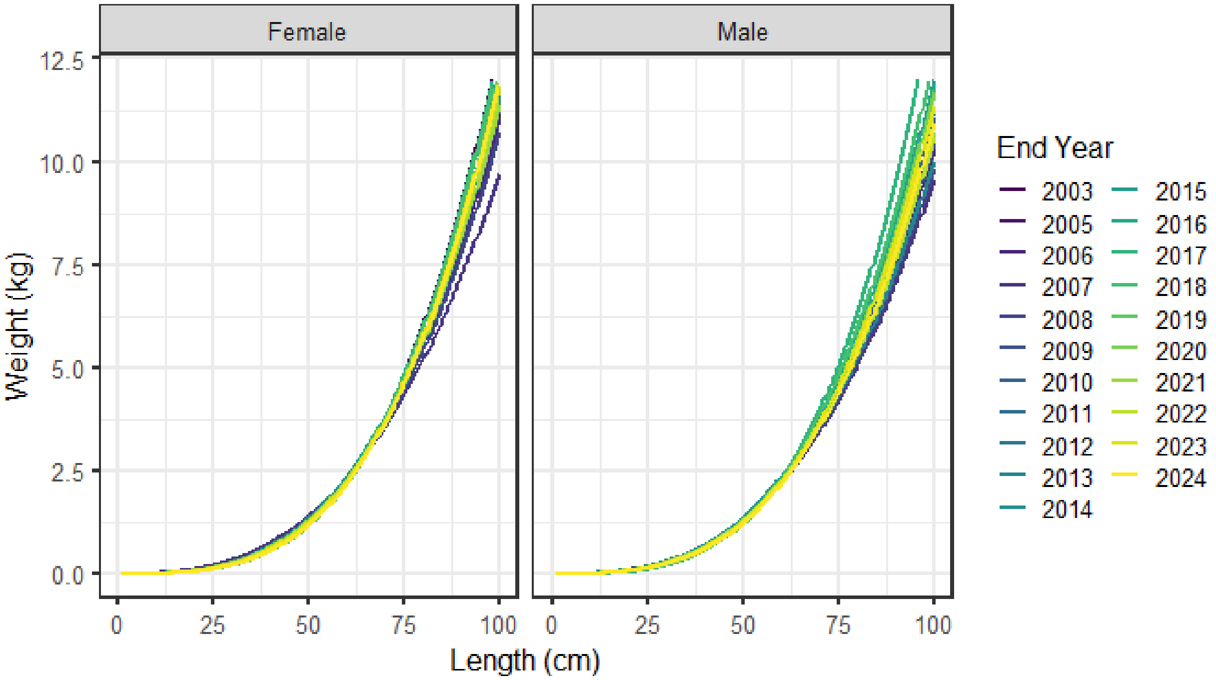

Figure 23. Estimated weight-length relationships when fit to StRS survey data from each individual year. Data across all observed cohorts in each year are included.

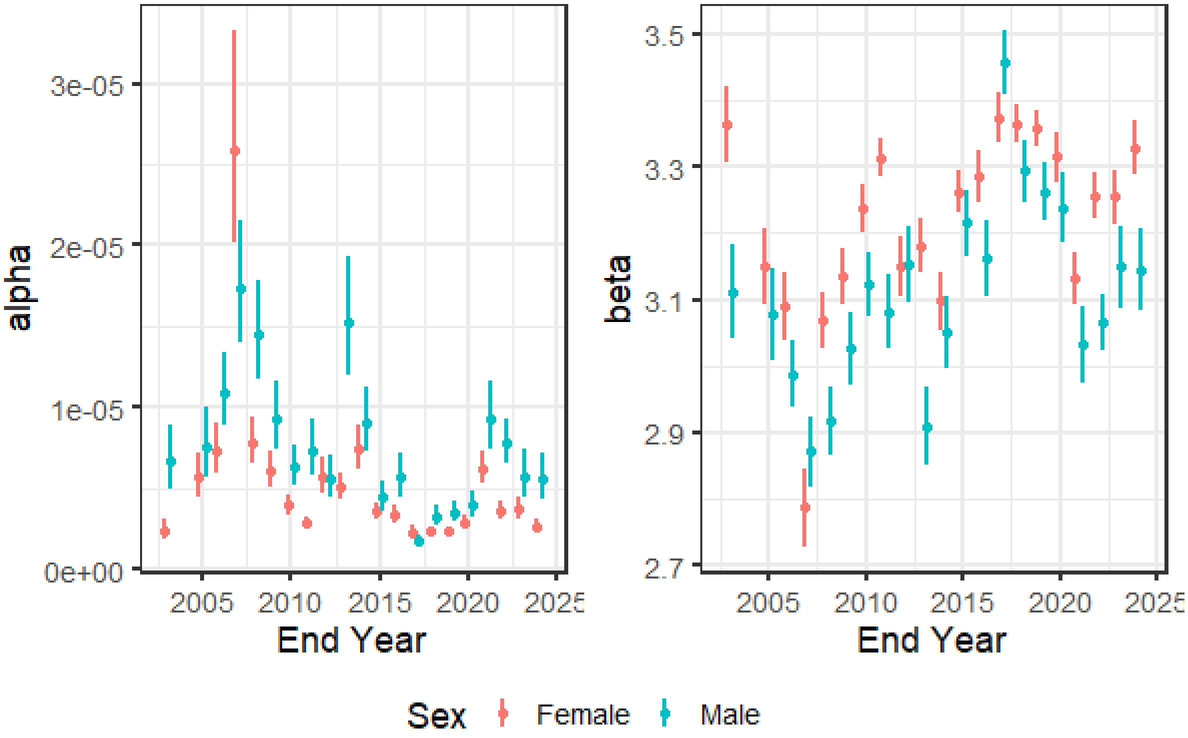

Figure 24. Changes in estimated weight-length model parameters over time when fit to StRS survey data from each individual year.

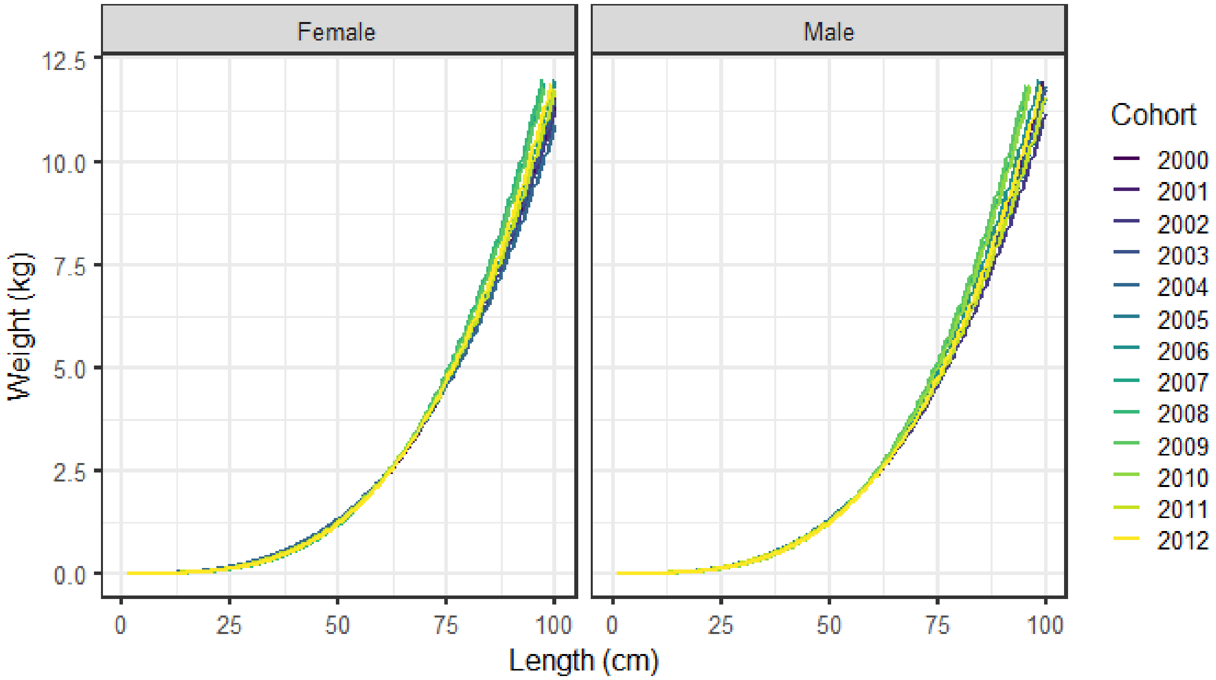

Figure 25. Estimated weight-length relationships when fit to StRS survey data from individual cohorts.

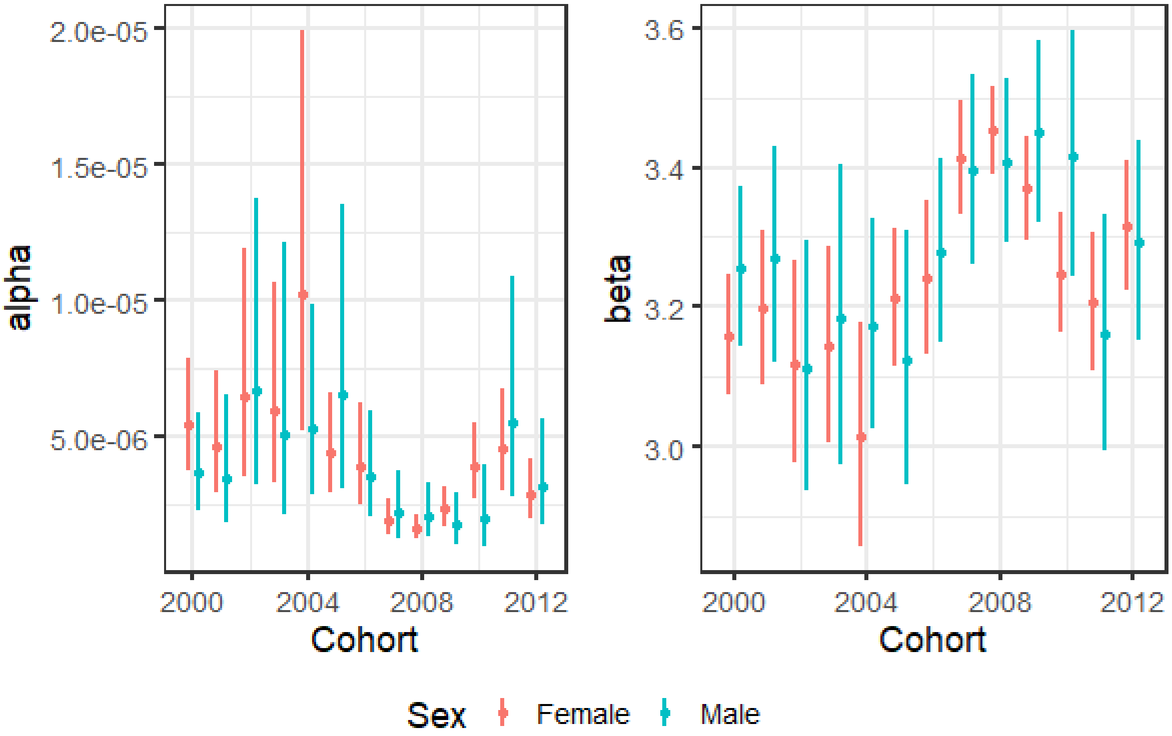

Figure 26. Changes in estimated weight-length model parameters over cohorts when fit to StRS survey data from each individual cohort.

3.4 MATURITY

3.4.1 Methods

Sablefish maturity stage was macroscopically inspected during at-sea sampling and assigned a code based on gonadal structure, colour, size, and developmental characteristics (Appendix Table A - 6). Specimens with assigned maturity codes of 1 or 2 are classified as immature, while maturity codes of 3 to 12 are classified as mature.

In recent years, the distribution of maturity codes among samples from the Sablefish Research and Assessment Survey has been tracked to look for changes in the proportion of Sablefish classified as being in the ‘resting’ maturity stage (Lacko et al. 2026). As the survey occurs in October – November, which is shortly before the peak spawning period of January – March for Sablefish, females that are still in resting stage during the survey may indicate that these fish are likely to skip spawning that year. ‘Skipped spawning’ refers to fish that have previously spawned but are not reproductively active in the current year. We present updated distributions of the proportion of fish in each maturity stage during the survey between 2003 and 2025.

Two approaches were considered for fitting maturity-at-age (MAA) curves to data: a logistic regression and a smoothing spline function. In the first approach, the proportion of Sablefish mature at age is estimated using a logistic regression model fit to observed maturity-age pairs by sex for individual specimens. The logistic regression model is notated as:

$$y_{s,i} = \text{Binomial}\left(\pi_{s,i}\right) \text{ , and} \tag{8}$$

$$\mathit{logit}(\pi_{s\,i}) = B_{0\,s} + B_{1\,s}x_{i\,s}\ \ , \tag{9}$$

where $y_{s,i}$ is an indicator variable with values of 1 (mature) or 0 (immature) for fish *i* of sex s, $\pi_{s,i}$ represents the expected probability of fish *i* of sex *s* being mature, $B_{0,s}$ and $B_{1,s}$ are sex-specific logistic regression parameters, and $x_{s,i}$ represents the age of specimen *i* by sex.

As with the LAA analysis, all ages were adjusted by adding the fraction of the calendar year elapsed from a birthdate of January 1 at the time of capture. This fraction was added to the assigned age to account for the time of sample collection within a year. The estimates of $B_{0,s}$ and $B_{1,s}$ from the logistic model fit were then used to calculate sex-specific ages at 50% and 95% maturity, $a_{50\%}$ and $a_{95\%}$ respectively, using:

$$a_{p\,s} = \left(\log\left({}^{p}/_{(1-p)}\right) - B_{0\,s}\right)/B_{1\,s}\ , \tag{10}$$

where, *p* represents the proportion mature.

In the second approach, the proportion mature at age was fit using a cubic spline smoothing function (Head et al. 2020). The spline approach allows increased flexibility in the shape of the maturity ogive compared to the logistic model which is restricted to an S-shaped relationship. Adjusted ages were grouped into 0.25 year bins (e.g., 2–2.25 years, 2.25–2.5 years, etc.) so that observed proportions mature could be calculated for each bin. The spline function was then fit directly to the proportions for each age bin. Splines were fit using the “`smooth.spline`” function in the R package stats (R Core Team, 2013). The ‘`uniroot`’ function in R was used to solve for $a_{50\%}$ and $a_{95\%}$.

The degree of flexibility in the spline curve is controlled by specifying the number of knots, which are inflection points in the smoothed line. We followed the approach of Head et al. (2020) to determine the fewest number of knots needed to reach stable predictions of the proportion mature at age. We examined knot values ranging from 4 to 16, and then visually identified 6 knots as the value at which estimates of the proportion mature at each age class stabilized for both data scenarios (Figure 27).

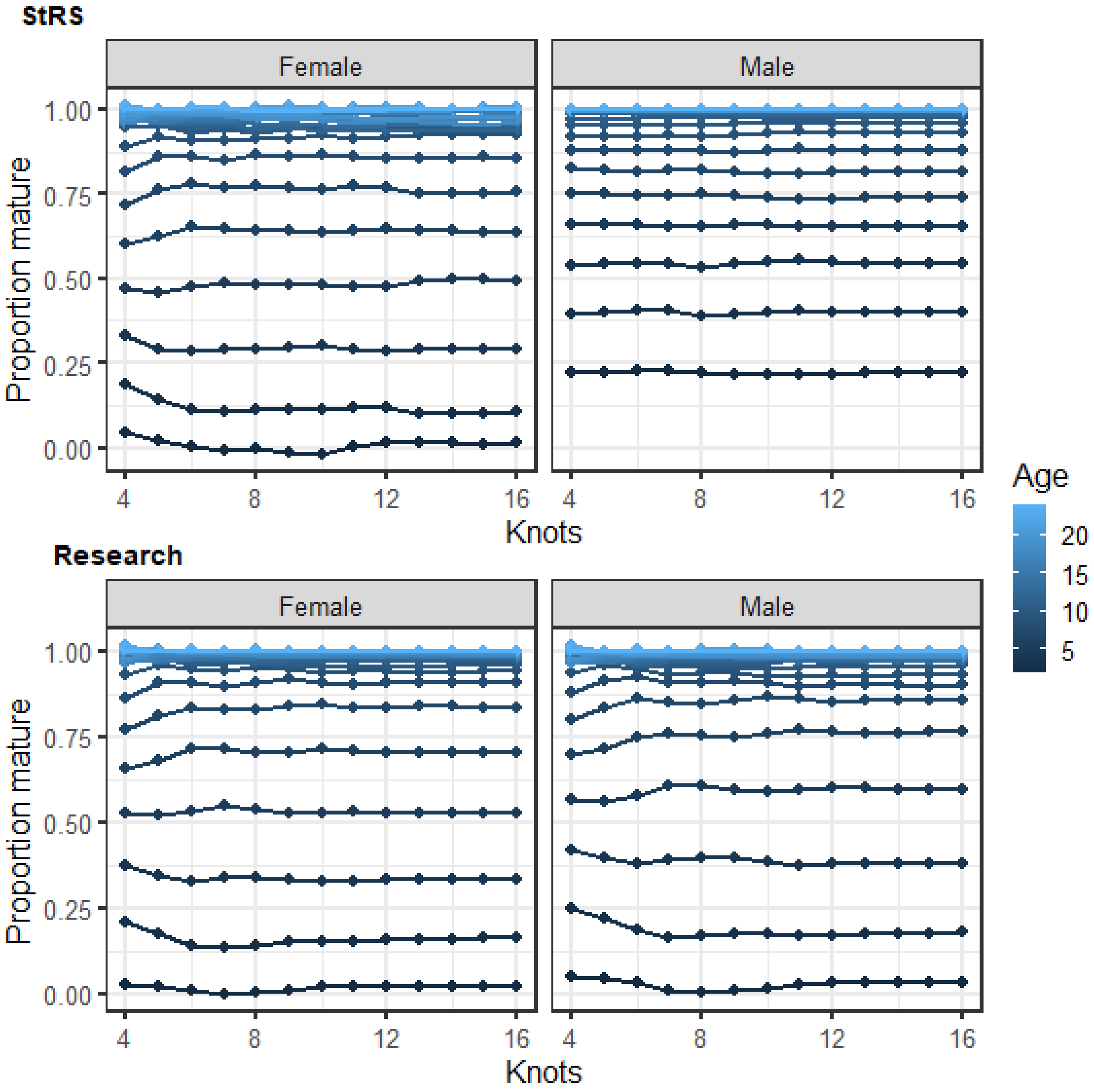

Figure 27. Evaluation of the impact of the number of knots specified for the spline maturity model on the estimated proportion mature at age. The most parsimonious knot is the lowest value to maintain acceptable stability for all age categories. We chose 6 knots based on this result.

Our ability to look at changes in MAA over time, both across cohorts and within cohorts, was limited by a lack of data. The observed proportions MAA calculated for each age bin were too variable to fit spline functions when data were subset to time periods or individual cohorts. While the logistic MAA model could be fit to individual time blocks (i.e., the across-cohort approach), it was necessary to use three-year time periods (e.g., 2003–2005, 2006–2008, etc.) instead of individual years. Logistic MAA models could be fit to individual cohorts. The last cohort included in the logistic model cohort analyses was 2012 so that observations were available up to at least age 12, as was done with cohort-based LAA analyses.

Finally, we looked for spatial differences in MAA north and south of 50°N latitude by fitting individual models to data sets from each area. Both logistic and spline MAA models were considered, with each model fit to both StRS and ‘All Research’ data.

3.4.2 Results

Over the past three years, samples from the StRS survey have shown a subtle increase in the proportion of fish observed to be in ‘resting’ maturity stage, possibly indicating an uptick in the prevalence of skipped spawning (Figure 28).

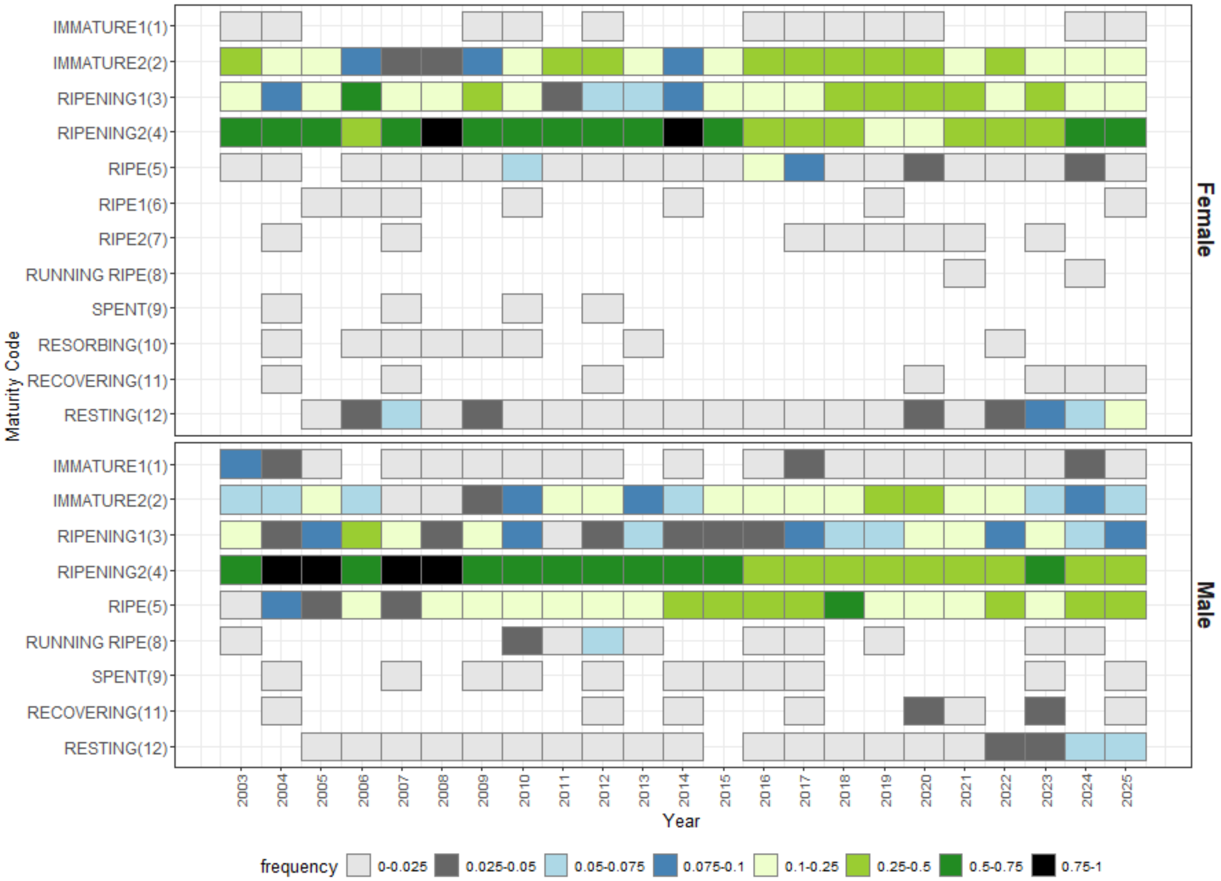

Figure 28. Relative frequency of maturity stages by survey year for female and male Sablefish caught on StRS sets. Maturity codes at stage 3 through to stage 12 are considered a mature fish.

The spline model fits the calculated proportion of mature fish more closely at younger ages (<4 years) compared to the logistic model for both sexes and data scenarios (Figure 29). The logistic model overestimates the proportion mature at young ages, with 10-20% of fish estimated to be mature at age 1. However, both models converge on similar predictions by ages 4-5. Estimates of $a_{50\%}$ and $a_{95\%}$ varied by data scenario and model, but there was no common pattern between male and females in terms of which data or model resulted in higher or lower estimates (Table 10, Figure 30).

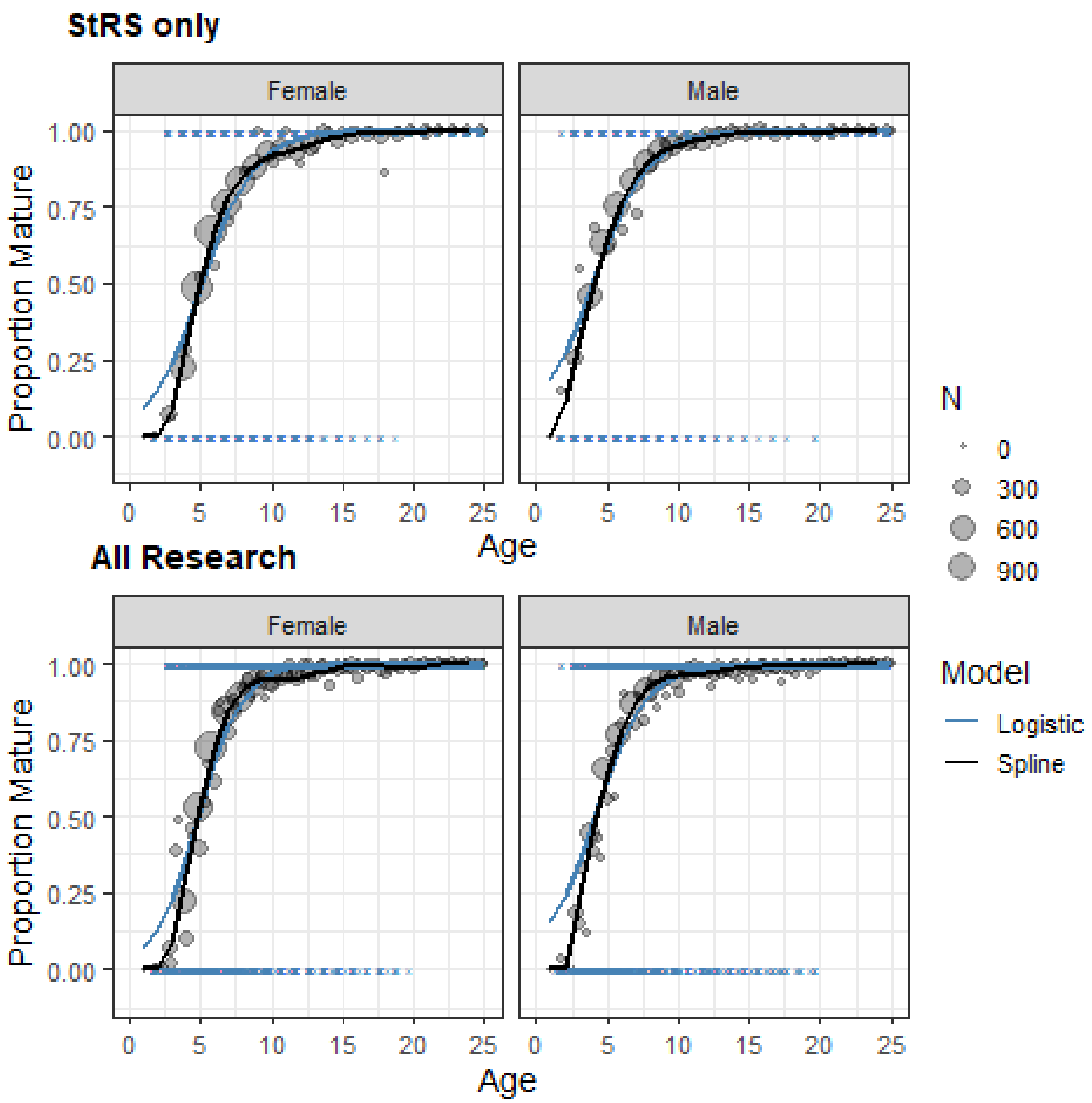

Figure 29. Predicted maturity-at-age relationships for Sablefish, separated out by sex (male or female), data source (StRS vs. All Research), and modelling method (Logistic regression vs. spline function). Blue x's show the underlying binary response data (0 = not mature, 1 = mature), while the grey bubbles show the proportions used to fit the spline function, with the size of the bubble indicating sample size (N) for a given age.

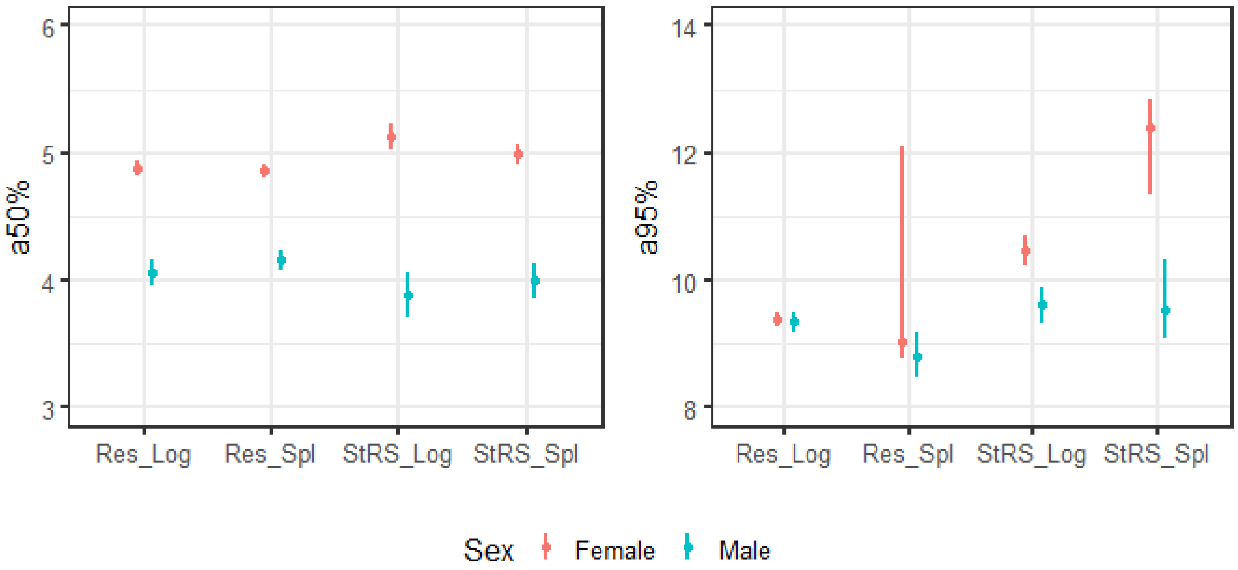

Figure 30. Comparison of estimated ages at 50% and 95% maturity (with 95% confidence intervals) for B.C. Sablefish, separated by sex (male or female), data source, and MAA model formulation. Abbreviations are as follows: Res_Log = All Research data with Logistic model, Res_Spl = All Research data with Spline model, StRS_Log= StRS data Logistic model, and StRS_Spl = StRS data with Spline model.

For female Sablefish in B.C., the estimated age at 50% maturity, $a_{50\%}$, was 5 years for all data scenarios and model types, which was about 2 years younger than reported in Alaska (Table 11). Estimates of $a_{95\%}$ are also about 2 years younger in B.C. compared to Alaska for both the 'Research: Logistic' and 'Research: Spline' combinations. When only StRS survey data were used, estimates of $a_{95\%}$ were similar for the two regions when using the 'StRS: Logistic' combination, but differed for B.C. when the spline model was applied. Estimated $a_{95\%}$ for the 'StRS: spline' combination was about 1.5 years older than the estimate from Alaska, which was derived using a logistic model. Estimated proportions mature at each age based on the 'StRS: spline' and 'Research: spline; combinations are provided in Table 12.

Table 10. Estimated age at 50% maturity (a_{50}) and age at 95% maturity (a_{95}) (and standard error) for maturity-at-age models, by data source, model type, and sex. The sample size for each analysis (N) is also shown.

a) Male

Data Source	N	Model	Data years	a_{50}	a_{95}
StRS	8,196	Logistic	2003 – 2024	3.88 (0.09)	9.61 (0.14)
		Spline	2003 – 2024	3.99 (0.08)	9.54 (0.31)
All Research	23,043	Logistic	1978 – 2024	4.06 (0.05)	9.34 (0.08)
		Spline	1978 - 2024	4.15 (0.04)	8.80 (0.18)

b) Female

Data Source	N	Model	Data years	a_{50}	a_{95}
StRS	10,229	Logistic	2003 – 2024	5.13 (0.05)	10.47 (0.12)
		Spline	2003 – 2024	5.00 (0.04)	12.39 (0.38)
All Research	34,064	Logistic	1978 – 2024	4.88 (0.03)	9.38 (0.06)
		Spline	1978 - 2024	4.86 (0.02)	9.03 (1.37)

Table 11. Comparison among regions of estimated maturity-at-age model parameters from recent stock assessments. Only female estimates are shown.

Region	$a_{50\%}$	$a_{95\%}$	Source	Notes
Alaska	~ 7	11	Goethel et al. 2024	
B.C.	5	8	Cox et al. 2023	Assumed based on literature review
U.S. West Coast	-	-	Haltuch et al. 2019	Parameterized as length at 50% maturity = 55.19 cm

Table 12. Estimated proportion mature at age for spline models, by sex and data source.

	Male		**Female**	
Age	**StRS**	**All Research**	**StRS**	**All Research**
1	0.000	0.000	0.000	0.000
2	0.117	0.000	0.000	0.000
3	0.322	0.240	0.087	0.087
4	0.500	0.469	0.303	0.313
5	0.649	0.649	0.500	0.529
6	0.768	0.784	0.665	0.715
7	0.854	0.876	0.787	0.850
8	0.909	0.929	0.862	0.923
9	0.940	0.953	0.902	0.950
10	0.956	0.961	0.920	0.951
11	0.965	0.964	0.931	0.947
12	0.974	0.969	0.944	0.953
13	0.982	0.976	0.959	0.966
14	0.988	0.983	0.972	0.981
15	0.992	0.988	0.983	0.993
16	0.994	0.990	0.989	0.997
17	0.994	0.990	0.991	0.995
18	0.993	0.989	0.992	0.991
19	0.993	0.989	0.992	0.987
20	0.993	0.991	0.993	0.987
21	0.995	0.995	0.995	0.993
22	0.998	1.000	0.999	1.000
23	1.000	1.000	1.000	1.000
24	1.000	1.000	1.000	1.000

Temporal analyses using the logistic MAA model did not produce credible results for either the across-cohort or within-cohort approach. Unrealistically high estimates of the proportion of fish mature at age 1 resulted for both the 3-year time periods and cohorts fits in several cases (Figure 31, Figure 32). These high estimates appear to be caused by small sample sizes for young fish for these time periods and/or cohorts. For example, 50% of age-1 females are estimated to be mature for the 2004–2006 time period despite only one fish under age 3 being observed during these three years.

No notable differences in MAA were observed between North and South regions for the logistic or spline models (results not shown).

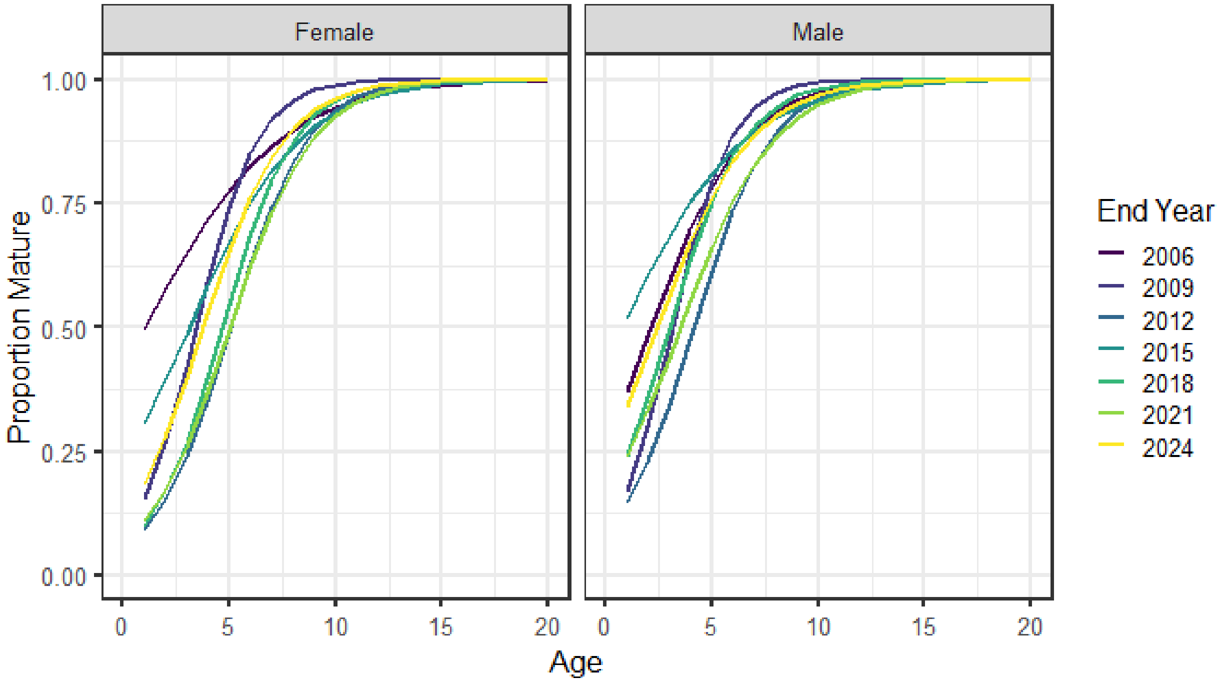

Figure 31. Estimated maturity-at-age relationships when fit to StRS survey data binned into 3-year periods using the Logistic model. For each period, data across all observed cohorts are included. End year indicates the last year of the 3-year bin (e.g., 2006 includes data from 2004–2006).

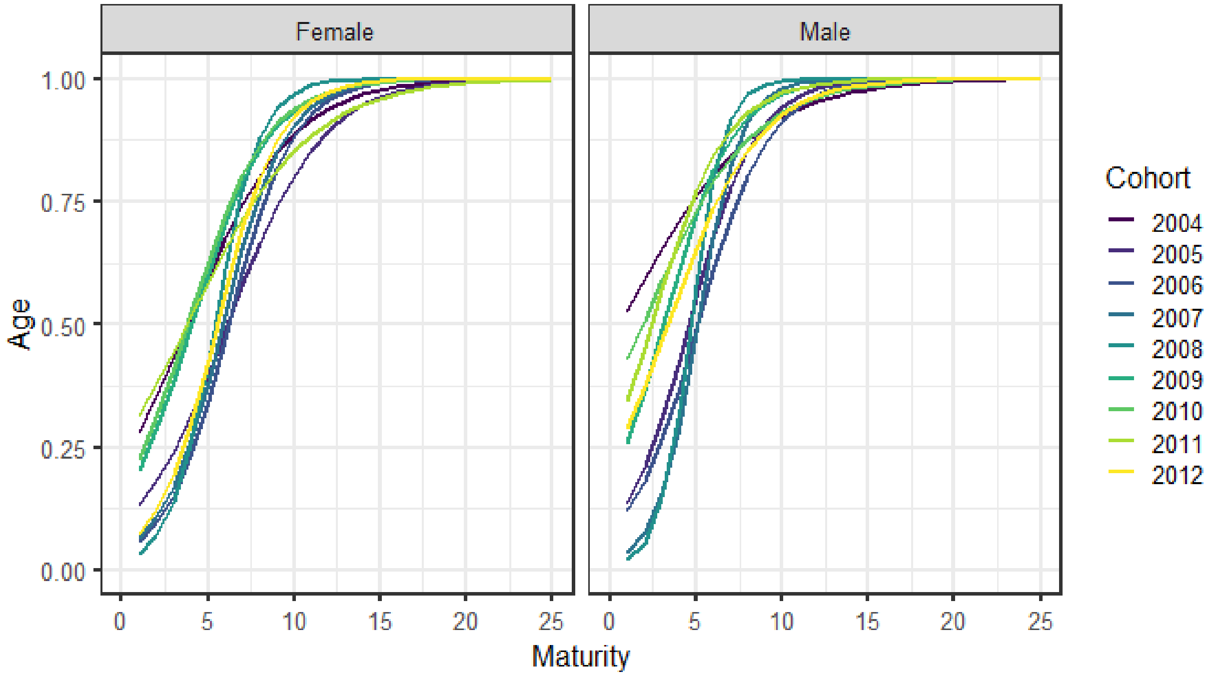

Figure 32. Estimated maturity-at-age relationships when the Logistic model is fit to StRS survey data from individual cohorts.

4 DISCUSSION

4.1 AGE COMPOSITION AND AGEING ERROR DATA

Updated age composition datasets from the StRS survey, the commercial trap fishery, and the commercial longline fishery support previous observations of a dominant 2016 cohort. Eight-year-old fish from this cohort are still the most dominant age class in 2024.

Estimates of ageing error derived using our updated double-read data set for 2025 were similar to those used for the 2019 and 2022 OM updates (DFO 2020, Johnson et al. 2025); however, estimated standard deviations of the error distribution at age were slightly higher in 2025. For example, the updated standard deviation at the maximum age (90 years) was 6.87 for the case where true age was set at the mean of the two age readings, compared to 4.80 in 2019. This result is likely due to the change in data selection criteria to only include blind double-read samples for this analysis. In contrast, secondary age readings were used for the 2019 analysis, where the second reader knew the age assignment made by the first reader. As a result, the percentage agreement between the two age readers dropped from 62% in the 2019 data set to 36% in our 2025 data set. However, changes in age reading staff over time may also have contributed to the difference.

Regardless of the method used to represent true age, the ratio of the standard deviation to true age decreased with increasing age, indicating the ageing precision increased with age. This pattern is commonly observed for fish species (e.g., Punt et al. 2008).

4.2 LENGTH-AT-AGE

Comparison of our updated time-invariant LAA results with published estimates from Alaska and the US West Coast support previously observed increases in length-at-age and asymptotic length with increasing latitude across the Northeast Pacific (Gertseva et al. 2017, Kapur et al. 2020). For the data scenarios and model types considered in this report, estimates of L_∞ were lower in B.C. compared to those estimated for Alaskan waters and higher than those estimated along the US West Coast. Similarly, estimates of the growth rate *k* for both sexes in B.C. were higher than estimated *k* parameters in Alaska, and lower than, or similar to, estimated *k* parameters along the US West Coast. This pattern is consistent with the temperature-size rule, which states that fish residing in warmer aquatic environments tend to growth faster as juveniles, but reach smaller asymptotic lengths as adults (Atkinson 1994, Van Rijn et al. 2017). As a result, we conclude that empirically derived LAA relationships for B.C. Sablefish presented in this report are credible and can be used to parameterize the Sablefish operating model, with the possible exception of the ‘StRS: Standard’ data and model combination.

The LAA parameter estimates from the ‘StRS: Standard’ combination differed from the other three combinations. The estimated L_1 for the ‘StRS: Standard’ combination was 44 cm for males and 40 cm for females, which is higher than previously documented sizes for age-1 Sablefish (described in Section 3.2.1). Given that our L_1 estimates correspond to the start of the second year of life from a January 1 birthdate (i.e., age 1.0), the average length of 40-44 cm from the ‘StRS: Standard’ combination falls outside the range of empirical observations. As a result, we place less credibility on the ‘StRS: Standard’ LAA model results than on the other three options. Differences in sample sizes, especially at young ages, may provide a partial explanation for the difference between the ‘StRS: Standard’ combination and the other three combinations. The ‘All Research’ dataset includes surveys that tend to see younger fish than the StRS survey, such as trawl surveys and Std. Inlet survey sets from the Sablefish research program (Table 3). Consequently, there are more data available at younger ages than when only the StRS survey data are used (Figure 2). Using the ‘Fixed L_1’ model compensates for this lack of data by essentially fixing the x-intercept and estimating one less parameter. In contrast, there are not enough data at young ages to reliably fit the ‘Standard’ von Bertalanffy model to StRS survey data.

Declines in Sablefish LAA were evident in recent years from both the across-cohort and within-cohort analyses. We restrict discussion of changes in LAA over time to the ‘Fixed L_1’ model since it is considered more reliable than the ‘Standard’ model when fit to StRS survey data. For Sablefish under age 10, the average LAA tends to be lower in recent years than in earlier years. Similarly, Sablefish from more recent cohorts tend to be smaller at age than fish from earlier cohorts. This pattern was maintained when trends in cohort-level LAA were examined separately for two different oceanographic zones in B.C., which were delineated at a latitude of 50°N. While these declines may reflect density-dependent effects, as suggested for Alaskan Sablefish (Cheng et al. 2024), uncertainty around confounding factors including environmental drivers of life-history variation in B.C. prevents definitive conclusions about the underlying mechanisms. Regardless of our understanding of potential drivers of change, the effects of time-varying LAA relationships on management outcomes should be considered when prioritizing revisions to the B.C. Sablefish operating model. For example, incorporating cohort-specific growth variability has been shown to lead to substantial differences in estimates of spawning stock biomass and recommended harvest levels for the Alaskan Sablefish stock (Cheng et al. 2024).

Finally, our results confirmed previously documented growth zonation for Sablefish in B.C. based on oceanographic influences (Kapur et al. 2020). This finding is not surprising given that previous analyses were based on the same data sets used here up to 2019. LAA tended to be larger north of the 50°N breakpoint associated with the North Pacific Current bifurcation than south of it for all combinations of sex, model, and data sets. The northern area showed larger estimated L_∞ and lower k than the southern area in all cases. This pattern is consistent with the temperature-size rule described above (Atkinson 1994, Van Rijn et al. 2017), as well as coastwide trends in LAA for Sablefish throughout the Northeast Pacific (Gertseva et al. 2017, Kapur et al. 2020).

4.3 WEIGHT-LENGTH

Estimated WL relationships are less dependent on data source than LAA relationships. While there are more observations from Sablefish with shorter lengths in the ‘All Research’ data sets compared to the ‘StRS’ data set, the overall effect on the estimated WL curve is negligible. Estimated parameters from both data sets are similar to those reported in the U.S. West Coast stock assessment (Haltuch et al. 2019). We conclude that WL model parameter estimates obtained using B.C. data can be used as required for the Sablefish OM.

While there are changes in WL curves over time, both across cohorts and among individual cohorts, differences are mostly evident for lengths greater than 60-75 cm. Estimated model parameters show a cyclical pattern over time, with periods of high α often coinciding with periods of low β. Cyclical patterns are usually consistent among independently derived estimates for males and females, especially using the cohort-level analysis, which suggests that these variations are real effects. However, given that differences in overall curves were generally small over much of the available size distribution, incorporation of temporal variability into the WL relationship is expected to have a smaller effect on OM outputs compared to the incorporation of time-varying LAA. Furthermore, there is no evidence of a declining trend in weights-at-length in recent years.

4.4 MATURITY

Based on a visual inspection of MAA model fits, the smoothing spline model does a better job fitting the proportion of mature fish at younger ages (<4 years) compared to the logistic model for both sexes and data scenarios. A key advantage of the spline function is that it allows more flexibility in the shape of the estimated curve compared to the logistic model, which is constrained to an S-shaped curve (Head et al. 2020). In addition, using a flexible spline model approach allows skipped spawning dynamics to be incorporated into the maturity ogive by allowing maturity to be non-asymptotic (Head et al. 2020). Skipped spawning has been documented for Sablefish in Alaska (Rodgveller et al. 2016) and is likely present in B.C. Sablefish as well given the observation of 'resting' fish on Sablefish surveys that have spawned previously but are not developing gonads by late fall. Research has recently been initiated to evaluate the frequency and potential stock assessment implications of skipped spawning for B.C. Sablefish.

A disadvantage of the spline modelling approach is that it requires more data to support the calculation of the proportion mature at discrete age bins compared to the logistic modelling approach. That requirement limited our ability to look for temporal trends in MAA using a spline function. While there was some evidence of temporal variation in maturity curves developed using the logistic model, unrealistically high estimates of the proportion of fish mature at age-1 for some time periods and/or cohorts suggests that maturity ogives estimated at this scale are unreliable. Given that reductions in growth can lead to changes in size- and age-at-maturity for marine fish species (Lorenzen 2008), future research into potential changes in age-at-maturity over time should be considered when planning revisions to the Sablefish OM. Such research could potentially include alternative functions for describing maturity and/or alternative approaches for modelling change over time. For example, a variation of the logistic model in which the proportion mature is held constant at zero for young ages could be considered, or hierarchical approaches that allow information to be shared among years could be explored.

5 CONCLUSIONS

Operating models for B.C. Sablefish have historically relied on U.S. regional estimates of LAA and MAA model parameters due to concerns about the credibility of B.C.-based estimates. However, several of the model-data combinations presented in this report produced credible estimates based on an updated comparison with U.S. values. Future parameterizations of the BC Sablefish operating model should consider adopting empirically-based estimates to improve the biological realism.

The analyses presented in this report show evidence of declining length-at-age in recent years and cohort-specific declines in asymptotic lengths. While further analyses with more advanced statistical modelling tools and additional years of data may improve our understanding of the magnitude of these changes, there is enough evidence at this stage to warrant scenario testing of the effects of changing growth on MP performance within the MSE framework.

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APPENDIX

Table A - 1. Annual number of available morphometric (length, weight) and biological (sex, maturity, otoliths, age) metrics, combined across all research survey data sources. Additional age readings for 2024 are expected but are not available for this report.

Year	Length	Weight	Sex	Maturity	Otoliths Collected	Age
1978	14,671	0	1,100	405	429	133
1979	44,806	248	2,551	1,782	1,554	1,443
1980	34,358	153	4,227	3,674	3,210	2,911
1981	27,704	226	4,892	4,457	2,446	2,345
1982	14,393	0	5,248	4,294	2,910	2,288
1983	13,339	0	3,608	3,118	2,723	1,066
1984	25,443	101	11,644	4,894	4,575	2,103
1985	28,902	0	20,399	5,564	7,073	2,975
1986	11,595	0	11,331	3,479	3,481	2,232
1987	5,784	0	2,710	2,404	1,170	502
1988	10,314	438	10,282	6,740	5,585	2,130
1989	9,241	95	8,320	7,343	4,289	3,884
1990	6,465	0	6,392	5,999	3,380	806
1991	6,082	520	2,831	2,568	2,135	1,053
1992	9,879	726	5,799	3,784	3,979	1,848
1993	11,495	0	3,548	3,522	3,523	1,782
1994	10,674	117	3,643	2,819	2,824	2,813
1995	21,430	620	5,205	3,751	3,784	3,376
1996	32,666	412	4,354	4,327	4,334	1,775
1997	23,676	708	4,054	4,066	4,066	241
1998	27,755	109	5,419	3,532	3,534	706
1999	30,953	5	3,571	3,571	3,571	540
2000	28,043	120	4,394	4,392	4,405	234
2001	27,853	891	9,376	4,340	3,232	252
2002	29,081	1,743	9,230	7,398	6,459	870
2003	48,307	6,350	23,662	21,791	10,130	1,125
2004	33,866	2,981	14,830	11,008	9,452	1,061
2005	29,879	6,396	13,384	11,897	7,312	1,146
2006	31,326	8,478	12,092	10,340	8,276	1,421
2007	25,995	6,922	9,361	8,451	7,113	1,305
2008	18,242	7,813	9,963	8,918	7,458	1,576
2009	17,231	7,185	9,771	7,645	7,083	1,475
2010	20,736	8,255	10,806	9,028	8,157	1,273
2011	19,927	6,847	7,369	6,286	6,159	1,114
2012	16,099	6,857	7,341	6,448	6,452	1,210
2013	13,419	5,379	5,619	4,923	4,915	1,015
2014	12,025	5,057	5,685	4,725	4,704	1,744
2015	16,529	6,257	6,753	5,084	5,078	922
2016	16,482	6,708	8,065	5,882	4,795	1,261
2017	25,085	8,894	9,264	6,046	6,024	1,186
2018	19,747	8,540	8,467	6,873	6,968	1,160
2019	20,745	8,450	8,402	6,398	6,386	1,167
2020	12,022	3,682	3,683	3,684	3,667	1,152
2021	14,219	6,116	6,106	4,818	4,807	1,200
2022	16,527	7,046	7,035	5,799	5,784	919
2023	6,698	4,523	6,693	3,508	3,503	876
2024*	16,948	5,042	7,067	4,028	3,973	786

Table A - 2. Annual number of available morphometric (length, weight) and biological (sex, maturity, otoliths, age) metrics, combined across all fishery data sources. Data for 2024 are incomplete due to a lag between sample collection and data processing.

Year	Length	Weight	Sex	Maturity	Otoliths Collected	Age
1978	656	0	655	200	430	210
1979	1,210	0	1,206	142	928	517
1980	5,000	141	3,745	2,015	2,492	2,304
1981	2,903	0	2,540	1,484	1,276	150
1982	5,005	0	4,719	1,623	2,984	600
1983	3,908	0	3,982	2,772	3,786	2,033
1984	1,510	0	1,509	323	323	50
1985	0	0	0	0	0	0
1986	1,668	0	606	402	402	50
1987	4,040	0	997	850	853	844
1988	1,412	381	1,413	1,372	1,413	955
1989	909	0	908	909	599	324
1990	0	0	0	0	0	0
1991	15,112	0	14,937	0	4,989	0
1992	42,037	0	37,804	618	9,299	896
1993	21,829	0	14,570	0	5,786	1,398
1994	1,590	1,480	1,591	0	1,546	1,296
1995	2,512	2,512	2,498	0	2,513	1,799
1996	7,837	2,131	7,690	0	2,639	935
1997	7,594	2,153	7,553	0	2,728	0
1998	17,390	3,614	6,887	0	5,096	669
1999	24,411	4,505	6,696	0	7,086	734
2000	13,625	3,594	5,850	0	5,344	577
2001	6,665	4,018	4,379	0	4,440	221
2002	4,317	2,587	2,745	0	2,788	464
2003	4,873	1,412	1,951	184	1,711	0
2004	6,073	0	5,934	1,435	1,649	564
2005	1,444	0	1,165	196	582	0
2006	476	181	473	0	402	0
2007	859	426	550	0	609	0
2008	786	726	786	0	786	0
2009	1,720	1,063	1,183	0	1,191	503
2010	1,756	1,105	1,230	0	1,279	614
2011	1,466	1,314	1,313	36	1,314	425
2012	2,726	1,137	2,720	0	1,572	423
2013	1,288	766	1,059	0	1,058	812
2014	1,132	544	1,043	0	1,058	737
2015	1,152	854	1,032	0	948	802
2016	1,080	552	806	0	819	604
2017	2,079	541	1,395	0	1,437	318
2018	1,073	420	1,025	0	1,076	0
2019	1,113	758	1,064	0	1,116	0
2020	974	968	925	0	974	382
2021	735	735	729	0	735	0
2022	1,144	1,144	1,098	0	1,144	171
2023	1,018	1,018	969	0	992	475
2024*	584	584	434	0	452	357

Table A - 3. Available number of paired length-age measurements from research surveys for length-at-age analysis, by year and data source. Only age estimates that used break and burn methodology are included.

Year	Sablefish Inlet Std	Sablefish Off. Std	Sablefish StRS	Sablefish Tagging	Bottom Trawl	Gillnet	Longline	Other Trap
1978	-	-	-	-	-	-	-	126
1979	-	-	-	-	750	75	-	583
1980	-	-	-	-	204	-	1035	1638
1981	-	-	-	-	485	-	-	1852
1982	-	-	-	-	-	-	-	2287
1983	-	-	-	-	-	-	-	1063
1984	-	-	-	-	-	-	-	2087
1985	-	-	-	-	-	-	-	2967
1986	-	-	-	-	-	-	-	2230
1987	-	-	-	-	-	-	-	486
1988	-	1422	-	-	-	-	-	698
1989	-	3872	-	-	-	-	-	-
1990	-	756	-	-	-	-	-	50
1991	-	1053	-	-	-	-	-	-
1992	-	1848	-	-	-	-	-	-
1993	-	1781	-	-	-	-	-	-
1994	453	2059	-	204	-	-	-	-
1995	772	1697	-	545	199	-	-	129
1996	-	979	-	792	-	-	-	-
1997	-	187	-	54	-	-	-	-
1998	-	704	-	-	-	-	-	-
1999	-	533	-	-	-	-	-	6
2000	-	234	-	-	-	-	-	-
2001	-	250	-	-	-	-	-	-
2002	-	867	-	-	-	-	-	-
2003	-	486	637	-	-	-	-	-
2004	-	418	642	-	-	-	-	-
2005	-	514	630	-	-	-	-	-
2006	253	668	498	-	-	-	-	-
2007	-	644	655	-	-	-	-	-
2008	175	672	728	-	-	-	-	-
2009	-	597	863	-	10	-	-	-
2010	288	3	976	-	-	-	-	-
2011	-	-	1111	-	-	-	-	-
2012	-	-	1207	-	-	-	-	-
2013	-	-	1011	-	-	-	-	-
2014	-	-	1741	-	-	-	-	-
2015	-	-	920	-	-	-	-	-
2016	-	-	1261	-	-	-	-	-
2017	-	-	1163	-	21	-	-	-
2018	-	-	1157	-	-	-	-	-
2019	-	-	1164	-	-	-	-	-
2020	-	-	1150	-	-	-	-	-
2021	-	-	1198	-	-	-	-	-
2022	-	-	919	-	-	-	-	-
2023	45	-	893	-	-	-	-	-
2024	-	-	783	-	-	-	-	-

Table A - 4. Available number of paired length and weight measurements from research surveys for weight-length analysis, by year and data source.

Year	Sablefish Inlet Std	Sablefish Off. Std	Sablefish StRS	Sablefish Tagging	Bottom Trawl	Long-line	Midwater Trawl	Shrimp Trawl	Other Trap
1979	-	-	-	-	245	-	1	-	-
1980	-	-	-	-	-	-	1	-	101
1981	-	-	-	-	-	-	-	-	225
1984	-	-	-	-	-	-	101	-	-
1988	-	438	-	-	-	-	-	-	-
1989	-	-	-	-	95	-	-	-	-
1991	-	520	-	-	-	-	-	-	-
1992	-	533	-	-	177	-	-	-	-
1994	-	91	-	-	-	-	-	-	-
1995	-	-	-	-	452	-	-	-	129
1996	-	158	-	57	195	-	-	-	-
1997	-	-	-	-	-	-	-	-	-
1998	-	-	-	-	109	-	-	-	-
1999	-	-	-	-	-	-	4	-	-
2000	-	-	-	-	119	-	-	-	-
2001	-	-	-	-	830	-	50	-	-
2002	369	590	-	-	775	-	-	-	-
2003	759	1833	2225	-	1352	75	-	102	-
2004	1172	1137	-	-	590	38	-	44	-
2005	935	2423	2091	-	940	-	-	-	-
2006	965	2250	4078	-	1050	-	-	123	-
2007	810	1707	3961	-	436	-	-	NA	-
2008	673	1977	4052	-	1073	-	-	26	-
2009	870	1751	4062	-	494	-	-	-	-
2010	1145	1849	4246	-	975	-	-	26	-
2011	1034	-	4881	-	790	-	15	77	36
2012	981	-	4549	-	1322	-	-	-	-
2013	864	-	3947	-	448	-	-	102	-
2014	789	-	3447	-	797	12	-	-	-
2015	912	-	3635	-	1703	-	-	-	-
2016	907	-	3782	-	971	120	-	923	-
2017	1023	-	3688	-	2757	-	9	1411	-
2018	1077	-	4387	-	2999	-	-	-	-
2019	1063	-	4328	-	2642	32	-	334	-
2020	-	-	3599	-	80	-	-	-	-
2021	260	-	3555	-	2208	34	-	30	14
2022	256	-	4290	-	2278	1	-	192	15
2023	168	-	2928	-	1149	19	11	117	121
2024	-	-	2749	-	2166	-	-	84	6

Table A - 5. Available number of paired maturity and age measurements from research surveys for maturity-at-age analysis, by year and data source. Only age estimates that used break and burn methodology are included.

Year	Sablefish Inlet Std	Sablefish Off. Std	Sablefish StRS	Sablefish Tagging	Bottom Trawl	Gillnet	Longline	Other Trap
1978	-	-	-	-	-	-	-	126
1979	-	-	-	-	501	75	-	583
1980	-	-	-	-	204	-	1037	1653
1981	-	-	-	-	289	-	-	1855
1982	-	-	-	-	-	-	-	2266
1983	-	-	-	-	-	-	-	1063
1984	-	-	-	-	-	-	-	2087
1985	-	-	-	-	-	-	-	2289
1986	-	-	-	-	-	-	-	2230
1987	-	-	-	-	-	-	-	485
1988	-	1421	-	-	-	-	-	699
1989	-	3874	-	-	-	-	-	-
1990	-	756	-	-	-	-	-	50
1991	-	1053	-	-	-	-	-	-
1992	-	1848	-	-	-	-	-	-
1993	-	1781	-	-	-	-	-	-
1994	453	2059	-	204	-	-	-	-
1995	772	1700	-	545	199	-	-	129
1996	-	979	-	792	-	-	-	-
1997	-	187	-	54	-	-	-	-
1998	-	706	-	-	-	-	-	-
1999	-	533	-	-	-	-	-	6
2000	-	234	-	-	-	-	-	-
2001	-	250	-	-	-	-	-	-
2002	-	868	-	-	-	-	-	-
2003	-	486	637	-	-	-	-	-
2004	-	418	642	-	-	-	-	-
2005	-	514	631	-	-	-	-	-
2006	253	668	498	-	-	-	-	-
2007	-	644	655	-	-	-	-	-
2008	175	672	729	-	-	-	-	-
2009	-	598	863	-	10	-	-	-
2010	288	3	979	-	-	-	-	-
2011	-	-	1112	-	-	-	-	-
2012	-	-	1208	-	-	-	-	-
2013	-	-	1015	-	-	-	-	-
2014	-	-	1744	-	-	-	-	-
2015	-	-	920	-	-	-	-	-
2016	-	-	1261	-	-	-	-	-
2017	-	-	1163	-	21	-	-	-
2018	-	-	1157	-	-	-	-	-
2019	-	-	1164	-	-	-	-	-
2020	-	-	1151	-	-	-	-	-
2021	-	-	1199	-	-	-	-	-
2022	-	-	919	-	-	-	-	-
2023	45	-	893	-	-	-	-	-
2024	-	-	783	-	-	-	-	-

Table A - 6. Maturity code, name and description for female and male Sablefish when maturity is assessed macroscopically.

Maturity Code	Sex	Maturity Name	Maturity Description
1	Female	IMMATURE 1	Thin string-like =1.5mm thick mid-section, translucent-white colour
2		IMMATURE2	Thickened to >5mm, does not extend length of body cavity, some folds sausage-like, translucent-white colour
3		RIPENING1	Eggs present, white opaque colour, encased in translucent sock, <25% cavity
4		RIPENING2	Eggs larger =1mm diameter, white in colour, blood vessels present on surface, >25% body cavity
5		RIPE	Eggs at least 1mm diameter, white in colour, gonad full size, >50% cavity
6		RIPE1	Gonad full size, >50% cavity but at least 25% have become translucent
7		RIPE2	Gonad full size, >50% cavity but at least 50% have become translucent
8		RUNNING RIPE	Stream of translucent eggs released when slight-moderate pressure is applied to external posterior region of body cavity
9		SPENT	Gonad is red-purple in colour, residual eggs may be present, outer wall of gonad flaccid
10		RESORBING	Eggs present but did not function normally (not normal)
11		RECOVERING	Still some red purple colour, not flaccid, whitish sheen to exterior surface
12		RESTING	Smooth elongated and round in shape, brown purple pulp interior, exterior surface has whitish sheen
1	Male	IMMATURE 1	Very thin string-like >1mm thick, translucent white colour
2		IMMATURE2	Thin string-like 3mm thick, extends length of body cavity, white-translucent colour
3		RIPENING1	Thick >10mm, visible folds, white smooth texture, =20% body cavity
4		RIPENING2	Thick >10mm, visible folds, white smooth texture with blood vessels present on surface, >30% body cavity
5		RIPE	Thick >10mm, visible folds, white smooth texture with blood vessels present on surface, folds delicate, some sperm may flow, >40% cavity
8		RUNNING RIPE	Lobes fully developed, sperm is released when slight pressure is applied to external posterior region of body cavity
9		SPENT	Lobes or folds are bloodshot, some sperm may be present when moderate pressure is applied to external posterior region of body cavity
11		RECOVERING	Lobes flat, brown in colour, bloodshot appearance on edges and ends of lobes
12		RESTING	Firm, light brown colour, wrinkles on surface