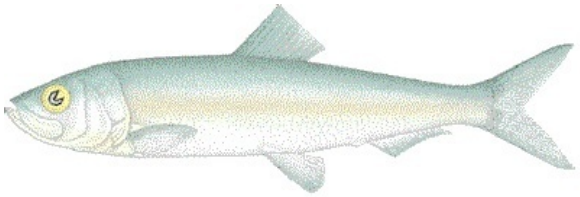
Pacific herring preliminary data summary for Prince Rupert District 2017

DFO Science*

September 7, 2017



Pacific herring (*Clupea pallasii*). Image credit: Fisheries and Oceans Canada (`www.pac.dfo-mpo.gc.ca`).

Disclaimer This report contains preliminary data, which may differ from data used and presented in the final Pacific herring stock assessment for Prince Rupert District 2017.

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1 Context

Pacific herring (*Clupea pallasii*) in British Columbia are assessed as 5 major and 2 minor stock assessment regions (SARs), and data are collected and summarized on this scale (Table 1, Figure 1). The Pacific herring data collection program includes fishery-dependent and -independent data from 1951 to 2017. This includes annual time series of commercial catch data, biological samples (providing information on proportion-at-age and weight-at-age), and spawn index data (conducted using a combination of surface and SCUBA surveys). In some areas, industry- and/or First Nations-operated in-season soundings programs are also conducted, and this information is used by resource managers, First Nations, and stakeholders to locate fish and identify areas of high and low herring biomass to plan harvesting activities. In-season acoustic soundings are not used by stock assessment to inform the estimation of spawning biomass.

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The following is a description of data collected for Pacific herring in the Prince Rupert District major SAR in 2017 (Figure 2). Data collected outside the SAR boundary are not included in this summary, and are not used for the purposes of stock assessment. Note that we refer to 'year' instead of 'herring season' in this report; therefore 2017 refers to the 2016/2017 herring season.

2 Data collection programs

In 2017, biological samples were collected by the "Nita Maria" in Big Bay and by the "Franciscan No.1" in Kitkatla. The "Nita Maria" sampled for 13 days, from March 15th to March 27th, and the "Franciscan No.1" operated for a total of 13 days, from March 14th to March 26th. The primary purpose of the test charter vessels was to collect biological samples from main bodies of herring from Big Bay and Kitkatla, identified from soundings. Both vessels were also used as management platforms for the seine roe ("Franciscan No.1", Kitkatla) and gillnet roe ("Nita Maria", Big Bay) fisheries. Herring spawn locations were primarily identified with fixed-wing overflights conducted by DFO Resource Management Area staff. Four flights were conducted this season, February-April. The dive charter vessel, "Royal Pride", operated a 20-day charter from March 27th to April 15th, surveying spawn throughout the stock area. All three charter vessels were funded by DFO, through a contract to the Herring Conservation Research Society.

3 Catch and biological samples

Landed commercial catch of Pacific herring by year and fishery is shown in Table 2 and Figure 3. In addition to annual catch variability, catch varies among statistical areas (Figure 4). Total harvested spawn on kelp (SOK) in 2017 in the Prince Rupert District major SAR is shown in Table 3; we also calculate the estimated spawning biomass associated with SOK harvest. See calculations to convert SOK to spawning biomass in Appendix A, page 21.

In 2017, 51 Pacific herring biological samples were collected and processed for the Prince Rupert District major SAR (Table 4, Table 5), and a total of 2,903 Pacific herring were aged in 2017. The locations in which the biological samples were collected are presented in Figure 5. Included herein are biological summaries of observed proportion-, number-, and weight-at-age (Figure 6, Table 6, and Figure 7, respectively). Biological summaries only include samples collected using seine nets (commercial and test) due to size-selectivity of other gear types such as gillnet.

4 Spawn survey data

Herring spawn surveys were conducted at 17 individual locations in 2017 in the Prince Rupert District major SAR (Table 7, and Figure 8). A summary of spawn from the last decade (2007 to 2016) is shown in Figure 9. Spawn surveys are conducted to estimate the

spawn length, width, number of egg layers, and substrate type, and these data are used to estimate the index of spawning biomass (i.e., the spawn index; Figure 10, Figure 11, Figure 12, Figure 13, and Table 8). The 'spawn index' represents the raw survey data only, and is not scaled by the spawn survey scaling parameter, q. Therefore, these data do not represent model estimates of spawning biomass, and are considered the minimum observed spawning biomass derived from egg counts. The spawn index has two distinct periods defined by the dominant survey method: surface surveys (1951–1987), and dive surveys (1988–2017).

Some herring Sections contribute more than others to the total spawn index, and the percentage contributed by Section varies yearly (Figure 13b, Figure 14). For example, in 2017, Section 042 contributed the most to the spawn index (63%). As with Sections, some Statistical Areas contribute more than others to the total spawn index (Figure 13c, Figure 15).

5 General observations

General observations provide context to the data summary report. The following observations were reported by area DFO Resource Management staff, and DFO Science staff:

- Herring were in shallow tight to the beach early as observed in the past few years. Traditionally herring hold along the 110 m edge before proceeding to the beach to spawn.
- Compared to average spawn timing, the start of the spawn was early, however the spawn was staggered until mid-April. Spawn started at Tree bluff (March 16$^{\text{th}}$), and finished in Stumaun Bay (mid-April).
- Spawning patterns were typical for the area (i.e., spawn distribution was similar to previous years).
- 2017 Sea surface temperatures ($\sim$ 6°C) were cooler compared to recent years ($\sim$ 8.2°C).
- Larval hatch out rates were back to normal (2-3 weeks).

Table 1. Pacific herring stock assessment regions (SARs) in British Columbia.

Name	Code	Type
Haida Gwaii	HG	Major
Prince Rupert District	PRD	Major
Central Coast	CC	Major
Strait of Georgia	SoG	Major
West Coast of Vancouver Island	WCVI	Major
Area 27	A27	Minor
Area 2 West	A2W	Minor

Table 2. Total landed commercial catch of Pacific herring in metric tonnes (t) by gear type in 2017 in the Prince Rupert District major stock assessment region (SAR). Legend: 'Gear1' represents the reduction, the food and bait, as well as the special use fishery; 'Gear2' represents the roe seine fishery; and 'Gear3' represents the roe gillnet fishery. Data from the spawn-on-kelp (SOK) fishery is not included. Note: 'WP' indicates that data are withheld due to privacy concerns.

Period	Catch (t)
Gear1	WP
Gear2	1,019
Gear3	1,398

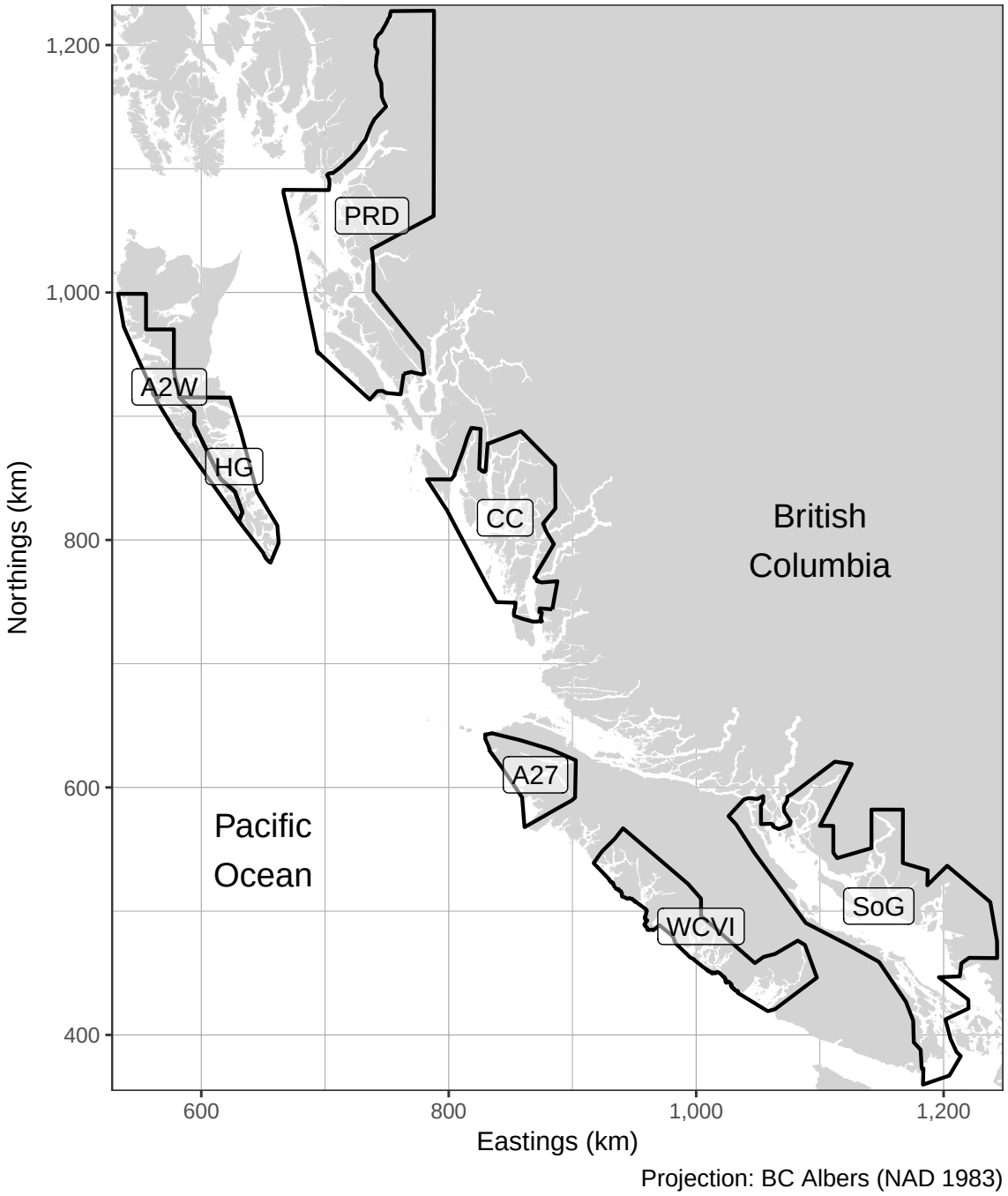

Figure 1. Boundaries for the Pacific herring stock assessment regions (SARs) in British Columbia: there are 5 major SARs (HG, PRD, CC, SoG, and WCVI), and 2 minor SARs (A27 and A2W; Table 1). Units: kilometres (km).

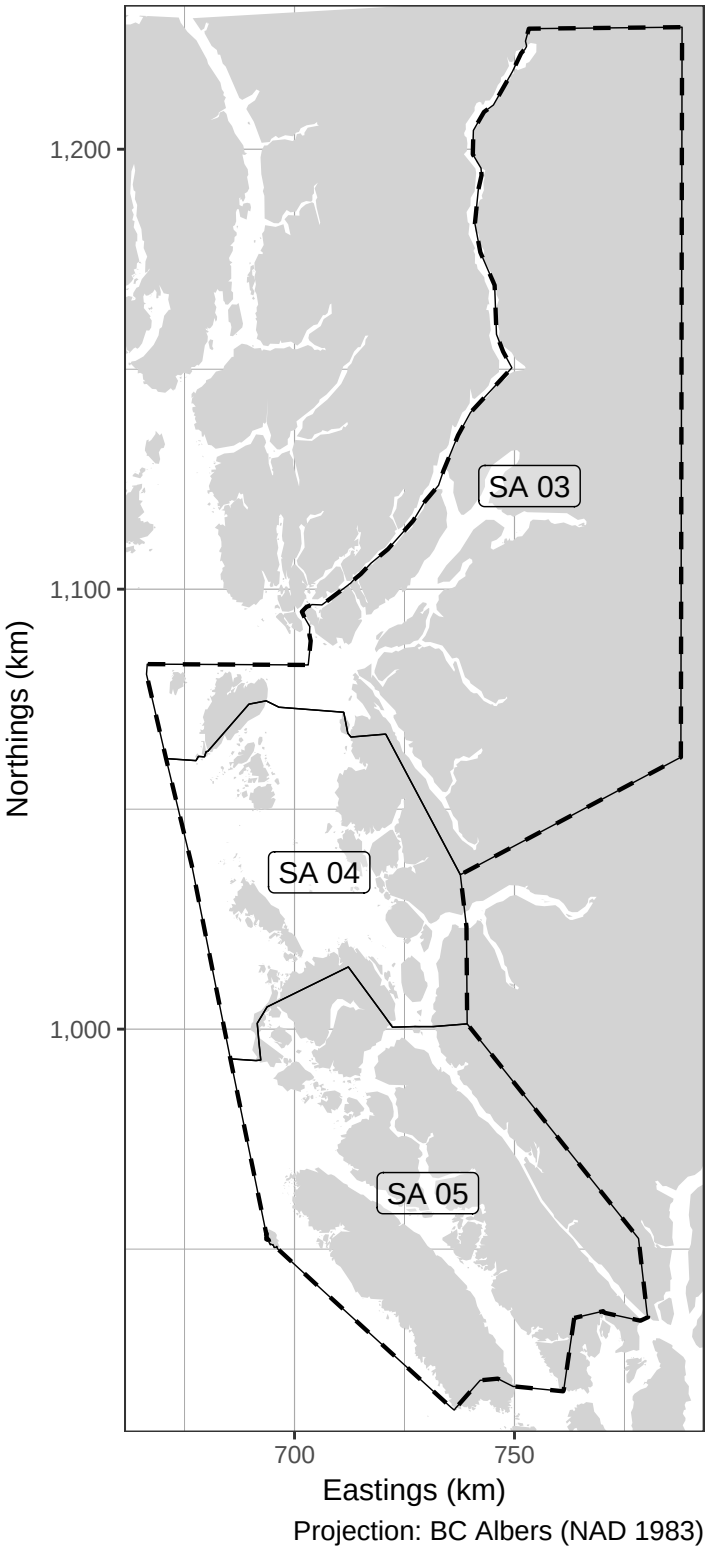

Figure 2. Boundaries for the Prince Rupert District major stock assessment region (SAR; thick dashed lines), and associated Statistical Areas (SA; thin solid lines). Units: kilometres (km).

Table 3. Total harvested Pacific herring spawn on kelp (SOK) in pounds (lb), and the associated estimate of spawning biomass in metric tonnes (t) from 2007 to 2017 in the Prince Rupert District major stock assessment region (SAR). See calculations to convert SOK to spawning biomass in Appendix A, page 21. Note: 'WP' indicates that data are withheld due to privacy concerns.

Year	Harvest (lb)	Spawning biomass (t)
2007	111,762	163
2008	166,572	243
2009	158,198	231
2010	108,834	159
2011	123,626	180
2012	87,494	128
2013	72,895	106
2014	113,269	165
2015	84,066	123
2016	WP	WP
2017	82,597	121

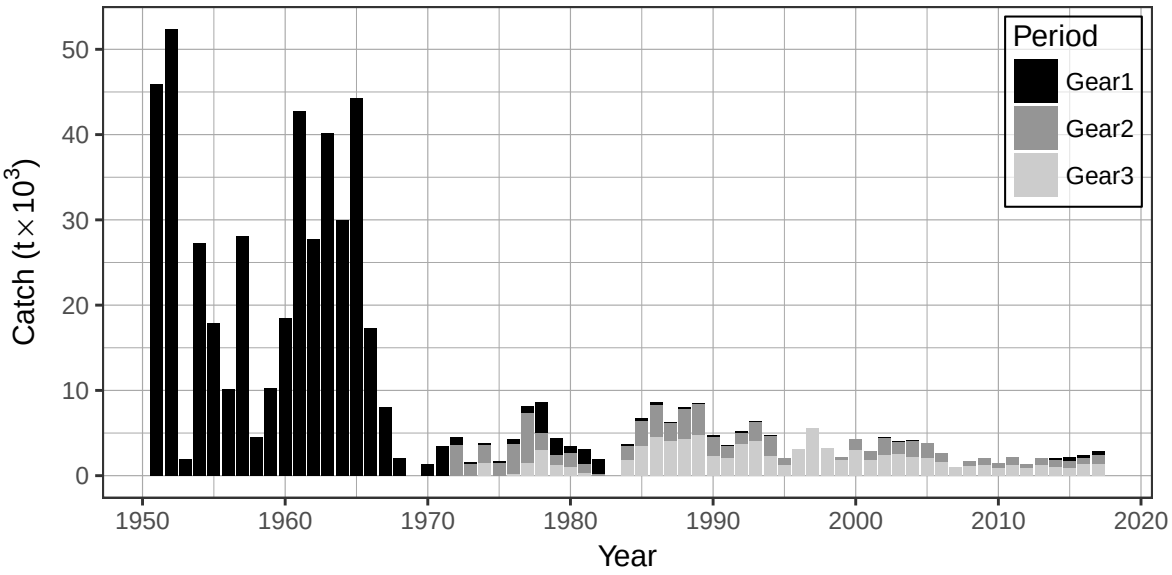

Figure 3. Time series of total landed catch in thousands of metric tonnes ($t \times 10^3$) of Pacific herring by gear type from 1951 to 2017 in the Prince Rupert District major stock assessment region (SAR). Legend: 'Gear1' represents the reduction, the food and bait, as well as the special use fishery; 'Gear2' represents the roe seine fishery; and 'Gear3' represents the roe gillnet fishery. Data from the spawn-on-kelp (SOK) fishery is not included.

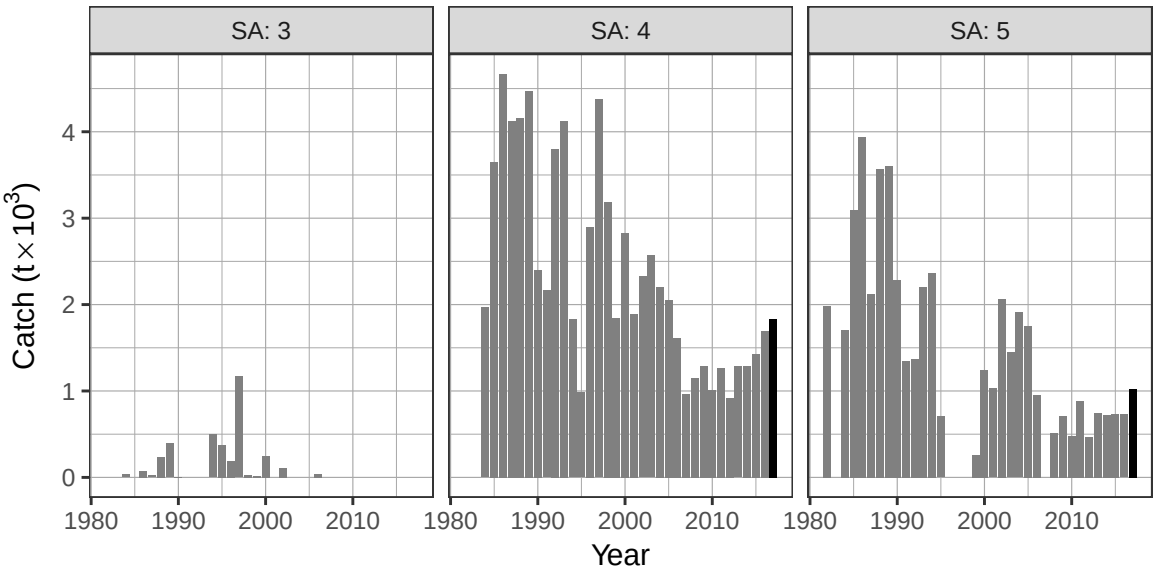

Figure 4. Time series of total landed catch in thousands of metric tonnes ($t \times 10^3$) of Pacific herring by statistical area (SA) from 1982 to 2017 in the Prince Rupert District major stock assessment region (SAR). The year 2017 has a darker bar to facilitate interpretation.

Table 4. Number of Pacific herring biological samples processed from 2007 to 2017 in the Prince Rupert District major stock assessment region (SAR). Each sample is approximately 100 fish.

	Number of samples		
Year	Commercial	Test	Total
2007	16	8	24
2008	32	25	57
2009	32	23	55
2010	28	19	47
2011	38	18	56
2012	27	21	48
2013	31	13	44
2014	30	2	32
2015	45	11	56
2016	33	11	44
2017	40	11	51

Table 5. Number and type of Pacific herring biological samples processed in 2017 in the Prince Rupert District major stock assessment region (SAR). Each sample is approximately 100 fish.

Type	Gear	Use	Number of samples
Commercial	Gillnet	Roe Fishery	18
Commercial	Seine	Food Fishery	5
Commercial	Seine	Other	3
Commercial	Seine	Roe Fishery	14
Test	Gillnet	Test Fishery	1
Test	Seine	Test Fishery	10

Table 6. Observed proportion-at-age for Pacific herring from 2007 to 2017 in the Prince Rupert District major stock assessment region (SAR). The age-10 class is a 'plus group' which includes fish ages 10 and older.

	Proportion-at-age								
Year	2	3	4	5	6	7	8	9	10
2007	0.037	0.485	0.220	0.107	0.030	0.098	0.012	0.010	0.001
2008	0.019	0.156	0.556	0.121	0.084	0.018	0.036	0.008	0.003
2009	0.003	0.219	0.181	0.445	0.074	0.051	0.012	0.015	0.001
2010	0.013	0.336	0.272	0.116	0.207	0.033	0.017	0.003	0.004
2011	0.005	0.361	0.310	0.155	0.061	0.086	0.014	0.006	0.002
2012	0.030	0.095	0.456	0.225	0.098	0.052	0.039	0.004	0.001
2013	0.007	0.418	0.176	0.218	0.118	0.032	0.022	0.009	0.000
2014	0.008	0.079	0.458	0.150	0.176	0.081	0.030	0.013	0.004
2015	0.047	0.531	0.067	0.191	0.060	0.067	0.025	0.009	0.003
2016	0.017	0.162	0.485	0.060	0.165	0.050	0.039	0.016	0.006
2017	0.014	0.151	0.179	0.438	0.063	0.099	0.029	0.020	0.007

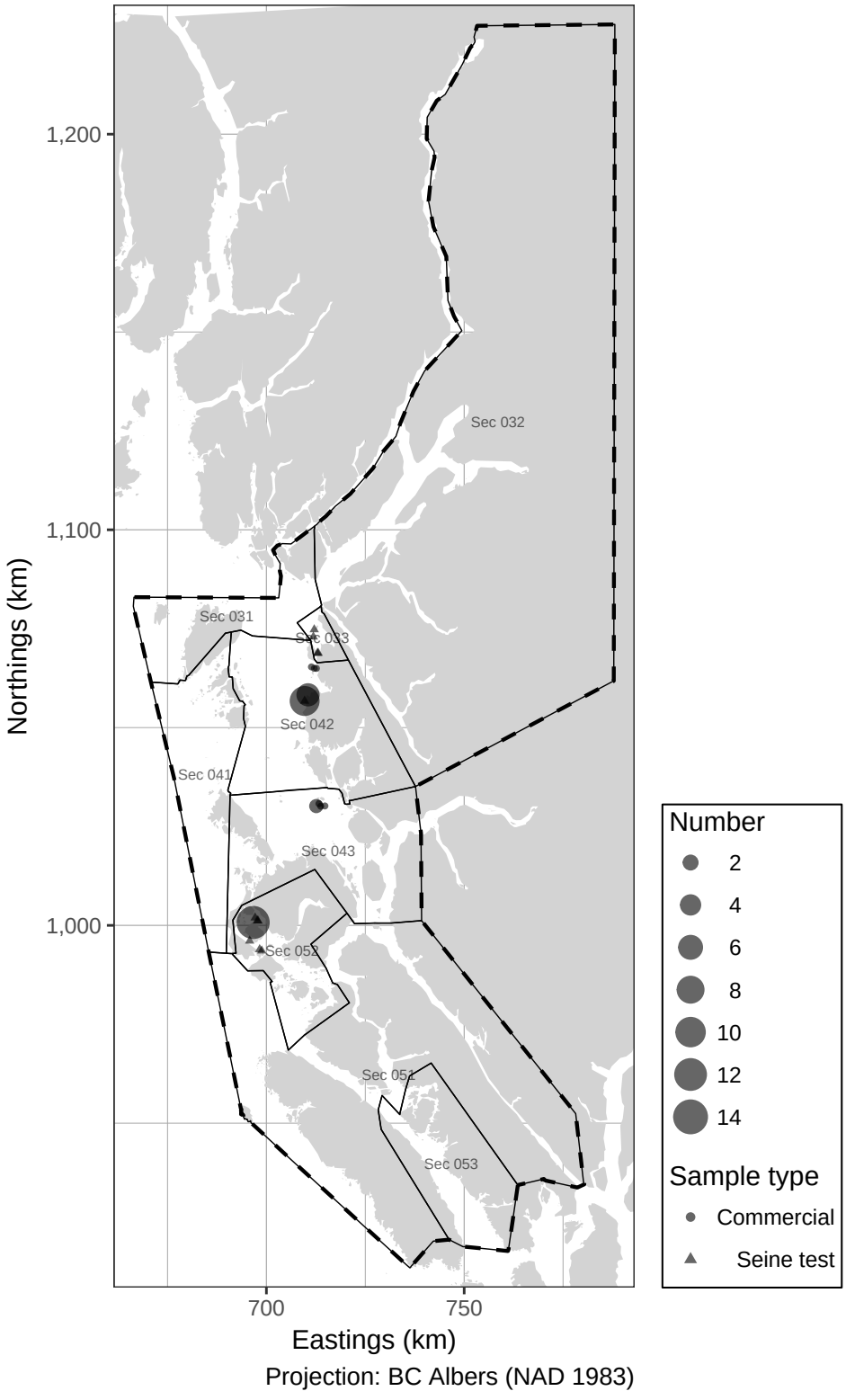

Figure 5. Location and type of Pacific herring biological samples collected in 2017 in the Prince Rupert District major stock assessment region (SAR; thick dashed lines), and associated Sections (Sec; thin solid lines). Units: kilometres (km).

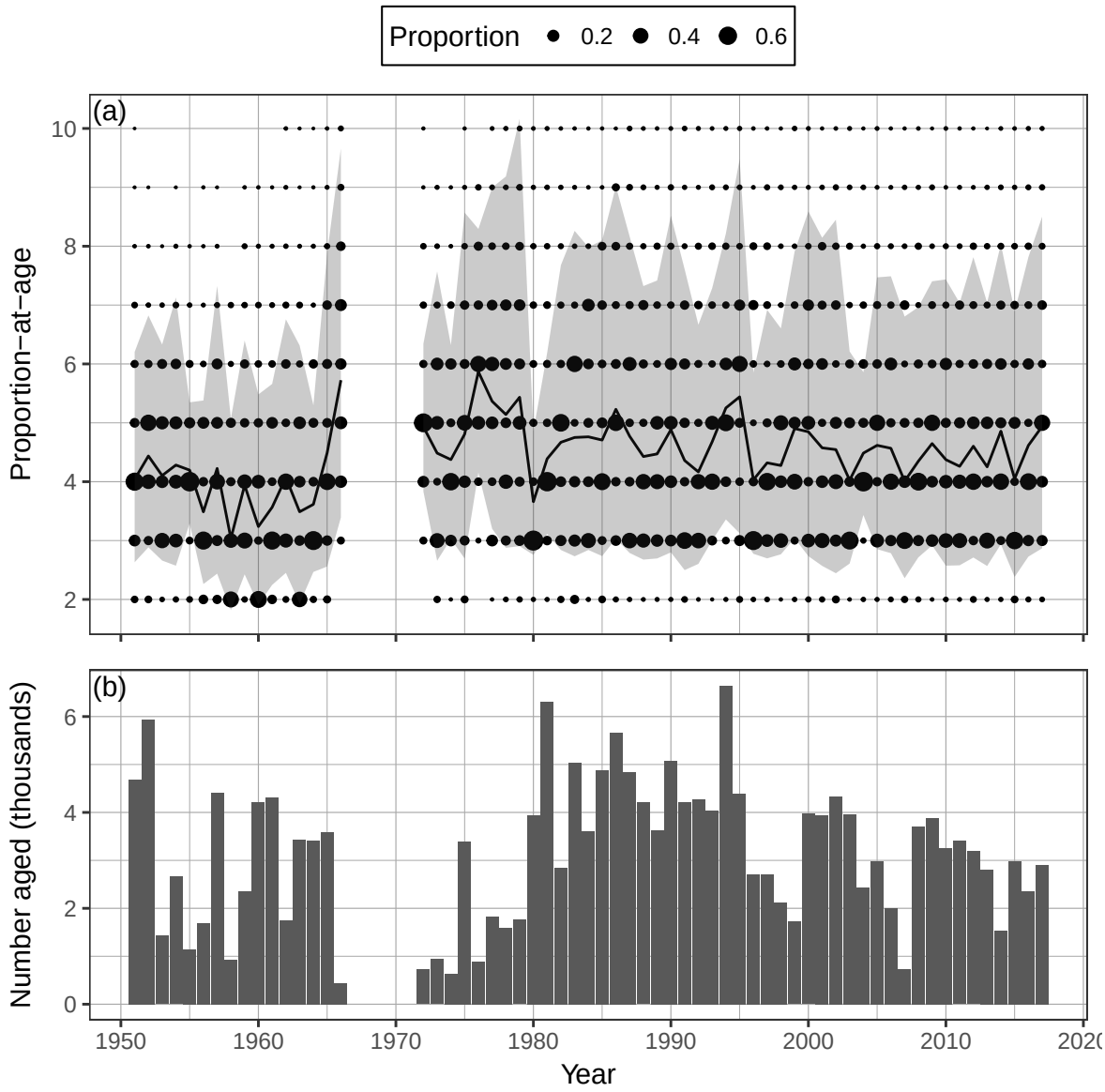

Figure 6. Time series of observed proportion-at-age (a) and number aged in thousands (b) of Pacific herring from 1951 to 2017 in the Prince Rupert District major stock assessment region (SAR). The black line is the mean age, and the shaded area is the approximate 90% distribution. Biological summaries only include samples collected using seine nets (commercial and test) due to size-selectivity of other gear types such as gillnet. The age-10 class is a 'plus group' which includes fish ages 10 and older.

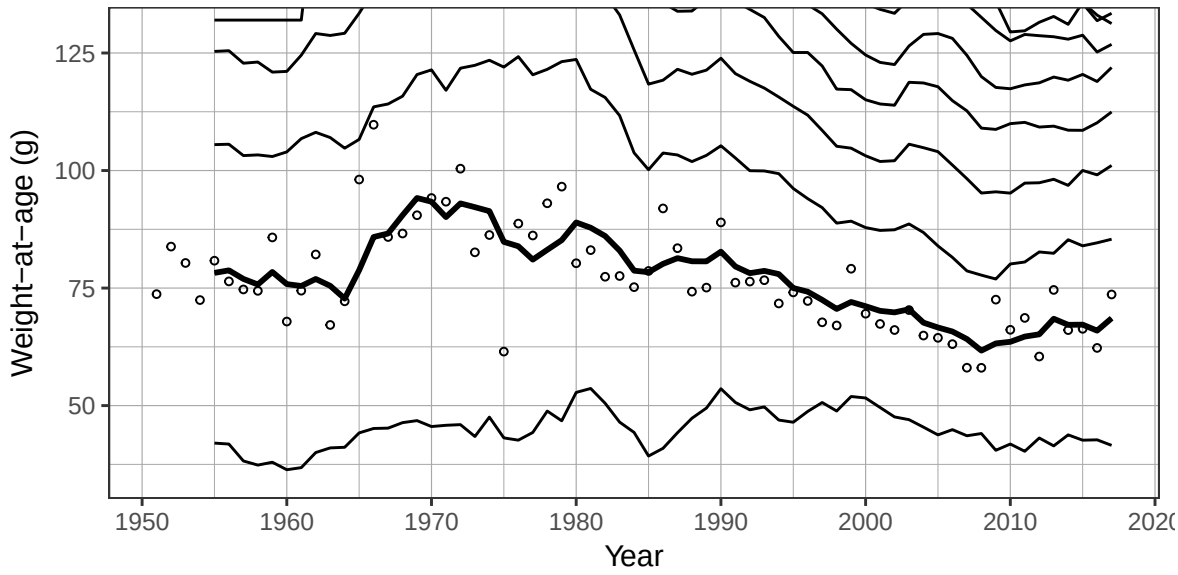

Figure 7. Time series of weight-at-age in grams (g) for age-3 (circles) and 5-year running mean weight-at-age (lines) for Pacific herring from 1951 to 2017 in the Prince Rupert District major stock assessment region (SAR). Lines show 5-year running means for age-2 to age-10 herring (incrementing higher from the lowest line); the thick black line highlights age-3 herring. Missing weight-at-age values (i.e., years where there are no biological samples) are imputed using one of two methods: missing values at the beginning of the time series are imputed by extending the first non-missing value backwards; other missing values are imputed as the mean of the previous 5 years. Biological summaries only include samples collected using seine nets (commercial and test) due to size-selectivity of other gear types such as gillnet. The age-10 class is a 'plus group' which includes fish ages 10 and older.

Table 7. Pacific herring spawn survey locations, and spawn index in metric tonnes (t) in 2017 in the Prince Rupert District major stock assessment region (SAR). The 'spawn index' represents the raw survey data only, and is not scaled by the spawn survey scaling parameter, q. Missing spawn index values (i.e., NA) indicate incomplete spawn surveys.

Statistical Area	Section	Location code	Location name	Spawn index (t)
03	033	211	Stumaun Bay	64
03	033	213	Cunningham Pass	481
03	033	216	Village Is	446
04	042	260	Big Bay	1,652
04	042	261	Swamp Is	2,080
04	042	262	Burnt Cliff Is	1,133
04	042	263	Tree Bluff	5,212
04	042	265	Belletti Pt	303
04	042	266	Pearl Hrbr	91
04	042	276	Duncan Bay	540
04	042	279	Tugwell Is	92
04	042	1380	Mist Is	40
04	042	1448	Reeks Pt	1,012
05	052	345	Serpentine Inlt	84
05	052	355	Dries Inlt	4,297
05	052	358	Kitkatla Cr	899
05	052	1416	Gurd Pt	809

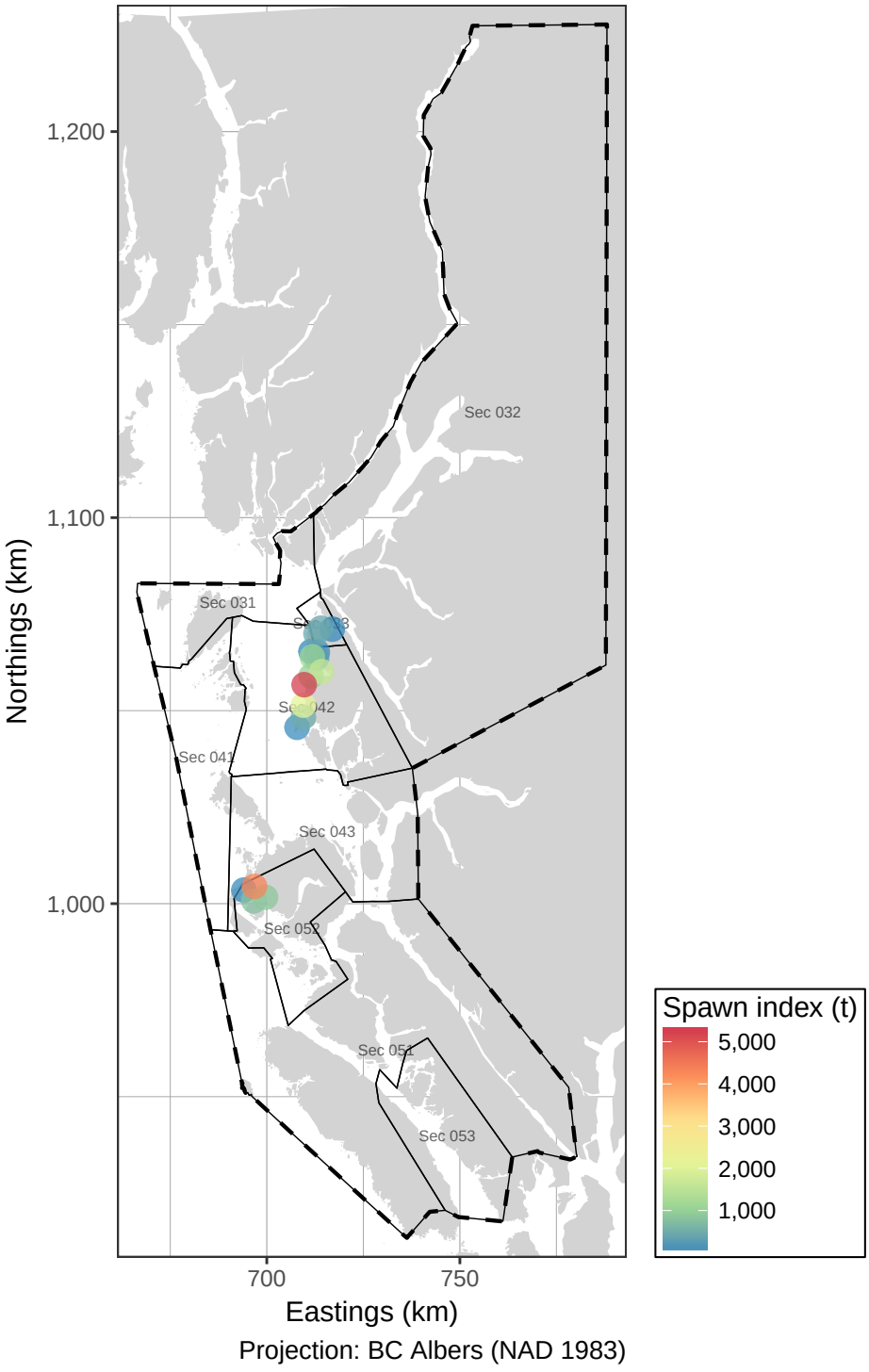

Figure 8. Pacific herring spawn survey locations, and spawn index in metric tonnes (t) in 2017 in the Prince Rupert District major stock assessment region (SAR; thick dashed lines), and associated Sections (Sec; thin solid lines). The 'spawn index' represents the raw survey data only, and is not scaled by the spawn survey scaling parameter, q. Missing spawn index values (grey circles) indicate incomplete spawn surveys. Units: kilometres (km).

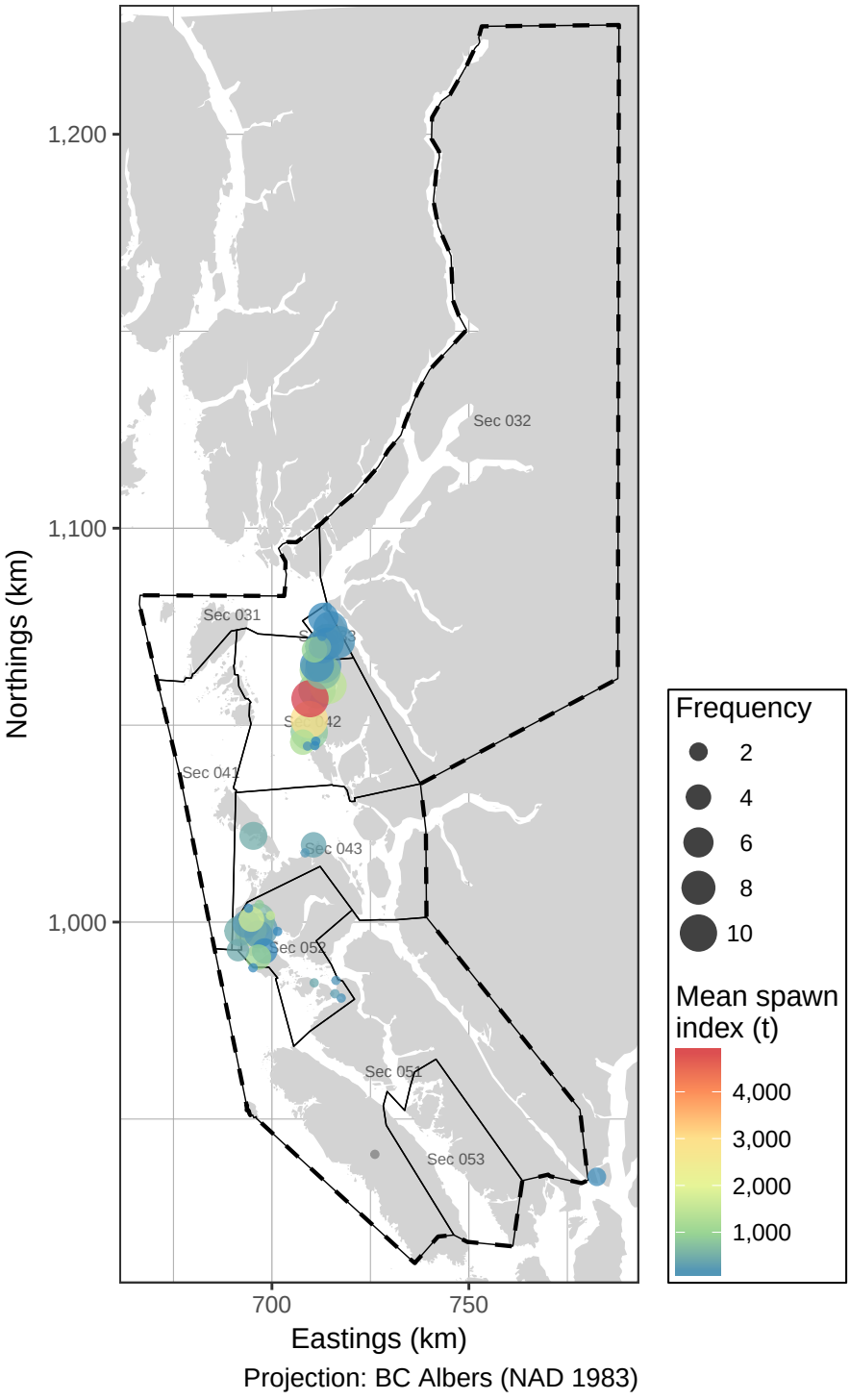

Figure 9. Pacific herring spawn survey locations, mean spawn index in metric tonnes (t), and spawn frequency from 2007 to 2016 in the Prince Rupert District major stock assessment region (SAR; thick dashed lines), and associated Sections (Sec; thin solid lines). The 'spawn index' represents the raw survey data only, and is not scaled by the spawn survey scaling parameter, q. Missing spawn index values (grey circles) indicate incomplete spawn surveys. Units: kilometres (km).

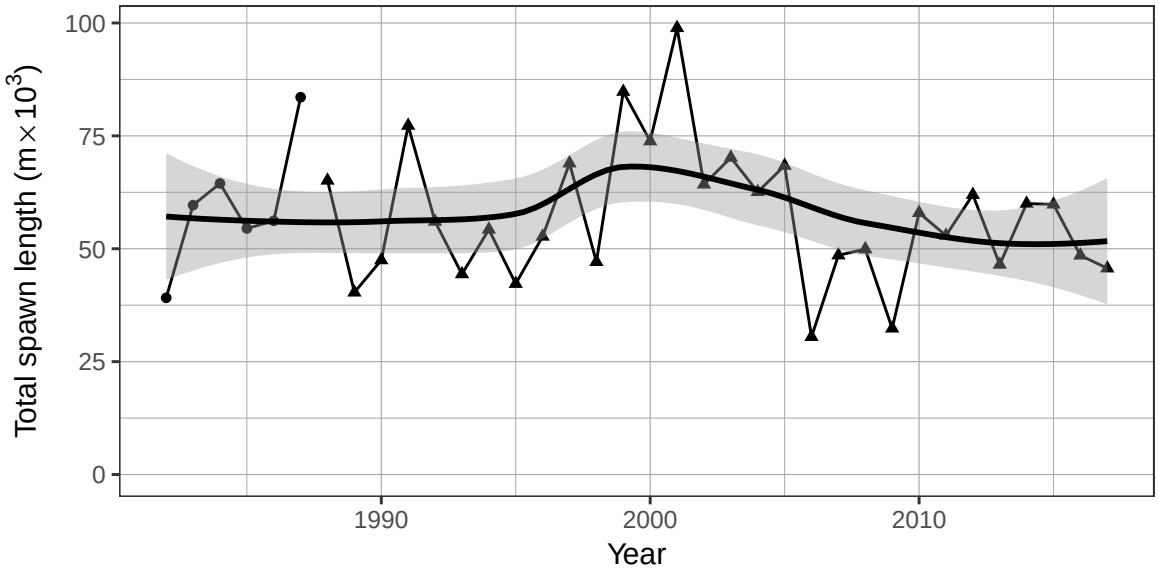

Figure 10. Time series of total spawn length in thousands of metres ($m \times 10^3$) for Pacific herring from 1982 to 2017 in the Prince Rupert District major stock assessment region (SAR). The thick black line is a loess curve, and the shaded area is the 90% confidence interval. The spawn index has two distinct periods defined by the dominant survey method: surface surveys (1951–1987), and dive surveys (1988–2017).

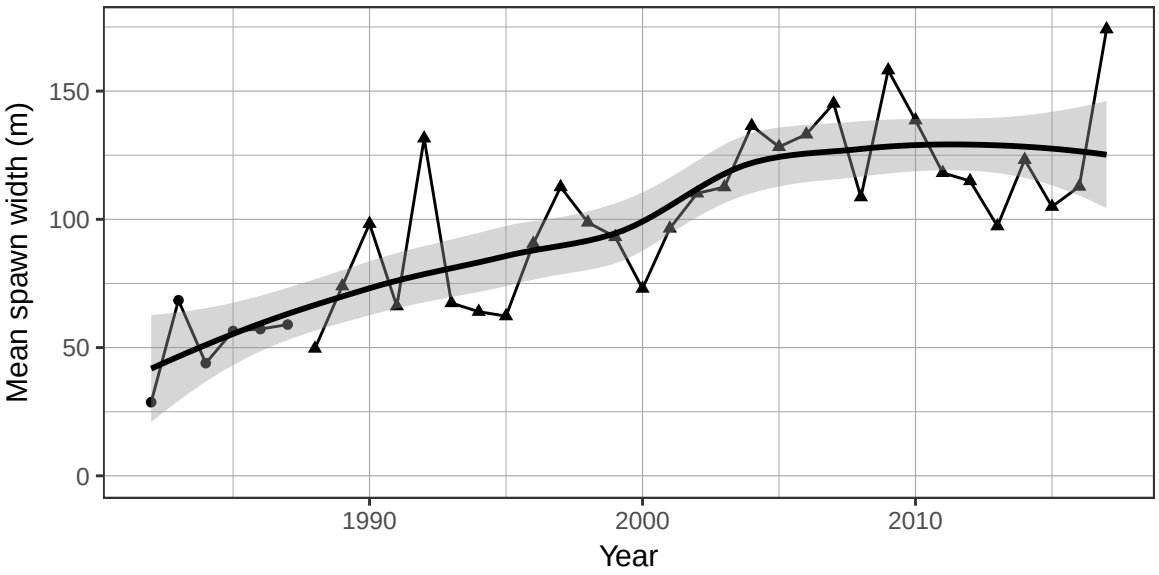

Figure 11. Time series of mean spawn width in metres (m) for Pacific herring from 1982 to 2017 in the Prince Rupert District major stock assessment region (SAR). The thick black line is a loess curve, and the shaded area is the 90% confidence interval. The spawn index has two distinct periods defined by the dominant survey method: surface surveys (1951–1987), and dive surveys (1988–2017).

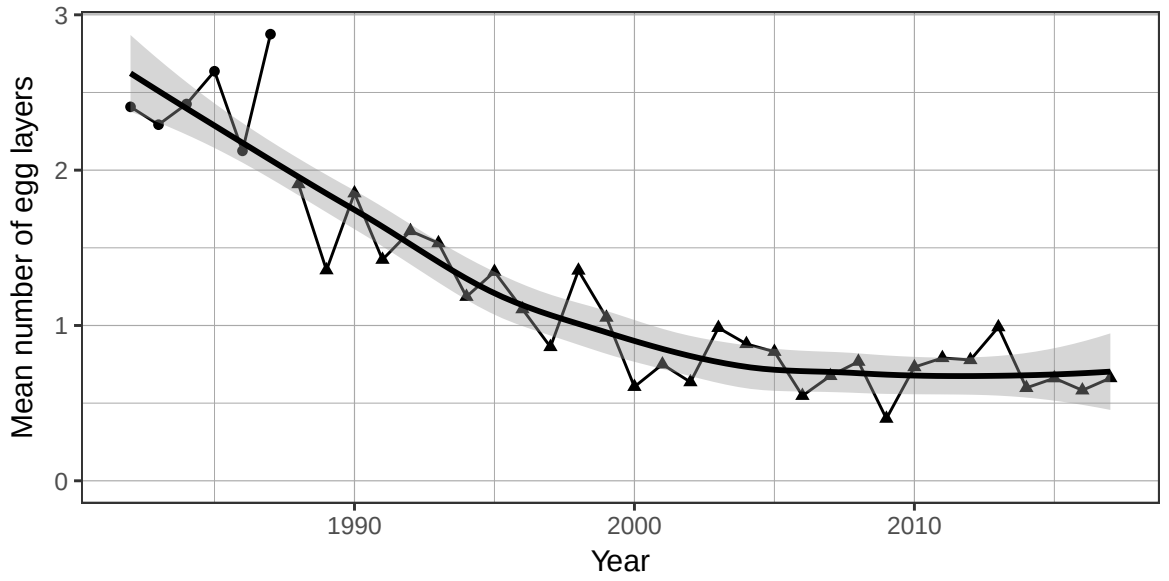

Figure 12. Time series of mean number of egg layers for Pacific herring from 1982 to 2017 in the Prince Rupert District major stock assessment region (SAR). The thick black line is a loess curve, and the shaded area is the 90% confidence interval. The spawn index has two distinct periods defined by the dominant survey method: surface surveys (1951–1987), and dive surveys (1988–2017).

Table 8. Summary of spawn survey data from 2007 to 2017 in the Prince Rupert District major stock assessment region (SAR). The spawn index has two distinct periods defined by the dominant survey method: surface surveys (1951–1987), and dive surveys (1988–2017). The 'spawn index' represents the raw survey data only, and is not scaled by the spawn survey scaling parameter, q. Units: metres (m), and metric tonnes (t).

Year	Total length (m)	Mean width (m)	Mean number of egg layers	Spawn index (t)
2007	48,560	145	0.676	15,700
2008	49,910	109	0.767	12,728
2009	32,360	158	0.400	11,961
2010	57,950	139	0.732	28,607
2011	52,925	118	0.791	21,097
2012	61,950	115	0.778	22,716
2013	46,500	97	0.989	25,755
2014	60,000	123	0.598	17,125
2015	59,825	105	0.661	17,407
2016	48,525	113	0.583	18,985
2017	45,675	174	0.662	19,235

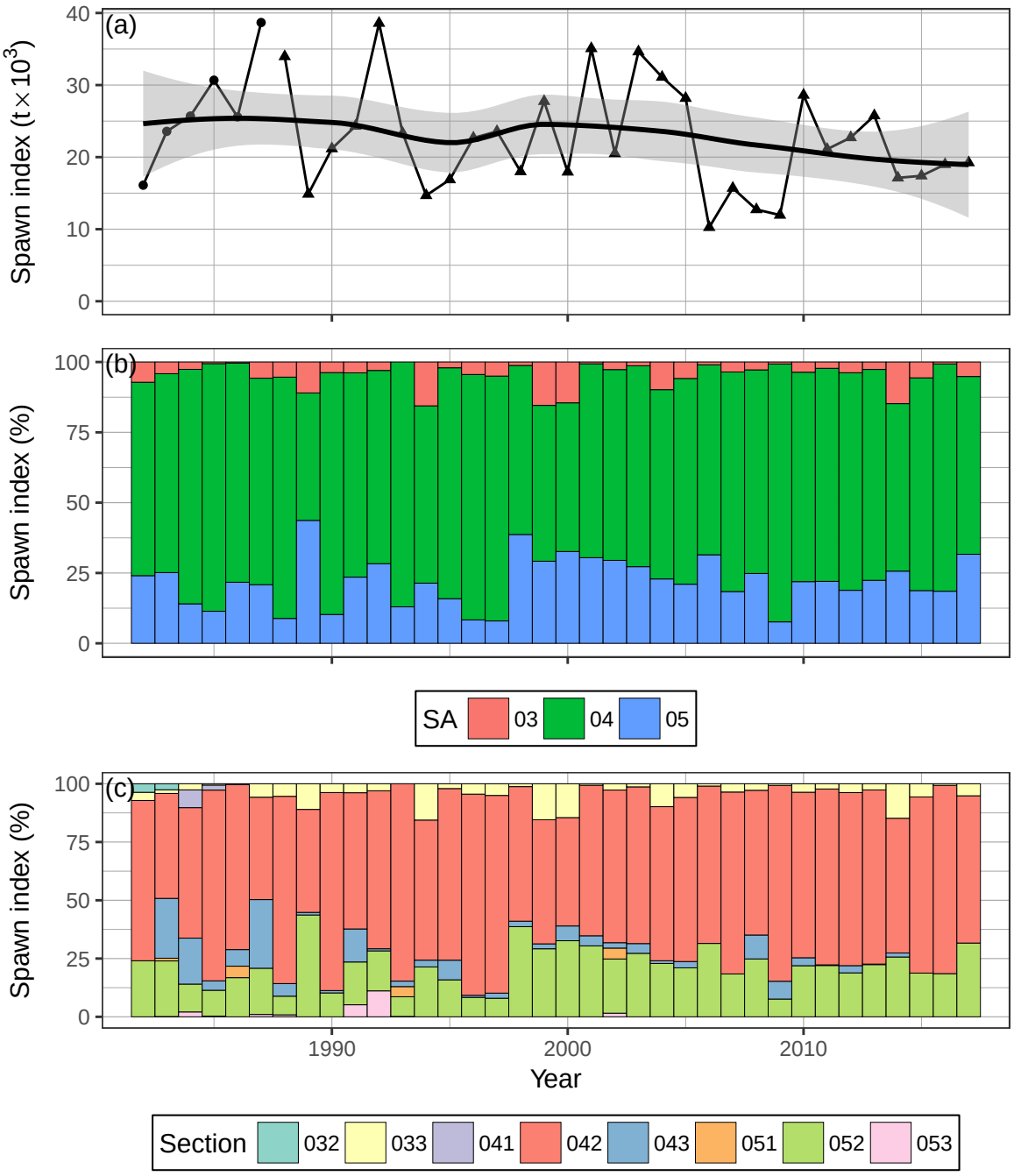

Figure 13. Time series of spawn index in thousands of metric tonnes ($t \times 10^3$) for Pacific herring from 1982 to 2017 in the Prince Rupert District major stock assessment region (SAR; a), as well as percent contributed by Statistical Area (SA), and Section (b, & c, respectively). The thick black line is a loess curve, and the shaded area is the 90% confidence interval. The spawn index has two distinct periods defined by the dominant survey method: surface surveys (1951–1987), and dive surveys (1988–2017). The 'spawn index' represents the raw survey data only, and is not scaled by the spawn survey scaling parameter, q.

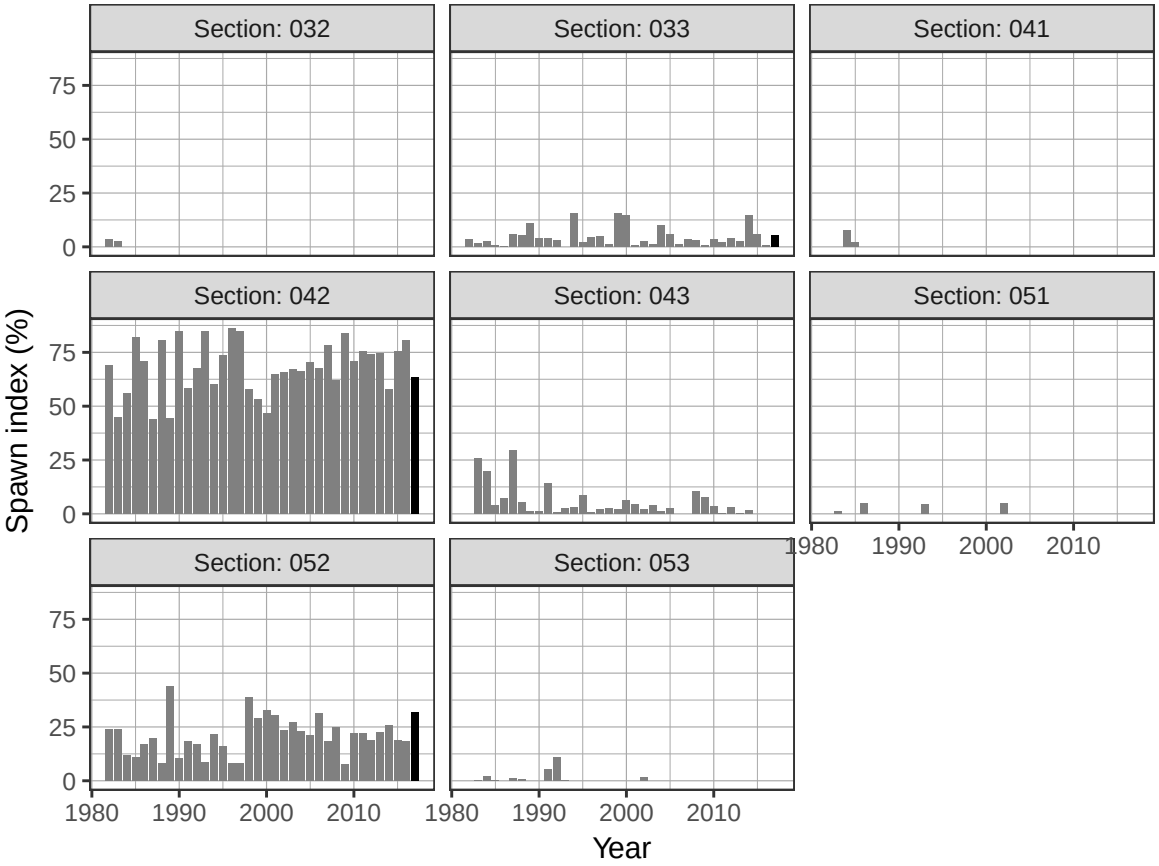

Figure 14. Time series of percent of spawn index by Section for Pacific herring from 1982 to 2017 in the Prince Rupert District major stock assessment region (SAR). The year 2017 has a darker bar to facilitate interpretation. The spawn index has two distinct periods defined by the dominant survey method: surface surveys (1951–1987), and dive surveys (1988–2017). The 'spawn index' represents the raw survey data only, and is not scaled by the spawn survey scaling parameter, q.

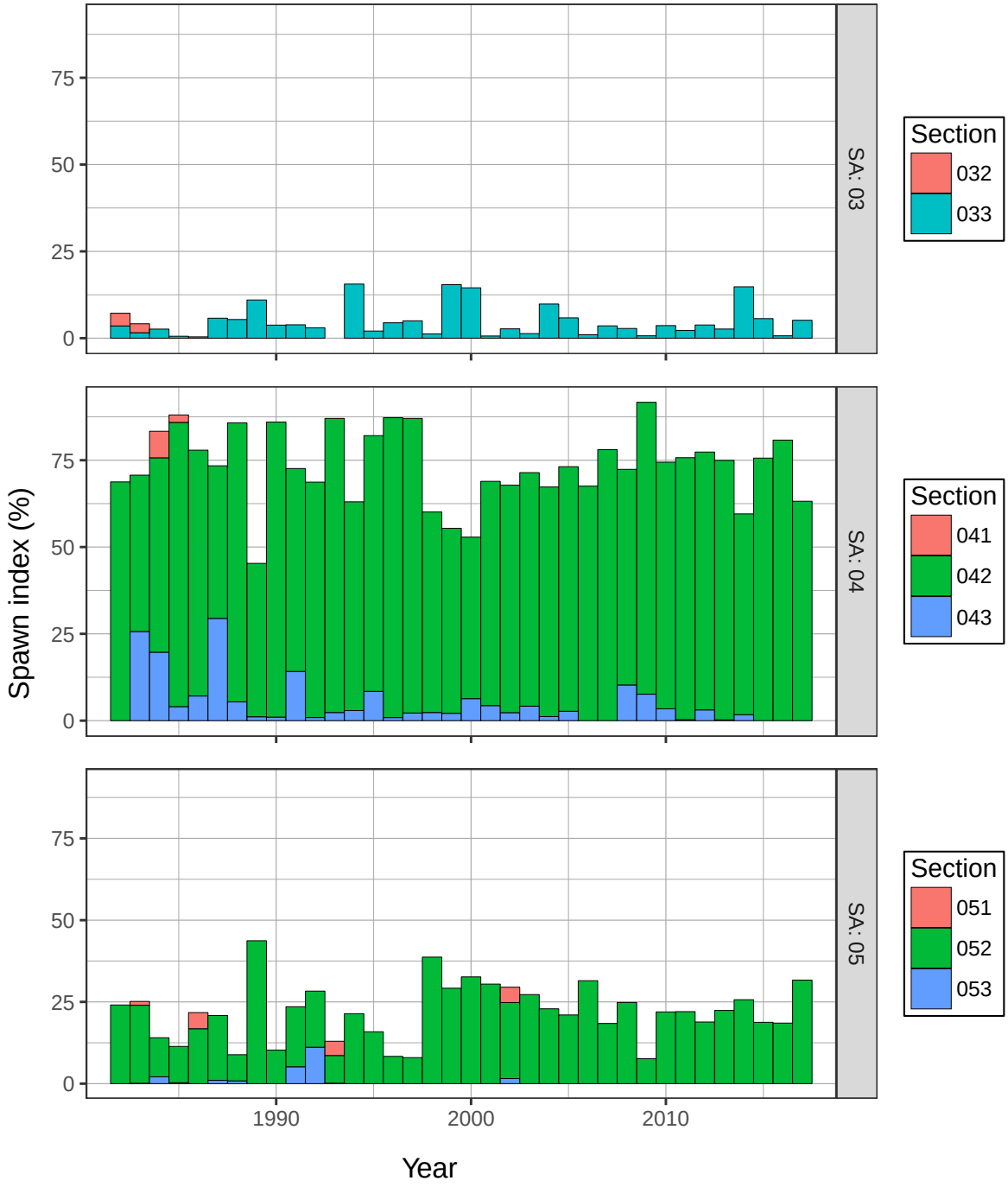

Figure 15. Time series of percent of spawn index by Statistical Area (SA) and Section for Pacific herring from 1982 to 2017 in the Prince Rupert District major stock assessment region (SAR). The spawn index has two distinct periods defined by the dominant survey method: surface surveys (1951–1987), and dive surveys (1988–2017). The 'spawn index' represents the raw survey data only, and is not scaled by the spawn survey scaling parameter, q.

Appendix A Spawn on kelp

Female Pacific herring produce an average of approximately 200,000 eggs per kilogram, kg of total body weight (Hay 1985; Hay and Brett 1988). We assume that females account for 50% of spawners, and we use the following egg conversion factor, *ECF* to convert eggs to tonnes, t of spawners

$$ECF = fecundity \cdot pFemale \cdot \frac{10^3 \text{ kg}}{\text{t}} \tag{1}$$

where *fecundity* is the number of eggs per kilogram of total female body weight in $\text{eggs} \cdot \text{kg}^{-1}$, *pFemale* is the proportion of spawners that are female, and *ECF* is in $\text{eggs} \cdot \text{t}^{-1}$. Thus, we convert eggs to spawning biomass in tonnes by dividing the number of eggs by $ECF = \text{eggs} \cdot 10^8 \cdot \text{t}^{-1}$. Although Pacific herring productivity is affected by environmental variability and other factors (Tanasichuk and Ware 1987; Hay and Brett 1988), we assume that bias from using Equation 1 is insignificant in most areas and years (Schweigert 1993).

Shields et al. (1985) collected information on the relationship between the number of egg layers in SOK product, and the proportion of the product weight that consisted of eggs and kelp. They determined that kelp represented an average of 12% of the total product weight. Since SOK product is universally brined at the time of harvest, it is necessary to also consider the uptake of salt by the eggs, which increases the overall product weight. However, there is uncertainty in the degree of brining that occurs prior to weighing the product. Nevertheless, Whyte and Englar (1977) determined that following a 24 hour brining period, the wet product weight increased about 13% due to salt uptake. However, by osmosis, the brining would also draw some water from the eggs; unfortunately this cannot be accounted for at this time. The last factor to consider is the mean fertilized egg weight, which was determined by Hay and Miller (1982) as $2.38 \cdot 10^{-6}$ kg. We estimate spawning biomass removed from the population by the SOK fishery as

$$SB = \frac{SOK \cdot eggKelpProp \cdot eggBrineProp}{eggWt \cdot ECF} \tag{2}$$

where *SOK* is the weight in kilograms of herring SOK harvest, *eggKelpProp* is the proportion of the SOK product that is eggs, not kelp (0.88), *eggBrineProp* is the proportion of SOK product that is eggs after brining (0.87), *eggWt* is the average weight in kilograms of a fertilized egg ($\text{kg} \cdot \text{egg}^{-1}$), and *SB* is the estimated spawning biomass in tonnes, based on Equation 1.

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