Pacific Herring preliminary data summary for Prince Rupert District 2021

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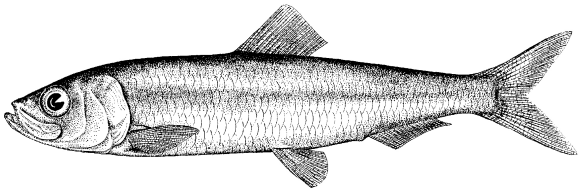

Pacific Herring (*Clupea pallasii*). Image credit: Fisheries and Oceans Canada.

Disclaimer This report contains preliminary data collected for Pacific Herring in 2021 in the Prince Rupert District 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

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 in 2021, 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.

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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 Prince Rupert District 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

In 2021, biological samples were collected by two seine test vessels:

- The "Nita Maria" collected samples in Big Bay for 13 days from March 15th to March 27th, and
- The "Viking Leader" collected samples in Kitkatla for 13 days from March 16th to March 28th.

The primary purpose of the test charter vessels was to collect biological samples from main bodies of herring from Big Bay and Kitkatla, identified from soundings. The dive charter vessel "Royal Pride" surveyed spawn for 20 days from April 7th to April 26th. All three charter 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. In addition to annual catch variability, catch varies among Statistical Areas (Figure 4). Total harvested spawn-on-kelp (SOK) in 2021 in the Prince Rupert District 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, 13 Pacific Herring biological samples were collected and processed for the Prince Rupert District major SAR (Table 5, Table 6), and a total of 1,162 Pacific Herring were aged in 2021. The locations in which the biological samples were collected are presented in 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 29 individual locations in 2021 in the Prince Rupert District major SAR (Table 8, and Figure 10). A summary of spawn from the last decade (2011 to 2020) is shown in Figure 11. Figure 12 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 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 coastwide 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 16b, Figure 18). For example, in 2021, Section 042 contributed the most to the spawn index (72%). As with Sections, some Statistical Areas 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 2021 (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:

- Continued COVID-19 precautions meant PRD Resource Management staff were not able to be on-grounds during the assessment activities.
- High winds and inclement weather throughout the test fishery were a challenge for charter operators.
- Large bodies of fish were observed in Kitkatla Inlet, but moved out and no spawn was observed in the typical locations at the top of the inlet.
- A significant spawn occurred on the outside of Kitkatla Inlet towards Joachim point and in front of Kitkatla Village.
- Water sea surface temperatures were similar to last year (5 to 6 degrees) and colder than recent years.
- Initial spawn occurred later than the last few years possibly due to the colder water temperatures.
- Egg deposition was better than average throughout both assessment areas.
- Collaboration on spawn surveys with local First Nations fishery programs greatly increased the capacity to assess the areas.
- Spawn occurred simultaneously throughout the assessment area.
- Perception of overall length of spawn is that it was below average.
- Good layers (6 to 8) observed from Big Bay south to Ryan Pt.
- No spawning observed at the north end of Porcher or Tugwell Island.
- Due to the late spawn, Lax Kw'alaams and Metlakatla were key in mapping and recording spawn for dives.

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 Prince Rupert District major stock assessment region (SAR).

Region	Statistical Area	Section
Prince Rupert District	03	031
Prince Rupert District	03	032
Prince Rupert District	03	033
Prince Rupert District	04	040
Prince Rupert District	04	041
Prince Rupert District	04	042
Prince Rupert District	04	043
Prince Rupert District	04	049
Prince Rupert District	05	050
Prince Rupert District	05	051
Prince Rupert District	05	052
Prince Rupert District	05	053
Prince Rupert District	05	059

Table 3. Total landed commercial catch of Pacific Herring in metric tonnes (t) by gear type in 2021 in the Prince Rupert District 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 Prince Rupert District 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	123,626	183
2012	87,494	130
2013	72,895	108
2014	113,269	168
2015	84,066	125
2016	WP	WP
2017	82,597	122
2018	20,832	31
2019	WP	WP
2020	0	0
2021	0	0

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

	Number of samples		
Year	Commercial	Test	Total
2011	38	18	56
2012	27	21	48
2013	31	13	44
2014	30	2	32
2015	45	11	56
2016	33	11	44
2017	40	11	51
2018	17	14	31
2019	2	13	15
2020	0	20	20
2021	0	13	13

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

Type	Gear	Use	Number of samples
Test	Seine	Test fishery	13

Table 7. Observed proportion-at-age for Pacific Herring from 2011 to 2021 in the Prince Rupert District major stock assessment region (SAR). The age-10 class is a 'plus group' which includes fish ages 10 and older.

	Proportion-at-age								
Year	2	3	4	5	6	7	8	9	10
2011	0.005	0.361	0.310	0.155	0.061	0.086	0.014	0.006	0.002
2012	0.030	0.095	0.456	0.225	0.098	0.052	0.039	0.004	0.001
2013	0.007	0.418	0.176	0.218	0.118	0.032	0.022	0.009	0.000
2014	0.008	0.079	0.458	0.150	0.176	0.081	0.030	0.013	0.004
2015	0.047	0.531	0.067	0.191	0.060	0.067	0.025	0.009	0.003
2016	0.017	0.162	0.485	0.060	0.165	0.050	0.039	0.016	0.006
2017	0.014	0.151	0.179	0.438	0.063	0.099	0.029	0.020	0.007
2018	0.048	0.413	0.132	0.158	0.189	0.029	0.017	0.009	0.006
2019	0.014	0.527	0.249	0.069	0.081	0.048	0.008	0.005	0.000
2020	0.004	0.023	0.762	0.154	0.031	0.017	0.007	0.002	0.001
2021	0.005	0.148	0.028	0.660	0.108	0.028	0.015	0.007	0.000

Table 8. Pacific Herring spawn survey locations, start date, and spawn index in metric tonnes (t) in 2021 in the Prince Rupert District 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)
03	033	Cunningham Pass	April 03	218
03	033	Flewin Pt	April 03	41
03	033	Grassy Pt	April 03	653
03	033	Harbour Rfs	April 03	0
03	033	Port Simpson	April 03	159
03	033	Stumaun Bay	April 03	673
03	033	Village Is	April 03	511
04	042	Belletti Pt	April 03	2,446
04	042	Big Bay	March 28	4,872
04	042	Burnt Cliff Is	April 03	2,028
04	042	Duncan Bay	April 03	740
04	042	Finlayson Is W	April 03	338
04	042	Flat Top Islets	April 03	33
04	042	Mist Is	April 03	27
04	042	Pearl Hrbr	April 03	238
04	042	Reeks Pt	April 02	1,085
04	042	Swamp Is	April 03	1,509
04	042	Tree Bluff	April 03	10,390
04	042	Tugwell Is	April 03	17
05	051	Joachim Pt	April 03	1,285
05	052	Cape George	April 03	841
05	052	Cessford Is	March 31	338
05	052	Chief Pt	March 27	2,146
05	052	Freeman Pass	April 03	518
05	052	Gladstone Is	March 25	74
05	052	Joachim Spit	April 03	1,310
05	052	Viscount Pt	March 31	111
05	052	Whiteley Pt	March 31	308
05	052	Willis Bay	March 31	155

Table 9. Summary of Pacific Herring spawn survey data from 2011 to 2021 in the Prince Rupert District major stock assessment region (SAR). The spawn index has two distinct periods defined by the dominant coastwide 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	52,925	118	0.8	21,097
2012	61,950	115	0.8	22,716
2013	46,500	97	1.0	25,755
2014	60,000	123	0.6	17,125
2015	59,825	105	0.7	17,407
2016	48,525	113	0.6	18,985
2017	45,675	174	0.7	19,235
2018	51,000	106	0.5	14,155
2019	87,125	110	0.6	27,190
2020	59,960	206	1.7	25,845
2021	72,250	118	1.3	33,062

8 Figures

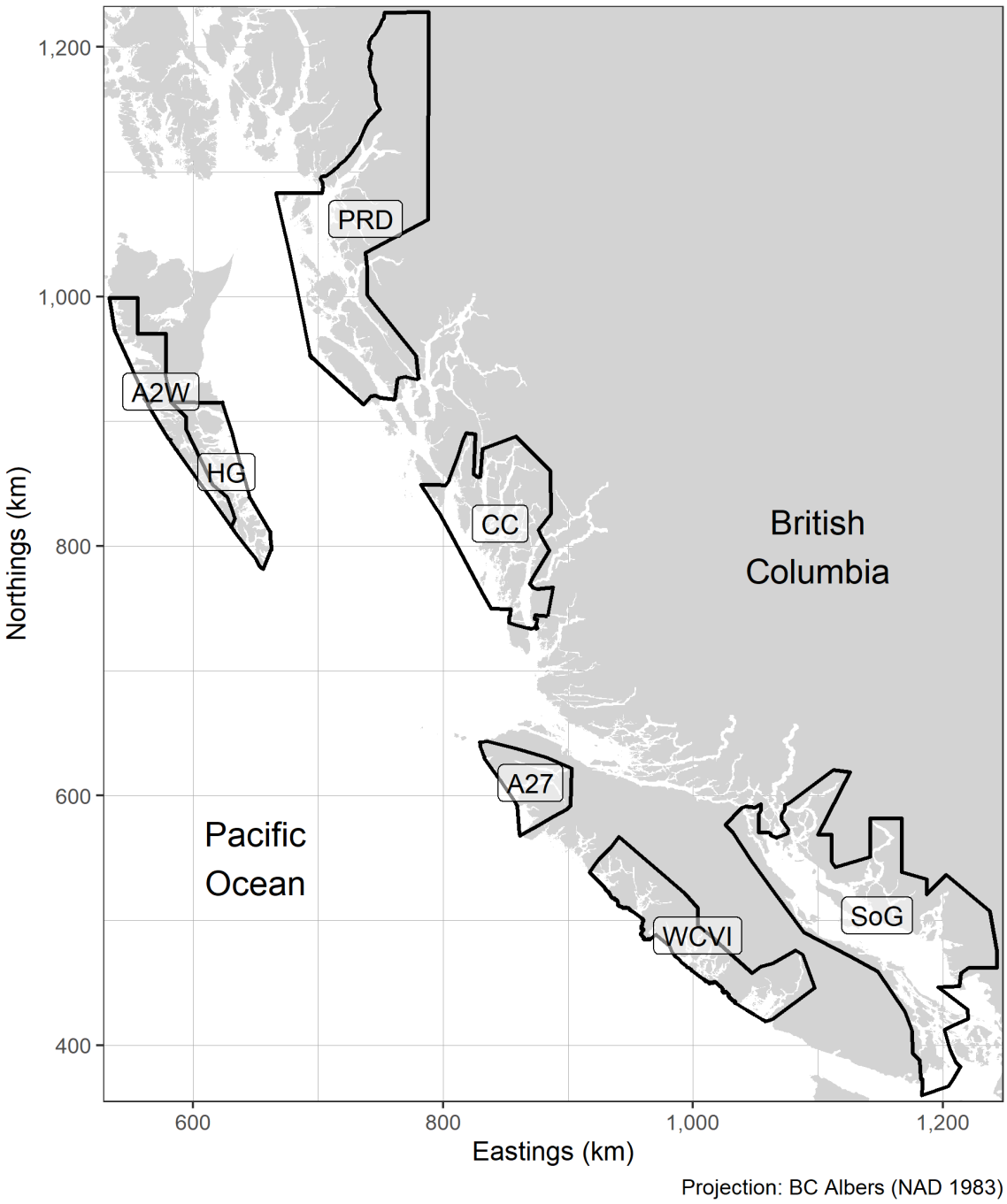

Figure 1. Boundaries for the Pacific Herring stock assessment regions (SARs) in British Columbia. There are 5 major SARs: Haida Gwaii (HG), Prince Rupert District (PRD), Central Coast (CC), Strait of Georgia (SoG), and West Coast of Vancouver Island (WCVI). There are 2 minor SARs: Area 27 (A27) and Area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

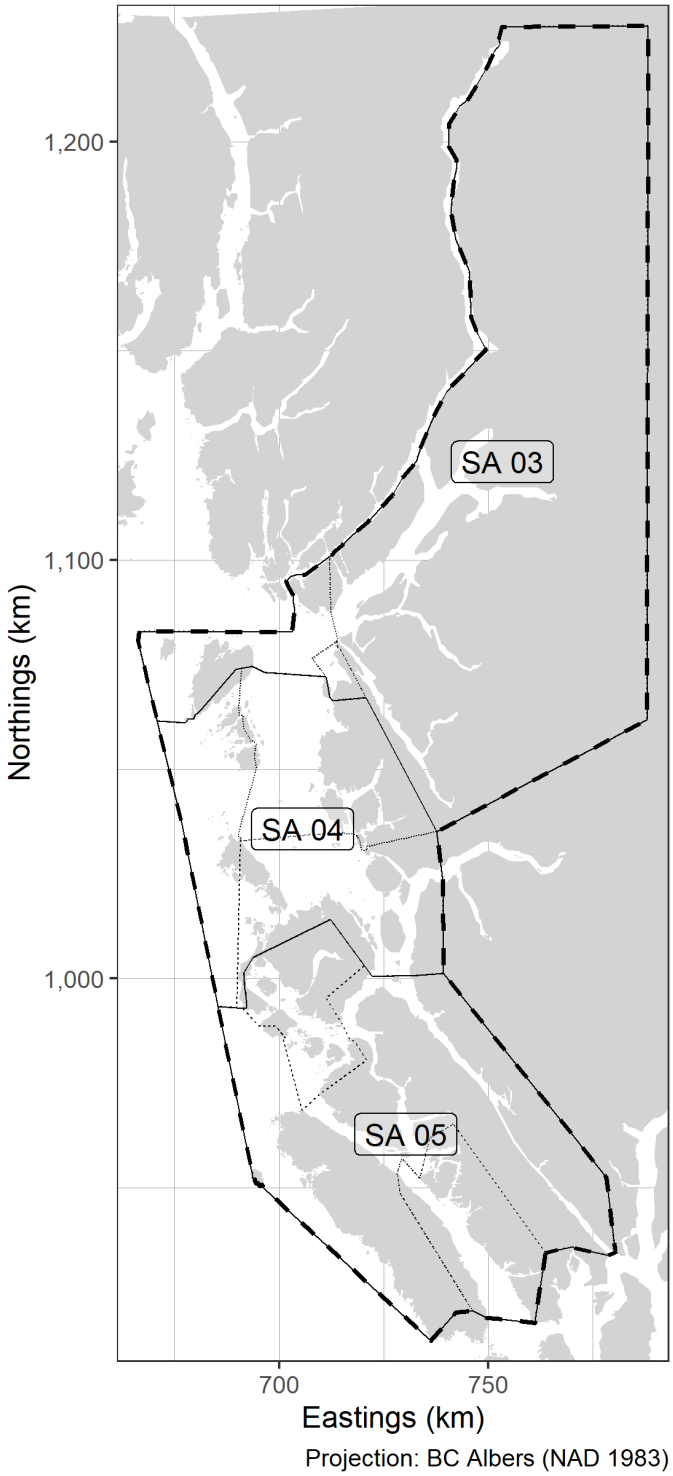

Figure 2. Boundaries for the Prince Rupert District major stock assessment region (SAR; thick dashed lines), associated Statistical Areas (SA; thin solid lines), and associated Sections (thin dotted lines). Units: kilometres (km).

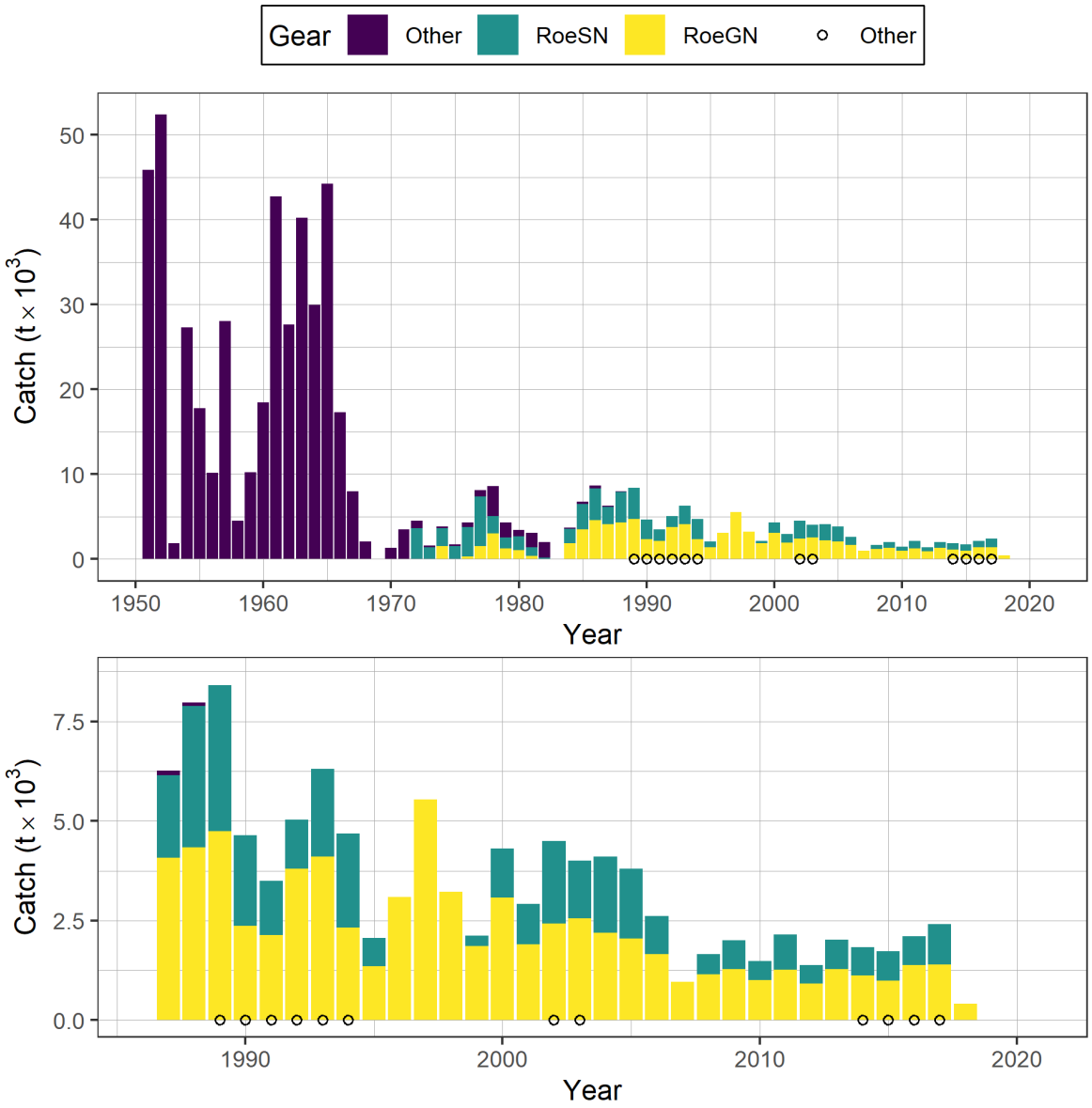

Figure 3. Time series of total landed catch in thousands of metric tonnes ($t \times 10^3$) of Pacific Herring by gear type from 1951 to 2021 in the Prince Rupert District major stock assessment region (SAR). Legend: 'Other' represents the reduction (1951 to 1970 only), the food and bait, as well as 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. Bottom panel shows catch since 1986 in more detail. Note: symbols indicate years in which catch by gear type (i.e., Other, RoeSN, RoeGN) is withheld due to privacy concerns.

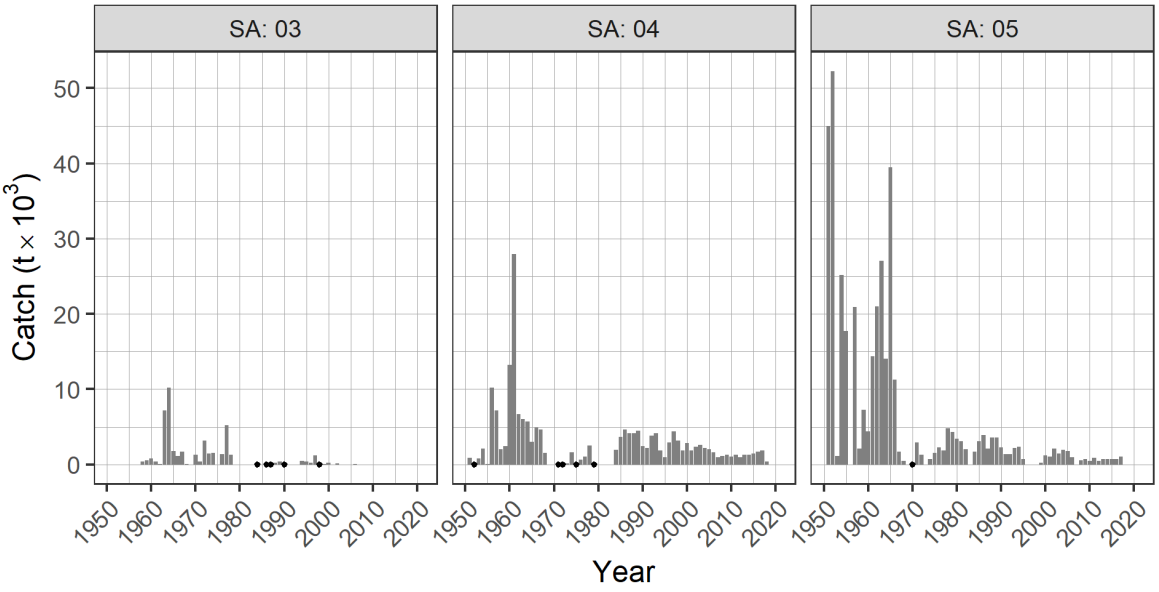

Figure 4. Time series of total landed catch in thousands of metric tonnes ($t \times 10^3$) of Pacific Herring by Statistical Area (SA) from 1951 to 2021 in the Prince Rupert District major stock assessment region (SAR). The year 2021 has a darker bar to facilitate interpretation. Note: symbols indicate years in which catch is withheld due to privacy concerns.

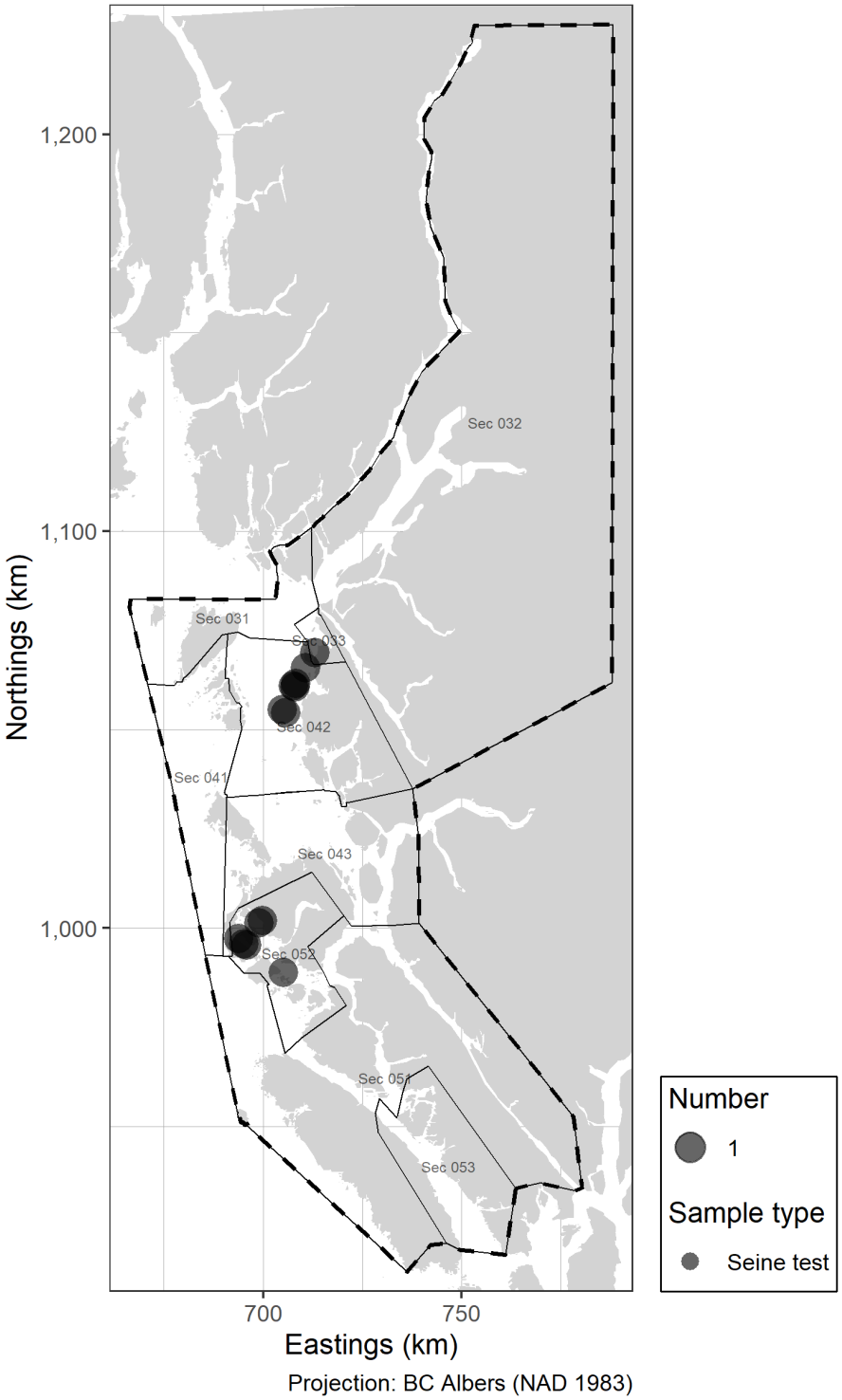

Figure 5. Location and type of Pacific Herring biological samples collected in 2021 in the Prince Rupert District major stock assessment region (SAR; thick dashed lines), and associated Sections (Sec; thin solid lines). Units: kilometres (km).

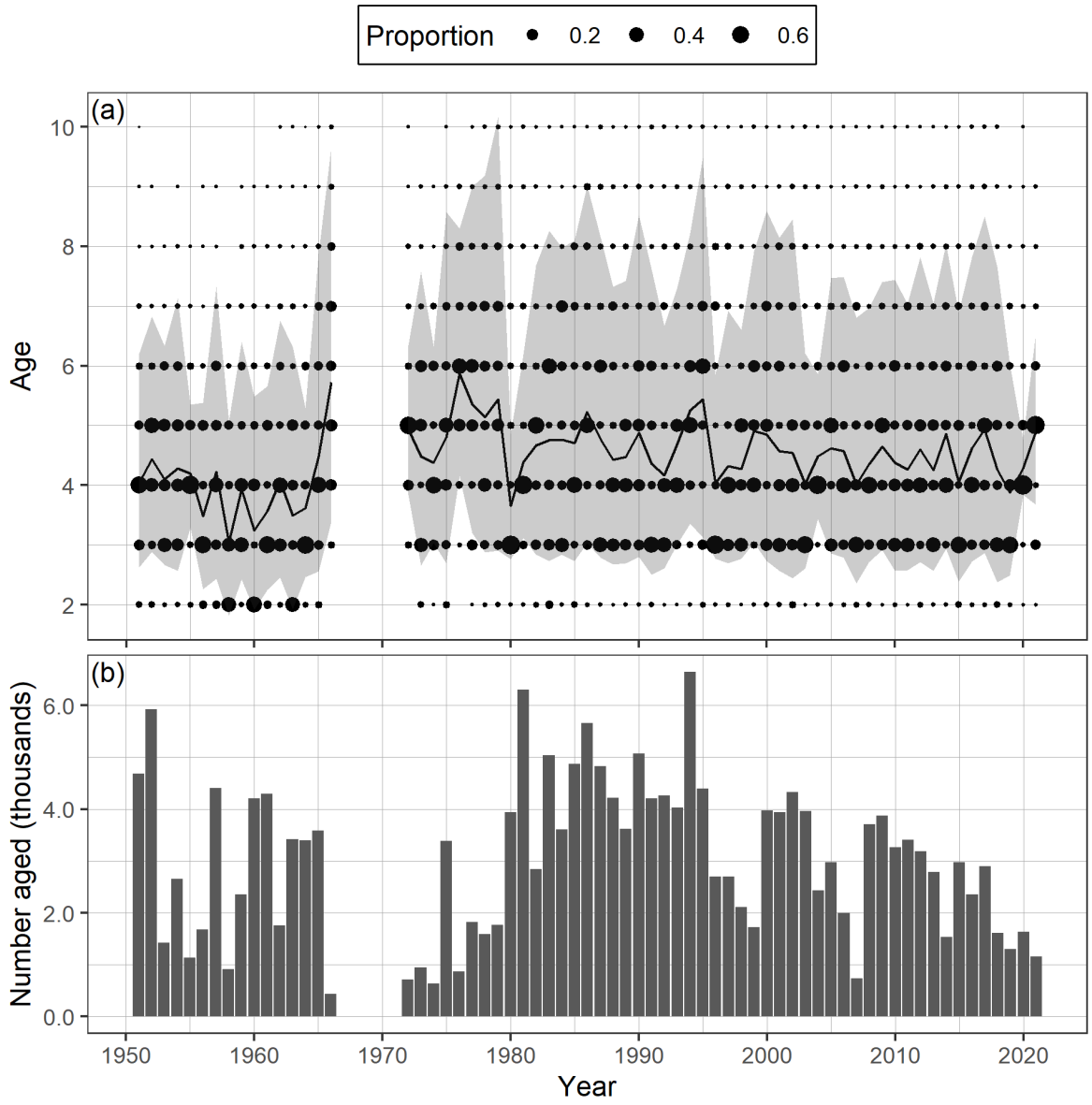

Figure 6. Time series of observed proportion-at-age (a) and number aged in thousands (b) of Pacific Herring from 1951 to 2021 in the Prince Rupert District major stock assessment region (SAR). The black line is the mean age, and the shaded area is the approximate 90% distribution. Biological summaries only include samples collected using seine nets (commercial and test) due to size-selectivity of other gear types such as gillnet. The age-10 class is a 'plus group' which includes fish ages 10 and older.

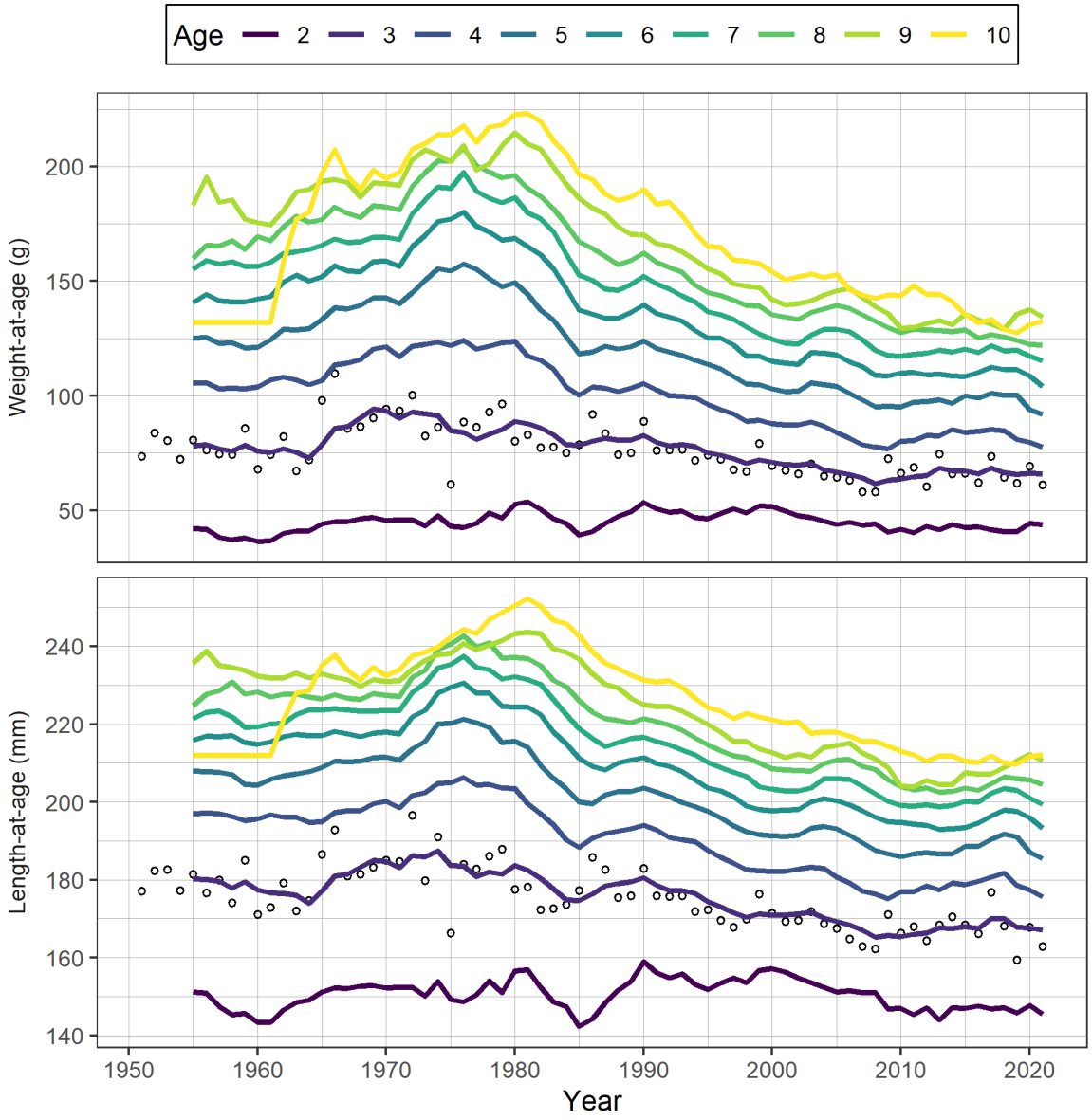

Figure 7. Time series of weight-at-age in grams (g) and length-at-age in milimetres (mm) for age-3 (circles) and 5-year running mean weight- and length-at-age (lines) for Pacific Herring from 1951 to 2021 in the Prince Rupert District major stock assessment region (SAR). Missing weight- and length-at-age 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.

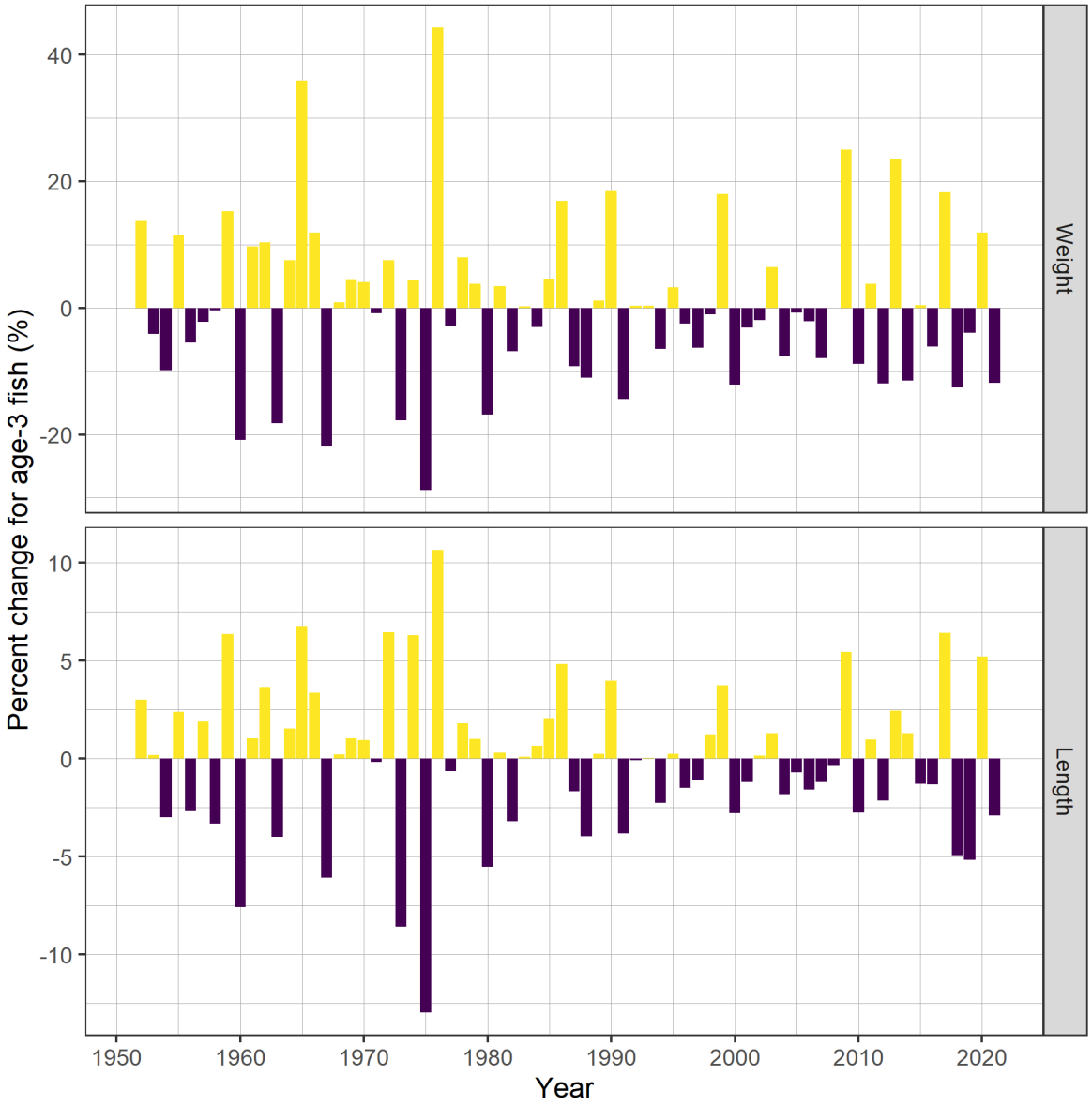

Figure 8. Time series of percent change (%) in weight and length for age-3 fish for Pacific Herring from 1951 to 2021 in the Prince Rupert District major stock assessment region (SAR). Percent change is $\delta_t = \frac{\alpha_t - \alpha_{t-1}}{\alpha_{t-1}}$ where α_t is the weight and length of age-3 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.

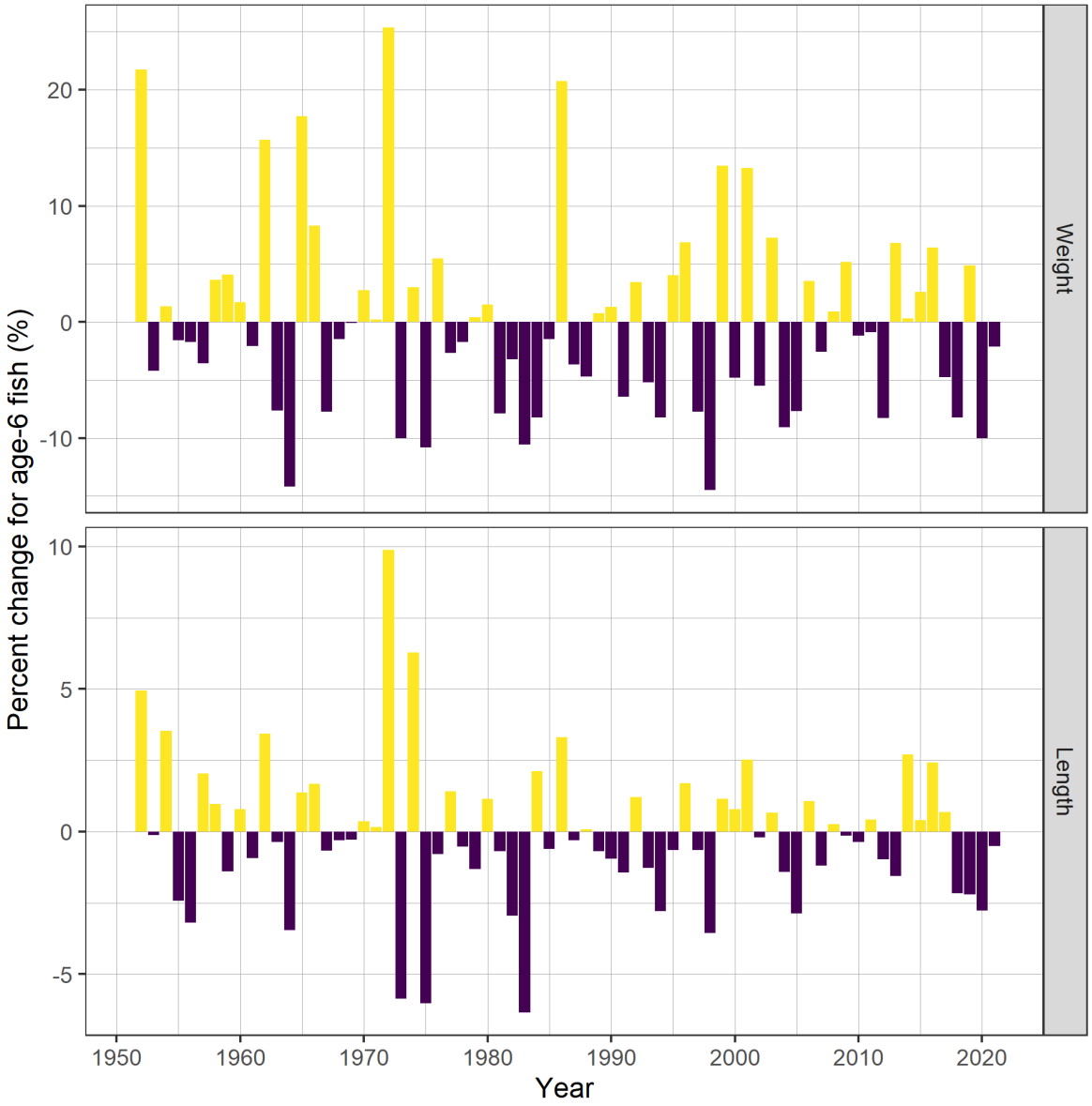

Figure 9. Time series of percent change (%) in weight and length for age-6 fish for Pacific Herring from 1951 to 2021 in the Prince Rupert District major stock assessment region (SAR). Percent change is $\delta_t = \frac{\alpha_t - \alpha_{t-1}}{\alpha_{t-1}}$ where α_t is the weight and length of age-6 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.

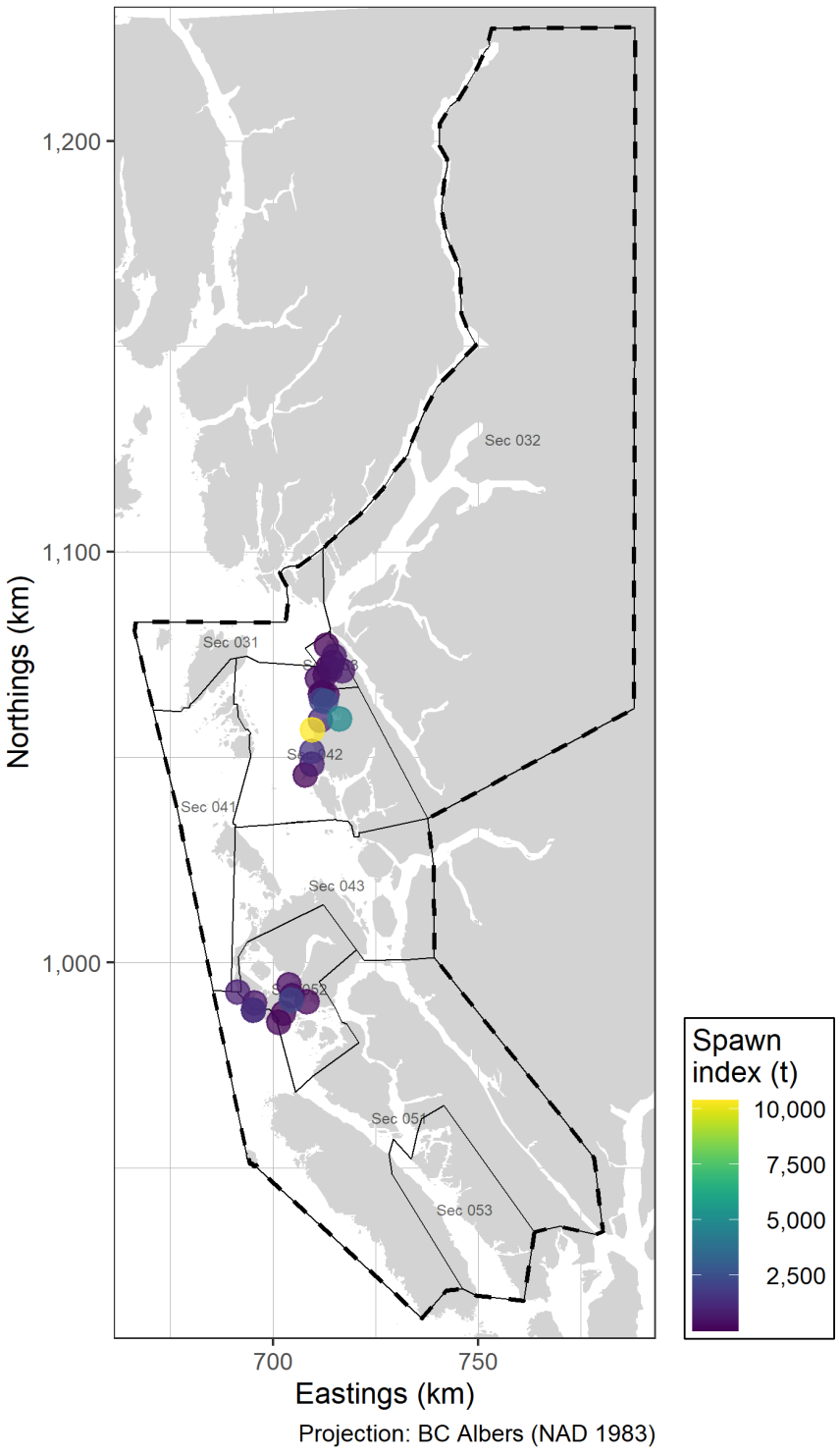

Figure 10. Pacific Herring spawn survey locations, and spawn index in metric tonnes (t) in 2021 in the Prince Rupert District major stock assessment region (SAR; thick dashed lines), and associated Sections (Sec; thin solid lines). The 'spawn index' is not scaled by the spawn survey scaling parameter, q. Missing spawn index values (grey circles) indicate incomplete spawn surveys. Units: kilometres (km).

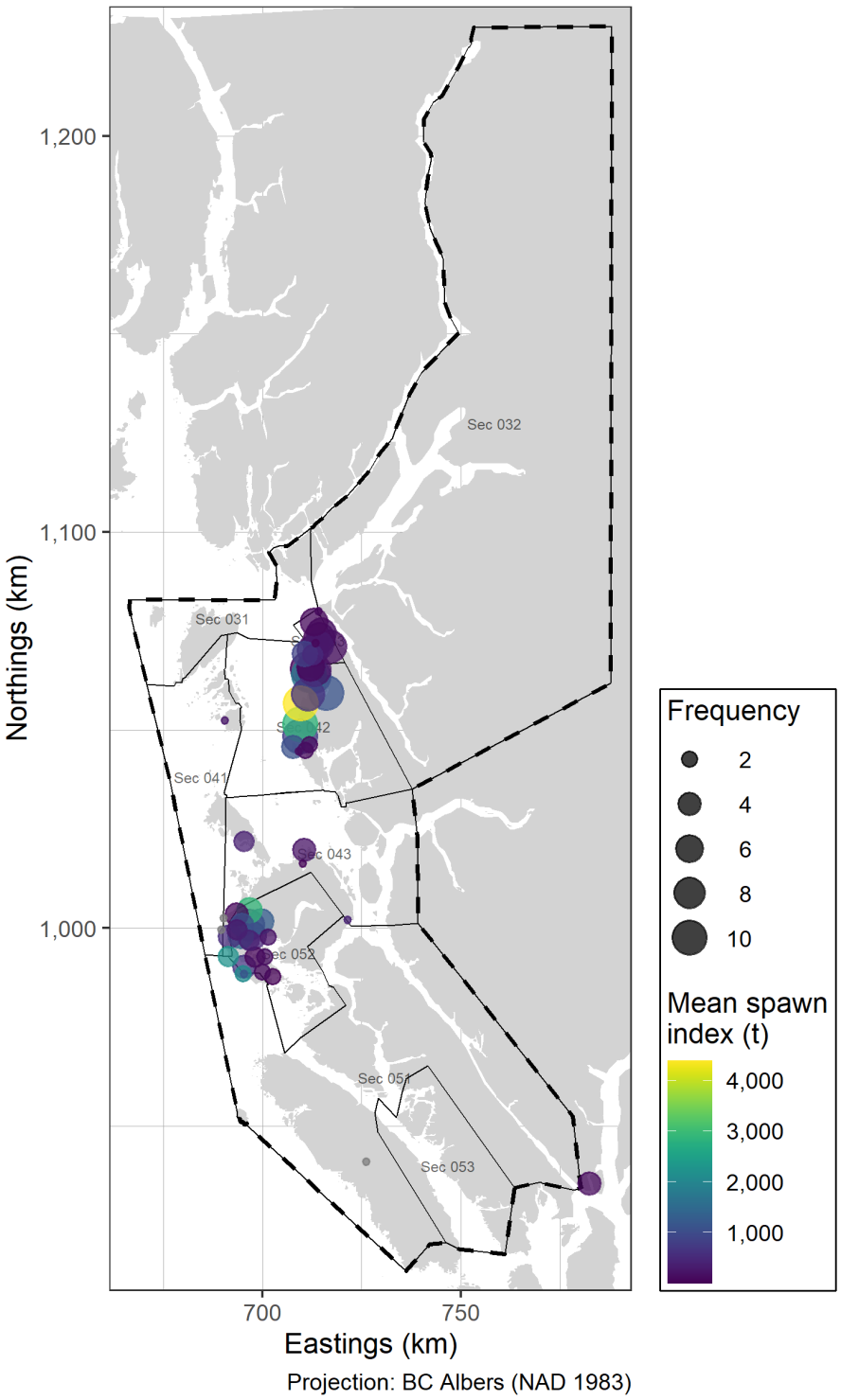

Figure 11. Pacific Herring spawn survey locations, mean spawn index in metric tonnes (t), and spawn frequency from 2011 to 2020 in the Prince Rupert District major stock assessment region (SAR; thick dashed lines), and associated Sections (Sec; thin solid lines). The 'spawn index' is not scaled by the spawn survey scaling parameter, q. Missing spawn index values (grey circles) indicate incomplete spawn surveys. Units: kilometres (km).

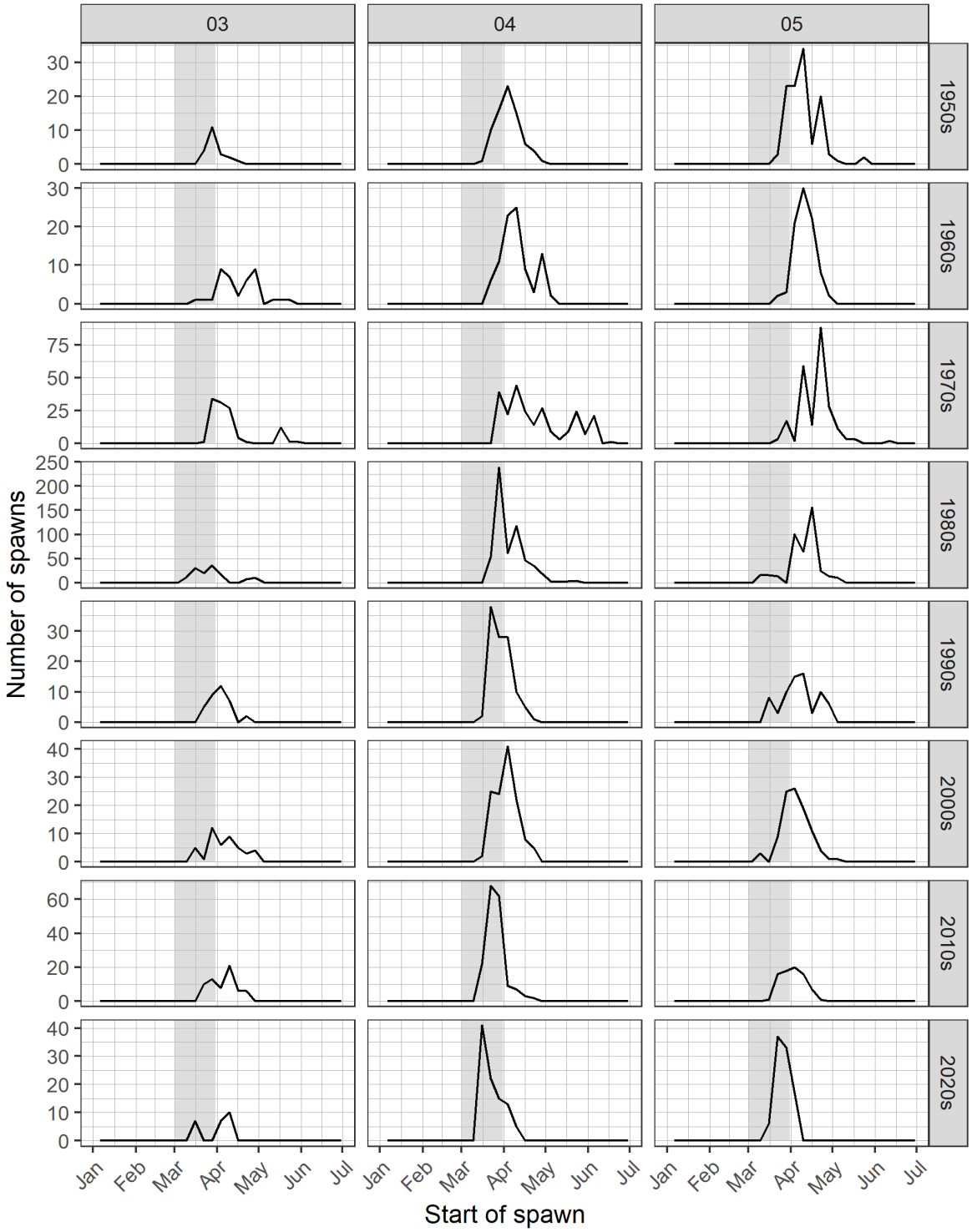

Figure 12. Pacific Herring spawn start date by decade and Statistical Area. Grey shaded regions indicate March 1st to 31st. Note that spawn size and intensity varies; therefore the number of spawns is not directly proportional to spawn extent or biomass.

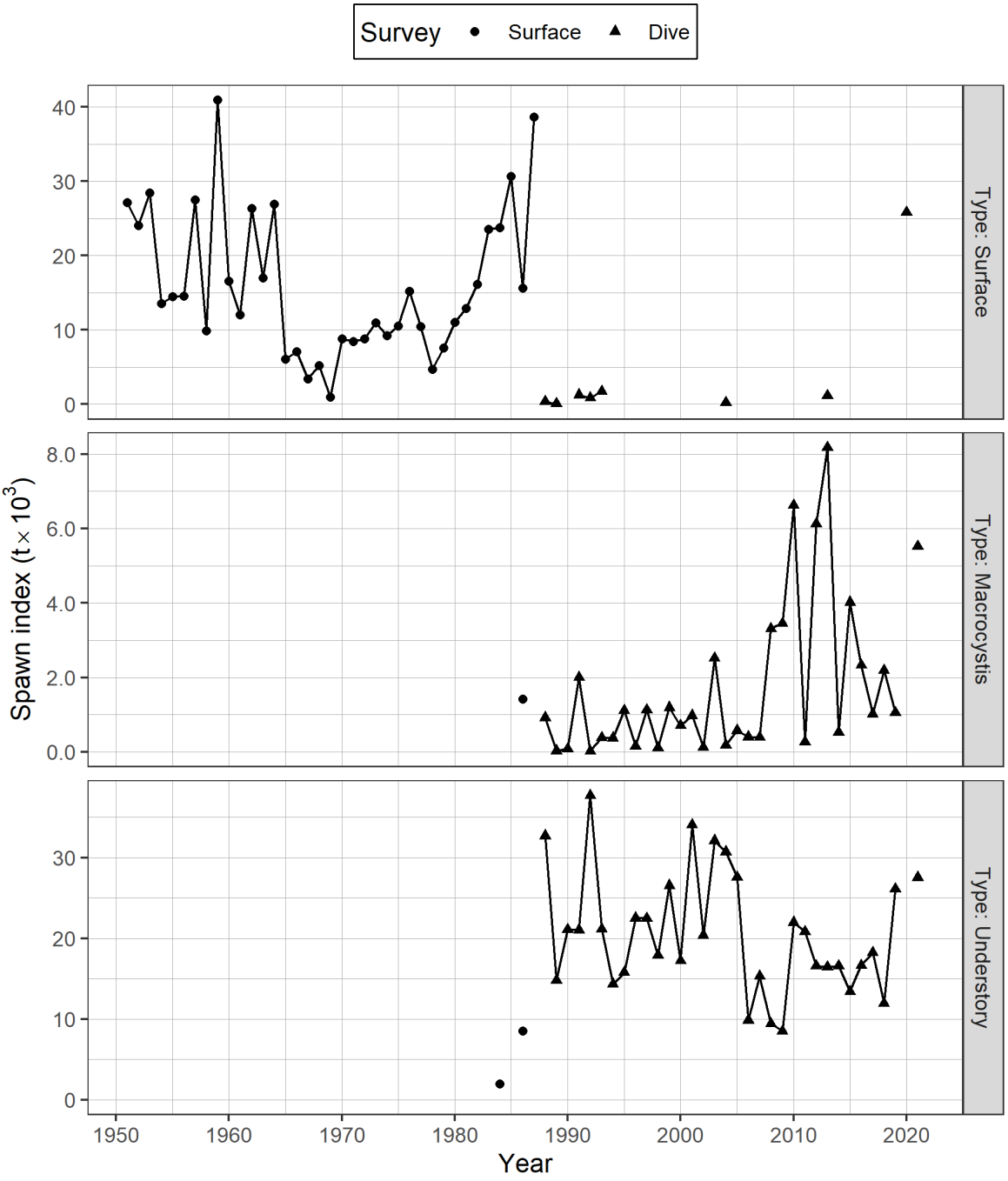

Figure 13. Time series of spawn index in thousands of metric tonnes ($t \times 10^3$) by type for Pacific Herring from 1951 to 2021 in the Prince Rupert District major stock assessment region (SAR). There are three types of spawn survey observations: observations of spawn taken from the surface usually 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 coastwide survey method: surface surveys (1951 to 1987), and dive surveys (1988 to 2021).

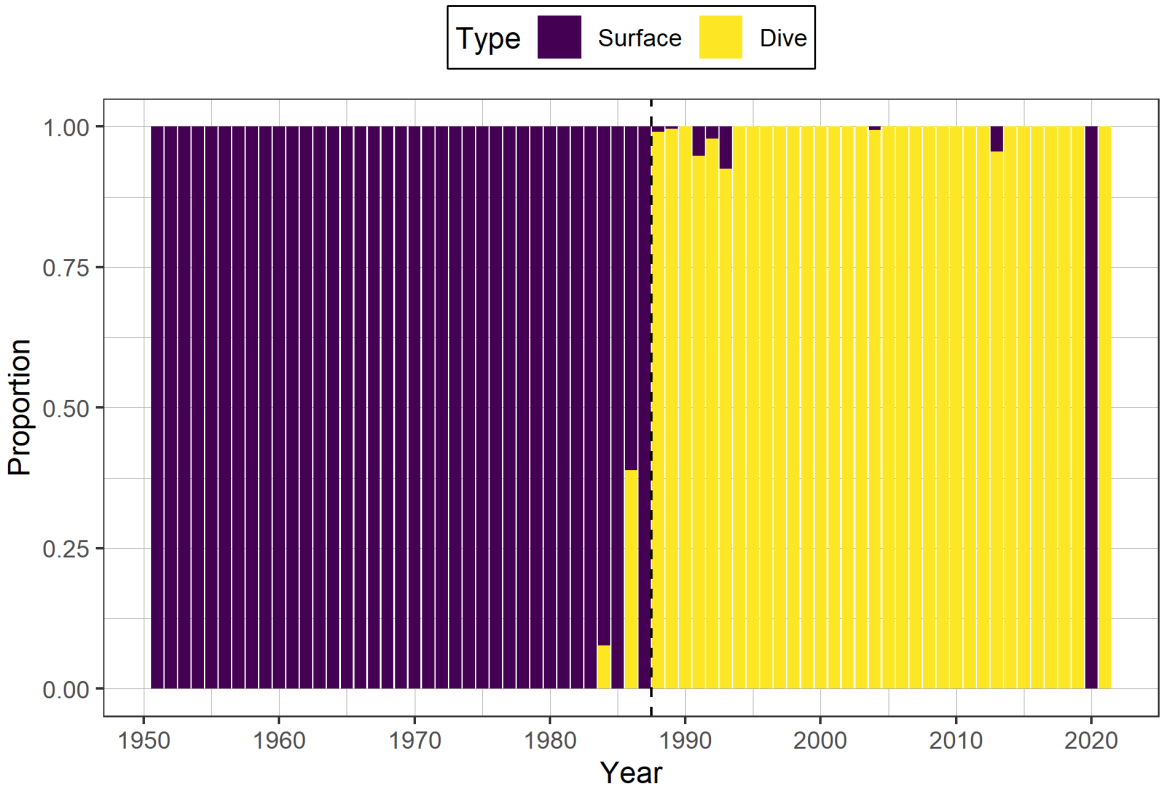

Figure 14. Time series of proportion of spawn index by surface and dive surveys for Pacific Herring from 1951 to 2021 in the Prince Rupert District major stock assessment region (SAR). The spawn index has two distinct periods defined by the dominant coastwide survey method: surface surveys (1951 to 1987), and dive surveys (1988 to 2021).

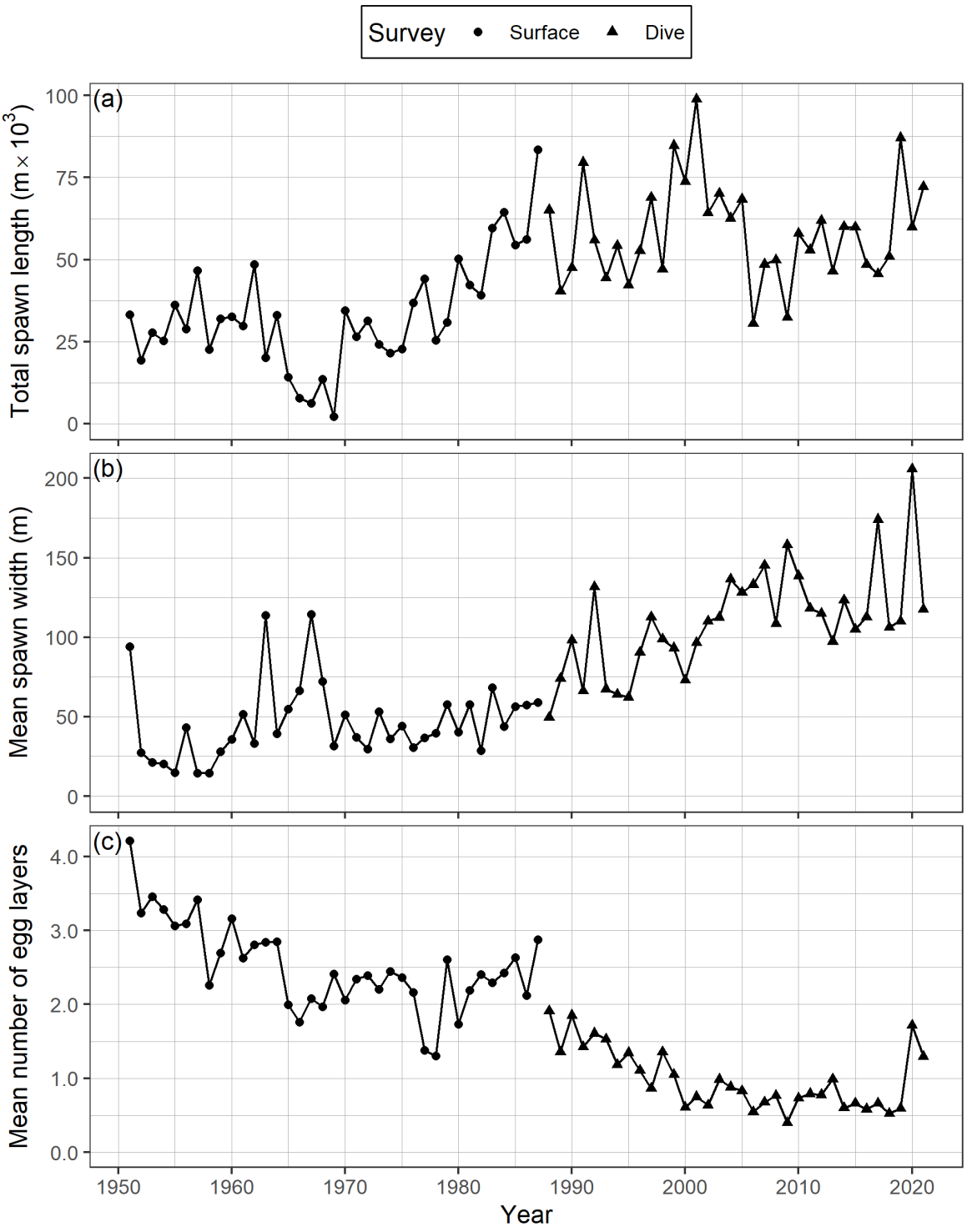

Figure 15. Time series of total spawn length in thousands of metres (m $\times$ 10^3; panel a), mean spawn width in metres (b), and mean number of egg layers (c) for Pacific Herring from 1951 to 2021 in the Prince Rupert District major stock assessment region (SAR). The spawn index has two distinct periods defined by the dominant coastwide survey method: surface surveys (1951 to 1987), and dive surveys (1988 to 2021).

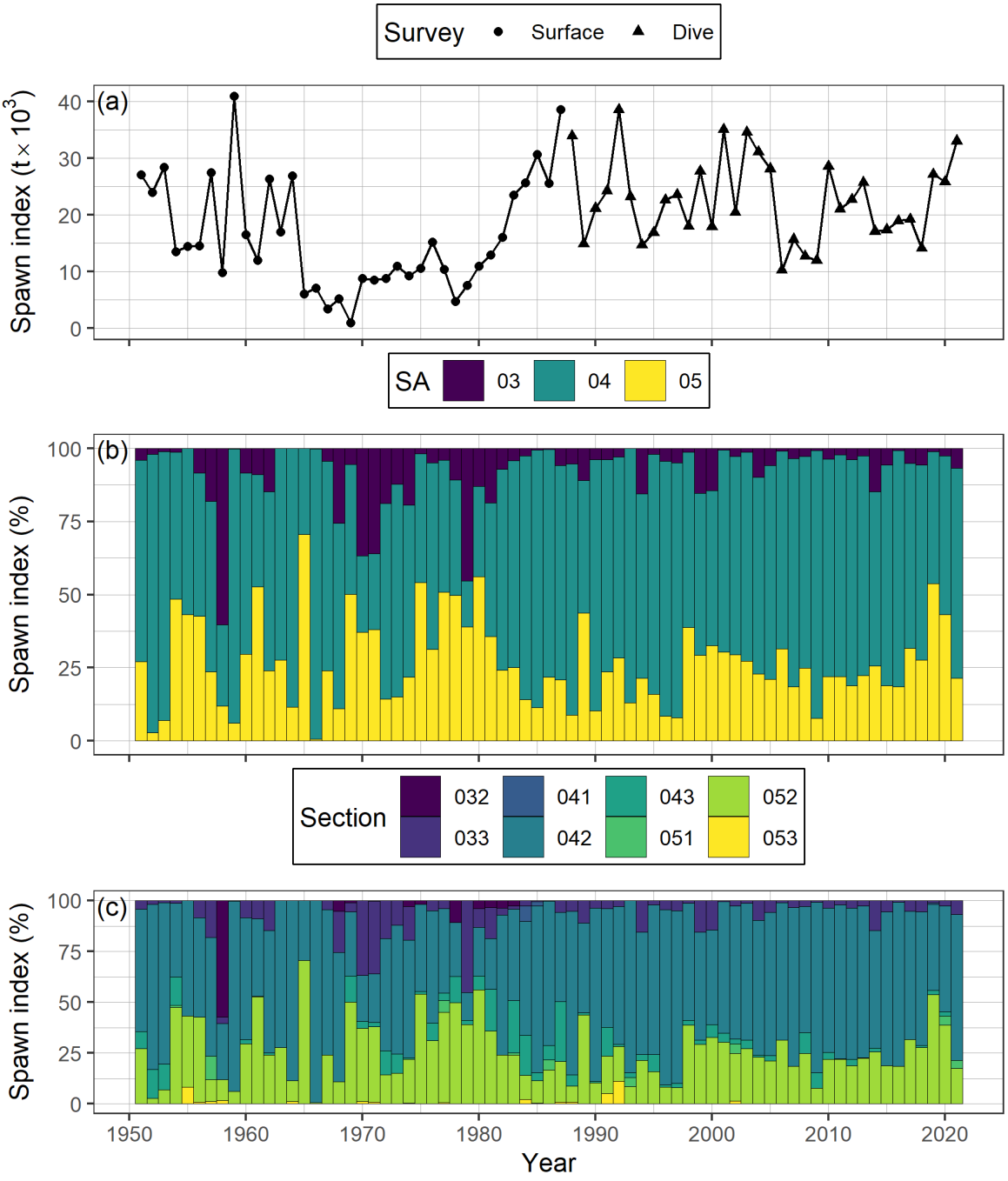

Figure 16. Time series of spawn index in thousands of metric tonnes (t $\times$ 10^3) for Pacific Herring from 1951 to 2021 in the Prince Rupert District major stock assessment region (SAR; panel a), as well as percent contributed by Statistical Area (SA), and Section (b, & c, respectively). The spawn index has two distinct periods defined by the dominant coastwide 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 13 and 14). The 'spawn index' is not scaled by the spawn survey scaling parameter, q.

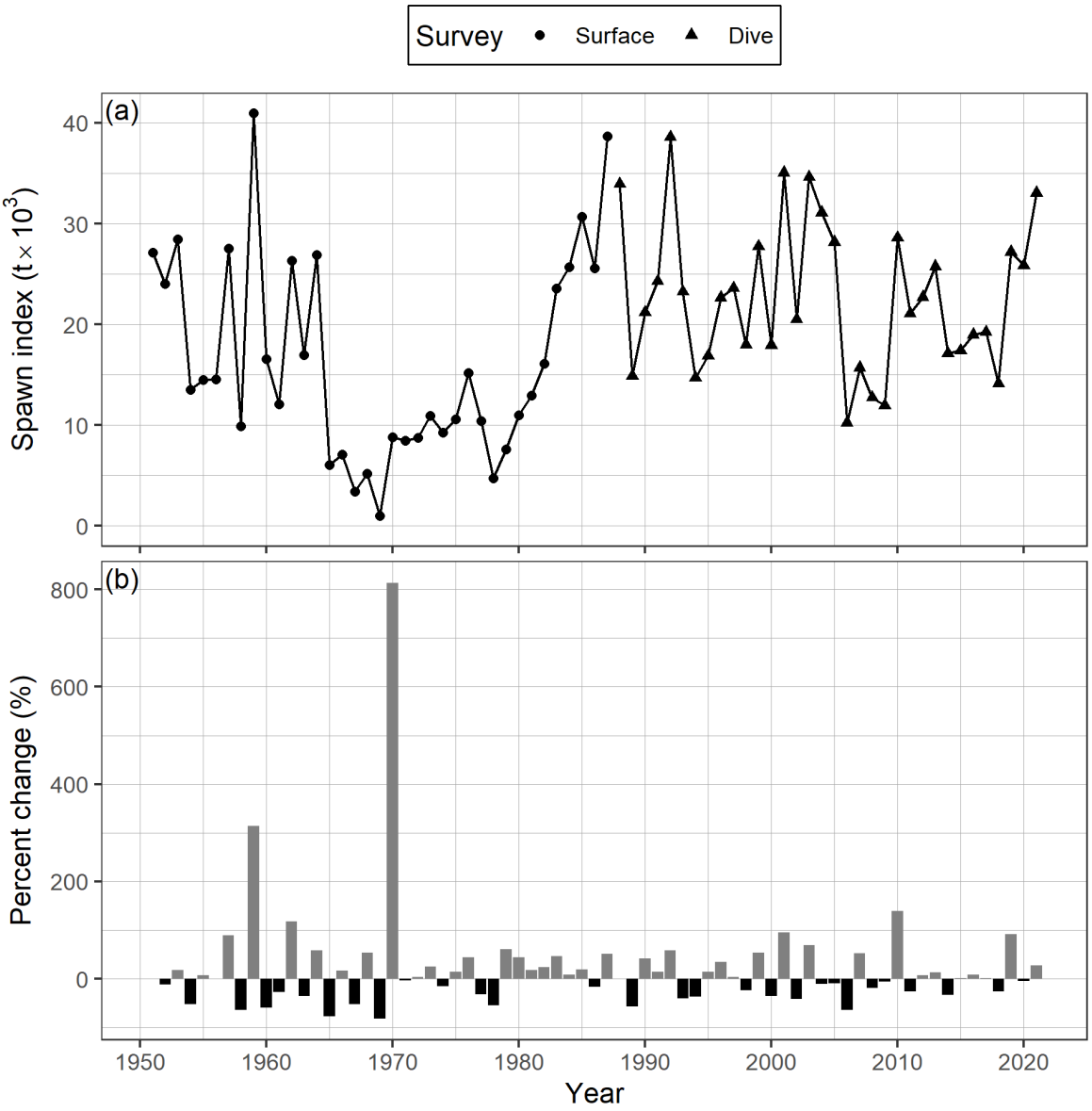

Figure 17. Time series of spawn index in thousands of metric tonnes ($t \times 10^3$) for Pacific Herring from 1951 to 2021 in the Prince Rupert District major stock assessment region (SAR; panel a), and percent change (b). Percent change is $\delta_t = \frac{\alpha_t - \alpha_{t-1}}{\alpha_{t-1}}$ where α_t is the spawn index in year t. The spawn index has two distinct periods defined by the dominant coastwide 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 13 and 14).

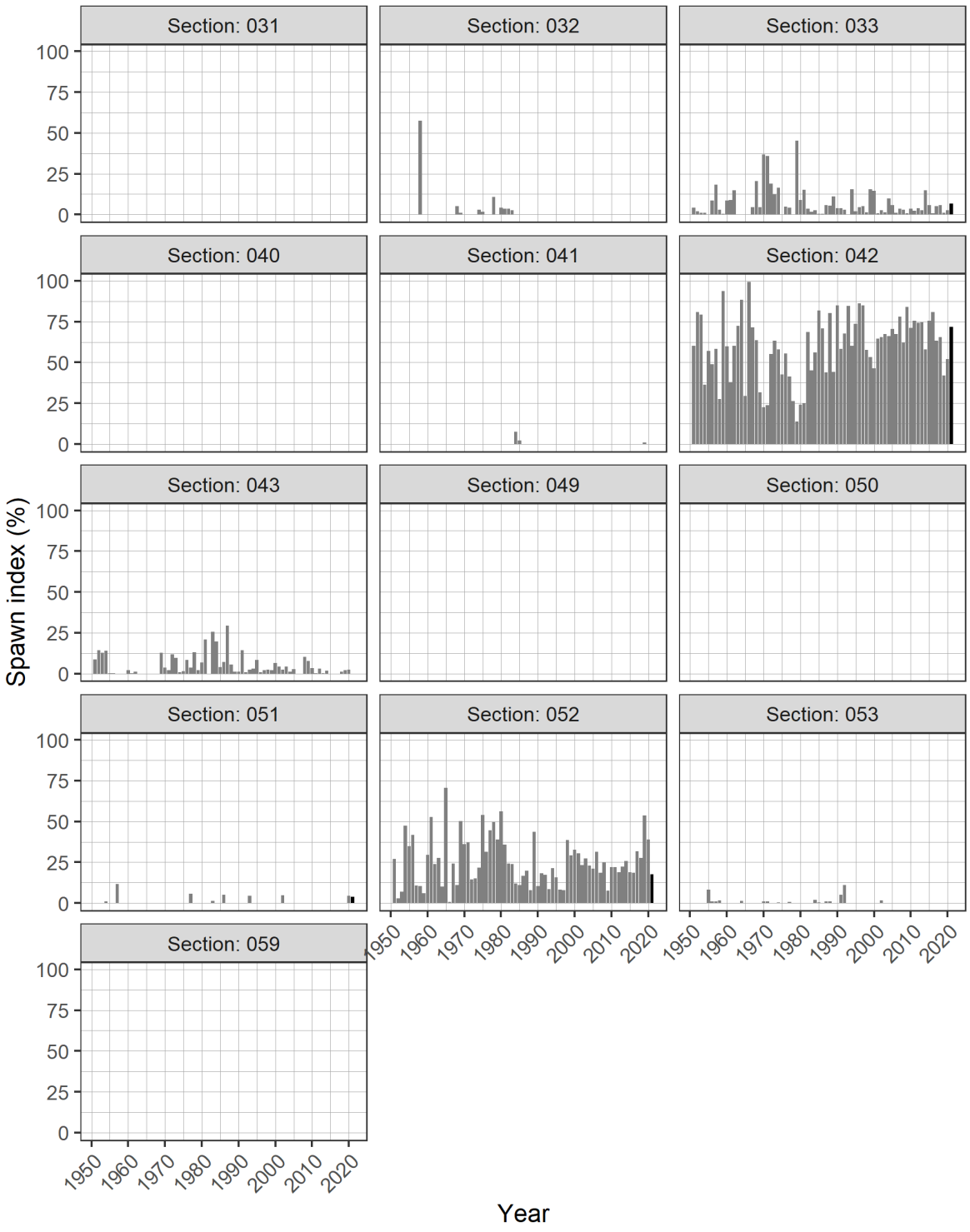

Figure 18. Time series of percent of spawn index by Section for Pacific Herring from 1951 to 2021 in the Prince Rupert District major stock assessment region (SAR). The year 2021 has a darker bar to facilitate interpretation. The spawn index has two distinct periods defined by the dominant coastwide 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.

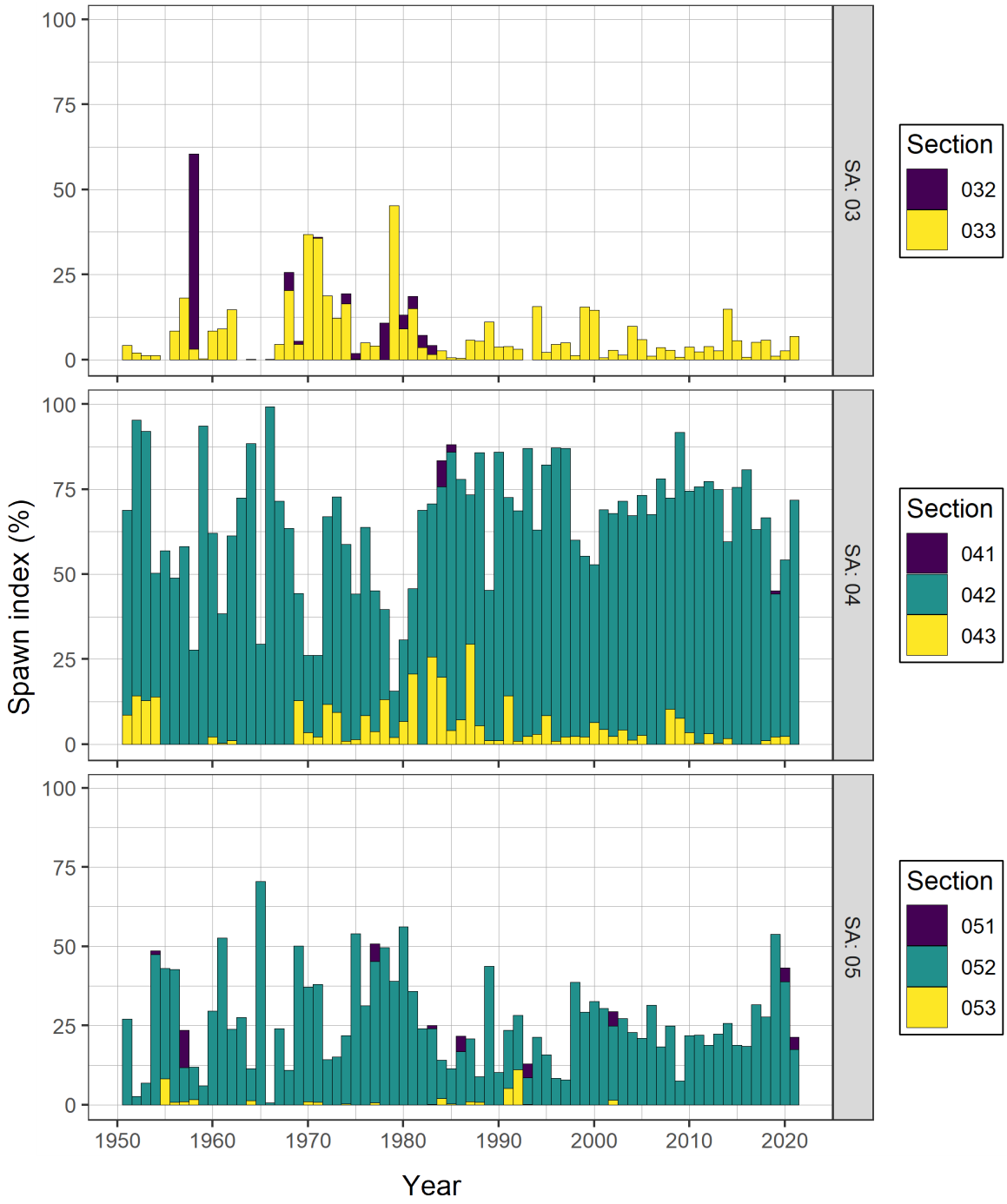

Figure 19. Time series of percent of spawn index by Statistical Area (SA) and Section for Pacific Herring from 1951 to 2021 in the Prince Rupert District major stock assessment region (SAR). The spawn index has two distinct periods defined by the dominant coastwide survey method: surface surveys (1951 to 1987), and dive surveys (1988 to 2021). The 'spawn index' is not scaled by the spawn survey scaling parameter, q.

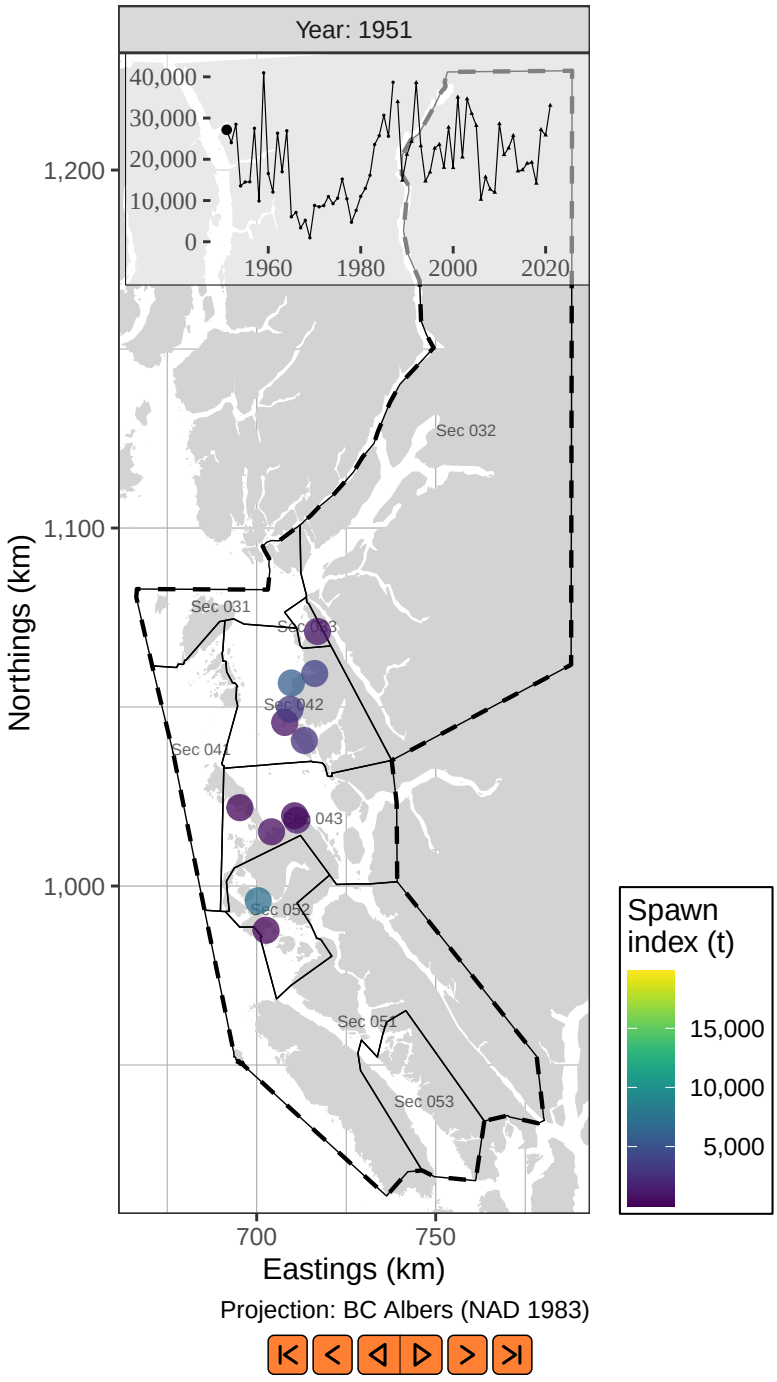

Figure 20. Animation of Pacific Herring spawn index in metric tonnes (t) by Location from 1951 to 2021 in the Prince Rupert District major stock assessment region (SAR; thick dashed lines), and associated Sections (Sec; thin solid lines). The spawn index has two distinct periods defined by the dominant coastwide 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). To view the animation: download the report, open it with Adobe, enable JavaScript, and click "play".