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Area 23 (Barkley Sound, Alberni Inlet) Sockeye Forecast for the 2023 Return

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SUMMARY

- For 2023 fishery management purposes, the Area 23 Roundtable has agreed to begin fisheries in the “Moderate” zone (500 000–700 000 adult return) for early season harvest management. Henderson Lake Sockeye remain a constraining stock in the “Low” zone.
- There is uncertainty among the 2023 forecast models. Predictions (Table 3) vary between 145 000 (Sea Surface Temperature), 276 000 (Coho Leading Indicator model), 465 000 (multivariate model), and 723 000 (sibling model). Forecast models for the 2023 aggregate Somass Sockeye return are described in Appendix A.
- All forecast models suggest Sproat Lake Sockeye will comprise the majority of the 2023 run. In 2019 and 2020 (broods returning as age 4 and 3 fish, respectively in 2023), escapements of Great Central Lake Sockeye were abnormally low (Figure 5). In addition, the estimated juvenile Sockeye abundances in Great Central Lake and Sproat Lake in the 2020 and 2021 sea-entry years were low compared to historic levels. Returns from the 2020 sea-entry year have thus far indicated a high marine survival rate, but the marine survival rate for the 2021 sea-entry year is more uncertain. Therefore, a precautionary management approach for early season fisheries is warranted until the total run size and stock composition can be more accurately determined. In-season estimates of stock composition will be available during the second and third weeks of June; the first run size reforecast is expected 22 June 2023.
- The recommended management outlook for Henderson Sockeye is the “Low” zone for harvest management, corresponding to an expected return of 15 000–25 000 (Table 4). The key consideration influencing this outlook is a high marine survival rate in 2020, and moderate spawner abundances in the main contributing brood years, 2018–2019.

BACKGROUND

Great Central Lake, Sproat Lake, and Henderson Lake are the three main Sockeye stocks returning to Barkley Sound (Area 23). The status of each stock is assessed as a separate Conservation Unit (CU) for implementation of Canada’s Wild Salmon Policy. From 1980–2022, the median adult terminal returns (catch and escapement) of Great Central Lake, Sproat Lake, and Henderson Lake Sockeye are 312 000, 241 000 and 23 000, respectively (Table 5). In the Somass Sockeye return, the historical median split between Great Central Lake and Sproat Lake abundance is 55% Great Central (inter-quartile range: 46–62% Great Central).

The pre-season biological forecasts for Somass Sockeye (outlined in this bulletin) inform a *management forecast* that guides June fishing plans (Table 8). The run size forecasts are revised weekly starting in the third week of June based on in-season indicators described later in this bulletin. The first in-season reforecast is anticipated no earlier than Thursday, 22 June 2023.

Data limitations preclude a statistical forecast for Henderson Sockeye. Instead, a management zone is set based on an outlook that considers spawner abundances and smolt abundances (when available) and indicators related to marine survival rates for the contributing brood years. This outlook informs the amount and timing of commercial gillnet openings in outer areas of Barkley Sound, which are more likely to intercept Henderson Sockeye (Table 9).

2023 SOMASS SOCKEYE BIOLOGICAL FORECASTS

Several indicators of varying accuracy are used to inform the pre-season Somass Sockeye biological forecasts: abundances of younger siblings from the same brood and smolt years as returning 2023 age classes, average sea surface temperatures and sea surface salinities recorded in outer Barkley Sound during the juvenile outmigration period (March–May), survival rates in Coho from the same brood year that return as adults one year earlier, and estimates of winter smolt abundances in Great Central and

Sproat Lakes. The predicted Somass aggregate return is further broken down into age- and stock-specific forecasts in Table 3.

Model forecasts for the 2023 aggregate Somass Sockeye return are described in detail in Appendix A and summarized here:

- The Multivariate forecast (Table 3, Figure 1) predicts a total return to the Somass river of 465000 (75% prediction interval: 170000–1281000) adult Sockeye. The predicted returns to Great Central and Sproat Lakes are 170000 and 295000 adult Sockeye, respectively (36% GCL).
- The Sibling forecast (Table 3) predicts a total return to the Somass river of 723000 adult Sockeye. The predicted returns to Great Central and Sproat Lakes are 307000 and 416000 adult Sockeye, respectively (42% GCL). The majority of adults predicted to return to GCL are age 4_2, whereas the strength of the SPL return is predicted to come as 5 year-olds (Table 3).
- The sea-surface-temperature-based SStM forecast (Table 3) predicts a total return to the Somass river of 145000 adult Sockeye. The predicted returns to Great Central and Sproat Lakes are 67000 and 76000 adult Sockeye, respectively (47% GCL). Spring marine temperatures at Amphitrite Point were above average in 2020 and close to average in 2021, which results in a "low" survival scenario (2.5%) for returning 5-year-olds and a "high" survival scenario (5%) for returning 4-year-olds. Indications from the 2020–2021 sea-entry years suggest marine survivals are likely average to high for these cohorts (Figure 6). However, smolt abundances were low in both Great Central and Sproat Lakes through 2020–2021 (Figure 4).
- The Coho Leading Indicator (CLI) model predicts a total return to the Somass river of 276000 adult Sockeye. The predicted returns to Great Central and Sproat Lakes are 62000 and 214000 adult Sockeye, respectively (22% GCL). The CLI model accounts for spawner abundances in the contributing brood years, as well as the survival rate of Coho from the contributing sea-entry years. Coho survival rates were slightly above the 6% average in 2020 (6.9%) and 2021 (7.4%).

2023 SOMASS SOCKEYE MANAGEMENT FORECAST

For fishery management purposes, the Area 23 Roundtable has agreed to manage to a forecast in the "Moderate" zone (see Table 8) corresponding to an expected return of 500000–700000 adult Sockeye.

Based on the projected return, a precautionary approach to fisheries management will be required until in-season information can inform run size estimates. In-season indicators that will be applied to inform management in 2023:

- Stock compositions from samples collected by the test fishery in June will be used as an indicator of the relative proportions of Great Central and Sproat Lake at the end of the run.
- Area D gillnet catch in Area 23 in the second and third weeks of June will be used as an indicator of the final Somass Sockeye adult return.
- The total cumulative accounting (escapement, catch, Alberni Inlet abundance estimate, and lower river abundance estimate) and estimated run timing will be used to predict the final Somass Sockeye adult return.
- Scale samples collected from the test boat, fisheries, and escapement at the fishways will inform the predicted age composition of the return.
- River temperatures and inlet conditions will inform holding patterns and migration conditions, which affect escapement timing, pre-spawn natural mortality, and susceptibility to fisheries.

2023 HENDERSON SOCKEYE OUTLOOK

The recommended management outlook for Henderson Sockeye is the "Low" zone for harvest management, corresponding to an expected return of 15000–25000 Sockeye (Table 4). Spawner abundances in the main contributing brood years were near the historical median of 13000 (12000

Sockeye in 2018, 13500 Sockeye in 2019; Table 4). Based on positive ocean indicators and data from incomplete brood years, marine survivals are expected to be high. Therefore, expectations are for a near-average Henderson sockeye return in 2023.

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APPENDIX A. FORECAST METHODOLOGY

Statistical forecast models

Four models have historically been used to forecast Sockeye returns to Great Central and Sproat Lakes: the Survival Stanza Method (SStM), Surface Salinity Method (SSM), Salmonid Enhancement Program Biostandard Method (SEPB), and Coho Leading Indicator Method (CLI; Hyatt et al. 2003). More recently, a sibling regression model has been developed that uses the relationships between the returns of Sockeye at earlier ages to predict future returns of their older siblings (*i.e.* predicts age 4, 5, and 6 returns based on the abundance of earlier returning age 3, 4, and 5 fish from matching brood years; Peterman 1982, DFO 2012). In 2021, a multivariate multiple regression model was developed that integrates data from younger sibling abundances, smolt abundances, and sea-entry conditions. The multivariate regression model considers not only the individual effects of each predictor, but also their interactions (*e.g.* smolt abundance is likely predictive of adult returns only when sea-entry conditions are favorable).

The SStM and SSM use annual estimates of the numbers of smolts from Great Central and Sproat Lakes and predictors of early marine survival (marine temperature and salinity measured off Amphitrite Point, Ucluelet, respectively) to estimate returns (Hyatt et al. 2003).

The CLI model is based on the observation that marine survivorships for both juvenile Sockeye and Coho migrating through Barkley Sound and up the West Coast of Vancouver Island often covary because both species face similar physical and biological conditions at sea-entry in a given year (Hyatt et al. 2003). Because Coho return one year earlier than most Sockeye, Coho survival values observed in one year can be used to predict survival of Sockeye returning the following year.

In general, the Sibling and SStM forecasts have provided the most accurate forecasts over the long term, with mean absolute percentage errors (MAPE) of 39% and 62%, respectively (Figure 7). Over the past 5 years, the Sibling and SSM models have performed the best (MAPEs of 41% and 80% respectively), while the SStM and CLI models have performed poorly (MAPEs of 90%, 183%, respectively; Figure 7). The Multivariate model appears to improve on the Sibling model, with a retrospective MAPE of 33% (Figure 8). The multiple regression analysis applied by the Multivariate model suggests that much of the variation in survival rates ascribed to sea-entry conditions in the smolt-based models is captured in the returning sibling abundances.

The forecasts generated from all methods are evaluated based on their relative accuracy at predicting past returns along with other relevant information (*e.g.* marine environmental conditions or observations). A heuristic management forecast for the Somass aggregate return is produced to guide early season fisheries. This forecast sets pre-season expectations and guides early-season harvest planning.

2022 forecast performance

The pre-season management forecast was in the “Low” zone with a predicted return of approximately 400 000 adult Somass Sockeye (Table 2).

The observed return of approximately 880 000 adult Somass Sockeye was in the 67th percentile of all runs recorded since 1977 (Table 1, Table 5, Figure 2). Fish from the 2016–2019 brood years returned in 2022, with the majority contributed from 2017 and 2018. The proportion of age 4_2 fish (61%) was well above the sibling model prediction (13%), but similar to predictions from the Multivariate, CLI, and SStM models (68%, 54%, and 53%, respectively). The 2022 return included above average jack (ages 3_2 and 4_3) returns to both Sproat Lake and Great Central Lake.

The proportion of Great Central Lake in the total return (34%) was lower than expected pre-season (41%; average of the 4 forecast models employed). The returns from the 2017 brood year appear to be weighted toward Great Central Lake (72% Great Central in the 2017 brood returns) but returns from the 2018 brood year are heavily dominated by Sproat Lake (90% Sproat in the 2018 brood returns; Table 6).

All models under-predicted the 2022 return (Table 2). The prediction from the sibling model was closest to the observed return (absolute percentage error: 45%). However, the sibling model also deviated most from the GCL/Sproat split in the final 2022 return, with a 54% predicted GCL. All models correctly predicted that the age 4_2 return to Sproat Lake would be the dominant component in the 2022 return. In the 2019 sea-entry year (age 5_2 and 6_3 Sockeye returning in 2022), the smolt abundance in GCL was average, and in 2020 GCL smolt abundance was very low; these abundances translated to a strong adult return to GCL in 2021. This combination of average and low smolt abundances in GCL led the smolt-based forecast models (CLI, SStM) to under-predict the return considerably; preliminary data from the 2020 sea-entry year suggest a high survival rate of 11.7% (Figure 6), well above the 6.9% and 5.0% applied in the CLI and SStM, respectively.

The return of approximately 26000 Henderson Lake Sockeye in 2022 exceeded the 10-year median of *c.* 16000 (Table 1, Table 5, Figure 3). The pre-season outlook was for a management zone of “very low” (*i.e.*, < 15,000 Sockeye). Pre-season expectations were based on the relatively low spawner abundance observed in the 2018 brood year, and an expectation for low marine survival rates to be experienced by the 2019 and 2020 sea-entry years. However, returns thus far from the 2020 sea-entry year indicate a high marine survival rate (see above).

Sources of uncertainty

The mean absolute percentage errors (MAPEs) for the five forecast models used to predict Somass Sockeye range from about 40–208%. Retrospective analysis suggests the Multivariate model is the best performing forecast (Table 3; Figure 7). On average, the observed return is about 40% higher or lower than the return predicted by the Multivariate model. Factors that contribute to forecast uncertainty include, but are not limited to: model structure, assumptions about the relationships between returns and the predictor variables, and uncertainty in the source data (*e.g.* smolt abundances, age compositions in historical returns).

For the Henderson Sockeye outlook, there is considerable uncertainty due to lower quality assessment data relative to the Somass stocks. There are less complete age data, relatively high uncertainty in the estimates of spawner abundance, and uncertainty in catch estimates. Catch estimates are particularly uncertain in recent years when the abundance of Henderson Sockeye is low relative to the Somass stocks. Under these circumstances, the probability of detection of Henderson Sockeye in catch samples is lower and therefore catch of Henderson Sockeye may be underestimated.

The relationships between available ocean indicators and survival rates in Area 23 Sockeye are uncertain. While there are weak correlations between spring sea surface temperatures and salinities measured at Amphitrite Point and Somass Sockeye survival, some years with seemingly excellent ocean conditions (*e.g.* 2002) have not yielded high survivorship. Investigative analyses carried out in 2023 suggest there is likely a better relationship between offshore sea surface temperatures (from ECCC buoy c46132 “South Brooks”) from February–April in sea-entry years compared to the nearshore temperatures recorded at the Amphitrite Point lightstation. However, 2019–2020 data are missing from the South Brooks historical record, so these data could not be used to predict 2023 returns. Smolt estimates for the 2018–2021 sea-entry years were derived from a revamped acoustic-trawl survey program and are considered to have better accuracy compared to previous years in the historical record.

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APPENDIX B. TABLES AND FIGURES

Table 1. Total return of Sockeye to Barkley Sound in 2022.

Conservation Unit	Age at Return						Total	Adults
	3_2	4_2	4_3	5_2	5_3	6's		
Great Central Lake	46770	65895	1621	157389	19065	55035	345775	297384
Sproat Lake	58148	545635	4013	30513	5301	5577	649187	587026
Henderson Lake		6598		19915			26513	26513
Combined Barkley Sound	**104918**	**618128**	**5634**	**207817**	**24366**	**60612**	**1021475**	**910923**

Table 2. Forecast performance of Somass Sockeye models for 2022. Absolute Percentage Error (APE) is the absolute value of (Forecast return – Observed return) × (Observed return)$^{-1}$.

2022 Management forecast: Low zone (*c.* 400000 adults)				
884410 observed	**Forecast 2022**			
	SStM	**CLI**	**Sibling**	**Multivariate**
Expected	169575	357714	488000	412000
Obs. − Exp.	714835	526696	396410	472410
APE	81%	60%	45%	53%

Table 3. Predictions by age and lake for 2023 from the four best-performing Somass Sockeye forecast models.

Forecast		Age at return					% of return
			4_2	**5_2**	**5_3 and 6_3**	**Total**	
Sibling	GCL		256,478	39,253	11,163	**306,894**	42%
	SPL		161,667	212,371	42,162	**416,200**	58%
	Total		418,144	251,625	53,325	**723,094**	
	% at age		13%	76%	10%		
			4s	**5s**		**Total**	
SStM	GCL		61,325	7,438		**68,763**	47%
	SPL		51,345	25,000		**76,345**	53%
	Total		112,670	32,438		**145,108**	
	% at age		78%	22%			
		4_2	**5_2**	**5_3**	**6_3**	**Total**	
CLI	GCL	28,783	18,758	5,566	8,578	**61,685**	22%
	SPL	113,013	81,833	15,374	3,705	**213,925**	78%
	Total	141,796	100,590	20,940	12,283	**275,610**	
	% at age	51%	36%	8%	4%		
		4_2	**5_2**	**5_3**	**6_3**	**Total**	
Multivariate	GCL	96,609	43,281	21,740	7,687	**169,317**	36%
	SPL	152,682	124,896	15,307	2,322	**295,207**	64%
	Total	249,291	168,177	37,047	10,009	**464,524**	
	% at age	54%	36%	8%	2%		

Table 4. Factors considered in the 2023 outlook for the Henderson Sockeye return.

Return Year	**Age at Return**	**Brood year**	**Spawner abundance**	**Smolt Year**	**Smolt Abundance**	**Marine Survival**
2023	4	2019	13.5k (avg.)	2021	*Pending*	average
	5	2018	12k (avg.)	2020	*Pending*	high

Table 5. Terminal adult return of Area 23 Sockeye; 1980–2022. All catch includes Henderson Sockeye.

RETURN YEAR	TEST FISHERY	FIRST NATIONS CATCH: Tseshaht / Hupacasath Total Catch	FIRST NATIONS CATCH: Barkley Bands (FSC)	FIRST NATIONS CATCH: Maanulth First Nation	FIRST NATIONS CATCH: Total First Nations	COMMERCIAL CATCH: Comm GN	COMMERCIAL CATCH: Comm SN	COMMERCIAL CATCH: Troll	COMMERCIAL CATCH: Special Use	COMMERCIAL CATCH: Total Comm Catch	RECREATIONAL: Recreational	TOTAL A23 CATCH	HED catch	ESCAPEMENT: GCL adults	ESCAPEMENT: SPR adults	ESCAPEMENT: HED	ESCAPEMENT: Ttl Adult Esc	TOTAL RETURN	HED return
1980	-	15,791	-		15,791	292,339	374,760	-	-	667,099	-	682,890		246,041	124,943	21,000	391,984	**1,074,874**	**21,000**
1981	-	17,000	-		17,000	391,950	617,474	-	-	1,009,424	-	1,026,424		195,124	118,710	40,000	353,834	**1,380,258**	**40,000**
1982	-	23,500	-		23,500	229,271	246,673	-	-	475,944	-	499,444		155,579	213,477	56,000	425,057	**924,501**	**56,000**
1983	-	30,000	-		30,000	315,478	603,827	-	-	919,305	-	949,305		339,204	239,763	45,000	623,967	**1,573,272**	**45,000**
1984	-	21,000	-		21,000	454,813	463,971	-	-	918,784	-	939,784		131,000	76,373	61,000	268,374	**1,208,158**	**61,000**
1985	77*	15,987	-		15,987	249,814	190,038	-	-	439,852	1,731	457,570		112,339	113,688	16,000	242,027	**699,597**	**16,000**
1986	2,885*	12,800	-		12,800	30,461	13,640	-	-	44,101	17	56,918		119,820	173,915	3,000	296,735	**353,653**	**3,000**
1987	6,993*	23,395	-		23,395	19,921	189,643	-	-	209,564	21,424	254,383		277,562	105,457	26,000	409,019	**663,402**	**26,000**
1988	10,470*	21,292	-		21,292	146,391	146,603	-	-	292,994	348	314,634		195,327	210,518	35,000	440,845	**755,479**	**35,000**
1989	648	23,395	-		23,395	4,145		-	-	4,145	139	27,679		171,652	133,349	36,000	341,000	**368,679**	**36,000**
1990	7,211*	10,480	-		10,480	3,617	8,062	-	-	11,679	14,430	36,589		163,320	93,631	32,000	288,952	**325,541**	**32,000**
1991	8,505*	36,523	-		36,523	282,833	762,634	-	-	1,045,467	78,551	1,160,541		402,976	140,123	37,000	580,099	**1,740,640**	**37,000**
1992	-	53,662	-		53,662	203,890	211,938	-	-	415,828	101,408	570,898		149,898	192,641	35,000	377,539	**948,437**	**35,000**
1993	11,997*	58,020	10,000		68,020	258,957	346,246	-	-	605,203	107,407	780,630		227,694	187,860	150,000	565,553	**1,346,183**	**150,000**
1994	10,475	53,656	10,000		63,656	74,981	-	-	-	74,981	30,261	179,373		113,121	142,162	18,000	273,282	**452,655**	**18,000**
1995	146	23,782	-		23,782	-	-	-	-	-	6,519	30,447		40,940	43,254	4,000	88,195	**118,642**	**4,000**
1996	4,513	28,139	-		28,139	-	-	-	-	-	28,033	60,685		157,087	207,716	56,000	420,804	**481,489**	**56,000**
1997	10,493	29,508	12,098		41,606	52,241	-	2,100	-	54,341	36,531	142,971		174,088	126,349	49,000	349,437	**492,408**	**49,000**
1998	17,522	45,200	30,859		76,059	49,924	-	9,003	-	58,927	55,421	207,929		184,542	142,360	82,000	408,902	**616,831**	**82,000**
1999	4,445	39,820	1,000		40,820	53,800	-	8,819	-	62,619	7,870	115,754		203,969	162,776	12,000	378,745	**494,499**	**12,000**
2000	6,904	36,649	16,500		53,149	16,260	-	5,236	-	21,496	24,315	105,864		52,043	108,568	23,000	183,611	**289,475**	**23,000**
2001	7,004	58,245	20,000		78,245	46,640	-	21,022	-	67,662	67,190	220,100		307,106	158,923	11,000	477,029	**697,130**	**11,000**
2002	9,207	99,014	41,575		140,589	131,176	202,893	51,087	-	385,156	58,718	593,670		259,482	190,971	18,000	468,453	**1,062,123**	**18,000**
2003	10,577	64,908	25,651		90,559	149,499	209,823	-	-	359,322	61,610	522,069		223,546	163,807	3,000	390,352	**912,421**	**3,000**
2004	10,318	119,522	28,673		148,195	46,420	48,041	-	-	94,461	81,836	334,810		213,021	113,798	3,000	329,819	**664,629**	**3,000**
2005	9,233	49,213	3,745		52,958	11,305	-	-	-	11,305	31,292	104,788		172,962	131,949	2,000	306,911	**411,700**	**2,000**
2006	11,188	35,808	5,000		40,808	5,449	-	-	-	5,449	30,514	87,959		135,493	61,940	3,000	200,433	**288,391**	**3,000**
2007	885	8,706	-		8,706	-	-	-	-	-	-	9,591		67,717	52,837	12,000	132,554	**142,145**	**12,000**
2008	-	-	-		-	-	-	-	-	-	-	-		59,589	65,333	11,000	135,921	**135,921**	**11,000**
2009	-	55,345	12,963		68,308	9,138	14,735	-	-	23,873	55,218	147,399		203,858	130,289	30,000	364,148	**511,547**	**30,000**
2010	-	85,596	20,915		106,511	240,170	495,495	-	-	735,665	77,462	919,638		255,339	296,956	30,000	582,296	**1,501,934**	**30,000**
2011	-	109,369		17,081	126,450	231,442	192,333	-	-	423,775	42,799	593,024	6,965	431,213	381,980	20,423	833,616	**1,426,640**	**27,388**
2012		154,951		18,047	172,998	116,106	79,550	-	-	195,656	16,940	385,593	5,942	147,440	192,226	17,133	356,800	**742,393**	**23,075**
2013	5,313	31,208		11,851	43,059	11,390	9,128	-	-	20,518	13,274	82,164	1,125	66,688	119,849	12,500	199,037	**281,201**	**13,625**
2014	9,636	164,319		19,659	183,978	169,685	243,937	-	5,190	418,812	16,313	628,739	21,656	66,298	159,751	11,837	237,885	**866,624**	**33,493**
2015	11,298	319,351		25,267	344,618	329,505	521,003	-	15,000	865,508	88,232	1,309,656	5,192	417,774	312,265	6,400	736,440	**2,046,096**	**11,592**
2016	8,887	170,326		26,765	197,091	161,607	228,329	-	13,124	403,060	51,680	660,719	23,111	220,952	211,926	10,700	443,578	**1,104,297**	**33,811**
2017	3,328	36,305		14,672	50,977	9,879	16,461	-	-	26,340	12,420	93,065	3,217	125,846	142,684	22,704	291,234	**384,299**	**25,921**
2018	4,837	35,886		18,278	54,164	10,785	6,075	-	-	16,860	5,566	81,427	626	36,418	146,312	12,203	194,933	**276,360**	**12,829**
2019	3,409	27,770		12,792	40,562	6,482	-	-	-	6,482	2,193	52,646	154	35,982	91,245	13,549	140,776	**193,422**	**13,703**
2020	6,314	35,890		7,876	43,766	6,961	-	-	-	6,961	6,575	63,616	443	109,174	131,529	4,589	245,292	**308,908**	**5,032**
2021	7,272	51,306		20,795	72,101	35,777	35,110	-	-	70,887	36,410	186,670	4,359	220,319	105,441	14,520	340,280	**526,950**	**18,879**
2022	7,872	98,114		22,698	120,812	99,292	108,395			207,687	9,531	345,902	7,731	194,241	366,294	18,646	579,181	**925,083**	**26,377**
MEDIAN	4,837	36,305	-	18,163	43,766 #	52,241	41,576	-	-	74,981	16,940	220,100	4,776	172,962	142,162	18,000	353,834	663,402	23,075
10 YR MED	6,793	43,806	#N/A	18,969	63,133 #	23,584	25,786	-	-	48,613 #	12,847	139,868		117,510	144,498	12,352	268,263	455,624	16,291
5 YR MED	6,314	35,890	#N/A	18,278	54,164 #	10,785	6,075	-	-	16,860 #	6,575	81,427		109,174	131,529	13,549	245,292	308,908	13,703

Table 6. Escapement, catch, and total return-at-age to date from brood years contributing to the 2023 Somass Sockeye return. *Note*.—data from each brood year span multiple return years; *e.g.* fish from the 2017 brood year returned as age 3s in 2020, 4s in 2021, 5s in 2022, and will return as age 6s in 2023.

		2017 brood year			2018 brood year			2019 brood year		
	Age	GCL	SPL	TOTAL	GCL	SPL	TOTAL	GCL	SPL	TOTAL
Escapement	3_2	22388	35746	58134	2958	74697	77655	39566	43668	83234
	4_2	85200	28397	113597	33947	347701	381648			
	4_3	1903	2202	4105	1384	3032	4416			
	5_2	110581	14378	124959						
	5_3	11833	2557	14390						
	TOTAL	*231905*	*83280*	*315185*	*38289*	*425430*	*463719*	*39566*	*43668*	*83234*
Catch	3_2	4423	4587	9010	1637	1034	2671	3918	13900	17818
	4_2	30847	19223	50070	31246	195225	226471			
	4_3	61	34	95	295	952	1247			
	5_2	46965	16642	63607						
	5_3	7825	2745	10570						
	TOTAL	*90121*	*43231*	*133352*	*33178*	*197211*	*230389*	*3918*	*13900*	*17818*
Total Return	3_2	26811	40333	67144	4595	75731	80326	43484	57568	101052
	4_2	116047	47620	163667	65193	542926	608119			
	4_3	1964	2236	4200	1679	3984	5663			
	5_2	157546	31020	188566						
	5_3	19658	5302	24960						
	TOTAL	**322026**	**126511**	**448537**	**71467**	**622641**	**694108**	**43484**	**57568**	**101052**
% of Somass return		72%	28%		10%	90%		43%	57%	

Table 7. Estimates of juvenile Sockeye abundance (millions) in Great Central, Sproat, and Henderson Lakes for smolt years 1980–2021. Most Sockeye returning in 2023 went to sea in 2020 and 2021. *Note.*—Since 2014 in GCL and 2015 in Sproat, age compositions are based on historical averages rather than observed scale ages in smolt biosamples (indicated with grey and italicized numbers in the table below).

Sea-entry year	**Great Central Lake**			**Sproat Lake**			**Henderson Lake**
	Age 1s	**Age 2s**	**Total**	**Age 1s**	**Age 2s**	**Total**	**Total**
1980	7.45	0.00	7.40	4.48	0.00	4.62	
1981	9.31	0.31	9.60	5.48	0.14	5.68	2.88
1982	6.79	2.75	9.50	7.93	0.33	8.34	2.15
1983	12.45	0.81	13.20	8.14	0.14	8.43	3.79
1984	7.66	1.46	9.10	9.37	0.27	9.64	4.30
1985	9.64	0.83	10.40	19.26	0.00	19.56	3.52
1986	7.11	2.45	9.50	5.79	0.14	6.97	4.26
1987	4.91	0.35	5.20	4.52	0.52	5.04	0.96
1988	3.41	0.43	3.80	8.69	0.00	8.89	0.03
1989	6.07	0.26	6.40	8.84	0.22	9.19	2.07
1990	6.75	0.51	7.20	10.10	0.49	11.18	2.57
1991	8.68	2.03	10.70	7.62	0.81	8.54	1.68
1992	4.58	0.21	4.80	5.42	0.28	5.88	0.86
1993	7.12	0.05	7.15	3.20	0.05	3.37	0.95
1994	3.13	0.77	3.90	9.69	0.36	5.99	0.90
1995	2.87	0.53	3.40	5.57	0.09	5.90	5.46
1996	6.71	2.69	9.40	9.33	0.32	9.78	0.33
1997	3.77	0.61	4.40	4.65	0.10	4.76	0.03
1998	16.71	0.09	16.79	17.21	0.02	18.12	1.97
1999	10.29	1.49	11.80	7.90	0.33	8.23	0.05
2000	6.34	0.16	6.50	8.33	0.00	8.46	2.06
2001	11.06	2.49	13.60	9.54	0.09	9.68	1.07
2002	3.31	0.03	3.73	7.10	0.22	7.48	2.14
2003	8.92	0.67	10.50	4.53	0.14	4.77	1.82
2004	8.27	1.35	10.90	8.21	0.26	8.60	1.37
2005	5.57	0.83	8.50	6.37	0.20	6.70	1.23
2006	2.35	1.27	4.00	3.35	0.11	3.50	0.83
2007	5.09	0.57	5.60	3.48	0.11	3.60	0.63
2008	4.15	0.65	4.78	4.86	0.14	5.00	0.48
2009	3.16	0.60	3.76	5.84	0.18	6.02	3.02
2010	4.65	0.52	5.17	4.83	0.15	4.98	1.39
2011	9.73	1.27	11.00	6.02	0.18	14.53	1.19
2012	14.32	1.34	15.66	13.00	0.19	13.44	0.28
2013	13.75	1.42	15.17	7.53	0.40	14.53	3.14
2014	8.59	1.52	10.11	*3.59*	*0.10*	3.69	1.81
2015	*0.66*	*0.09*	0.75	*1.18*	*0.03*	1.21	0.61
2016	*3.35*	*0.44*	3.79	*4.04*	*0.11*	4.15	
2017	*15.07*	*1.99*	17.06	*5.35*	*0.15*	5.50	
2018	*15.13*	*1.99*	17.12	*5.58*	*0.15*	5.73	
2019	*7.86*	*1.04*	8.90	*1.90*	*0.05*	1.95	pending
2020	*0.75*	*0.10*	0.85	*4.55*	*0.12*	4.67	pending
2021	*1.97*	*0.26*	2.23	*1.59*	*0.04*	1.63	pending
Median	*6.77*	*0.72*	*8.70*	*5.81*	*0.14*	*6.01*	*1.50*

Table 8. Excerpt from the management plan: Standardized Area 23 Sockeye Fishing Regime for early-season (June) fisheries. Typically, commercial seine fisheries are not planned until late June. However, all fisheries may be adjusted depending on in-season assessment results.

MANAGEMENT ZONE	FORECAST RUN SIZE	MAANULTH FIRST NATIONS	RECREATIONAL	TSUMASS ECONOMIC OPPORTUNITY	COMMERCIAL SEINE*	COMMERCIAL GILLNET
1 - Critical	**Less than 200,000**	no harvest	no harvest	no harvest	no harvest	no harvest
2 - Very Low	**200,000 to 350,000**	Open, fishing to target through limited effort (designated g/n vessels)	2 fish/day + Area restrictions + Late opening	Community/elder seine 1 day/week g/n	no harvest	1 day/week starting 64 (1 day total)
3 - Low	**350,000 to 500,000**	Open, fishing to target through limited effort (designated g/n vessels)	2 fish/day + Area restrictions	Community/elder seine 2 days/week g/n	seine fishing to target	1 day/week starting 63 (2 days total)
4 - Moderate	**500,000 to 700,000**	Open, fishing to target through limited effort (designated g/n vessels)	4 fish/day (time-area closures if required)	Community/elder seine 3 days/week g/n	seine fishing to target	1 day/week starting 62 (3 days total)
5 - High	**700,000 to 1,000,000**	Open, fishing to target through limited effort (designated g/n vessels)	4 fish/day (time-area closures if required)	Community/elder seine 4 days/week g/n	seine fishing to target	1 day/week starting 62 (3 days total)
6 - Abundant	**1,000,000 +**	Open, fishing to target through limited effort (designated g/n vessels)	4 fish/day	Community/elder seine 5 days/week g/n	seine fishing to target	1 day/week starting 61 (4 days total)

Table 9. Excerpt from the management plan: General guidelines for allowable fishery openings in the outside area (Barkley Sound) for Area D Gillnet associated with the Henderson Sockeye outlook. These guidelines are designed to reduce the exploitation rate of Henderson Sockeye as the expected abundance declines. Additional time and area measures may be applied in-season depending on environmental conditions and observed migration behavior.

MANAGEMENT ZONE	***HENDERSON RUN SIZE***	***REFERENCE POINT***	***TAC***[1]	***HARVEST REGIME***[2]		
				Outside Area Openings	***Outside Area Closure***	***Maximum Harvest Rate***
1 - Very Low	**UP to 15,000**		-	June only	July 1	9%
2 - Low	**15,000 to 25,000**	low end	1,317	June + up to 1 day July	July 8	9%
		high end	2,926			12%
3 - Moderate	**25,000 to 45,000**	low end	2,926	June + up to 2 days July (1 per week)	July 15	12%
		high end	7,900			18%
4 - High	**45,000 to 60,000**	low end	7,900	June + up to 3 days July (up to 2 per week)	July 15	18%
		high end	14,045			23%
5 - Abundant	**60,000 to 150,000**	low end	14,045	June + up to 4 days July (2 per week)	July 15	23%
		high end	43,890			29%

1. *Not including TAC associated with Maanulth Treaty or Maanulth Harvest Agreement.*
2. *The harvest regime may be adjusted based on the results of catch composition analysis.*

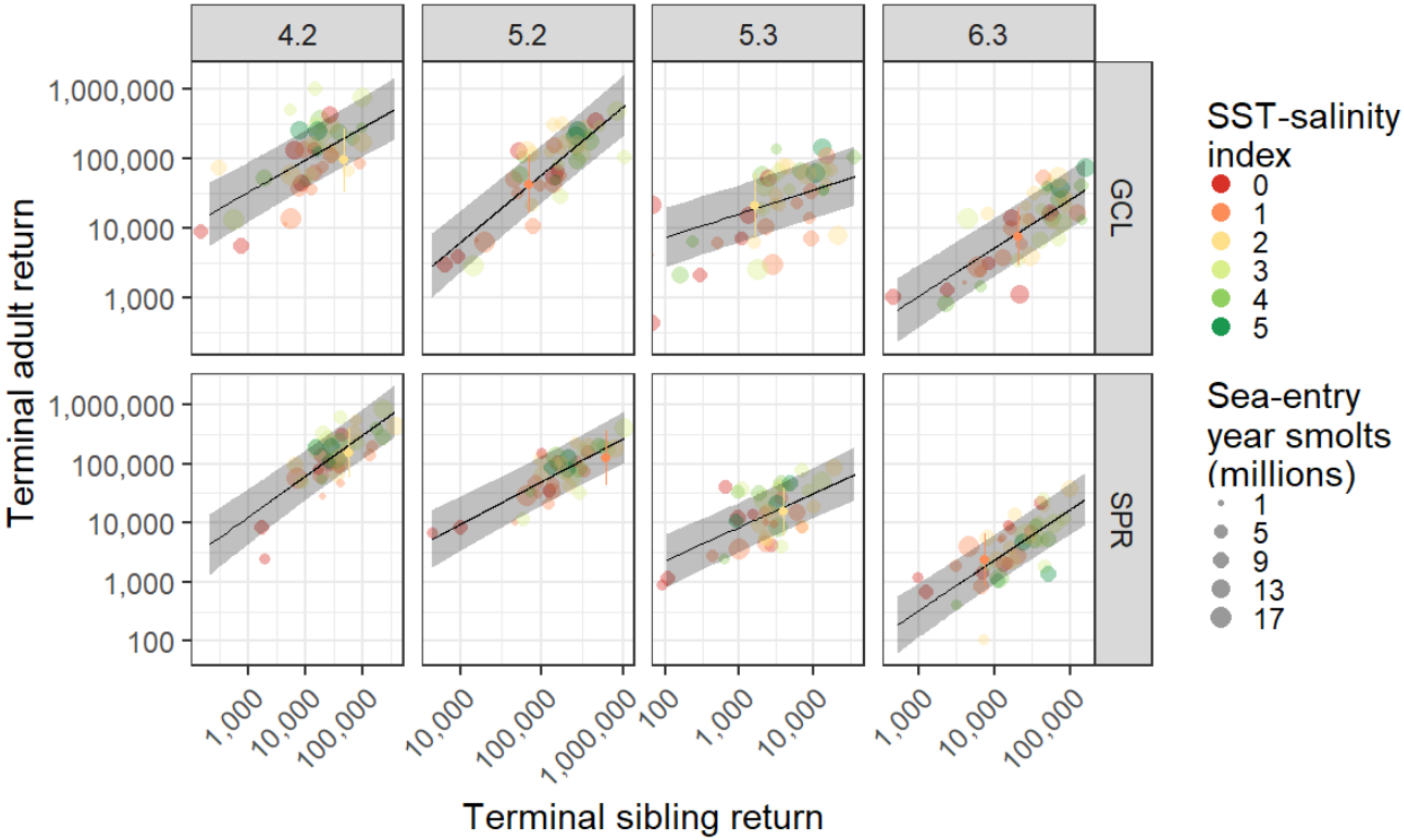

Figure 1. Multivariate model predictions and observed returns by Gilbert-Rich age (columns) and lake (rows; GCL = Great Central Lake, SPR = Sproat Lake). Black lines and the shaded areas around them show the mean predictions and 75% prediction interval, respectively. Point forecasts and prediction intervals for 2023 are overlaid on each panel as dots with whiskers. The 6-point SST-salinity index was developed to reflect the relative hospitability of ocean conditions for juvenile Somass Sockeye during their Spring outmigration period; higher values reflect lower sea surface temperatures and higher salinities.

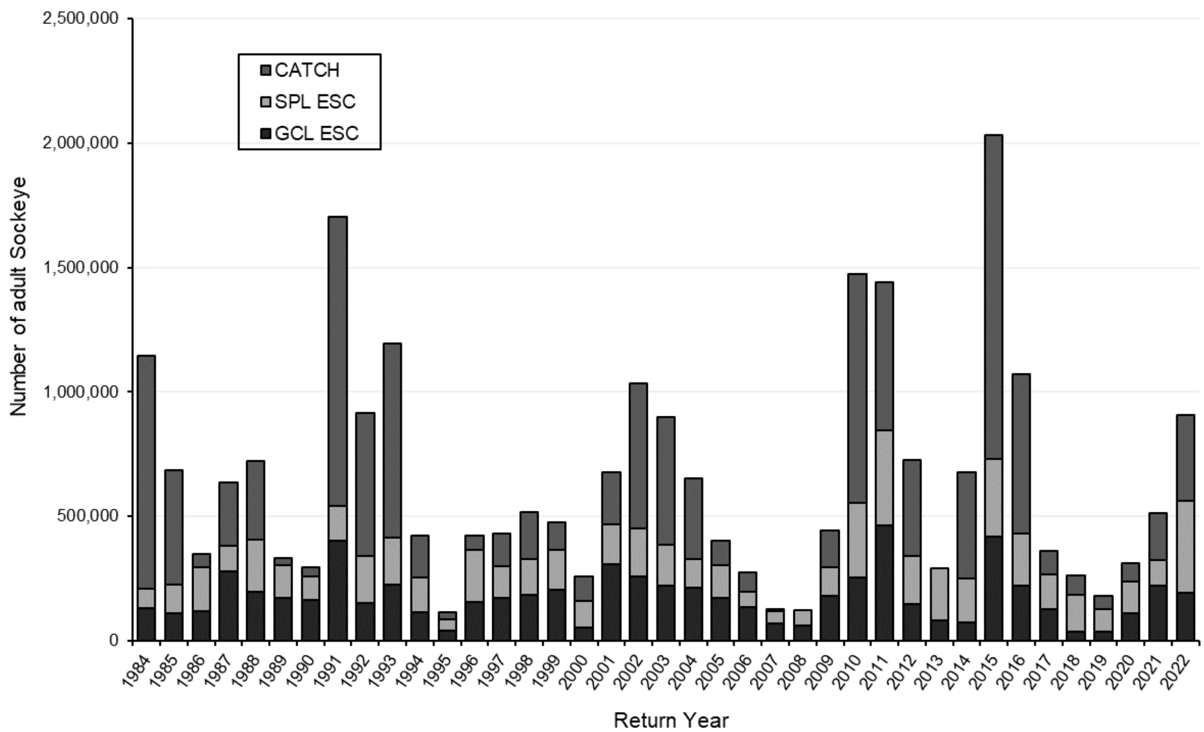

Figure 2. Estimated adult returns of Somass (Great Central and Sproat Lake) Sockeye, 1984–2022.

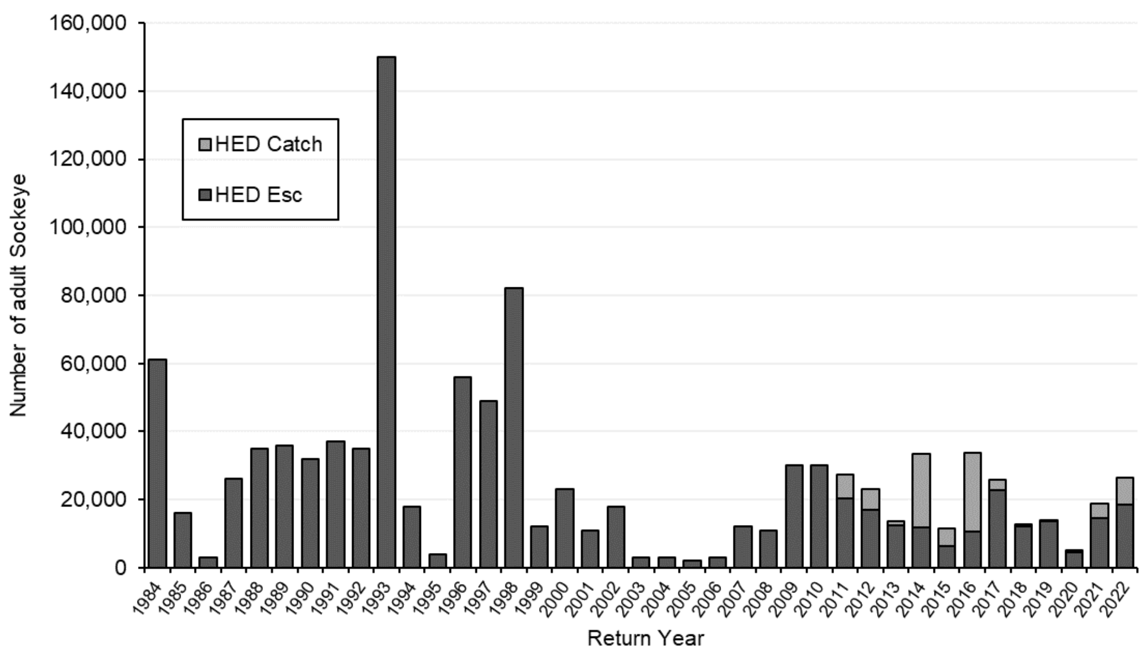

Figure 3. Estimated adult returns of Henderson Lake Sockeye, 1984–2022.

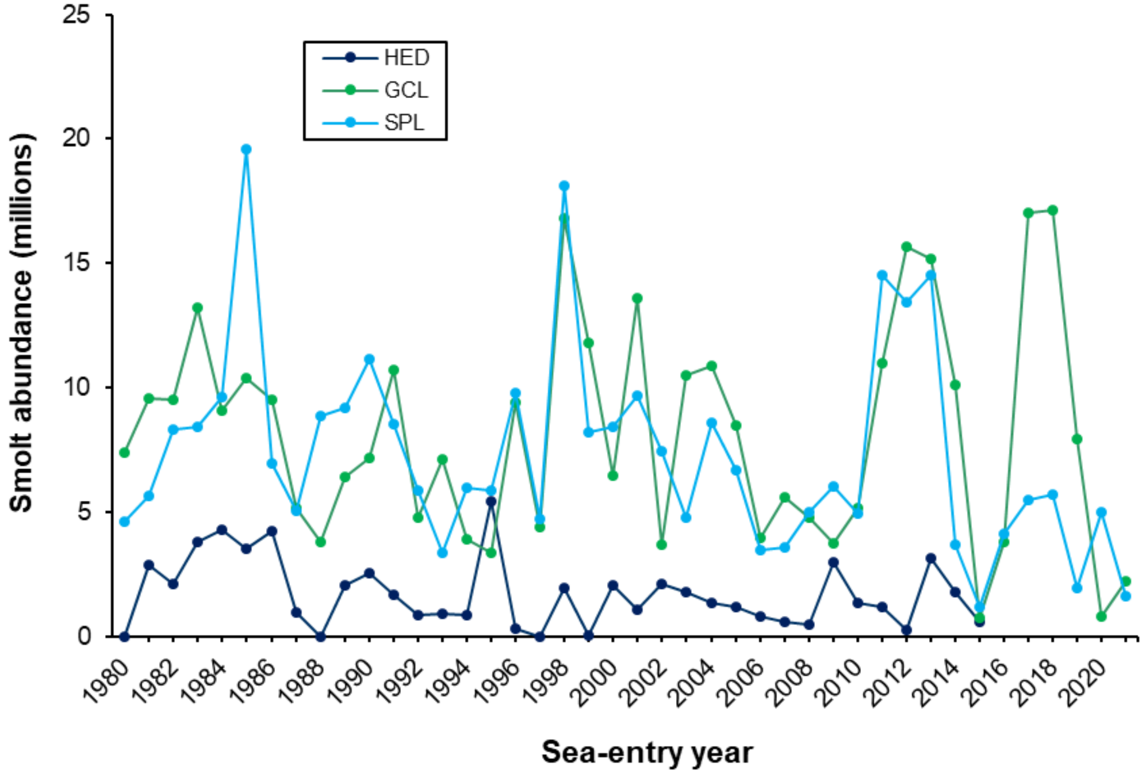

Figure 4. Estimated Sockeye “pre-smolt” juvenile abundances for Great Central, Sproat, and Henderson Lakes by sea-entry year. Most adult Sockeye returning in 2023 are associated with the production from the 2019 and 2020 sea-entry years.

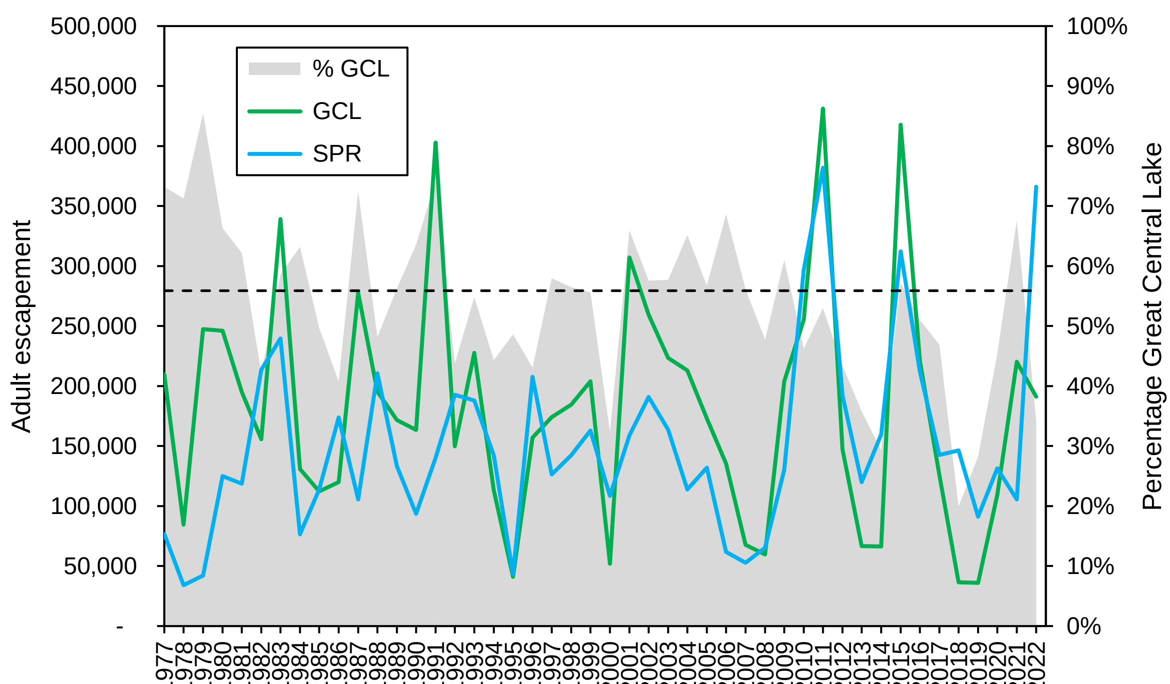

Figure 5. Time series of adult escapements to the Somass River. The black dashed line shows the historical median % GCL in the total return (56%).

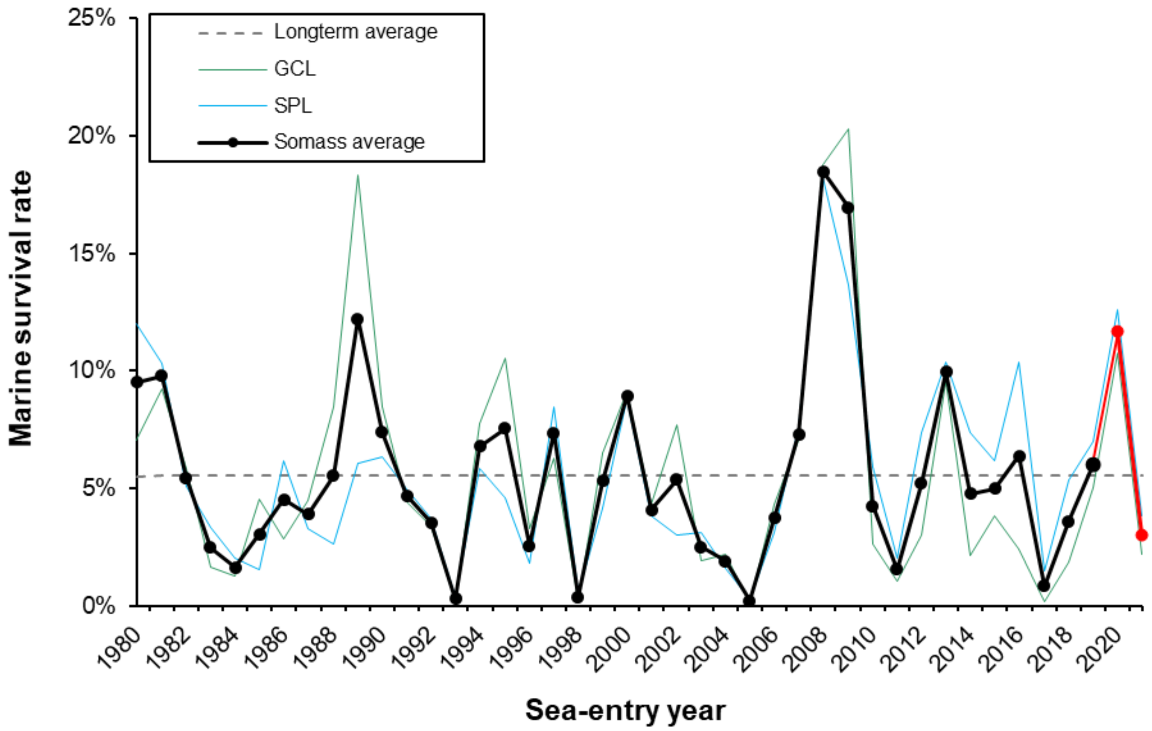

Figure 6. Time series of the marine survival rate index for Somass Sockeye stocks. Red dots and lines indicate the sea-entry years associated with the 2023 return; most adult Sockeye returning in 2023 went to sea in 2020 (5_2 and 6_3 Sockeye) and 2021 (4_2 and 5_3 Sockeye). Although the survival rate index for those years is incomplete (not all fish that went to sea in those years have returned as adults), observed survivorships for the past 4 sea-entry years appear below average.

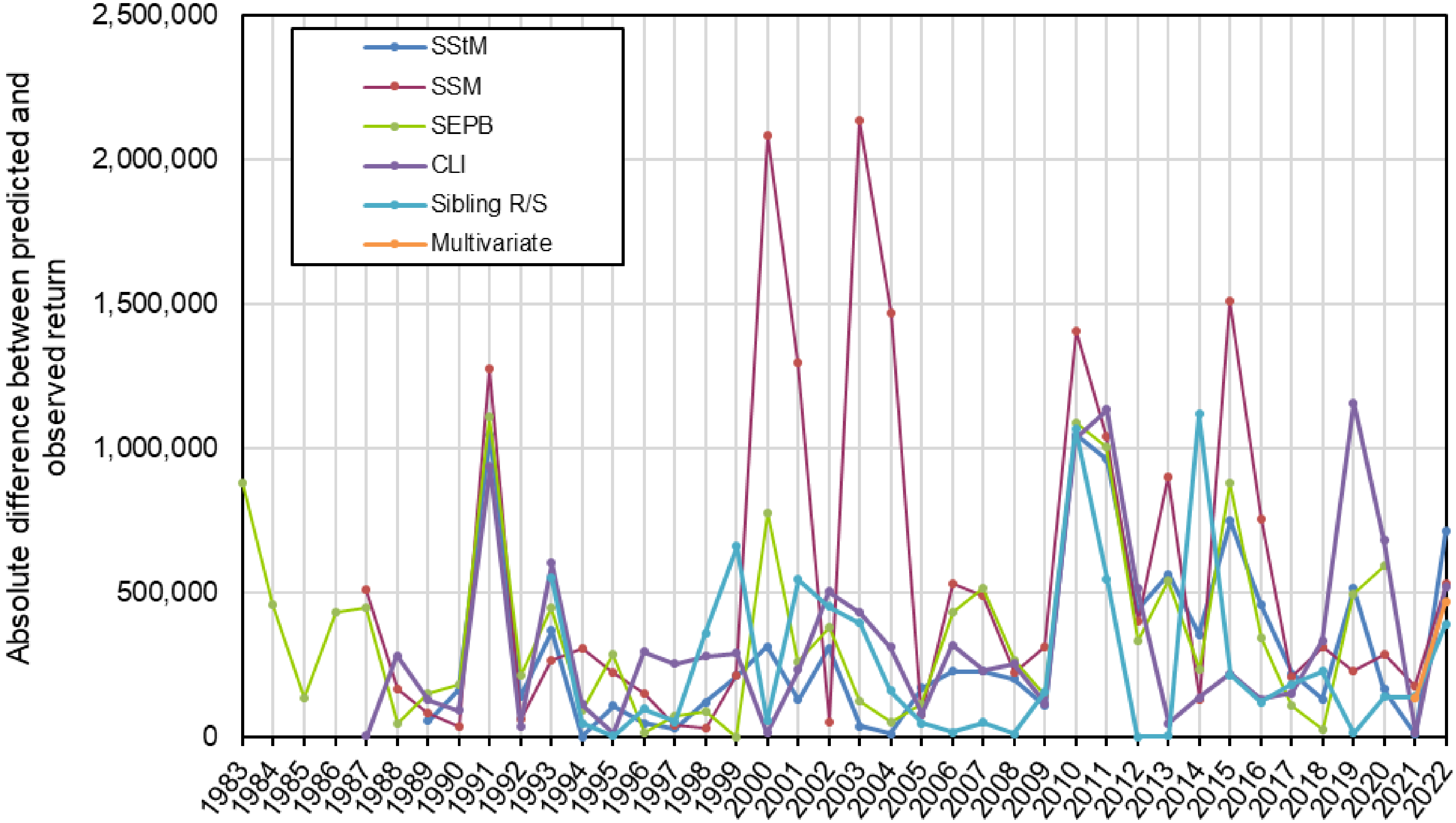

Figure 7. Time series of differences between predictions from the various forecast models and the observed Somass Sockeye returns.

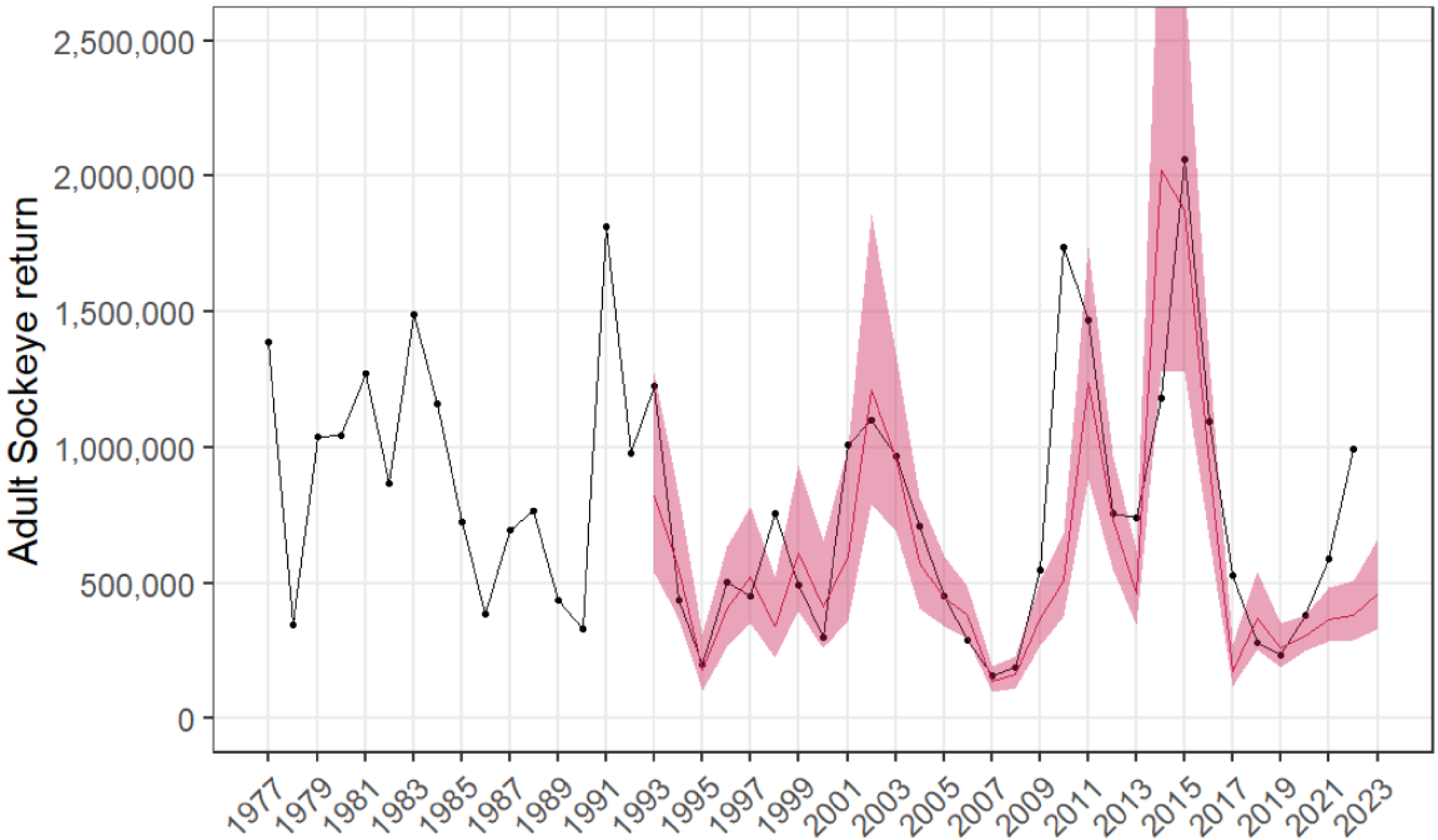

Figure 8. Retrospective analysis of multivariate forecast performance. The observed returns of Somass Sockeye adults are plotted as black dots connected by the black line. The red line shows the multivariate forecast model predictions for each year, and the red shaded area shows its 75% prediction interval.