Pacific Herring preliminary data summary for West Coast of Vancouver Island 2021

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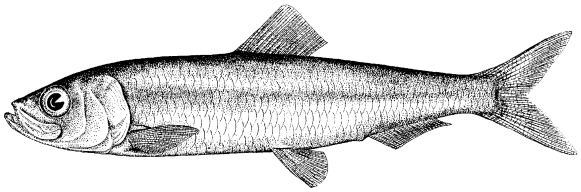
July 8, 2021



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

Disclaimer This report contains preliminary data collected for Pacific Herring in 2021 in the West Coast of Vancouver Island major stock assessment region (SAR). These data may differ from data used and presented in the final stock assessment.

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1 COVID-19 pandemic

1.1 Data collection and analysis in 2020

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

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surveyed by surface surveys instead of underwater dive surveys in Prince Rupert District and Haida Gwaii.

Although Pacific Herring biological samples were collected as usual, the pandemic delayed the analysis of biological data for all SARs. This delay was 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 resulted in delayed provision of age data for Pacific Herring and many other species. Despite these delays, biological data was available for use in the 2020 stock assessment.

1.2 Data collection and analysis in 2021

Compared to 2020, the COVID-19 pandemic had fewer impacts to Pacific Herring data collection and analysis in 2021. Spawn surveys proceeded as usual in most areas, with dive surveys in all major areas except Haida Gwaii. Haida Gwaii would normally have a dive survey, but had surface surveys in 2021 due to COVID-19. The collection and analysis of biological data was not affected by the COVID-19 pandemic in 2021.

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 2021. 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 2021 in the West Coast of Vancouver Island 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). Note that we refer to 'year' instead of 'herring season' in this report; therefore 2021 refers to the 2020/2021 Pacific Herring season.

3 Data collection programs

Biological samples were collected by the seine charter vessel "Proud Canadian" for 21 days from February 20th to March 12th. The primary purpose of the test charter vessel was to collect biological samples from main bodies of herring from Statistical Areas 23,

24, and 25. Nearshore herring samples were collected by the Nuu-chah-nulth staff as part of a sampling program and on-going collaboration between WCVI First Nations and DFO. These nearshore biological samples were collected from spawning aggregations using cast nets. WCVI First Nations spawn reconnaissance charters reported spawn activity in all three areas. Herring spawn locations were primarily identified with fixed-wing overflights conducted by DFO Resource Management Area staff. Thirteen flights were conducted this season in February and March.

Two dive charter vessels operated in WCVI:

- The "Pachena No.1" surveyed 15 days from March 18th to April 1st, and
- The "Seaveyor" surveyed 10 days from March 20th to April 3rd.

The seine test charter vessel and the dive survey vessels were funded by DFO, through a contract to the Herring Conservation Research Society.

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 2021 in the West Coast of Vancouver Island 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 2021, 22 Pacific Herring biological samples were collected and processed for the West Coast of Vancouver Island major SAR (Table 5, Table 6), and a total of 1,023 Pacific Herring were aged in 2021. Differences between biological data collected from two sampling protocols regarding the number-, proportion-, weight-, and length-at-age for Pacific Herring in 2021 in the West Coast of Vancouver Island major SAR are shown in Table 7, Table 8, Table 9, and Table 10, respectively. The nearshore sampling program is a multi-year pilot study (using cast nets), therefore only biological data from the seine samples were used for the purposes of stock assessment. Summaries of data collected by the nearshore sampling program are shown in Table 11, Table 12, Table 13, and Table 14. In addition, Figure 9 and Figure 10 show differences in length-at-age between the two sampling protocols, and differences by Statistical Area, respectively. The locations in

which the biological samples were collected are presented in Figure 4. Included herein are biological summaries of observed proportion-, number-, weight-, and length-at-age (Figure 5, Table 15, and Figure 6, respectively). We also show the percent change in weight and length for age-3 and age-6 fish (Figure 7 & Figure 8, 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 26 individual locations in 2021 in the West Coast of Vancouver Island major SAR (Table 16, and Figure 11). A summary of spawn from the last decade (2011 to 2020) is shown in Figure 12. Figure 13 shows spawn start date by decade and Statistical Area. 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 14, Figure 15, Figure 16, Figure 17, Table 17, and Figure 18). 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 2021).

Some Pacific Herring Sections contribute more than others to the total spawn index, and the percentage contributed by Section varies yearly (Figure 17b, Figure 19). For example, in 2021, Section 242 contributed the most to the spawn index (60%). As with Sections, some Statistical Areas contribute more than others to the total spawn index (Figure 17c, Figure 20). An animation shows the spawn index by spawn survey location from 1951 to 2021 (Figure 21).

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:

- First Nation charters worked effectively and test samples were taken from Areas 23, 24 and 25.
- Supplemental funding from the Bligh Island environmental response was available for extending reconnaissance flights.
- Inclement weather interfered with overflights as well as test vessel operations.

- Major spawns occurred later and were during a shorter time window.
- Colder water temperatures than previous season.
- No assessment on late spawn at Maquinna to Bajo that occurred April 1st.
- Grey Whales were observed in lower numbers on the WCVI until later in March.

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 and Sections for Pacific Herring in the West Coast of Vancouver Island major stock assessment region (SAR).

Region	Statistical Area	Section
West Coast of Vancouver Island	23	230
West Coast of Vancouver Island	23	231
West Coast of Vancouver Island	23	232
West Coast of Vancouver Island	23	233
West Coast of Vancouver Island	23	239
West Coast of Vancouver Island	24	240
West Coast of Vancouver Island	24	241
West Coast of Vancouver Island	24	242
West Coast of Vancouver Island	24	243
West Coast of Vancouver Island	24	244
West Coast of Vancouver Island	24	245
West Coast of Vancouver Island	24	249
West Coast of Vancouver Island	25	250
West Coast of Vancouver Island	25	251
West Coast of Vancouver Island	25	252
West Coast of Vancouver Island	25	253
West Coast of Vancouver Island	25	259

Table 3. Total landed commercial catch of Pacific Herring in metric tonnes (t) by gear type in 2021 in the West Coast of Vancouver Island major stock assessment region (SAR). Legend: 'Other' represents the reduction (1951 to 1970 only), 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	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 2011 to 2021 in the West Coast of Vancouver Island 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)
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
2021	0	0

Table 5. Number of Pacific Herring biological samples processed from 2011 to 2021 in the West Coast of Vancouver Island major stock assessment region (SAR). Each sample is approximately 100 fish.

	Number of samples		
Year	Commercial	Test	Total
2011	0	28	28
2012	0	10	10
2013	0	5	5
2014	0	4	4
2015	0	20	20
2016	0	25	25
2017	0	19	19
2018	0	42	42
2019	0	25	25
2020	0	19	19
2021	0	22	22

Table 6. Number and type of Pacific Herring biological samples processed in 2021 in the West Coast of Vancouver Island major stock assessment region (SAR). Each sample is approximately 100 fish.

Type	Gear	Use	Number of samples
Test	Other	Nearshore	9
Test	Seine	Test fishery	13

Table 7. Observed number-at-age of Pacific Herring by sample type in 2021 in the West Coast of Vancouver Island major stock assessment region (SAR). The age-10 class is a 'plus group' which includes fish ages 10 and older. Legend: 'Nearshore' refers to samples collected using cast nets as part of a pilot study with First Nations.

	Number-at-age								
Sample type	2	3	4	5	6	7	8	9	10
Nearshore	47	479	146	90	11	5	8	1	1
Seine test	177	545	139	121	14	9	13	3	2
Total	224	1024	285	211	25	14	21	4	3

Table 8. Observed proportion-at-age of Pacific Herring by sample type in 2021 in the West Coast of Vancouver Island major stock assessment region (SAR). The age-10 class is a 'plus group' which includes fish ages 10 and older. Legend: 'Nearshore' refers to samples collected using cast nets as part of a pilot study with First Nations.

	Proportion-at-age								
Sample type	2	3	4	5	6	7	8	9	10
Nearshore	0.060	0.608	0.185	0.114	0.014	0.006	0.010	0.001	0.001
Seine test	0.173	0.533	0.136	0.118	0.014	0.009	0.013	0.003	0.002
Total	0.124	0.565	0.157	0.117	0.014	0.008	0.012	0.002	0.002

Table 9. Observed mean weight-at-age in grams (g) of Pacific Herring by sample type in 2021 in the West Coast of Vancouver Island major stock assessment region (SAR). The age-10 class is a 'plus group' which includes fish ages 10 and older. Legend: 'Nearshore' refers to samples collected using cast nets as part of a pilot study with First Nations.

	Mean weight-at-age (g)								
Sample type	2	3	4	5	6	7	8	9	10
Nearshore	57	71	82	101	111	90	124	121	121
Seine test	45	77	90	111	115	142	145	128	130
Total	47	74	86	107	113	123	137	126	127

Table 10. Observed mean length-at-age in millimetres (mm) of Pacific Herring by sample type in 2021 in the West Coast of Vancouver Island major stock assessment region (SAR). The age-10 class is a 'plus group' which includes fish ages 10 and older. Legend: 'Nearshore' refers to samples collected using cast nets as part of a pilot study with First Nations.

	Mean length-at-age (mm)								
Sample type	2	3	4	5	6	7	8	9	10
Nearshore	156	172	180	193	202	188	208	209	197
Seine test	149	171	180	191	191	203	208	200	207
Total	150	171	180	192	196	198	208	202	204

Table 11. Observed number-at-age of Pacific Herring for nearshore samples from 2015 to 2021 in the West Coast of Vancouver Island major stock assessment region (SAR). The age-10 class is a 'plus group' which includes fish ages 10 and older. Legend: 'Nearshore' refers to samples collected using cast nets as part of a pilot study with First Nations.

	Number-at-age								
Year	2	3	4	5	6	7	8	9	10
2015	67	64	130	10	3	3	0	0	0
2016	32	537	161	122	13	3	2	0	0
2017	43	56	355	89	64	4	0	0	0
2018	171	203	142	1157	196	105	18	0	1
2019	101	616	82	37	106	15	6	0	0
2020	168	161	179	28	8	34	6	2	2
2021	47	479	146	90	11	5	8	1	1
Total	629	2116	1195	1533	401	169	40	3	4

Table 12. Observed proportion-at-age of Pacific Herring for nearshore samples from 2015 to 2021 in the West Coast of Vancouver Island major stock assessment region (SAR). The age-10 class is a 'plus group' which includes fish ages 10 and older. Legend: 'Nearshore' refers to samples collected using cast nets as part of a pilot study with First Nations.

	Proportion-at-age								
Year	2	3	4	5	6	7	8	9	10
2015	0.242	0.231	0.469	0.036	0.011	0.011	0.000	0.000	0.000
2016	0.037	0.617	0.185	0.140	0.015	0.003	0.002	0.000	0.000
2017	0.070	0.092	0.581	0.146	0.105	0.007	0.000	0.000	0.000
2018	0.086	0.102	0.071	0.581	0.098	0.053	0.009	0.000	0.001
2019	0.105	0.640	0.085	0.038	0.110	0.016	0.006	0.000	0.000
2020	0.286	0.274	0.304	0.048	0.014	0.058	0.010	0.003	0.003
2021	0.060	0.608	0.185	0.114	0.014	0.006	0.010	0.001	0.001
Total	0.103	0.347	0.196	0.252	0.066	0.028	0.007	0.000	0.001

Table 13. Observed mean weight-at-age in grams (g) of Pacific Herring for nearshore samples from 2015 to 2021 in the West Coast of Vancouver Island major stock assessment region (SAR). The age-10 class is a 'plus group' which includes fish ages 10 and older. Legend: 'Nearshore' refers to samples collected using cast nets as part of a pilot study with First Nations.

	Mean weight-at-age (g)								
Year	2	3	4	5	6	7	8	9	10
2015	51	67	76	81	109	104	NA	NA	NA
2016	49	66	72	81	88	83	88	NA	NA
2017	58	70	85	91	94	98	NA	NA	NA
2018	53	77	85	95	103	107	112	NA	114
2019	54	70	81	100	111	116	118	NA	NA
2020	56	69	85	94	114	125	110	131	120
2021	57	71	82	101	111	90	124	121	121
Total	54	70	82	94	103	110	114	128	118

Table 14. Observed mean length-at-age in millimetres (mm) of Pacific Herring for nearshore samples from 2015 to 2021 in the West Coast of Vancouver Island major stock assessment region (SAR). The age-10 class is a 'plus group' which includes fish ages 10 and older. Legend: 'Nearshore' refers to samples collected using cast nets as part of a pilot study with First Nations.

	Mean length-at-age (mm)								
Year	2	3	4	5	6	7	8	9	10
2015	154	170	178	182	199	200	NA	NA	NA
2016	154	171	178	186	188	197	192	NA	NA
2017	166	178	190	193	197	201	NA	NA	NA
2018	159	179	188	196	200	202	211	NA	220
2019	155	170	179	191	198	203	201	NA	NA
2020	156	169	180	186	200	205	197	214	204
2021	156	172	180	193	202	188	208	209	197
Total	157	172	184	194	199	202	206	212	206

Table 15. Observed proportion-at-age for Pacific Herring from 2011 to 2021 in the West Coast of Vancouver Island 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
2011	0.048	0.630	0.211	0.096	0.009	0.005	0.000	0.000	0.000
2012	0.021	0.186	0.621	0.103	0.059	0.007	0.003	0.000	0.000
2013	0.034	0.241	0.150	0.475	0.050	0.045	0.005	0.000	0.000
2014	0.029	0.752	0.147	0.029	0.032	0.007	0.000	0.004	0.000
2015	0.140	0.238	0.505	0.068	0.017	0.028	0.004	0.000	0.001
2016	0.040	0.648	0.168	0.124	0.014	0.003	0.004	0.001	0.000
2017	0.025	0.076	0.664	0.132	0.082	0.016	0.002	0.002	0.000
2018	0.053	0.133	0.109	0.566	0.096	0.035	0.005	0.002	0.000
2019	0.055	0.504	0.097	0.049	0.232	0.040	0.018	0.003	0.000
2020	0.180	0.275	0.347	0.047	0.024	0.100	0.022	0.004	0.000
2021	0.173	0.533	0.136	0.118	0.014	0.009	0.013	0.003	0.002

Table 16. Pacific Herring spawn survey locations, start date, and spawn index in metric tonnes (t) in 2021 in the West Coast of Vancouver Island 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)
23	232	Amphitrite Pt	March 12	87
23	232	Equis Beach	March 25	81
23	232	Forbes Is	March 12	47
23	232	Lyall Pt	March 25	593
23	232	Macoah Pass	March 12	369
23	232	Maggie Rvr	March 12	123
23	232	Mayne Bay	March 25	1,559
23	232	Newcombe Chnl	March 12	344
23	232	Spring Cv	March 13	365
23	232	Two Rivers +	March 12	835
24	242	Antons Spit	February 09	4,087
24	242	Hesquiat Hrbr	March 12	924
24	242	Hesquiat Hrbr Hd	March 12	101
24	242	Hesquiat Pen	March 12	4,622
24	242	Hesquiat Pt	March 12	6,160
24	242	Leclaire Pt	March 12	947
24	242	Rondeault Pt	February 09	707
24	243	Stewardson Inlt	February 17	NA
24	244	McNeil Pen	March 18	435
24	245	Whitesand Cv	March 12	3,255
24	249	Florencia Bay	March 18	116
25	252	Escalante Rocks	March 29	1,189
25	252	Maquinna Pt	April 01	NA
25	253	Inner Nuchatlitz	March 13	124
25	253	Outer Nuchatlitz	March 12	1,137
25	253	Port Langford	March 09	1,134

Table 17. Summary of Pacific Herring spawn survey data from 2011 to 2021 in the West Coast of Vancouver Island 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 2021). 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)
2011	54,735	65	2.3	9,663
2012	14,953	221	2.3	5,407
2013	33,775	103	1.1	12,258
2014	35,825	144	1.1	13,937
2015	20,450	276	1.1	11,323
2016	60,575	122	1.4	20,528
2017	44,200	181	1.3	15,734
2018	61,825	137	1.5	28,107
2019	49,325	131	1.2	17,030
2020	44,125	163	0.9	18,761
2021	45,851	204	1.1	29,339

8 Figures

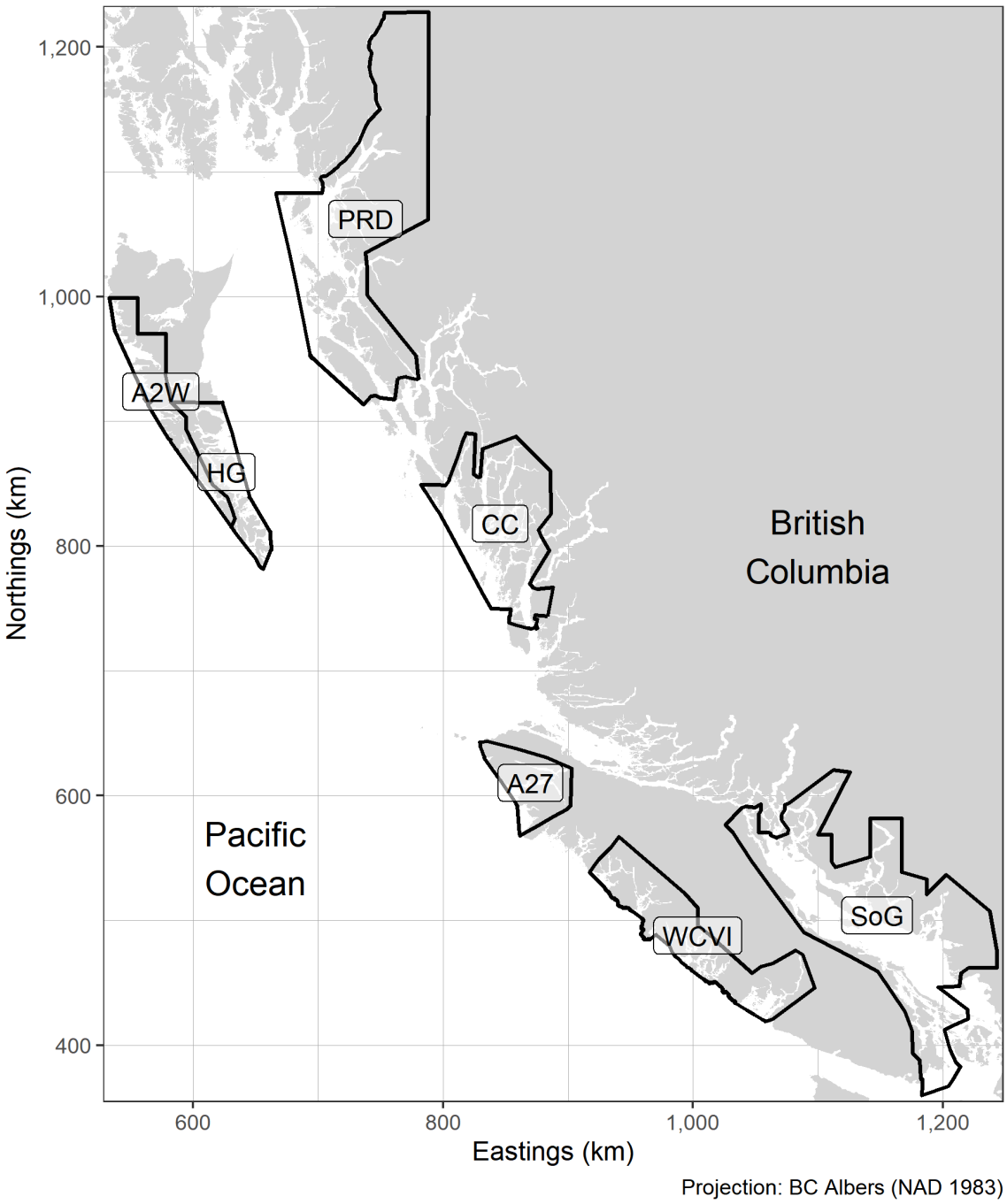

Figure 1. Boundaries for the Pacific Herring stock assessment regions (SARs) in British Columbia. There are 5 major SARs: Haida Gwaii (HG), Prince Rupert District (PRD), Central Coast (CC), Strait of Georgia (SoG), and West Coast of Vancouver Island (WCVI). There are 2 minor SARs: Area 27 (A27) and Area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

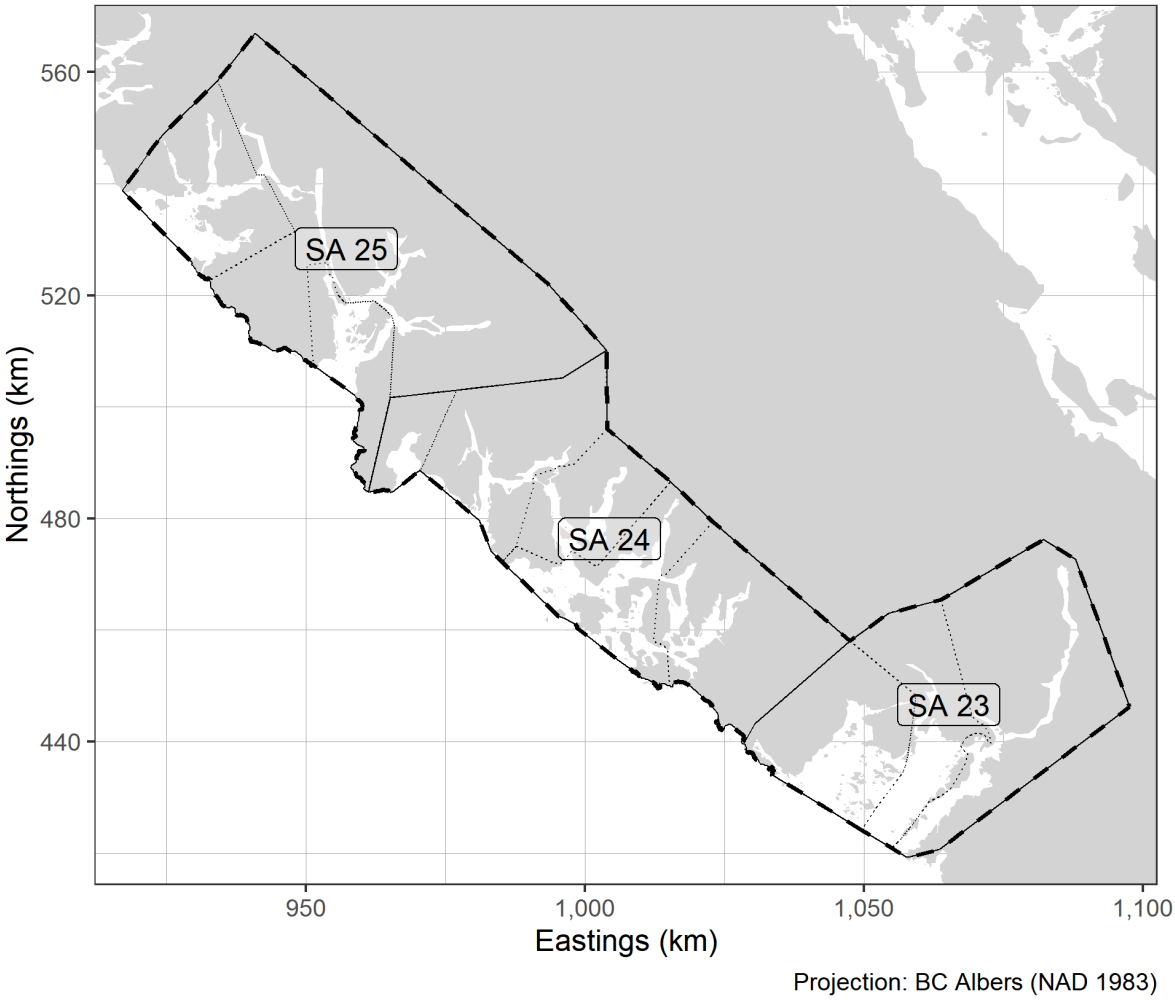

Figure 2. Boundaries for the West Coast of Vancouver Island major stock assessment region (SAR; thick dashed lines), associated Statistical Areas (SA; thin solid lines), and associated Sections (thin dotted lines). Units: kilometres (km).

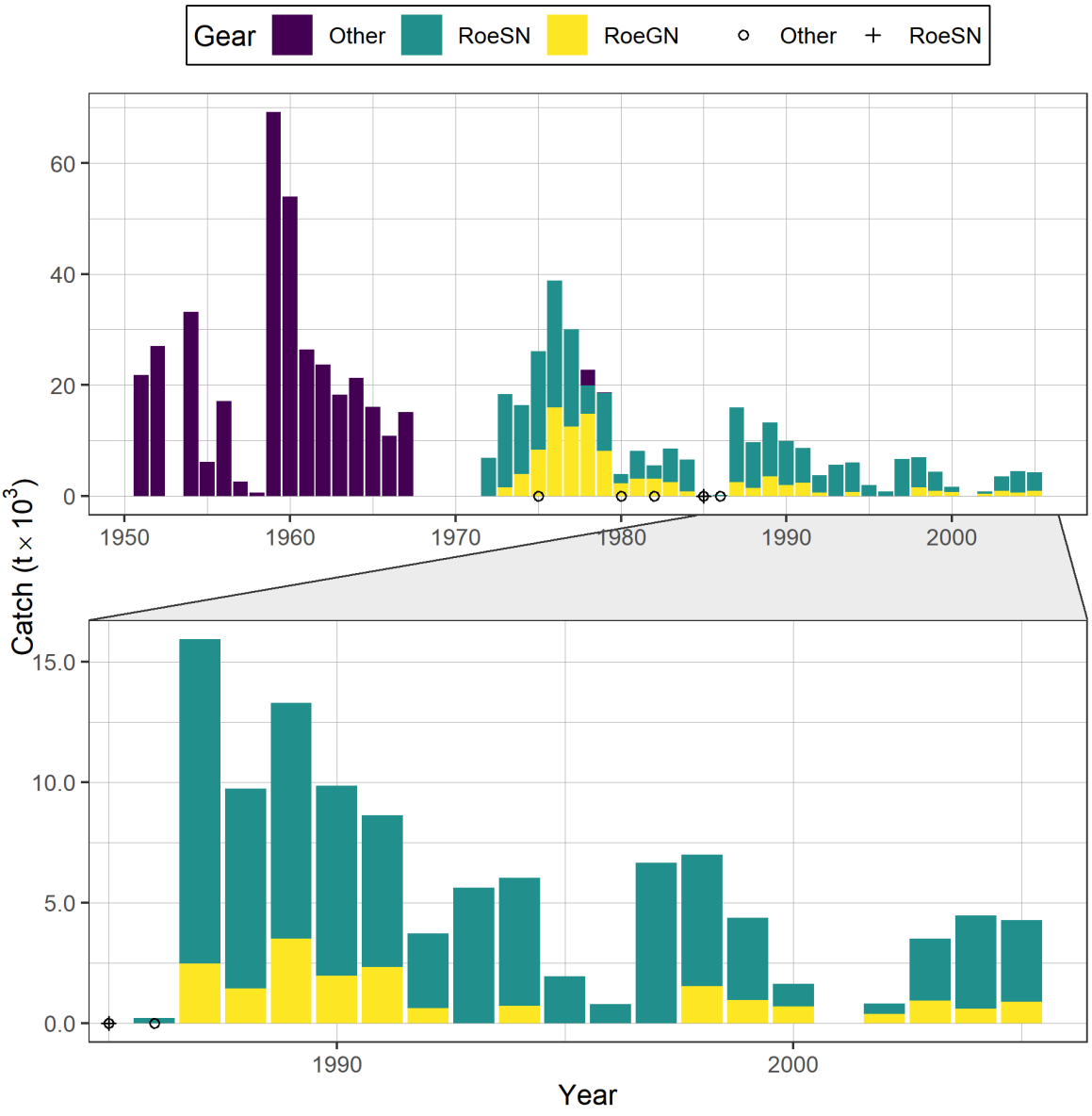

Figure 3. Time series of total landed catch in thousands of metric tonnes ($t \times 10^3$) of Pacific Herring by gear type from 1951 to 2021 in the West Coast of Vancouver Island major stock assessment region (SAR). Legend: 'Other' represents the reduction (1951 to 1970 only), the food and bait, as 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.

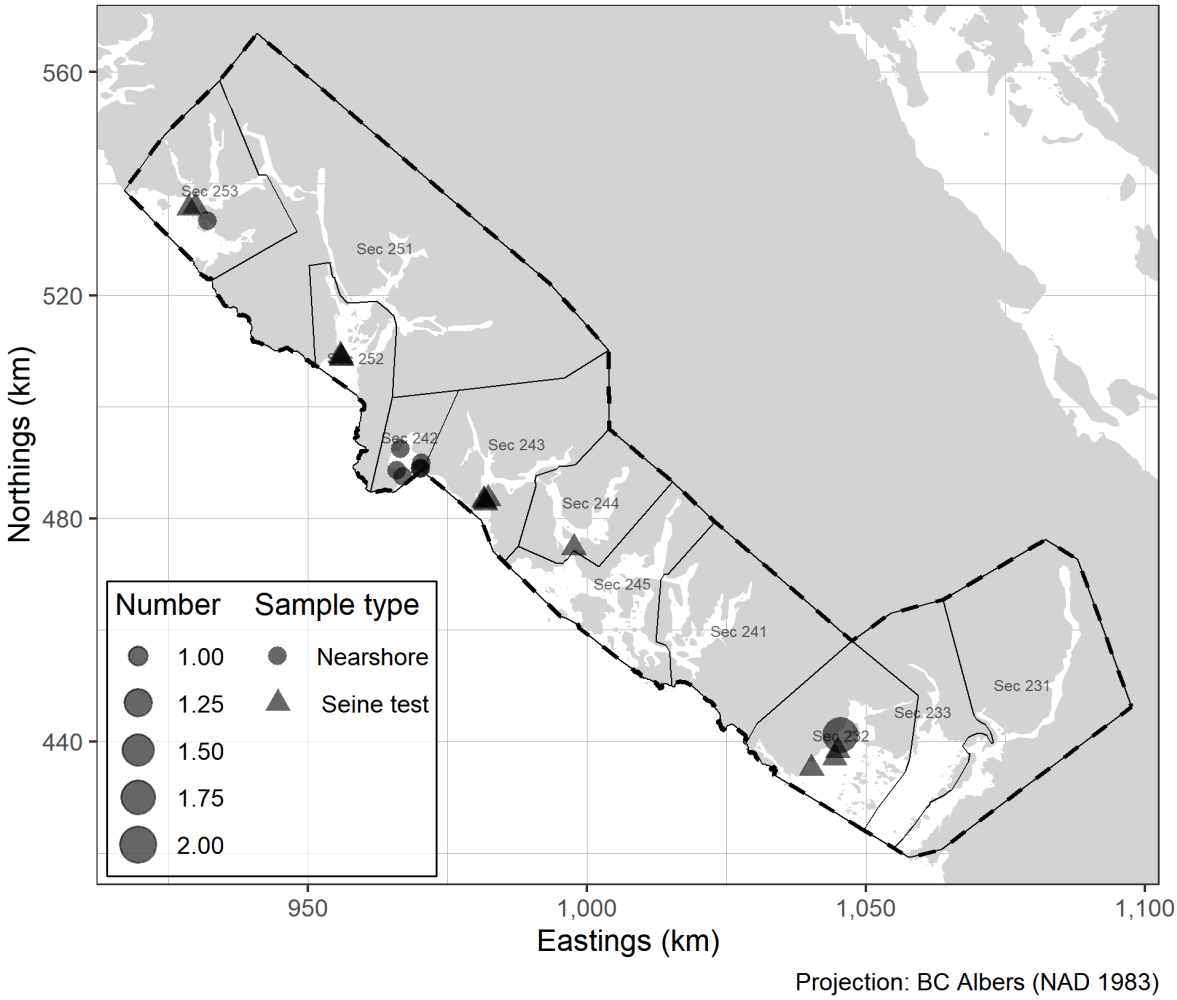

Figure 4. Location and type of Pacific Herring biological samples collected in 2021 in the West Coast of Vancouver Island major stock assessment region (SAR; thick dashed lines), and associated Sections (Sec; thin solid lines). Units: kilometres (km).

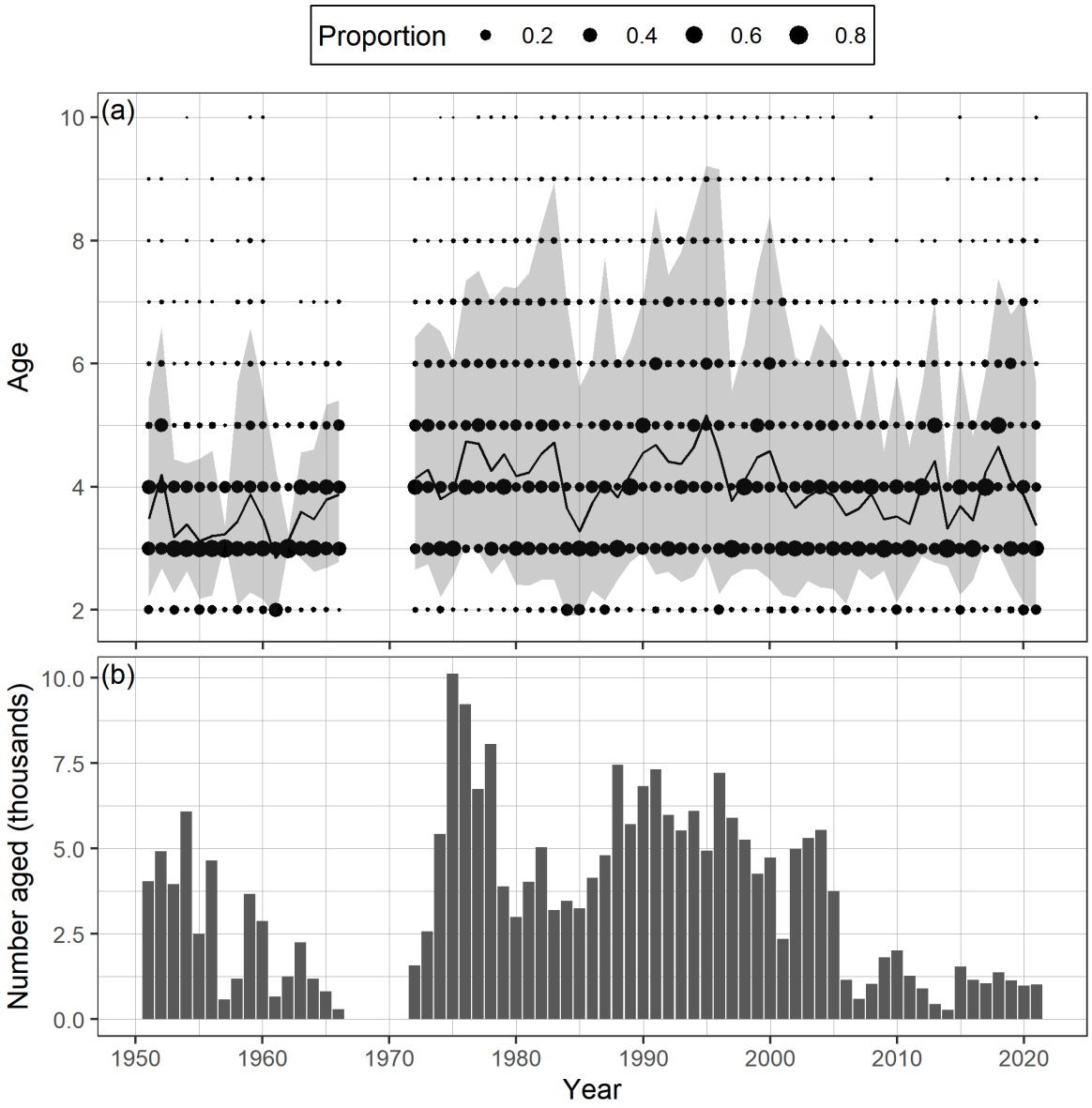

Figure 5. Time series of observed proportion-at-age (a) and number aged in thousands (c) of Pacific Herring from 1951 to 2021 in the West Coast of Vancouver Island major stock assessment region (SAR). The black line is the mean age, and the shaded area is the approximate 90% distribution. Biological 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.

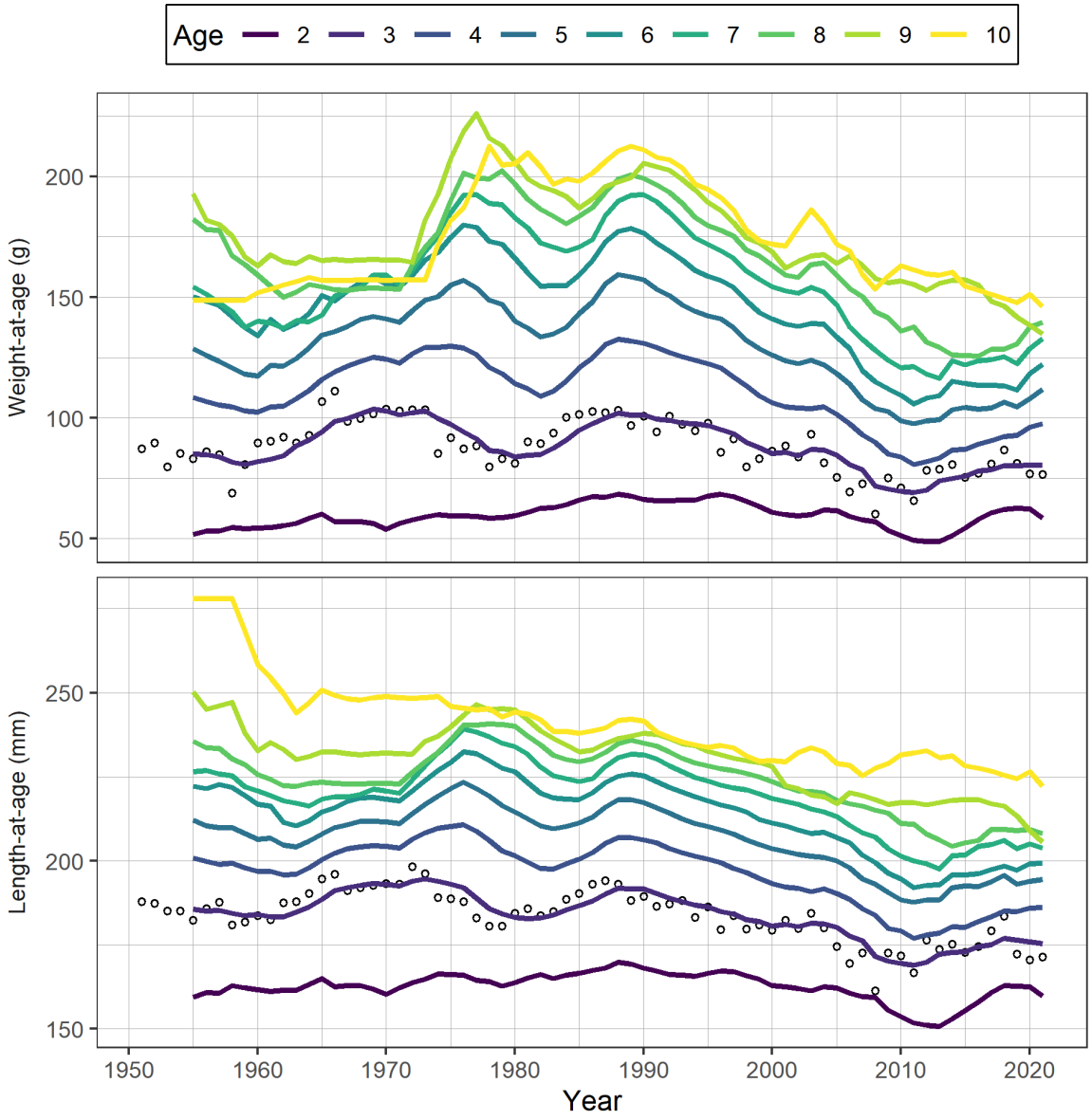

Figure 6. Time series of weight-at-age in grams (g) and length-at-age in milimetres (mm) for age-3 (circles) and 5-year running mean weight- and length-at-age (lines) for Pacific Herring from 1951 to 2021 in the West Coast of Vancouver Island major stock assessment region (SAR). Missing weight- and length-at-age 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.

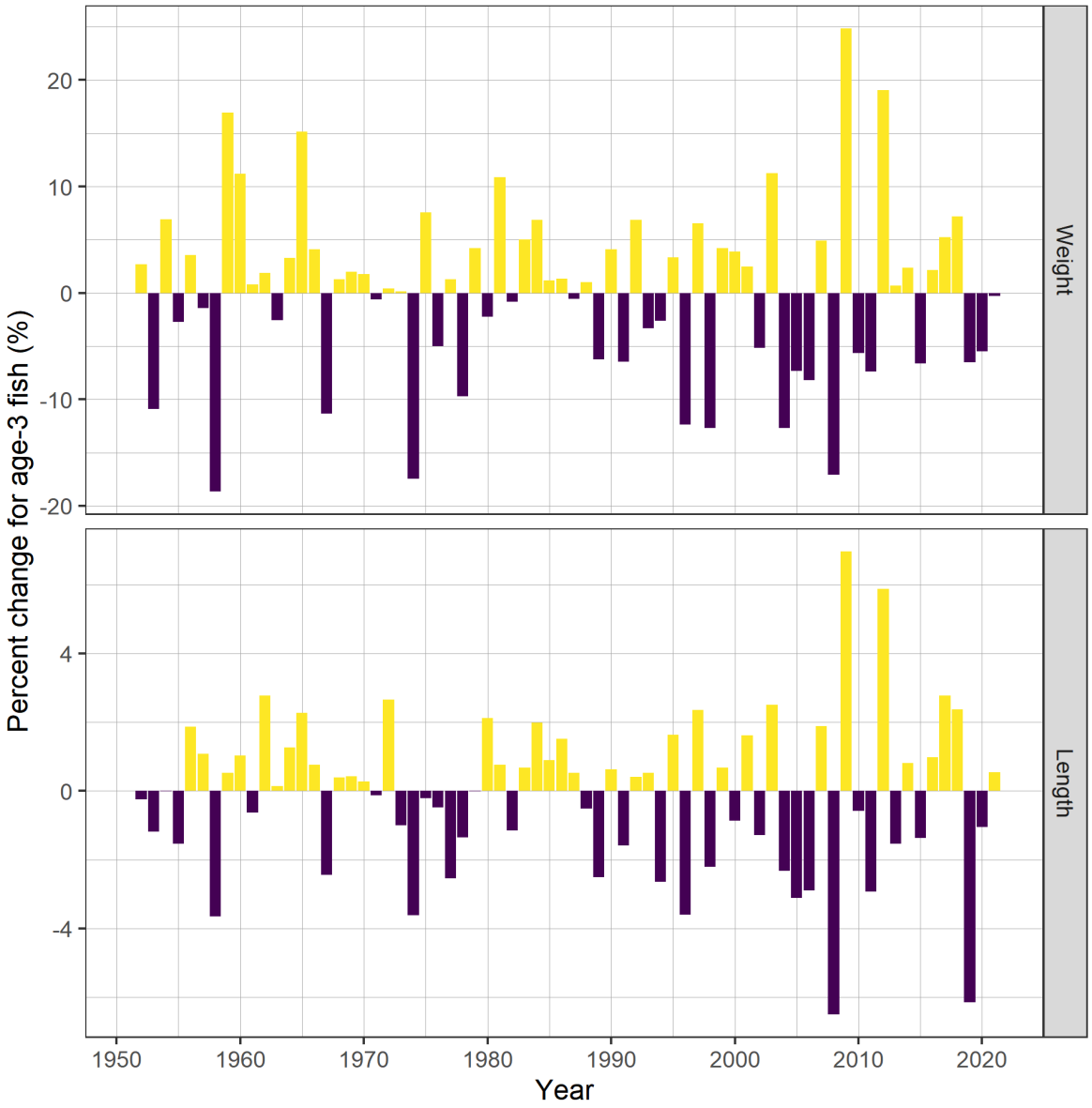

Figure 7. Time series of percent change (%) in weight and length for age-3 fish for Pacific Herring from 1951 to 2021 in the West Coast of Vancouver Island major stock assessment region (SAR). Percent change is $\delta_t = \frac{\alpha_t - \alpha_{t-1}}{\alpha_{t-1}}$ where α_t is the weight and length 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.

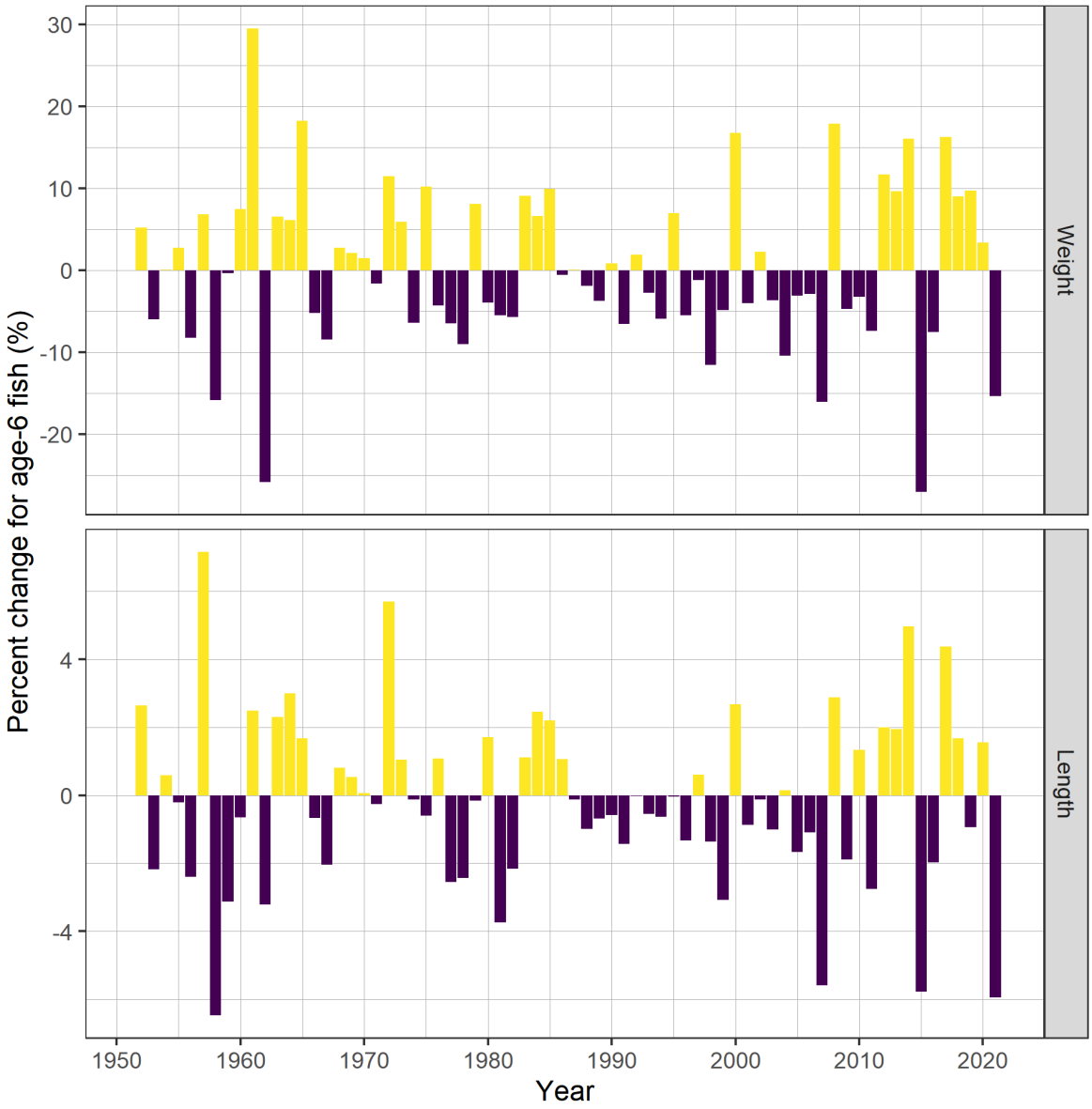

Figure 8. Time series of percent change (%) in weight and length for age-6 fish for Pacific Herring from 1951 to 2021 in the West Coast of Vancouver Island major stock assessment region (SAR). Percent change is $\delta_t = \frac{\alpha_t - \alpha_{t-1}}{\alpha_{t-1}}$ where α_t is the weight and length 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.

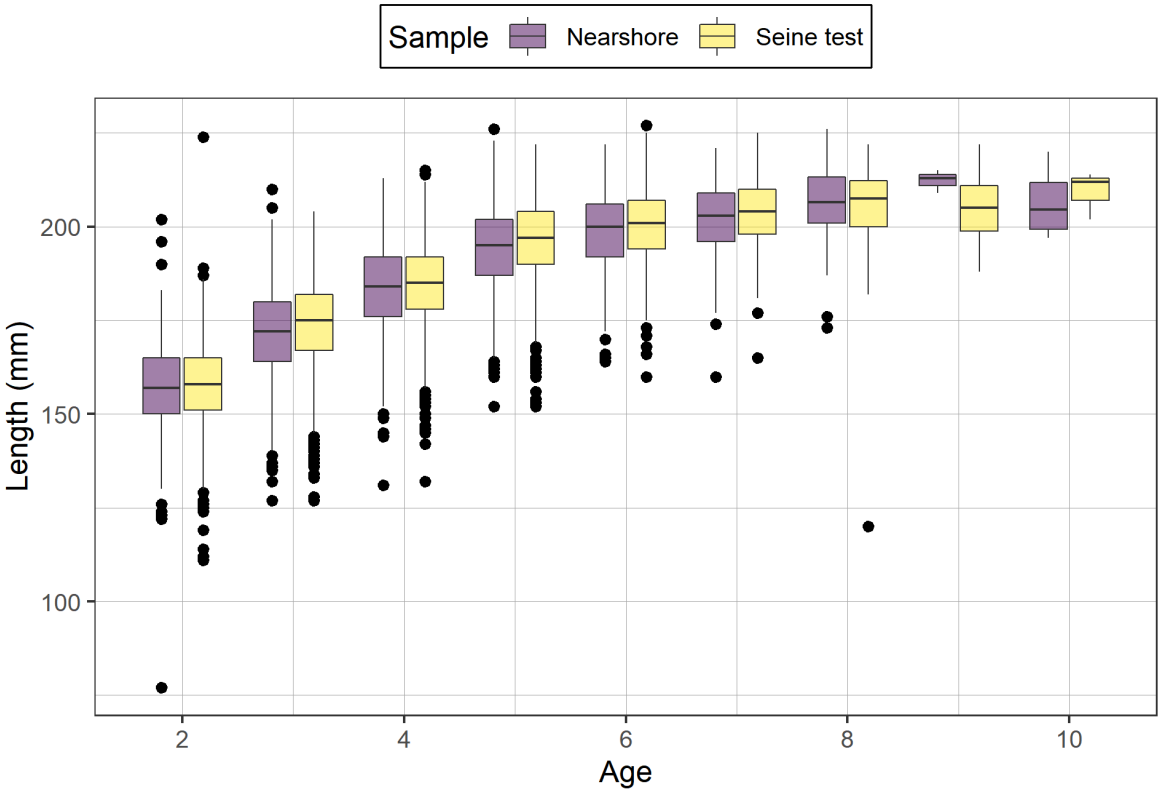

Figure 9. Length-at-age in millimetres (mm) of Pacific Herring from 2015 to 2021 in the West Coast of Vancouver Island major stock assessment region (SAR) by sample type. The outer edges of the boxes indicate the 25th and 75th percentiles, and the middle lines indicate the 50th percentiles (i.e., medians). The whiskers extend to 1.5 $\times$ IQR, where IQR is the distance between the 25th and 75th percentiles, and dots indicate outliers. Biological summaries only include samples collected using seine nets (commercial and test) due to size-selectivity of other gear types such as gillnet. Legend: 'Nearshore' refers to samples collected using cast nets as part of a pilot study with First Nations. The age-10 class is a 'plus group' which includes fish ages 10 and older.

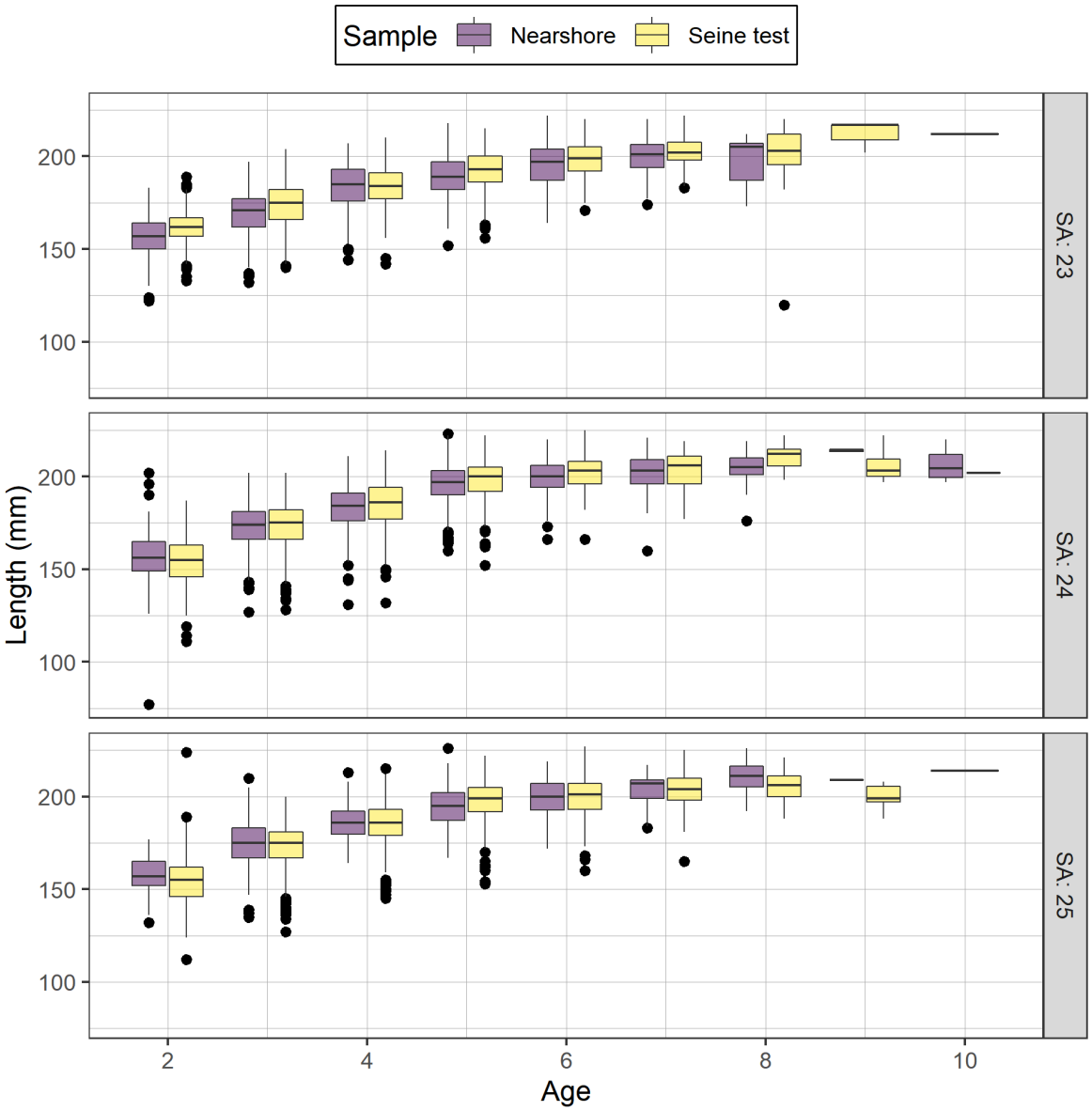

Figure 10. Length-at-age in millimetres (mm) of Pacific Herring from 2015 to 2021 in the West Coast of Vancouver Island major stock assessment region (SAR) by sample type and statistical area (SA). The outer edges of the boxes indicate the 25th and 75th percentiles, and the middle lines indicate the 50th percentiles (i.e., medians). The whiskers extend to 1.5 $\times$ IQR, where IQR is the distance between the 25th and 75th percentiles, and dots indicate outliers. Biological summaries only include samples collected using seine nets (commercial and test) due to size-selectivity of other gear types such as gillnet. Legend: 'Nearshore' refers to samples collected using cast nets as part of a pilot study with First Nations. The age-10 class is a 'plus group' which includes fish ages 10 and older.

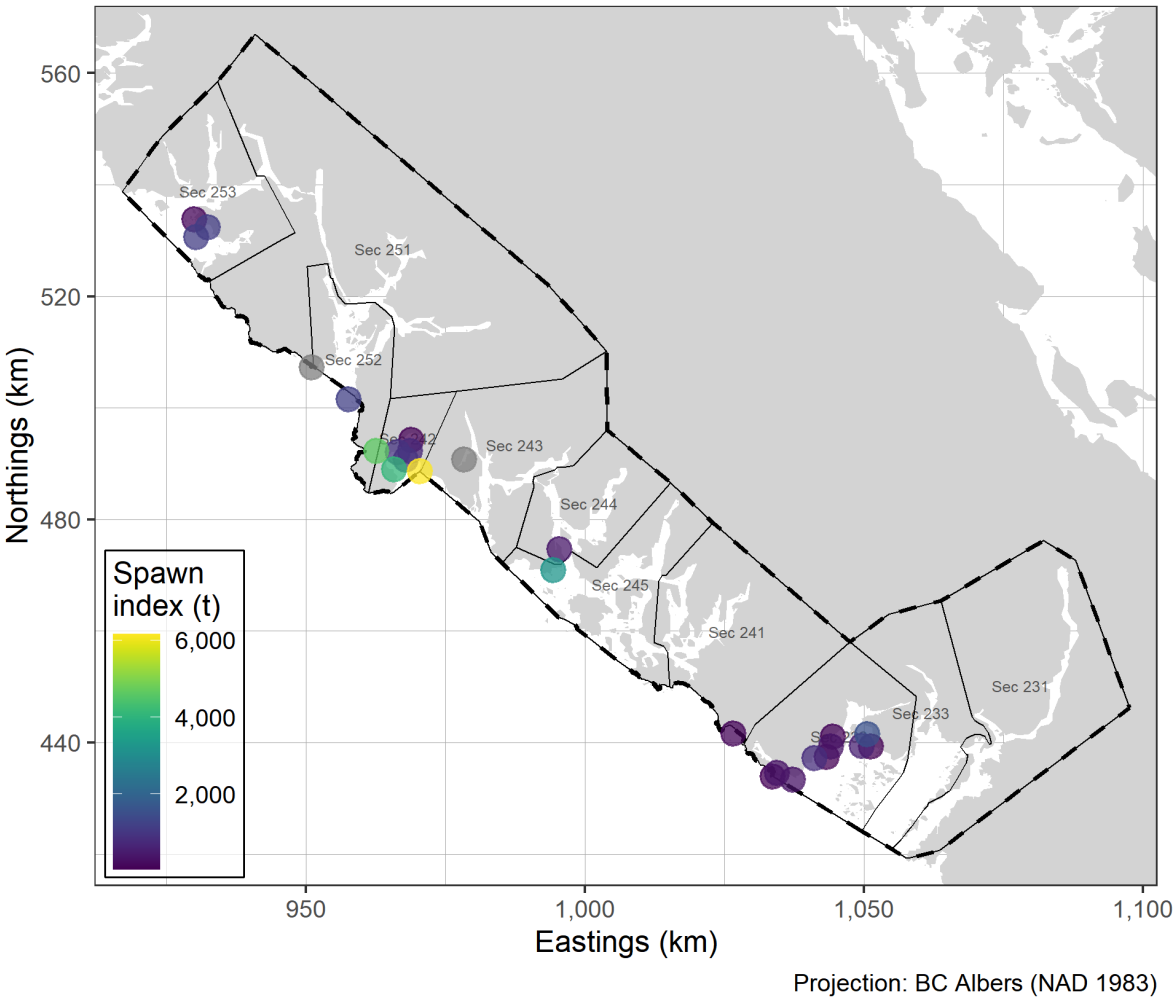

Figure 11. Pacific Herring spawn survey locations, and spawn index in metric tonnes (t) in 2021 in the West Coast of Vancouver Island major stock assessment region (SAR; thick dashed lines), and associated Sections (Sec; thin solid lines). The 'spawn index' is not scaled by the spawn survey scaling parameter, q. Missing spawn index values (grey circles) indicate incomplete spawn surveys. Units: kilometres (km).

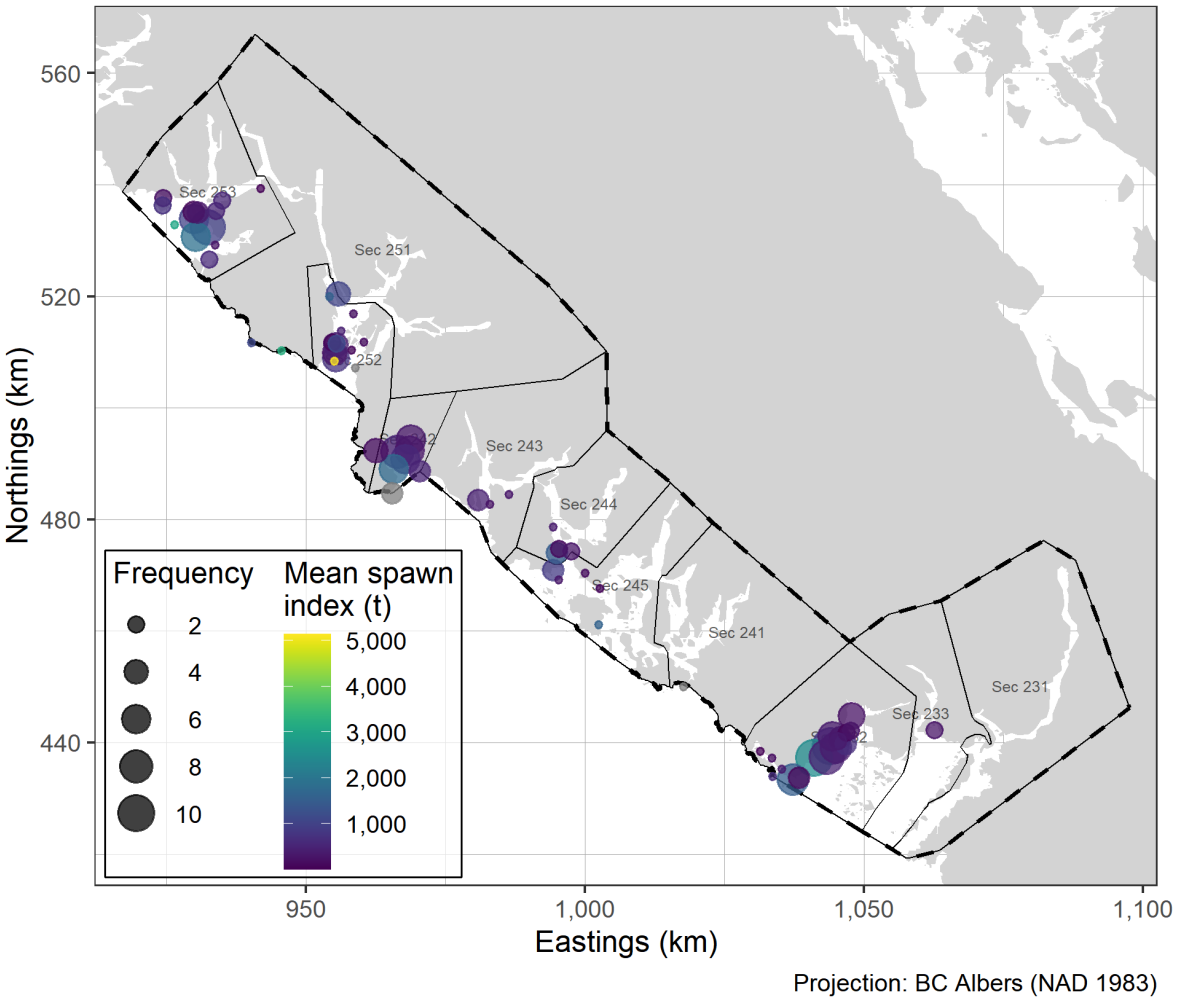

Figure 12. Pacific Herring spawn survey locations, mean spawn index in metric tonnes (t), and spawn frequency from 2011 to 2020 in the West Coast of Vancouver Island major stock assessment region (SAR; thick dashed lines), and associated Sections (Sec; thin solid lines). The 'spawn index' is not scaled by the spawn survey scaling parameter, q. Missing spawn index values (grey circles) indicate incomplete spawn surveys. Units: kilometres (km).

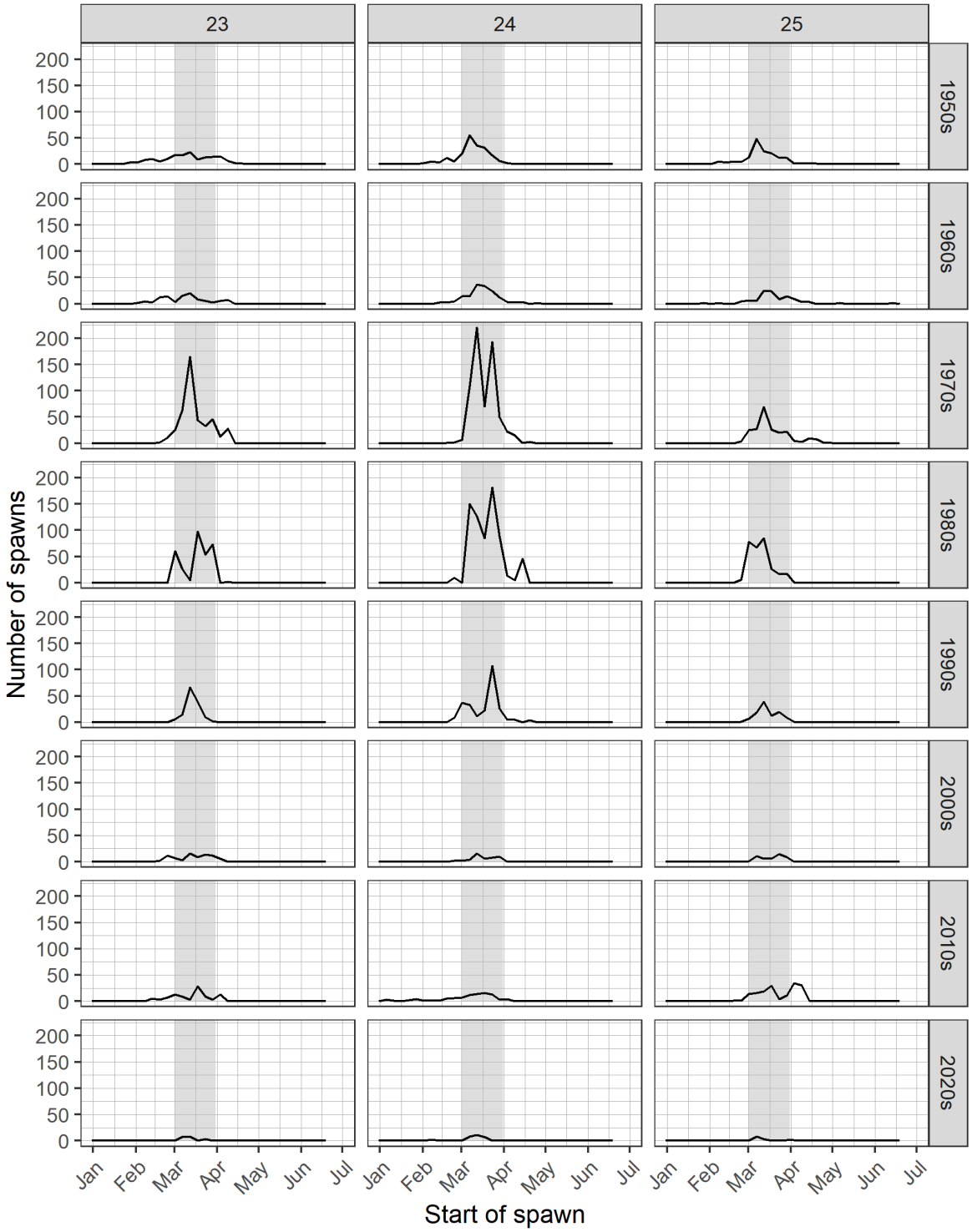

Figure 13. Pacific Herring spawn start date by decade and Statistical Area. Grey shaded regions indicate March 1st to 31st. Note that spawn size and intensity varies; therefore the number of spawns is not directly proportional to spawn extent or biomass.

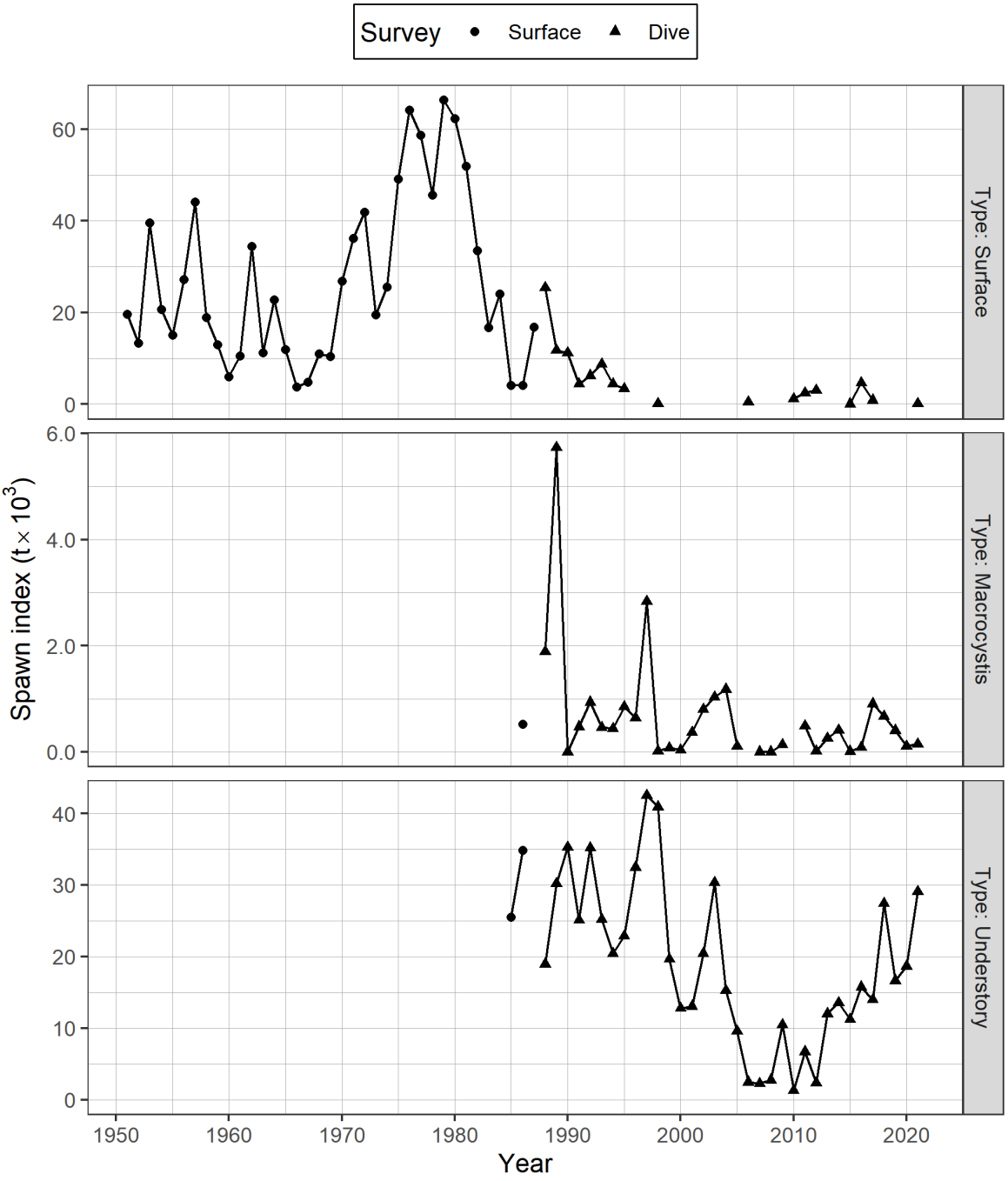

Figure 14. Time series of spawn index in thousands of metric tonnes ($t \times 10^3$) by type for Pacific Herring from 1951 to 2021 in the West Coast of Vancouver Island major stock assessment region (SAR). There are three types of spawn survey observations: observations of spawn taken from the surface 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 2021).

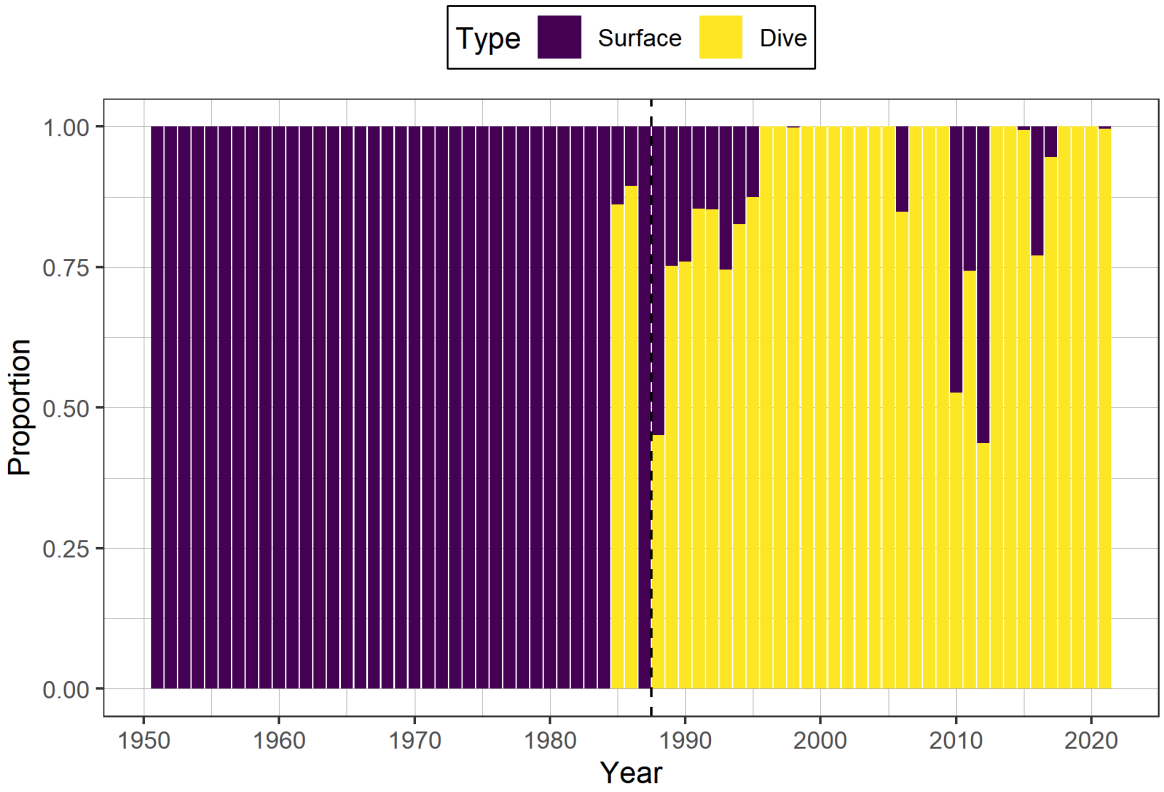

Figure 15. Time series of proportion of spawn index by surface and dive surveys for Pacific Herring from 1951 to 2021 in the West Coast of Vancouver Island major stock assessment region (SAR). The spawn index has two distinct periods defined by the dominant survey method: surface surveys (1951 to 1987), and dive surveys (1988 to 2021).

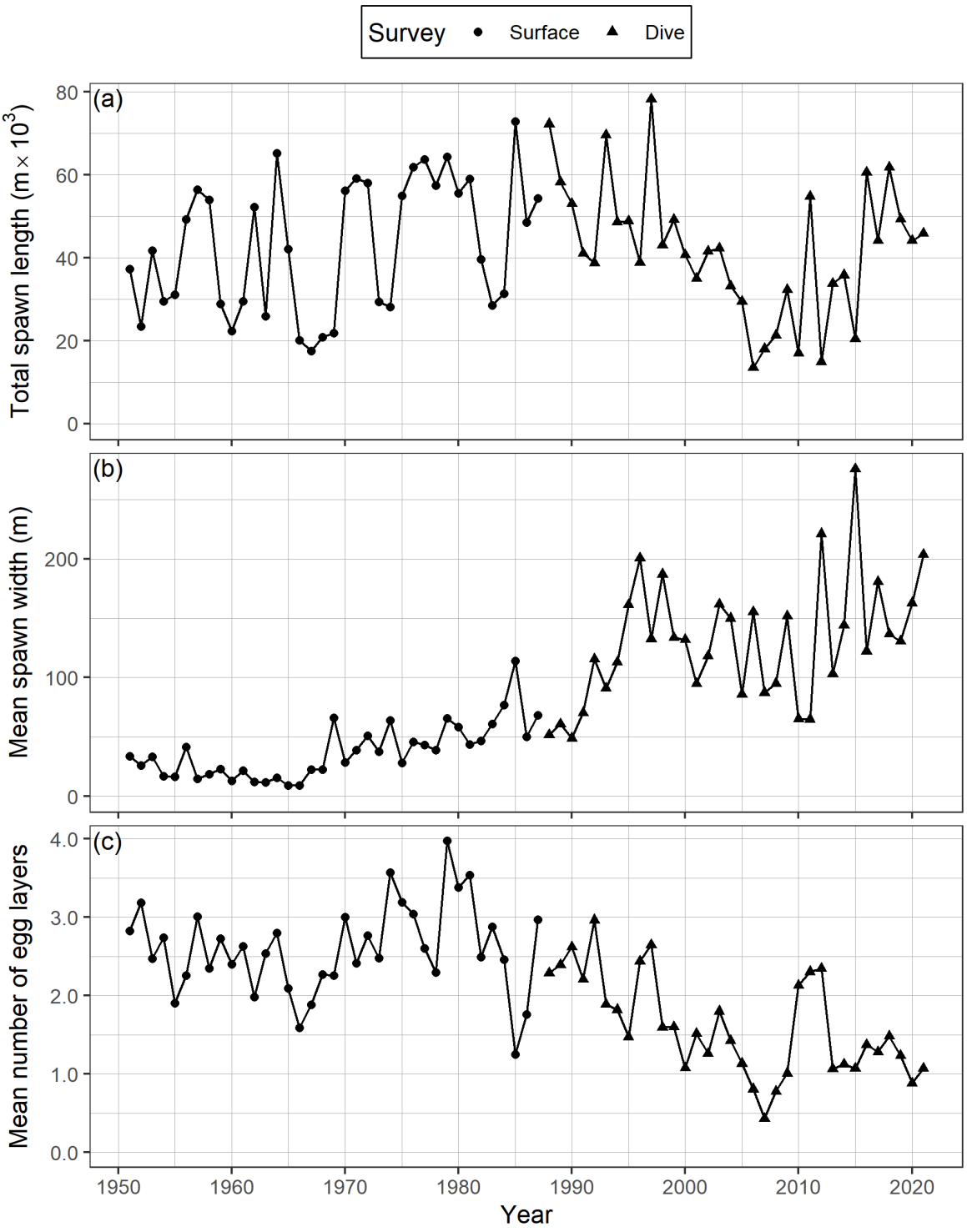

Figure 16. Time series of total spawn length in thousands of metres (m $\times$ 10^3; panel a), mean spawn width in metres (b), and mean number of egg layers (c) for Pacific Herring from 1951 to 2021 in the West Coast of Vancouver Island major stock assessment region (SAR). The spawn index has two distinct periods defined by the dominant survey method: surface surveys (1951 to 1987), and dive surveys (1988 to 2021).

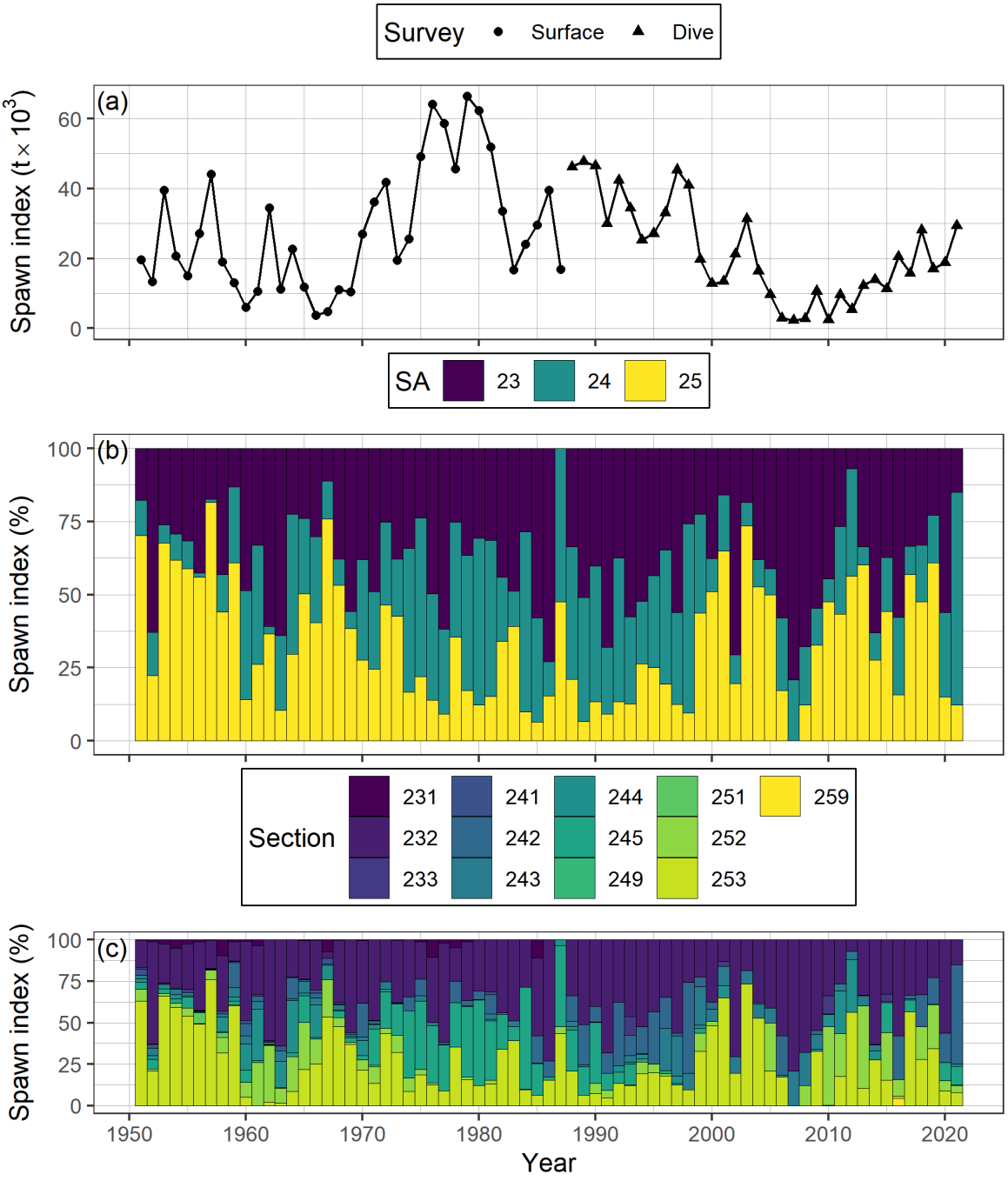

Figure 17. Time series of spawn index in thousands of metric tonnes ($t \times 10^3$) for Pacific Herring from 1951 to 2021 in the West Coast of Vancouver Island major stock assessment region (SAR; panel a), as well as percent contributed by Statistical Area (SA), and Section (b, & c, respectively). The spawn index has two distinct periods defined by the dominant survey method: surface surveys (1951 to 1987), and dive surveys (1988 to 2021). Note that spawn surveys in the dive survey period (1988 to 2021) are a combination of surface and dive surveys (Figures 14 and 15). The 'spawn index' is not scaled by the spawn survey scaling parameter, q.

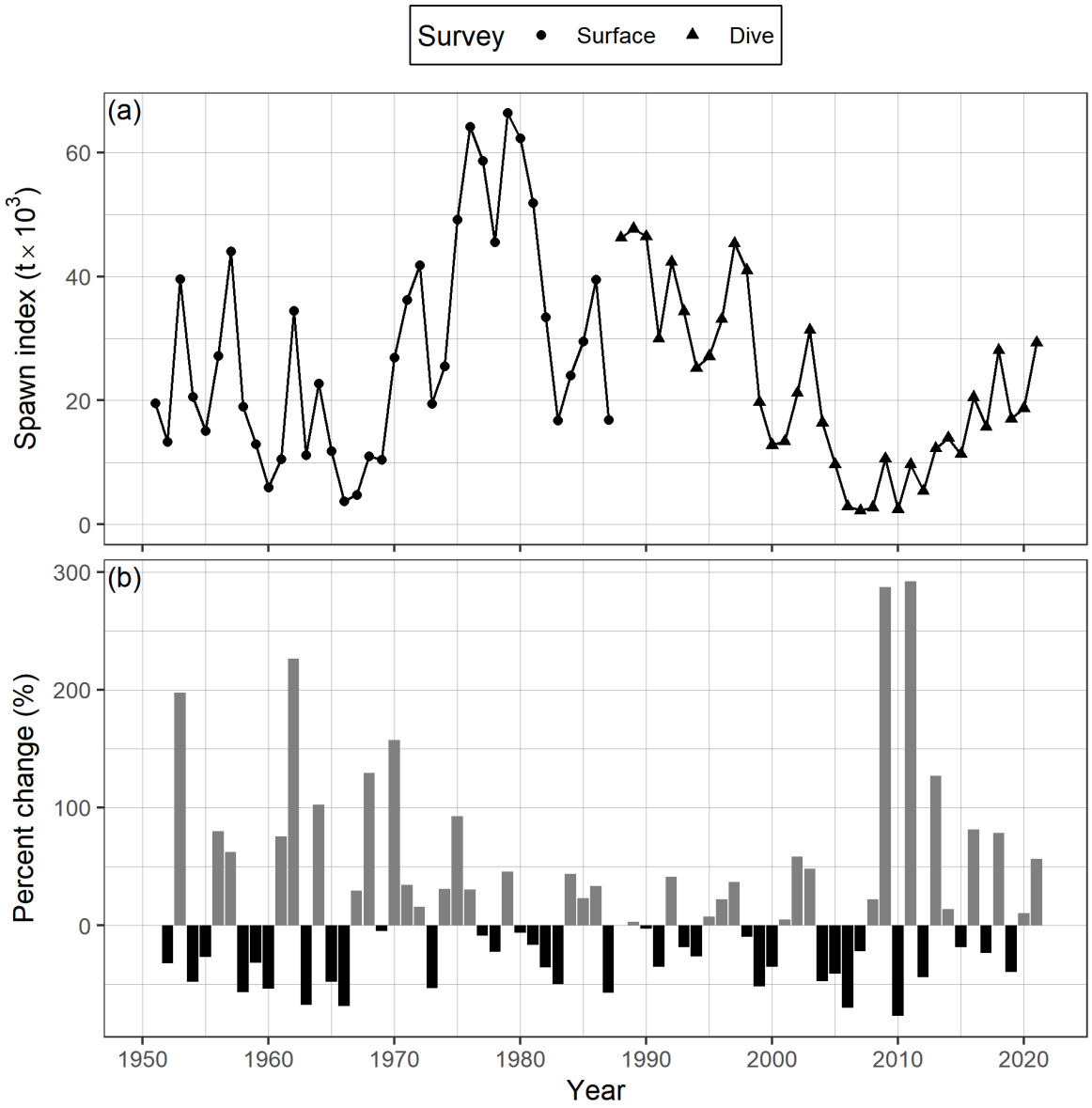

Figure 18. Time series of spawn index in thousands of metric tonnes ($t \times 10^3$) for Pacific Herring from 1951 to 2021 in the West Coast of Vancouver Island major stock assessment region (SAR; panel a), and percent change (b). Percent change is $\delta_t = \frac{\alpha_t - \alpha_{t-1}}{\alpha_{t-1}}$ 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 2021). The 'spawn index' is not scaled by the spawn survey scaling parameter, q. Note that spawn surveys in the dive survey period (1988 to 2021) are a combination of surface and dive surveys (Figures 14 and 15).

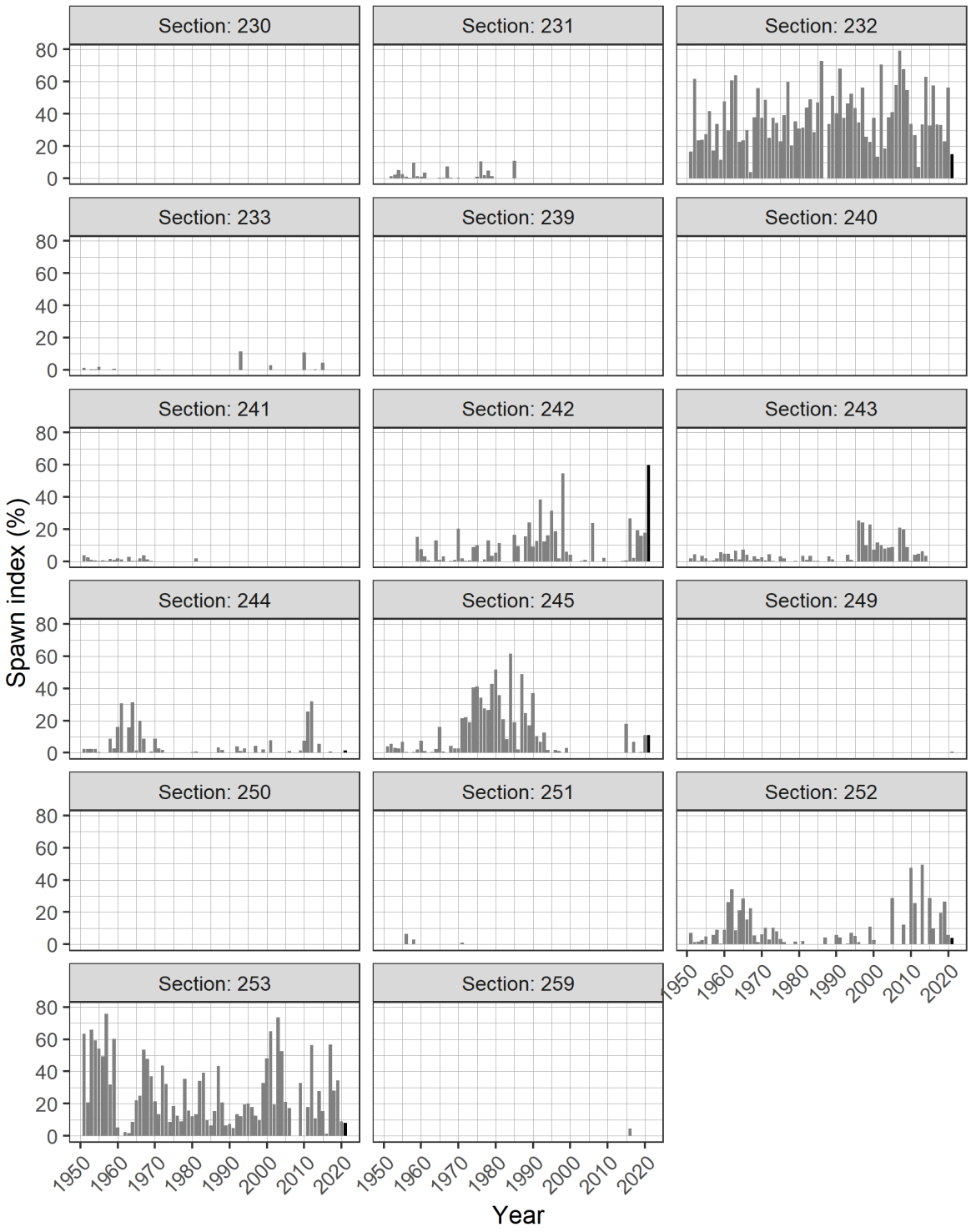

Figure 19. Time series of percent of spawn index by Section for Pacific Herring from 1951 to 2021 in the West Coast of Vancouver Island major stock assessment region (SAR). The year 2021 has a darker bar to facilitate interpretation. The spawn index has two distinct periods defined by the dominant survey method: surface surveys (1951 to 1987), and dive surveys (1988 to 2021). The 'spawn index' is not scaled by the spawn survey scaling parameter, q.

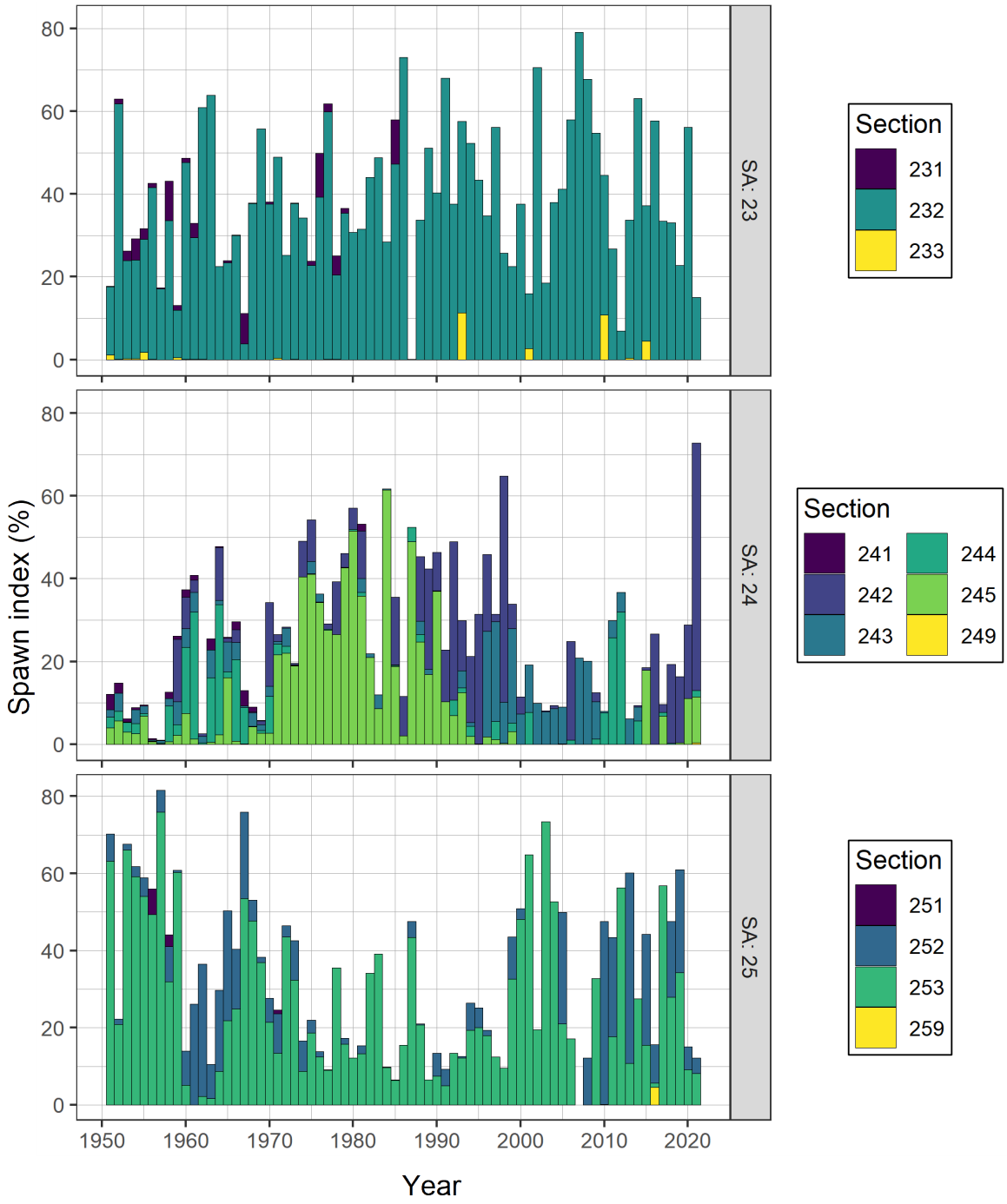

Figure 20. Time series of percent of spawn index by Statistical Area (SA) and Section for Pacific Herring from 1951 to 2021 in the West Coast of Vancouver Island major stock assessment region (SAR). The spawn index has two distinct periods defined by the dominant survey method: surface surveys (1951 to 1987), and dive surveys (1988 to 2021). The 'spawn index' is not scaled by the spawn survey scaling parameter, q.

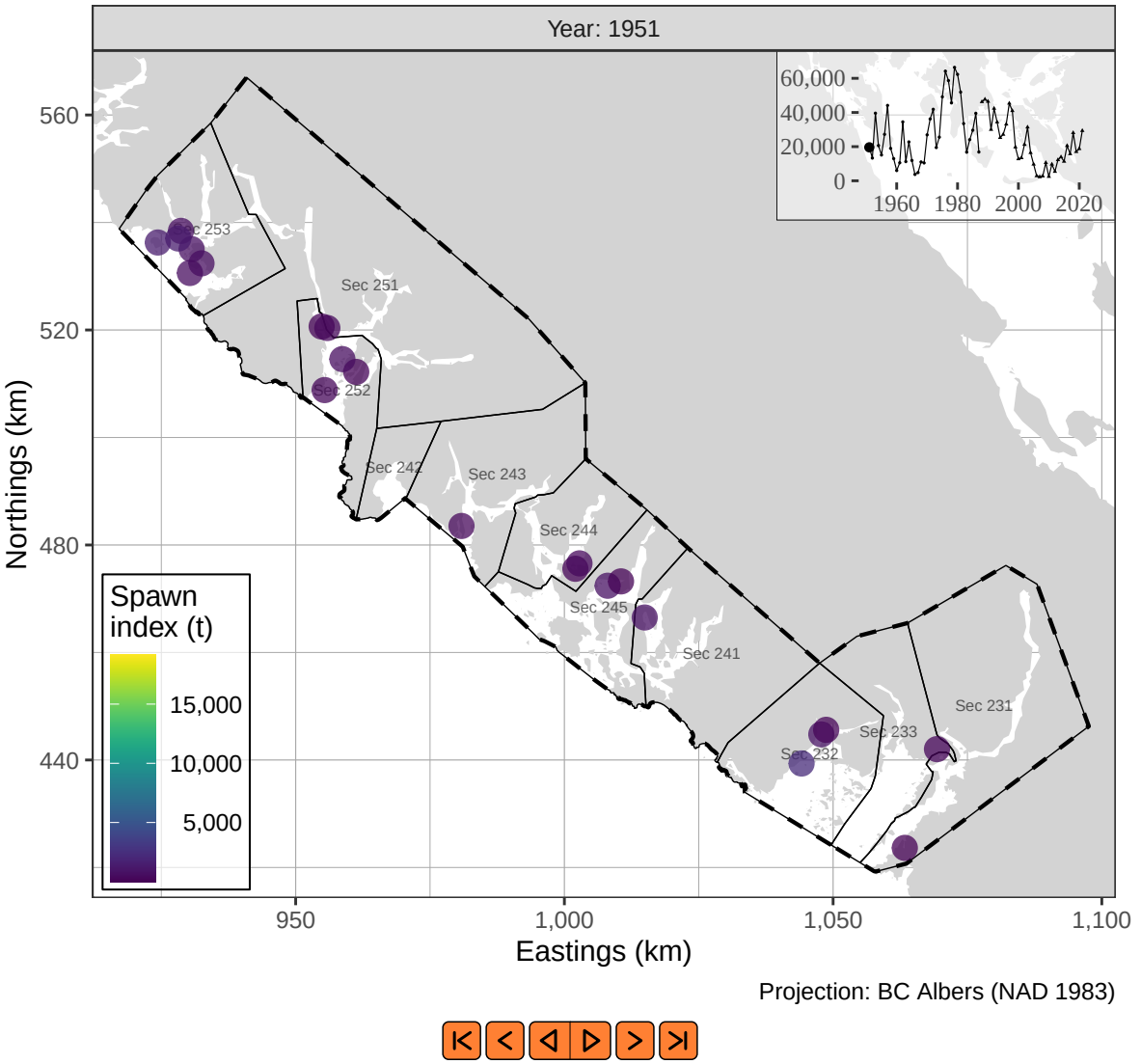

Figure 21. Animation of Pacific Herring spawn index in metric tonnes (t) by Location from 1951 to 2021 in the West Coast of Vancouver Island major stock assessment region (SAR; thick dashed lines), and associated Sections (Sec; thin solid lines). The spawn index has two distinct periods defined by the dominant survey method: surface surveys (1951 to 1987), and dive surveys (1988 to 2021). 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).