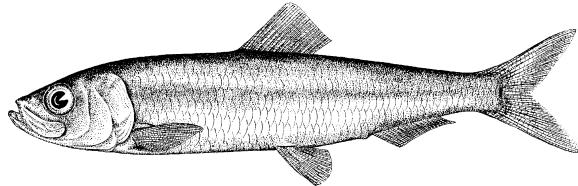


Pacific Herring preliminary data summary for Strait of Georgia 2020

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

Disclaimer This report contains preliminary data collected for Pacific Herring in 2020 in the Strait of Georgia major stock assessment regions (SAR). These data may differ from data used and presented in the final stock assessment.

1 COVID-19 pandemic

The COVID-19 pandemic impacted our ability to collect and analyse Pacific Herring data throughout British Columbia in 2020. The pandemic and associated provincial response changed rapidly during the Pacific Herring field program season. Despite these challenges, surveyors assessed all major observed spawns in the 5 major stock assessment regions (SARs). However, these changes impacted our ability to assess spawn in SARs with later spawns more than SARs with earlier spawns. For example, spawns were surveyed by surface surveys instead of underwater dive surveys in Prince Rupert District and Haida Gwaii.

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Although Pacific Herring biological samples were collected as usual, the pandemic delayed the analysis of biological data for all SARs. This delay is most notable for age data which are analysed at the sclerochronology lab at the Pacific Biological Station. This lab closed on March 16th, and resumed limited ageing analysis on July 6th. This has resulted in delayed provision of age data for Pacific Herring and many other species. To address this backlog efficiently, senior science staff and fisheries managers at DFO prioritized species to analyse in the sclerochronology lab.

We now have biological data for Pacific Herring in 2020. This updated version of the report contains biological data that was absent from the previous version. We appreciate your patience and understanding as we continue to work from home in these uncertain and changing times.

2 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 2020. 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.

The following is a description of data collected for Pacific Herring in 2020 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 2020 refers to the 2019/2020 Pacific Herring season.

3 Data collection programs

Biological samples were collected by the seine charter vessel “Denman Isle” for 27 days from February 20th to March 19th. Three additional Industry test vessels collected biological samples between February 27th to March 20th. The primary purpose of the test charter vessel was to collect biological samples from main bodies of herring in Statistical Areas 14 and 17, as identified from soundings.

Herring spawn locations were primarily identified with fixed-wing overflights conducted by DFO Resource Management Area staff. Fifteen flights were conducted this season, between February and April. Four dive charter vessels operated in the SoG:

- The “Viking Spirit” surveyed 21 days from March 13th to April 2nd,
- The “Ocean Cloud” surveyed 12 days from March 12th to March 23rd,
- The “Seaveyor” surveyed 1 day on the Sunshine Coast on March 2nd, and
- A-Tlegay divers surveyed Statistical Area 13 on March 2nd.

The first three dive vessels and the seine charter vessel “Denman Isle” were funded by DFO, through a contract to the Herring Conservation Research Society. A-Tlegay divers were funded by AFS. Additional sampling and sounding efforts conducted through the Industry Test Program were funded by the Herring Industry.

4 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 2020 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 2020, 132 Pacific Herring biological samples were collected and processed for the Strait of Georgia major SAR (Table 5, Table 6), and a total of 5,791 Pacific Herring were aged in 2020. 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). We also show the percent change in weight and length for age-3 and age-6 fish (Figure 8 & Figure 9, 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.

5 Spawn survey data

Pacific Herring spawn surveys were conducted at 52 individual locations in 2020 in the Strait of Georgia major SAR (Table 8, and Figure 10). A summary of spawn from the last decade (2010 to 2019) is shown in Figure 11. Figure 12 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 13, Figure 14, Figure 15, Figure 16, Table 9, and Figure 17). See the [draft spawn index technical report](#) for calculations to convert SOK harvest to spawning biomass. 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 2020).

Some Pacific Herring Sections contribute more than others to the total spawn index, and the percentage contributed by Section varies yearly (Figure 16b, Figure 18). For example, in 2020, Section 143 contributed the most to the spawn index (43%). As with Sections, some Groups contribute more than others to the total spawn index (Figure 16c, Figure 19). An animation shows the spawn index by spawn survey location from 1951 to 2020 (Figure 20).

6 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:

- As planned, the assessment program included a seine charter, two dive boats, and a management platform.
- All major observed spawns were surveyed.
- Overall spawn and fishery timing was average in 2020, with the exception of a late spawn in Sechelt Inlet.
- The overall length of spawn observed during the flight program was similar to recent years, however there were fewer flights this year.
- Spawn in the Strait of Georgia was observed along most of the East coast of Vancouver Island from Shelter Point to Neck Point, and around Denman and Hornby Islands.
- Most of the Strait of Georgia spawn was between Qualicum Bay and Cape Lazo, and along the West side of Denman Island. As with recent years, some late spawn was observed around Hornby and Denman Islands, with the addition of extensive spawn between Blunden Point and Icarus Point near Nanaimo.

- Additional spawn was reported in Areas 15, 16, and 18. Spawn was also reported in Area 17 south (Mudge Island, Cedar, and Yellow Point), a change from an absence in these areas in recent years.
- The presence of sea lions in the Strait of Georgia during the herring season continues to grow, and impacts the ability to obtain biological samples in some areas and times. A small number of Humpback Whales were also observed.
- In Puget Sound, the preliminary estimate of herring spawning biomass is 17,635 tonnes. This is the highest biomass since 1980, and is an underestimate because some areas were not surveyed due to COVID-19.

7 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&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	14&17
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	14&17
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 2020 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 are not included. Note: data may be withheld due to privacy concerns (WP).

Gear	Catch (t)
Other	2,193
RoeSN	1,831
RoeGN	6,415

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 2010 to 2020 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: data may be withheld due to privacy concerns (WP).

Year	Harvest (lb)	Spawning biomass (t)
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
2020	0	0

Table 5. Number of Pacific Herring biological samples processed from 2010 to 2020 in the Strait of Georgia major stock assessment region (SAR). Each sample is approximately 100 fish.

Year	Number of samples		
	Commercial	Test	Total
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
2020	106	26	132

Table 6. Number and type of Pacific Herring biological samples processed in 2020 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	57
Commercial	Seine	Bait fishery	10
Commercial	Seine	Food fishery	16
Commercial	Seine	Roe fishery	23
Test	Seine	Test fishery	26

Table 7. Observed proportion-at-age for Pacific Herring from 2010 to 2020 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	
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	
2020	0.125	0.527	0.209	0.082	0.036	0.017	0.004	0.002	0.000	

Table 8. Pacific Herring spawn survey locations, start date, and spawn index in metric tonnes (t) in 2020 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	Smelt Bay	March 10	1,080
	14	Kitty Coleman Beach	February 21	5,041
	14	Kye Bay	March 08	4,043
	14	Little Rvr	March 08	60
	14	Oyster Bay	March 08	1,880
	14	Oyster Rvr	March 08	2,504
	14	Seal Bay+	March 08	25
	14	Baynes Snd	March 08	537
	14	Boyle Pt	March 09	177
	14	Cape Lazo	March 08	5,094
	14	Fillongley Park	March 06	2,389
	14	Gartley Pt	March 08	60
	14	Goose Spit	March 08	55
	14	Gravelly Bay	March 09	459
	14	Komas Bluff	March 06	12,289
	14	Seal Islets	March 06	5,878
	14	Tralee Pt	March 06	1,791
	14	Whalebone Pt	March 08	3,240
	14	Whaling Station Bay	March 09	2,133
	14	Willemar Bluff	March 08	126
	14	Big Qualicum Rvr	March 08	12,254
	14	Bowser	March 12	83
	14	Columbia Beach	March 08	7,196
	14	Cottam Pt	March 19	1,283
	14	Englishman Rvr	March 17	3,280
	14	French Cr	March 08	8,798
	14	Little Qualicum Rvr	March 08	628
	14	Madrona Pt	March 19	1,309
	14	Northwest Bay	March 19	2,522
	14	Nuttal Bay	March 19	1,694
	14	Parksville Bay	March 10	3,852
	14	Qualicum Bay	March 09	2,050
	14	Qualicum Beach	March 10	3,710
	14	Rathetrevor Beach	March 17	977
	15	Grief Pt	March 08	915
	15	Hernando Is	March 10	1,791
	15	Lang Bay	March 08	1,041
	15	Myrtle Pt (Cr, Rks)	March 08	8,288

Table 8 continued

Statistical Area	Section	Location name	Start date	Spawn index (t)
15	152	Scuttle Bay	February 25	356
16	162	Blind Bay	January 30	NA
16	163	Pender Hrbr	January 24	NA
16	165	Salmon Inlt	March 23	234
17	172	Dorcas Pt	March 19	1,738
17	172	Icarus Pt	March 30	819
17	172	Lantzville	April 06	47
17	172	Nankivell Pt	March 19	658
17	172	Neck Pt	April 06	514
17	172	Sunrise Beach +	March 30	395
17	173	Cedar Ramp +	April 08	266
17	173	Mudge Is	April 11	557
28	280	False Cr	February 06	38
28	280	Indian Arm	May 18	NA

Table 9. Summary of Pacific Herring spawn survey data from 2010 to 2020 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 2020). 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)
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	82,865	140	1.1	63,038
2020	154,345	133	1.4	116,151

8 Figures

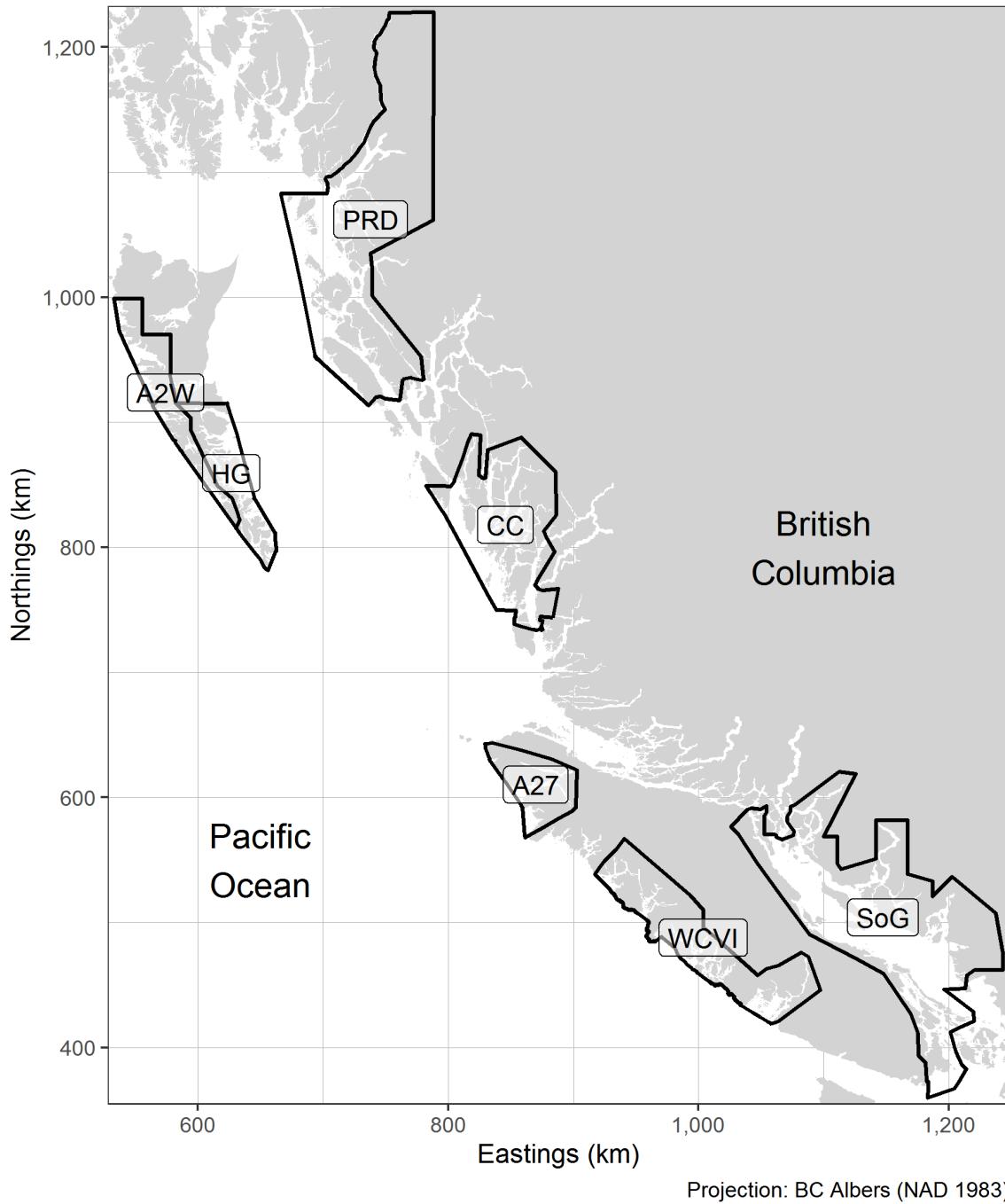


Figure 1. Boundaries for the Pacific Herring stock assessment regions (SARs) in British Columbia. There are 5 major SARs: Haida Gwaii (HG), Prince Rupert District (PRD), Central Coast (CC), Strait of Georgia (SoG), and West Coast of Vancouver Island (WCVI). There are 2 minor SARs: Area 27 (A27) and Area 2 West (A2W). Units: kilometres (km).

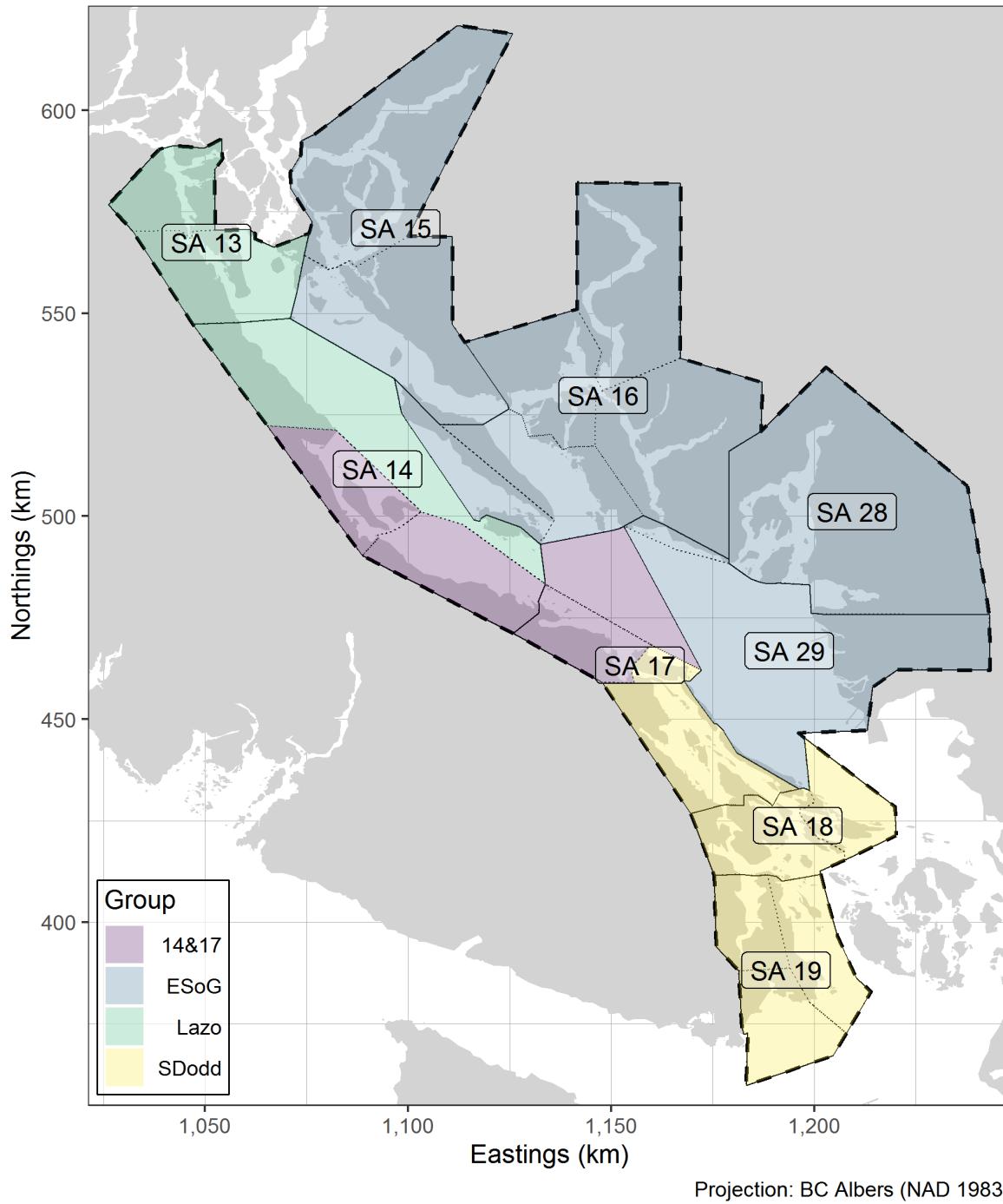


Figure 2. Boundaries for the Strait of Georgia major stock assessment region (SAR; thick dashed lines), associated Statistical Areas (SA; thin solid lines), and associated Sections (thin dotted lines). Units: kilometres (km). Legend: '14&17' is Statistical Areas 14 and 17 (excluding Section 173); 'ESoG'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

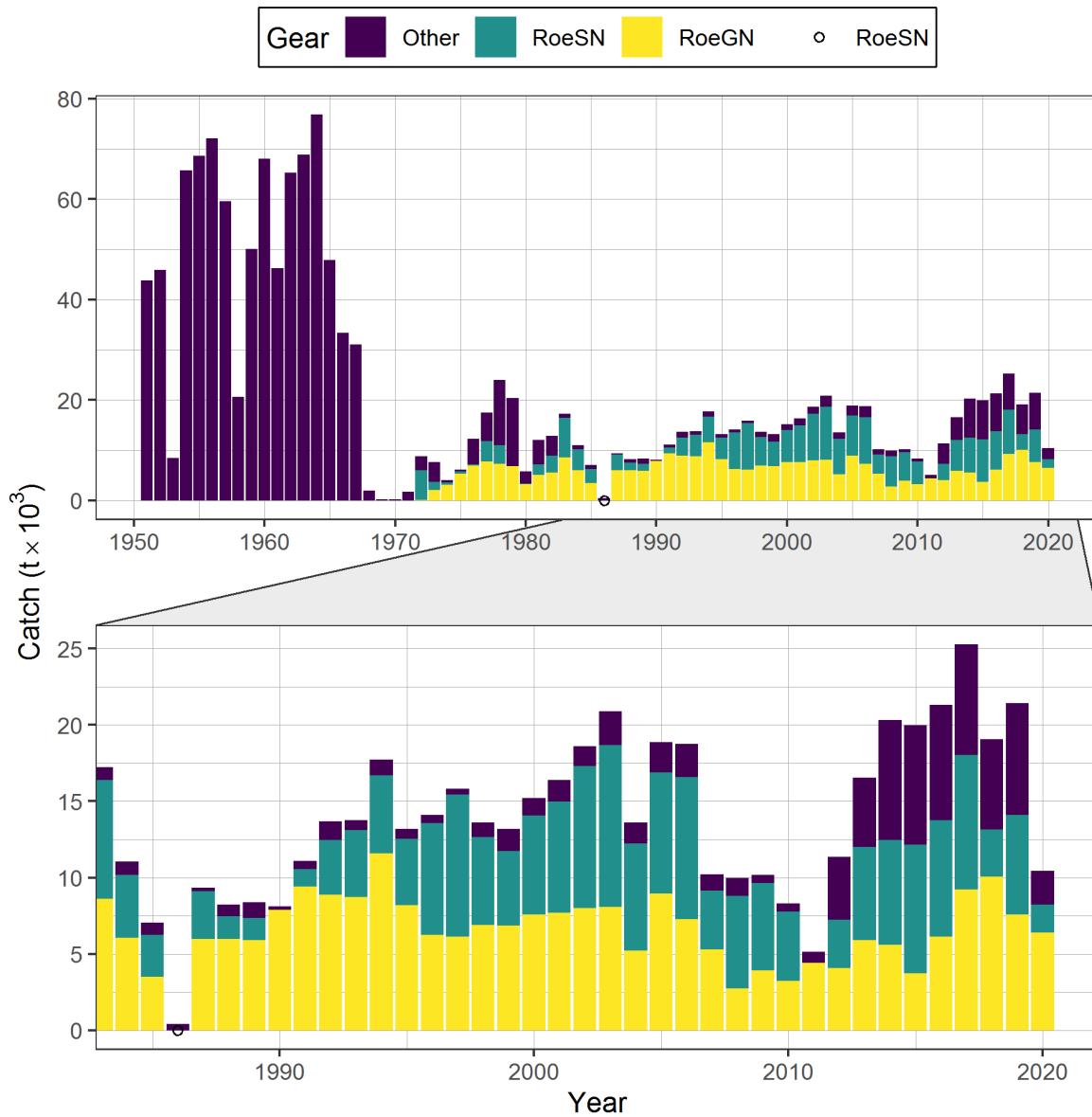


Figure 3. Time series of total landed catch in thousands of metric tonnes ($t \times 10^3$) of Pacific Herring by gear type from 1951 to 2020 in the Strait of Georgia major stock assessment region (SAR). Legend: ‘Other’ represents the reduction, the food and bait, as well as the special use fishery; ‘RoeSN’ represents the roe seine fishery; and ‘RoeGN’ represents the roe gillnet fishery. Data from the spawn-on-kelp (SOK) fishery are not included. Note: symbols indicate years in which catch by gear type (i.e., Other, RoeSN, RoeGN) is withheld due to privacy concerns.

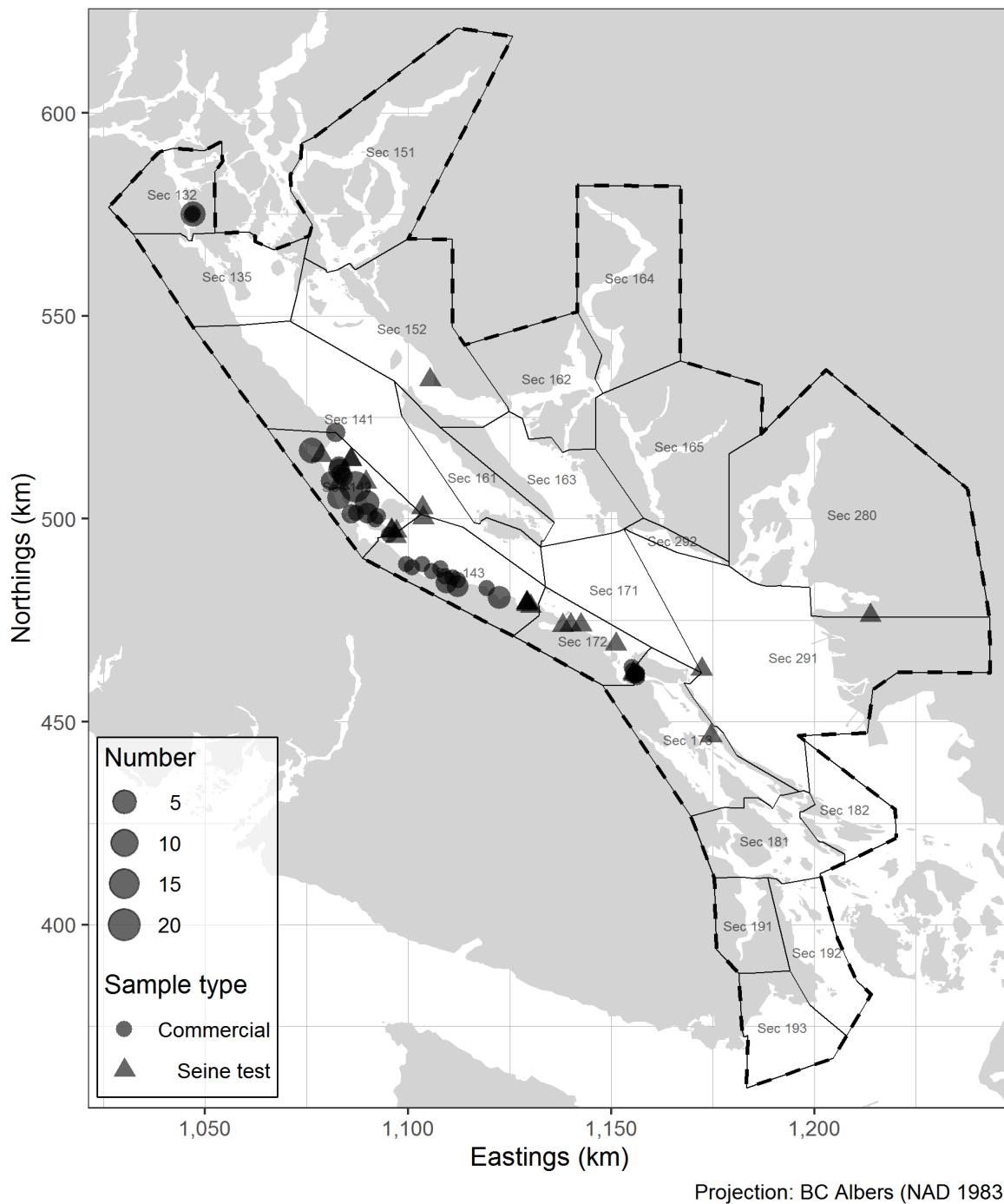


Figure 4. Location and type of Pacific Herring biological samples collected in 2020 in the Strait of Georgia major stock assessment region (SAR; thick dashed lines), and associated Sections (Sec; thin solid lines). Units: kilometres (km).

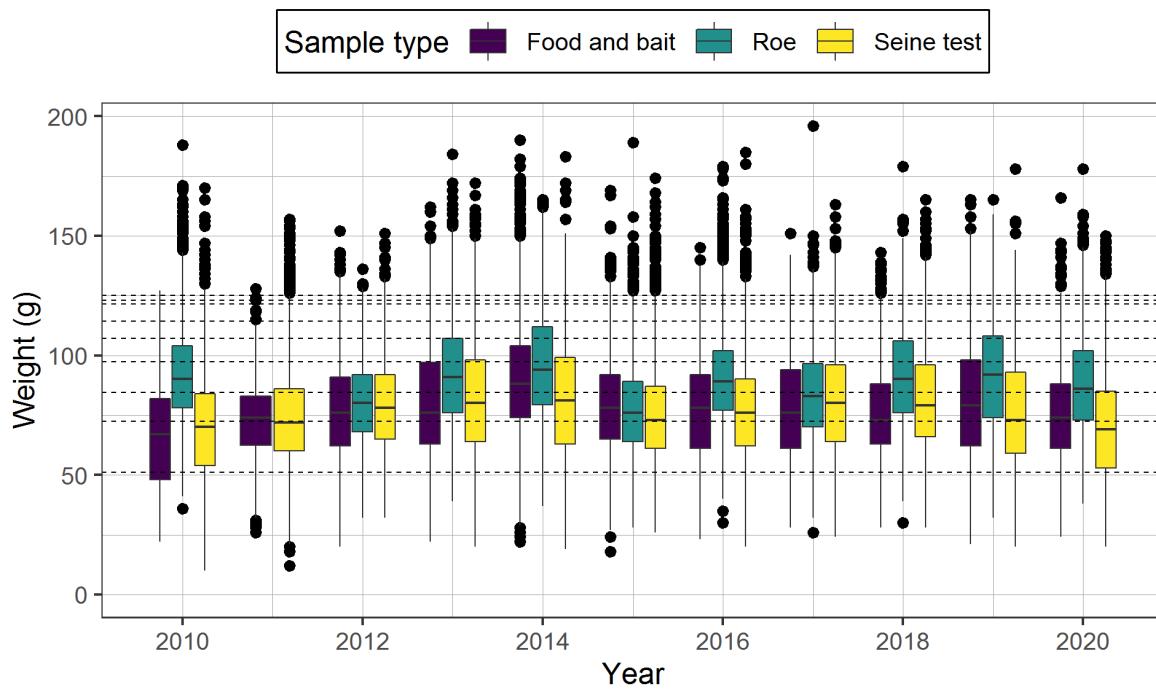


Figure 5. Time series of weight in grams (g) of Pacific Herring by sample type from 2010 to 2020 in the Strait of Georgia major stock assessment region (SAR) in Statistical Areas 14 and 17. The outer edges of the boxes indicate the 25th and 75th percentiles, and the middle lines indicate the 50th percentiles (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.

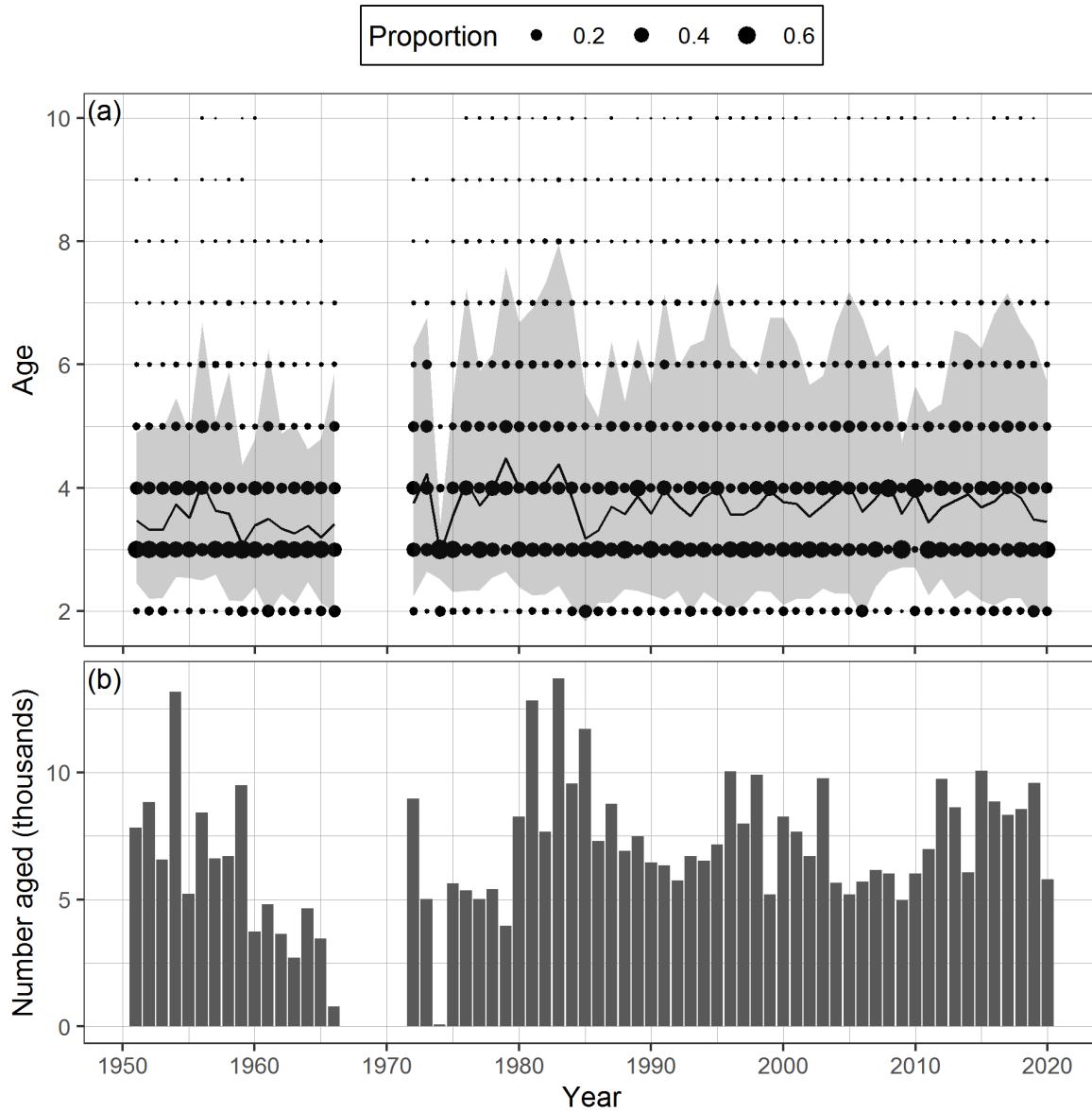


Figure 6. Time series of observed proportion-at-age (a) and number aged in thousands (b) of Pacific Herring from 1951 to 2020 in the Strait of Georgia major stock assessment region (SAR). The black line is the mean age, and the shaded area is the approximate 90% distribution. Biological summaries only 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.

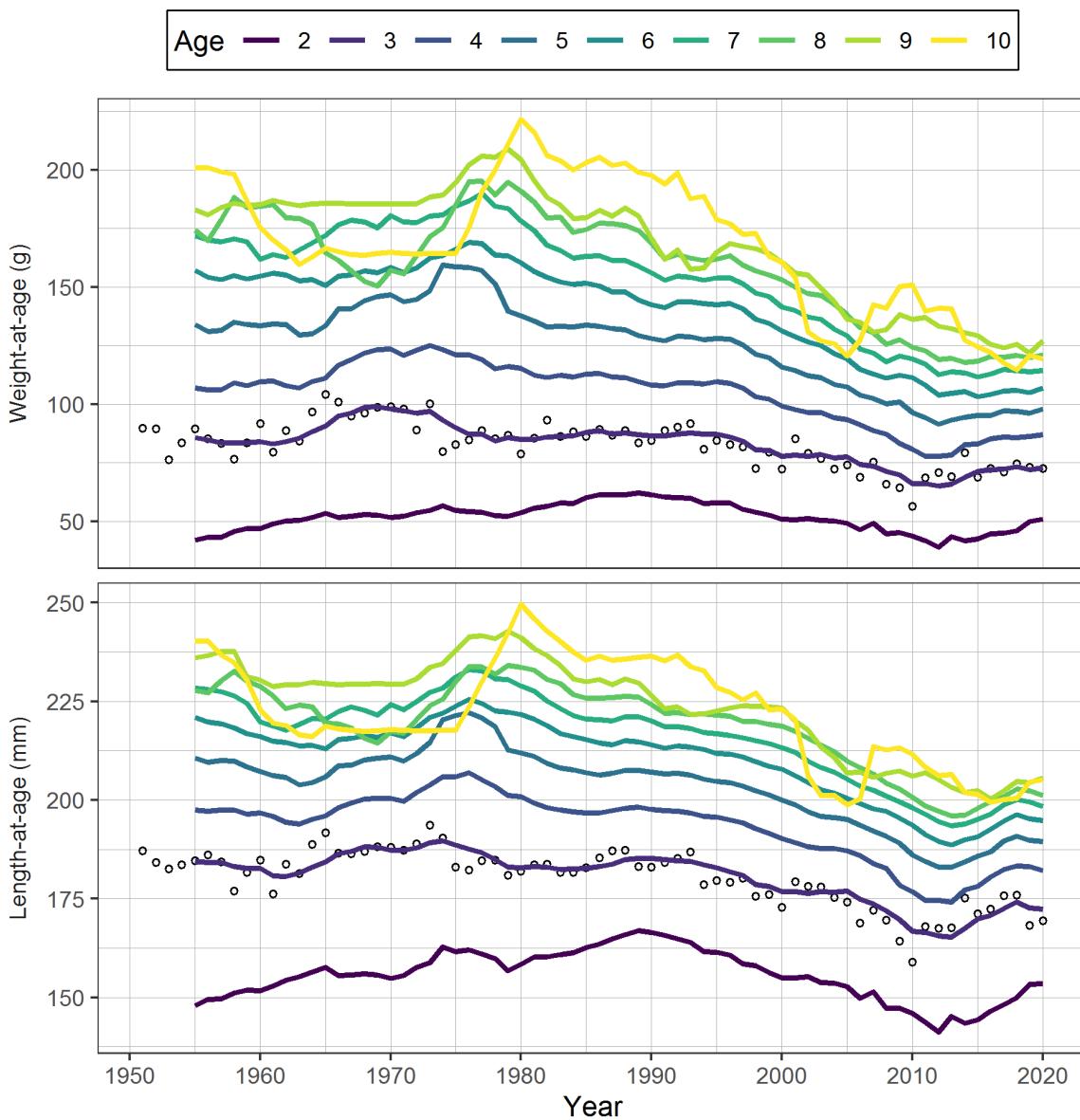


Figure 7. Time series of weight-at-age in grams (g) and length-at-age in millimetres (mm) for age-3 (circles) and 5-year running mean weight- and length-at-age (lines) for Pacific Herring from 1951 to 2020 in the Strait of Georgia major stock assessment region (SAR). Missing weight- and length-at-age 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.

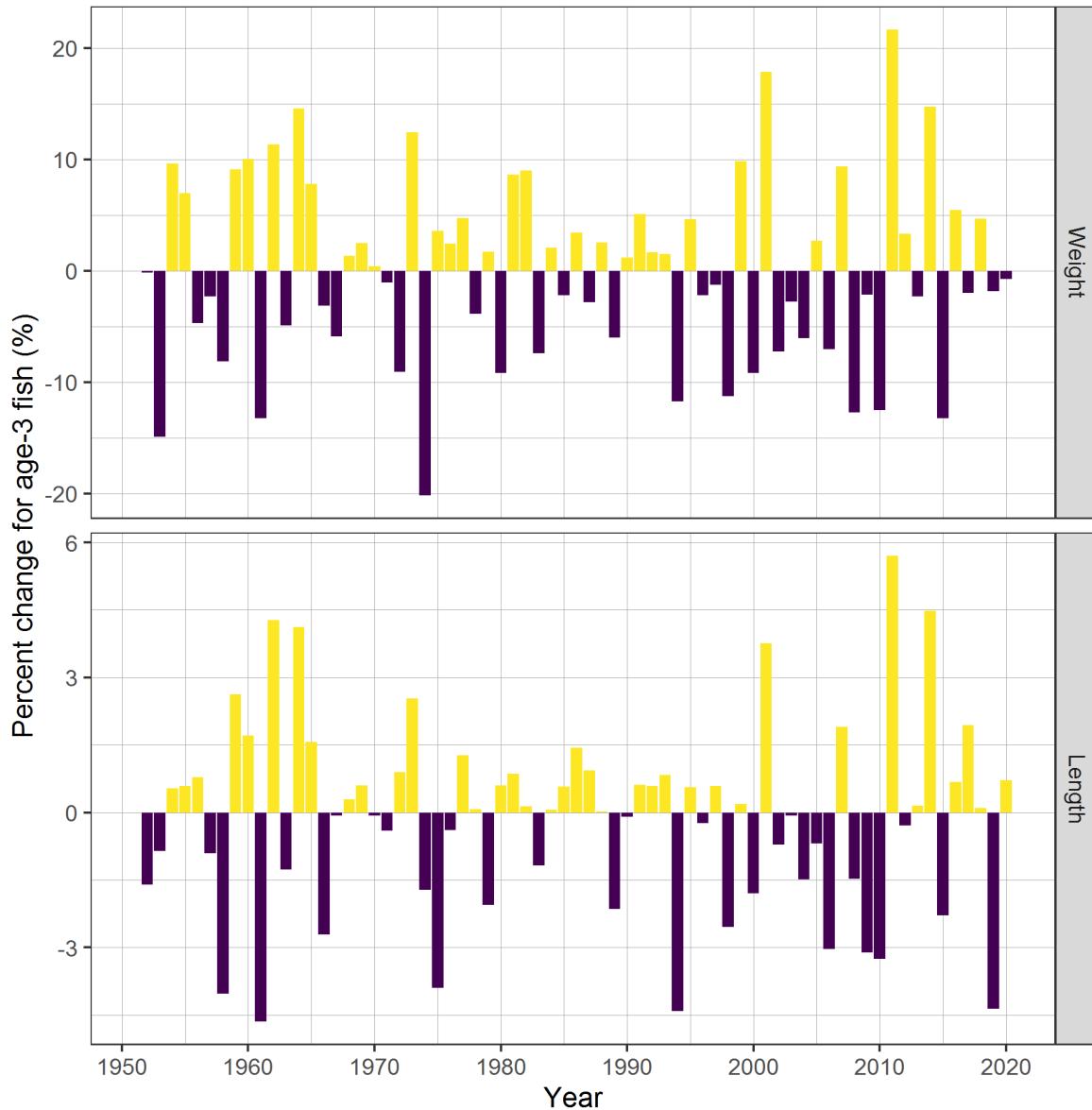


Figure 8. Time series of percent change (%) in weight and length for age-3 fish for Pacific Herring from 1951 to 2020 in the Strait of Georgia major stock assessment region (SAR). Percent change is $\delta_t = \frac{\alpha_t - \alpha_{t-1}}{\alpha_{t-1}}$ where α_t is the weight and length of age-3 fish, respectively, in year t . Biological summaries only include samples collected using seine nets (commercial and test) due to size-selectivity of other gear types such as gillnet.

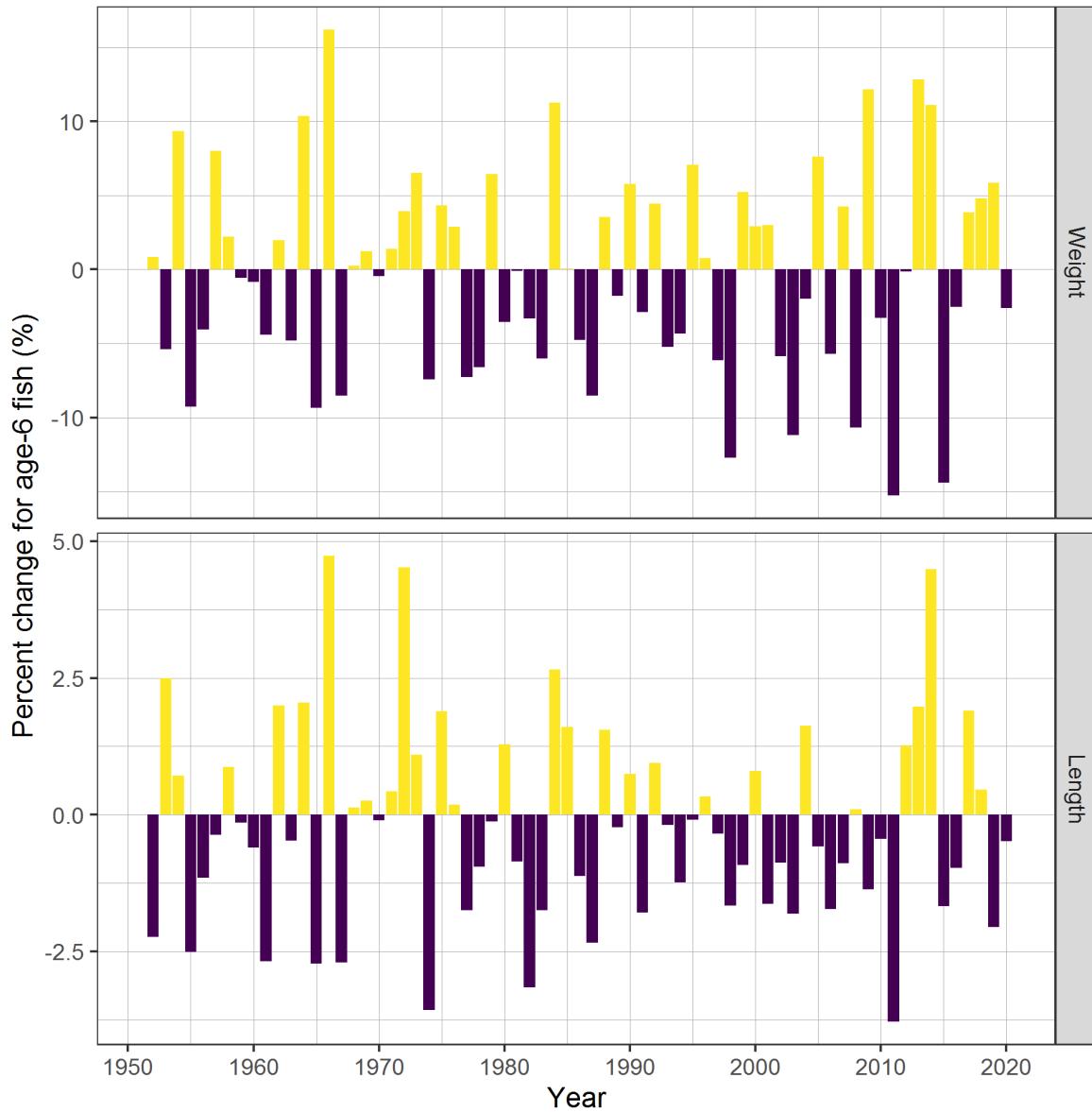


Figure 9. Time series of percent change (%) in weight and length for age-6 fish for Pacific Herring from 1951 to 2020 in the Strait of Georgia major stock assessment region (SAR). Percent change is $\delta_t = \frac{\alpha_t - \alpha_{t-1}}{\alpha_{t-1}}$ where α_t is the weight and length of age-6 fish, respectively, in year t . Biological summaries only include samples collected using seine nets (commercial and test) due to size-selectivity of other gear types such as gillnet.

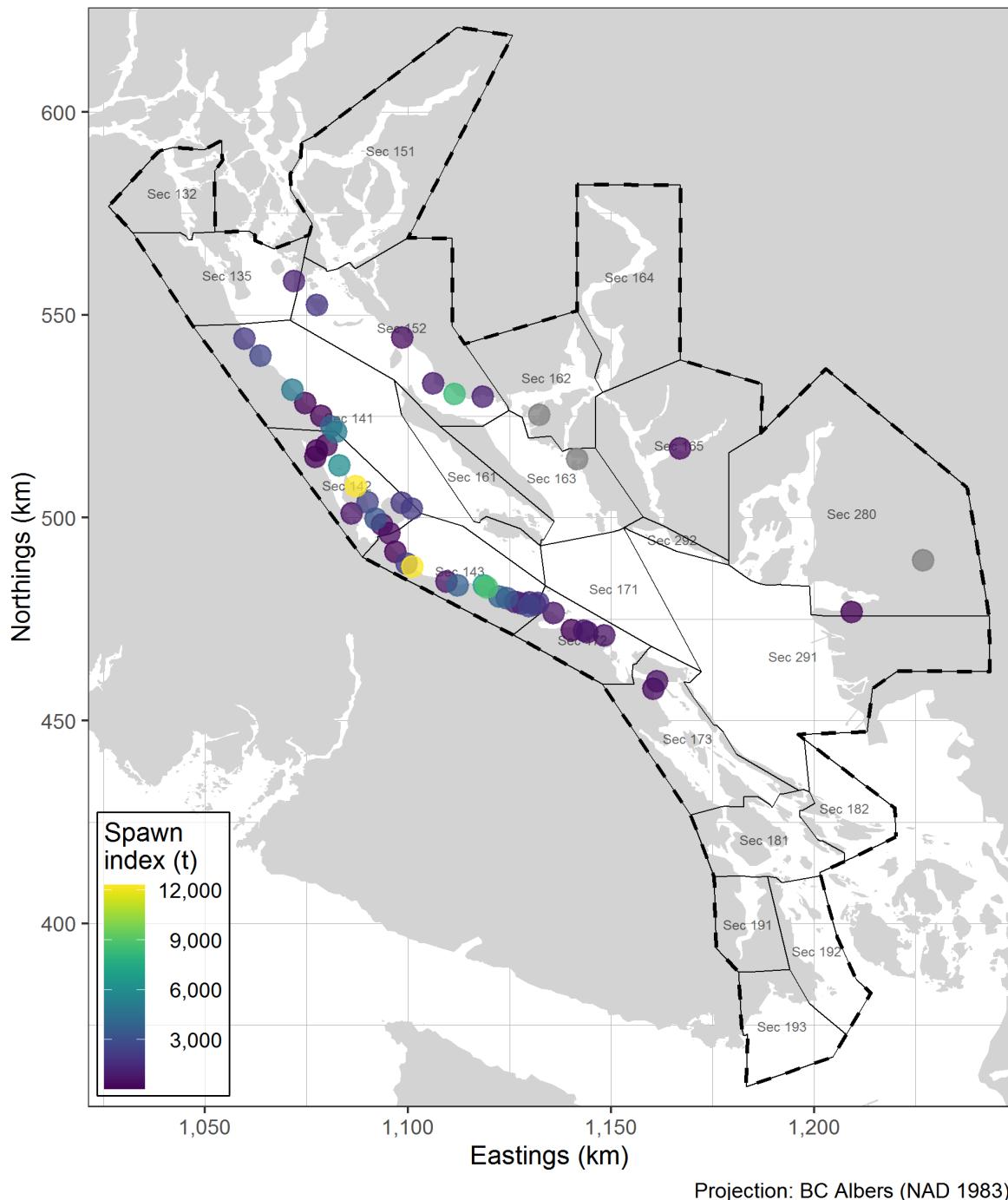


Figure 10. Pacific Herring spawn survey locations, and spawn index in metric tonnes (t) in 2020 in the Strait of Georgia major stock assessment region (SAR; thick dashed lines), and associated Sections (Sec; thin solid lines). The ‘spawn index’ is not scaled by the spawn survey scaling parameter, q . Missing spawn index values (grey circles) indicate incomplete spawn surveys. Units: kilometres (km).

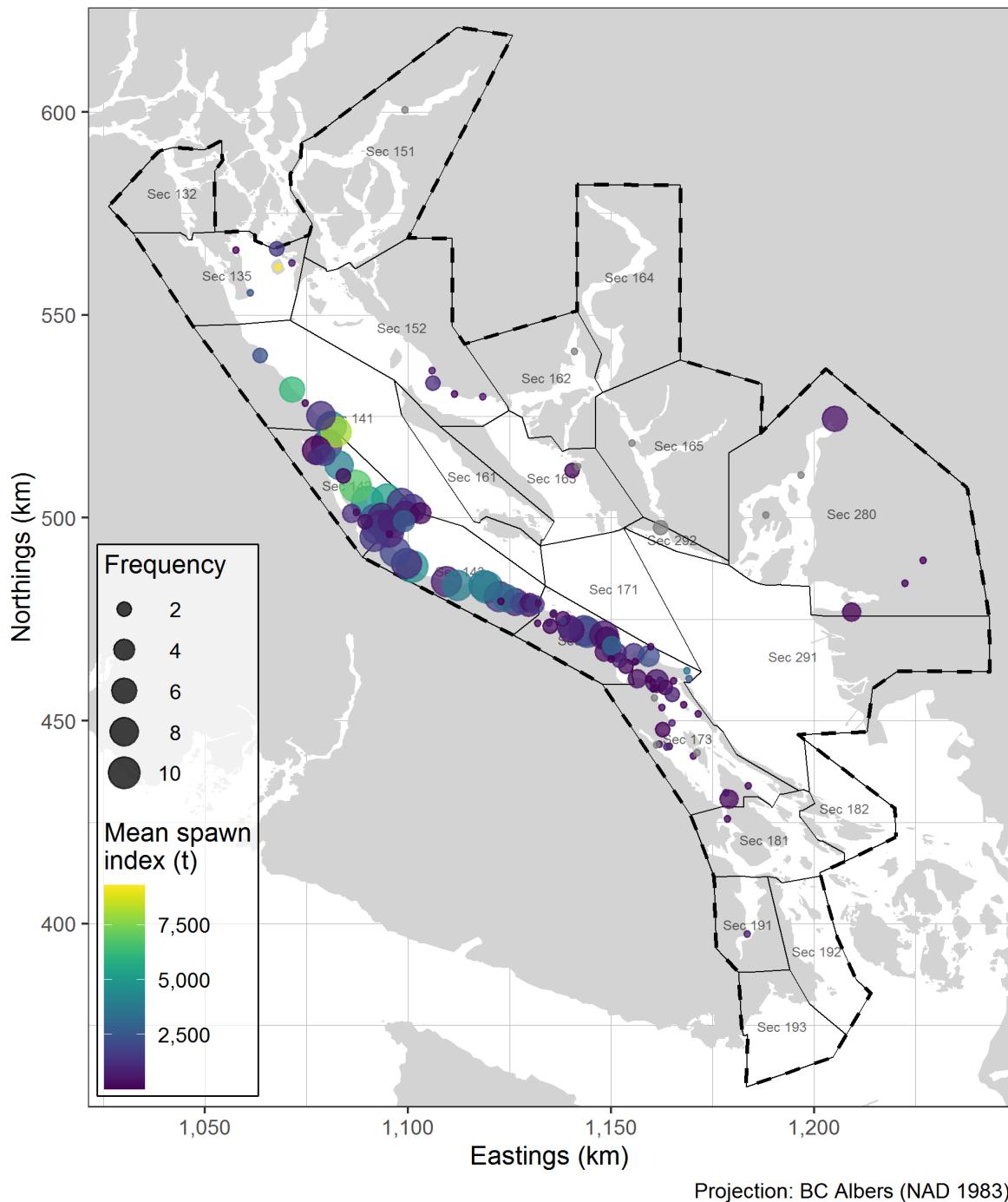


Figure 11. Pacific Herring spawn survey locations, mean spawn index in metric tonnes (t), and spawn frequency from 2010 to 2019 in the Strait of Georgia major stock assessment region (SAR; thick dashed lines), and associated Sections (Sec; thin solid lines). The ‘spawn index’ is not scaled by the spawn survey scaling parameter, q . Missing spawn index values (grey circles) indicate incomplete spawn surveys. Units: kilometres (km).

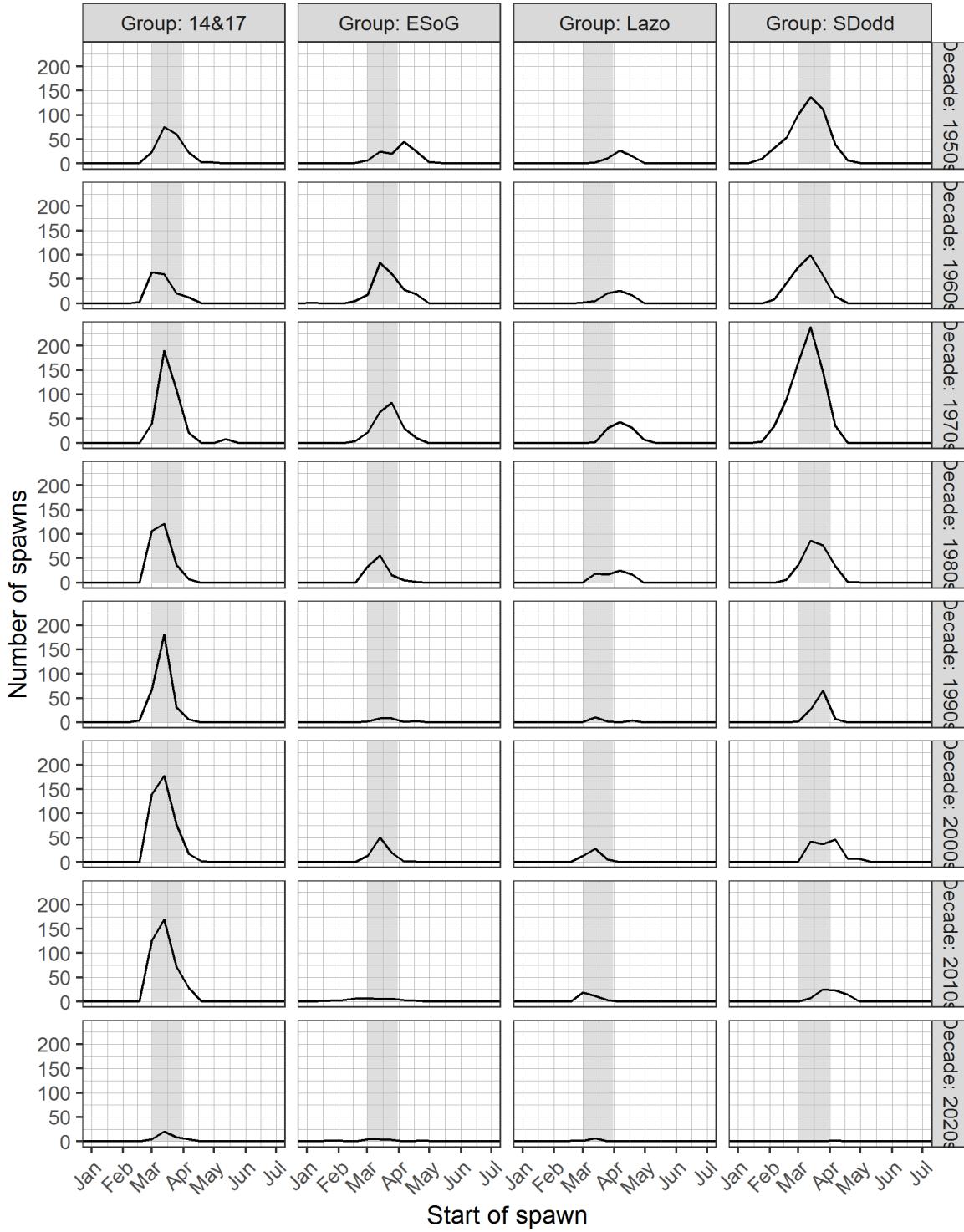


Figure 12. Pacific Herring spawn start date by decade and Group. Grey shaded regions indicate March 1st to 31st. Note that spawn size and intensity varies; therefore the number of spawns is not directly proportional to spawn extent or biomass. Legend: '14&17' is Statistical Areas 14 and 17 (excluding Section 173); 'ESoG' is eastern Strait of Georgia; 'Lazo' is above Cape Lazo; and 'SDodd' is South of Dodd Narrows

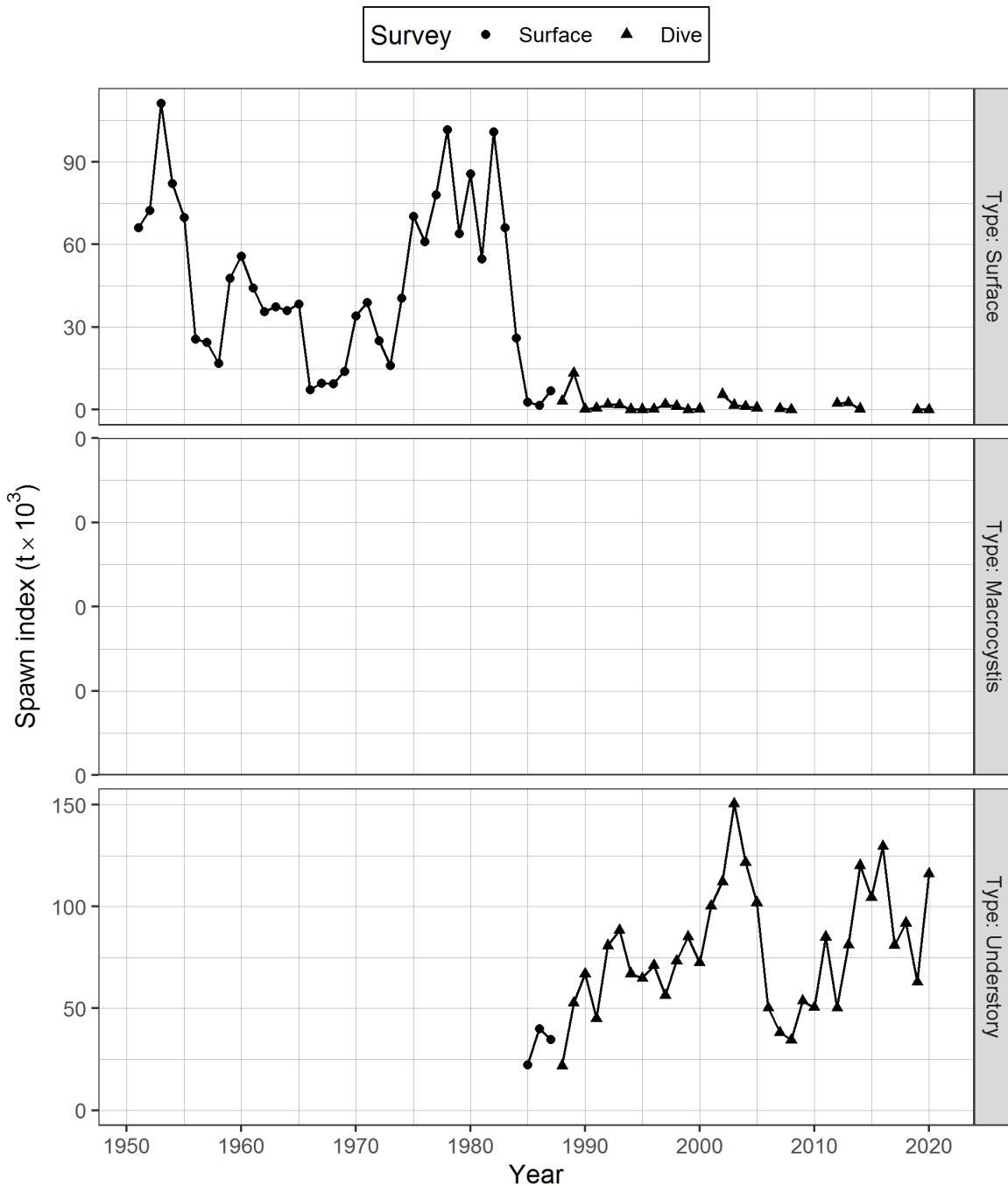


Figure 13. Time series of spawn index in thousands of metric tonnes ($t \times 10^3$) by type for Pacific Herring from 1951 to 2020 in the Strait of Georgia major stock assessment region (SAR). There are three types of spawn survey observations: observations of spawn taken from the surface usually at 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 2020).

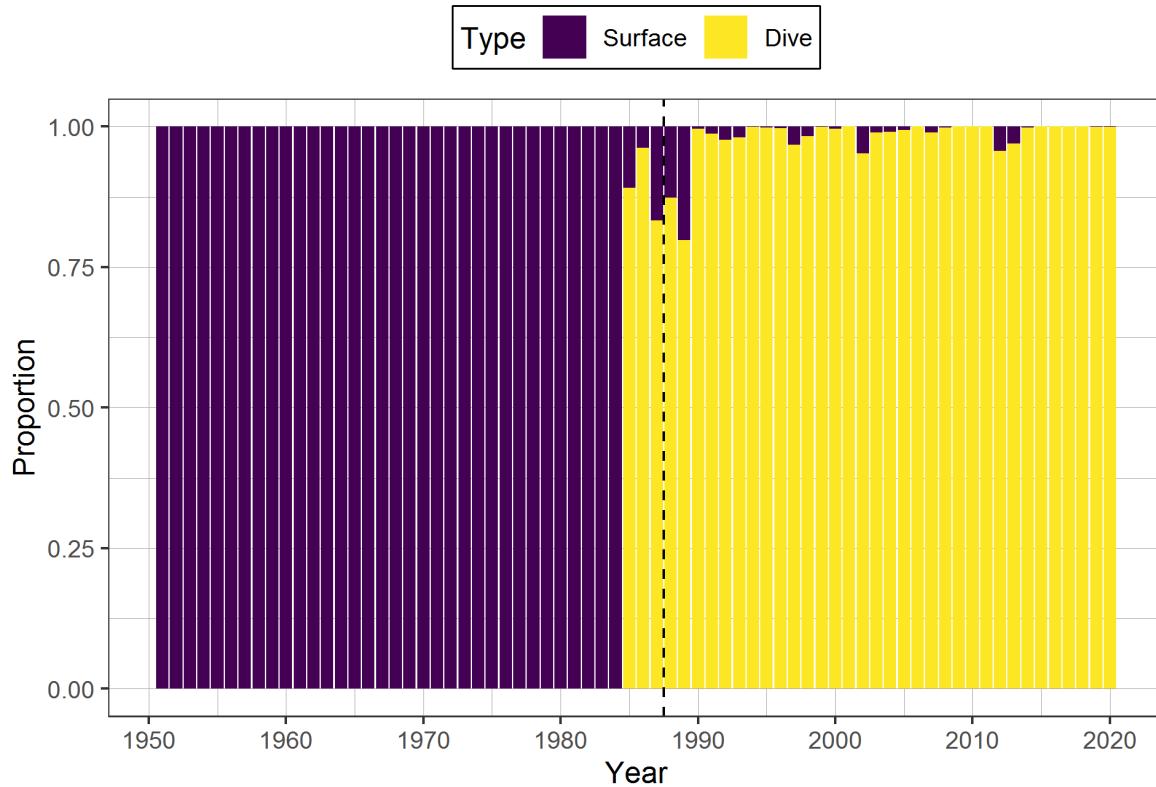


Figure 14. Time series of proportion of spawn index by surface and dive surveys for Pacific Herring from 1951 to 2020 in the Strait of Georgia major stock assessment region (SAR). The spawn index has two distinct periods defined by the dominant survey method: surface surveys (1951 to 1987), and dive surveys (1988 to 2020).

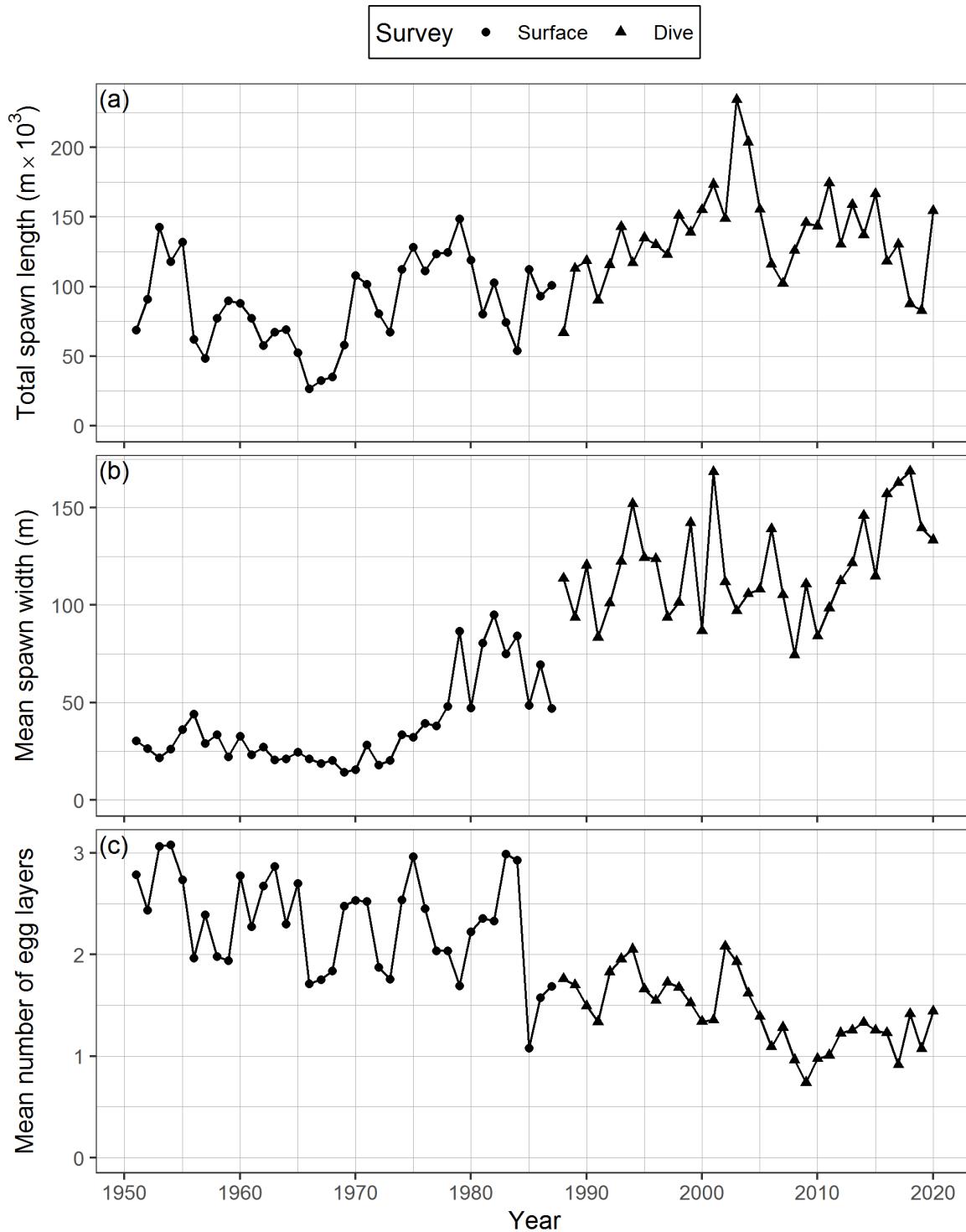


Figure 15. Time series of total spawn length in thousands of metres ($m \times 10^3$; panel a), mean spawn width in metres (b), and mean number of egg layers (c) for Pacific Herring from 1951 to 2020 in the Strait of Georgia major stock assessment region (SAR). The spawn index has two distinct periods defined by the dominant survey method: surface surveys (1951 to 1987), and dive surveys (1988 to 2020).

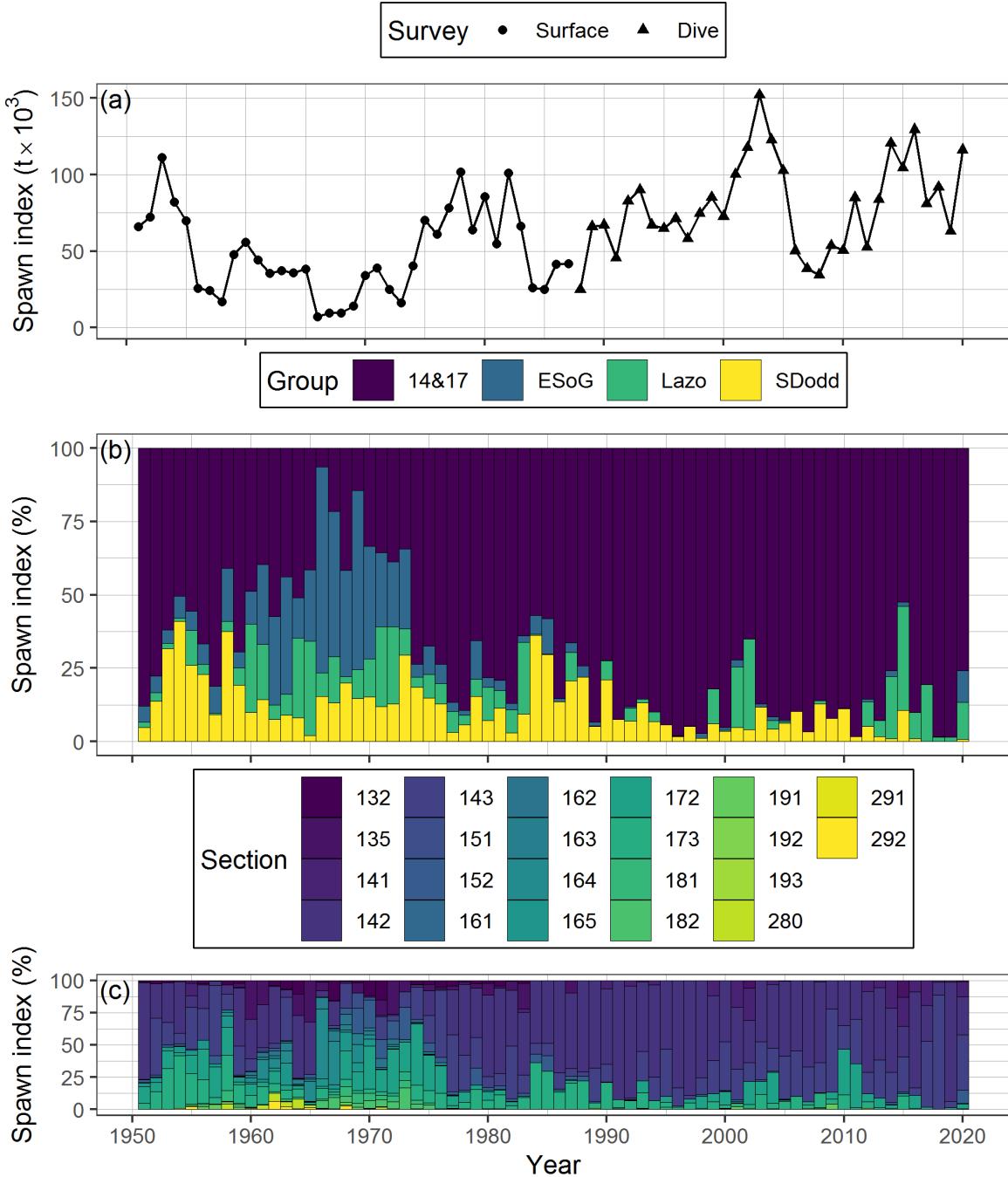


Figure 16. Time series of spawn index in thousands of metric tonnes ($t \times 10^3$) for Pacific Herring from 1951 to 2020 in the Strait of Georgia major stock assessment region (SAR; panel a), as well as percent contributed by Group, and Section (b, & c, respectively). The spawn index has two distinct periods defined by the dominant survey method: surface surveys (1951 to 1987), and dive surveys (1988 to 2020). 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

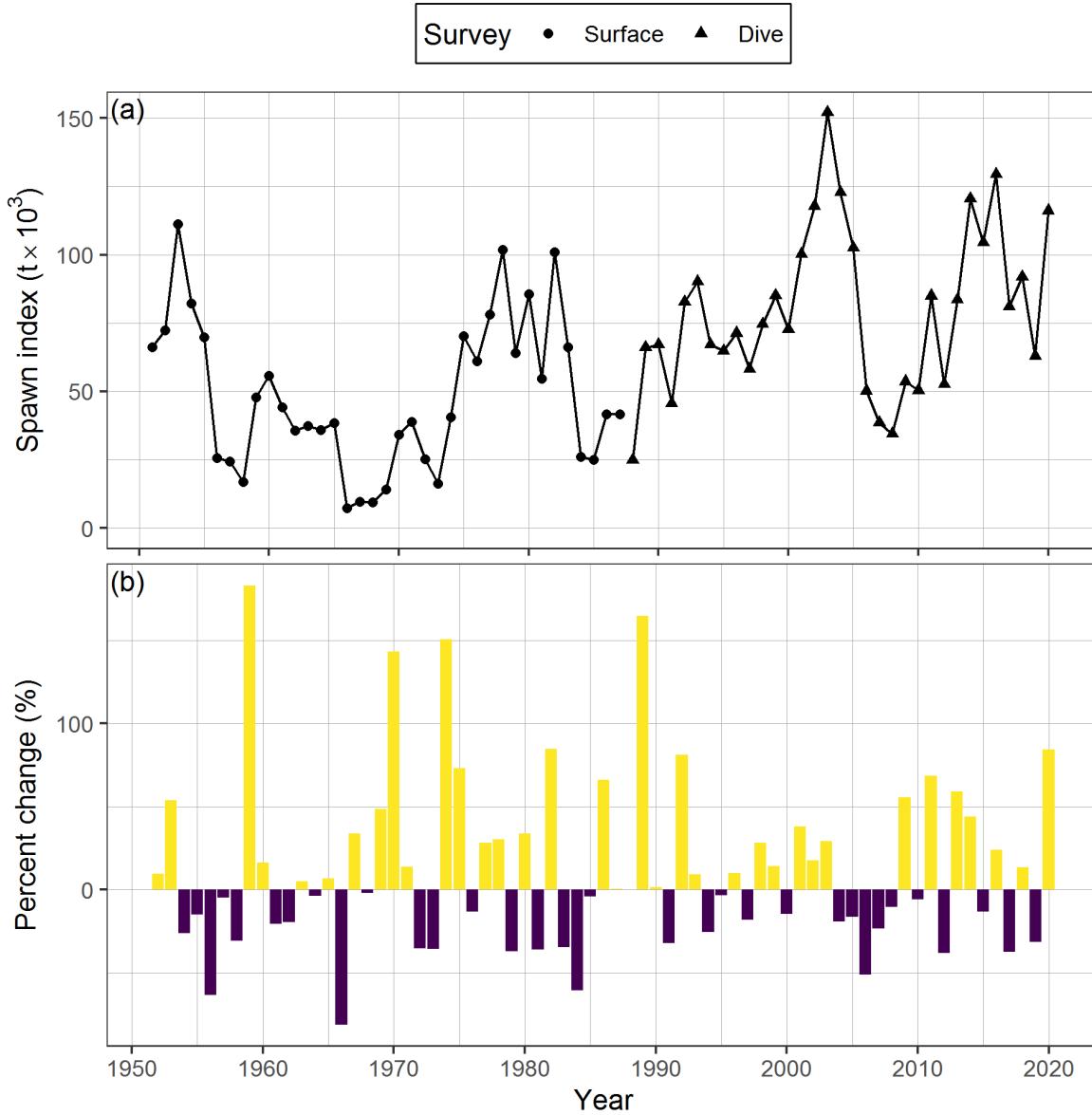


Figure 17. Time series of spawn index in thousands of metric tonnes ($t \times 10^3$) for Pacific Herring from 1951 to 2020 in the Strait of Georgia major stock assessment region (SAR; panel a), and percent change (b). Percent change is $\delta_t = \frac{\alpha_t - \alpha_{t-1}}{\alpha_{t-1}}$ where α_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 2020). The ‘spawn index’ is not scaled by the spawn survey scaling parameter, q .

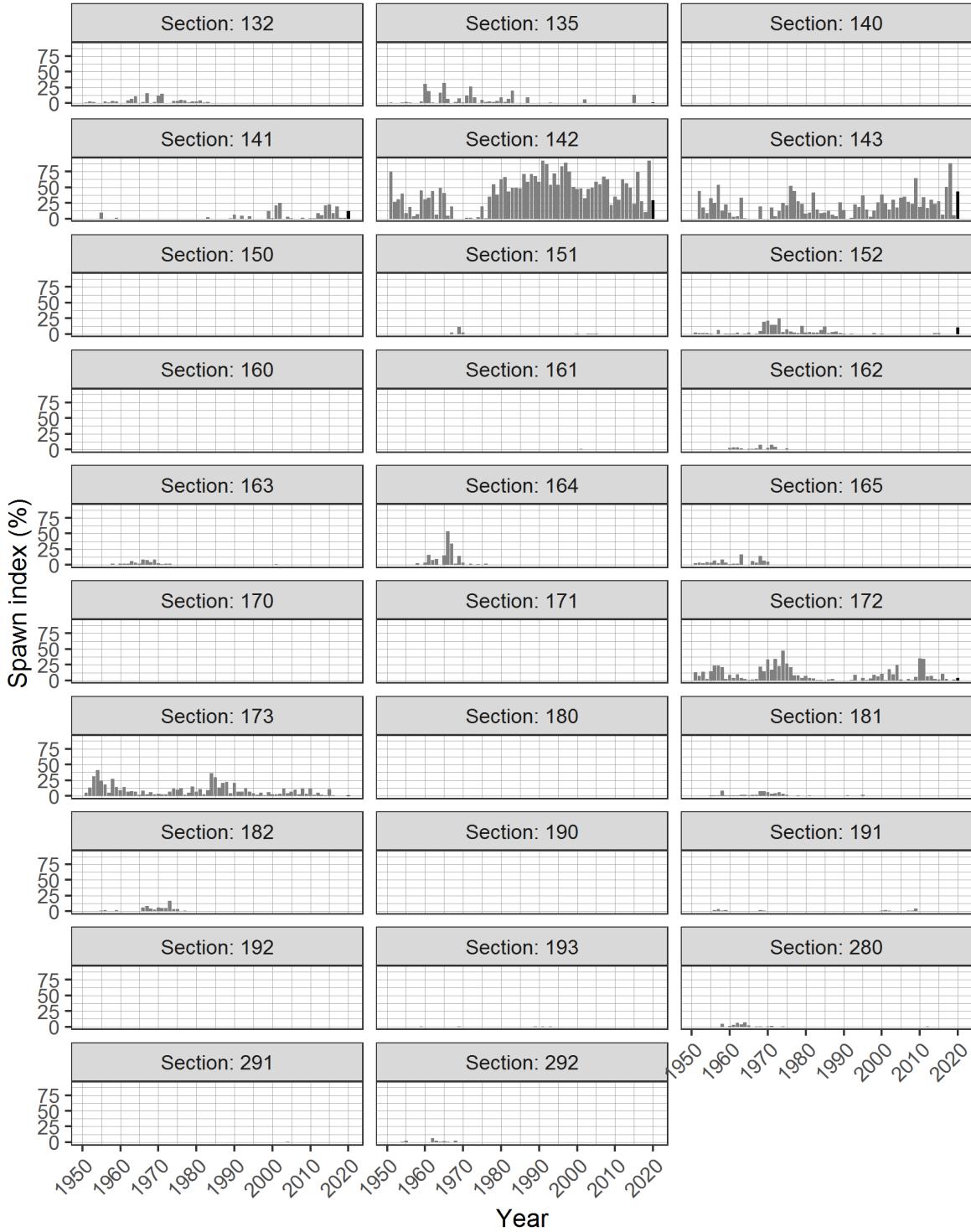


Figure 18. Time series of percent of spawn index by Section for Pacific Herring from 1951 to 2020 in the Strait of Georgia major stock assessment region (SAR). The year 2020 has a darker bar to facilitate interpretation. The spawn index has two distinct periods defined by the dominant survey method: surface surveys (1951 to 1987), and dive surveys (1988 to 2020). The ‘spawn index’ is not scaled by the spawn survey scaling parameter, q .

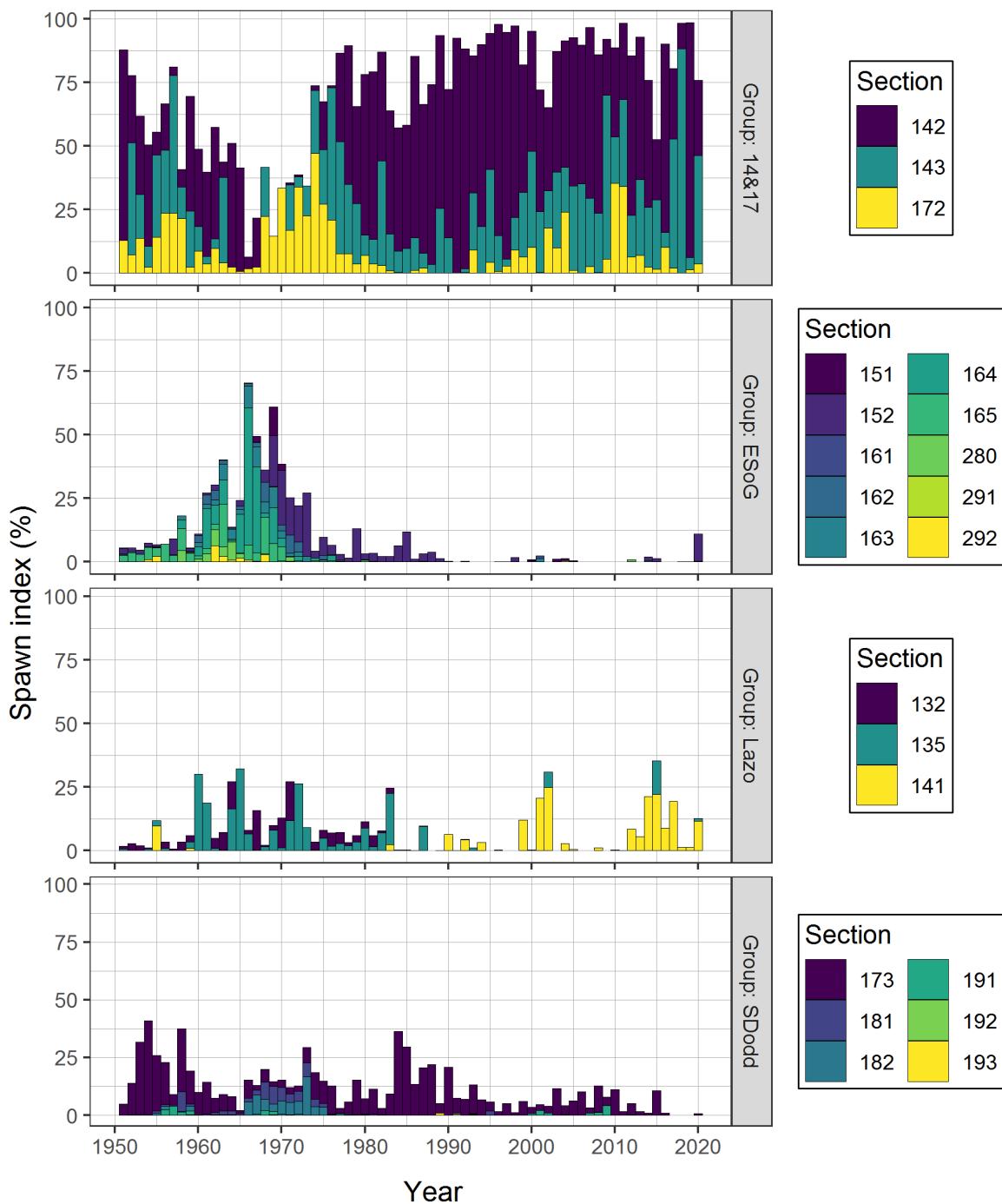


Figure 19. Time series of percent of spawn index by Group and Section for Pacific Herring from 1951 to 2020 in the Strait of Georgia major stock assessment region (SAR). The spawn index has two distinct periods defined by the dominant survey method: surface surveys (1951 to 1987), and dive surveys (1988 to 2020). 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 20. Animation of Pacific Herring spawn index in metric tonnes (t) by Location from 1951 to 2020 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 2020). The ‘spawn index’ is not scaled by the spawn survey scaling parameter, q . Missing spawn index values (grey circles) indicate incomplete spawn surveys. Inset tracks time series of total spawn index. Units: kilometres (km).