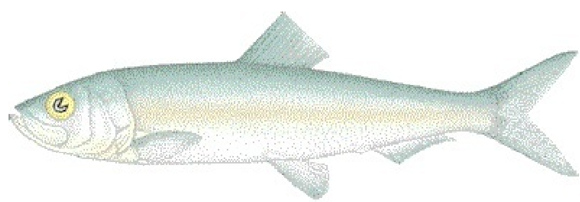
Pacific herring preliminary data summary for Area 27 2017

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 Area 27 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 Area 27 minor 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

- "Seaveyor" surveyed the area April 17th to April 19st.
- Survey effort is concentrated in Section 273 and identification of spawning events relies largely on communication from local residents to the DFO Resource Manager.
- Spawn dive survey in Area 27 found only 2 transects with spawn. The survey team scouted the rest of the area, but found no other spawn.

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 Area 27 minor 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 19.

In 2017, 0 Pacific herring biological samples were collected and processed for the Area 27 minor SAR (Table 4, Table 5), and a total of 0 Pacific herring were aged in 2017. Included herein are biological summaries of observed proportion-, number-, and weight-at-age (Figure 4, Table 6, and Figure 5, 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 1 individual location in 2017 in the Area 27 minor SAR (Table 7, and Figure 6). A summary of spawn from the last decade (2007 to 2016) is shown in Figure 7. 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 8, Figure 9, Figure 10, Figure 11, 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 11b, Figure 12). For example, in 2017, Section 273 contributed the most to the spawn index (100%). As with Sections, some Statistical Areas contribute more than others to the total spawn index (Figure 11c, Figure 13).

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:

- The WCVI spawn flight does not cover Area 27.
- Dive team deployment has been dependent on observations from local residents for the last few years, because the SOK licence holders have elected not to operate.
- When no spawn reports had been received by late in the season, DFO Resource Management initiated a vessel-based reconnaissance patrol on April 6th; the patrol witnessed one small active spawn, and found another very small older spawn.
- In the last few years the spawn in Area 27 was reported in early- to mid-March, so it's possible that an earlier spawn was undetected in 2017.

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 Area 27 minor 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

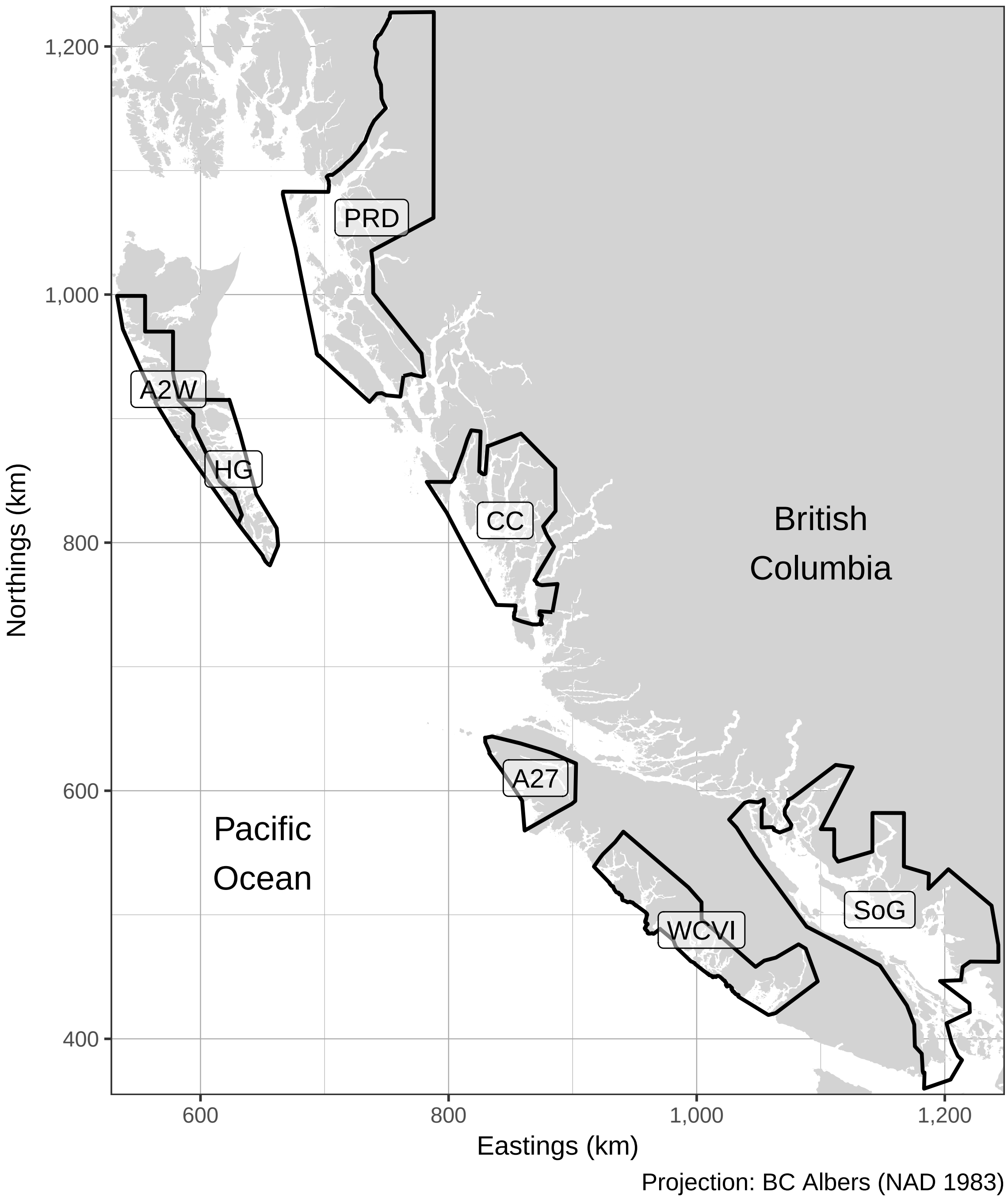

Figure 1. Boundaries for the Pacific herring stock assessment regions (SARs) in British Columbia: there are 5 major SARs (HG, PRD, CC, SoG, and WCVI), and 2 minor SARs (A27 and A2W; Table 1). Units: kilometres (km).

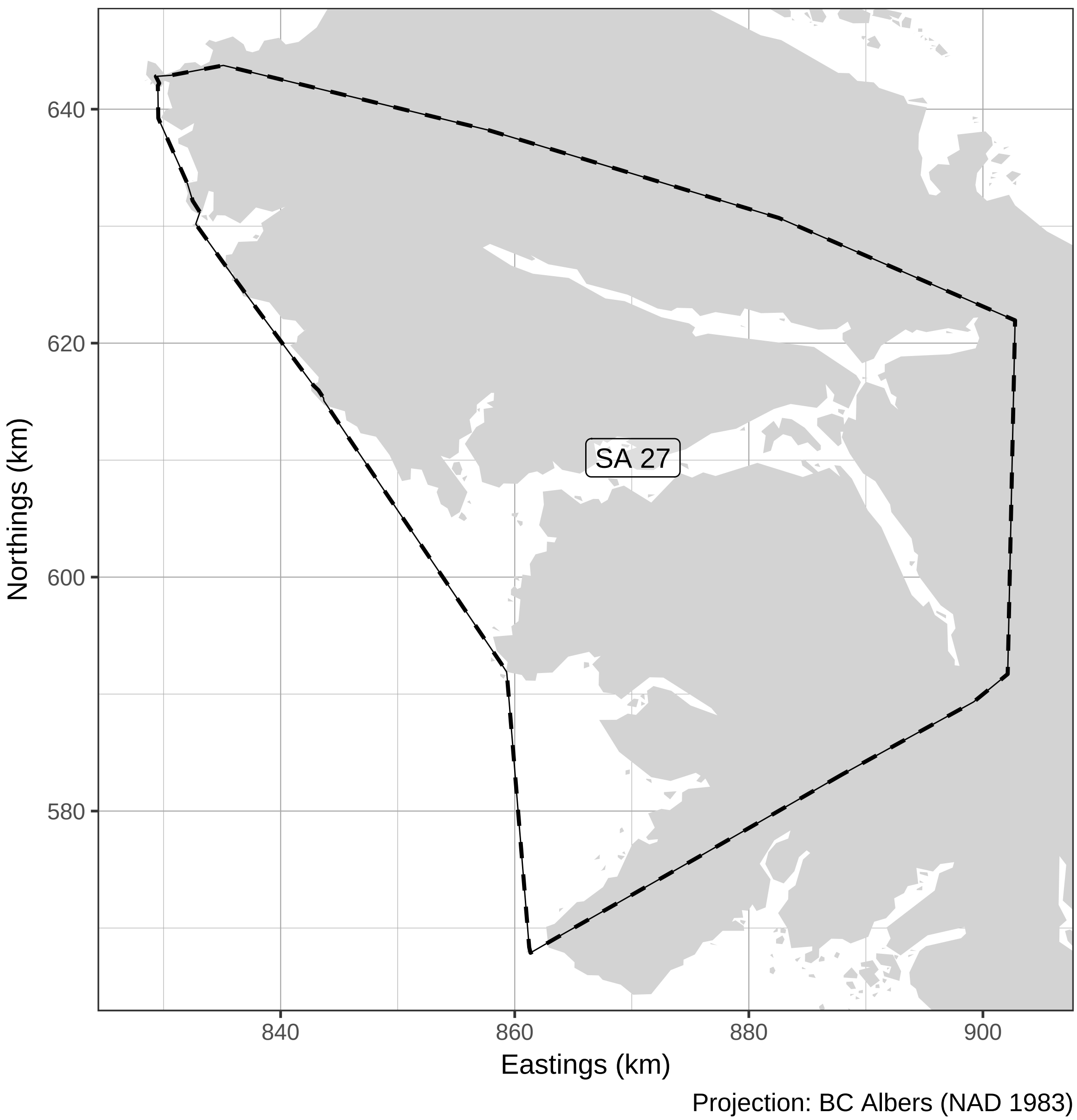

Figure 2. Boundaries for the Area 27 minor stock assessment region (SAR; thick dashed lines), and associated Statistical Areas (SA; thin solid lines). Units: kilometres (km).

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 Area 27 minor stock assessment region (SAR). See calculations to convert SOK to spawning biomass in Appendix A, page 19. Note: 'WP' indicates that data are withheld due to privacy concerns.

Year	Harvest (lb)	Spawning biomass (t)
2007	52,691	77
2008	41,291	60
2009	42,325	62
2010	WP	WP
2011	WP	WP
2012	WP	WP
2013	WP	WP
2014	WP	WP
2015	0	0
2016	0	0
2017	0	0

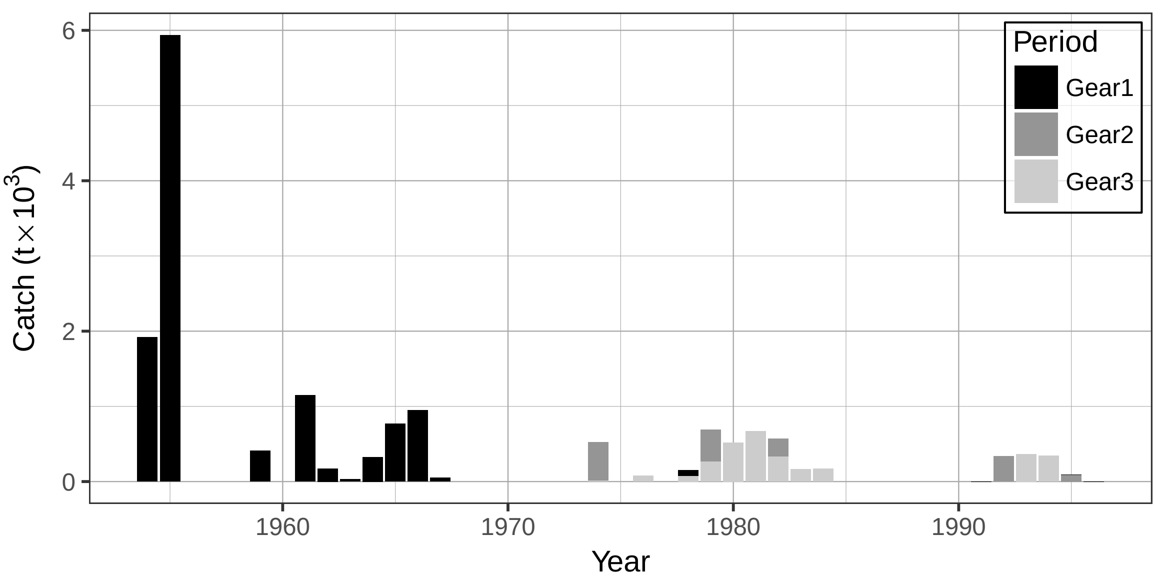

Figure 3. Time series of total landed catch in thousands of metric tonnes ($t \times 10^3$) of Pacific herring by gear type from 1951 to 2017 in the Area 27 minor stock assessment region (SAR). Legend: 'Gear1' represents the reduction, the food and bait, as well as the special use fishery; 'Gear2' represents 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 Area 27 minor stock assessment region (SAR). Each sample is approximately 100 fish.

	Number of samples		
Year	Commercial	Test	Total
2007	5	0	5
2008	4	0	4
2009	8	0	8
2010	3	0	3
2011	3	0	3
2012	7	0	7
2013	6	0	6
2014	0	0	0
2015	0	0	0
2016	0	0	0
2017	0	0	0

Table 5. Number and type of Pacific herring biological samples processed in 2017 in the Area 27 minor stock assessment region (SAR). Each sample is approximately 100 fish.

Type	Gear	Use	Number of samples
NA	NA	NA	0

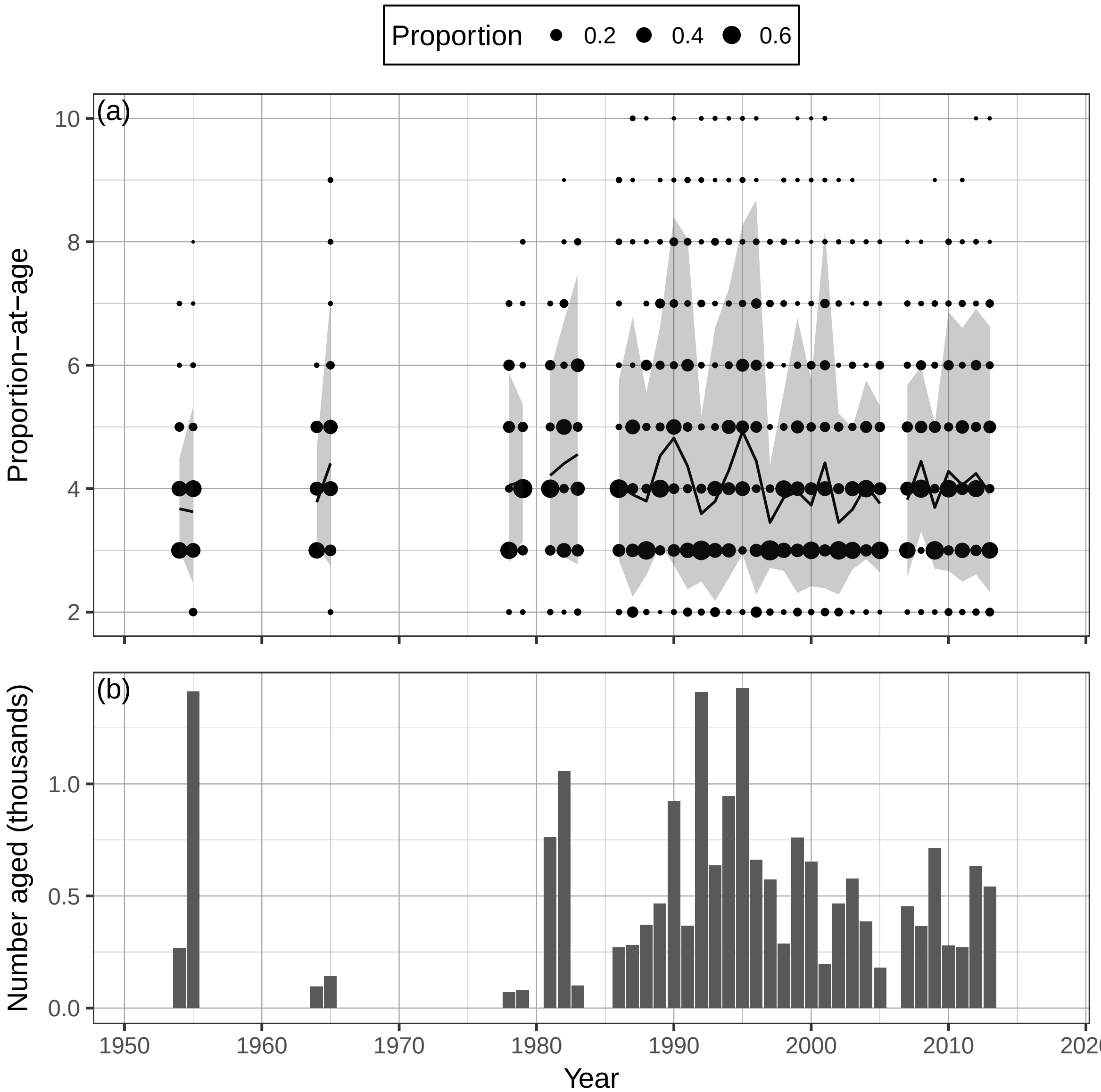

Figure 4. Time series of observed proportion-at-age (a) and number aged in thousands (b) of Pacific herring from 1951 to 2017 in the Area 27 minor stock assessment region (SAR). The black line is the mean age, and the shaded area is the approximate 90% distribution. Biological summaries only include 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 Area 27 minor 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	0.461	0.309	0.159	0.035	0.022	0.002	0.000	0.000
2008	0.016	0.033	0.596	0.219	0.120	0.014	0.003	0.000	0.000
2009	0.013	0.627	0.102	0.200	0.032	0.025	0.000	0.001	0.000
2010	0.054	0.126	0.554	0.090	0.129	0.022	0.025	0.000	0.000
2011	0.022	0.389	0.237	0.274	0.030	0.037	0.007	0.004	0.000
2012	0.040	0.172	0.503	0.120	0.134	0.016	0.013	0.000	0.002
2013	0.078	0.471	0.094	0.235	0.054	0.065	0.002	0.000	0.002
2014	NA	NA	NA	NA	NA	NA	NA	NA	NA
2015	NA	NA	NA	NA	NA	NA	NA	NA	NA
2016	NA	NA	NA	NA	NA	NA	NA	NA	NA
2017	NA	NA	NA	NA	NA	NA	NA	NA	NA

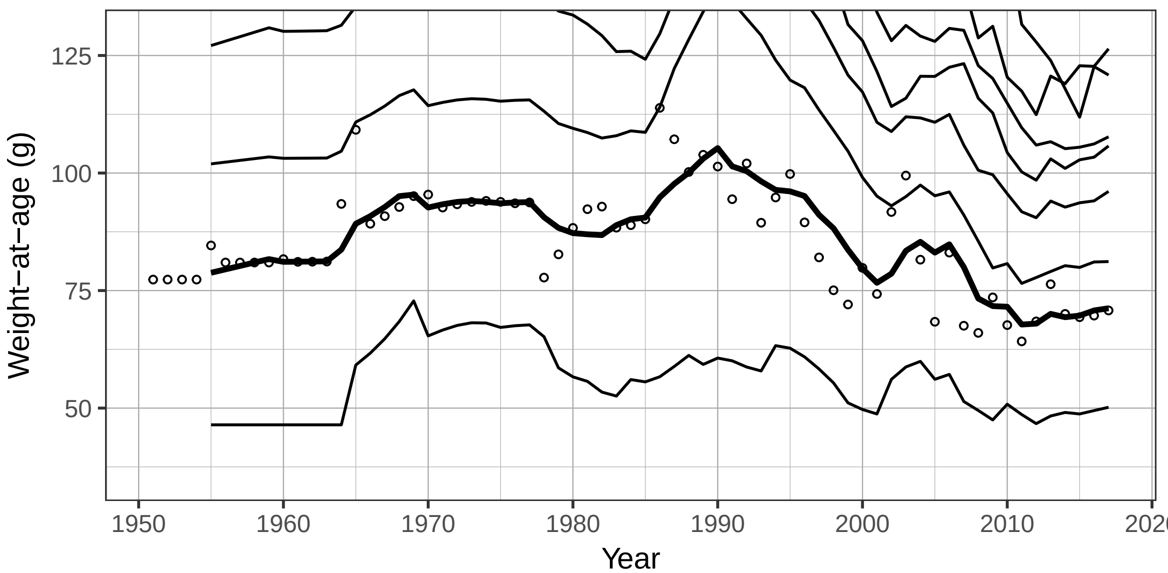

Figure 5. Time series of weight-at-age in grams (g) for age-3 (circles) and 5-year running mean weight-at-age (lines) for Pacific herring from 1951 to 2017 in the Area 27 minor stock assessment region (SAR). Lines show 5-year running means for age-2 to age-10 herring (incrementing higher from the lowest 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 location, and spawn index in metric tonnes (t) in 2017 in the Area 27 minor 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)
27	273	1327	Moores Is	26

Table 8. Summary of spawn survey data from 2007 to 2017 in the Area 27 minor 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	14,860	55	0.676	2,248
2008	3,300	59	0.846	796
2009	12,730	21	0.578	1,201
2010	11,270	32	0.707	846
2011	4,900	26	1.274	547
2012	13,310	38	0.250	744
2013	12,500	38	0.368	914
2014	7,575	102	0.859	1,307
2015	9,800	38	1.128	2,169
2016	11,375	52	0.441	814
2017	350	45	0.378	26

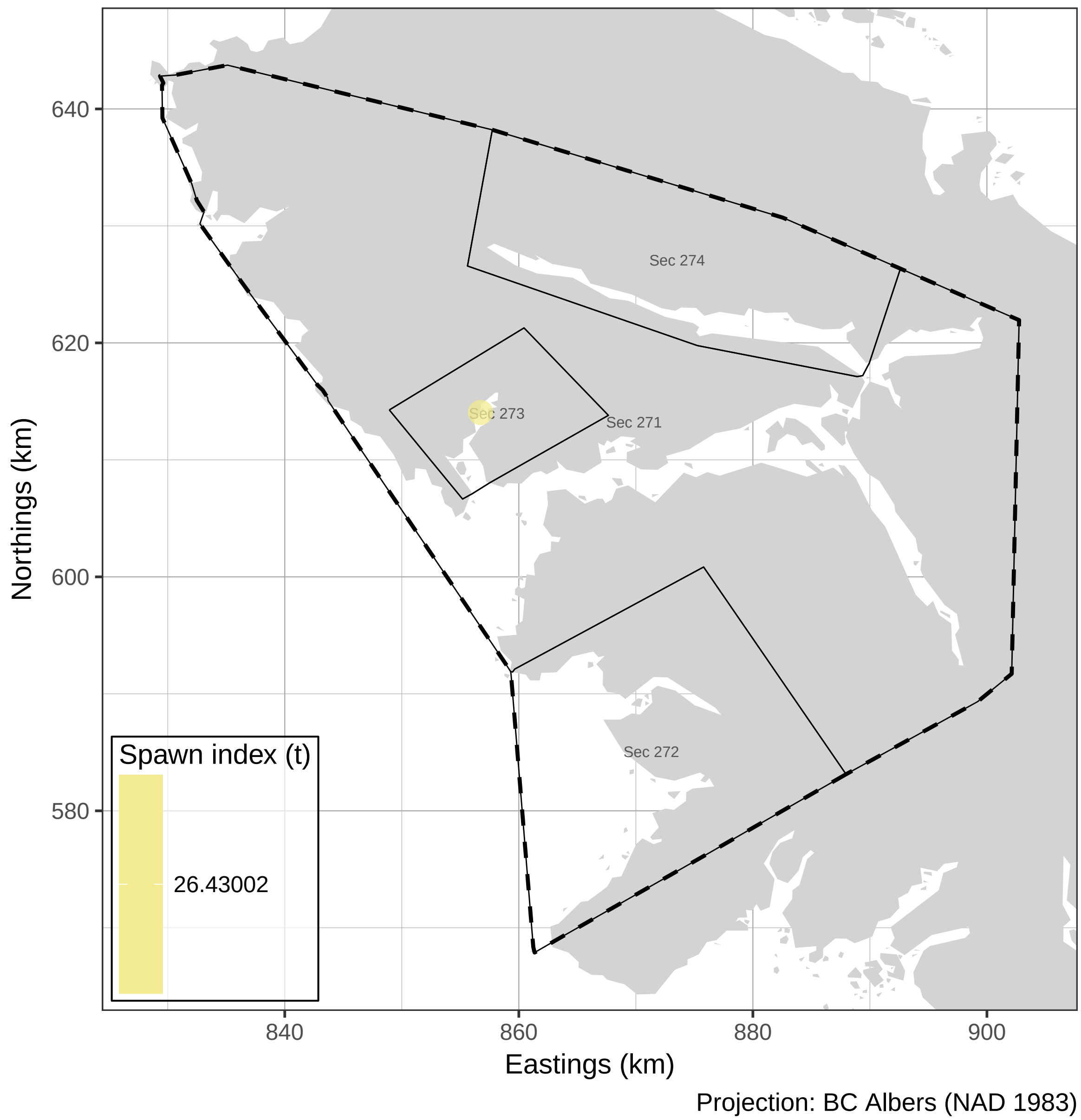

Figure 6. Pacific herring spawn survey location, and spawn index in metric tonnes (t) in 2017 in the Area 27 minor stock assessment region (SAR; thick dashed lines), and associated Sections (Sec; thin solid lines). The 'spawn index' represents the raw survey data only, and is not scaled by the spawn survey scaling parameter, q. Missing spawn index values (grey circles) indicate incomplete spawn surveys. Units: kilometres (km).

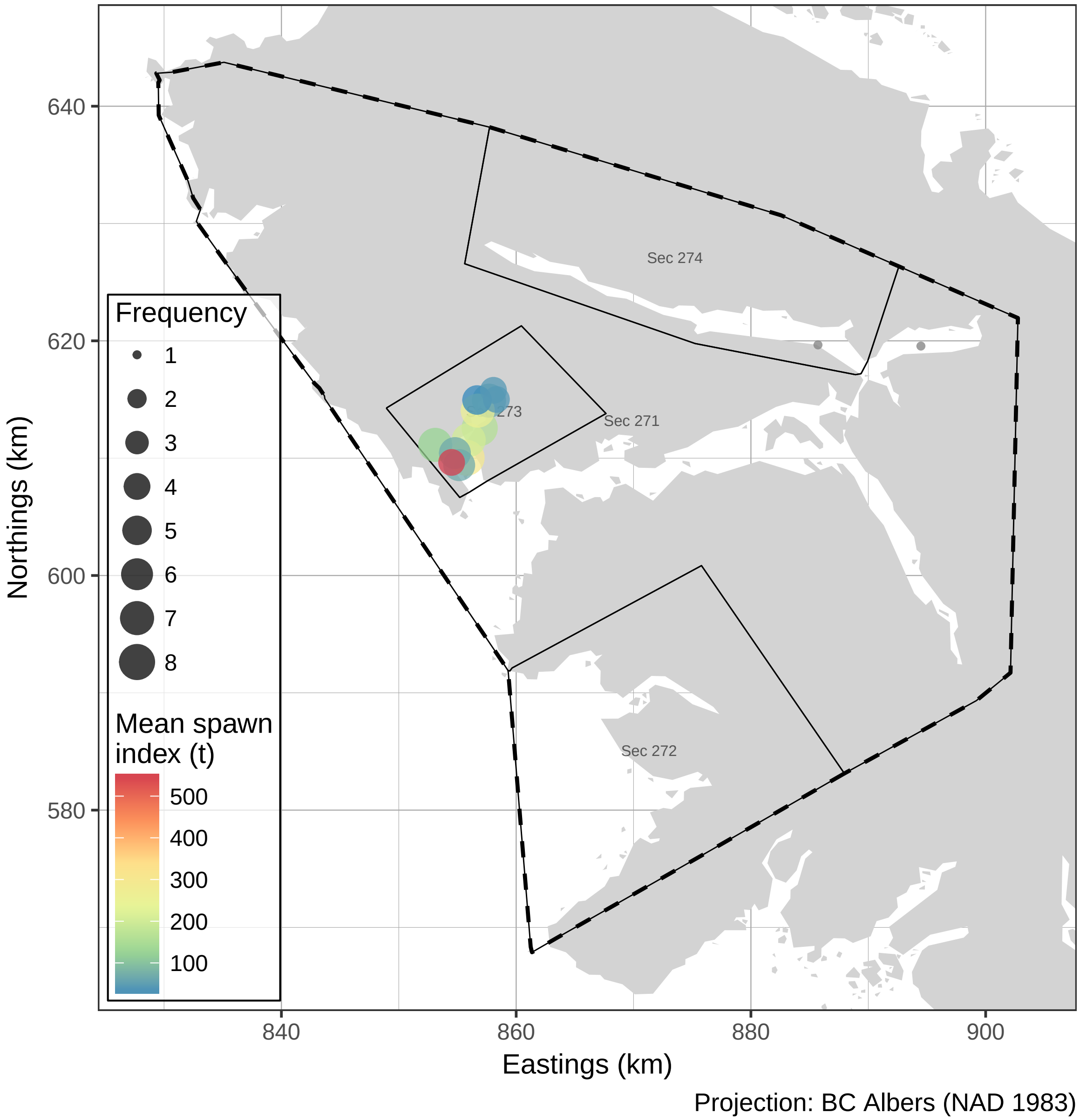

Figure 7. Pacific herring spawn survey location, mean spawn index in metric tonnes (t), and spawn frequency from 2007 to 2016 in the Area 27 minor stock assessment region (SAR; thick dashed lines), and associated Sections (Sec; thin solid lines). The ‘spawn index’ represents the raw survey data only, and is not scaled by the spawn survey scaling parameter, q. Missing spawn index values (grey circles) indicate incomplete spawn surveys. Units: kilometres (km).

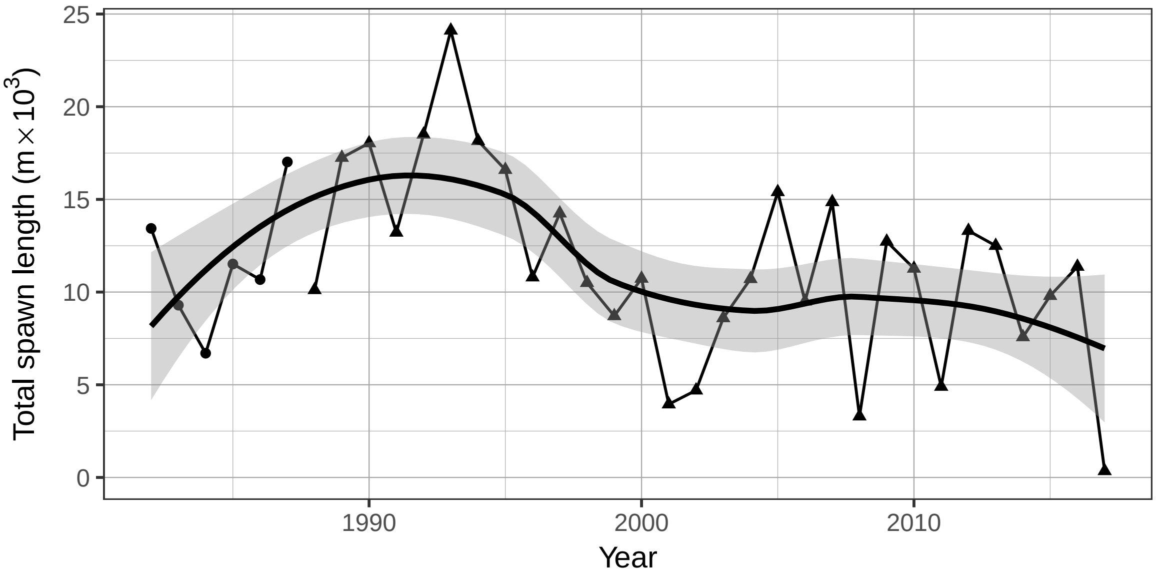

Figure 8. Time series of total spawn length in thousands of metres (m $\times$ 10^3) for Pacific herring from 1982 to 2017 in the Area 27 minor stock assessment region (SAR). The thick black line is a loess curve, and the shaded area is the 90% confidence interval. The spawn index has two distinct periods defined by the dominant survey method: surface surveys (1951–1987), and dive surveys (1988–2017).

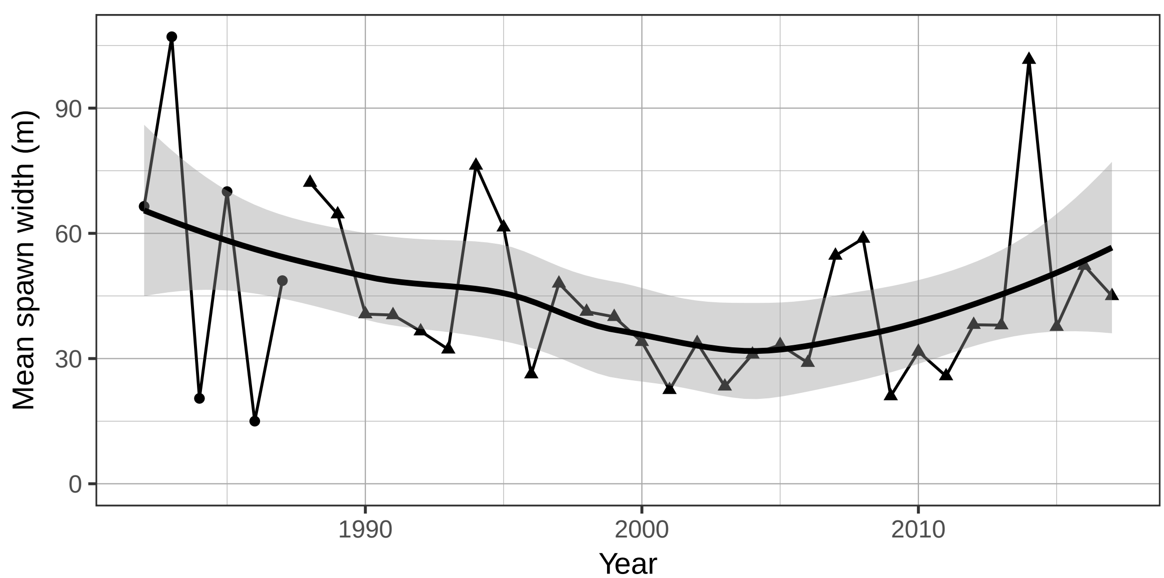

Figure 9. Time series of mean spawn width in metres (m) for Pacific herring from 1982 to 2017 in the Area 27 minor stock assessment region (SAR). The thick black line is a loess curve, and the shaded area is the 90% confidence interval. The spawn index has two distinct periods defined by the dominant survey method: surface surveys (1951–1987), and dive surveys (1988–2017).

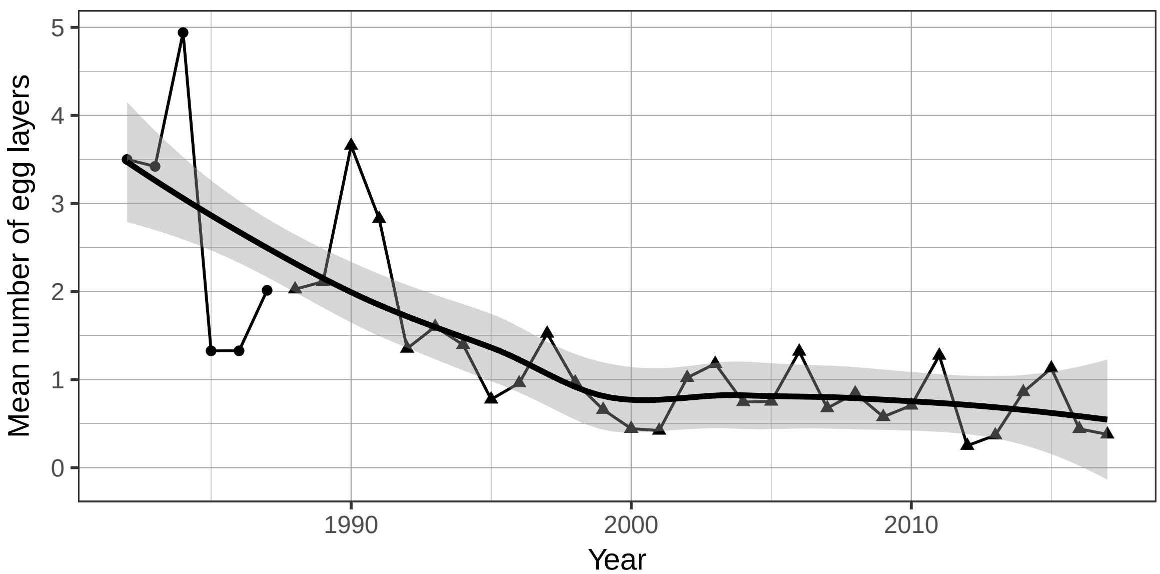

Figure 10. Time series of mean number of egg layers for Pacific herring from 1982 to 2017 in the Area 27 minor stock assessment region (SAR). The thick black line is a loess curve, and the shaded area is the 90% confidence interval. The spawn index has two distinct periods defined by the dominant survey method: surface surveys (1951–1987), and dive surveys (1988–2017).

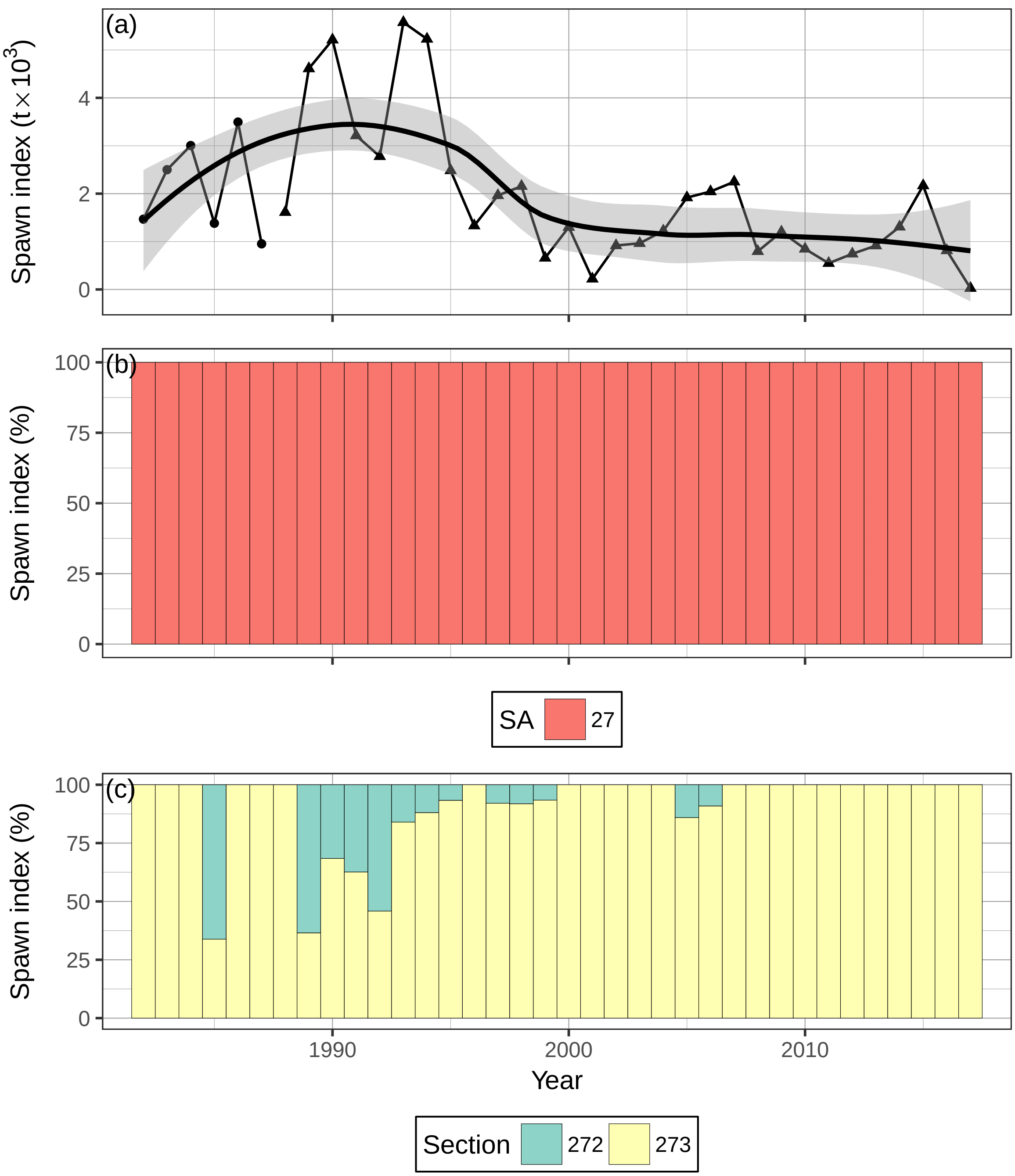

Figure 11. Time series of spawn index in thousands of metric tonnes ($t \times 10^3$) for Pacific herring from 1982 to 2017 in the Area 27 minor stock assessment region (SAR; a), as well as percent contributed by Statistical Area (SA), and Section (b, & c, respectively). The thick black line is a loess 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.

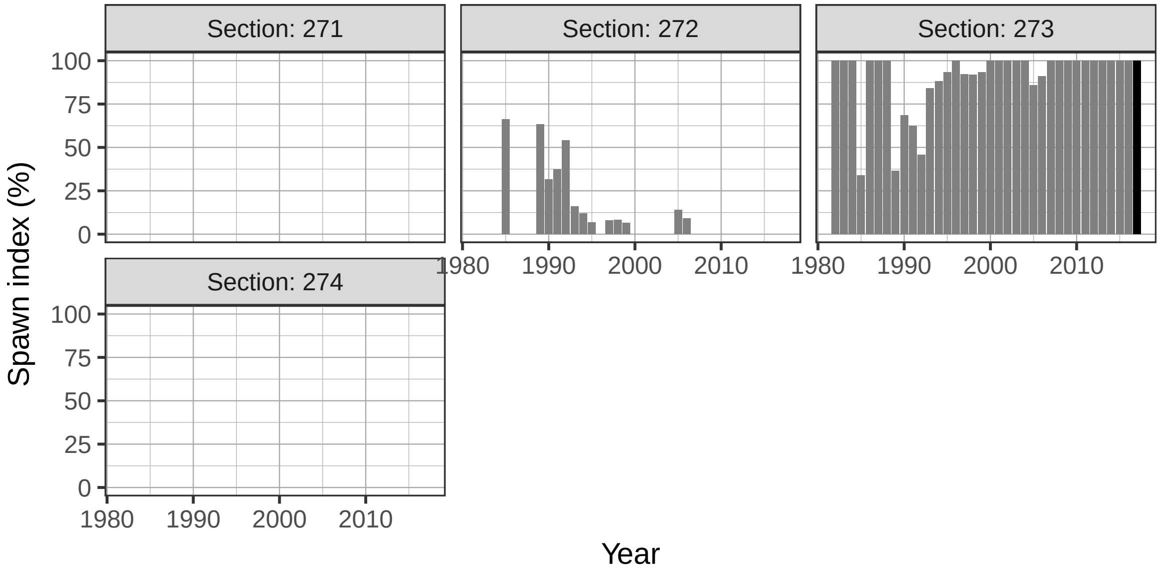

Figure 12. Time series of percent of spawn index by Section for Pacific herring from 1982 to 2017 in the Area 27 minor stock assessment region (SAR). The year 2017 has a darker bar to facilitate interpretation. The spawn index has two distinct periods defined by the dominant survey method: surface surveys (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.

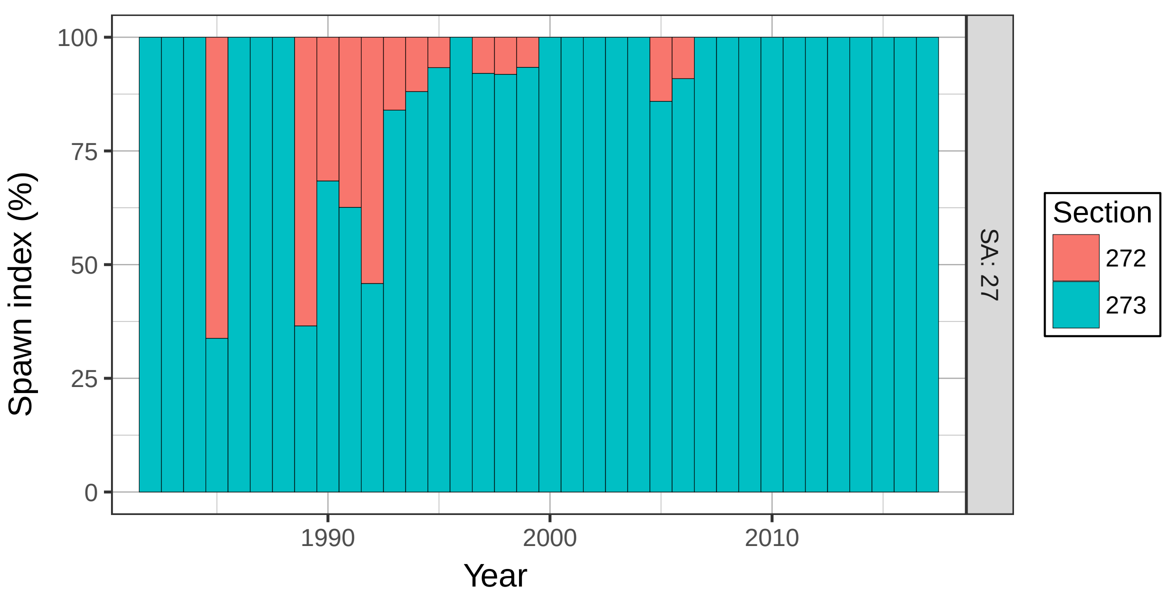

Figure 13. Time series of percent of spawn index by Statistical Area (SA) and Section for Pacific herring from 1982 to 2017 in the Area 27 minor stock assessment region (SAR). The spawn index has two distinct periods defined by the dominant survey method: surface surveys (1951–1987), and dive surveys (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.

References

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