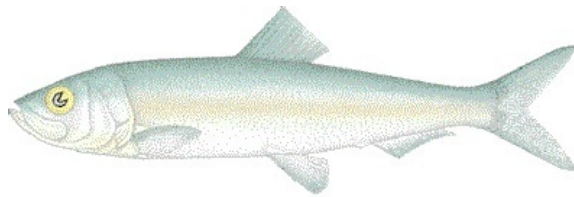# Pacific herring preliminary data summary for Prince Rupert District 2016

DFO Science*

June 16, 2017

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

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**Disclaimer**  This report contains preliminary data. Therefore, the data may differ from data used and presented in the final Pacific herring stock assessment for Prince Rupert District 2016.

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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 2016. 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 2016 (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 2016 refers to the 2015/2016 herring season.

# 2 Data collection programs

In 2016, 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 14th to March 27th, and the "Franciscan No.1" operated for a total of 18 days, from March 15th to April 2nd. 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. Five 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. Observations of spawning activity were detected from overflights, conducted by the local DFO Resource Manager. All three charter vessels were funded by DFO, through a contract to the Herring Conservation Research Society.

# 3 Catch and biological samples

There were commercial fishing opportunities for seine, gillnet, food and bait, and spawn on kelp (SOK) in 2016 in the Prince Rupert District major stock area. The total landed commercial catch of Pacific herring from all fisheries in 2016 in the Prince Rupert District major SAR was 2,426 t, which is 12.1% more than last year (Table 2 and Figure 3). In addition to annual catch variability, catch varies among statistical areas (Figure 4). The total harvested spawn on kelp (SOK) in 2016 in the Prince Rupert District major SAR was 27,430 lb, which is associated with an estimated spawning biomass of 228 t (Table 3). We use the following equation to convert SOK harvest to spawning biomass [ref?]

$$SB = SOK \cdot 0.00832 \tag{1}$$

where $SOK$ is SOK harvest in pounds, and $SB$ is spawning biomass in tonnes.

In 2016, 44 Pacific herring biological samples were collected and processed for the Prince Rupert District major SAR (Table 4, Table 5), and a total of 2,361 Pacific herring were aged in 2016. 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 27 locations in 2016 in the Prince Rupert District major SAR (Table 7, Figure 8). Spawn surveys are conducted to estimate the spawn length, width, number of 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 (1988–2016).

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 2016, Section 042 contributed the most to the spawn index (81%). 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:

- Majority of spawn surveyed in Kitkatla was on the south end of Porcher extending out into Freeman Pass. The spawn on the east-side of Gurd Island was smaller than what we have seen in the recent past.

- Spawning patterns in the Big Bay area were typical for the area (i.e., similar distribution of spawn to previous years).

- Warmer than usual water temperatures were reported ($\sim 8.2$°C), contributing to earlier larval hatch-out rates. This is similar to 2015 observations.

- Spawn length was below the long term average (since 1980). Spawn width was above average and consistent with results since 2000 onward. Spawn layers was below long-term average (since 1980), but very consistent since 2000.

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 fishery in 2016 in the Prince Rupert District major stock assessment region (SAR).

| Fishery | Use | Catch (t) |
|---------|-----|-----------|
| Gillnet | Roe | 1,380 |
| Seine | Food | 316 |
| Seine | Roe | 729 |

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 2006 to 2016 in the Prince Rupert District major stock assessment region (SAR).

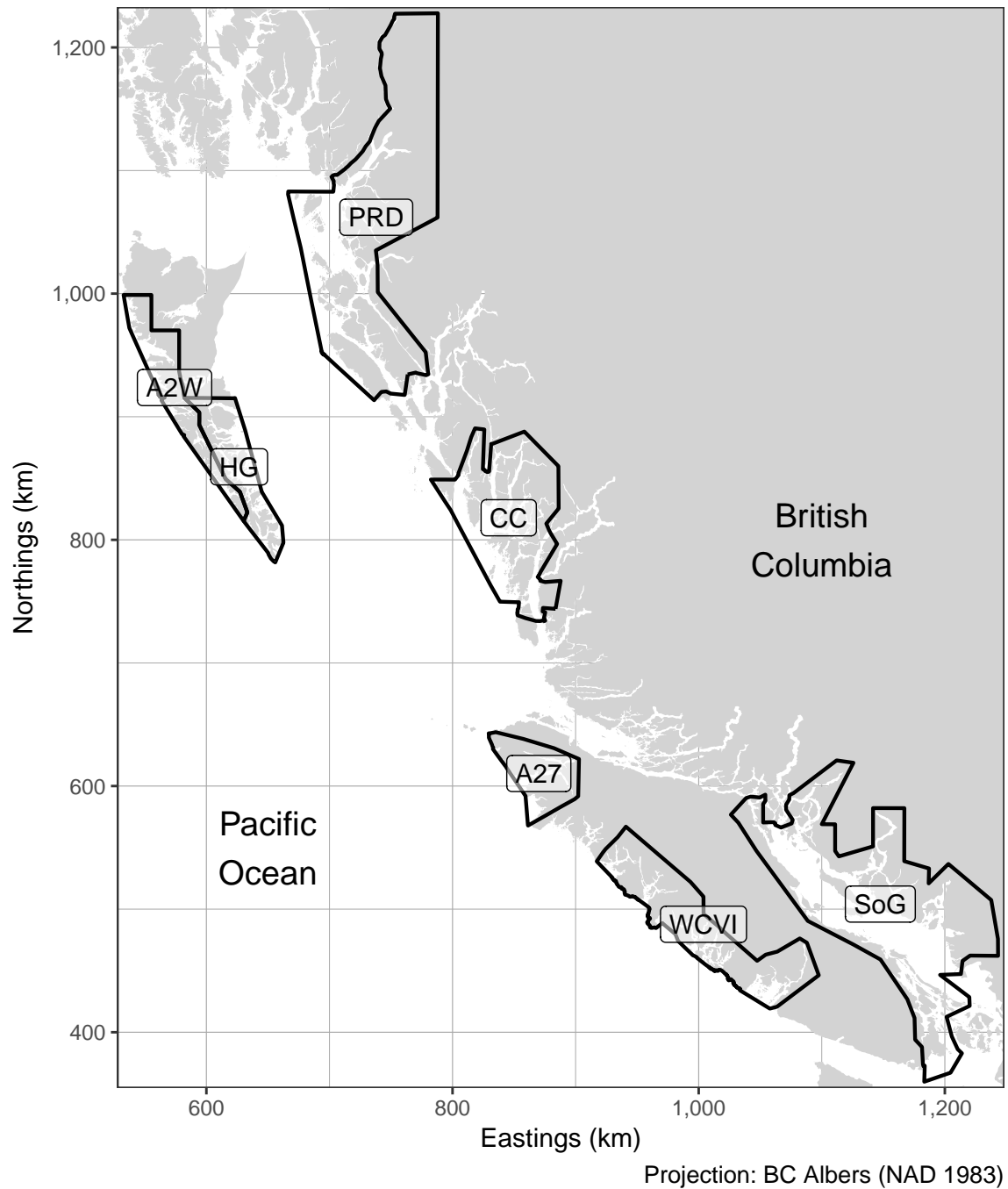| Year | Harvest (lb) | Spawning biomass (t) |
|------|--------------|----------------------|
| 2006 | 82,202 | 684 |
| 2007 | 111,762 | 930 |
| 2008 | 166,572 | 1,386 |
| 2009 | 158,198 | 1,316 |
| 2010 | 108,834 | 905 |
| 2011 | 123,626 | 1,028 |
| 2012 | 87,494 | 728 |
| 2013 | 72,895 | 606 |
| 2014 | 113,269 | 942 |
| 2015 | 84,066 | 699 |
| 2016 | 27,430 | 228 |

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). Units: kilometres (km). Also see Table 1.
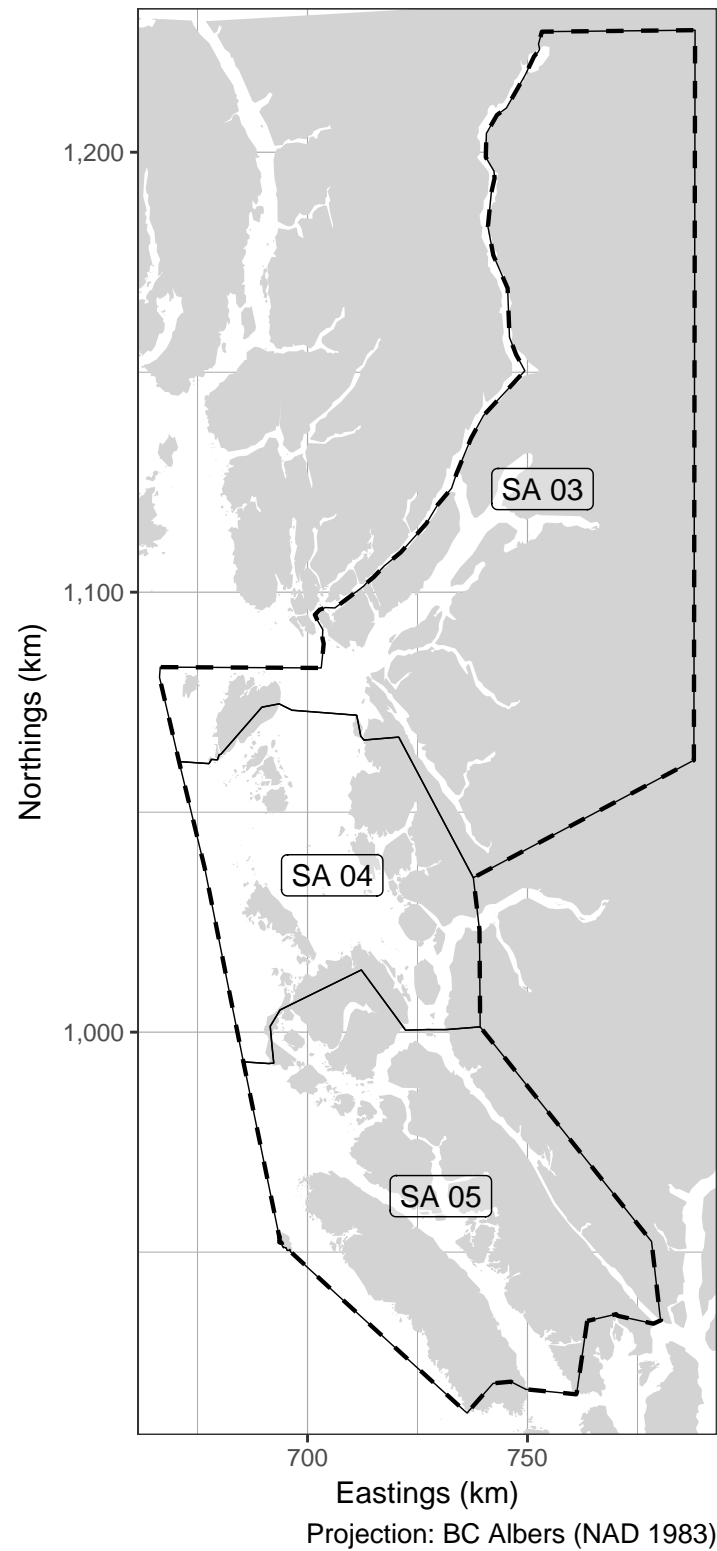
Figure 2. Boundaries for the Prince Rupert District major stock assessment region (SAR; thick dashed lines), and associated Statistical Areas (SA; thin solid lines). Units: kilometres (km).
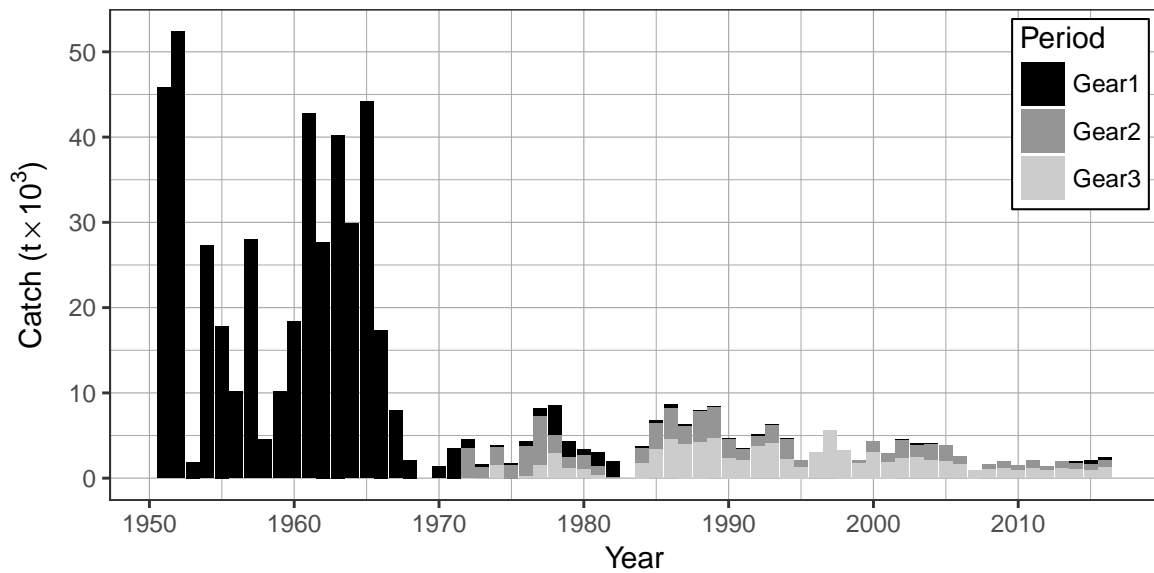
Figure 3. Time series of total landed catch in thousands of metric tonnes (t × 10³) of Pacific herring by gear type from 1951 to 2016 in the Prince Rupert District major stock assessment region (SAR). Legend: 'Gear1' represents the reduction, the food and bait, as well as the special use fishery; 'Gear2' represents the roe seine fishery; and 'Gear3' represents the roe gillnet fishery.
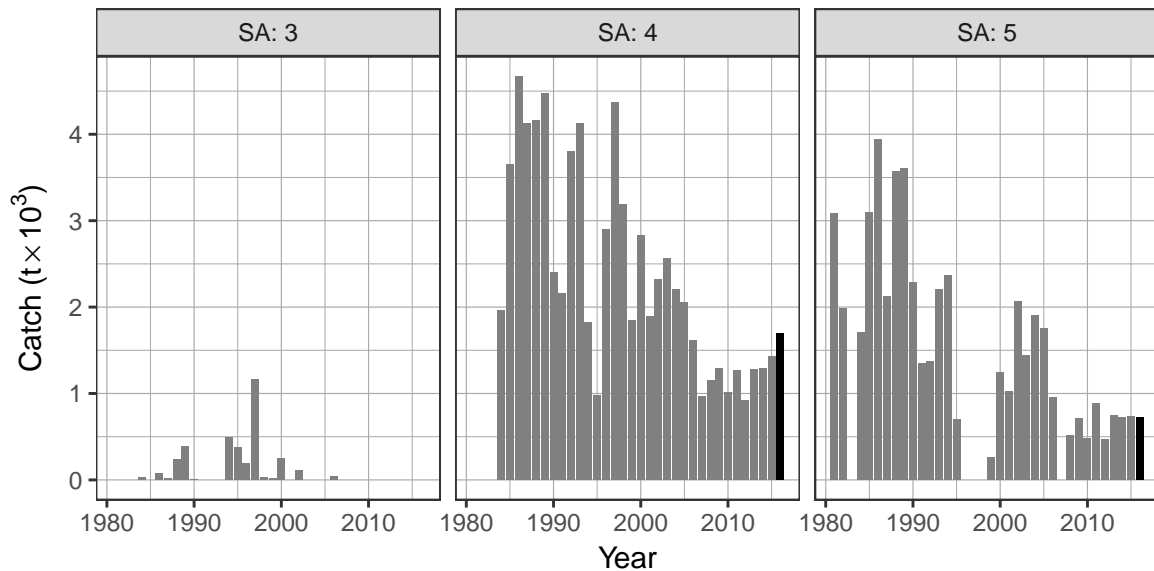
Figure 4. Time series of total landed catch in thousands of metric tonnes (t × 10³) of Pacific herring by statistical area (SA) from 1981 to 2016 in the Prince Rupert District major stock assessment region (SAR). The year 2016 has a darker bar to facilitate interpretation.

Table 4. Number of Pacific herring biological samples processed from 2006 to 2016 in the Prince Rupert District major stock assessment region (SAR). Each sample is approximately 100 fish.

| Year | Number of samples | | |
|------|------------|------|-------|
|      | Commercial | Test | Total |
| 2006 | 11 | 18 | 29 |
| 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 |

Table 5. Number and type of Pacific herring biological samples processed in 2016 in the Prince Rupert District major stock assessment region (SAR). Each sample is approximately 100 fish.

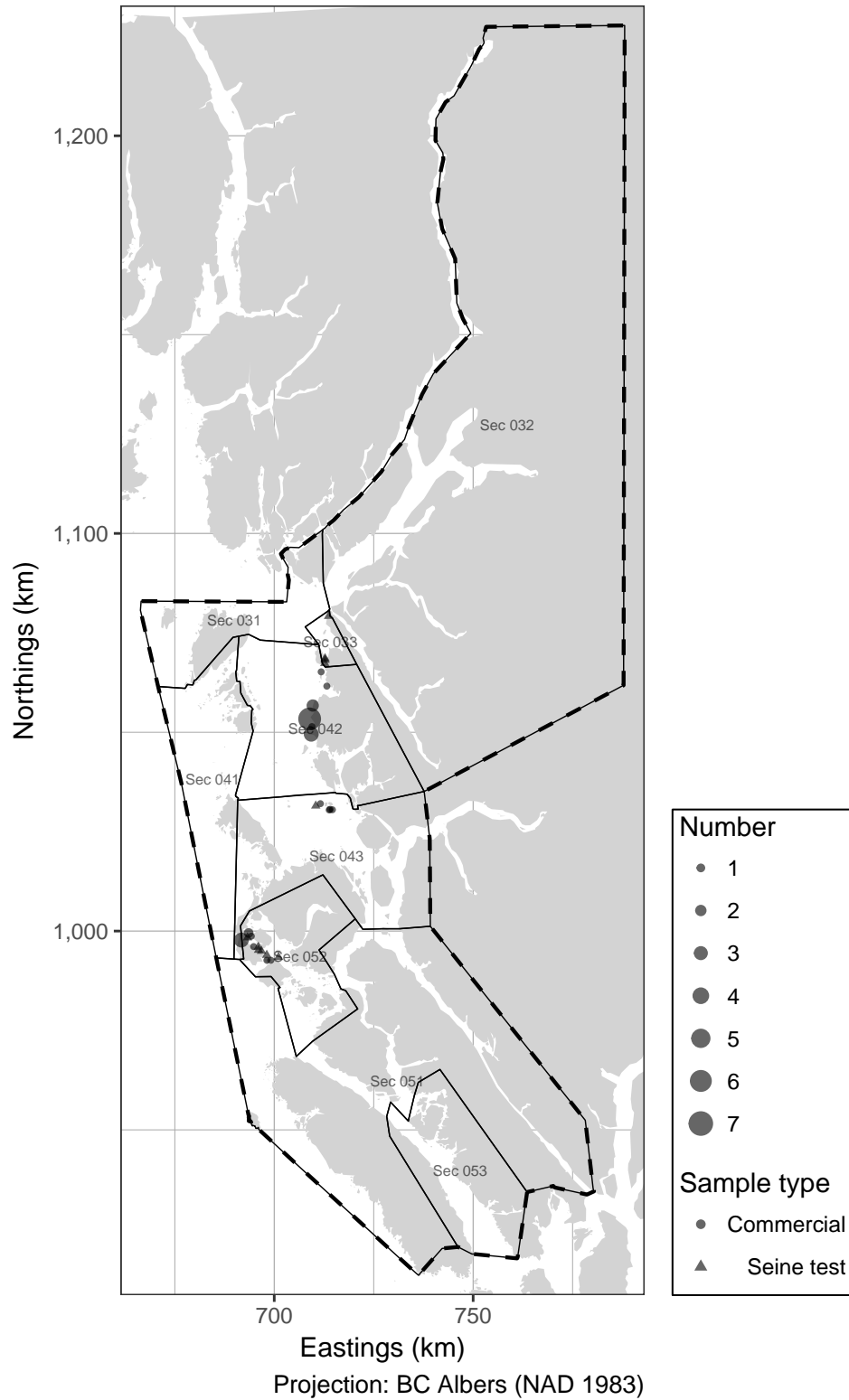| Type | Gear | Use | Number of samples |
|------|------|-----|-------------------|
| Commercial | Gillnet | Roe Fishery | 17 |
| Commercial | Seine | Food Fishery | 4 |
| Commercial | Seine | Other | 3 |
| Commercial | Seine | Roe Fishery | 9 |
| Test | Seine | Test Fishery | 11 |

Figure 5. Location and type of Pacific herring biological samples collected in 2016 in the Prince Rupert District major stock assessment region (SAR; thick dashed lines), and associated Sections (Sec; thin solid lines). Units: kilometres (km).
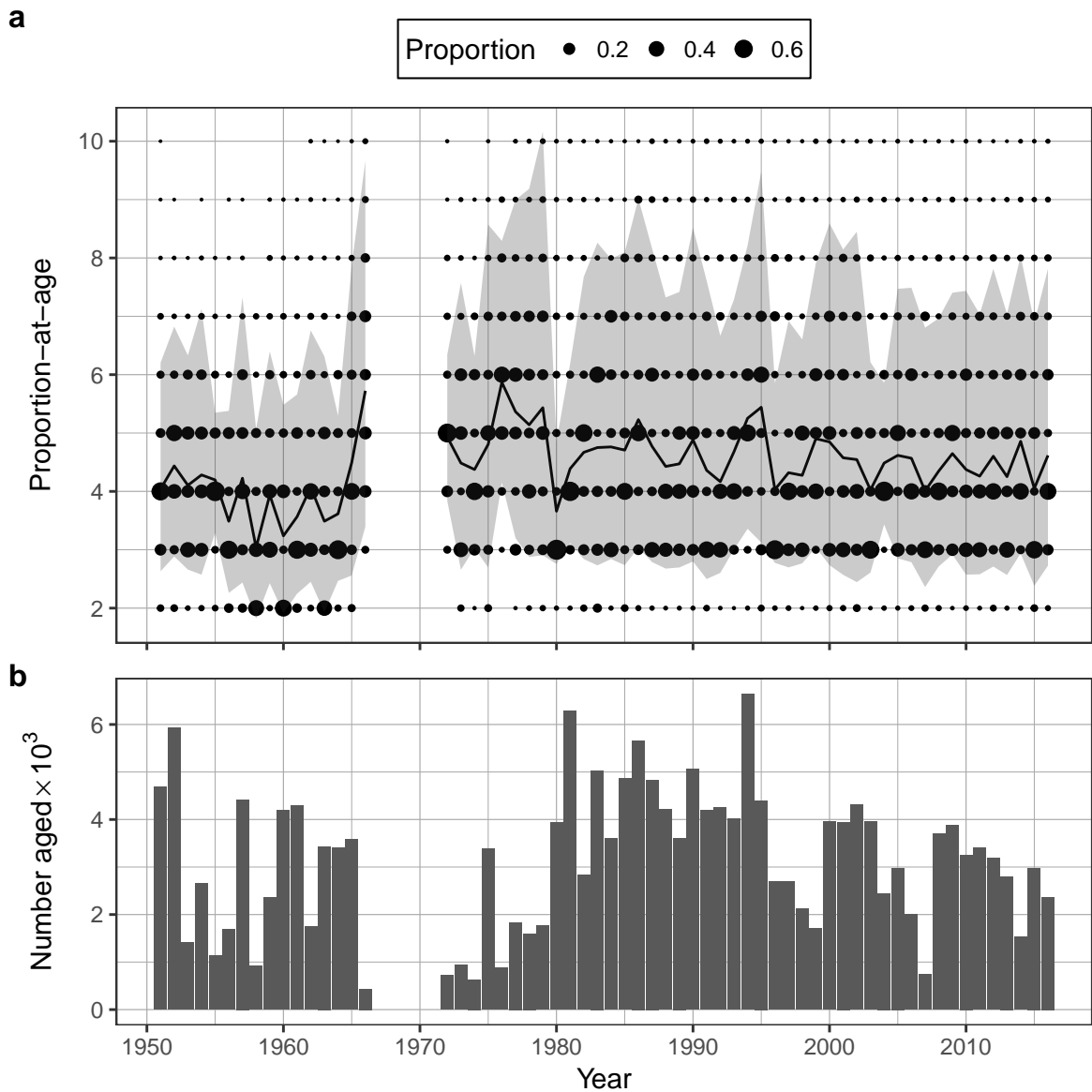
Figure 6. Time series of observed proportion-at-age (a) and number aged (b) of Pacific herring from 1951 to 2016 in the Prince Rupert District major stock assessment region (SAR). The black line is the mean age, and the shaded area is the approximate 90% distribution. Biological summaries only include 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.

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Table 6. Observed proportion-at-age for Pacific herring from 2006 to 2016 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 |
| 2006 | 0.014 | 0.163 | 0.443 | 0.088 | 0.230 | 0.039 | 0.016 | 0.004 | 0.001 |
| 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 |
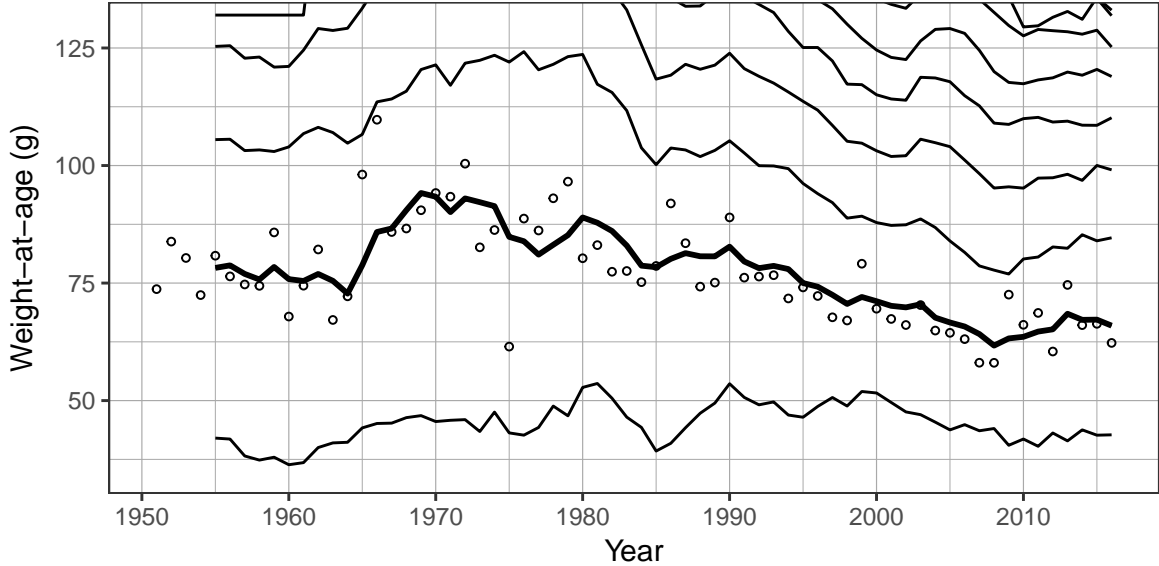
Figure 7. Time series of weight-at-age in grams (g) for age-3 (circles) and 5-year running mean weight-at-age (lines) for Pacific herring from 1951 to 2016 in the Prince Rupert District major stock assessment region (SAR). Lines show 5-year running means for age-2 to age-10 herring (incrementing higher 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 2016 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 | 49 |
| 03 | 033 | 213 | Cunningham Pass | 6 |
| 03 | 033 | 215 | Finlayson Is E | 5 |
| 03 | 033 | 217 | Grassy Pt | 28 |
| 03 | 033 | 218 | Port Simpson | 23 |
| 03 | 033 | 1488 | Flewin Pt | 20 |
| 04 | 042 | 239 | Finlayson Is W | 525 |
| 04 | 042 | 260 | Big Bay | 883 |
| 04 | 042 | 261 | Swamp Is | 3,551 |
| 04 | 042 | 262 | Burnt Cliff Is | 2,336 |
| 04 | 042 | 263 | Tree Bluff | 4,858 |
| 04 | 042 | 265 | Belletti Pt | 1,062 |
| 04 | 042 | 266 | Pearl Hrbr | 14 |
| 04 | 042 | 276 | Duncan Bay | 845 |
| 04 | 042 | 279 | Tugwell Is | 713 |
| 04 | 042 | 281 | Observation Pt | 82 |
| 04 | 042 | 1380 | Mist Is | 76 |
| 04 | 042 | 1448 | Reeks Pt | 371 |
| 04 | 042 | 1668 | Flat Top Islets | 22 |
| 05 | 051 | 301 | Banks Is | NA |
| 05 | 052 | 336 | Cape George | 892 |
| 05 | 052 | 338 | Freeman Pass | 572 |
| 05 | 052 | 344 | Porcher Pen | 1,613 |
| 05 | 052 | 348 | Clamshell Is | 201 |
| 05 | 052 | 350 | Absalom Is | 9 |
| 05 | 052 | 354 | Gurd Is | 127 |
| 05 | 052 | 356 | Wilcox Grp | 103 |
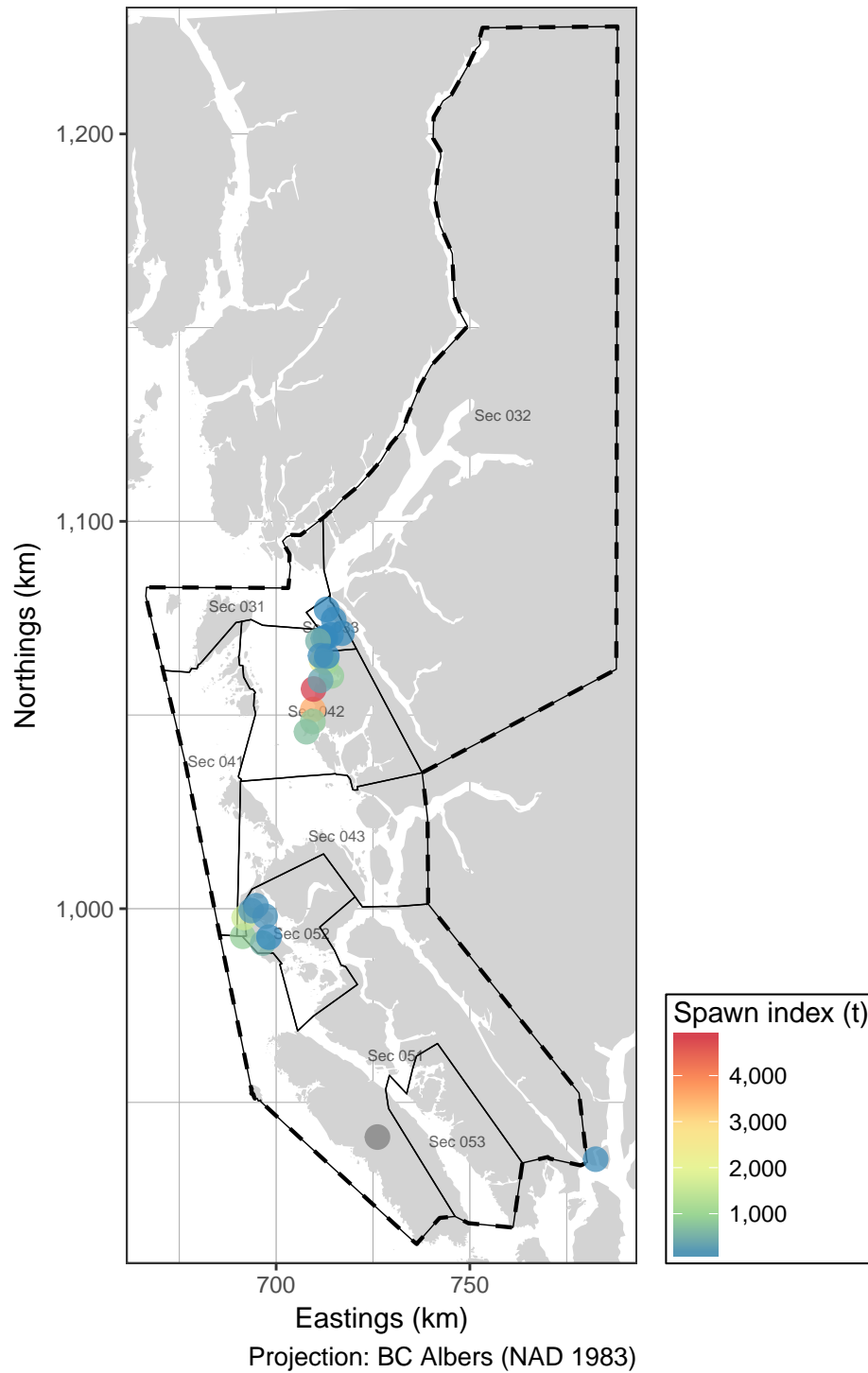
Figure 8. Location of Pacific herring spawning locations in 2016 in the Prince Rupert District major stock assessment region (SAR; thick dashed lines), and associated Sections (Sec; thin solid lines). The 'spawn index' represents the raw survey data only, and is not scaled by the spawn survey scaling parameter, $q$. Missing spawn index values (grey circles) indicate incomplete spawn surveys. Units: kilometres (km), and metric tonnes (t).
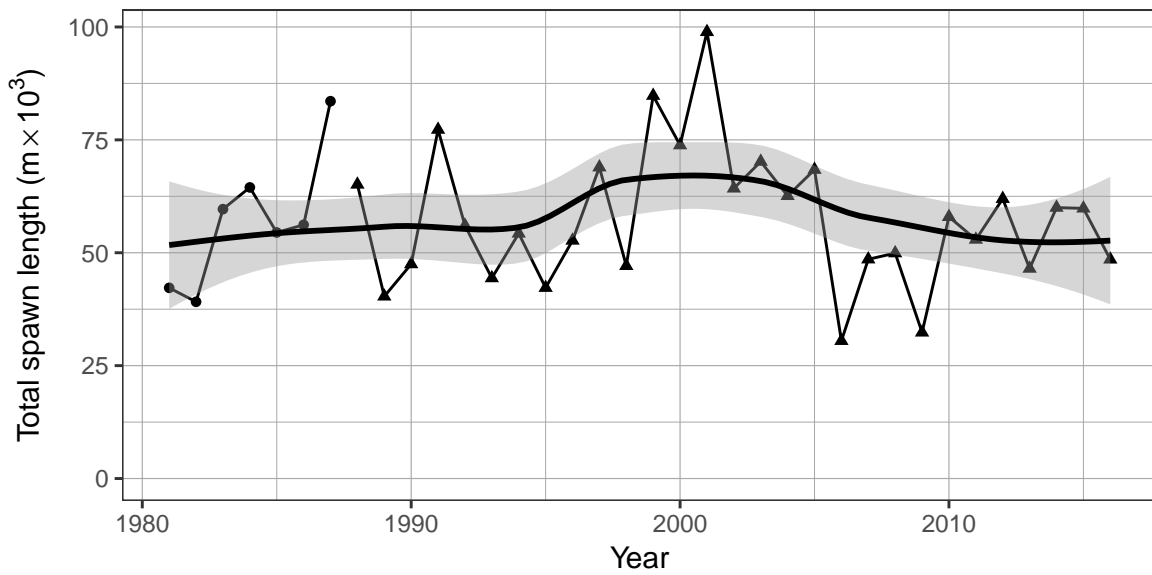
Figure 9. Time series of total spawn length in thousands of metres (m × $10^3$) for Pacific herring from 1981 to 2016 in the Prince Rupert District major stock assessment region (SAR). The thick black line is a loess curve, and the shaded area is the 90% confidence interval. The spawn index has two distinct periods defined by the dominant survey method: surface surveys (1951–1987), and dive surveys (1988–2016).
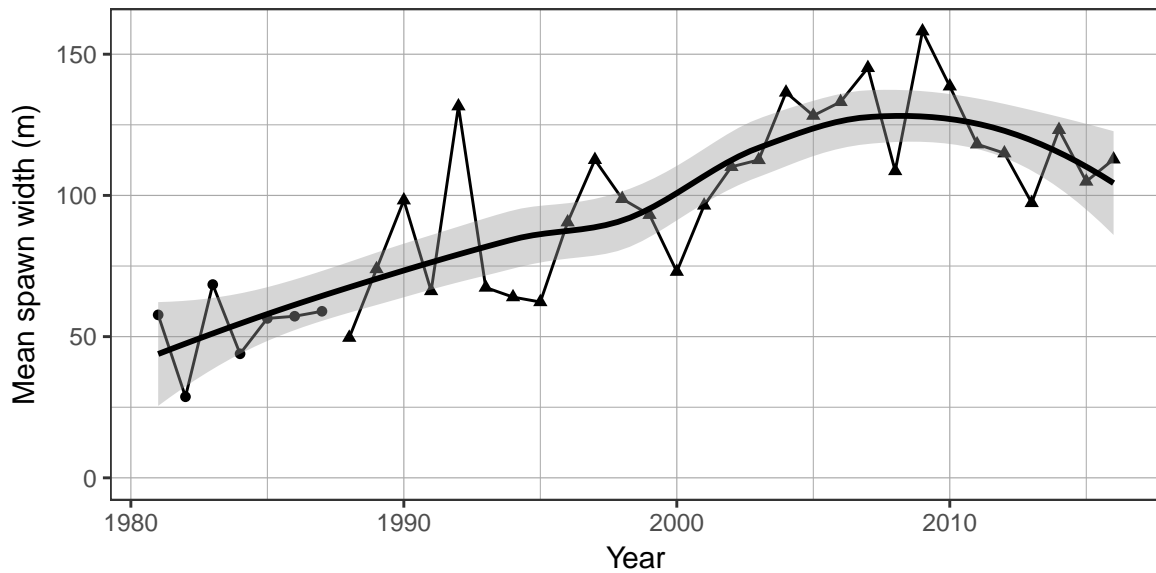


Figure 10. Time series of mean spawn width in metres (m) for Pacific herring from 1981 to 2016 in the Prince Rupert District major stock assessment region (SAR). The thick black line is a loess curve, and the shaded area is the 90% confidence interval. The spawn index has two distinct periods defined by the dominant survey method: surface surveys (1951–1987), and dive surveys (1988–2016).
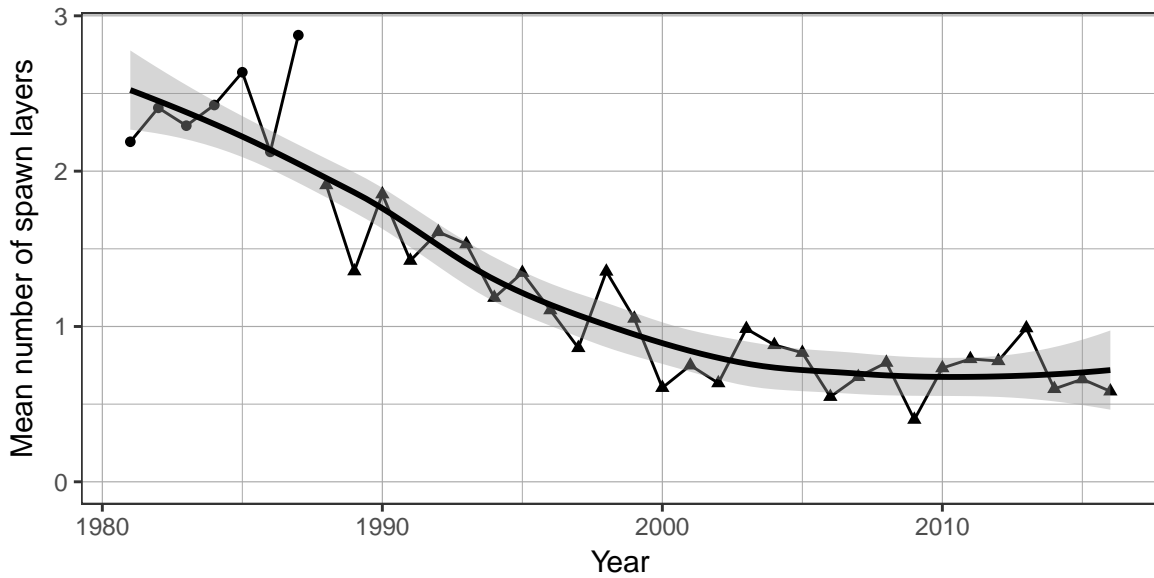
Figure 11. Time series of mean number of spawn layers for Pacific herring from 1981 to 2016 in the Prince Rupert District major stock assessment region (SAR). The thick black line is a loess curve, and the shaded area is the 90% confidence interval. The spawn index has two distinct periods defined by the dominant survey method: surface surveys (1951–1987), and dive surveys (1988–2016).

Table 8. Summary of spawn survey data from 2006 to 2016 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 (1988–2016). 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).

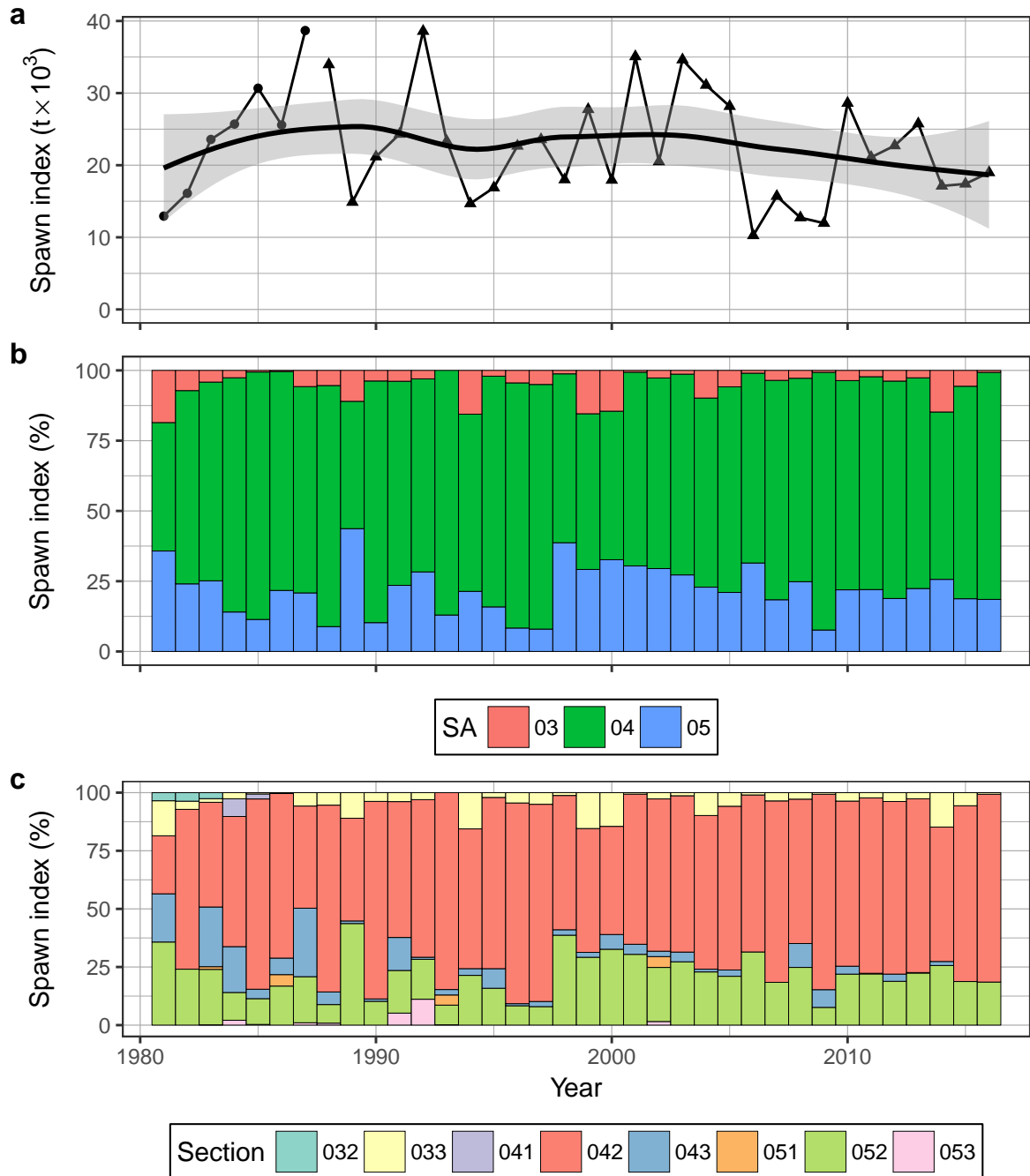| Year | Total length (m) | Mean width (m) | Mean number of layers | Spawn index (t) |
|------|------------------|----------------|-----------------------|-----------------|
| 2006 | 30,500 | 133 | 0.547 | 10,255 |
| 2007 | 48,560 | 145 | 0.676 | 15,700 |
| 2008 | 49,910 | 109 | 0.767 | 12,728 |
| 2009 | 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 |

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Figure 12. Time series of spawn index in thousands of metric tonnes $(t \times 10^3)$ for Pacific herring from 1981 to 2016 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 (1988–2016). The 'spawn index' represents the raw survey data only, and is not scaled by the spawn survey scaling parameter, $q$.
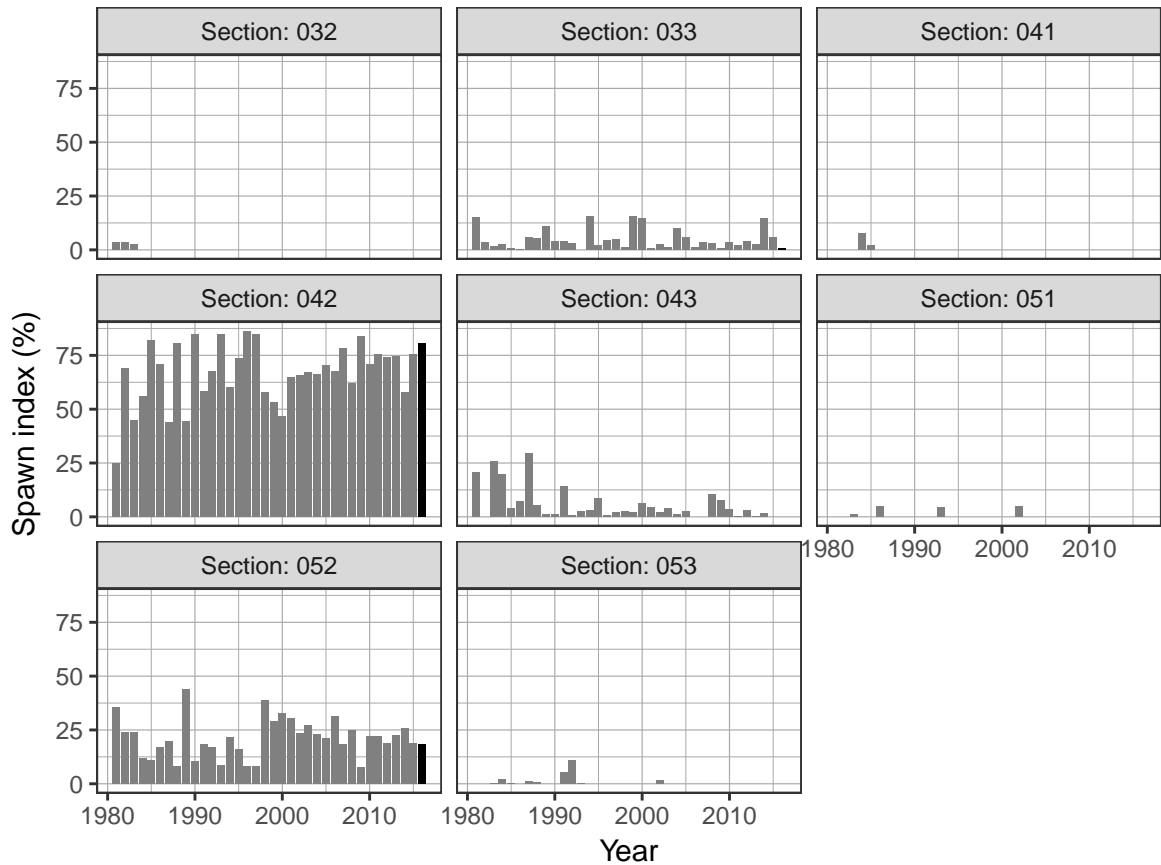
Figure 13. Time series of percent of spawn index by Section for Pacific herring from 1981 to 2016 in the Prince Rupert District major stock assessment region (SAR). The year 2016 has a darker bar to facilitate interpretation. The spawn index has two distinct periods defined by the dominant survey method: surface surveys (1951–1987), and dive surveys (1988–2016). The 'spawn index' represents the raw survey data only, and is not scaled by the spawn survey scaling parameter, $q$.
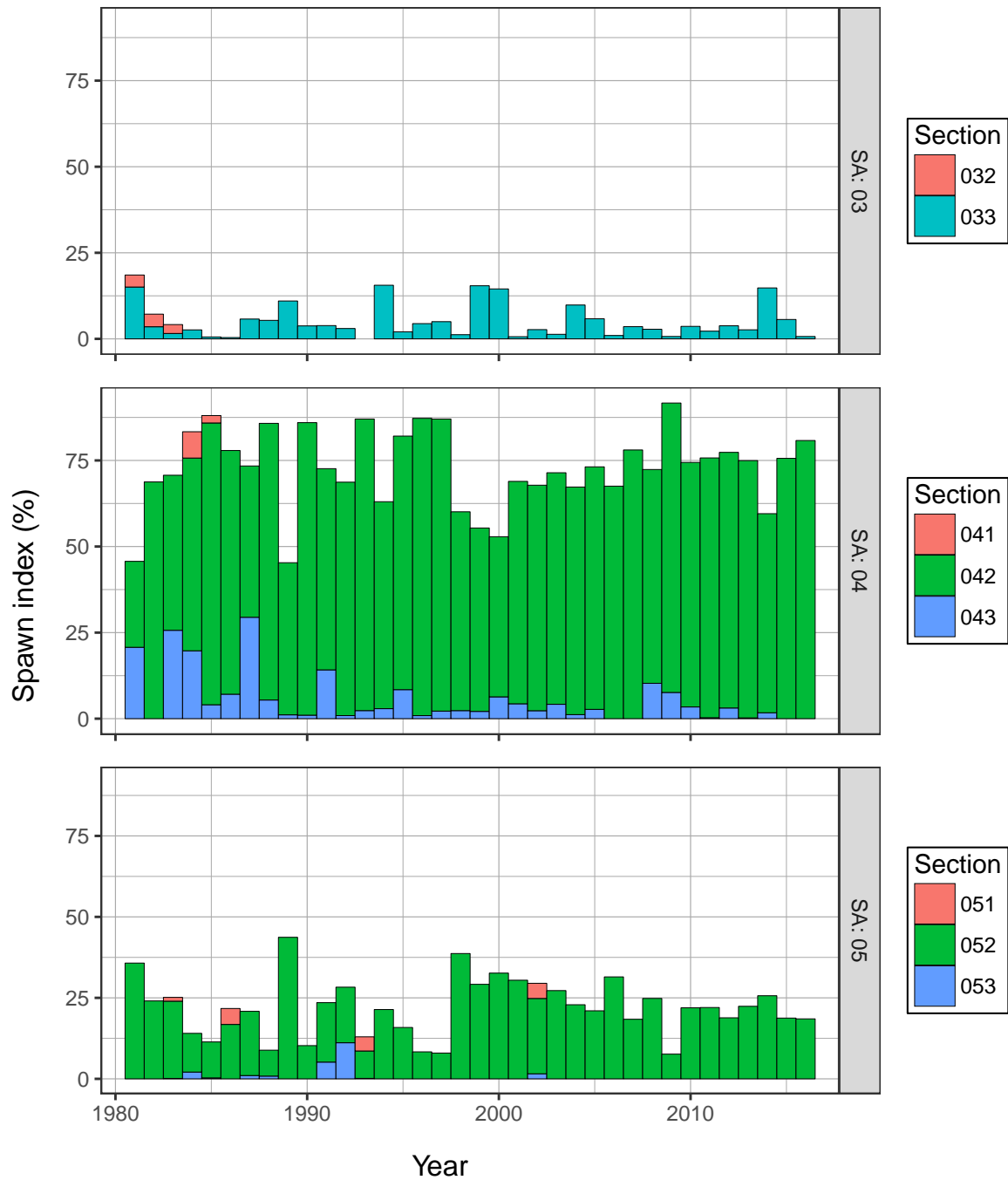
Figure 14. Time series of percent of spawn index by Statistical Area (SA) and Section for Pacific herring from 1981 to 2016 in the Prince Rupert District major stock assessment region (SAR). The spawn index has two distinct periods defined by the dominant survey method: surface surveys (1951–1987), and dive surveys (1988–2016). The 'spawn index' represents the raw survey data only, and is not scaled by the spawn survey scaling parameter, $q$.