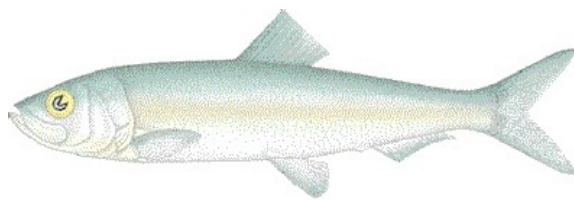


Pacific herring preliminary data summary for Strait of Georgia 2017

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 Strait of Georgia 2017.

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 Strait of Georgia 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

Biological samples were collected by the seine charter vessel “Denman Isle” for 30 days from February 20th to March 21st. Four additional Industry test vessels collected biological samples between February 22nd to March 16th. The primary purpose of the test charter vessel was to collect biological samples from main bodies of herring in Statistical Areas 14 and 17, identified from soundings.

Herring spawn locations were primarily identified with fixed-wing overflights conducted by DFO Resource Management Area staff. Twenty-four flights were conducted this season, February–April. Three dive charter vessels operated in the SOG:

- The charter vessel “Viking Spirit” surveyed 21 days from March 12th to April 4th,
- The charter vessel “Ocean Cloud” surveyed 12 days from March 13th to March 24th,
- The “Seaveyor” surveyed 2 days in the Strait of Georgia.

All three dive vessels and the seine charter vessel “Denman Isle” were funded by DFO, through a contract to the Herring Conservation Research Society (HCRS). Additional sampling and sounding efforts conducted through the Industry Test Program were funded by the Herring Industry.

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 Strait of Georgia major SAR is shown in Table 3; we also calculate the estimated spawning biomass associated with SOK harvest.

In 2017, 148 Pacific herring biological samples were collected and processed for the Strait of Georgia major SAR (Table 4, Table 5), and a total of 8,326 Pacific herring were aged in 2017. The locations in which the biological samples were collected are presented in Figure 4. Biological samples collected using seine gear shows that there is considerable variability in fish weight by year and sample type (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 40 individual locations in 2017 in the Strait of Georgia 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 143 contributed the most to the spawn index (51%). As with Sections, some Groups 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:

- Majority of spawn occurred in Area 14 (98%) with the remaining spawn occurring in Area 17.
- Overall spawn length was average (130 km), width was above average (similar to 2016), and egg layers was below average (0.9).
- Reported spawns in Squamish/Woodfibre (four spawns through January to March), False Creek, and Defence Island (Howe Sound). These spawns were not surveyed, and are recorded as incomplete spawn records.
- The total catch (25,279 t) is the largest removal in the roe herring fishery era.

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 Strait of Georgia 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 | 7,260 |
| Gear2 | 8,796 |
| Gear3 | 9,223 |

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 Strait of Georgia major stock assessment region (SAR). 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 |

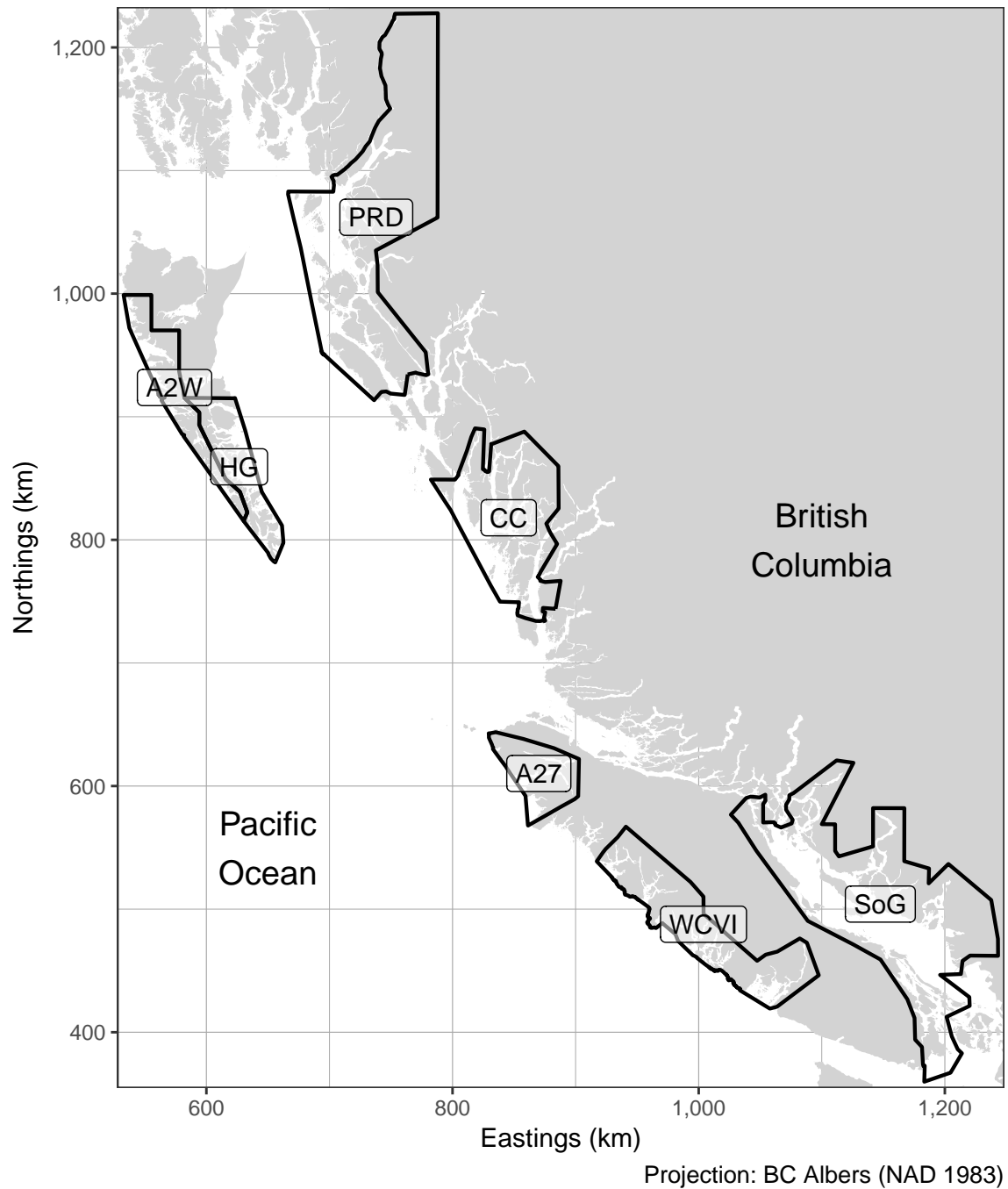


Figure 1. Boundaries for the Pacific herring stock assessment regions (SARs) in British Columbia: there are 5 major SARs (HG, PRD, CC, SoG, and WCVI), and 2 minor SARs (A27 and A2W; Table 1). Units: kilometres (km).

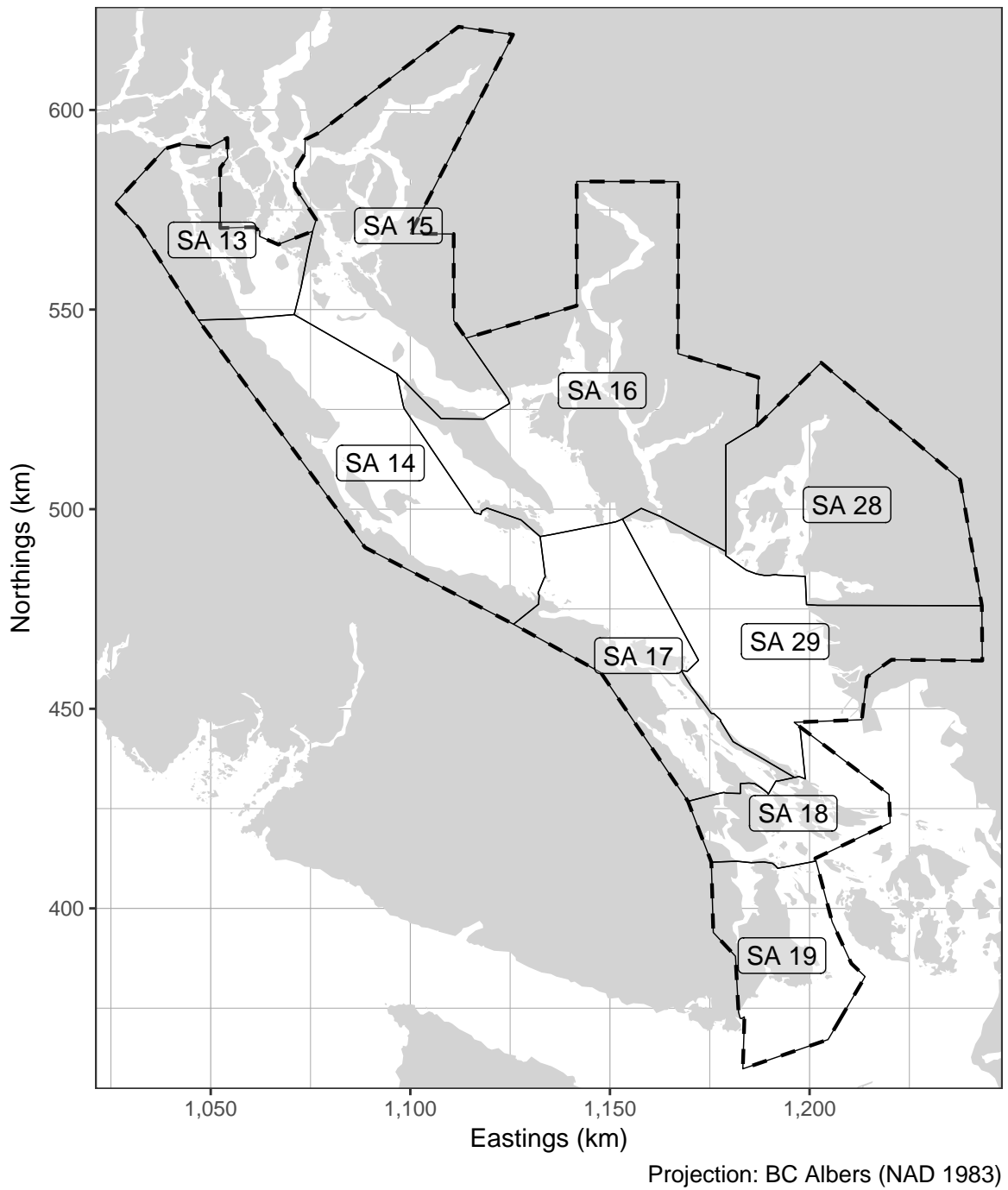


Figure 2. Boundaries for the Strait of Georgia major stock assessment region (SAR; thick dashed lines), and associated Statistical Areas (SA; thin solid lines). Units: kilometres (km).

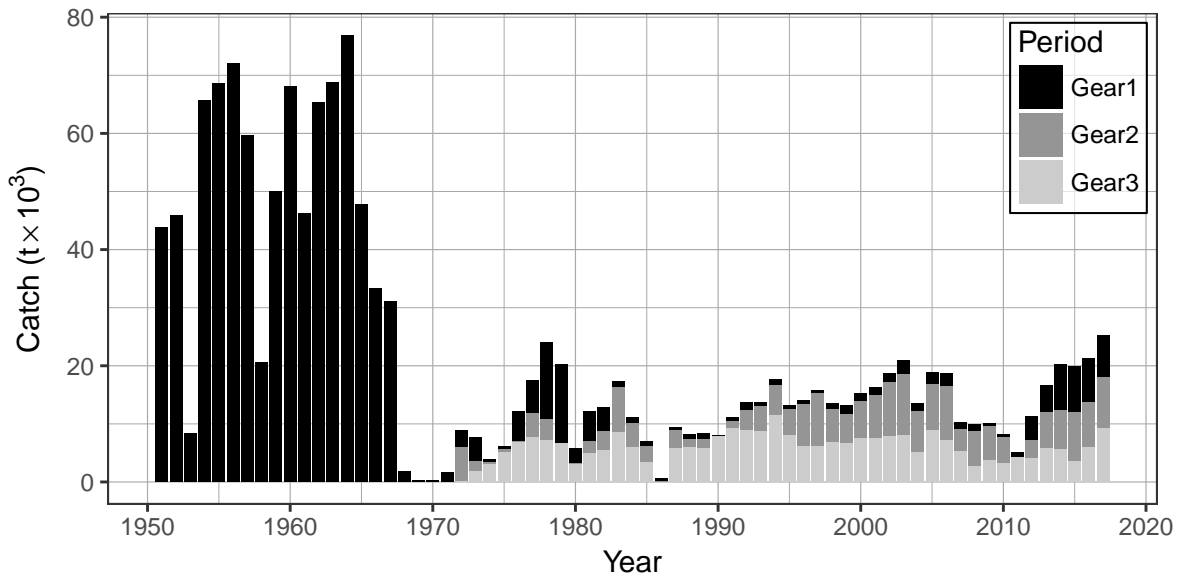


Figure 3. Time series of total landed catch in thousands of metric tonnes ($t \times 10^3$) of Pacific herring by gear type from 1951 to 2017 in the Strait of Georgia major stock assessment region (SAR). Legend: ‘Gear1’ represents the reduction, the food and bait, as well as the special use fishery;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

| Year | Number of samples | | |
|------|-------------------|------|-------|
| | Commercial | Test | Total |
| 2007 | 79 | 40 | 119 |
| 2008 | 74 | 24 | 98 |
| 2009 | 43 | 28 | 71 |
| 2010 | 47 | 37 | 84 |
| 2011 | 48 | 60 | 108 |
| 2012 | 102 | 42 | 144 |
| 2013 | 97 | 25 | 122 |
| 2014 | 82 | 11 | 93 |
| 2015 | 120 | 38 | 158 |
| 2016 | 123 | 38 | 161 |
| 2017 | 121 | 27 | 148 |

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

| Type | Gear | Use | Number of samples |
|------------|---------|--------------|-------------------|
| Commercial | Gillnet | Roe Fishery | 45 |
| Commercial | Seine | Bait Fishery | 11 |
| Commercial | Seine | Food Fishery | 39 |
| Commercial | Seine | Roe Fishery | 26 |
| Test | Seine | Test Fishery | 27 |

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

| Year | Proportion-at-age | | | | | | | | |
|------|-------------------|-------|-------|-------|-------|-------|-------|-------|-------|
| | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| 2007 | 0.024 | 0.484 | 0.275 | 0.122 | 0.057 | 0.031 | 0.007 | 0.002 | 0.000 |
| 2008 | 0.066 | 0.113 | 0.608 | 0.139 | 0.047 | 0.018 | 0.007 | 0.001 | 0.000 |
| 2009 | 0.005 | 0.672 | 0.144 | 0.123 | 0.037 | 0.012 | 0.005 | 0.002 | 0.000 |
| 2010 | 0.139 | 0.044 | 0.688 | 0.053 | 0.055 | 0.013 | 0.005 | 0.002 | 0.001 |
| 2011 | 0.096 | 0.610 | 0.101 | 0.164 | 0.016 | 0.009 | 0.003 | 0.001 | 0.000 |
| 2012 | 0.034 | 0.424 | 0.442 | 0.039 | 0.055 | 0.005 | 0.002 | 0.000 | 0.000 |
| 2013 | 0.124 | 0.304 | 0.299 | 0.230 | 0.018 | 0.023 | 0.002 | 0.000 | 0.000 |
| 2014 | 0.046 | 0.480 | 0.181 | 0.153 | 0.117 | 0.010 | 0.010 | 0.001 | 0.000 |
| 2015 | 0.103 | 0.374 | 0.362 | 0.088 | 0.046 | 0.023 | 0.002 | 0.001 | 0.000 |
| 2016 | 0.153 | 0.267 | 0.334 | 0.178 | 0.040 | 0.016 | 0.009 | 0.001 | 0.001 |
| 2017 | 0.100 | 0.304 | 0.267 | 0.215 | 0.089 | 0.018 | 0.006 | 0.002 | 0.000 |

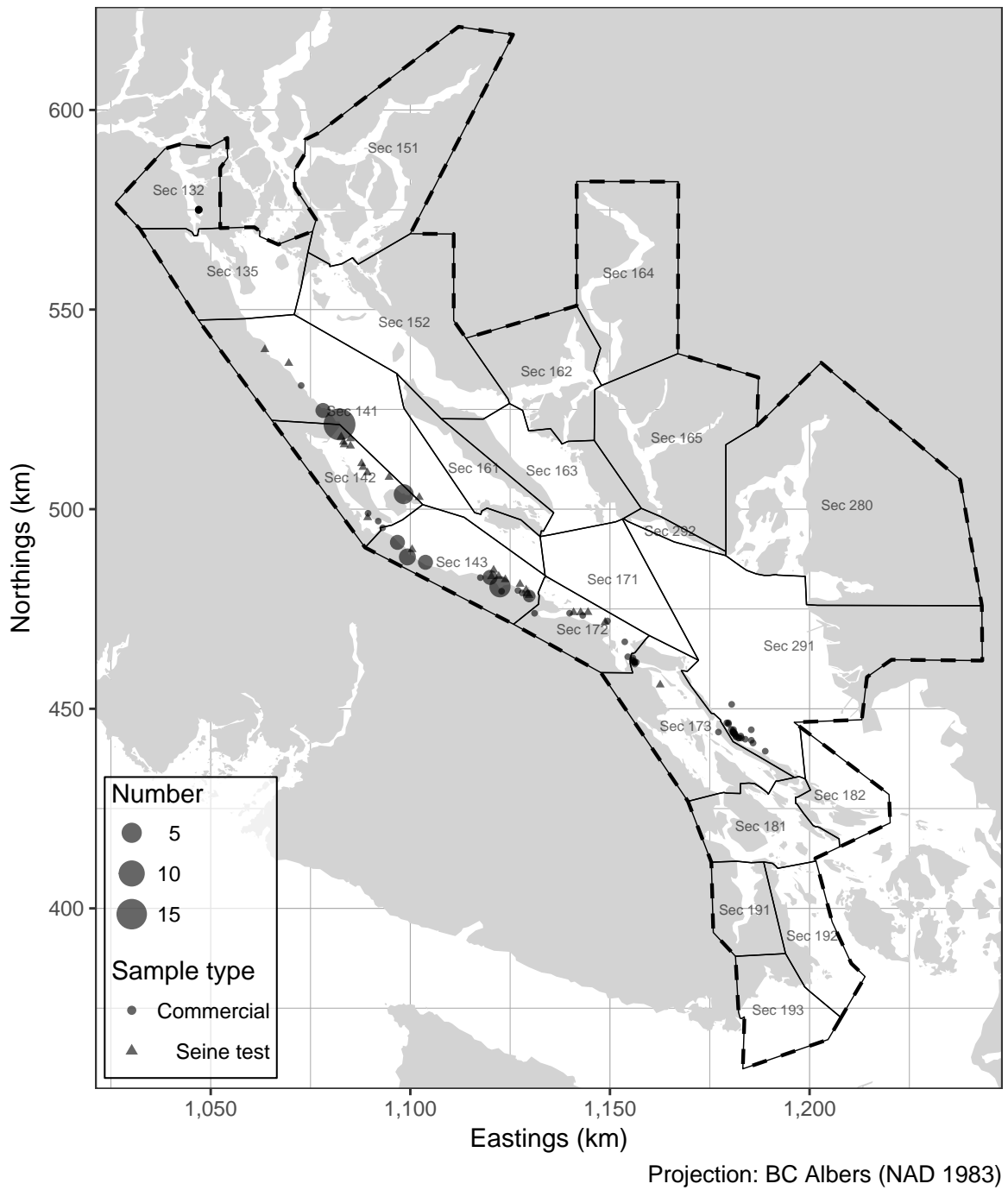


Figure 4. Location and type of Pacific herring biological samples collected in 2017 in the Strait of Georgia major stock assessment region (SAR; thick dashed lines), and associated Sections (Sec; thin solid lines). Units: kilometres (km).

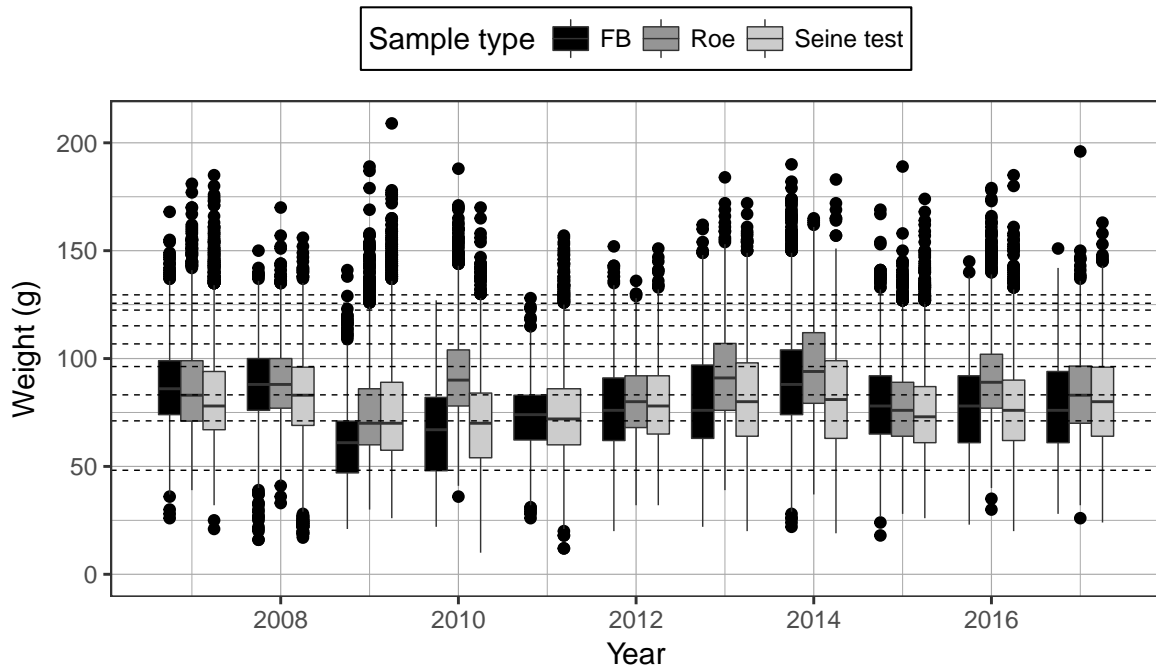


Figure 5. Time series of weight in grams (g) of Pacific herring by sample type from 2007 to 2017 in the Strait of Georgia major stock assessment region (SAR). The outer edges of the boxes indicate the 25th and 75th percentiles, and the middle lines indicate the 50th percentiles (i.e., medians). The whiskers extend to $1.5 \times \text{IQR}$, where IQR is the distance between the 25th and 75th percentiles, and dots indicate outliers. Horizontal dashed lines indicate the mean weight-at-age for age-2 (lowest line) to age-10 (incrementing higher from age-2) fish. 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. Legend: ‘FB’ is food and bait.

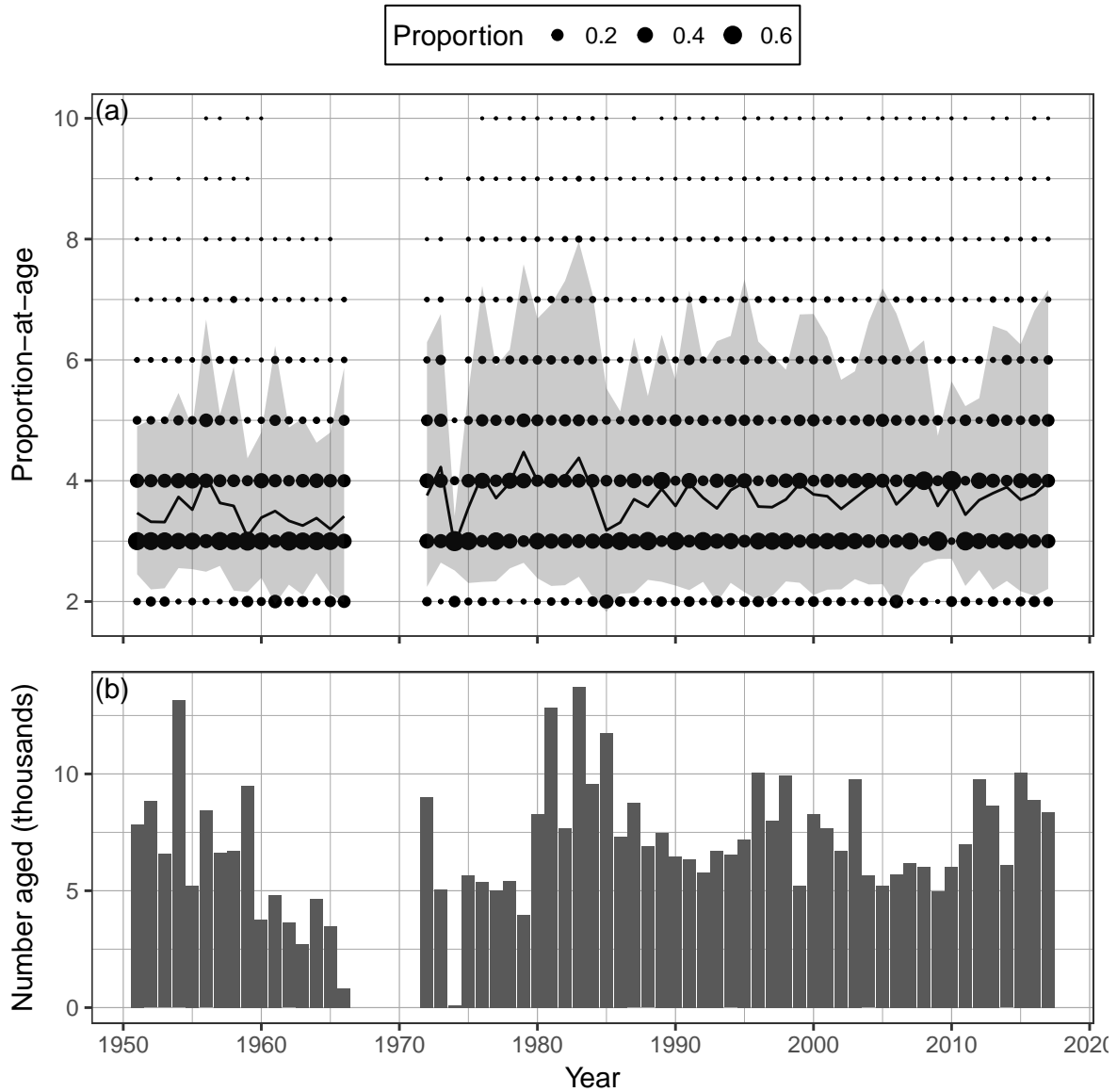


Figure 6. Time series of observed proportion-at-age (a) and number aged in thousands (b) of Pacific herring from 1951 to 2017 in the Strait of Georgia major stock assessment region (SAR). The black line is the mean age, and the shaded area is the approximate 90% distribution. Biological summaries only 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.

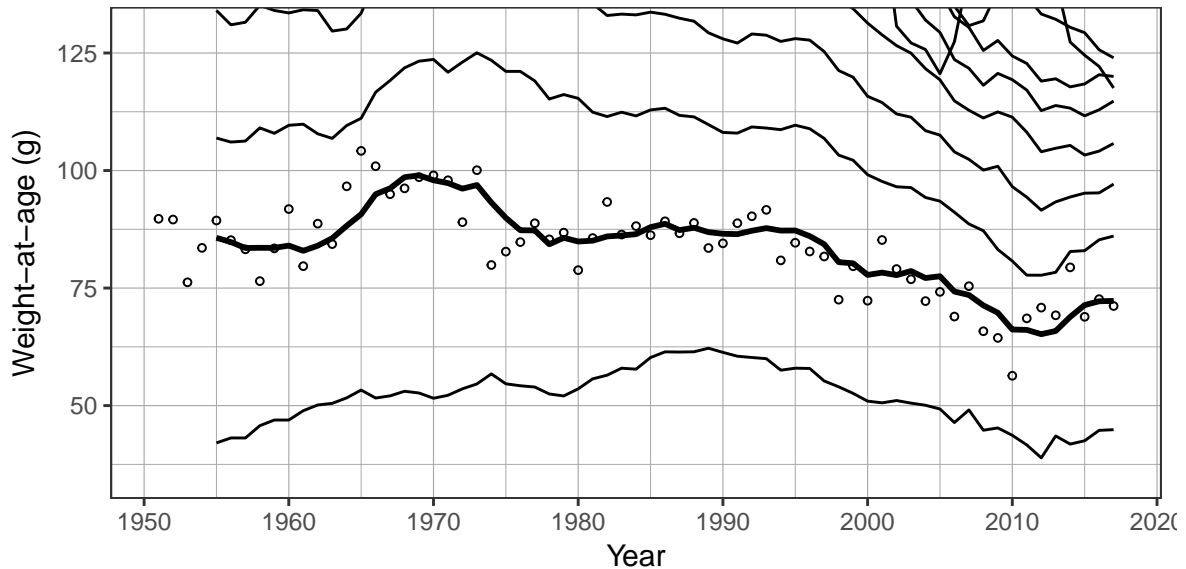


Figure 7. Time series of weight-at-age in grams (g) for age-3 (circles) and 5-year running mean weight-at-age (lines) for Pacific herring from 1951 to 2017 in the Strait of Georgia major stock assessment region (SAR). Lines show 5-year running means for age-2 to age-10 herring (incrementing higher from 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 Strait of Georgia 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) |
|------------------|---------|---------------|---------------------|-----------------|
| 14 | 141 | 815 | Kye Bay | 4,327 |
| 14 | 141 | 1627 | Kitty Coleman Beach | 8,562 |
| 14 | 141 | 1854 | Little Rvr | 2,850 |
| 14 | 142 | 814 | Cape Lazo | 6,502 |
| 14 | 142 | 837 | Komas Bluff | 5,330 |
| 14 | 142 | 840 | Seal Islets | 16 |
| 14 | 142 | 841 | Repulse Pt | 831 |
| 14 | 142 | 1484 | Boyle Pt | 226 |
| 14 | 142 | 1558 | Willemar Bluff | 738 |
| 14 | 142 | 1560 | Whaling Station Bay | 1,503 |
| 14 | 142 | 1680 | Fillongley Park | 2,689 |
| 14 | 142 | 1754 | Whalebone Pt | 152 |
| 14 | 142 | 1769 | Collishaw Pt | 3,025 |
| 14 | 142 | 1770 | Tralee Pt | 1,531 |
| 14 | 142 | 1884 | Goose Spit | 20 |
| 14 | 143 | 810 | Qualicum Beach | 3,866 |
| 14 | 143 | 823 | Northwest Bay | 262 |
| 14 | 143 | 824 | Nuttal Bay | 1,618 |
| 14 | 143 | 825 | Bowser | 2,828 |
| 14 | 143 | 831 | Big Qualicum Rvr | 8,851 |
| 14 | 143 | 834 | French Cr | 5,117 |
| 14 | 143 | 835 | Little Qualicum Rvr | 1,197 |
| 14 | 143 | 1500 | Cottam Pt | 543 |
| 14 | 143 | 1501 | Madrona Pt | 1,088 |
| 14 | 143 | 1502 | Rath Trevor Beach | 209 |
| 14 | 143 | 1594 | Englishman Rvr | 2,907 |
| 14 | 143 | 1677 | Mapleguard Pt | 937 |
| 14 | 143 | 1679 | Parksville Bay | 3,978 |
| 14 | 143 | 1815 | Qualicum Bay | 2,110 |
| 14 | 143 | 1908 | Columbia Beach | 5,599 |
| 17 | 172 | 922 | Neck Pt | 32 |
| 17 | 172 | 931 | Hammond Bay | 0 |
| 17 | 172 | 997 | Blunden Pt | 222 |
| 17 | 172 | 998 | Lantzville | 515 |
| 17 | 172 | 1002 | Icarus Pt | 538 |
| 17 | 172 | 1563 | Lagoon Hd | 54 |
| 17 | 172 | 1573 | Sunrise Beach + | 289 |
| 28 | 280 | 1336 | Squamish | NA |

| <i>Table 7 continued</i> | | | | | |
|--------------------------|---------|---------------|---------------|-----------------|----|
| Statistical Area | Section | Location code | Location name | Spawn index (t) | |
| 28 | 280 | 1951 | False Cr | | NA |
| 28 | 280 | 1966 | Defence Is | | NA |

Table 8. Summary of spawn survey data from 2007 to 2017 in the Strait of Georgia 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 | 102,365 | 105 | 1.283 | 38,524 |
| 2008 | 125,980 | 75 | 0.963 | 34,507 |
| 2009 | 145,860 | 111 | 0.740 | 53,652 |
| 2010 | 143,520 | 84 | 0.975 | 50,454 |
| 2011 | 174,550 | 99 | 1.009 | 85,001 |
| 2012 | 130,405 | 112 | 1.227 | 52,636 |
| 2013 | 158,955 | 122 | 1.255 | 83,693 |
| 2014 | 137,090 | 146 | 1.331 | 120,468 |
| 2015 | 166,750 | 115 | 1.253 | 104,481 |
| 2016 | 118,300 | 157 | 1.229 | 129,502 |
| 2017 | 130,440 | 163 | 0.916 | 81,064 |

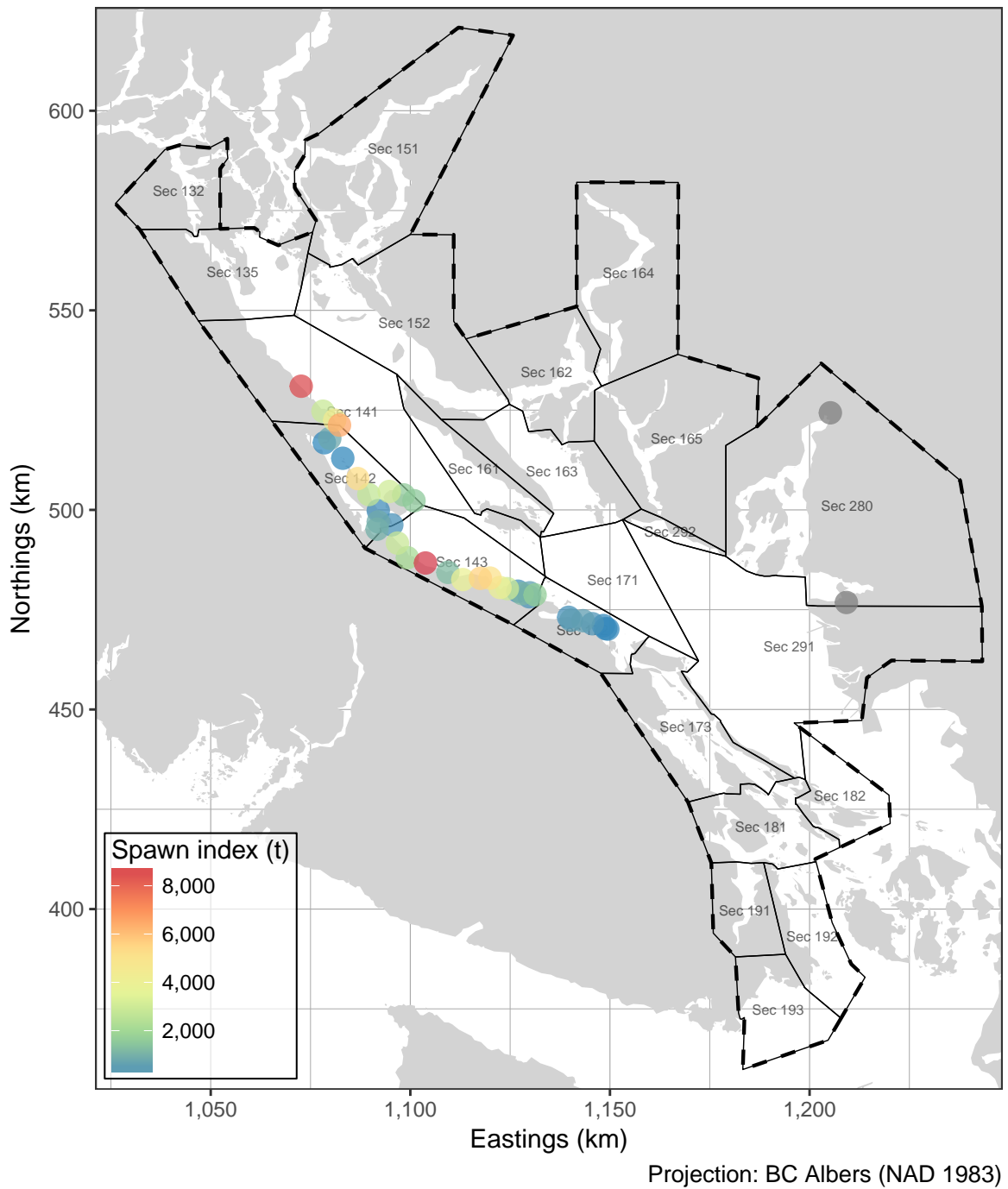


Figure 8. Pacific herring spawn survey locations, and spawn index in metric tonnes (t) in 2017 in the Strait of Georgia major stock assessment region (SAR; thick dashed lines), and associated Sections (Sec; thin solid lines). The ‘spawn index’ represents the raw survey data only, and is not scaled by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

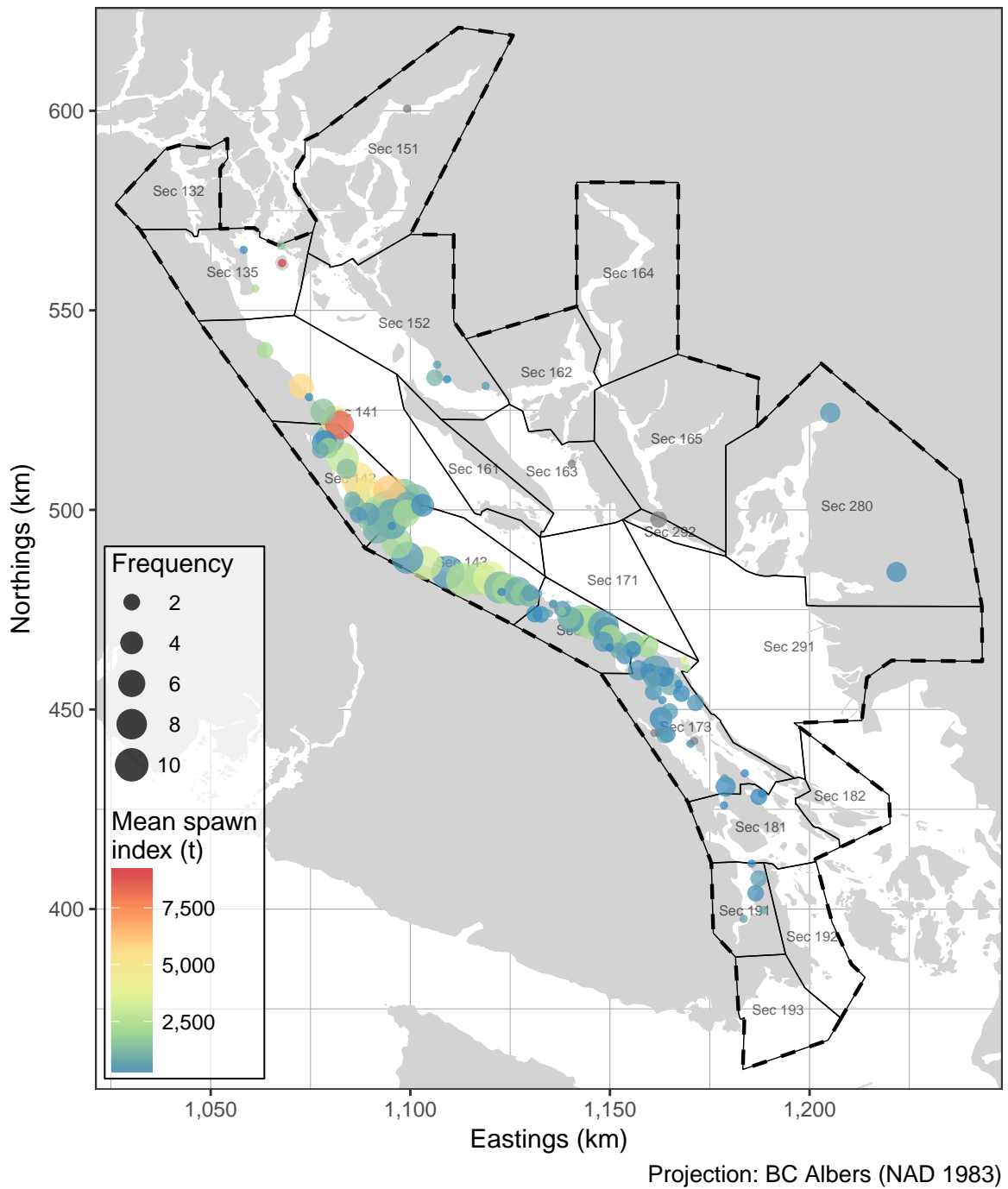


Figure 9. Pacific herring spawn survey locations, mean spawn index in metric tonnes (t), and spawn frequency from 2007 to 2016 in the Strait of Georgia major stock assessment region (SAR; thick dashed lines), and associated Sections (Sec; thin solid lines). The ‘spawn index’ represents the raw survey 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).

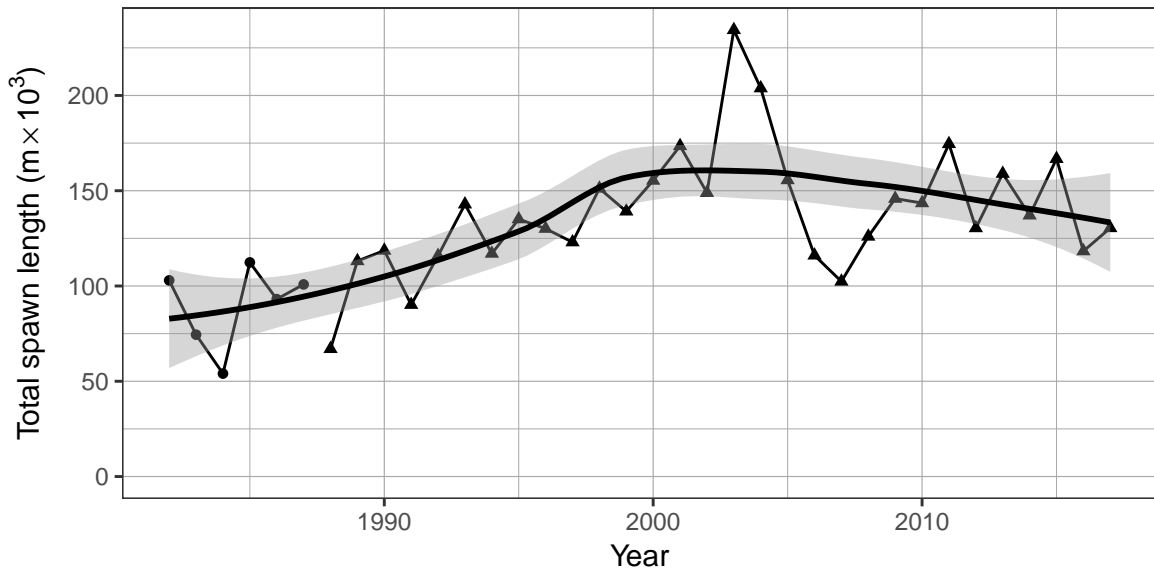


Figure 10. Time series of total spawn length in thousands of metres ($m \times 10^3$) for Pacific herring from 1982 to 2017 in the Strait of Georgia major stock assessment region (SAR). The thick black line is a loess curve, and the shaded area is the 90% confidence interval. The spawn index has two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

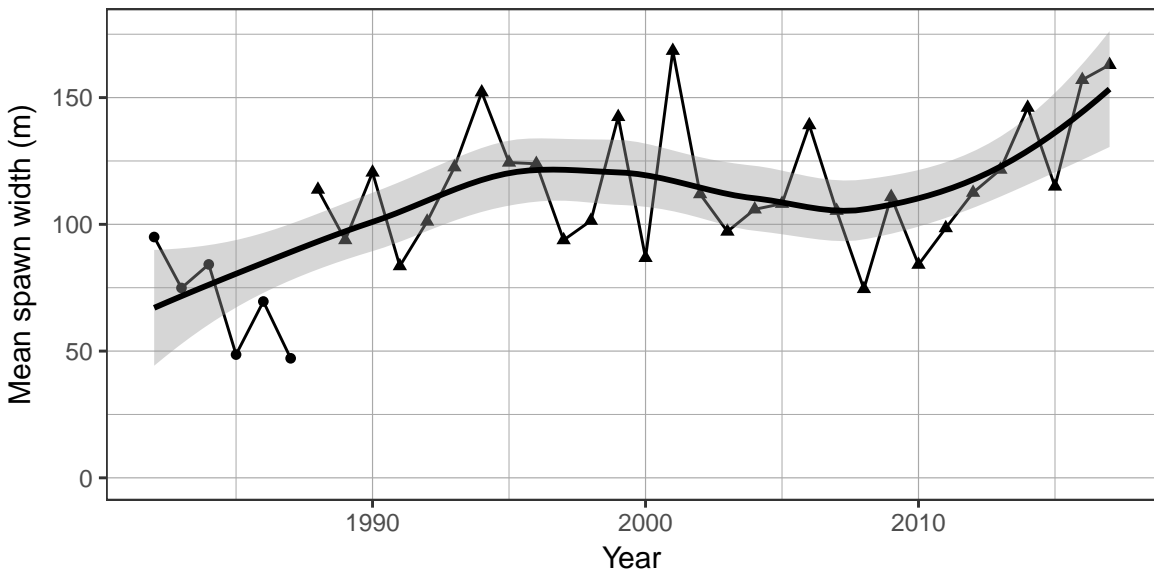


Figure 11. Time series of mean spawn width in metres (m) for Pacific herring from 1982 to 2017 in the Strait of Georgia major stock assessment region (SAR). The thick black line is a loess curve, and the shaded area is the 90% confidence interval. The spawn index has two distinct periods defined by the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

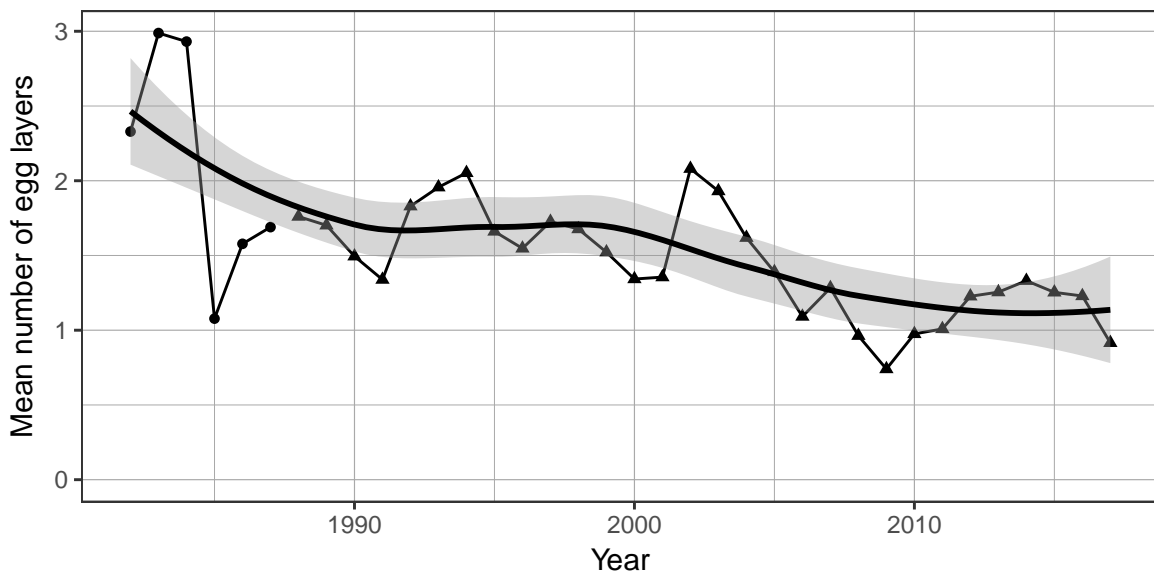


Figure 12. Time series of mean number of egg layers for Pacific herring from 1982 to 2017 in the Strait of Georgia major stock assessment region (SAR). The thick black line is a loess curve, and the shaded area is the 90% confidence interval. The spawn index has two distinct periods defined by the dominant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

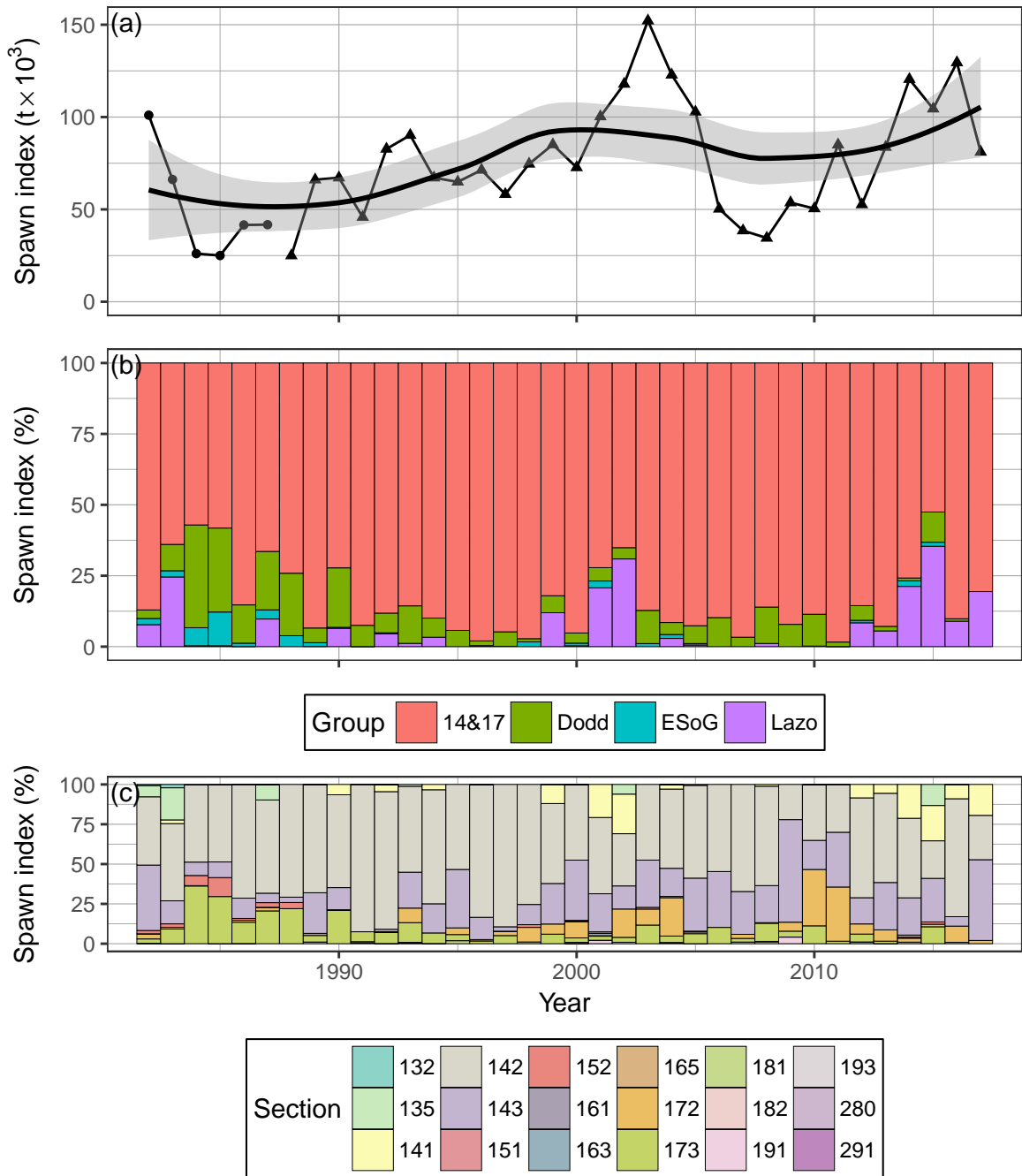


Figure 13. Time series of spawn index in thousands of metric tonnes ($t \times 10^3$) for Pacific herring from 1982 to 2017 in the Strait of Georgia major stock assessment region (SAR; a), as well as percent contributed by Group, and Section (b, & c, respectively). The thick black line is a loess curve, 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 . Legend: ‘14&17’ is Statistical Areas 14 and 17 (excluding Section 173); ‘Dodd’ is below Dodd Narrows; ‘ESoG’ is eastern Strait of Georgia; and ‘Lazo’ is above Cape Lazo.

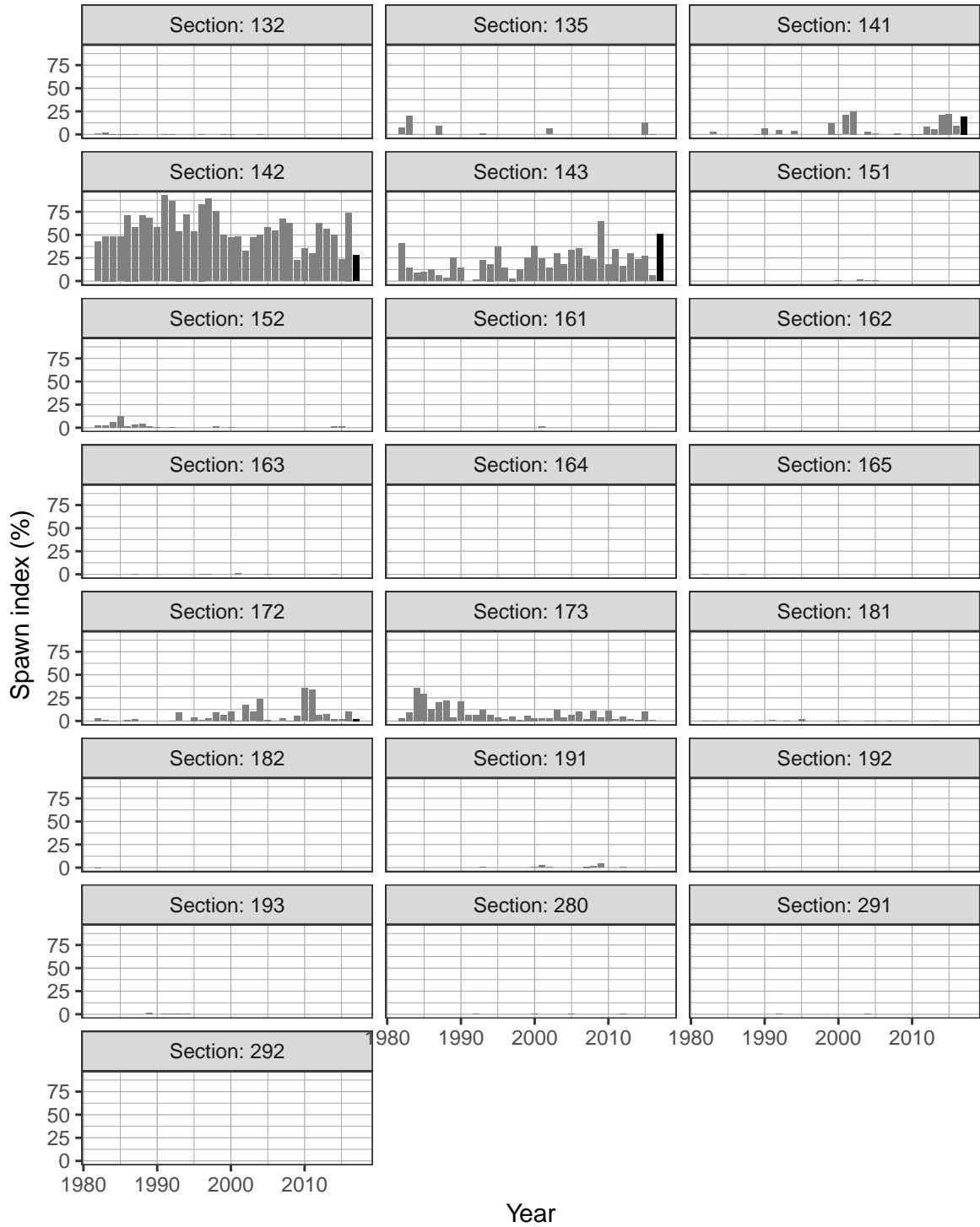


Figure 14. Time series of percent of spawn index by Section for Pacific herring from 1982 to 2017 in the Strait of Georgia major stock assessment region (SAR). The year 2017 has a darker bar to facilitate interpretation. The spawn index has two distinct periods defined by the dominant survey method: 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 .

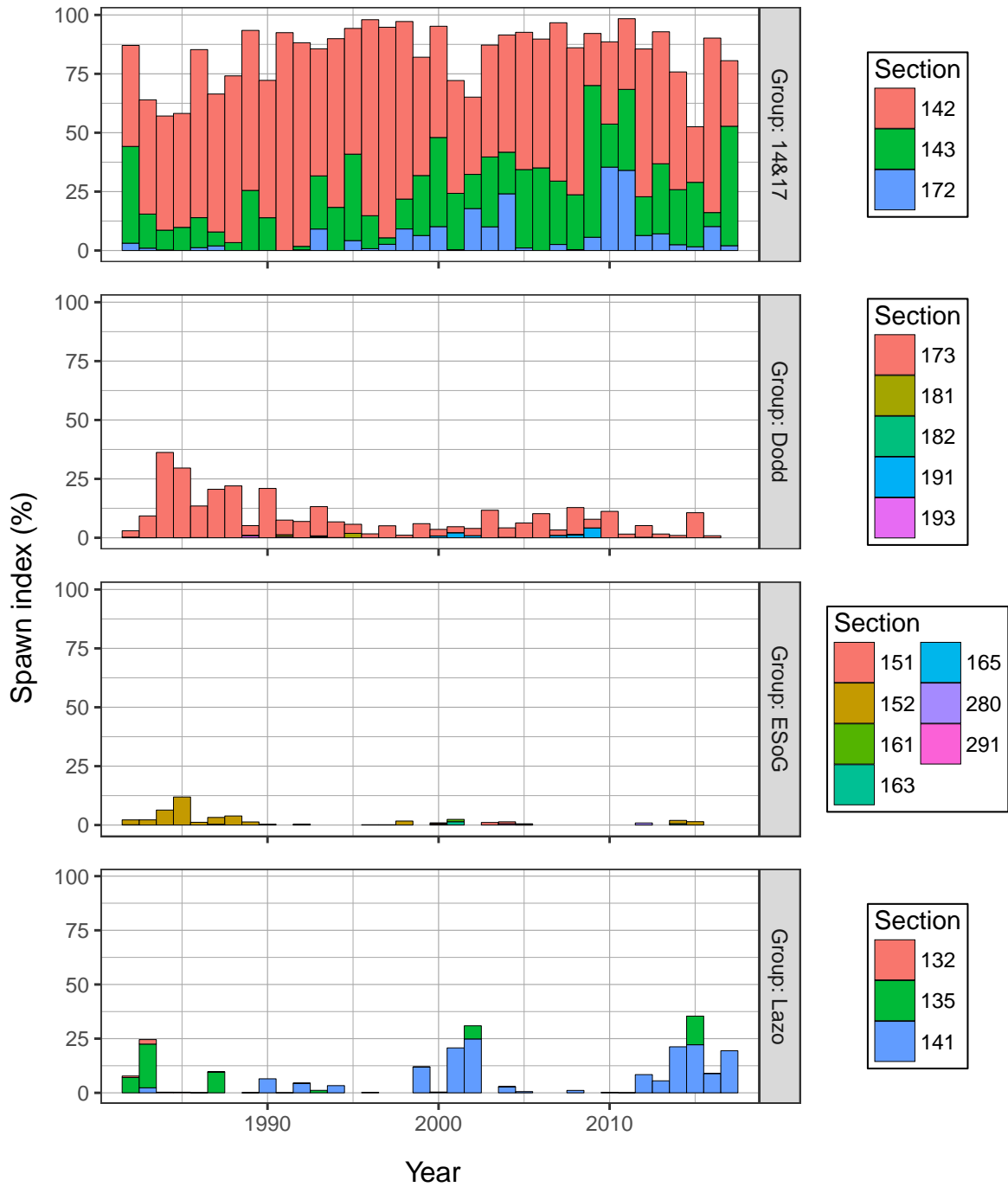


Figure 15. Time series of percent of spawn index by Group and Section for Pacific herring from 1982 to 2017 in the Strait of Georgia major stock assessment region (SAR). The spawn index has two distinct periods defined by the dominant survey method: surface surveys (1951–1987), and dive surveys (1988–2017). The ‘spawn index’ represents the raw survey data only, and is not scaled by the spawn survey scaling parameter, q . Legend: ‘14&17’ is Statistical Areas 14 and 17 (excluding Section 173); ‘Dodd’ is below Dodd Narrows; ‘ESoG’ is eastern Strait of Georgia; and ‘Lazo’ is above Cape Lazo.