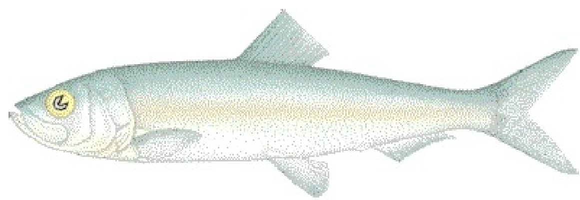
Pacific herring preliminary data summary for Haida Gwaii 2017

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 Haida Gwaii 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.

The following is a description of data collected for Pacific herring in the Haida Gwaii major SAR in 2017 (Figure 2). Data collected outside the SAR boundary are not

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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 "Queens Reach", a seine test charter vessel funded by the DFO. The primary purpose of the test charter vessel was to collect biological samples from main bodies of herring from Haida Gwaii major (priority) and minor stock areas, identified from soundings. The "Queens Reach" operated a 25-day charter from March 9th to April 2rd, collecting samples from HG and Area 2W. The spawn reconnaissance vessel, Haida Guardian, operated a 19-day charter from April 1th to April 19th; they were also assisted by the "Victoria Rose" for three days at the start. The dive charter vessel "Haida Spirit" operated a 20-day charter from April 6rd to April 26nd. These vessels were funded by DFO, through a contract to the HCRS, with 6 days of the reconnaissace survey funded by the Haida Nation (via AFS). The dive survey contract was awarded to and operated by the Haida Nation.

3 Catch and biological samples

Landed commercial catch of Pacific herring by year and fishery is shown in Table 2 and Figure 3. Total harvested spawn on kelp (SOK) in 2017 in the Haida Gwaii 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, 8 Pacific herring biological samples were collected and processed for the Haida Gwaii major SAR (Table 4, Table 5), and a total of 739 Pacific herring were aged in 2017. The locations in which the biological samples were collected are presented in Figure 4. Included herein are biological summaries of observed proportion-, number-, and weight-at-age (Figure 5, Table 6, and Figure 6, 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 Haida Gwaii major SAR (Table 7, and Figure 7). A summary of spawn from the last decade (2007 to 2016) is shown in Figure 8. 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 9, Figure 10, Figure 11, Figure 12, 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 12b, Figure 13). For example, in 2017, Section 021 contributed the most to the spawn index (79%). As with Sections, some Statistical Areas contribute more than others to the total spawn index (Figure 12c, Figure 14).

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 abundance was concentrated along the North Shore of Burnaby Island with reduced abundances in other historical areas (e.g., Selwyn, Skincuttle and Louscoone Inlets).
- Test samples showed Herring size to be more broadly distributed, which suggests a broad range of age classes.
- Similar to last year, spawn was concentrated along the outer exposed shore of Burnaby Island.
- Water temperatures were cooler than 2016.
- The dive survey was unable to survey approximately 22 transects worth of shoreline (7.7 km) primarily along the NE shore of Burnaby Island due to unsafe diving conditions.
- Spawn (2.5 km) in Louscoone occurred very early at the beginning of March and was also not surveyed.
- Dive team reports that spawn deposition was thin and patchy compared to previous seasons.
- Compared to last year, observed soundings were higher, while observed spawn was lower.

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 Haida Gwaii 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	0
Gear2	0
Gear3	0

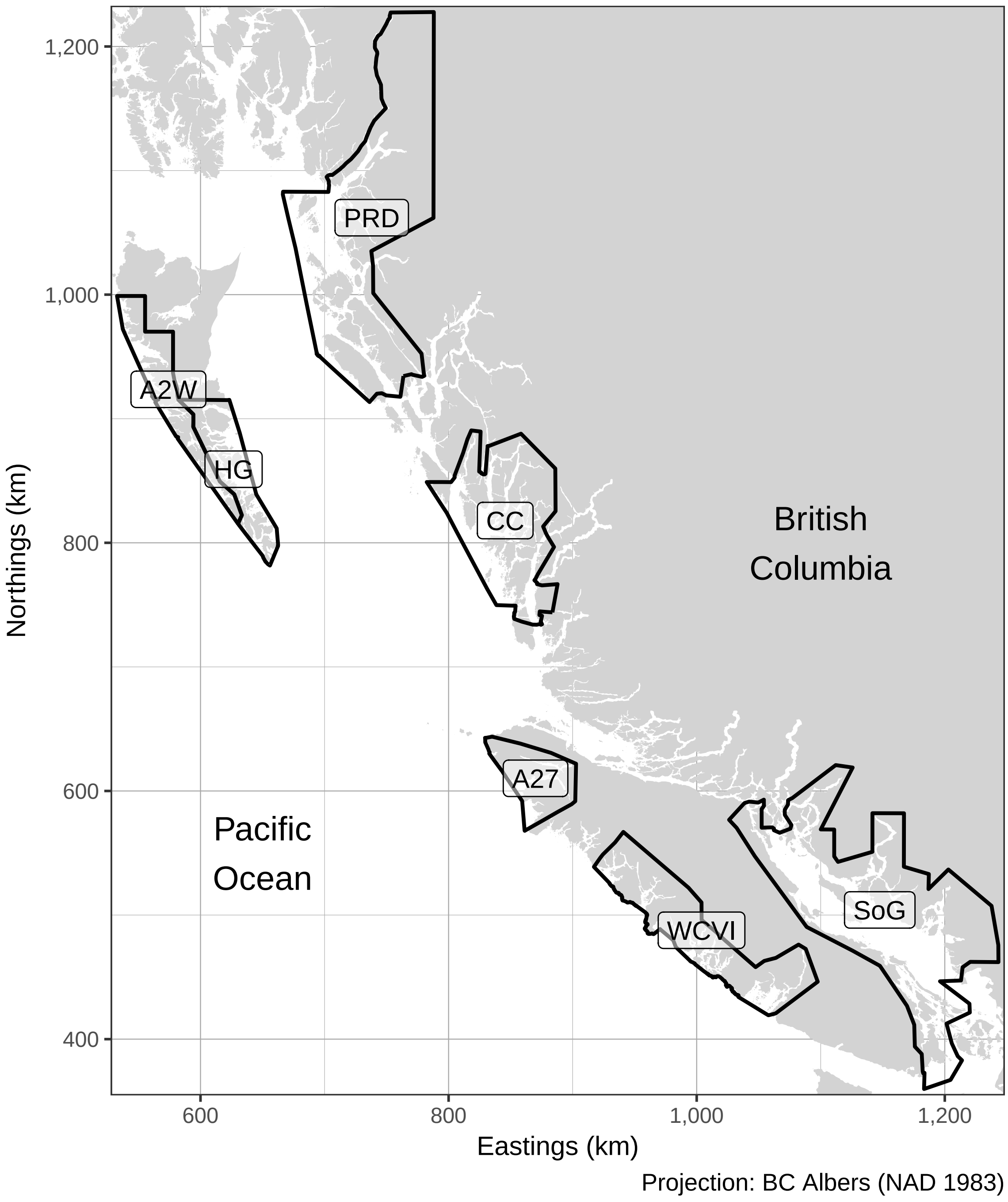

Figure 1. Boundaries for the Pacific herring stock assessment regions (SARs) in British Columbia: there are 5 major SARs (HG, PRD, CC, SoG, and WCVI), and 2 minor SARs (A27 and A2W; Table 1). Units: kilometres (km).

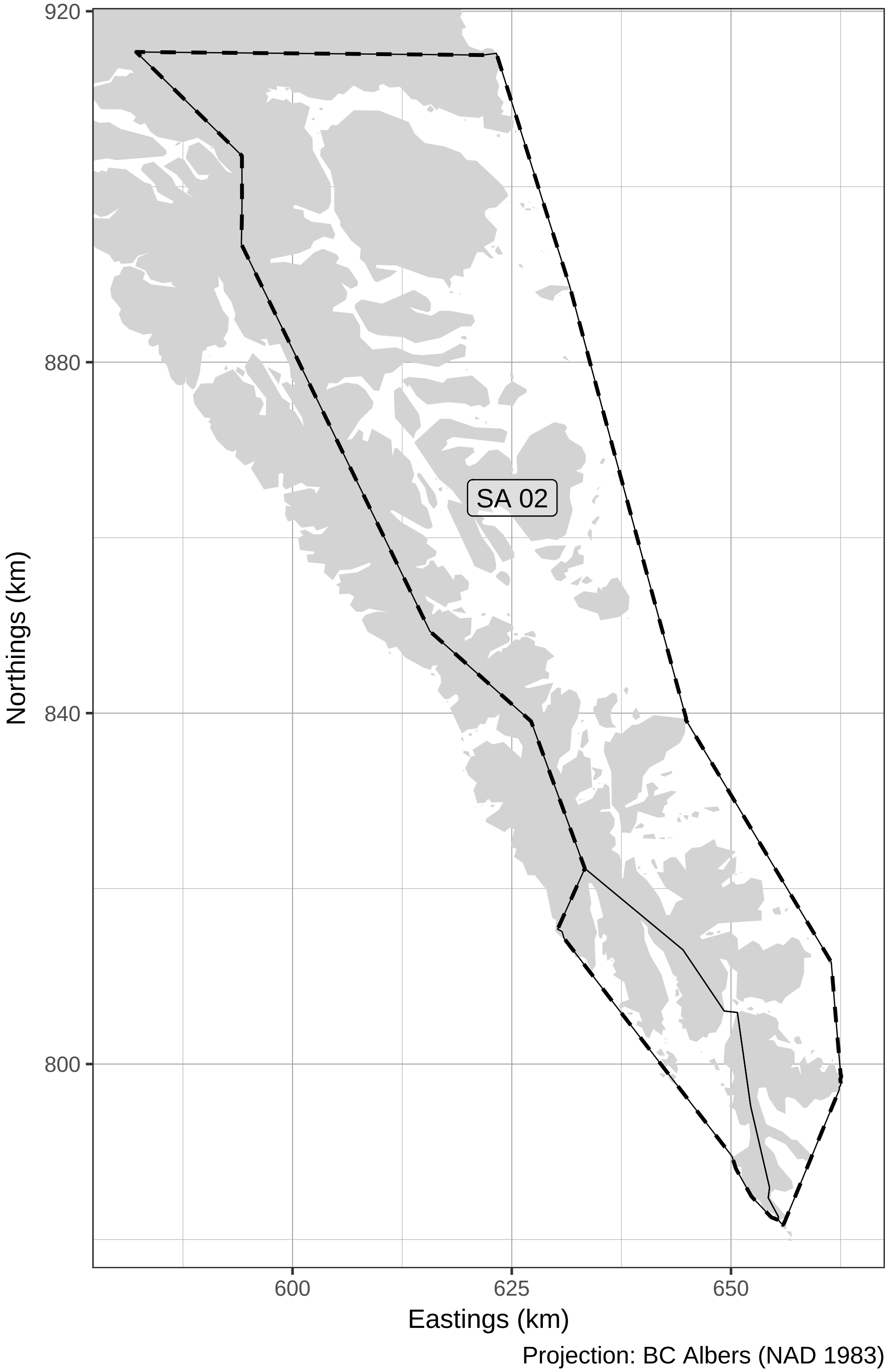

Figure 2. Boundaries for the Haida Gwaii major stock assessment region (SAR; thick dashed lines), and associated Statistical Areas (SA; thin solid lines). Units: kilometres (km).

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 Haida Gwaii 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	0	0
2008	0	0
2009	0	0
2010	0	0
2011	0	0
2012	0	0
2013	0	0
2014	0	0
2015	0	0
2016	0	0
2017	0	0

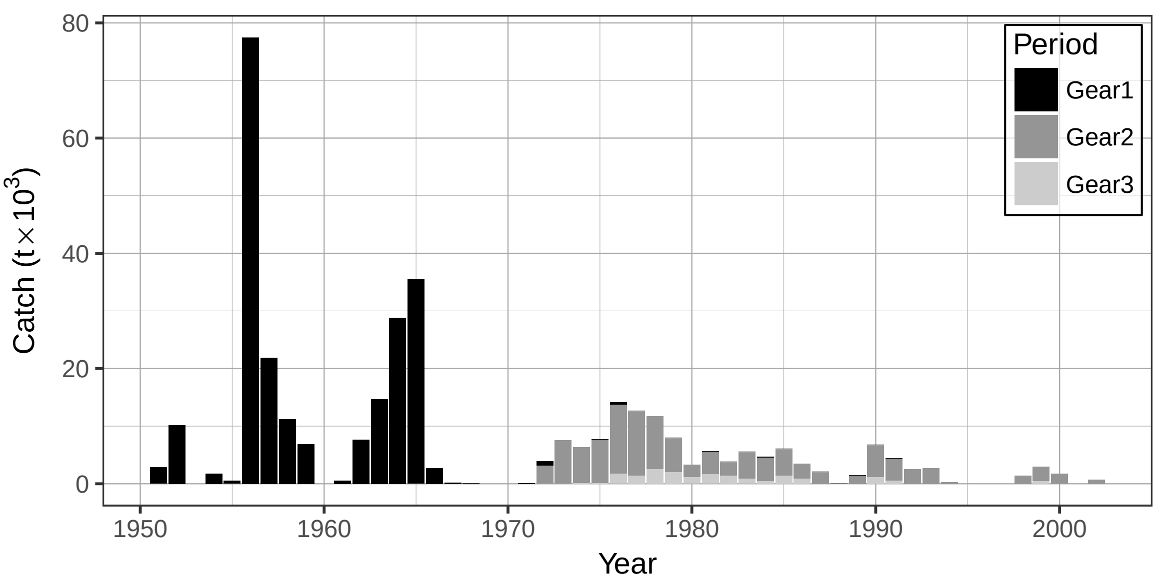

Figure 3. Time series of total landed catch in thousands of metric tonnes (t $\times$ 10^3) of Pacific herring by gear type from 1951 to 2017 in the Haida Gwaii major stock assessment region (SAR). Legend: 'Gear1' represents the reduction, the food and bait, as well as the special use fishery; 'Gear2'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

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

	Number of samples		
Year	Commercial	Test	Total
2007	0	6	6
2008	1	9	10
2009	0	12	12
2010	0	12	12
2011	0	13	13
2012	0	9	9
2013	0	12	12
2014	0	12	12
2015	0	11	11
2016	0	5	5
2017	0	8	8

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

Type	Gear	Use	Number of samples
Test	Seine	Test Fishery	8

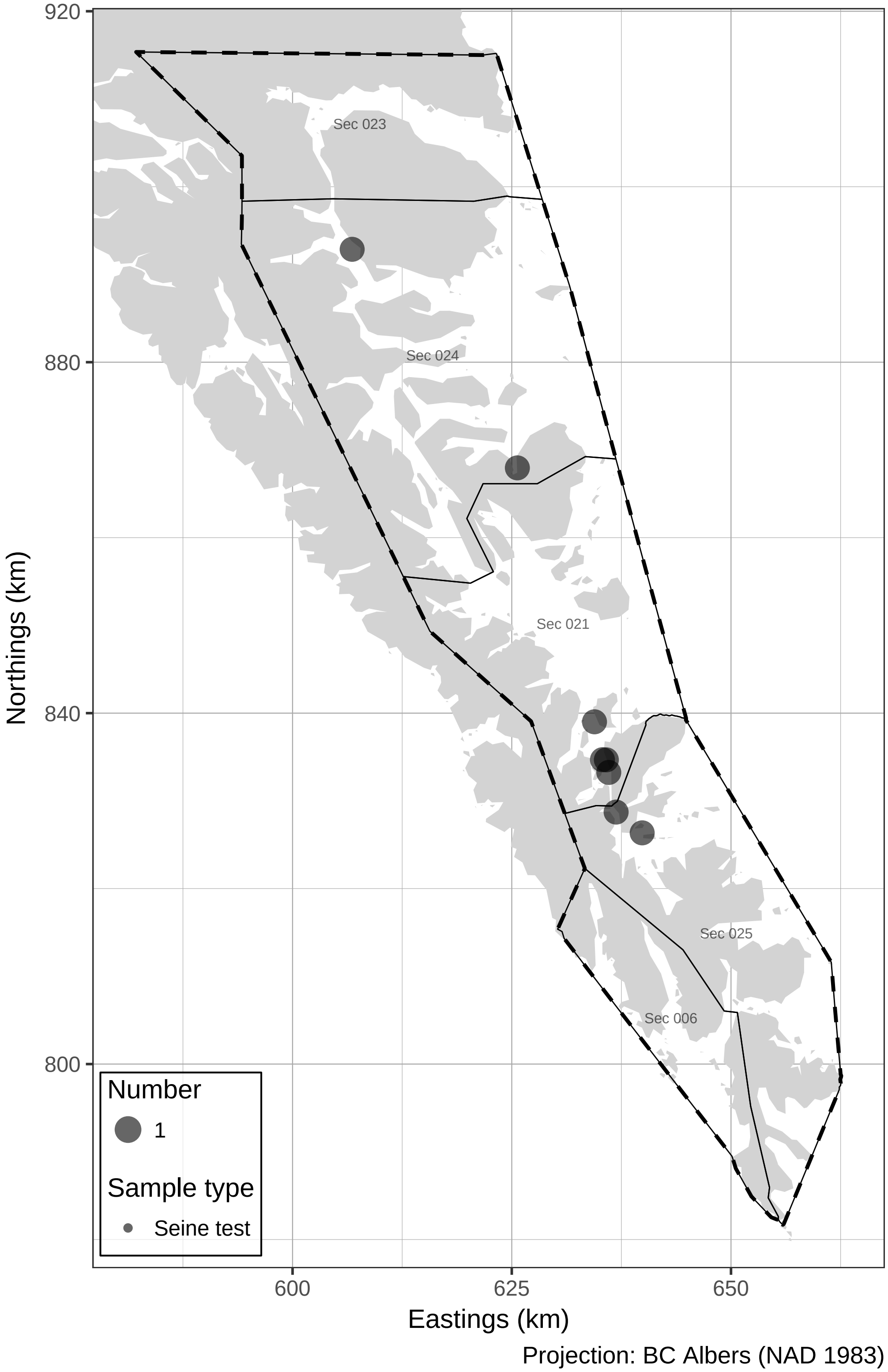

Figure 4. Location and type of Pacific herring biological samples collected in 2017 in the Haida Gwaii major stock assessment region (SAR; thick dashed lines), and associated Sections (Sec; thin solid lines). Units: kilometres (km).

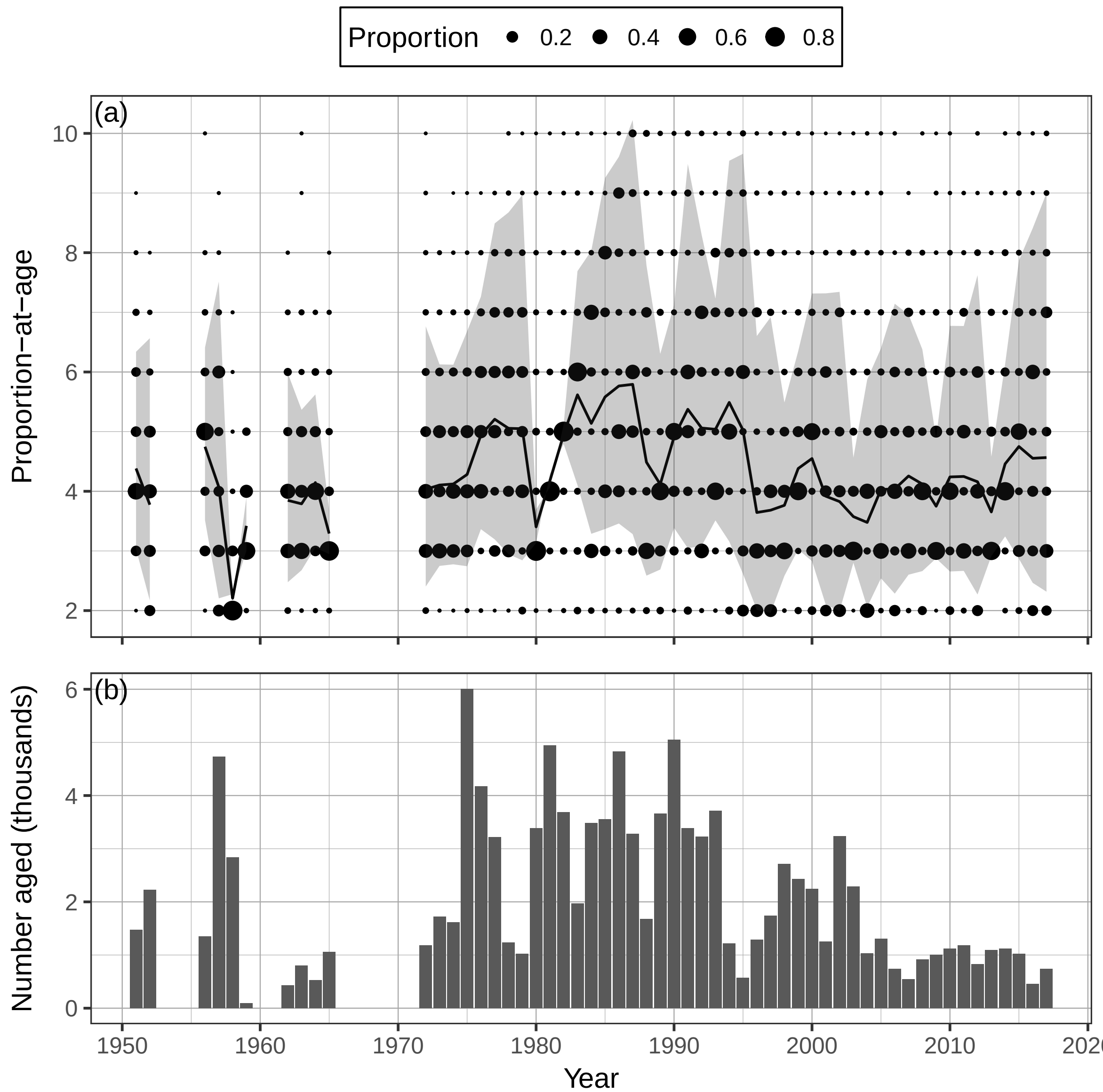

Figure 5. Time series of observed proportion-at-age (a) and number aged in thousands (b) of Pacific herring from 1951 to 2017 in the Haida Gwaii major stock assessment region (SAR). The black line is the mean age, and the shaded area is the approximate 90% distribution. Biological summaries only include 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.

Table 6. Observed proportion-at-age for Pacific herring from 2007 to 2017 in the Haida Gwaii 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	0.011	0.452	0.143	0.209	0.059	0.103	0.022	0.002	0.000
2008	0.093	0.074	0.634	0.076	0.086	0.018	0.016	0.000	0.002
2009	0.001	0.643	0.076	0.221	0.020	0.029	0.004	0.005	0.001
2010	0.082	0.085	0.589	0.056	0.153	0.017	0.013	0.003	0.002
2011	0.018	0.442	0.076	0.314	0.055	0.085	0.008	0.003	0.000
2012	0.174	0.148	0.380	0.040	0.203	0.018	0.030	0.002	0.004
2013	0.000	0.677	0.125	0.128	0.019	0.041	0.005	0.004	0.000
2014	0.014	0.037	0.684	0.115	0.094	0.014	0.034	0.005	0.003
2015	0.034	0.218	0.055	0.519	0.059	0.079	0.018	0.014	0.004
2016	0.166	0.162	0.170	0.058	0.376	0.044	0.020	0.002	0.002
2017	0.138	0.322	0.100	0.112	0.050	0.200	0.049	0.015	0.014

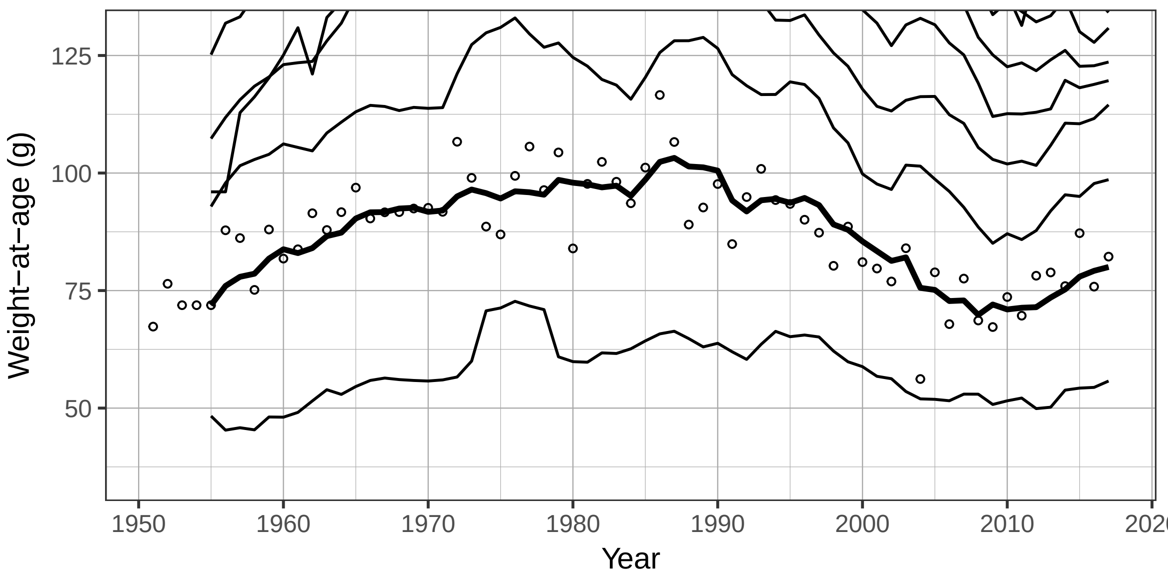

Figure 6. Time series of weight-at-age in grams (g) for age-3 (circles) and 5-year running mean weight-at-age (lines) for Pacific herring from 1951 to 2017 in the Haida Gwaii major stock assessment region (SAR). Lines show 5-year running means for age-2 to age-10 herring (incrementing higher from the 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 Haida Gwaii 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)
00	006	1847	Louscoone Inlt E	NA
02	021	165	Huxley Is	42
02	021	166	Burnaby Str	124
02	021	178	Section Cv	231
02	021	1552	Scudder Pt	264
02	021	1553	Alder Is	39
02	021	1582	Saw Rf	869
02	021	1583	Section Is	365
02	021	1738	Alder Is Cr	250
02	021	1845	Haswell Bay	51
02	021	1849	Nakons Islet	NA
02	021	1959	Marco Is	137
02	024	138	Powrivco Bay	31
02	024	1739	Kilmington Pt	22
02	025	1410	Smithe Pt	NA
02	025	1606	Poole Inlt	253
02	025	1859	Scudder Cr	337

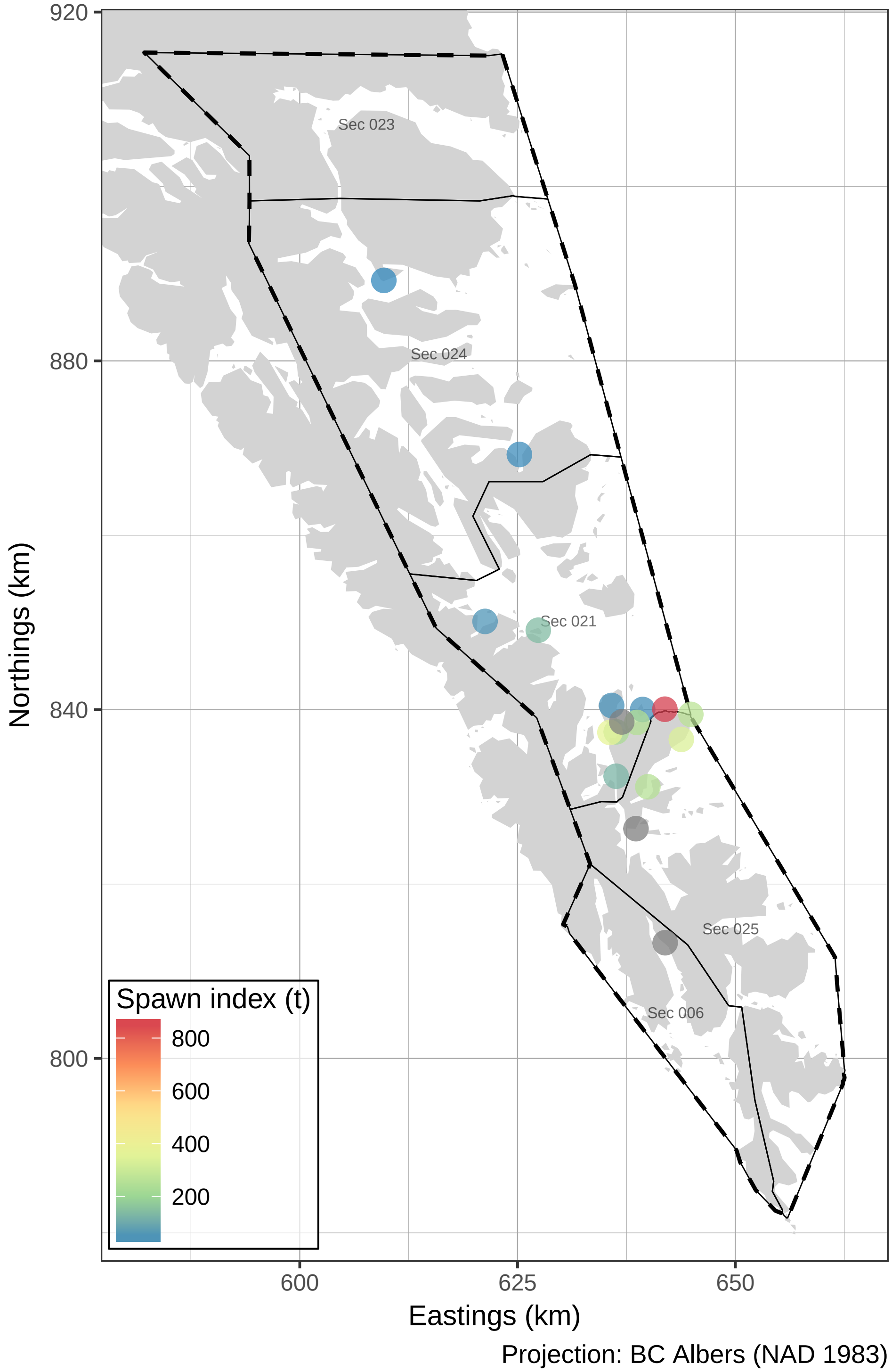

Figure 7. Pacific herring spawn survey locations, and spawn index in metric tonnes (t) in 2017 in the Haida Gwaii major stock assessment region (SAR; thick dashed lines), and associated Sections (Sec; thin solid lines). The 'spawn index' represents the raw survey data only, and is not scaled by the spawn survey scaling parameter, q. Missing spawn index values (grey circles) indicate incomplete spawn surveys. Units: kilometres (km).

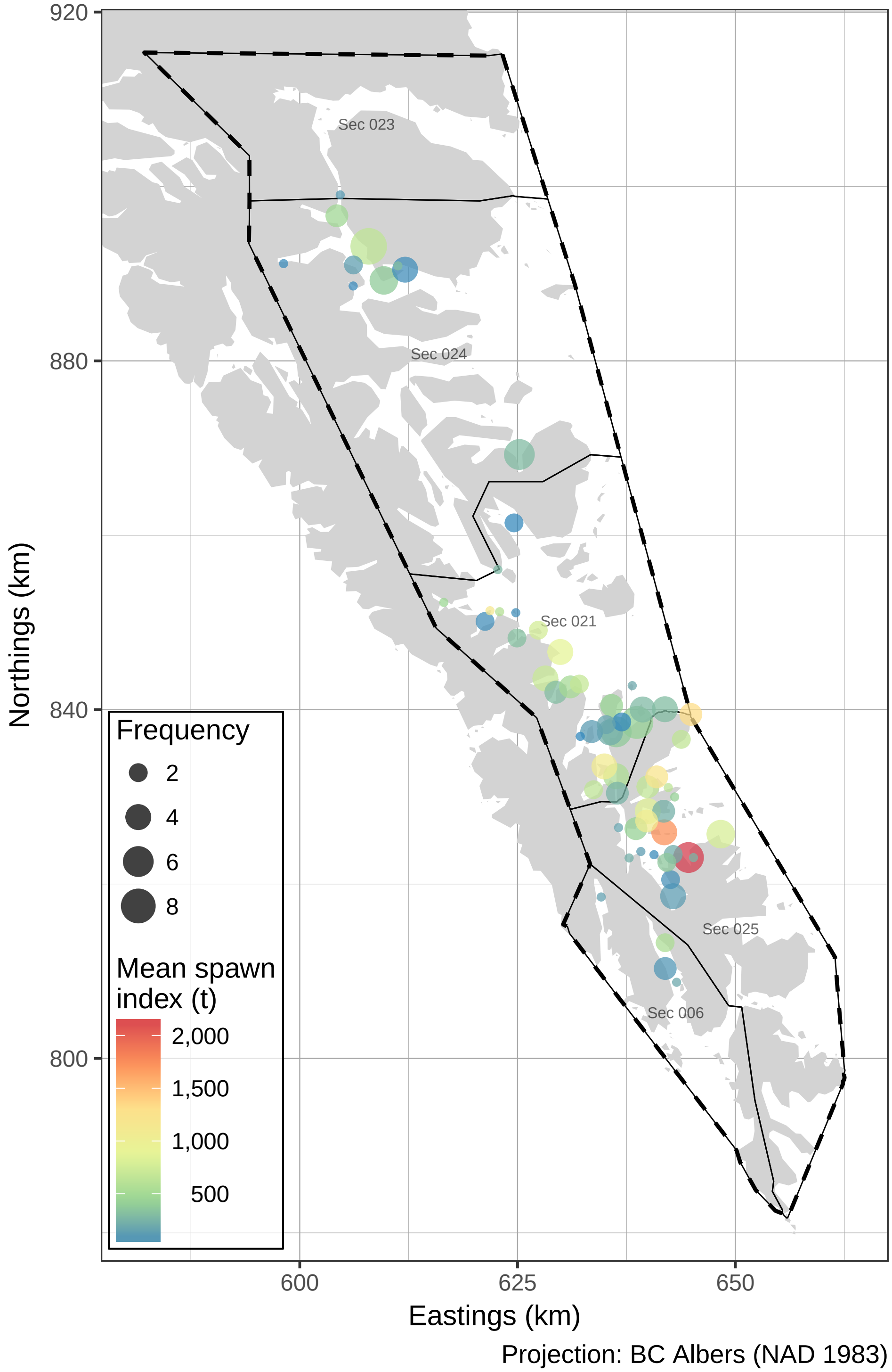

Figure 8. Pacific herring spawn survey locations, mean spawn index in metric tonnes (t), and spawn frequency from 2007 to 2016 in the Haida Gwaii major stock assessment region (SAR; thick dashed lines), and associated Sections (Sec; thin solid lines). The 'spawn index' represents the raw survey data 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).

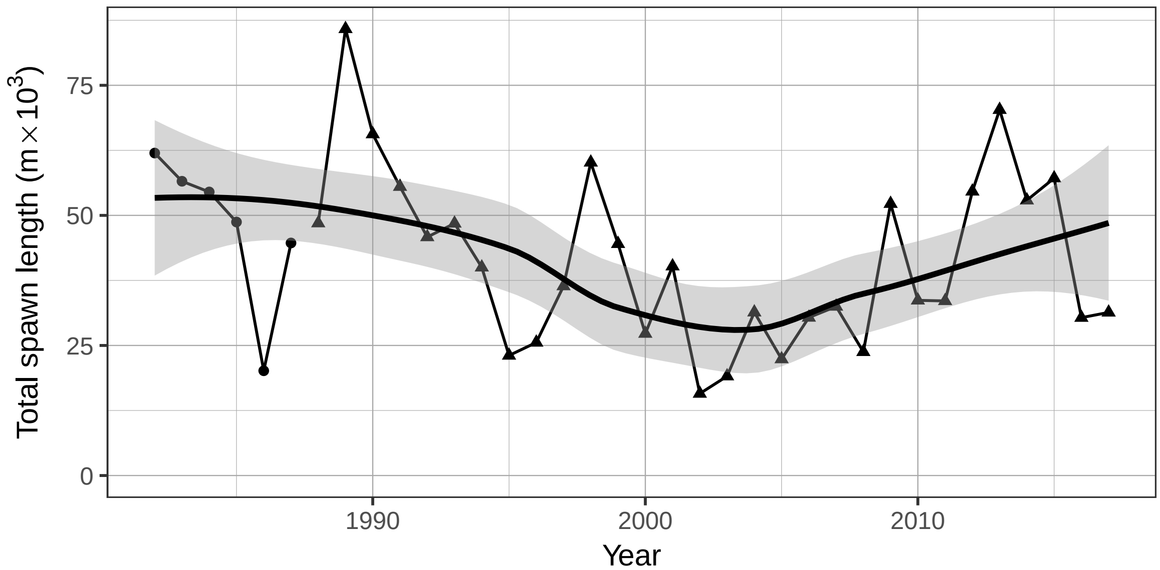

Figure 9. Time series of total spawn length in thousands of metres (m $\times$ 10^3) for Pacific herring from 1982 to 2017 in the Haida Gwaii major stock assessment region (SAR). The thick black line is a loess curve, and the shaded area is the 90% confidence interval. The spawn index has two distinct periods defined by the dominant survey method: surface surveys (1951–1987), and dive surveys (1988–2017).

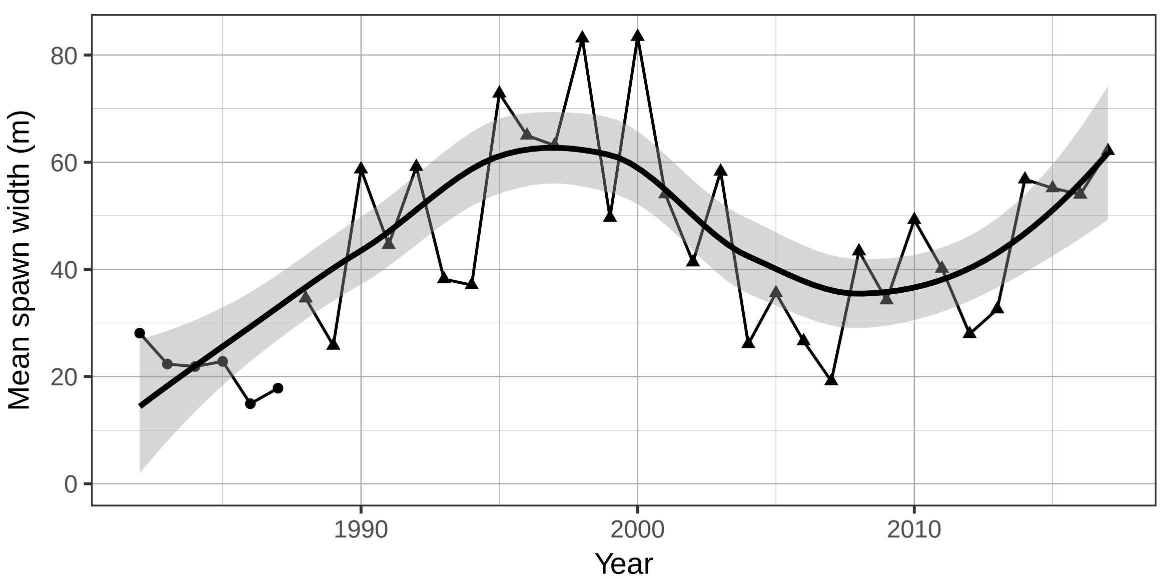

Figure 10. Time series of mean spawn width in metres (m) for Pacific herring from 1982 to 2017 in the Haida Gwaii major stock assessment region (SAR). The thick black line is a loess curve, and the shaded area is the 90% confidence interval. The spawn index has two distinct periods defined by the dominant survey method: surface surveys (1951–1987), and dive surveys (1988–2017).

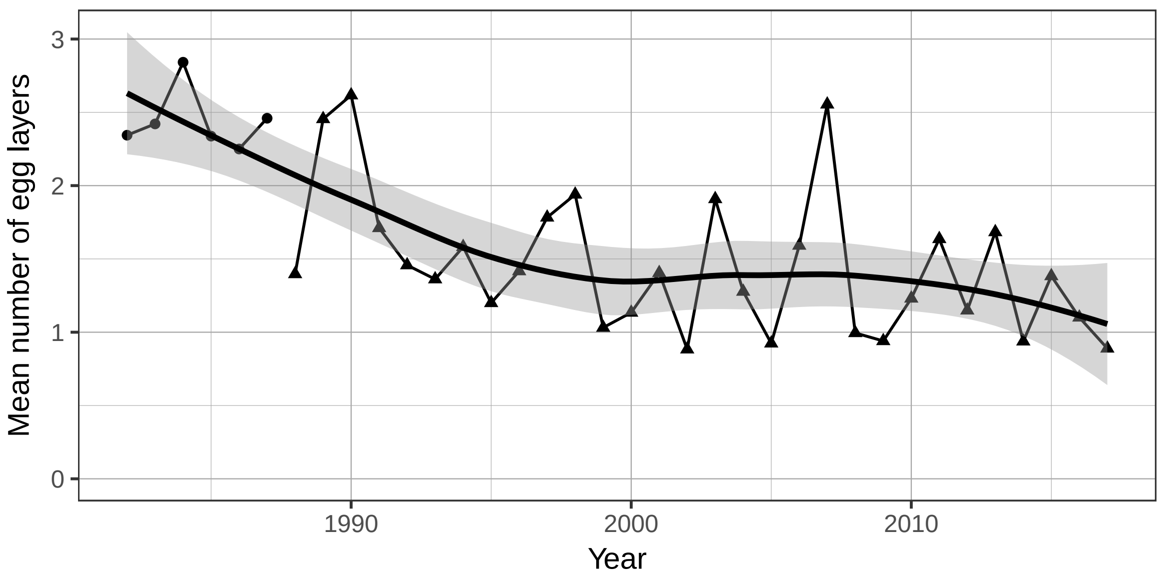

Figure 11. Time series of mean number of egg layers for Pacific herring from 1982 to 2017 in the Haida Gwaii major stock assessment region (SAR). The thick black line is a loess curve, and the shaded area is the 90% confidence interval. The spawn index has two distinct periods defined by the dominant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

Table 8. Summary of spawn survey data from 2007 to 2017 in the Haida Gwaii 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	32,483	19	2.554	9,436
2008	23,770	43	0.995	4,213
2009	52,239	34	0.940	9,794
2010	33,670	49	1.230	6,845
2011	33,560	40	1.636	7,554
2012	54,610	28	1.149	9,720
2013	70,300	33	1.683	16,025
2014	52,900	57	0.938	10,566
2015	57,150	55	1.383	13,102
2016	30,345	54	1.101	6,888
2017	31,350	62	0.889	3,016

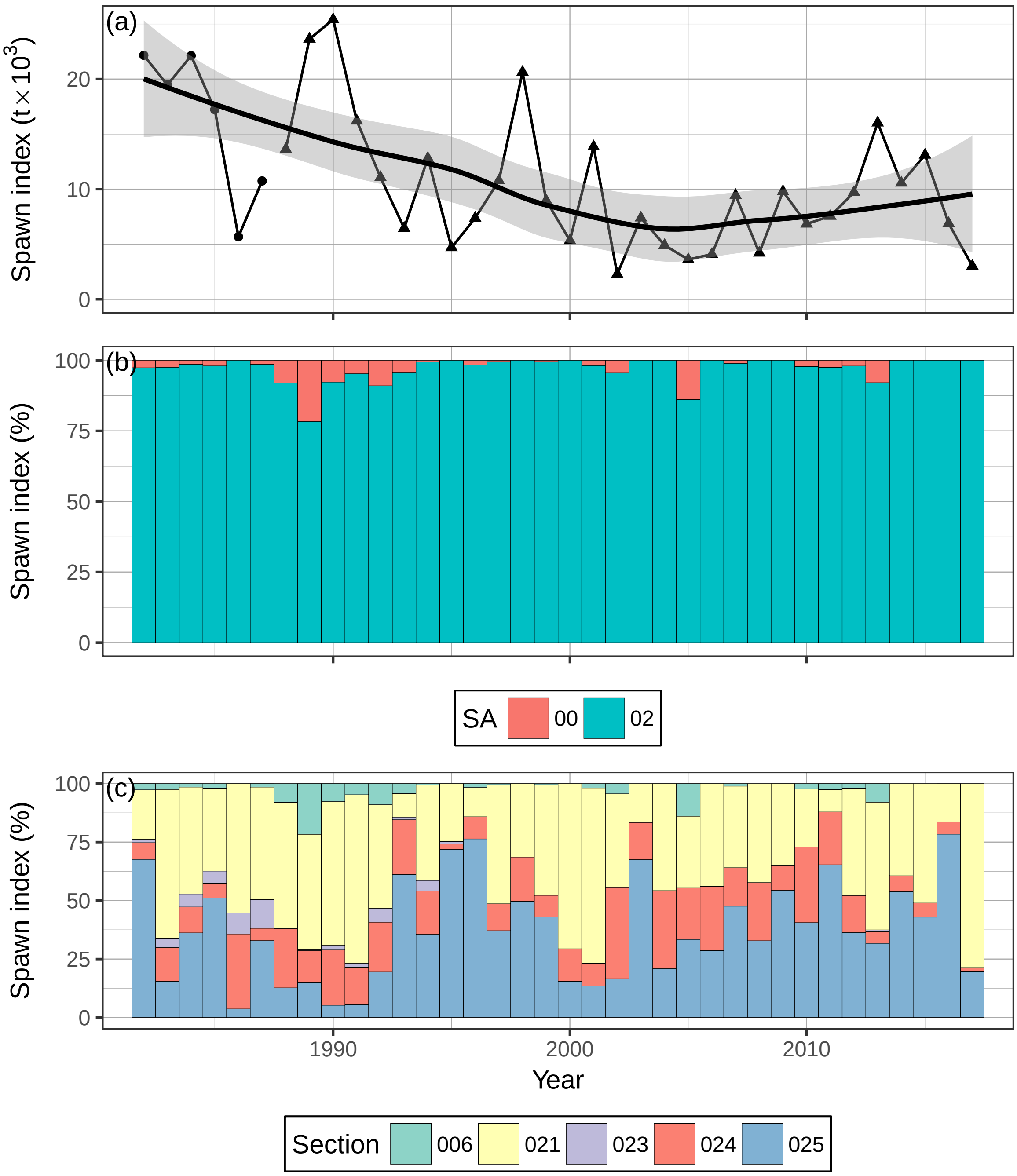

Figure 12. Time series of spawn index in thousands of metric tonnes (t $\times$ 10^3) for Pacific herring from 1982 to 2017 in the Haida Gwaii major stock assessment region (SAR; a), as well as percent contributed by Statistical Area (SA), and Section (b, & c, respectively). The thick black line is a 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.

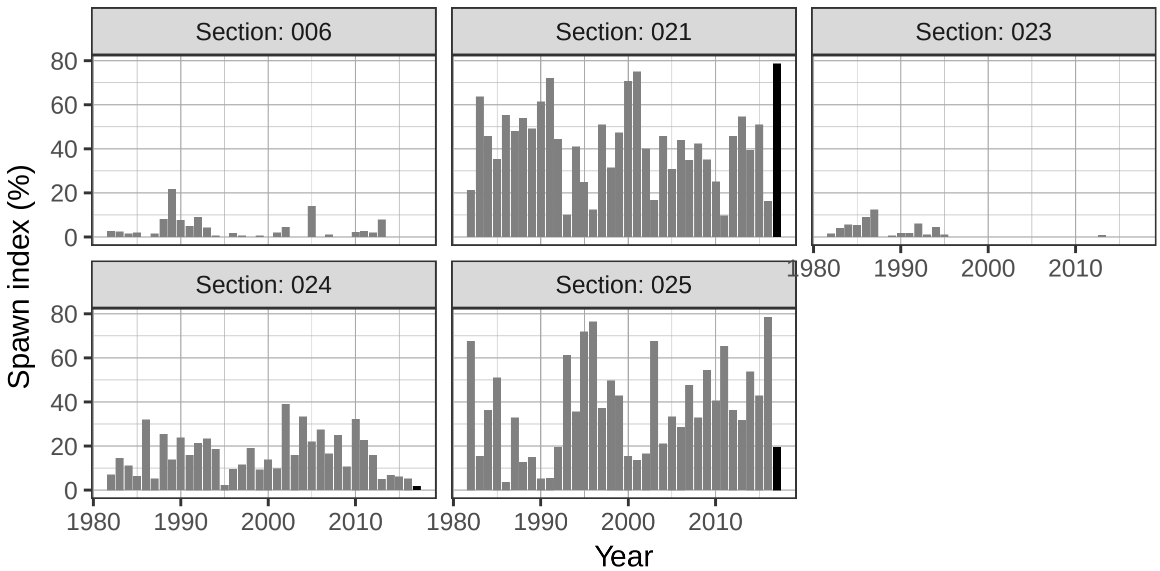

Figure 13. Time series of percent of spawn index by Section for Pacific herring from 1982 to 2017 in the Haida Gwaii major stock assessment region (SAR). The year 2017 has a darker bar to facilitate interpretation. The spawn index has two distinct periods defined by the dominant survey method: surface 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.

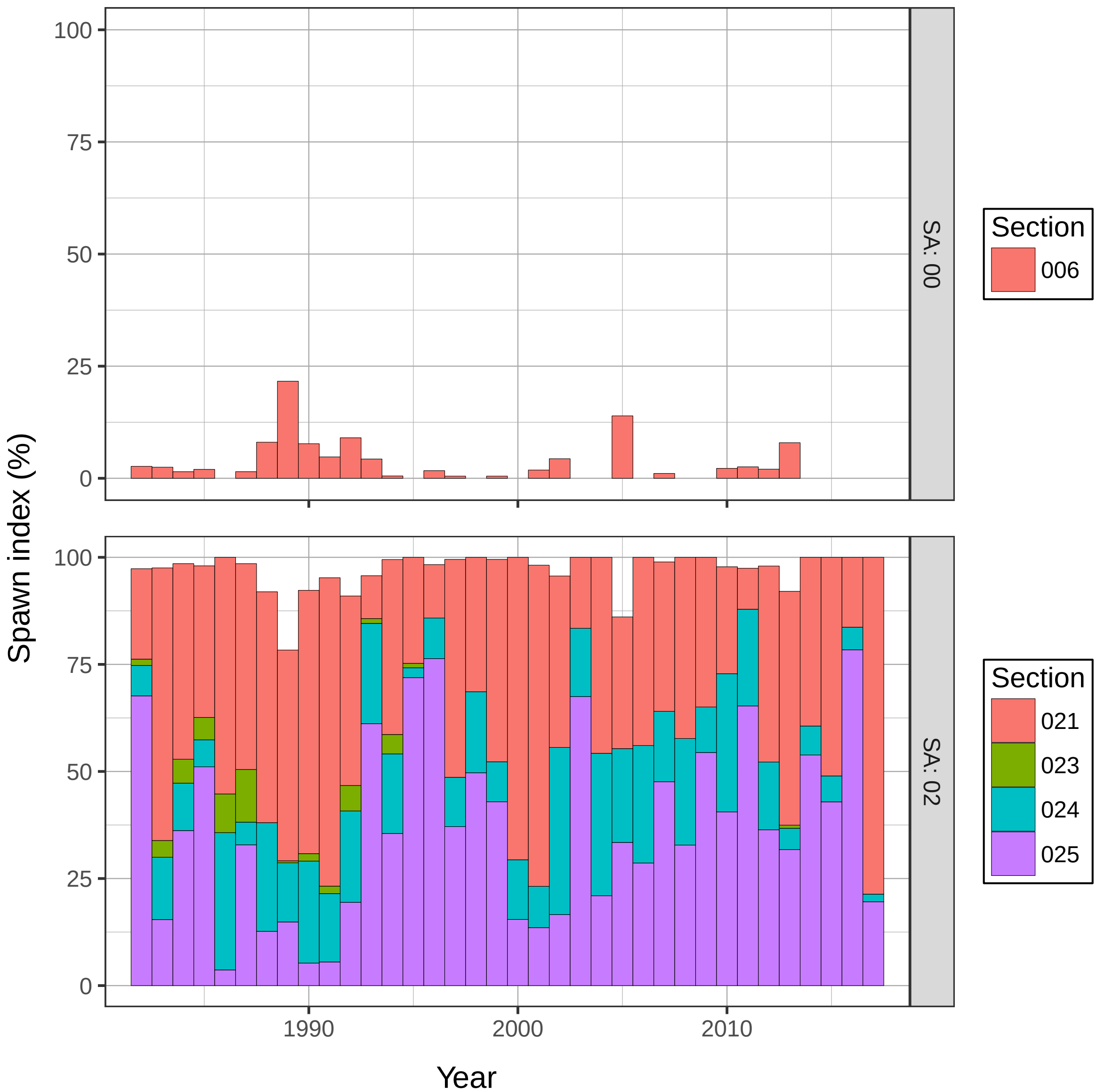

Figure 14. Time series of percent of spawn index by Statistical Area (SA) and Section for Pacific herring from 1982 to 2017 in the Haida Gwaii major stock assessment region (SAR). The spawn index has two distinct periods defined by the dominant survey method: surface surveys (1951–1987), and dive surveys (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

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

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

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

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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