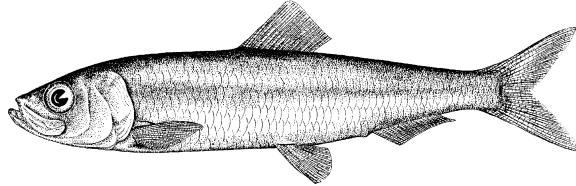


# Pacific Herring preliminary data summary for Strait of Georgia 2019

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Pacific Herring (*Clupea pallasii*). Image credit: [Fisheries and Oceans Canada](#).

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**Disclaimer** This report contains preliminary data collected for Pacific Herring in 2019 in the Strait of Georgia major stock assessment regions (SAR). These data may differ from data used and presented in the final stock assessment.

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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 2019. 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 Pacific 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 2019 in the Strait of Georgia major SAR (Figure 2). Data collected outside the SAR boundary are not included in this summary, and are not used for the purposes of stock assessment. Although we summarise data at the scale of the SAR for stock assessments, we summarise data at finer spatial scales in this report: locations are nested within sections, sections are nested within statistical areas, and statistical areas are nested within SARs (Table 2). For the Strait of Georgia major SAR, we use another level of spatial aggregation which we refer to as a ‘group’. Note that we refer to ‘year’ instead of ‘herring season’ in this report; therefore 2019 refers to the 2018/2019 Pacific Herring season.

## 2 Data collection programs

Biological samples were collected by the seine charter vessel “Denman Isle” for 27 days from February 20<sup>th</sup> to March 18<sup>th</sup>. Four additional Industry test vessels collected biological samples between February 27<sup>th</sup> to March 20<sup>th</sup>. 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-two flights were conducted this season, between February and April. Two dive charter vessels operated in the SoG:

- The “Viking Spirit” surveyed 21 days from March 21<sup>st</sup> to April 13<sup>th</sup>, and
- The “Ocean Cloud” surveyed 6 days from March 20<sup>th</sup> to March 25<sup>th</sup>.

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

## 3 Catch and biological samples

In the 1950s and 1960s, the reduction fishery dominated Pacific Herring catch; starting in the 1970s, catch has been predominantly from roe seine and gillnet fisheries. The reduction fishery is different from current fisheries in several ways. First, the reduction fishery caught Pacific Herring of all ages, whereas current fisheries target spawning (i.e., mature) fish. Thus, reduction fisheries included age-1 fish which are not typically caught in current fisheries. Second, the reduction fishery has some uncertainty regarding the quantity and location of catch; in some cases this may affect our ability to allocate catch to a specific SAR. For the roe gillnet fishery, all Pacific Herring catch has been validated by a dockside monitoring program since 1998; the catch validation program started in 1999 for the roe seine fishery. Finally, the reduction fishery operated during the winter months, whereas roe fisheries typically target spawning fish between February and April.

Landed commercial catch of Pacific Herring by year and fishery is shown in Table 3 and Figure 3. Total harvested spawn on kelp (SOK) in 2019 in the Strait of Georgia

major SAR is shown in Table 4; we also calculate the estimated spawning biomass associated with SOK harvest. See the [draft spawn index technical report](#) for calculations to convert SOK harvest to spawning biomass.

In 2019, 160 Pacific Herring biological samples were collected and processed for the Strait of Georgia major SAR (Table 5, Table 6), and a total of 9,574 Pacific Herring were aged in 2019. 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-, weight-, and length-at-age (Figure 6, Table 7, 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. Only representative biological samples are included, where ‘representative’ indicates whether the Pacific Herring sample in the set accurately reflects the larger Pacific Herring school.

## 4 Spawn survey data

Pacific Herring spawn surveys were conducted at 36 individual locations in 2019 in the Strait of Georgia major SAR (Table 8, and Figure 8). A summary of spawn from the last decade (2009 to 2018) is shown in Figure 9. Figure 10 shows spawn start date by decade and Group. 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 11, Figure 12, Figure 13, Table 9, and Figure 14). We describe the calculations used to estimate the spawn index in the [draft spawn index technical report](#). The ‘spawn index’ 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 to 1987), and dive surveys (1988 to 2019).

Some Pacific Herring Sections contribute more than others to the total spawn index, and the percentage contributed by Section varies yearly (Figure 13b, Figure 15). For example, in 2019, Section 142 contributed the most to the spawn index (92%). As with Sections, some Groups contribute more than others to the total spawn index (Figure 13c, Figure 16). An animation shows the spawn index by spawn survey location from 1951 to 2019 (Figure 17).

## 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 majority of spawn in SoG was along the West side of Denman Island this year.

- As in recent years, there was a lack of spawn observed in Statistical Area 17 South.
- Lack of spawn deposition in some common locations like Qualicum beach to Columbia beach on Vancouver Island.

## 6 Tables

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. Statistical Areas, Sections, and Groups for Pacific Herring in the Strait of Georgia major stock assessment region (SAR). Legend: ‘14&amp;17’ is Statistical Areas 14 and 17 (excluding Section 173); ‘ESoG’ is eastern Strait of Georgia; ‘Lazo’ is above Cape Lazo; and ‘SDodd’ is South of Dodd Narrows

Region	Statistical Area	Section	Group
Strait of Georgia	13	132	Lazo
Strait of Georgia	13	135	Lazo
Strait of Georgia	14	140	NA
Strait of Georgia	14	141	Lazo
Strait of Georgia	14	142	14&17
Strait of Georgia	14	143	14&17
Strait of Georgia	15	150	ESoG
Strait of Georgia	15	151	ESoG
Strait of Georgia	15	152	ESoG
Strait of Georgia	16	160	ESoG
Strait of Georgia	16	161	ESoG
Strait of Georgia	16	162	ESoG
Strait of Georgia	16	163	ESoG
Strait of Georgia	16	164	ESoG
Strait of Georgia	16	165	ESoG
Strait of Georgia	17	170	NA
Strait of Georgia	17	171	14&17
Strait of Georgia	17	172	14&17
Strait of Georgia	17	173	SDodd
Strait of Georgia	18	180	SDodd
Strait of Georgia	18	181	SDodd
Strait of Georgia	18	182	SDodd
Strait of Georgia	19	190	SDodd

<i>Table 2 continued</i>				
Region	Statistical Area	Section	Group	
Strait of Georgia	19	191	SDodd	
Strait of Georgia	19	192	SDodd	
Strait of Georgia	19	193	SDodd	
Strait of Georgia	28	280	ESoG	
Strait of Georgia	29	291	ESoG	
Strait of Georgia	29	292	ESoG	

Table 3. Total landed commercial catch of Pacific Herring in metric tonnes (t) by gear type in 2019 in the Strait of Georgia major stock assessment region (SAR). Legend: ‘Other’ represents the reduction, the food and bait, as well as the special use fishery; ‘RoeSN’ represents the roe seine fishery; and ‘RoeGN’ 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.

Gear	Catch (t)
Other	0
RoeSN	0
RoeGN	0

Table 4. Total harvested Pacific Herring spawn on kelp (SOK) in pounds (lb), and the associated estimate of spawning biomass in metric tonnes (t) from 2009 to 2019 in the Strait of Georgia major stock assessment region (SAR). See the [draft spawn index technical report](#) for calculations to convert SOK harvest to spawning biomass. Note: ‘WP’ indicates that data are withheld due to privacy concerns.

Year	Harvest (lb)	Spawning biomass (t)
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
2018	0	0
2019	0	0

Table 5. Number of Pacific Herring biological samples processed from 2009 to 2019 in the Strait of Georgia major stock assessment region (SAR). Each sample is approximately 100 fish.

Year	Number of samples		
	Commercial	Test	Total
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
2018	116	28	144
2019	125	35	160

Table 6. Number and type of Pacific Herring biological samples processed in 2019 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	43
Commercial	Seine	Bait fishery	7
Commercial	Seine	Food fishery	45
Commercial	Seine	Roe fishery	30
Test	Seine	Test fishery	35

Table 7. Observed proportion-at-age for Pacific Herring from 2009 to 2019 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	
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	
2018	0.077	0.418	0.247	0.144	0.082	0.026	0.004	0.002	0.000	
2019	0.238	0.349	0.222	0.110	0.051	0.023	0.006	0.001	0.000	

Table 8. Pacific Herring spawn survey locations, start date, and spawn index in metric tonnes (t) in 2019 in the Strait of Georgia major stock assessment region (SAR). The ‘spawn index’ is not scaled by the spawn survey scaling parameter,  $q$ . Missing spawn index values (NAs) indicate incomplete spawn surveys.

Statistical Area	Section	Location name	Start date	Spawn index (t)
13	135	Whaletown Bay	December 18	NA
14	141	Kye Bay	March 16	888
14	141	Little Rvr	March 19	0
14	142	Baynes Snd	March 16	577
14	142	Boyle Pt	March 17	2,787
14	142	Cape Lazo	March 16	5,531
14	142	Chrome Is	March 17	72
14	142	Collishaw Pt	March 08	1,835
14	142	Comox Bar	March 14	84
14	142	Fillongley Park	March 15	6,973
14	142	Gartley Pt	March 16	554
14	142	Goose Spit	March 16	18
14	142	Gravelly Bay	March 16	2,585
14	142	Komas Bluff	March 14	16,170
14	142	Repulse Pt	March 16	2,541
14	142	Seal Islets	March 13	11,355
14	142	Shingle Spit	March 17	114
14	142	Tralee Pt	March 16	941
14	142	Whalebone Pt	March 15	5,306
14	142	Willemar Bluff	March 16	699
14	143	Big Qualicum Rvr	March 19	283
14	143	Bowser	March 19	1,051
14	143	French Cr	March 09	271
14	143	Mapleguard Pt	April 01	1,054
14	143	Parksville Bay	March 09	11
14	143	Qualicum Bay	March 18	467
16	162	Hotham Snd	March 29	NA
16	163	Bargain Bay	March 03	NA
16	165	Sechelt Int	May 09	NA
17	172	Blunden Pt	April 08	113
17	172	Icarus Pt	April 08	524
17	172	Lantzville	April 08	92
17	172	Sunrise Beach +	April 08	70
28	280	False Cr	March 02	29
28	280	Gambier Island	April 18	NA
28	280	Squamish	January 26	NA

Table 9. Summary of Pacific Herring spawn survey data from 2009 to 2019 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 to 1987), and dive surveys (1988 to 2019). The ‘spawn index’ 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)
2009	145,860	111	0.7	53,652
2010	143,520	84	1.0	50,454
2011	174,550	99	1.0	85,001
2012	130,405	112	1.2	52,636
2013	158,955	122	1.3	83,693
2014	137,090	146	1.3	120,468
2015	166,750	115	1.3	104,481
2016	118,300	157	1.2	129,502
2017	130,440	163	0.9	81,064
2018	87,745	169	1.4	91,939
2019	81,815	143	1.1	62,994

## 7 Figures

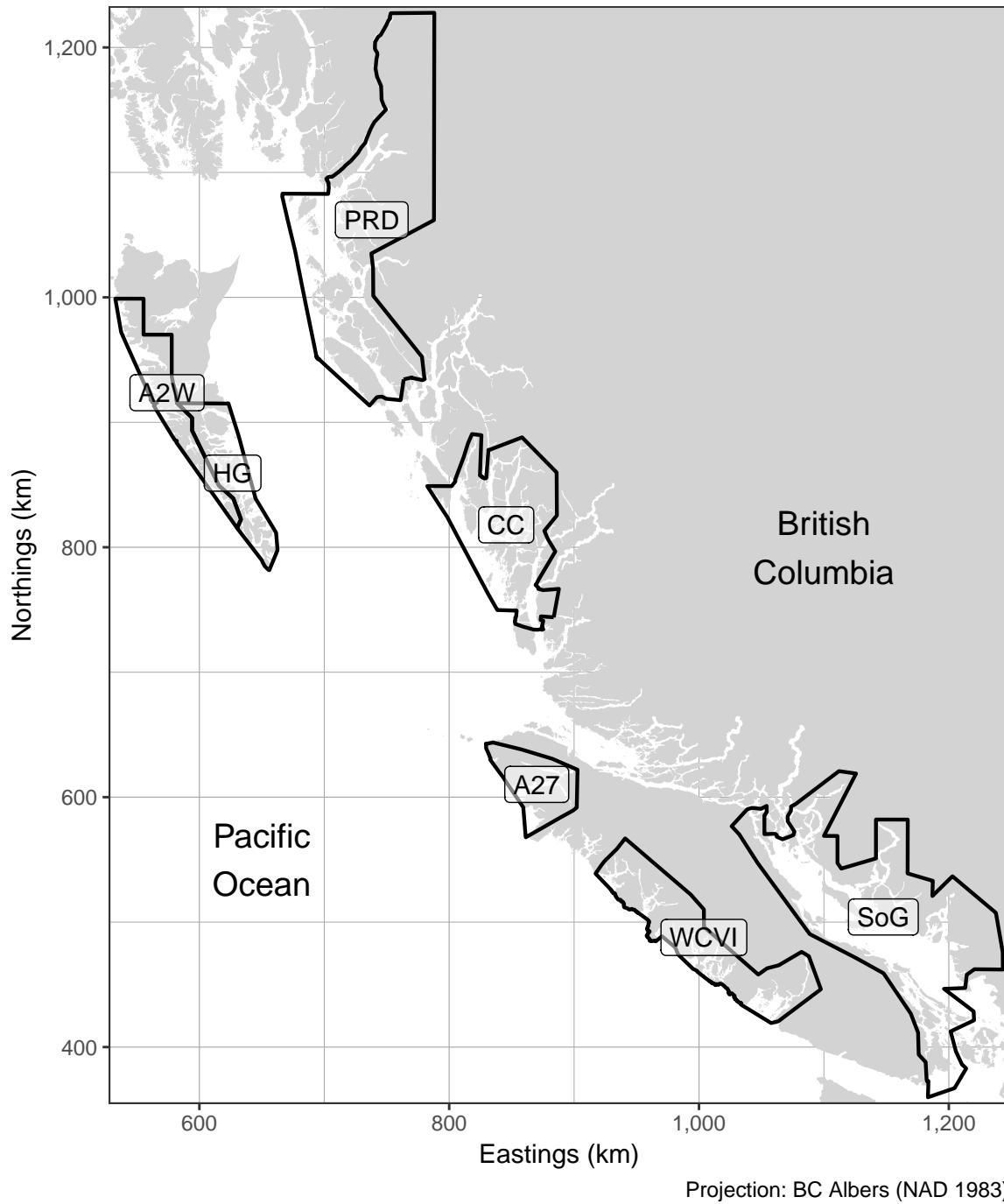


Figure 1. Boundaries for the Pacific Herring stock assessment regions (SARs) in British Columbia: there are 5 major SARs (HG, PRD, CC, SoG, and WCVI), and 2 minor SARs (A27 and A2W; Table 1). Units: kilometres (km).

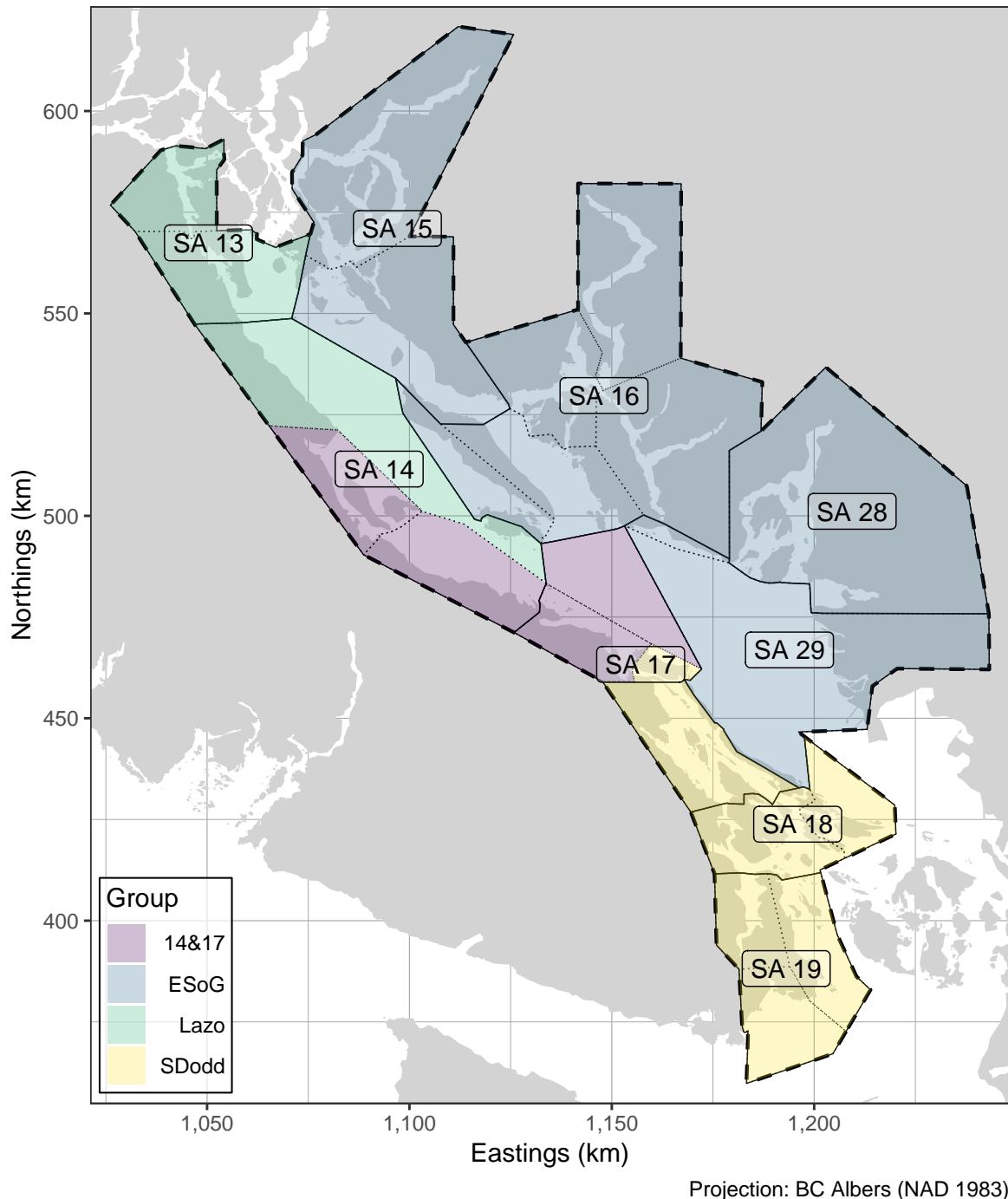


Figure 2. Boundaries for the Strait of Georgia major stock assessment region (SAR; thick dashed lines), associated Statistical Areas (SA; thin solid lines), and associated Sections (thin dotted lines). Units: kilometres (km). Legend: '14&17' is Statistical Areas 14 and 17 (excluding Section 173); 'ESoG' is eastern Strait of Georgia; 'Lazo' is above Cape Lazo; and 'SDodd' is South of Dodd Narrows

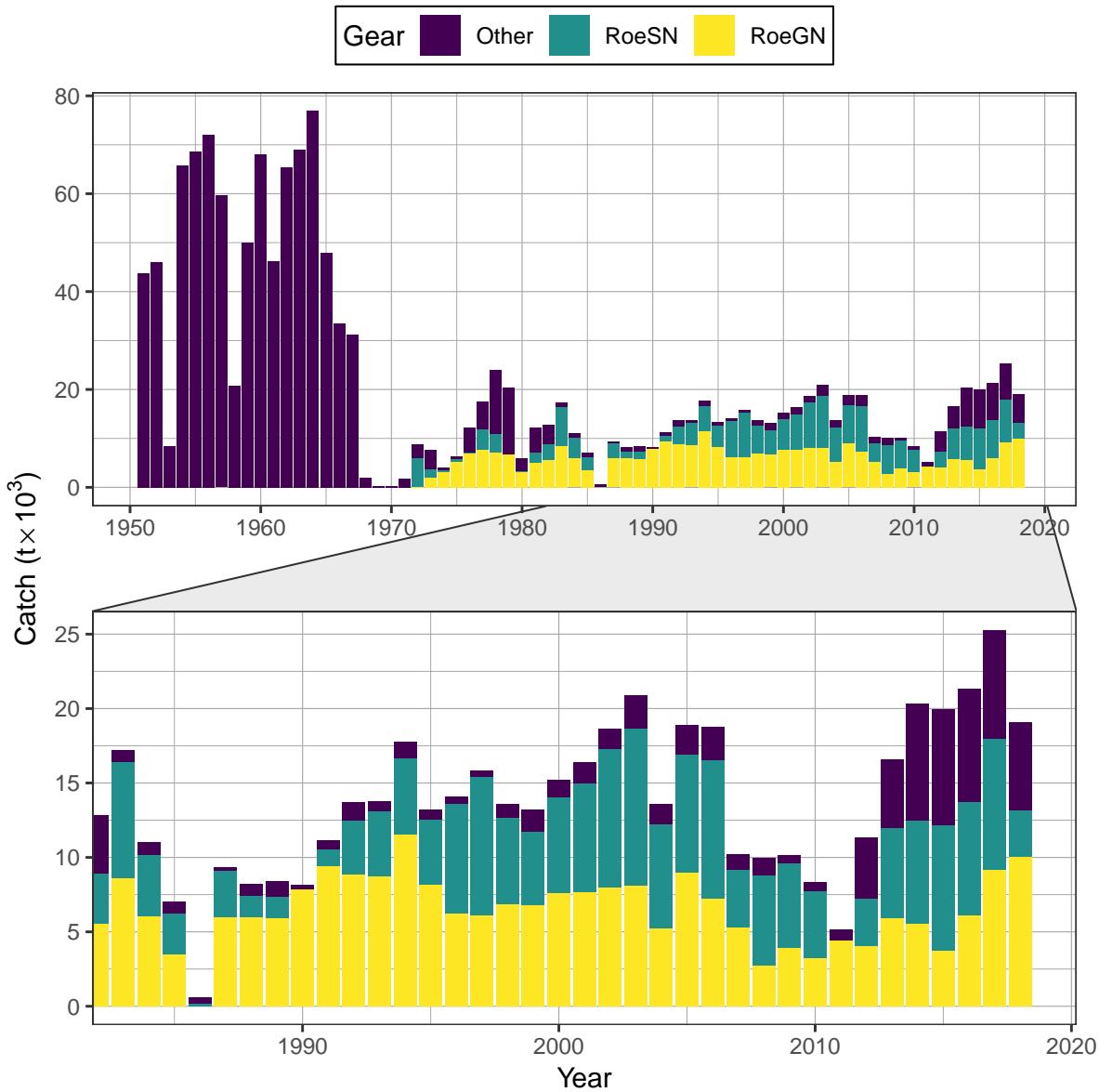


Figure 3. Time series of total landed catch in thousands of metric tonnes ( $t \times 10^3$ ) of Pacific Herring by gear type from 1951 to 2019 in the Strait of Georgia major stock assessment region (SAR). Legend: ‘Other’ represents the reduction, the food and bait, as well as the special use fishery; ‘RoeSN’ represents the roe seine fishery; and ‘RoeGN’ represents the roe gillnet fishery. Data from the spawn-on-kelp (SOK) fishery is not included.

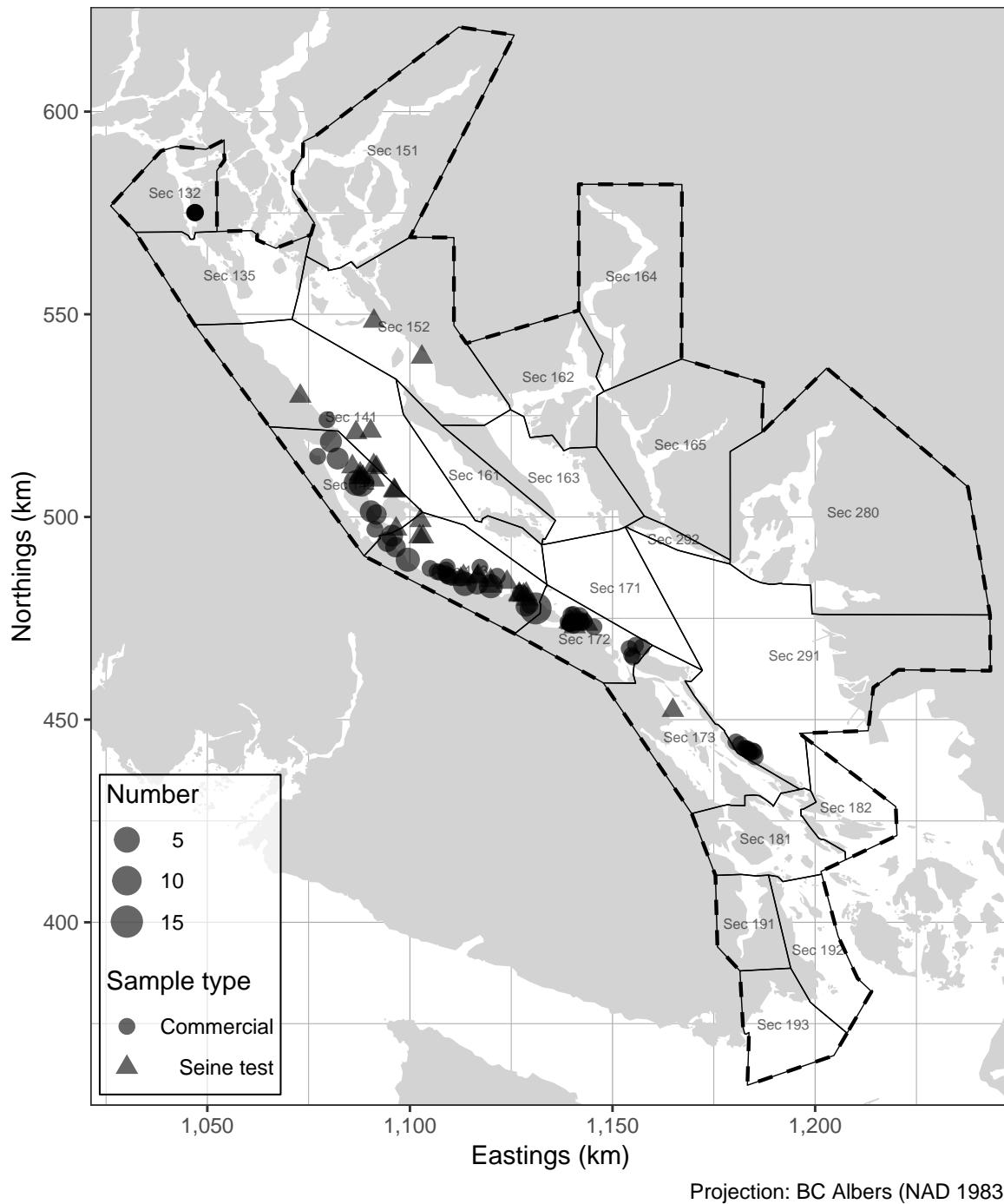


Figure 4. Location and type of Pacific Herring biological samples collected in 2019 in the Strait of Georgia major stock assessment region (SAR; thick dashed lines), and associated Sections (Sec; thin solid lines). Units: kilometres (km).

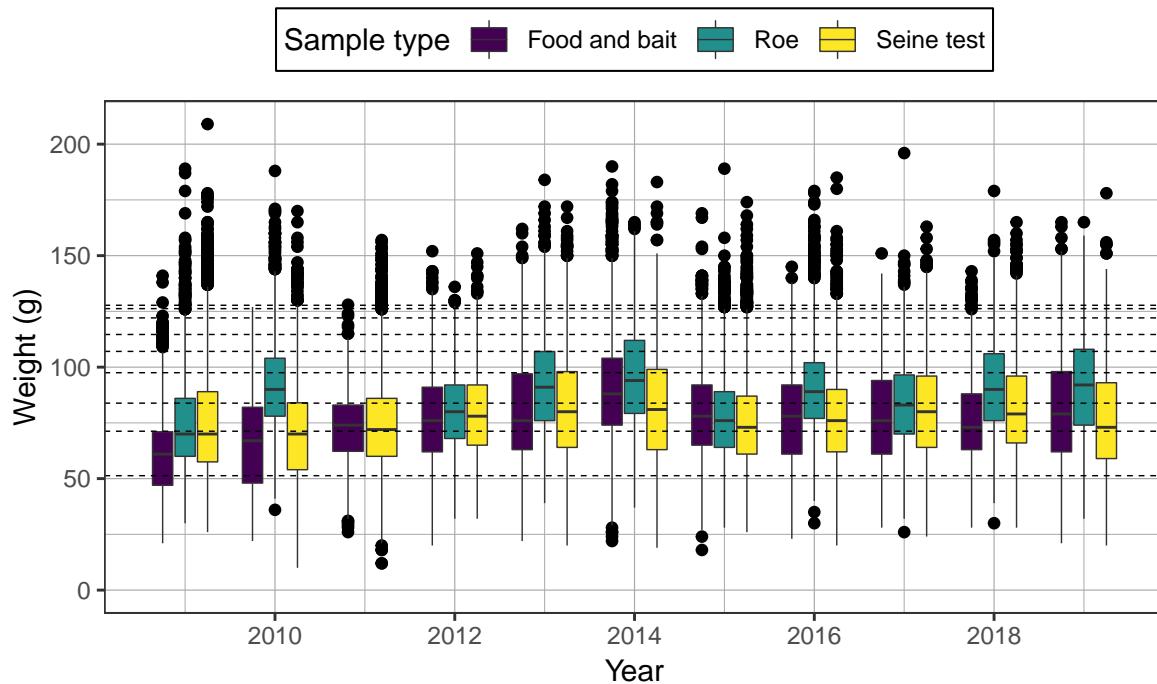


Figure 5. Time series of weight in grams (g) of Pacific Herring by sample type from 2009 to 2019 in the Strait of Georgia major stock assessment region (SAR) in Statistical Areas 14 and 17. The outer edges of the boxes indicate the 25<sup>th</sup> and 75<sup>th</sup> percentiles, and the middle lines indicate the 50<sup>th</sup> percentiles (i.e., medians). The whiskers extend to  $1.5 \times \text{IQR}$ , where IQR is the distance between the 25<sup>th</sup> and 75<sup>th</sup> 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.

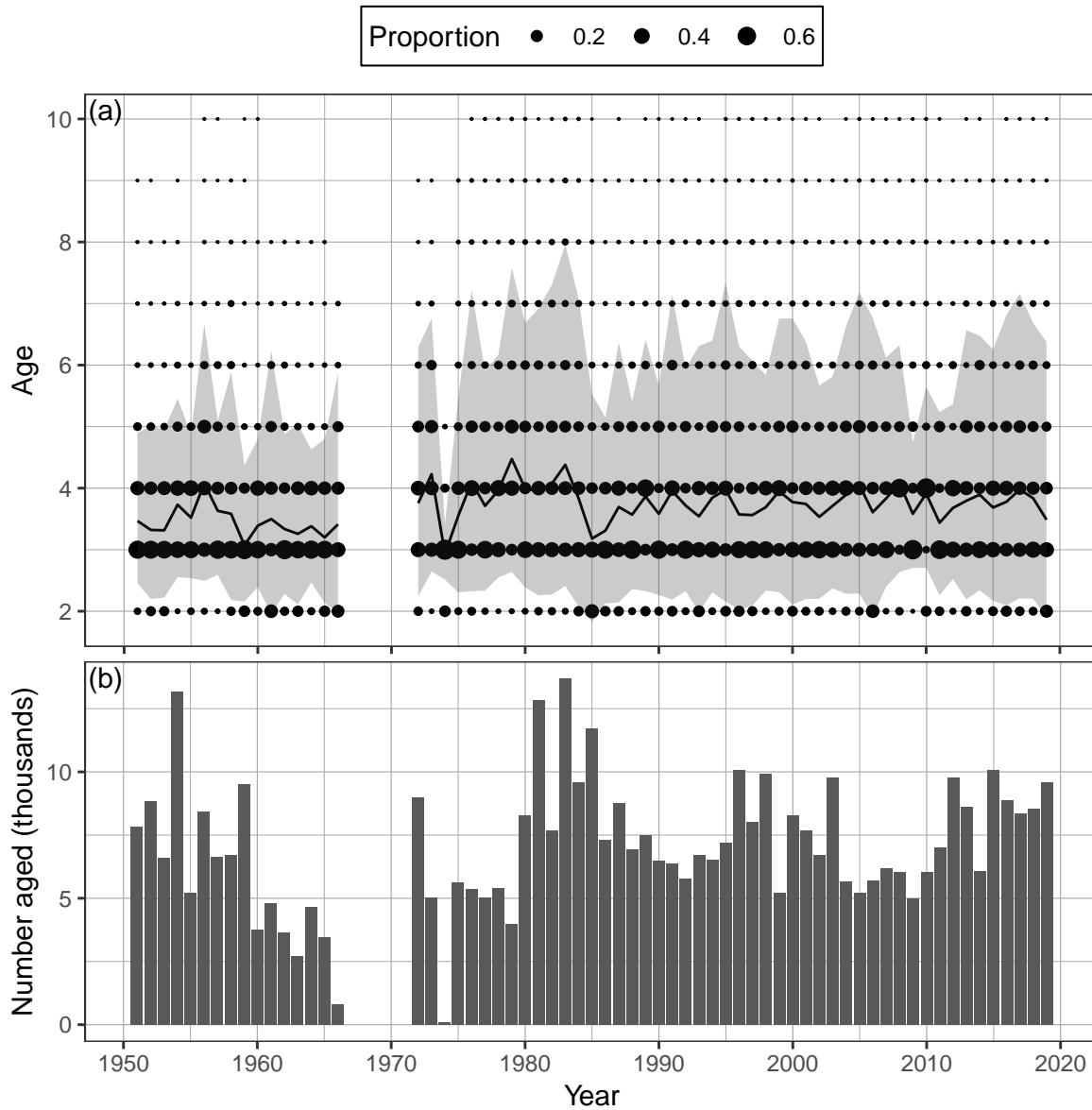


Figure 6. Time series of observed proportion-at-age (a) and number aged in thousands (b) of Pacific Herring from 1951 to 2019 in the Strait of Georgia major stock assessment region (SAR). The black line is the mean age, and the shaded area is the approximate 90% distribution. Biological summaries only 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.

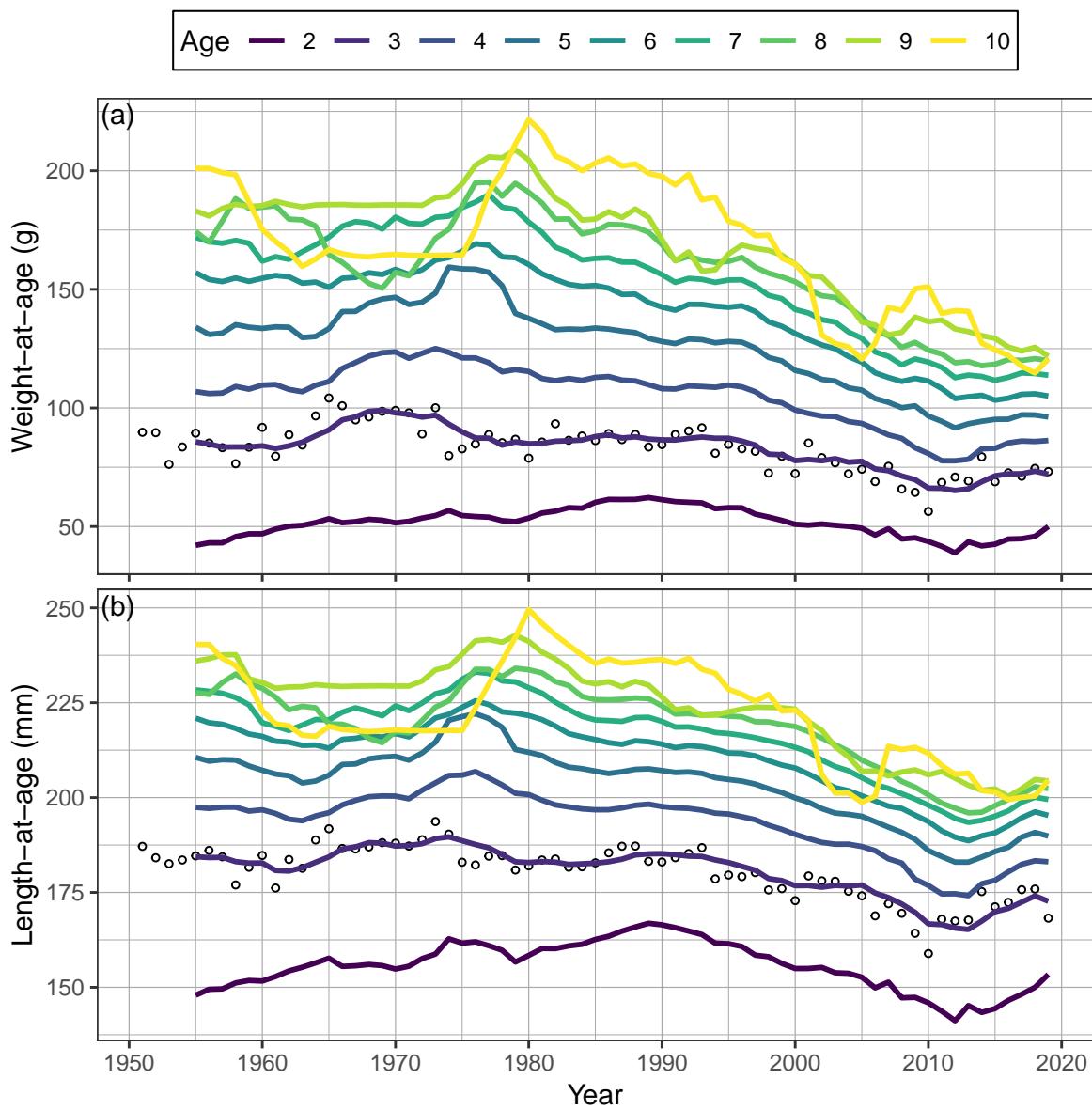


Figure 7. Time series of weight-at-age in grams (g; panel a) and length-at-age in millimetres (mm; panel b) for age-3 (circles) and 5-year running mean weight- and length-at-age (lines) for Pacific Herring from 1951 to 2019 in the Strait of Georgia major stock assessment region (SAR). Missing weight- and length-at-age values (i.e., years with 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.

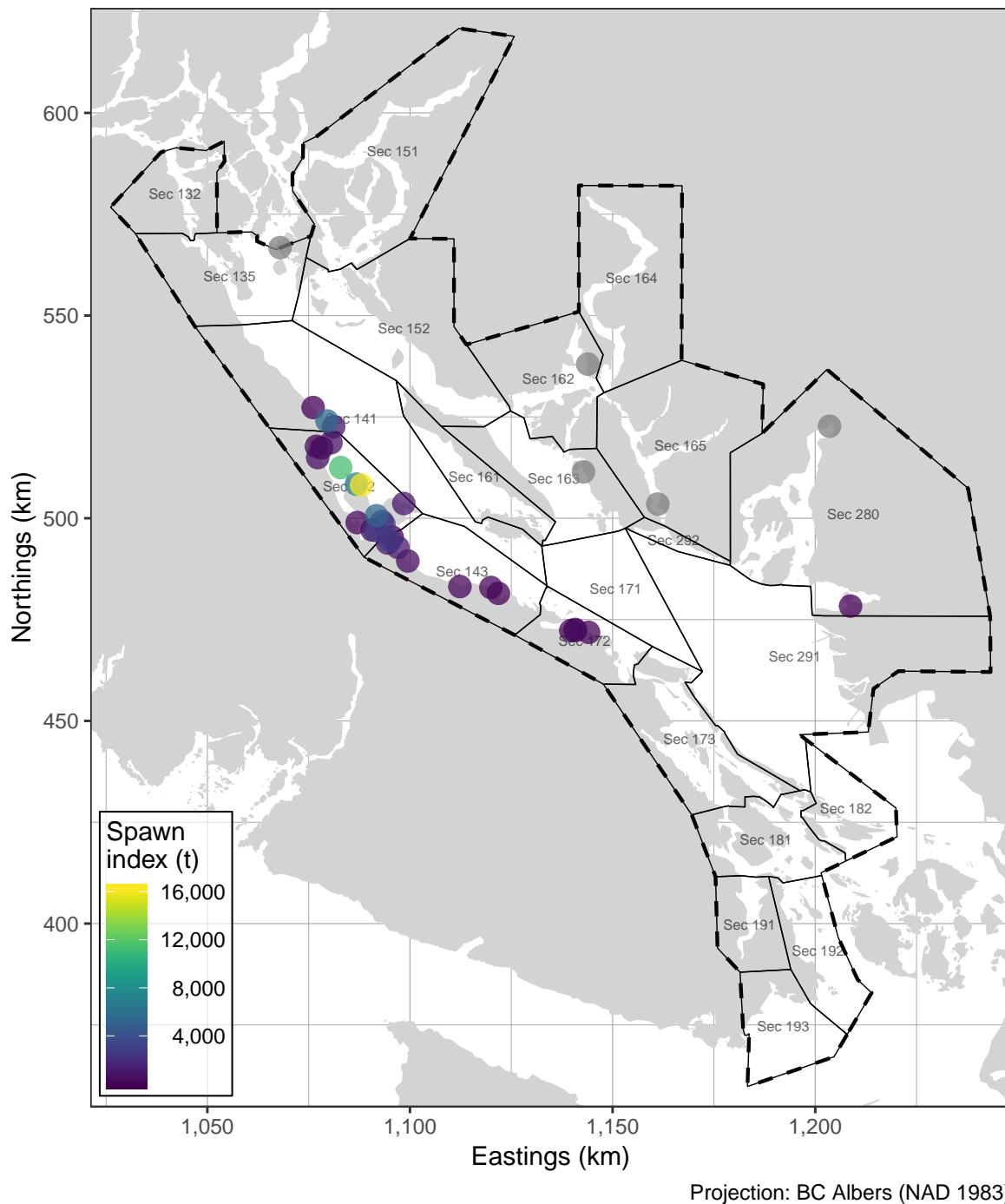


Figure 8. Pacific Herring spawn survey locations, and spawn index in metric tonnes (t) in 2019 in the Strait of Georgia major stock assessment region (SAR; thick dashed lines), and associated Sections (Sec; thin solid lines). The ‘spawn index’ is not scaled by the spawn survey scaling parameter,  $q$ . Missing spawn index values (grey circles) indicate incomplete spawn surveys. Units: kilometres (km).

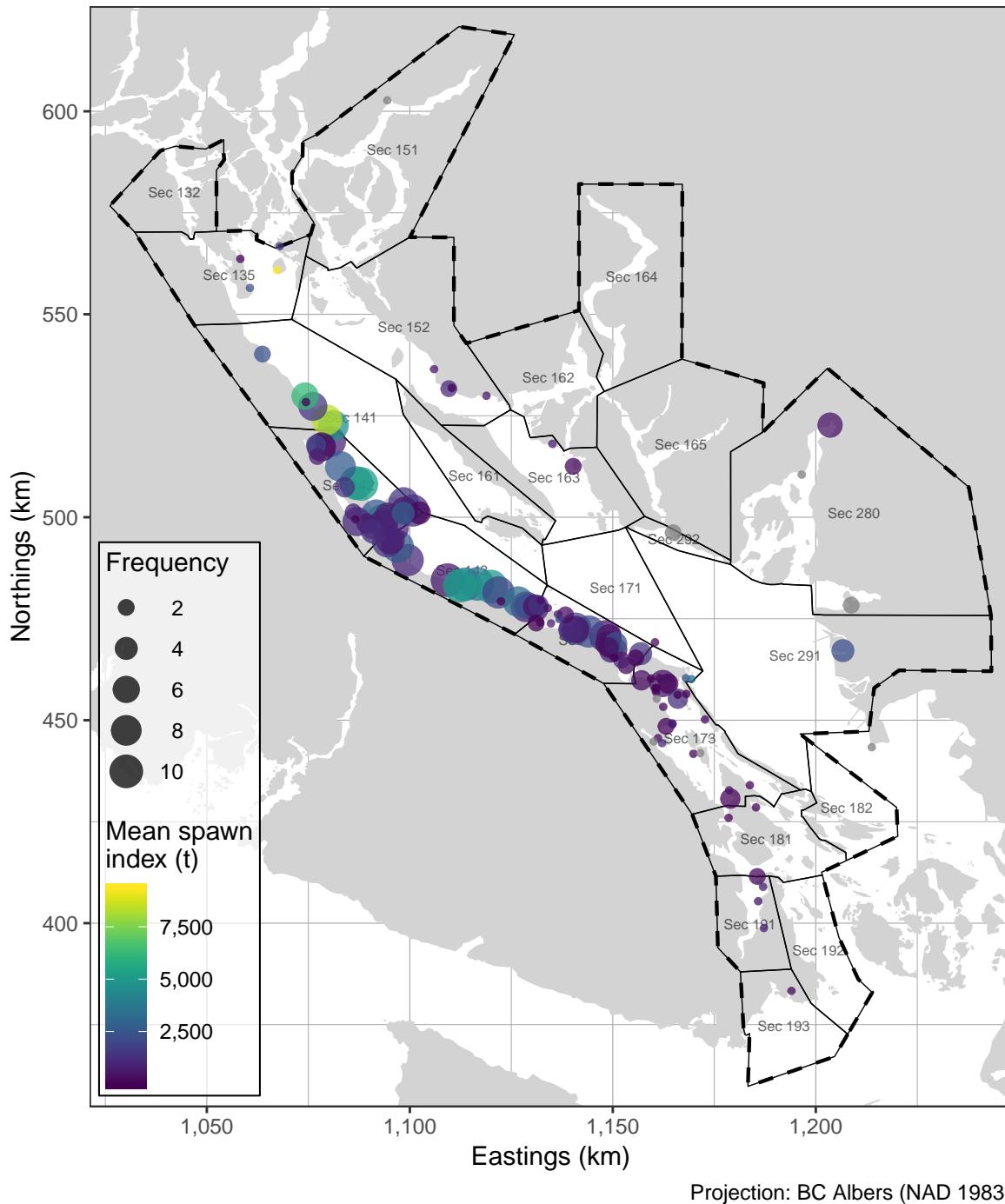


Figure 9. Pacific Herring spawn survey locations, mean spawn index in metric tonnes (t), and spawn frequency from 2009 to 2018 in the Strait of Georgia major stock assessment region (SAR; thick dashed lines), and associated Sections (Sec; thin solid lines). The ‘spawn index’ is not scaled by the spawn survey scaling parameter,  $q$ . Missing spawn index values (grey circles) indicate incomplete spawn surveys. Units: kilometres (km).

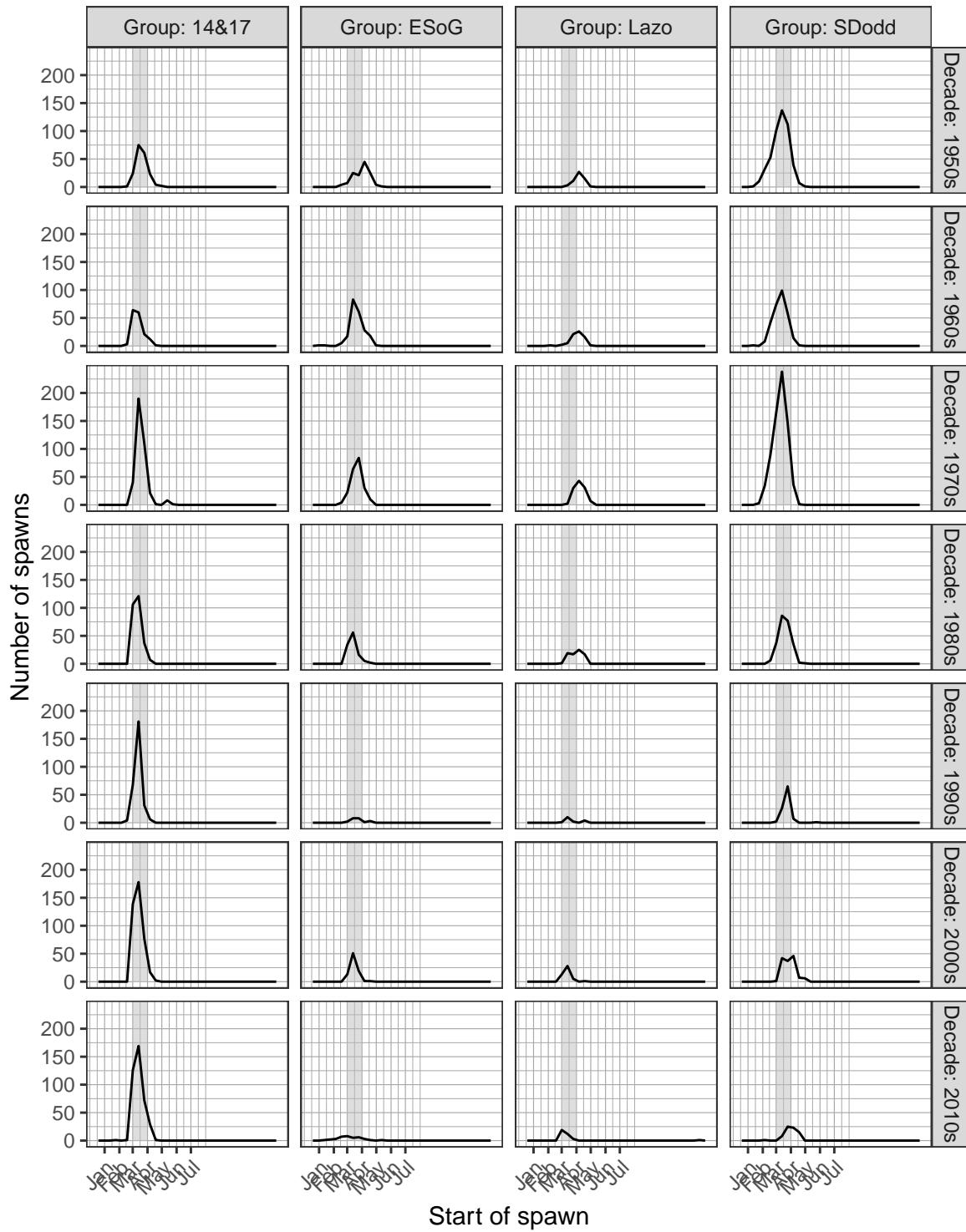


Figure 10. Pacific Herring spawn start date by decade and Group. Grey shaded regions indicate March 1<sup>st</sup> to 31<sup>st</sup>. Note that spawn size and intensity varies; therefore the number of spawns is not directly proportional to spawn extent or biomass. Legend: '14&17' is Statistical Areas 14 and 17 (excluding Section 173); 'ESoG' is eastern Strait of Georgia; 'Lazo' is above Cape Lazo; and 'SDodd' is South of Dodd Narrows

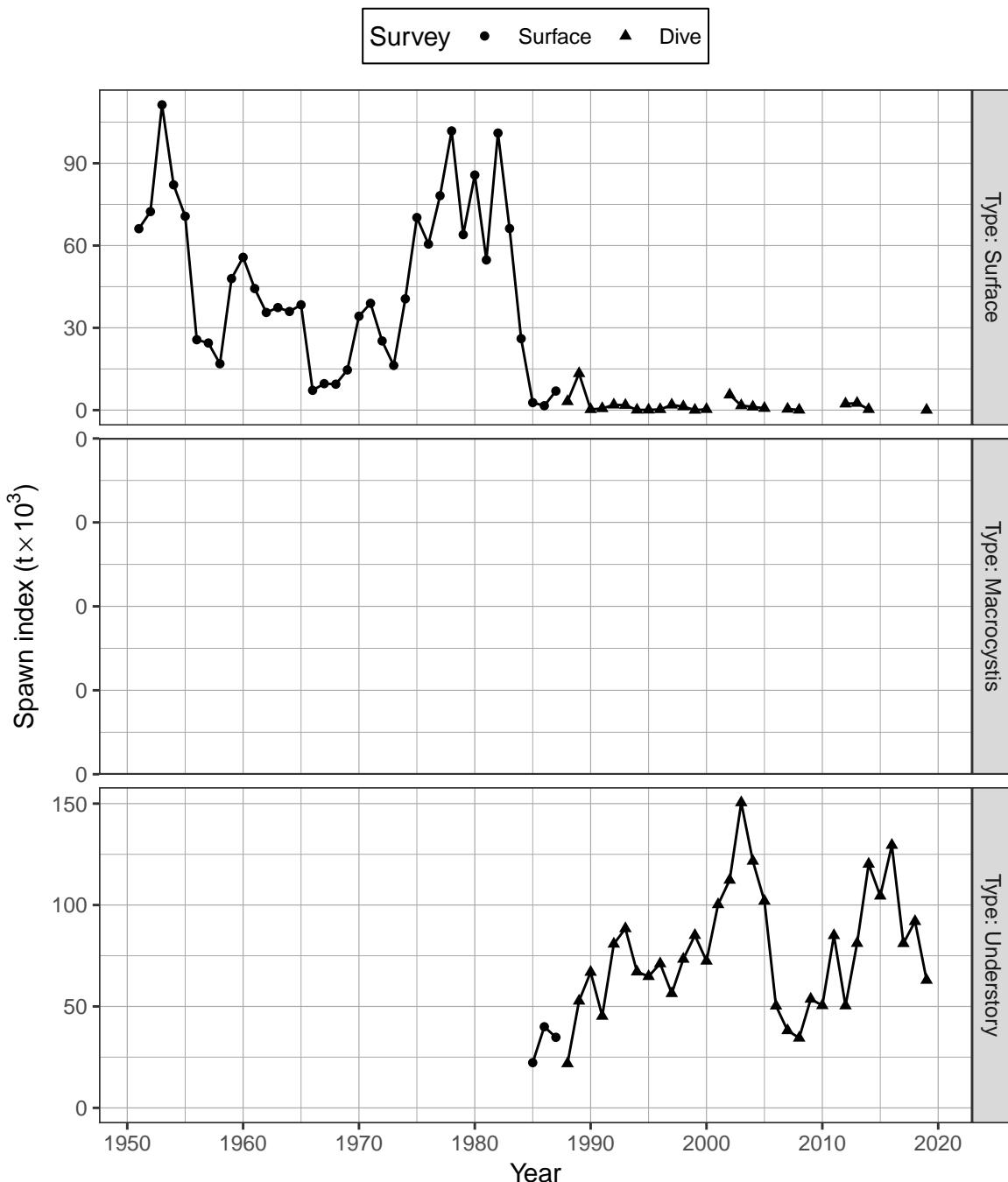


Figure 11. Time series of spawn index in thousands of metric tonnes ( $t \times 10^3$ ) by type for Pacific Herring from 1951 to 2019 in the Strait of Georgia major stock assessment region (SAR). There are three types of spawn survey observations: observations of spawn taken from the surface usually at low tide, underwater observations of spawn on giant kelp, *Macrocystis* (*Macrocystis* spp.), and underwater observations of spawn on other types of algae and the substrate, which we refer to as ‘understory.’ The spawn index has two distinct periods defined by the dominant survey method: surface surveys (1951 to 1987), and dive surveys (1988 to 2019).

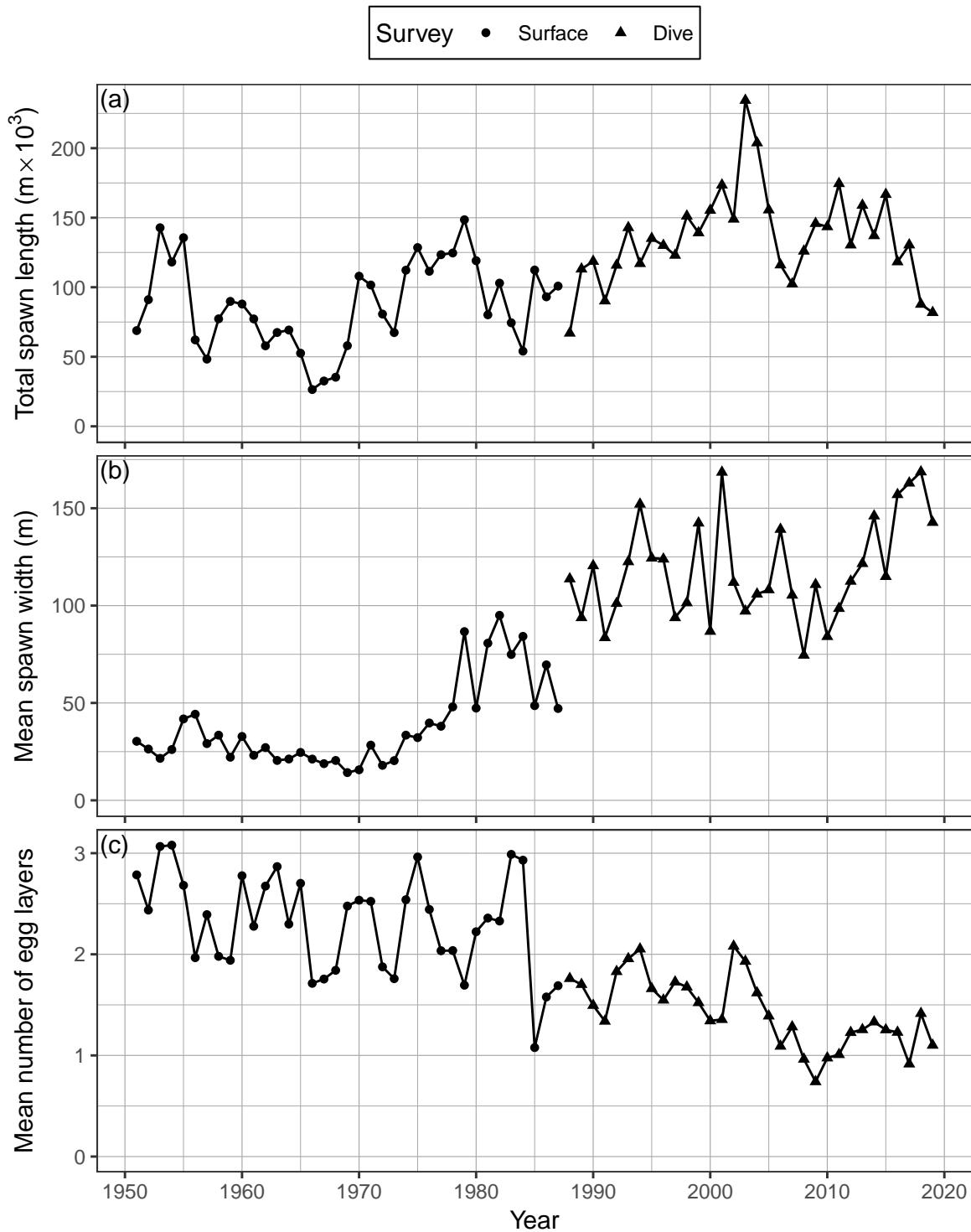


Figure 12. Time series of total spawn length in thousands of metres ( $m \times 10^3$ ; panel a), mean spawn width in metres (b), and mean number of egg layers (c) for Pacific Herring from 1951 to 2019 in the Strait of Georgia major stock assessment region (SAR). The spawn index has two distinct periods defined by the dominant survey method: surface surveys (1951 to 1987), and dive surveys (1988 to 2019).

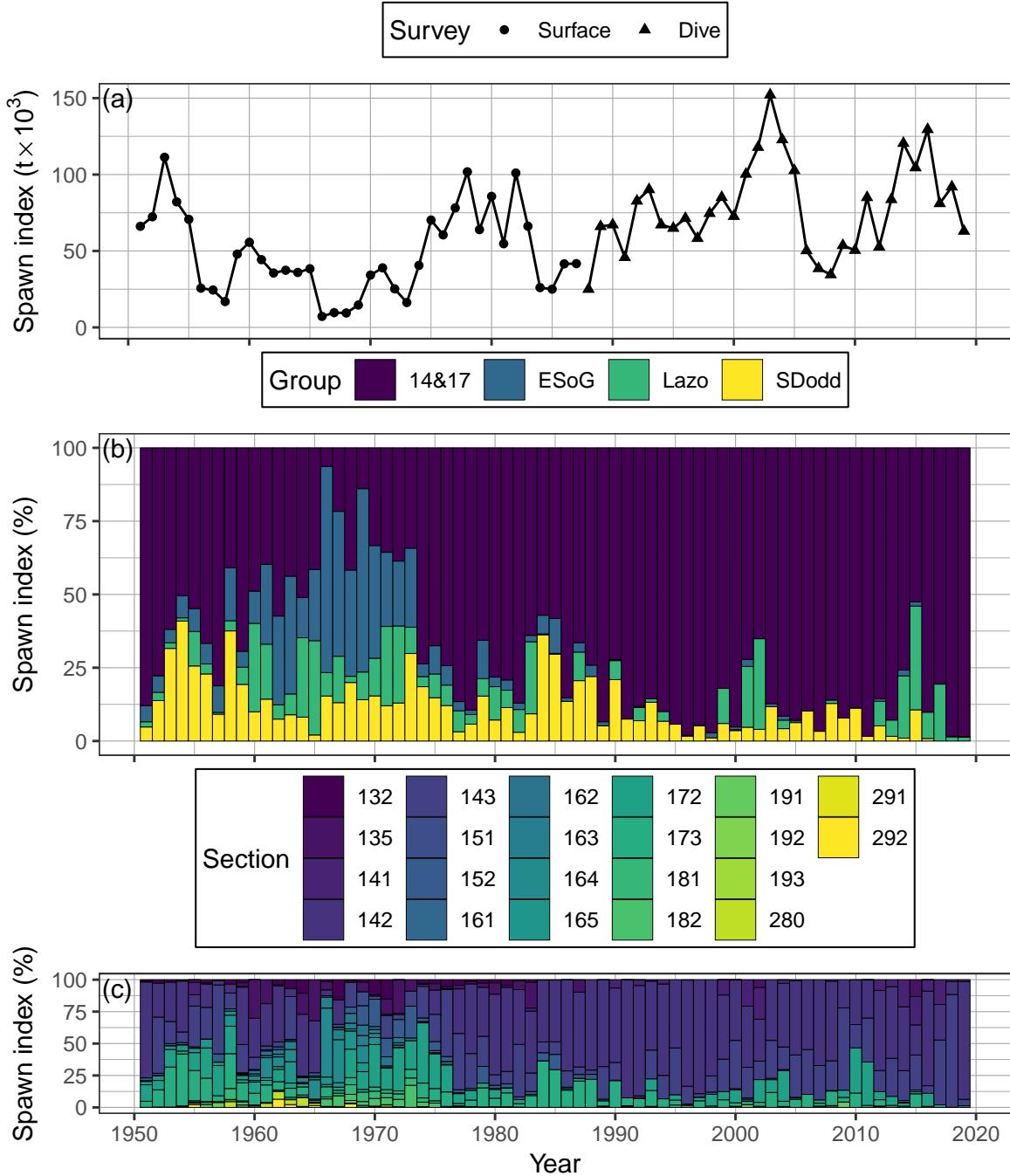


Figure 13. Time series of spawn index in thousands of metric tonnes ( $t \times 10^3$ ) for Pacific Herring from 1951 to 2019 in the Strait of Georgia major stock assessment region (SAR; panel a), as well as percent contributed by Group, and Section (b, & c, respectively). The spawn index has two distinct periods defined by the dominant survey method: surface surveys (1951 to 1987), and dive surveys (1988 to 2019). The ‘spawn index’ is not scaled by the spawn survey scaling parameter,  $q$ . Legend: ‘14&17’ is Statistical Areas 14 and 17 (excluding Section 173); ‘ESoG’ is eastern Strait of Georgia; ‘Lazo’ is above Cape Lazo; and ‘SDodd’ is South of Dodd Narrows

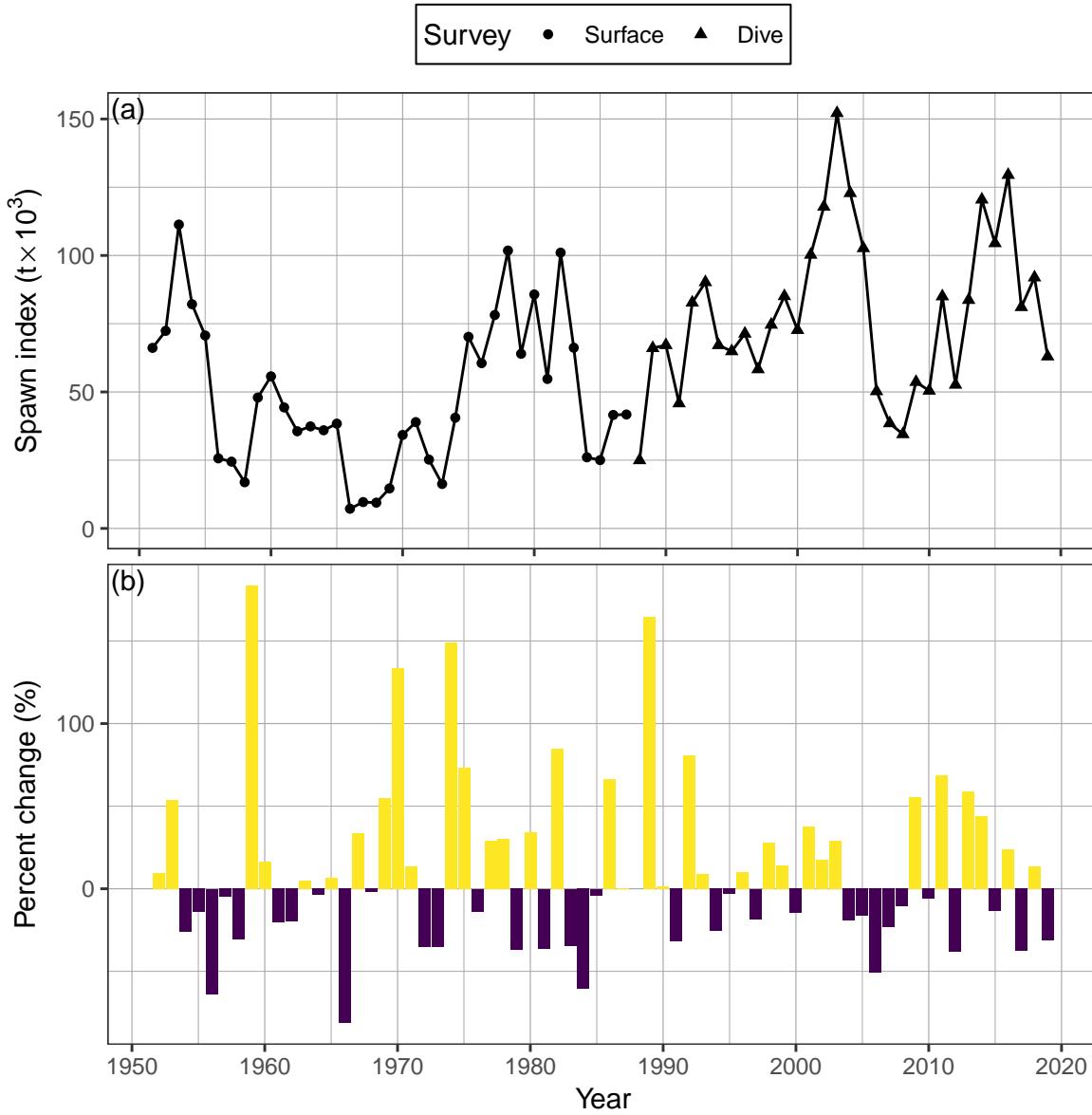


Figure 14. Time series of spawn index in thousands of metric tonnes ( $t \times 10^3$ ) for Pacific Herring from 1951 to 2019 in the Strait of Georgia major stock assessment region (SAR; panel a), and percent change (b). We calculate percent change as  $\delta_t = \frac{I_t - I_{t-1}}{I_{t-1}}$  where  $I_t$  is the spawn index in year  $t$ . The spawn index has two distinct periods defined by the dominant survey method: surface surveys (1951 to 1987), and dive surveys (1988 to 2019). The ‘spawn index’ is not scaled by the spawn survey scaling parameter,  $q$ .

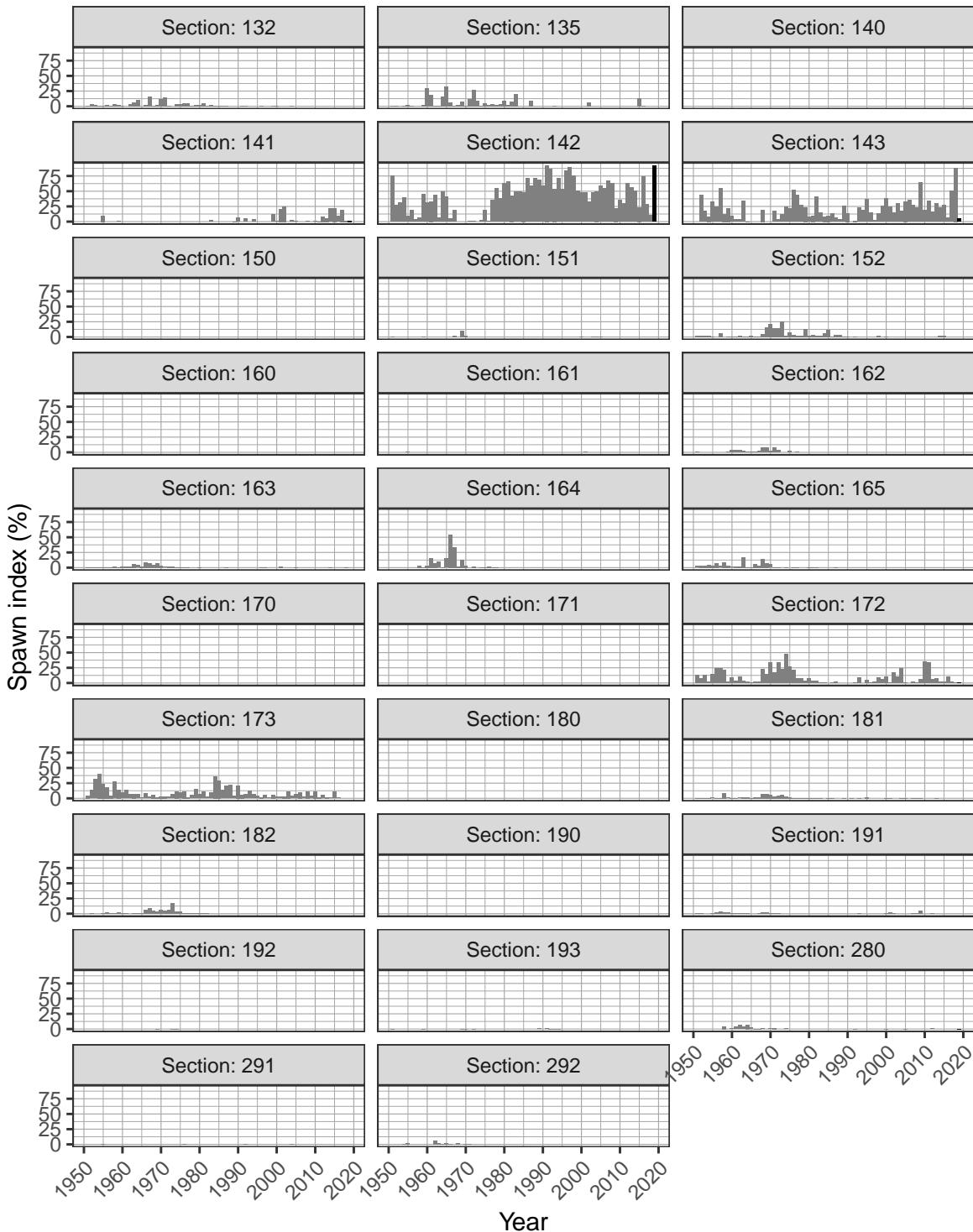


Figure 15. Time series of percent of spawn index by Section for Pacific Herring from 1951 to 2019 in the Strait of Georgia major stock assessment region (SAR). The year 2019 has a darker bar to facilitate interpretation. The spawn index has two distinct periods defined by the dominant survey method: surface surveys (1951 to 1987), and dive surveys (1988 to 2019). The ‘spawn index’ is not scaled by the spawn survey scaling parameter,  $q$ .

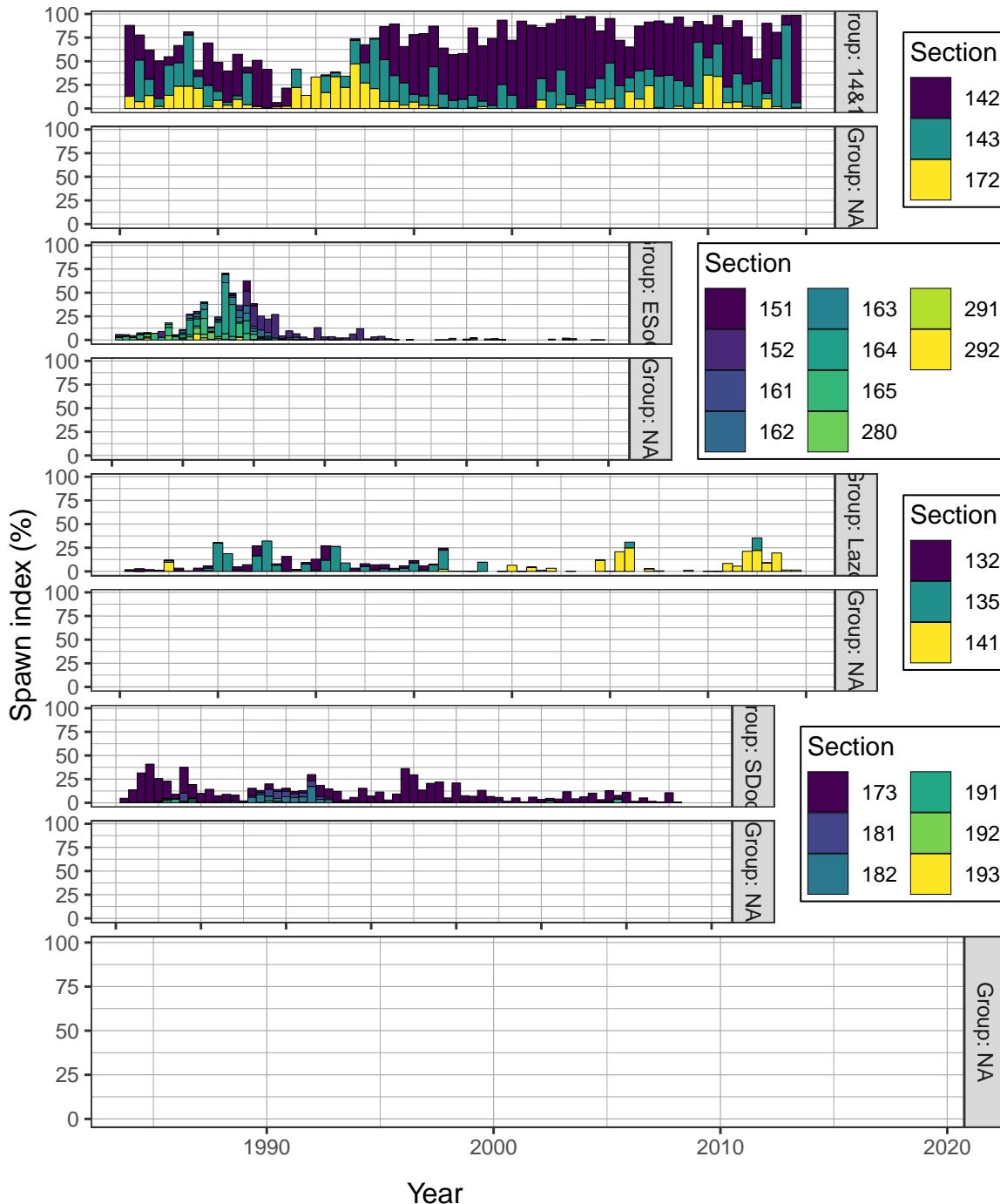


Figure 16. Time series of percent of spawn index by Group and Section for Pacific Herring from 1951 to 2019 in the Strait of Georgia major stock assessment region (SAR). The spawn index has two distinct periods defined by the dominant survey method: surface surveys (1951 to 1987), and dive surveys (1988 to 2019). The ‘spawn index’ is not scaled by the spawn survey scaling parameter,  $q$ . Legend: ‘14&17’ is Statistical Areas 14 and 17 (excluding Section 173); ‘ESoG’ is eastern Strait of Georgia; ‘Lazo’ is above Cape Lazo; and ‘SDodd’ is South of Dodd Narrows

Figure 17. Animation of Pacific Herring spawn survey locations and spawn index in metric tonnes (t) from 1951 to 2019 in the Strait of Georgia major stock assessment region (SAR; thick dashed lines), and associated Sections (Sec; thin solid lines). The spawn index has two distinct periods defined by the dominant survey method: surface surveys (1951 to 1987), and dive surveys (1988 to 2019). The ‘spawn index’ is not scaled by the spawn survey scaling parameter,  $q$ . Missing spawn index values (grey circles) indicate incomplete spawn surveys. The inset shows the total spawn index by year. Units: kilometres (km).