Pacific Herring preliminary data summary for Prince Rupert District 2022

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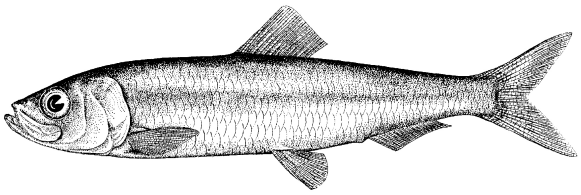
November 9, 2022



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

Disclaimer This report contains preliminary data collected for Pacific Herring in 2022 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 and 2021, the COVID-19 pandemic had fewer impacts to Pacific Herring data collection and analysis in 2022. Spawn surveys proceeded as usual in most areas in 2022. The collection and analysis of biological data was not affected by the COVID-19 pandemic in 2022.

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

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this scale (Table 1, Figure 1). The Pacific Herring data collection program includes fishery-dependent and -independent data from 1951 to 2022. 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 2022 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 2022 refers to the 2021/2022 Pacific Herring season.

3 Data collection programs

In 2022, biological samples were collected by two seine test vessels:

- The *Nita Maria* collected samples in Big Bay for 13 days from March 15$^{\text{th}}$ to March 27$^{\text{th}}$, and
- The *Viking Leader* collected samples in Kitkatla for 13 days from March 15$^{\text{th}}$ to March 27$^{\text{th}}$.

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 March 30$^{\text{th}}$ to April 18$^{\text{th}}$. Herring spawn locations were primarily identified with fixed-wing overflights. Two spawn flights were conducted this season on March 30$^{\text{th}}$ and April 5$^{\text{th}}$. Additional on-grounds spawn observations were provided by Lax Kw'alaams Band and Metlakatla First Nation.

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 2022 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 2022, 10 Pacific Herring biological samples were collected and processed for the Prince Rupert District major SAR (Table 5, Table 6), and a total of 918 Pacific Herring were aged in 2022. 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 28 individual locations in 2022 in the Prince Rupert District major SAR (Table 8, and Figure 10). A summary of spawn from the last decade (2012 to 2021) 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 2022).

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 2022, Section 042 contributed the most to the spawn index (71%). 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 2022 (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:

- Area 4
  - Sea surface temperatures were cold at 4°C.
  - With the colder sea surface temperatures, herring were holding and behaving in a manner which has not been observed in recent years.
  - Kelp was more abundant from Tree Bluff south to Duncan Bay.
  - Overall spawn was more intense over two days and was protracted. Spawning occurred slowly over the season opposed to the warmer sea temperatures with a short spawn and quick hatch out.
  - Herring were large and healthy.
  - Peak sounding was above average at 15k.
  - Overall length of spawn was shorter, but the layers were thicker.
- Area 5
  - Water temperature was colder than recent years but warmer than Area 4 (about 6°C).
  - Significant and consistent storm activity over the duration of the test fishery and dive survey.
  - Large schools observed in the inlet and tended to congregate in large schools close to the bottom and the beaches. Fish appeared longer and larger in the test sets than in recent years.
  - There was an observed increase in sea lion abundance and activity throughout the area.
  - Spawn appeared to commence at the end of March and was distributed throughout the inlet and along the outside from Cape George towards Oval Point.
  - Reports of reduced kelp coverage throughout the area.

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 2022 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 2012 to 2022 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)
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
2022	0	0

Table 5. Number of Pacific Herring biological samples processed from 2012 to 2022 in the Prince Rupert District major stock assessment region (SAR). Each sample is approximately 100 fish. Note: Nearshore samples are not used in stock assessments.

	Number of samples			
Year	Commercial	Test	Nearshore	Total
2012	27	21	0	48
2013	31	13	0	44
2014	30	2	0	32
2015	45	11	0	56
2016	33	11	0	44
2017	40	11	0	51
2018	17	14	0	31
2019	2	13	0	15
2020	0	20	0	20
2021	0	13	0	13
2022	0	10	0	10

Table 6. Number and type of Pacific Herring biological samples processed in 2022 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	10

Table 7. Observed proportion-at-age for Pacific Herring from 2012 to 2022 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
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
2022	0.007	0.121	0.200	0.052	0.521	0.076	0.015	0.005	0.002

Table 8. Pacific Herring spawn survey locations, start date, and spawn index in metric tonnes (t) in 2022 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 indicate incomplete surveys (NAs).

Statistical Area	Section	Location name	Start date	Spawn index (t)
03	033	Maskelyne Is	April 01	18
04	042	Belletti Pt	March 25	1,424
04	042	Big Bay	March 25	2,130
04	042	Burnt Cliff Is	March 25	2,969
04	042	Duncan Bay	March 24	735
04	042	Flat Top Islets	March 26	6
04	042	Pearl Hrbr	March 26	41
04	042	Reeks Pt	March 25	1,134
04	042	Swamp Is	March 25	5,664
04	042	Tree Bluff	March 24	10,787
04	043	Butler Cv	March 28	489
04	043	Fan Island	March 30	2,533
05	051	Joachim Pt	March 30	32
05	052	Absalom Is	March 30	343
05	052	Cape George	March 30	1,392
05	052	Cessford Is	March 30	51
05	052	Chief Pt	March 30	3
05	052	Clamshell Is	March 30	666
05	052	Dries Inlt	March 30	86
05	052	Freeman Pass	March 30	1,006
05	052	Goschen Is	March 30	89
05	052	Gurd Pt	March 30	555
05	052	Joachim Spit	April 05	26
05	052	Ness Is	March 30	703
05	052	Nubble Pt	March 30	390
05	052	Robert Is	March 30	81
05	052	Serpentine Inlt	March 30	335
05	052	Wilcox Grp	March 30	1,533

Table 9. Summary of Pacific Herring spawn survey data from 2012 to 2022 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 2022). 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)
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
2022	64,925	92	1.4	35,220

8 Figures

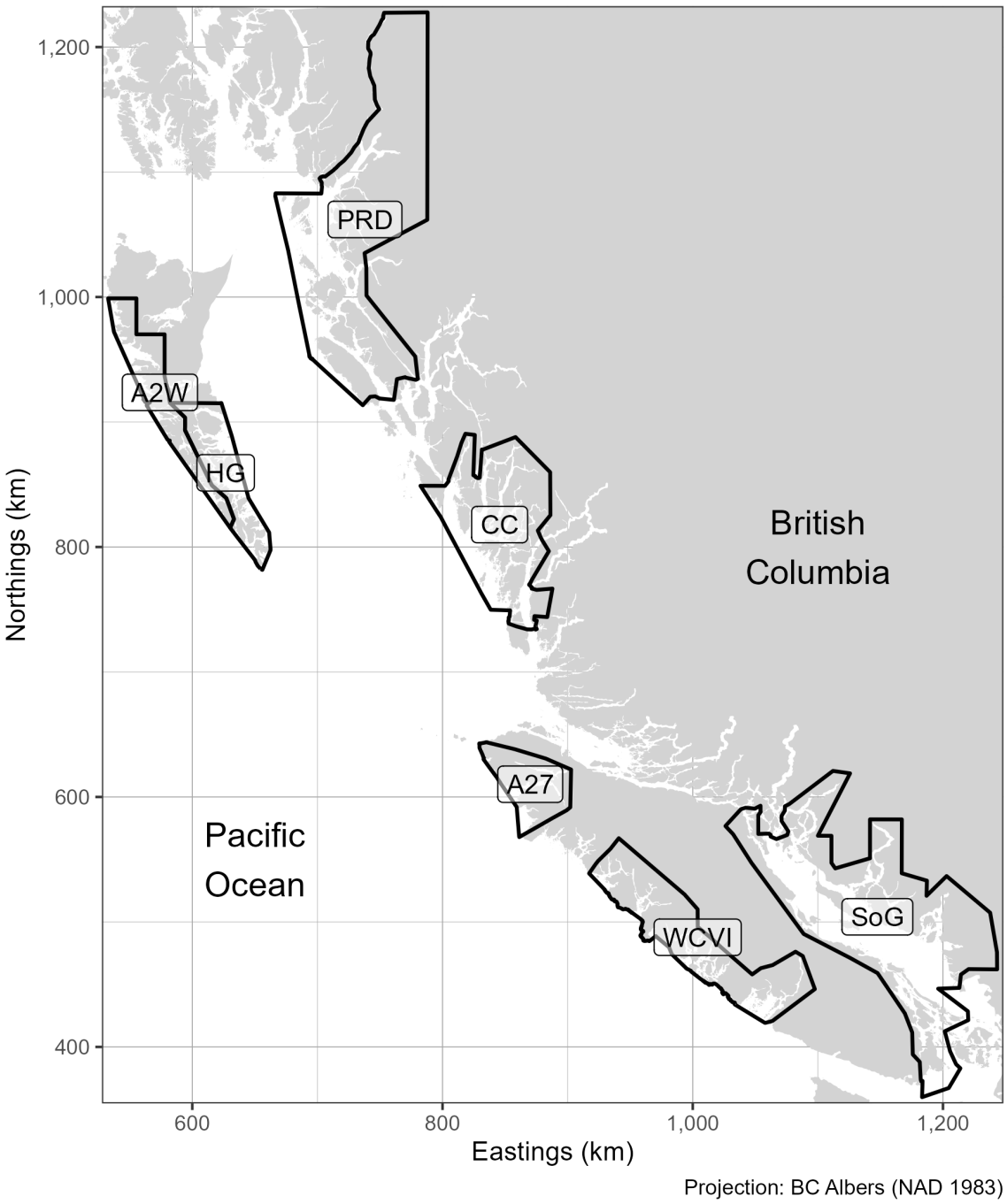

Figure 1. Boundaries for the Pacific Herring stock assessment regions (SARs) in British Columbia. There are 5 major SARs: Haida Gwaii (HG), Prince Rupert District (PRD), Central Coast (CC), Strait of Georgia (SoG), and West Coast of Vancouver Island (WCVI). There are 2 minor SARs: Area 27 (A27) and Area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

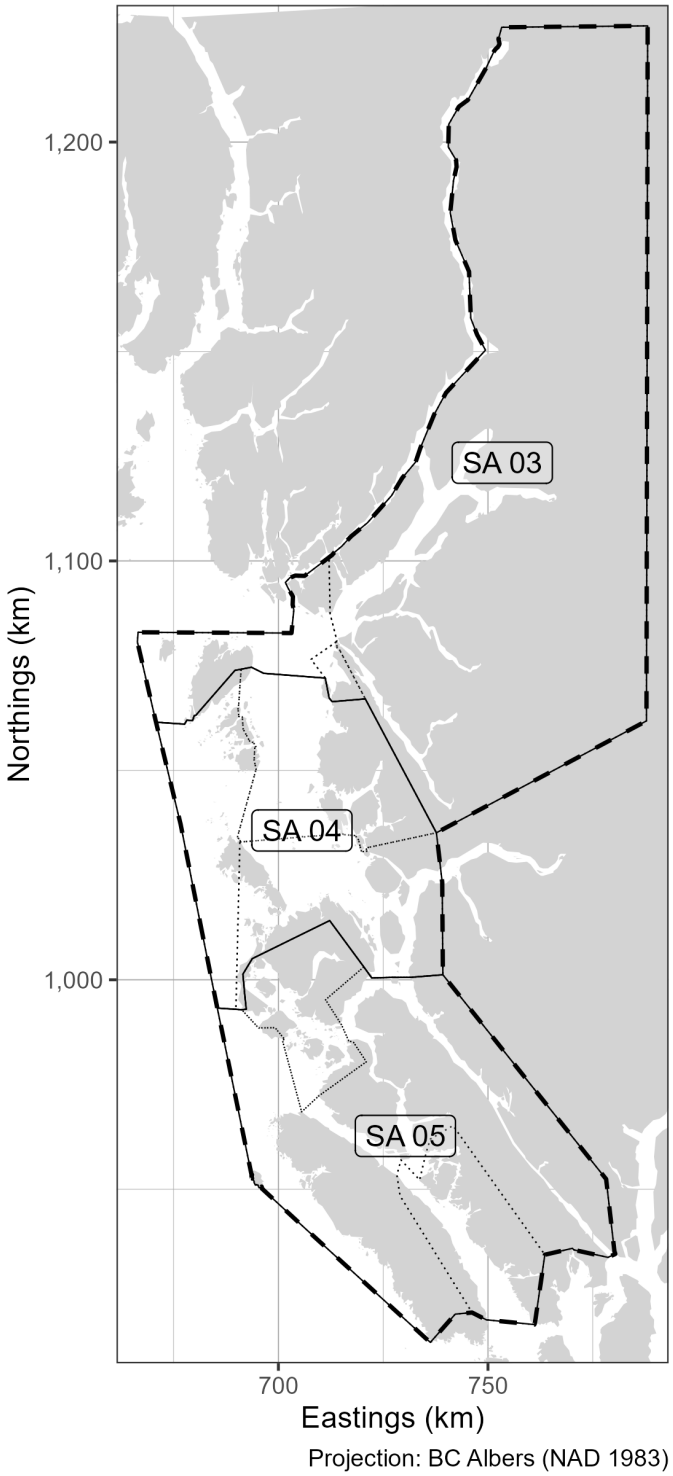

Figure 2. Boundaries for the Prince Rupert District major stock assessment region (SAR; thick dashed lines), associated Statistical Areas (SA; thin solid lines), and associated Sections (thin dotted lines). Units: kilometres (km).

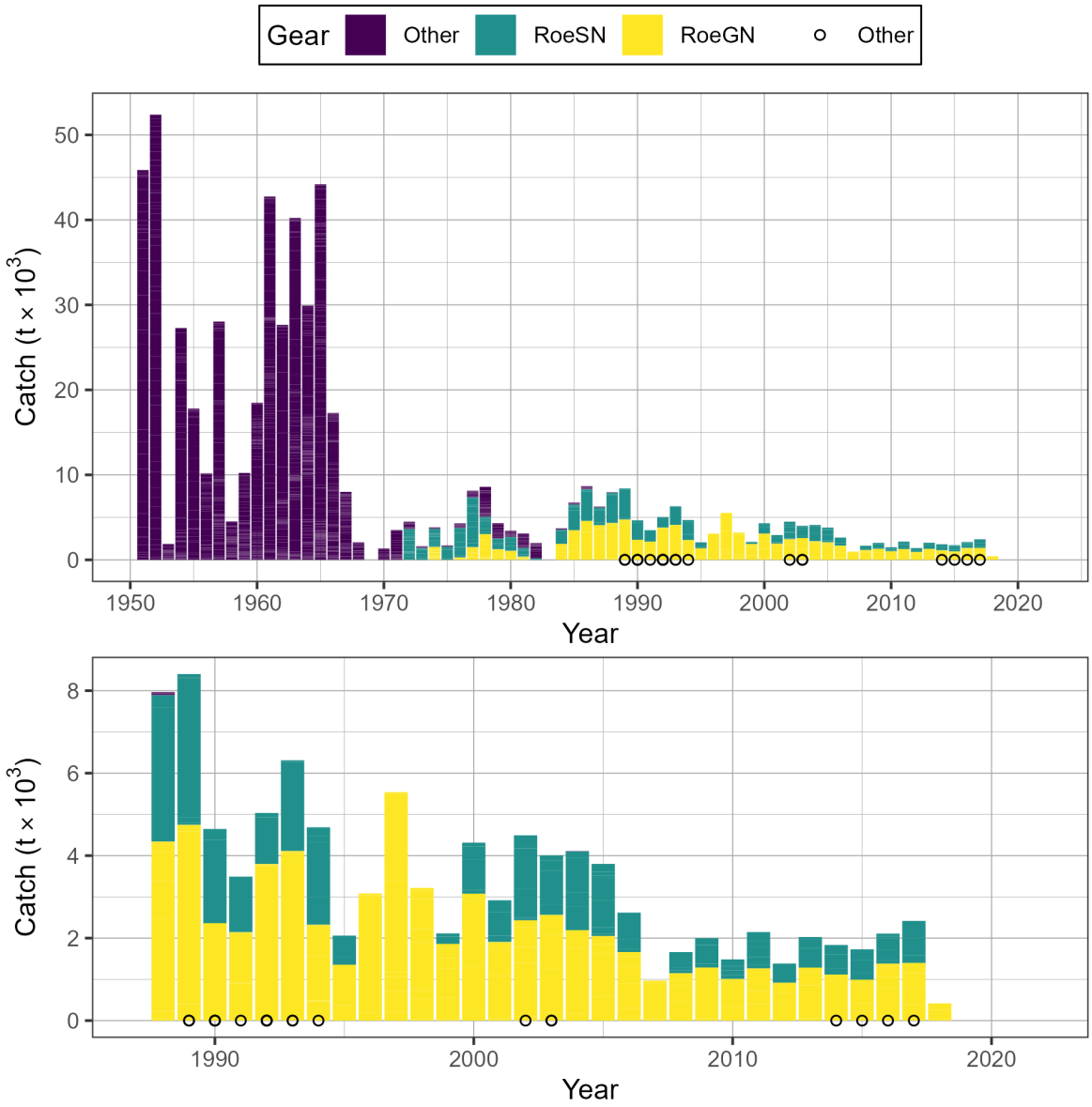

Figure 3. Time series of total landed catch in thousands of metric tonnes ($t \times 10^3$) of Pacific Herring by gear type from 1951 to 2022 in the Prince Rupert District major stock assessment region (SAR). Legend: 'Other' represents the reduction (1951 to 1970 only), the food and bait, as well as 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 1987 in more detail. Note: symbols indicate years in which catch by gear type (i.e., Other, RoeSN, RoeGN) is withheld due to privacy concerns.

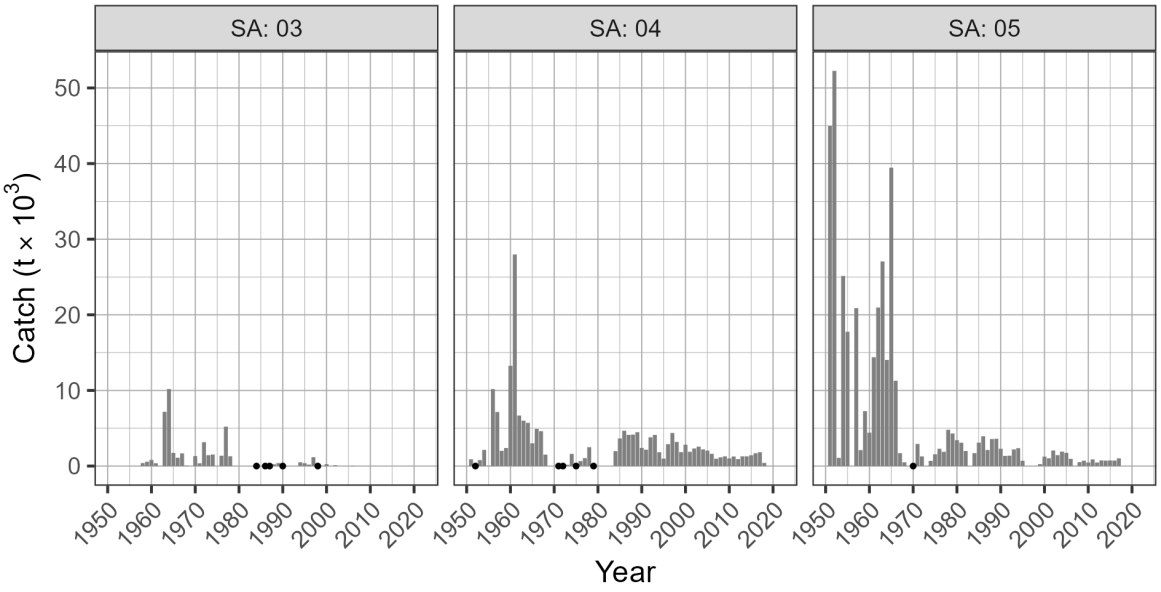

Figure 4. Time series of total landed catch in thousands of metric tonnes ($t \times 10^3$) of Pacific Herring by Statistical Area (SA) from 1951 to 2022 in the Prince Rupert District major stock assessment region (SAR). The year 2022 has a darker bar to facilitate interpretation. Note: symbols indicate years in which catch is withheld due to privacy concerns.

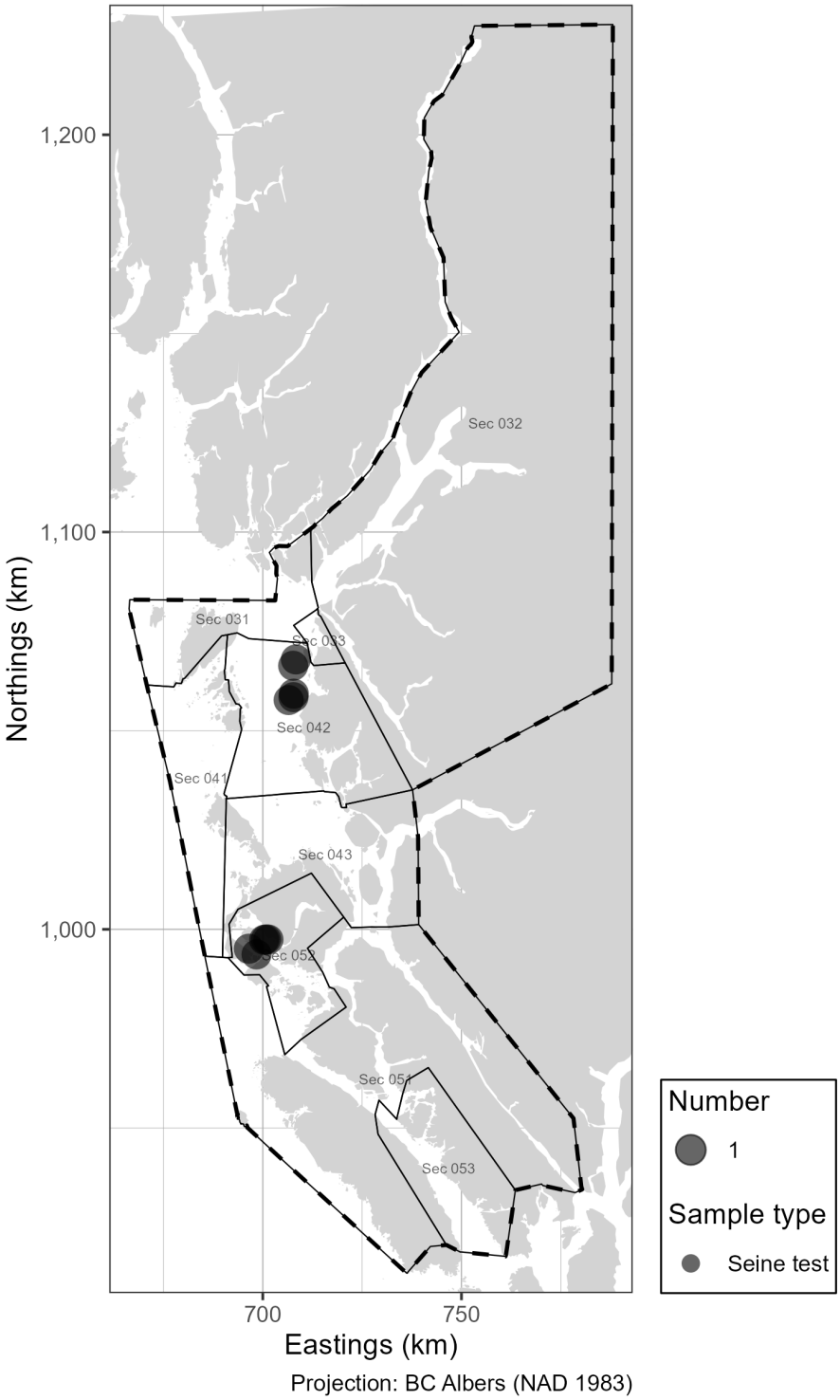

Figure 5. Location and type of Pacific Herring biological samples collected in 2022 in the Prince Rupert District major stock assessment region (SAR; thick dashed lines), and associated Sections (Sec; thin solid lines). Units: kilometres (km).

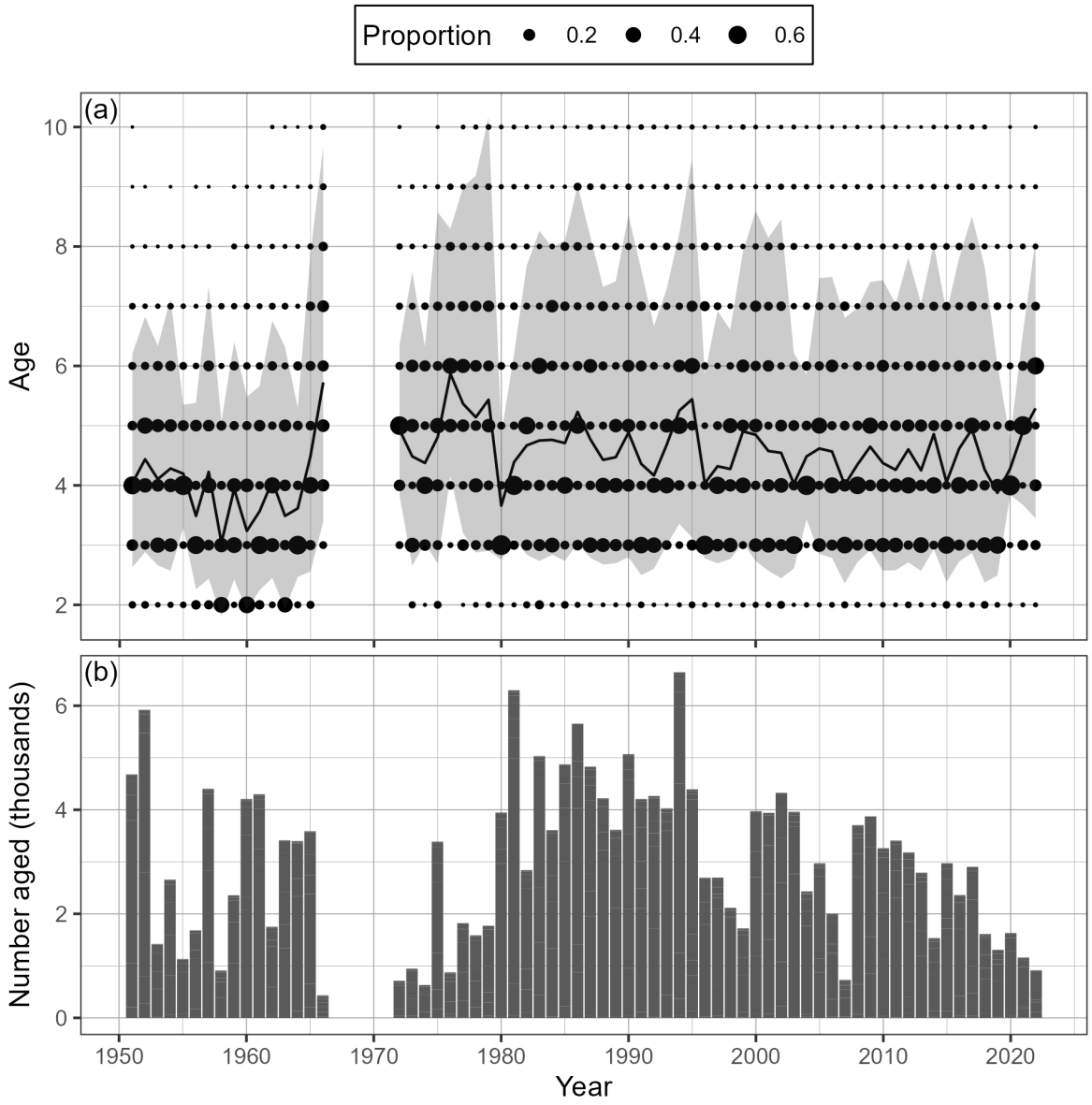

Figure 6. Time series of observed proportion-at-age (a) and number aged in thousands (b) of Pacific Herring from 1951 to 2022 in the Prince Rupert District major stock assessment region (SAR). The black line is the mean age, and the shaded area is the approximate 90% distribution. Biological summaries 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.

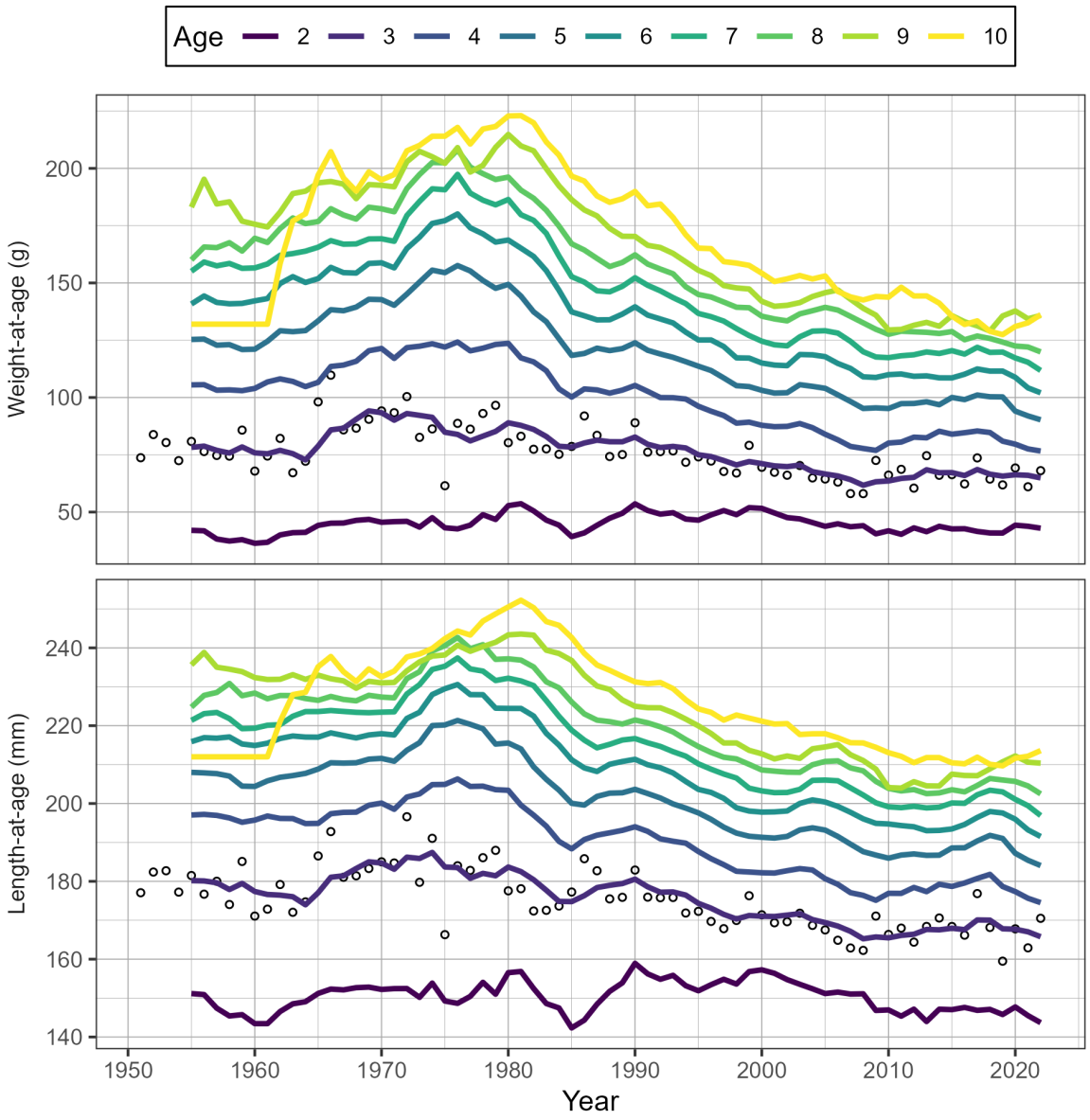

Figure 7. Time series of weight-at-age in grams (g) and length-at-age in milimetres (mm) for age-3 (circles) and 5-year running mean weight- and length-at-age (lines) for Pacific Herring from 1951 to 2022 in the Prince Rupert District major stock assessment region (SAR). Missing weight- and length-at-age 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.

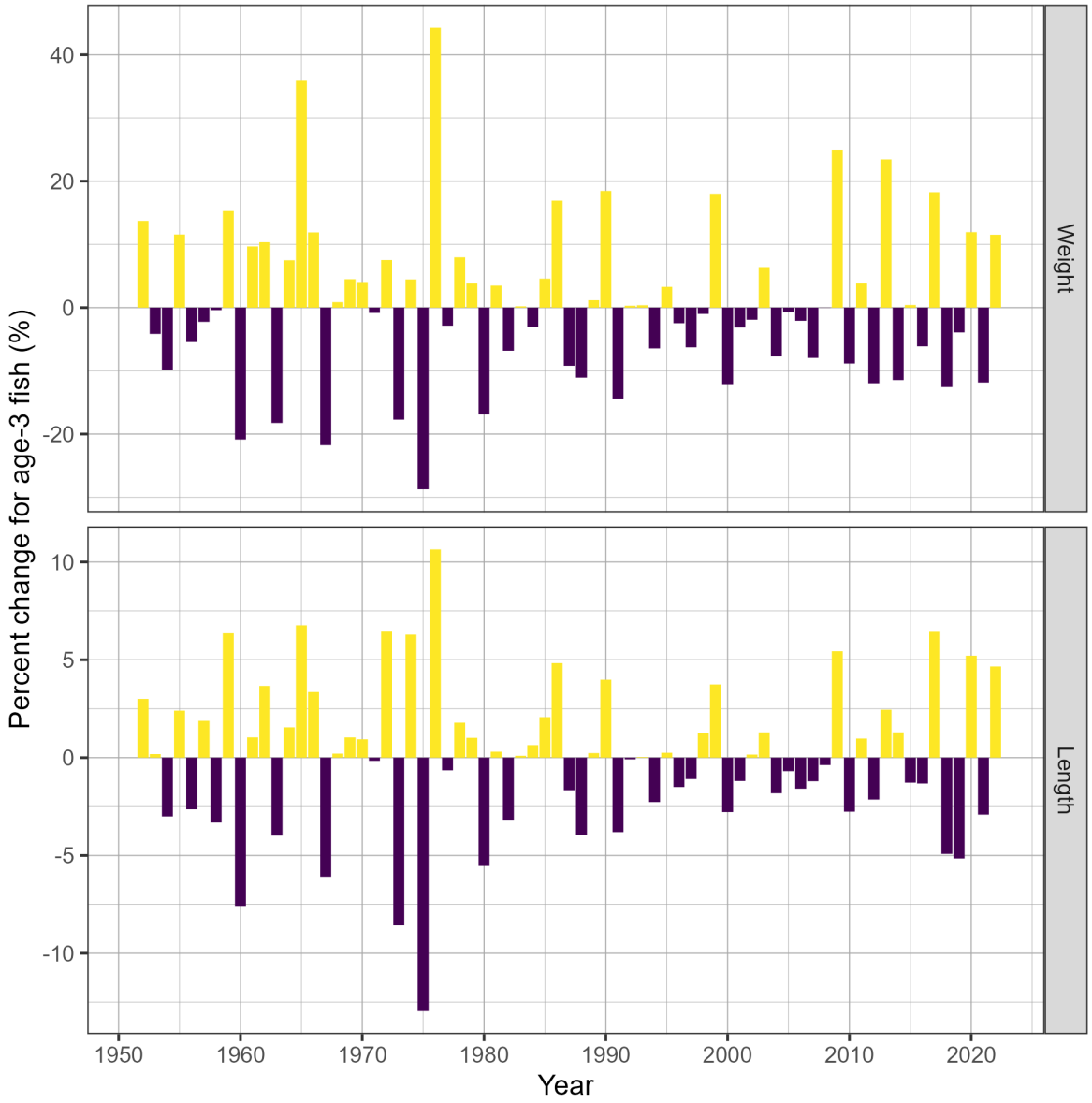

Figure 8. Time series of percent change (%) in weight and length for age-3 fish for Pacific Herring from 1951 to 2022 in the Prince Rupert District major stock assessment region (SAR). Percent change is $\delta_t = \frac{\alpha_t - \alpha_{t-1}}{\alpha_{t-1}}$ where α_t is the weight and length of age-3 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.

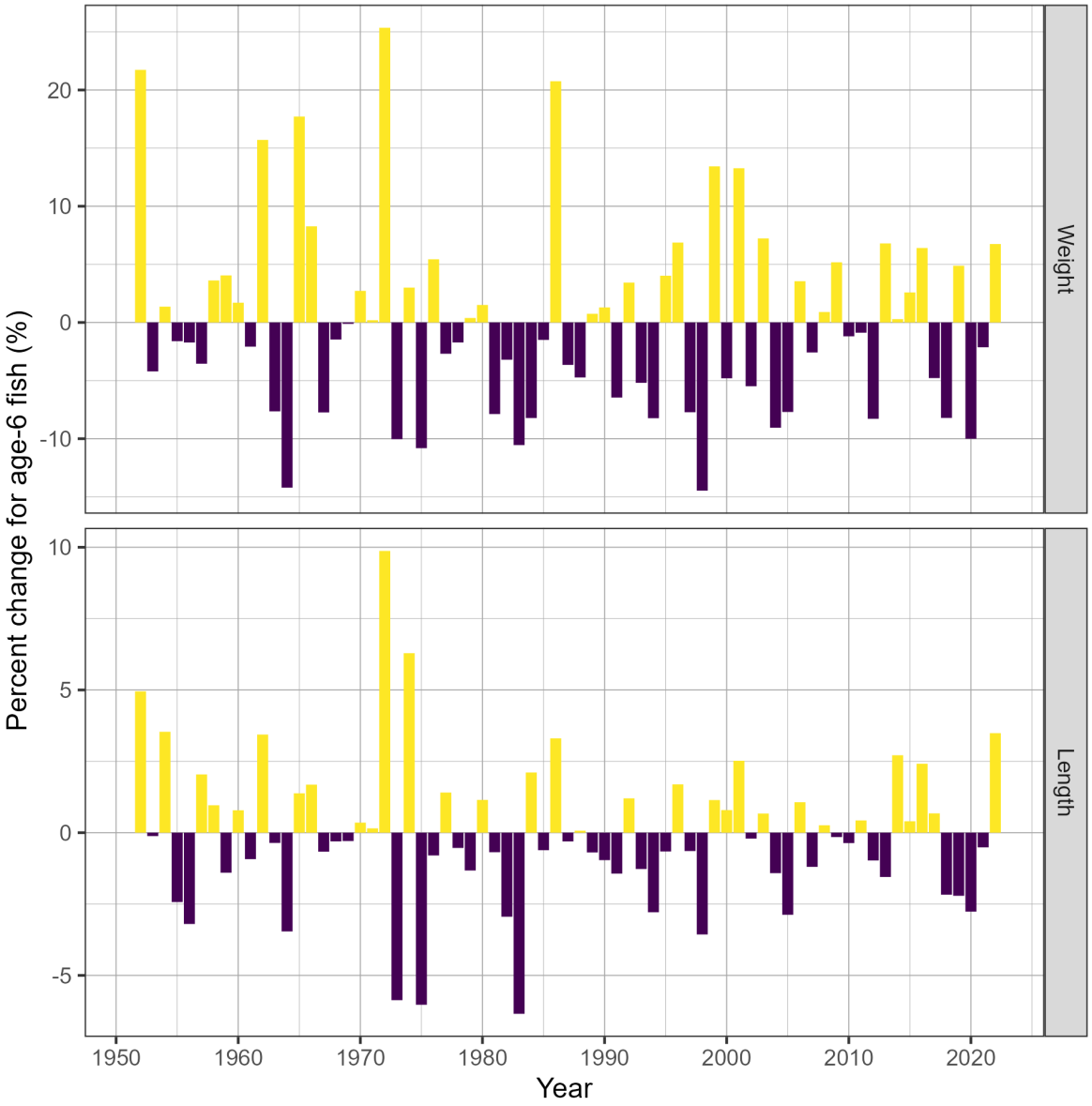

Figure 9. Time series of percent change (%) in weight and length for age-6 fish for Pacific Herring from 1951 to 2022 in the Prince Rupert District major stock assessment region (SAR). Percent change is $\delta_t = \frac{\alpha_t - \alpha_{t-1}}{\alpha_{t-1}}$ where α_t is the weight and length of age-6 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.

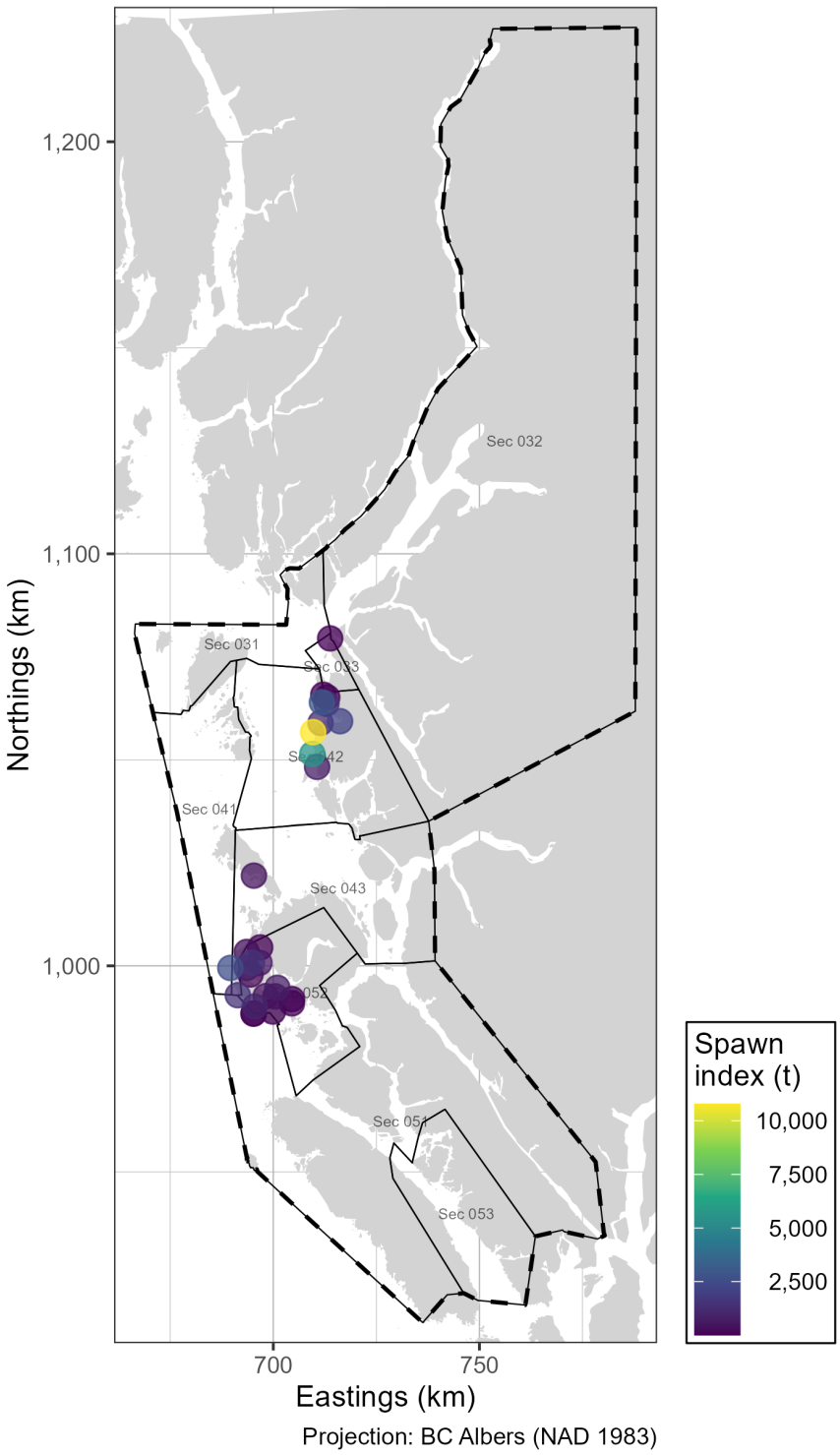

Figure 10. Pacific Herring spawn survey locations, and spawn index in metric tonnes (t) in 2022 in the Prince Rupert District major stock assessment region (SAR; thick dashed lines), and associated Sections (Sec; thin solid lines). The 'spawn index' is not scaled by the spawn survey scaling parameter, q. Missing spawn index values indicate incomplete surveys (grey circles). Units: kilometres (km).

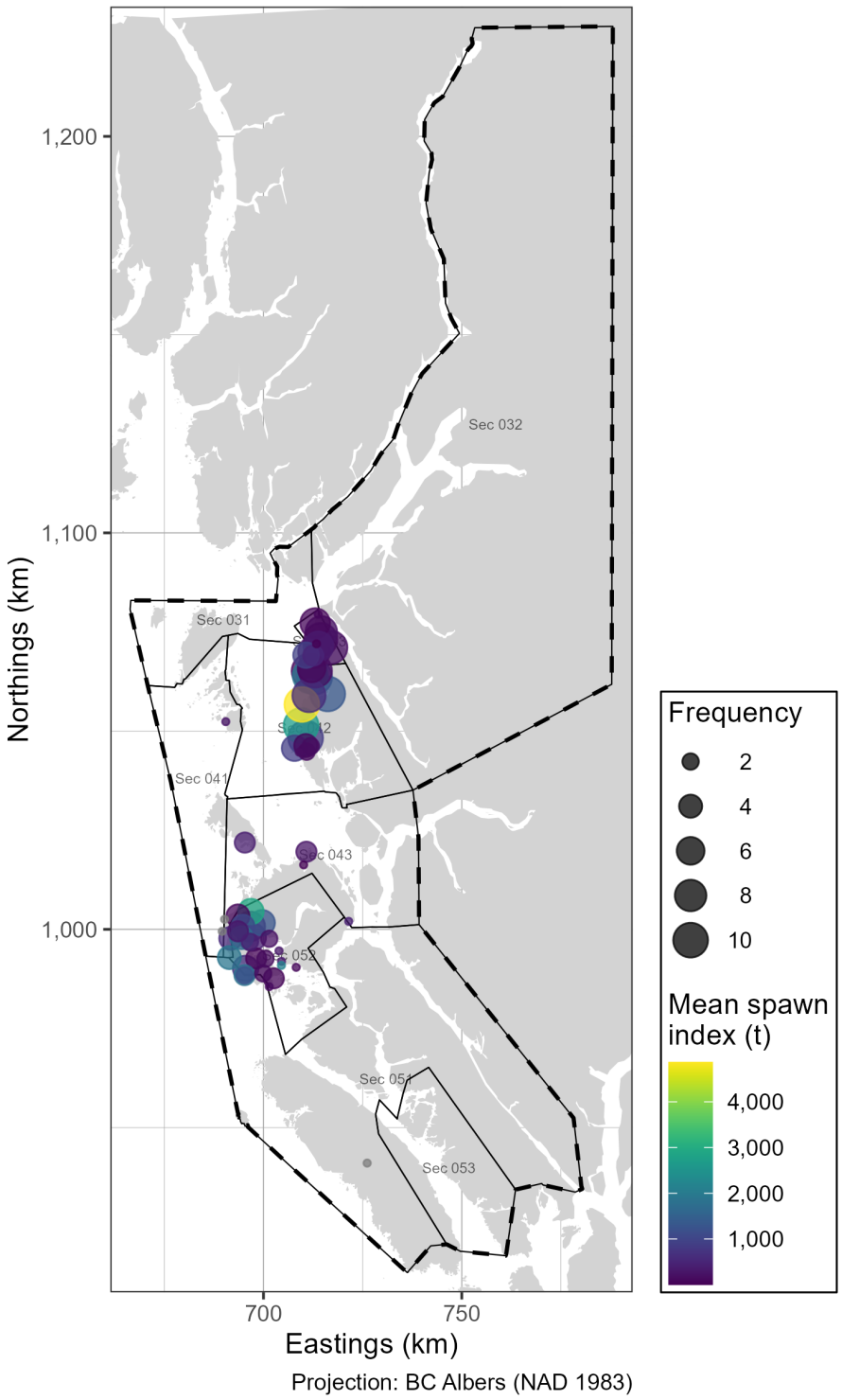

Figure 11. Pacific Herring spawn survey locations, mean spawn index in metric tonnes (t), and spawn frequency from 2012 to 2021 in the Prince Rupert District major stock assessment region (SAR; thick dashed lines), and associated Sections (Sec; thin solid lines). The 'spawn index' is not scaled by the spawn survey scaling parameter, q. Missing spawn index values indicate incomplete surveys (grey circles). Units: kilometres (km).

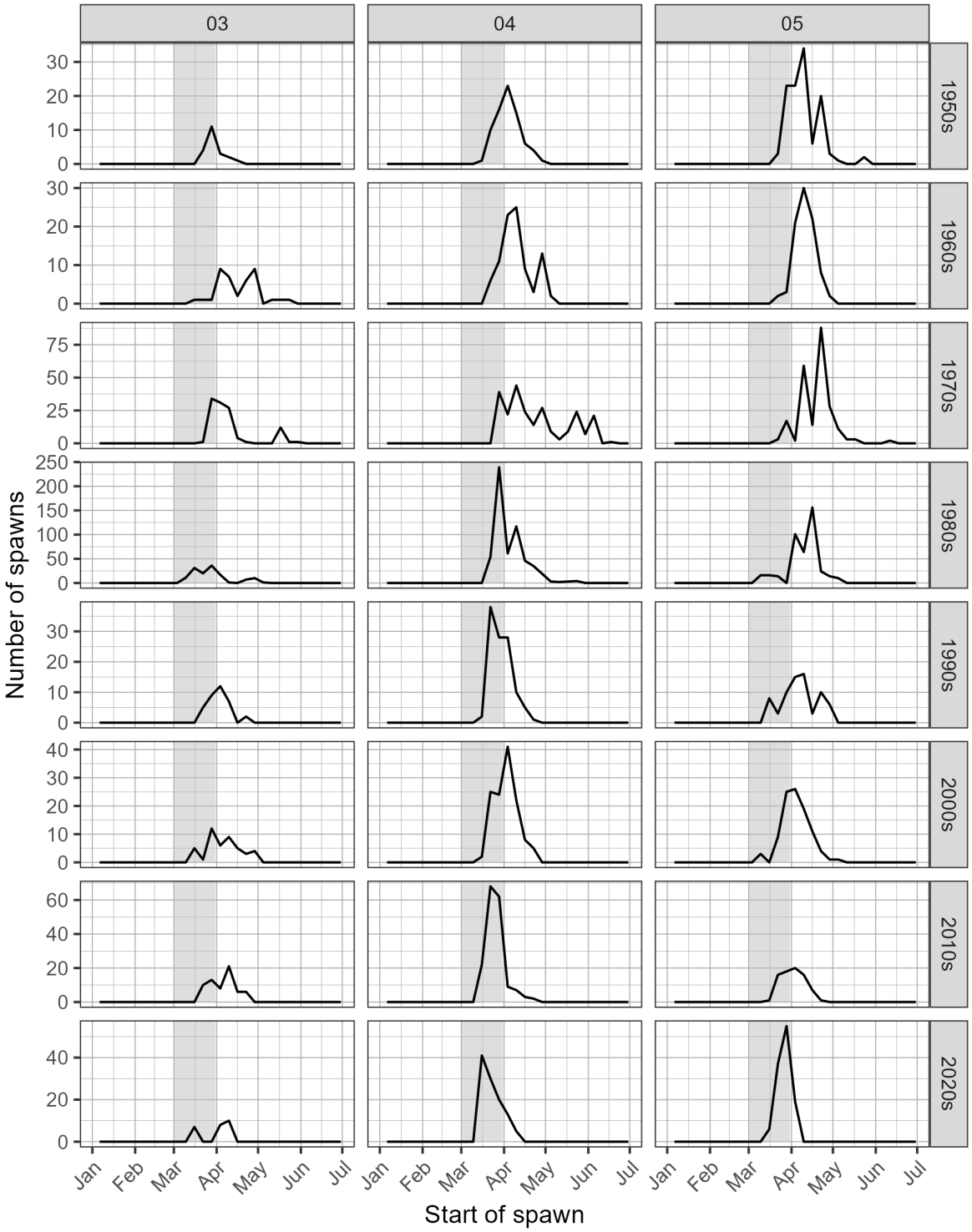

Figure 12. Pacific Herring spawn start date by decade and Statistical Area. Grey shaded regions indicate March 1st to 31st. Note that spawn size and intensity varies; therefore the number of spawns is not directly proportional to spawn extent or biomass.

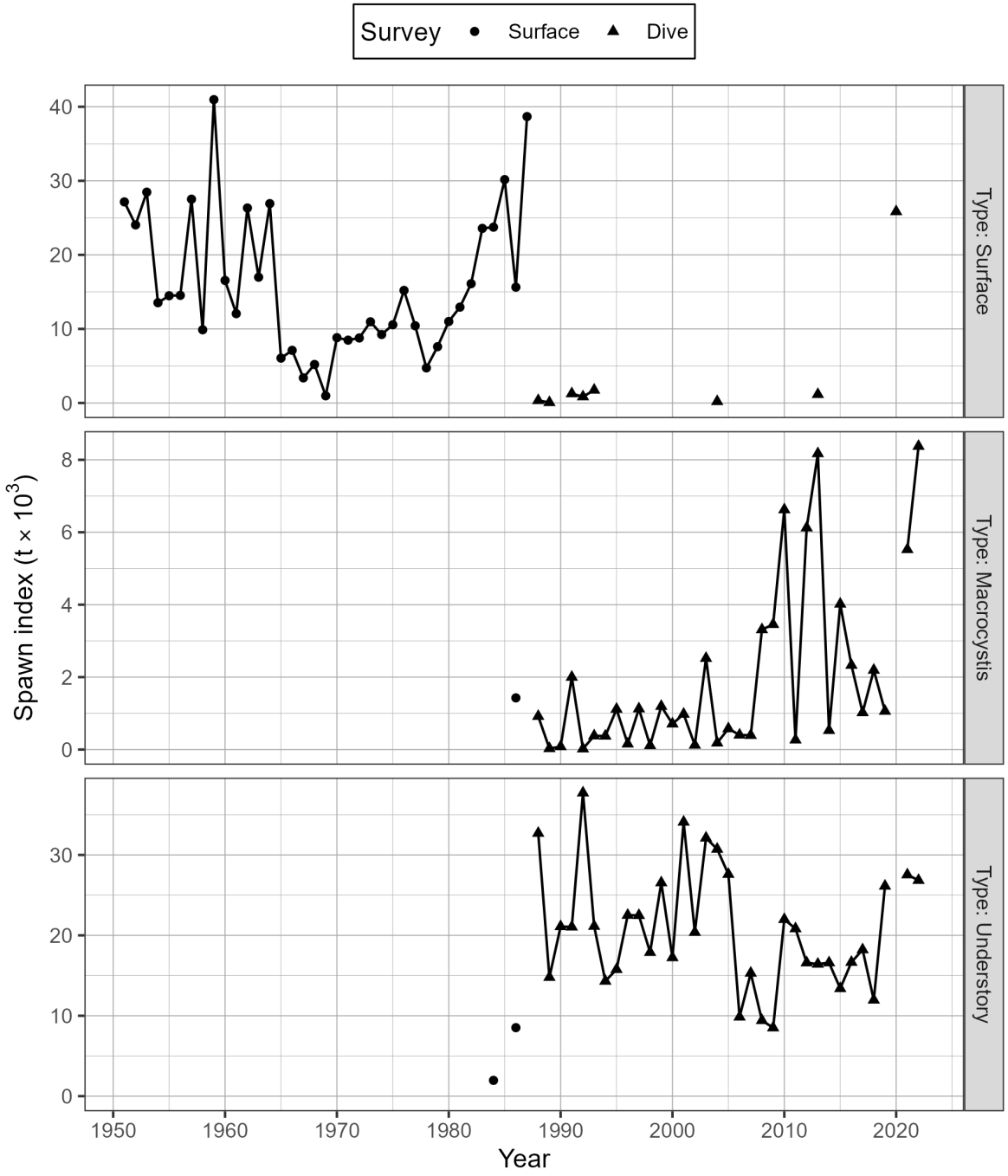

Figure 13. Time series of spawn index in thousands of metric tonnes ($t \times 10^3$) by type for Pacific Herring from 1951 to 2022 in the Prince Rupert District major stock assessment region (SAR). There are three types of spawn survey observations: observations of spawn taken from the surface usually 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 2022).

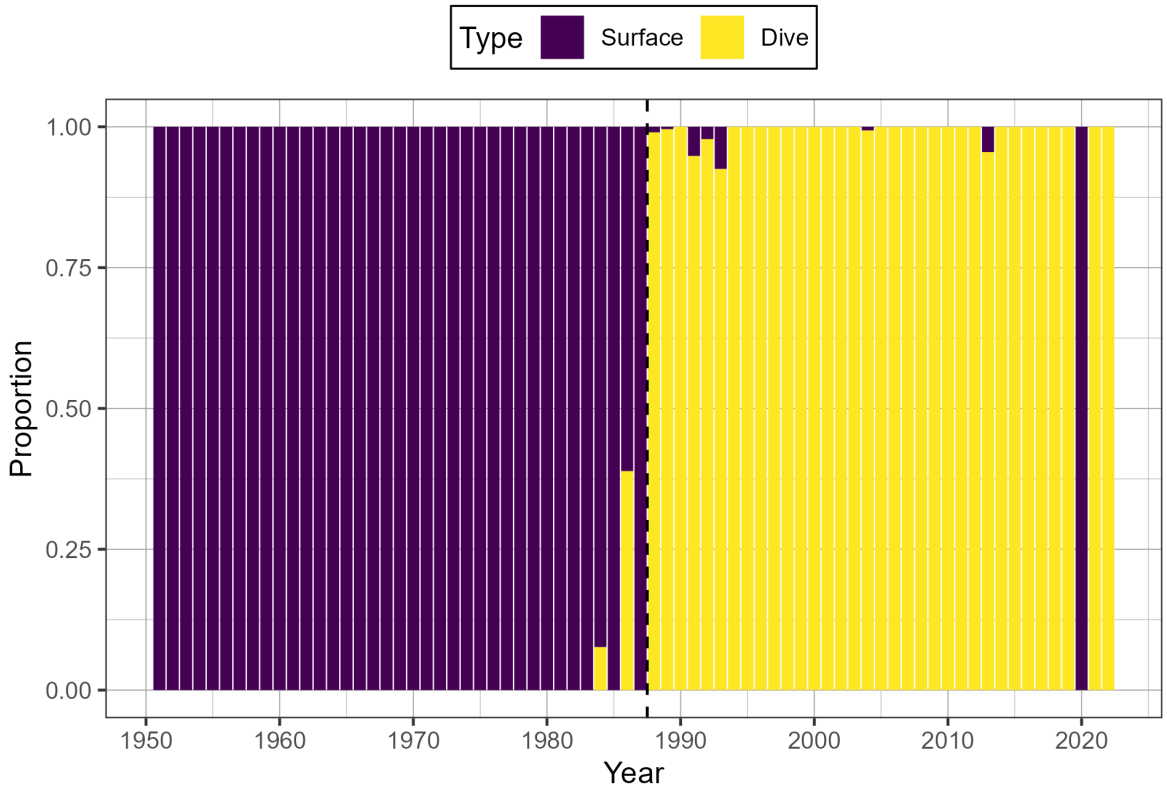

Figure 14. Time series of proportion of spawn index by surface and dive surveys for Pacific Herring from 1951 to 2022 in the Prince Rupert District major stock assessment region (SAR). The spawn index has two distinct periods defined by the dominant coastwide survey method: surface surveys (1951 to 1987), and dive surveys (1988 to 2022).

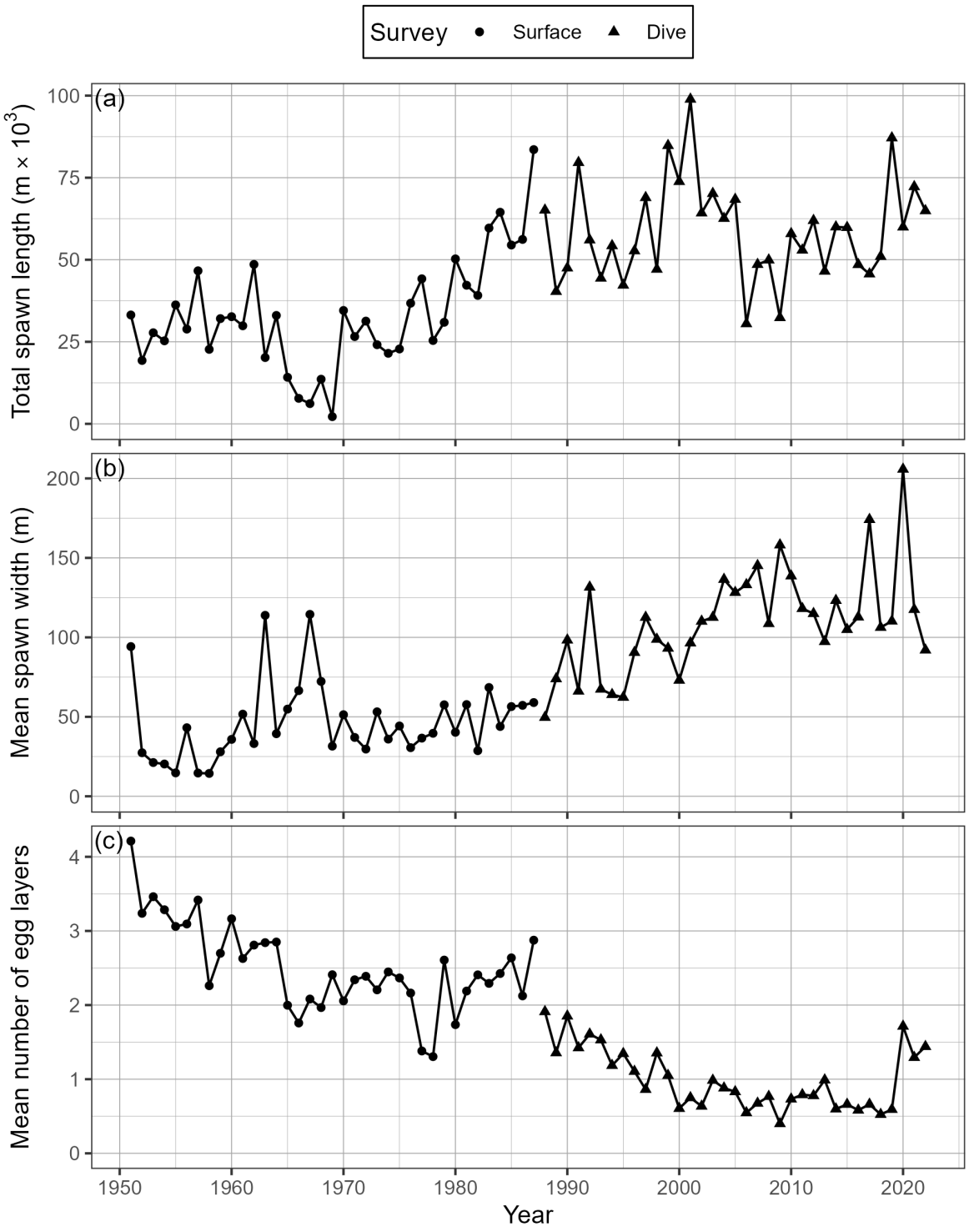

Figure 15. Time series of total spawn length in thousands of metres ($m \times 10^3$; panel a), mean spawn width in metres (b), and mean number of egg layers (c) for Pacific Herring from 1951 to 2022 in the Prince Rupert District major stock assessment region (SAR). The spawn index has two distinct periods defined by the dominant coastwide survey method: surface surveys (1951 to 1987), and dive surveys (1988 to 2022).

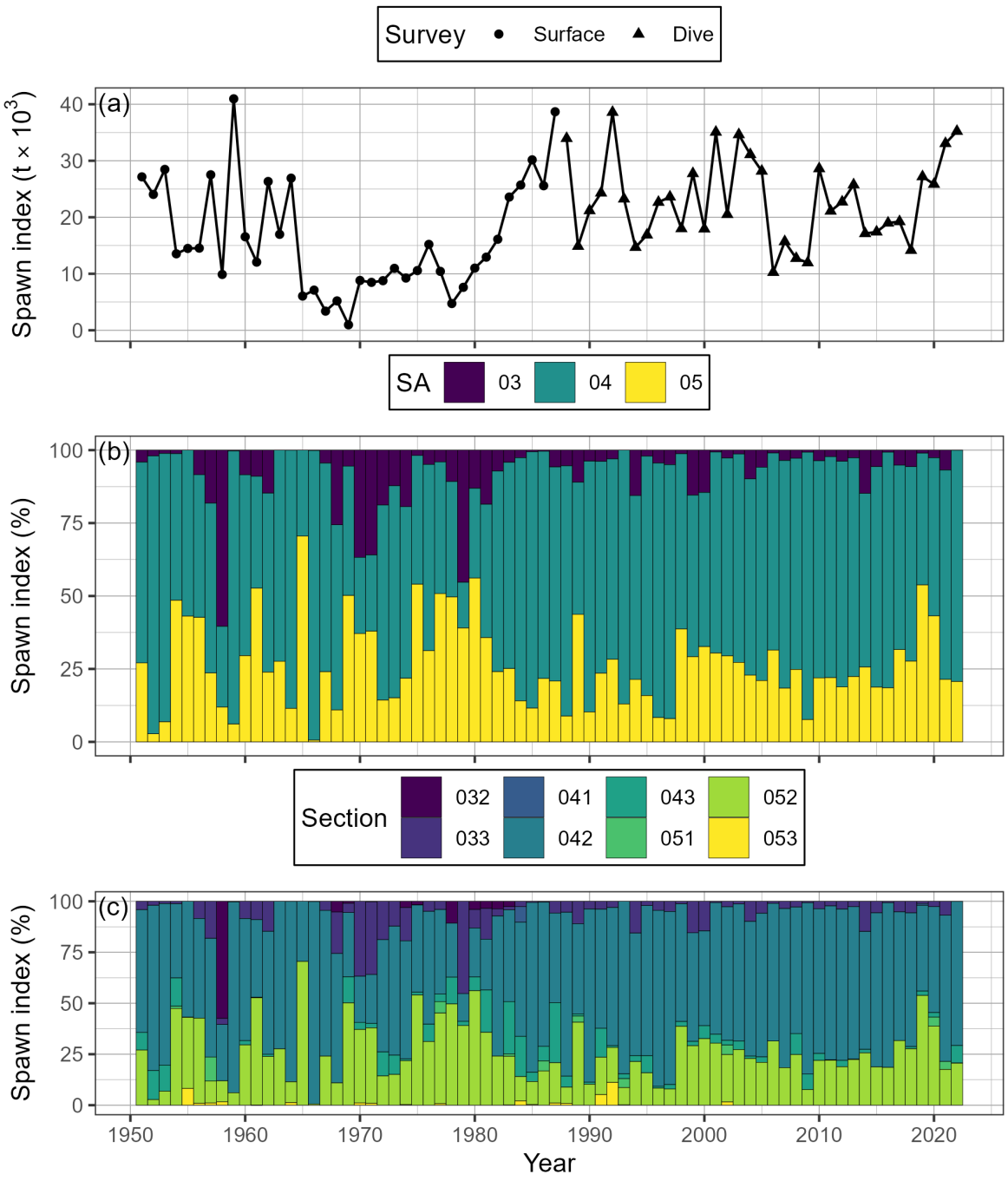

Figure 16. Time series of spawn index in thousands of metric tonnes (t $\times$ 10^3) for Pacific Herring from 1951 to 2022 in the Prince Rupert District major stock assessment region (SAR; panel a), as well as percent contributed by Statistical Area (SA), and Section (b, & c, respectively). The spawn index has two distinct periods defined by the dominant coastwide survey method: surface surveys (1951 to 1987), and dive surveys (1988 to 2022). Note that spawn surveys in the dive survey period (1988 to 2022) 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.

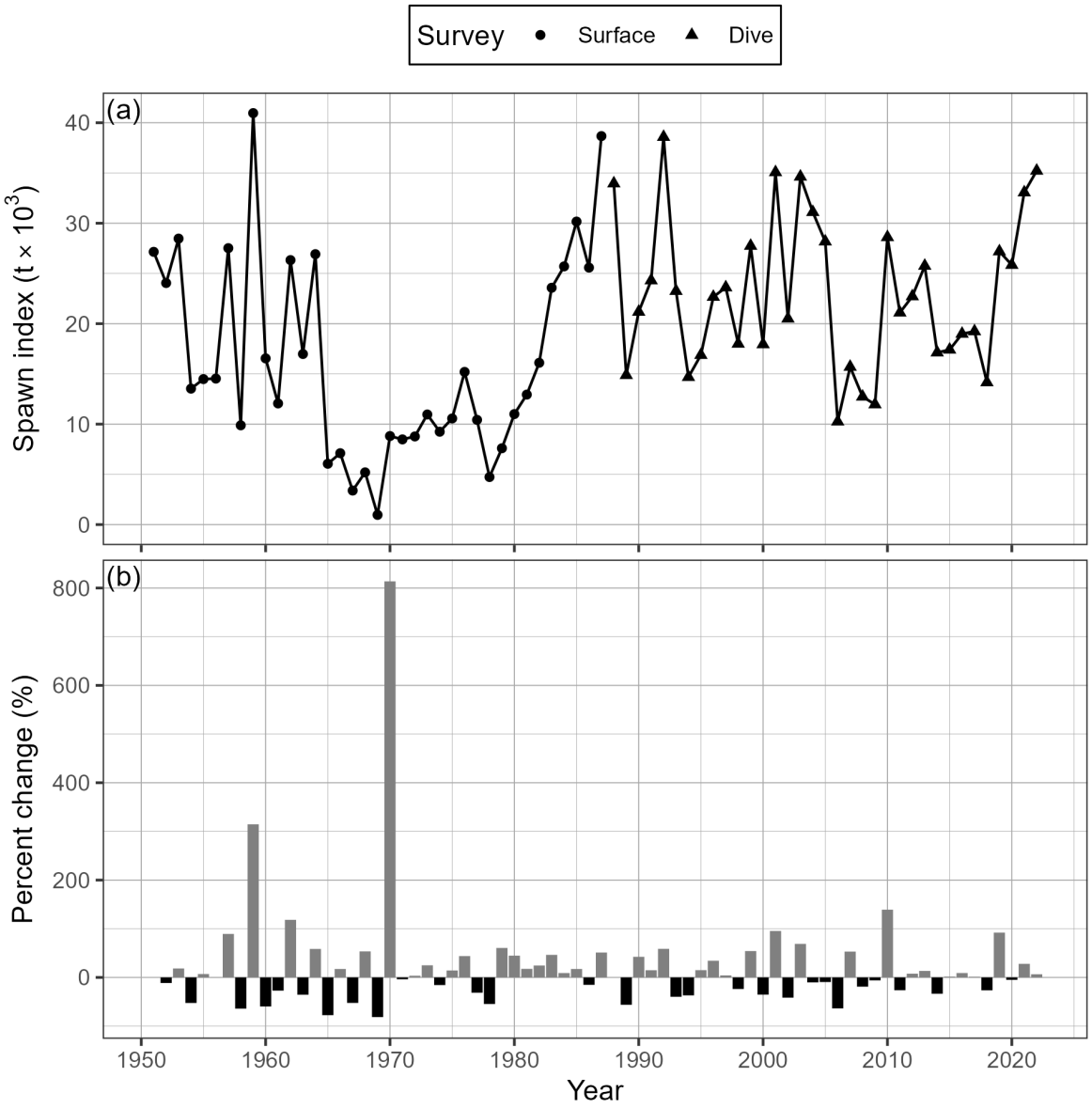

Figure 17. Time series of spawn index in thousands of metric tonnes ($t \times 10^3$) for Pacific Herring from 1951 to 2022 in the Prince Rupert District major stock assessment region (SAR; panel a), and percent change (b). Percent change is $\delta_t = \frac{\alpha_t - \alpha_{t-1}}{\alpha_{t-1}}$ where 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 2022). The 'spawn index' is not scaled by the spawn survey scaling parameter, q. Note that spawn surveys in the dive survey period (1988 to 2022) are a combination of surface and dive surveys (Figures 13 and 14).

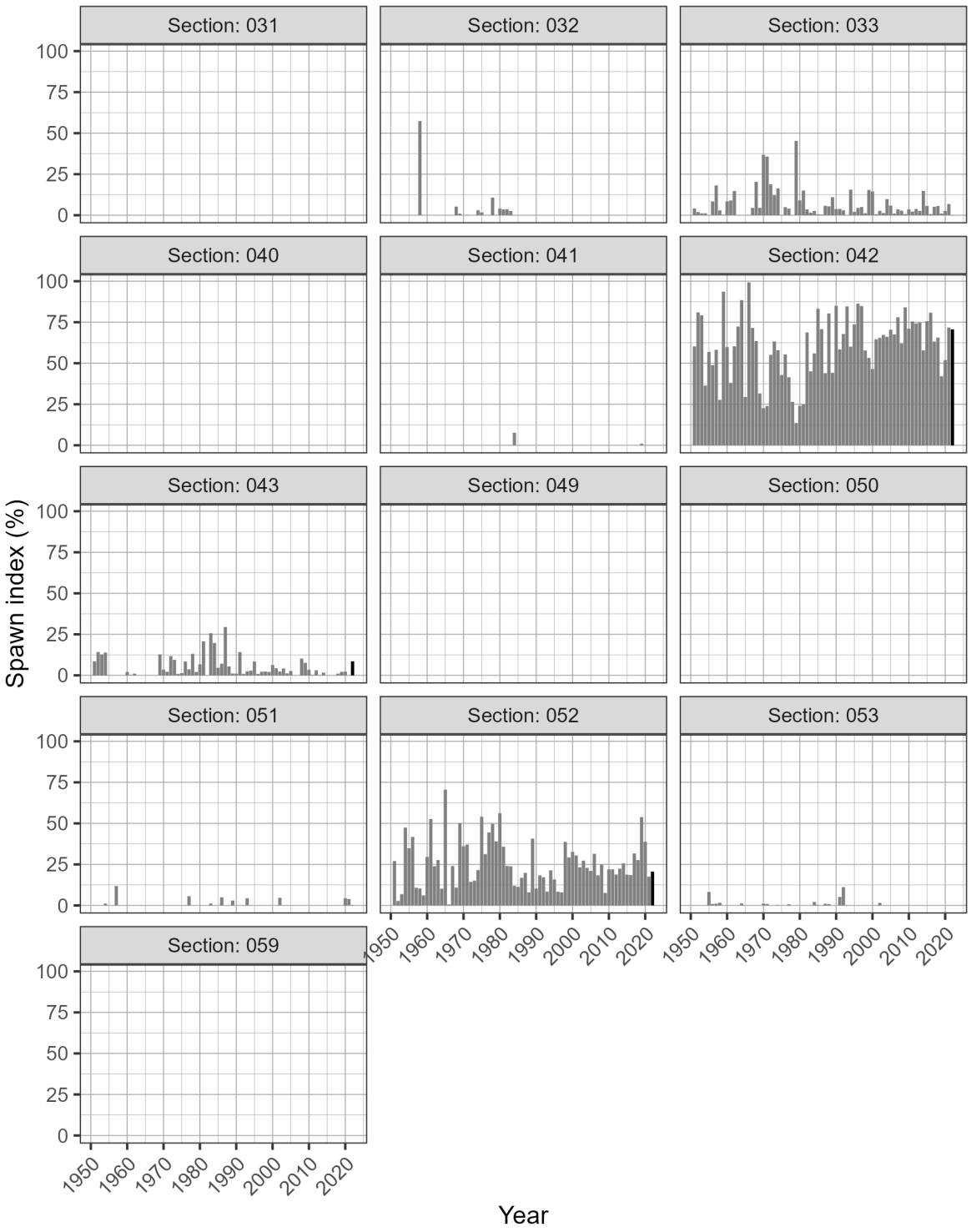

Figure 18. Time series of percent of spawn index by Section for Pacific Herring from 1951 to 2022 in the Prince Rupert District major stock assessment region (SAR). The year 2022 has a darker bar to facilitate interpretation. The spawn index has two distinct periods defined by the dominant coastwide survey method: surface surveys (1951 to 1987), and dive surveys (1988 to 2022). The 'spawn index' is not scaled by the spawn survey scaling parameter, q.

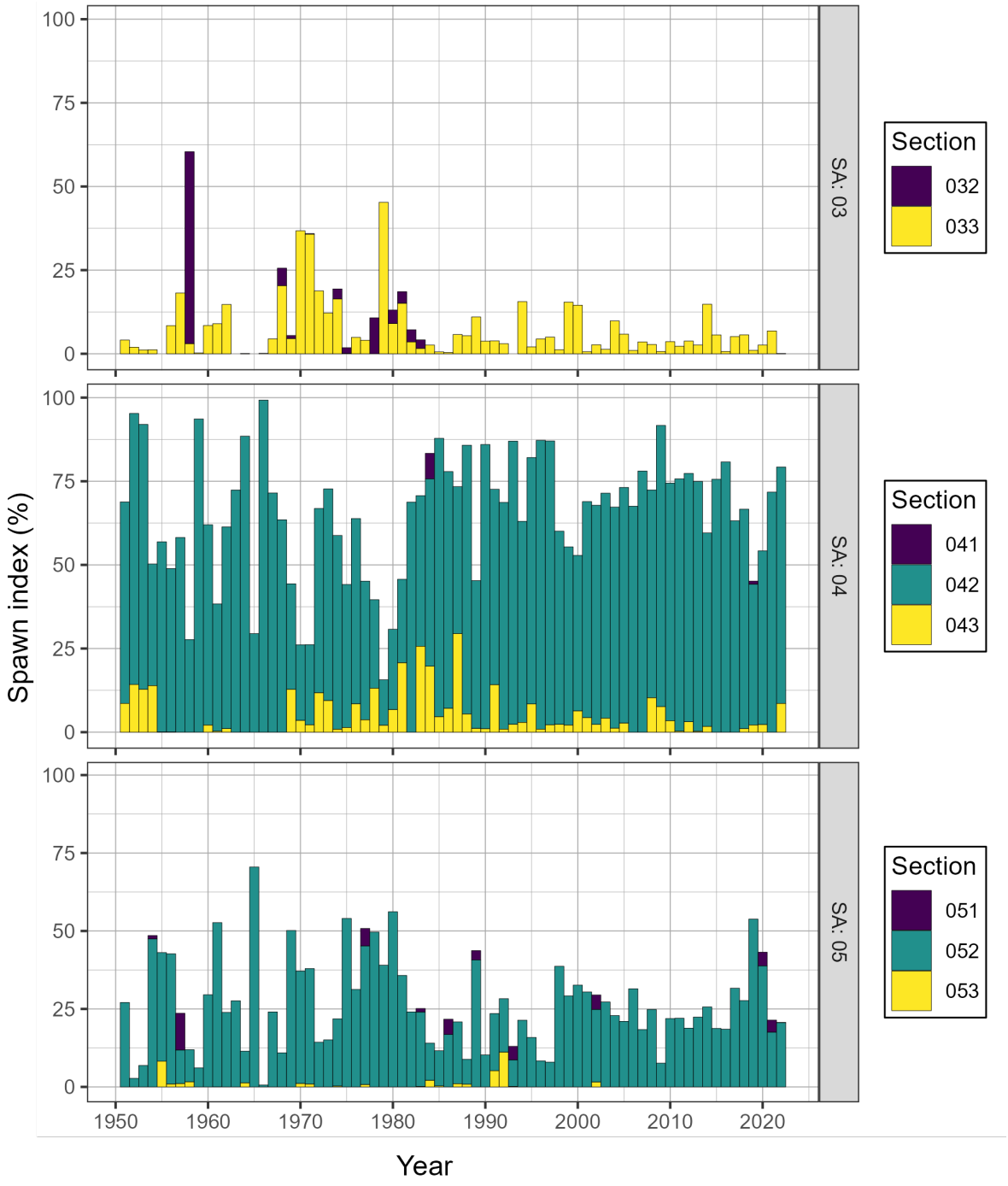

Figure 19. Time series of percent of spawn index by Statistical Area (SA) and Section for Pacific Herring from 1951 to 2022 in the Prince Rupert District major stock assessment region (SAR). The spawn index has two distinct periods defined by the dominant coastwide survey method: surface surveys (1951 to 1987), and dive surveys (1988 to 2022). 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 2022 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 2022). The 'spawn index' is not scaled by the spawn survey scaling parameter, q. Missing spawn index values indicate incomplete surveys (grey circles). Inset tracks the total spawn index. Units: kilometres (km). View the animation: download the report, open with Adobe, enable Java, and click "play".