Pacific Herring preliminary data summary for Haida Gwaii 2019

Jaclyn Cleary* Matthew Grinnell†

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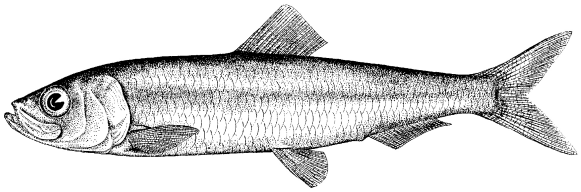

Pacific Herring (*Clupea pallasii*). Image credit: Fisheries and Oceans Canada.

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

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1 Context

Pacific Herring (*Clupea pallasii*) in British Columbia are assessed as 5 major and 2 minor stock assessment regions (SARs), and data are collected and summarized on this scale (Table 1, Figure 1). The Pacific Herring data collection program includes fishery-dependent and -independent data from 1951 to 2019. This includes annual time series of commercial catch data, biological samples (providing information on proportion-at-age and weight-at-age), and spawn index data conducted using a combination of surface and SCUBA surveys. In some areas, industry- and/or First Nations-operated in-season soundings programs are also conducted, and this information is used by resource managers, First Nations, and stakeholders to locate fish and identify areas of high and low Pacific Herring biomass to plan harvesting activities. In-season acoustic soundings are not used by stock assessment to inform the estimation of spawning biomass.

*DFO Science, Pacific Biological Station (email: Jaclyn.Cleary@dfo-mpo.gc.ca).
†DFO Science, Pacific Biological Station (email: Matthew.Grinnell@dfo-mpo.gc.ca).

The following is a description of data collected for Pacific Herring in 2019 in the Haida Gwaii 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 2019 refers to the 2018/2019 Pacific Herring season.

2 Data collection programs

In 2019, biological samples were collected by the "Queens Reach", a seine test charter vessel funded by DFO. The primary purpose of the test charter vessel was to collect biological samples from main bodies of herring from Haida Gwaii major (priority) and minor stock areas, identified from soundings. The "Queens Reach" operated a 25 day charter from March 9th to April 2nd, collecting samples from HG and Area 2 West. The spawn reconnaissance vessel "Victoria Rose" operated a 19 day charter from March 31st to April 18th. The dive charter vessel "Haida Spirit" operated an 18 day charter from April 3rd to April 20th. These vessels were funded by DFO, through a contract to the Herring Conservation Research Society. The dive survey contract was awarded to and operated by the Haida Nation.

3 Catch and biological samples

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

Landed commercial catch of Pacific Herring by year and fishery is shown in Table 3 and Figure 3. Total harvested spawn on kelp (SOK) in 2019 in the Haida Gwaii major SAR is shown in Table 4; we also calculate the estimated spawning biomass associated with SOK harvest. See the draft spawn index techincal report for calculations to convert SOK harvest to spawning biomass.

In 2019, 10 Pacific Herring biological samples were collected and processed for the Haida Gwaii major SAR (Table 5, Table 6), and a total of 904 Pacific Herring were aged in 2019. 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 7, and Figure 6, respectively). Biological summaries only include samples collected using seine nets (commercial and test) due to size-selectivity of other gear types such as gillnet. Only representative biological samples are included, where 'representative' indicates whether the Pacific Herring sample in the set accurately reflects the larger Pacific Herring school.

4 Spawn survey data

Pacific Herring spawn surveys were conducted at 31 individual locations in 2019 in the Haida Gwaii major SAR (Table 8, and Figure 7). A summary of spawn from the last decade (2009 to 2018) is shown in Figure 8. Figure 9 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 10, Figure 11, Figure 12, Table 9, and Figure 13). We describe the calculations used to estimate the spawn index in the draft spawn index techincal report. The 'spawn index' is not scaled by the spawn survey scaling parameter, q. Therefore, these data do not represent model estimates of spawning biomass, and are considered the minimum observed spawning biomass derived from egg counts. The spawn index has two distinct periods defined by the dominant survey method: surface surveys (1951 to 1987), and dive surveys (1988 to 2019).

Some Pacific Herring Sections contribute more than others to the total spawn index, and the percentage contributed by Section varies yearly (Figure 12b, Figure 14). For example, in 2019, Section 021 contributed the most to the spawn index (74%). As with Sections, some Statistical Areas contribute more than others to the total spawn index (Figure 12c, Figure 15). An animation shows the spawn index by spawn survey location from 1951 to 2019 (Figure 16).

5 General observations

General observations provide context to the data summary report. The following observations were reported by area DFO Resource Management staff, and DFO Science staff:

- Test charter soundings were similar to last year (16,000 tons).
- Majority of spawning occurred between March 30$^{\text{th}}$ and April 10$^{\text{th}}$.
- Biomass was concentrated around Burnaby Island.
- Significant spawn was observed north of Louise Narrows in Carmichael Passage.
- Increase in spawn length with increase in the number of spawn locations compared to last year.
- Increase in surface surveys to cover off locations where the spawn survey was unable to access.

- Dive survey only surveyed alternate transects to complete survey across the region.
- Spawns in Louscoone were not surveyed.

6 Tables

Table 1. Pacific Herring stock assessment regions (SARs) in British Columbia.

Name	Code	Type
Haida Gwaii	HG	Major
Prince Rupert District	PRD	Major
Central Coast	CC	Major
Strait of Georgia	SoG	Major
West Coast of Vancouver Island	WCVI	Major
Area 27	A27	Minor
Area 2 West	A2W	Minor

Table 2. Statistical Areas and Sections for Pacific Herring in the Haida Gwaii major stock assessment region (SAR).

Region	Statistical Area	Section
Haida Gwaii	00	006
Haida Gwaii	02	021
Haida Gwaii	02	023
Haida Gwaii	02	024
Haida Gwaii	02	025

Table 3. Total landed commercial catch of Pacific Herring in metric tonnes (t) by gear type in 2019 in the Haida Gwaii major stock assessment region (SAR). Legend: 'Other' represents the reduction, the food and bait, as well as the special use fishery; 'RoeSN' represents the roe seine fishery; and 'RoeGN' represents the roe gillnet fishery. Data from the spawn-on-kelp (SOK) fishery is not included. Note: 'WP' indicates that data are withheld due to privacy concerns.

Gear	Catch (t)
Other	0
RoeSN	0
RoeGN	0

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

Year	Harvest (lb)	Spawning biomass (t)
2009	0	0
2010	0	0
2011	0	0
2012	0	0
2013	0	0
2014	0	0
2015	0	0
2016	0	0
2017	0	0
2018	0	0
2019	0	0

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

	Number of samples		
Year	Commercial	Test	Total
2009	0	12	12
2010	0	12	12
2011	0	13	13
2012	0	9	9
2013	0	12	12
2014	0	12	12
2015	0	11	11
2016	0	5	5
2017	0	8	8
2018	0	11	11
2019	0	10	10

Table 6. Number and type of Pacific Herring biological samples processed in 2019 in the Haida Gwaii 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 2009 to 2019 in the Haida Gwaii 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
2009	0.001	0.643	0.076	0.221	0.020	0.029	0.004	0.005	0.001
2010	0.082	0.085	0.589	0.056	0.153	0.017	0.013	0.003	0.002
2011	0.018	0.442	0.076	0.314	0.055	0.085	0.008	0.003	0.000
2012	0.174	0.148	0.380	0.040	0.203	0.018	0.030	0.002	0.004
2013	0.000	0.677	0.125	0.128	0.019	0.041	0.005	0.004	0.000
2014	0.014	0.037	0.684	0.115	0.094	0.014	0.034	0.005	0.003
2015	0.034	0.218	0.055	0.519	0.059	0.079	0.018	0.014	0.004
2016	0.166	0.162	0.170	0.058	0.376	0.044	0.020	0.002	0.002
2017	0.138	0.322	0.100	0.112	0.050	0.200	0.049	0.015	0.014
2018	0.045	0.404	0.242	0.098	0.063	0.072	0.070	0.004	0.002
2019	0.018	0.540	0.312	0.077	0.022	0.018	0.012	0.001	0.000

Table 8. Pacific Herring spawn survey locations, start date, and spawn index in metric tonnes (t) in 2019 in the Haida Gwaii 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)
00	006	Louscoone Inlt	April 01	184
02	021	Alder Is	March 30	98
02	021	Alder Is Cr	March 30	1,725
02	021	Burnaby Str	April 03	NA
02	021	Hutton Inlt	April 05	6
02	021	Huxley Is	March 30	805
02	021	Island Bay	April 02	1,590
02	021	Marco Is	April 02	225
02	021	Nakons Islet	March 30	81
02	021	Saw Rf	March 30	143
02	021	Scudder Pt	March 30	3,113
02	021	Section Cv	March 30	93
02	021	Section Is	March 30	688
02	023	Carmichael Pass	March 30	294
02	023	Cumshewa Inlt	April 27	NA
02	024	Atli Inlt	April 08	286
02	024	Lagoon Inlt	April 11	21
02	024	Sewell Inlt	April 11	157
02	025	Bolkus Is	April 03	64
02	025	Boulder Is	April 01	2
02	025	Francis Bay	March 30	1
02	025	Huston Inlt	April 04	103
02	025	Huston Pt	April 01	NA
02	025	Poole Inlt	March 30	283
02	025	Rebecca Pt	March 30	946
02	025	Scudder Cr	March 30	240
02	025	Slim Inlt	April 01	230
02	025	Smithe Pt	April 04	114
02	025	Swan Bay	April 04	88
02	025	Swan Is	April 04	NA
02	025	Tangle Cv	April 03	42

Table 9. Summary of Pacific Herring spawn survey data from 2009 to 2019 in the Haida Gwaii major stock assessment region (SAR). The spawn index has two distinct periods defined by the dominant survey method: surface surveys (1951 to 1987), and dive surveys (1988 to 2019). The 'spawn index' is not scaled by the spawn survey scaling parameter, q. Units: metres (m), and metric tonnes (t).

Year	Total length (m)	Mean width (m)	Mean number of egg layers	Spawn index (t)
2009	52,239	34	0.9	9,794
2010	33,670	49	1.2	6,845
2011	33,560	40	1.6	7,554
2012	54,610	28	1.1	9,720
2013	70,300	33	1.7	16,025
2014	52,900	57	0.9	10,566
2015	57,150	55	1.4	13,102
2016	30,345	54	1.1	6,888
2017	31,350	62	0.9	3,016
2018	35,575	44	1.1	4,588
2019	77,965	40	1.4	11,624

7 Figures

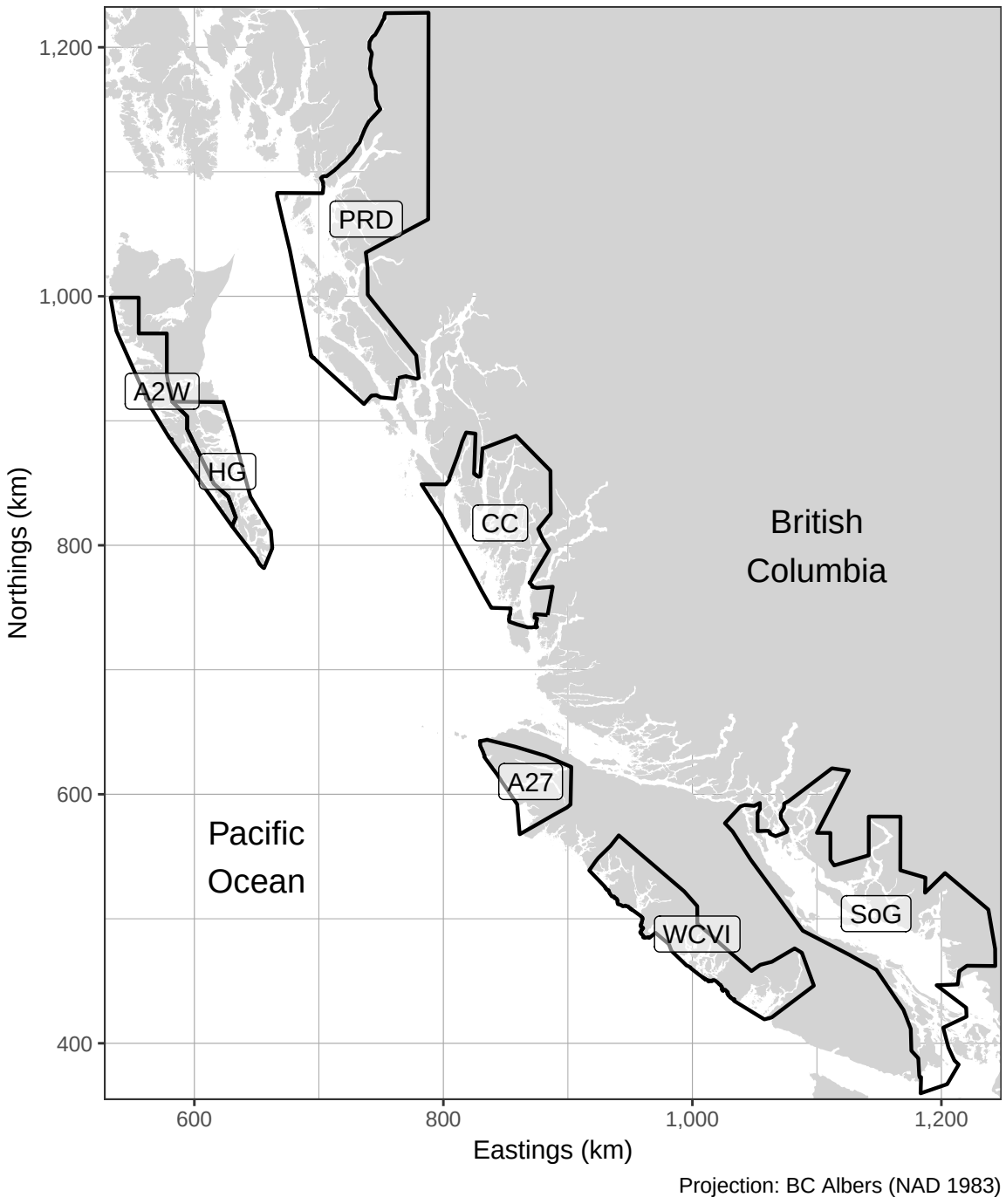

Figure 1. Boundaries for the Pacific Herring stock assessment regions (SARs) in British Columbia: there are 5 major SARs (HG, PRD, CC, SoG, and WCVI), and 2 minor SARs (A27 and A2W; Table 1). Units: kilometres (km).

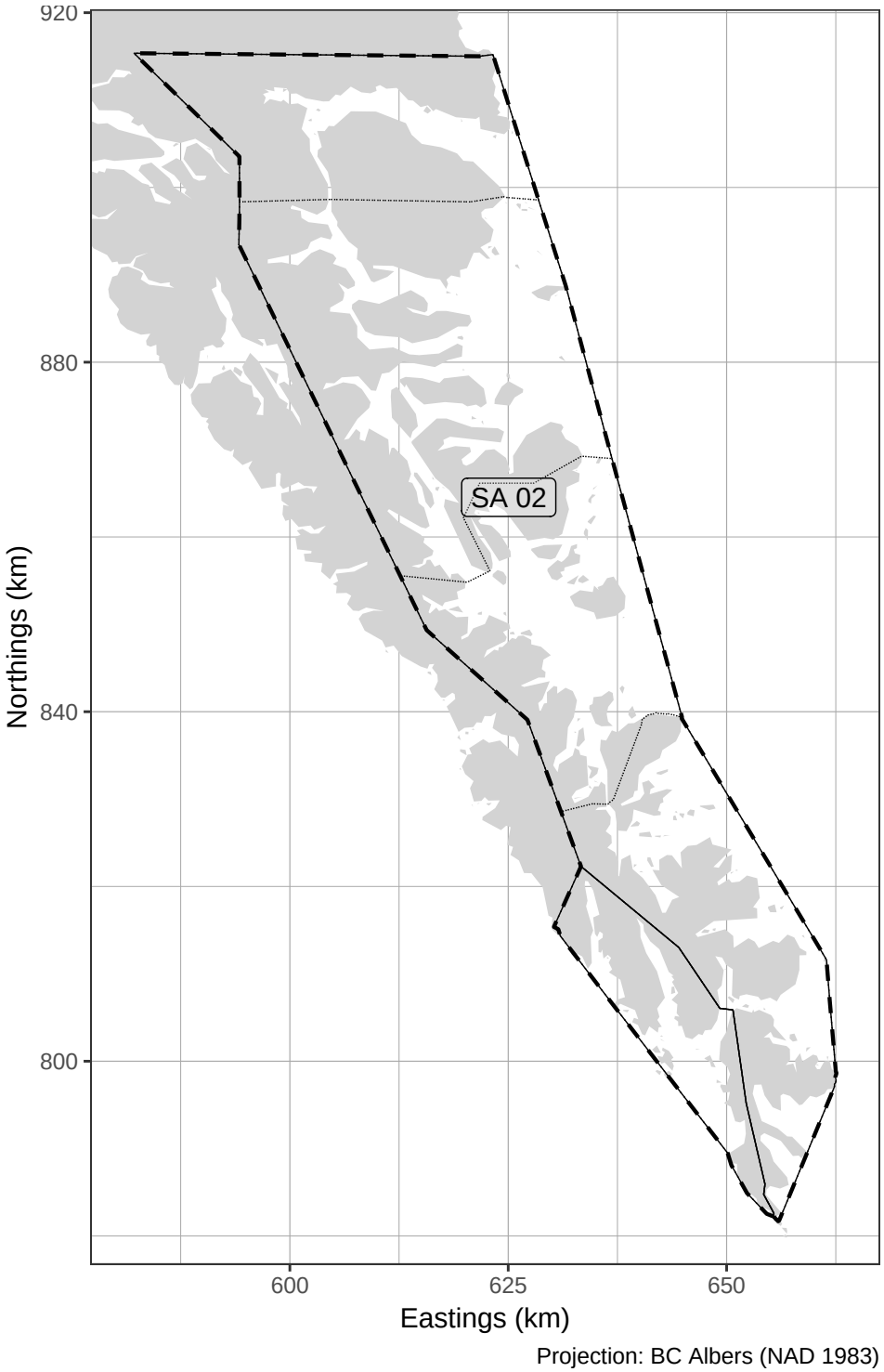

Figure 2. Boundaries for the Haida Gwaii major stock assessment region (SAR; thick dashed lines), associated Statistical Areas (SA; thin solid lines), and associated Sections (thin dotted lines). Units: kilometres (km).

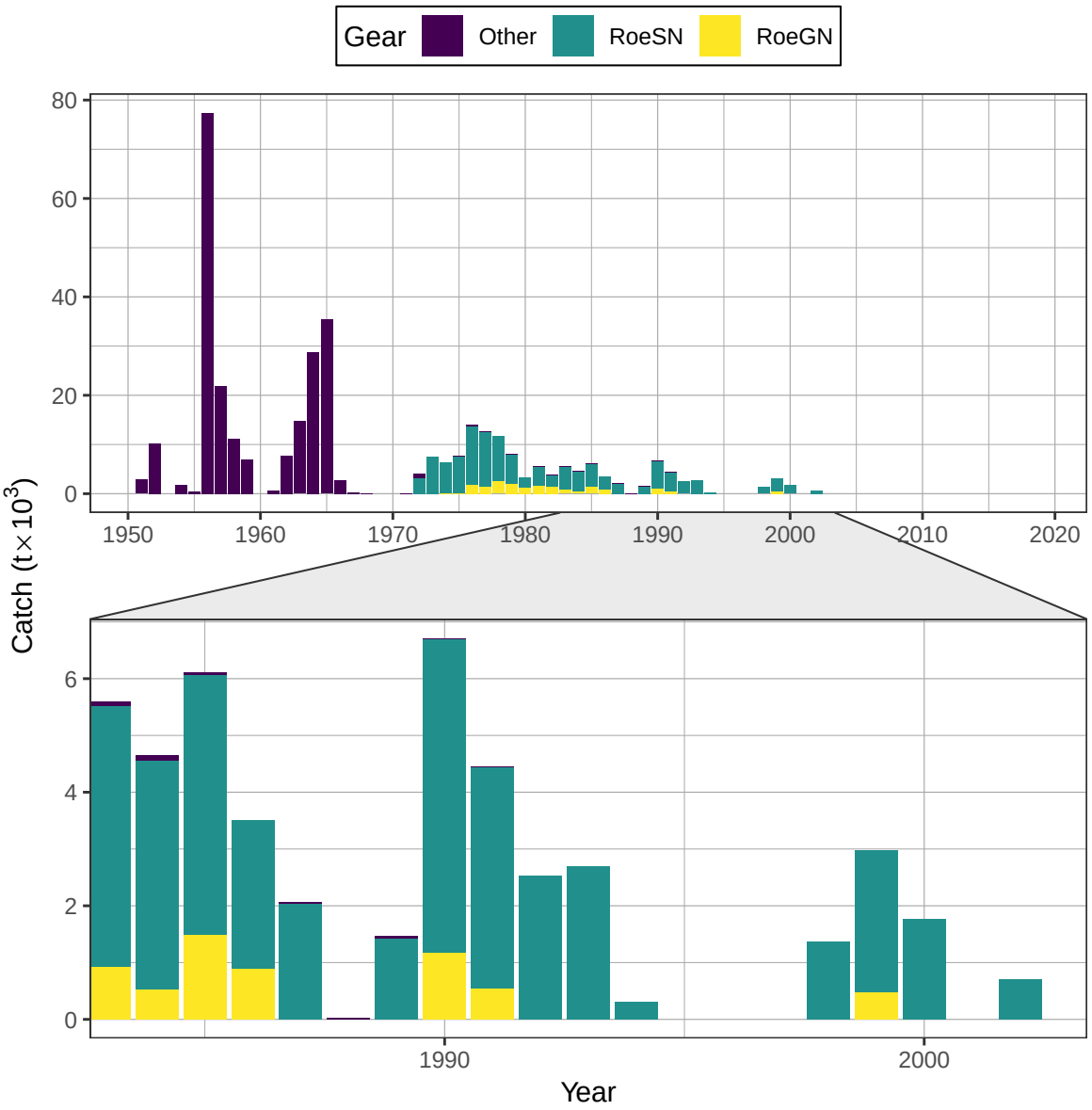

Figure 3. Time series of total landed catch in thousands of metric tonnes ($t \times 10^3$) of Pacific Herring by gear type from 1951 to 2019 in the Haida Gwaii major stock assessment region (SAR). Legend: 'Other' represents the reduction, the food and bait, as well as the special use fishery; 'RoeSN'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

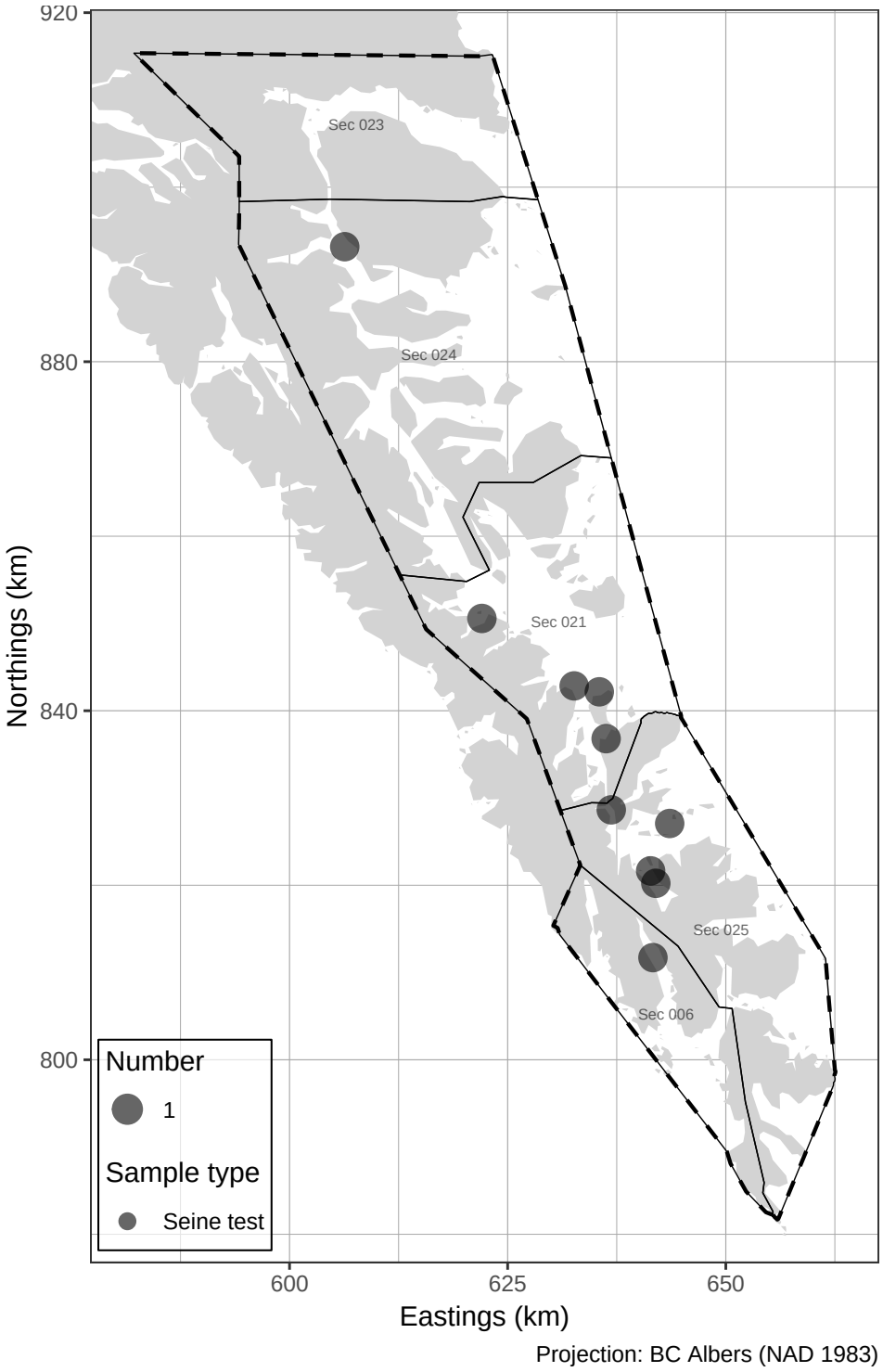

Figure 4. Location and type of Pacific Herring biological samples collected in 2019 in the Haida Gwaii major stock assessment region (SAR; thick dashed lines), and associated Sections (Sec; thin solid lines). Units: kilometres (km).

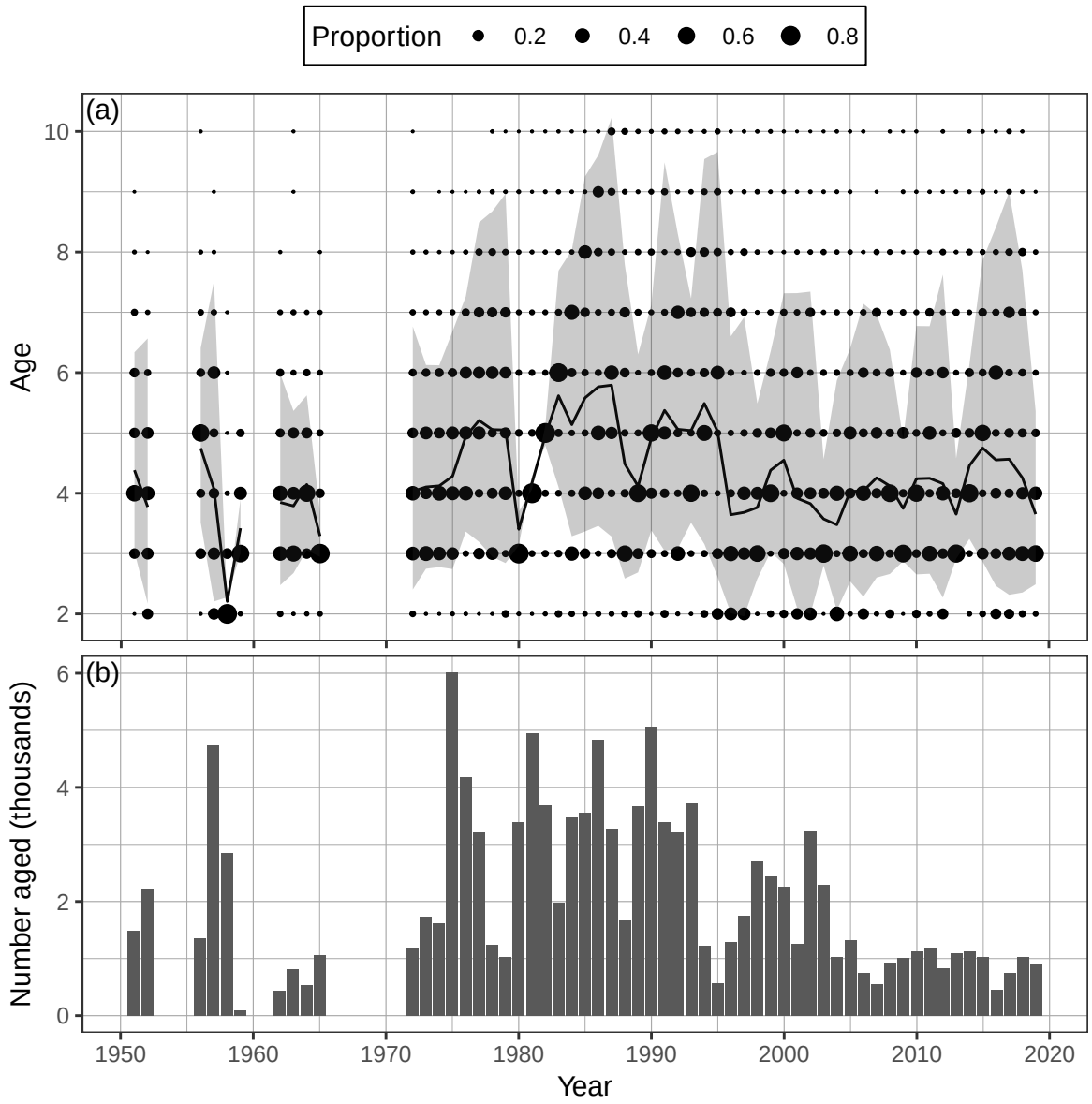

Figure 5. Time series of observed proportion-at-age (a) and number aged in thousands (c) of Pacific Herring from 1951 to 2019 in the Haida Gwaii major stock assessment region (SAR). The black line is the mean age, and the shaded area is the approximate 90% distribution. Biological summaries only include 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.

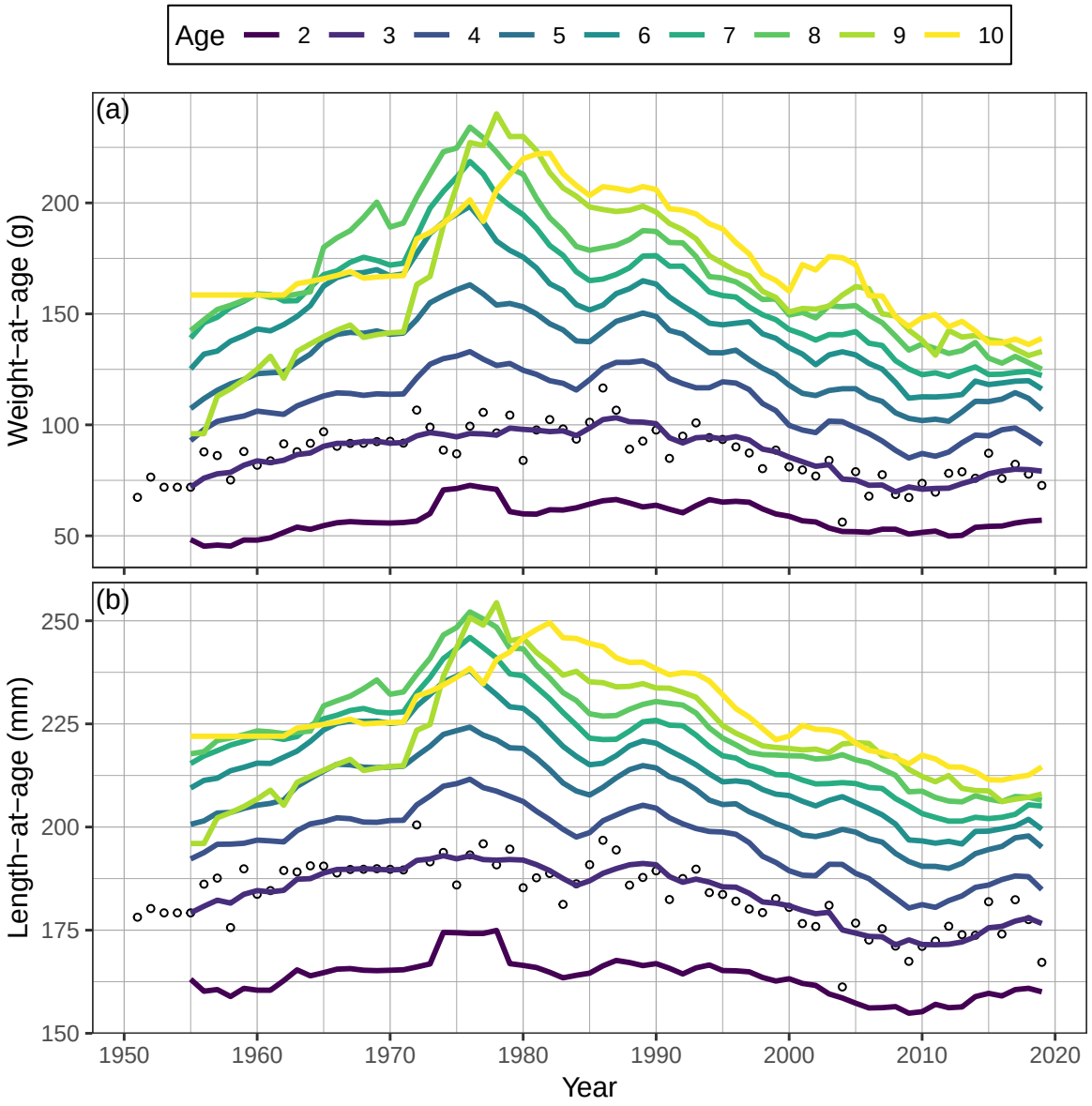

Figure 6. Time series of weight-at-age in grams (g; panel a) and length-at-age in milimetres (mm; panel b) for age-3 (circles) and 5-year running mean weight- and length-at-age (lines) for Pacific Herring from 1951 to 2019 in the Haida Gwaii major stock assessment region (SAR). Missing weight- and length-at-age 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.

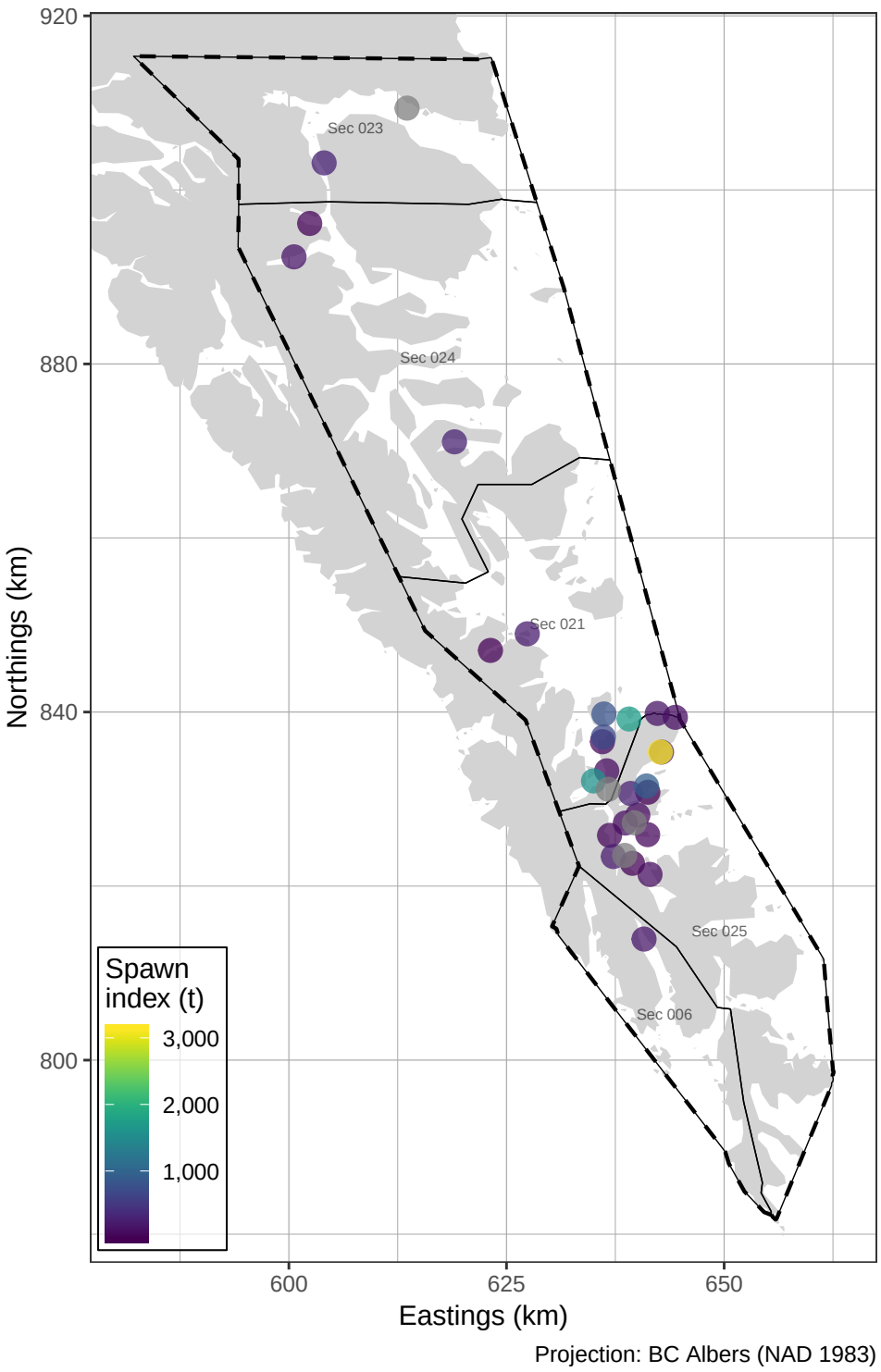

Figure 7. Pacific Herring spawn survey locations, and spawn index in metric tonnes (t) in 2019 in the Haida Gwaii major stock assessment region (SAR; thick dashed lines), and associated Sections (Sec; thin solid lines). The 'spawn index' is not scaled by the spawn survey scaling parameter, q. Missing spawn index values (grey circles) indicate incomplete spawn surveys. Units: kilometres (km).

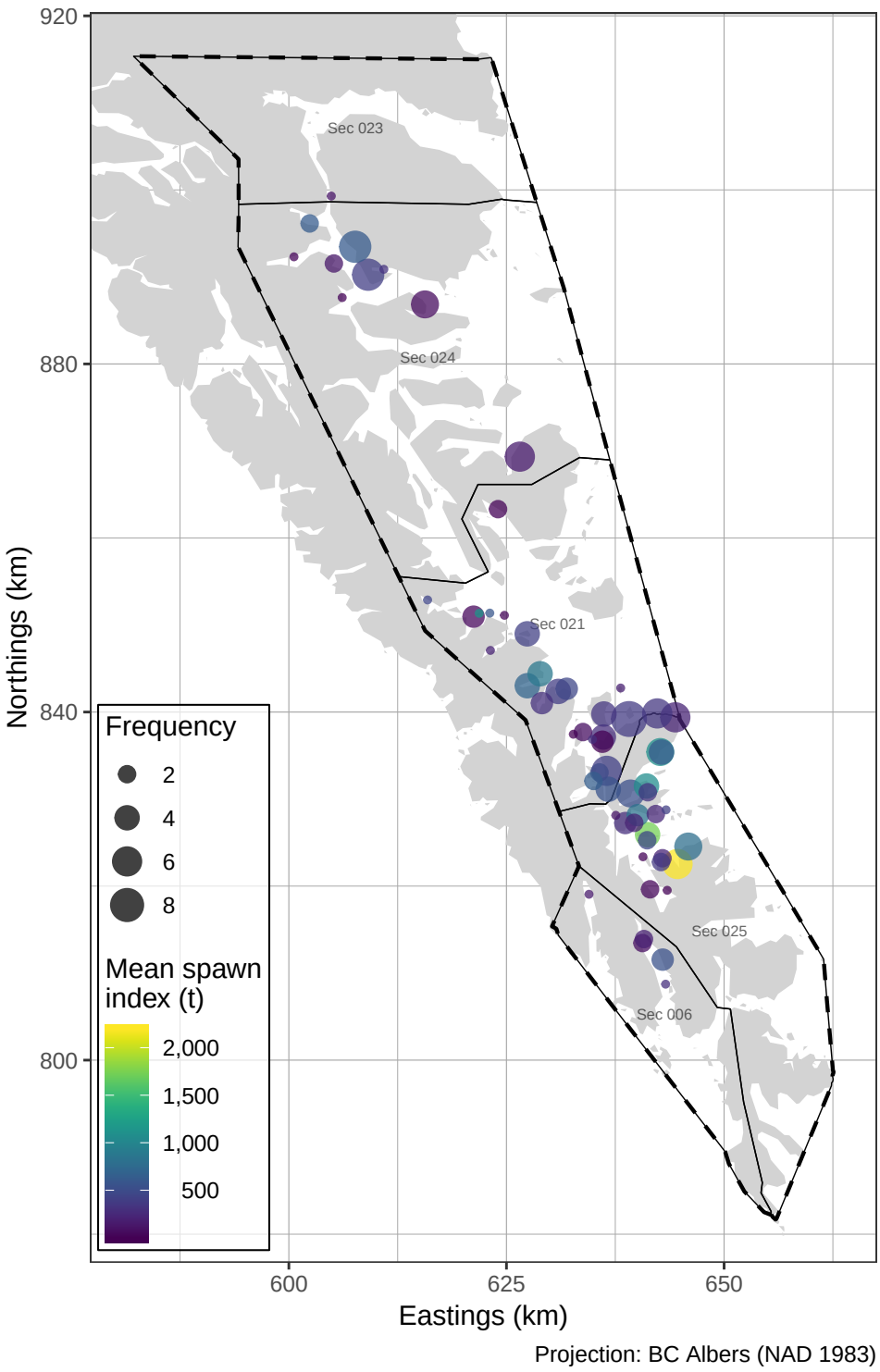

Figure 8. Pacific Herring spawn survey locations, mean spawn index in metric tonnes (t), and spawn frequency from 2009 to 2018 in the Haida Gwaii major stock assessment region (SAR; thick dashed lines), and associated Sections (Sec; thin solid lines). The 'spawn index' is not scaled by the spawn survey scaling parameter, q. Missing spawn index values (grey circles) indicate incomplete spawn surveys. Units: kilometres (km).

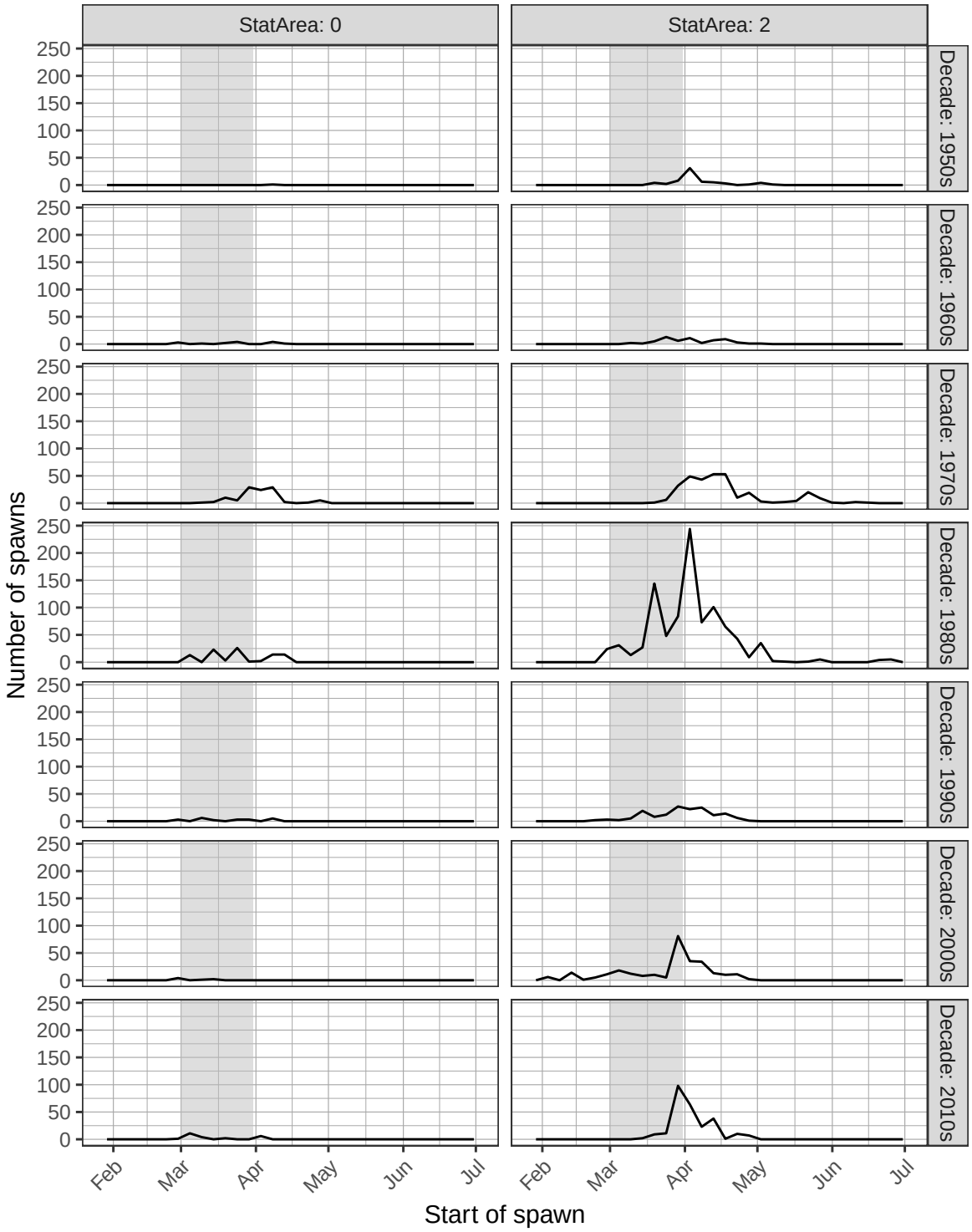

Figure 9. Pacific Herring spawn start date by decade and Statistical Area. Grey shaded regions indicate March 1st to 31st. Note that spawn size and intensity varies; therefore the number of spawns is not directly proportional to spawn extent or biomass.

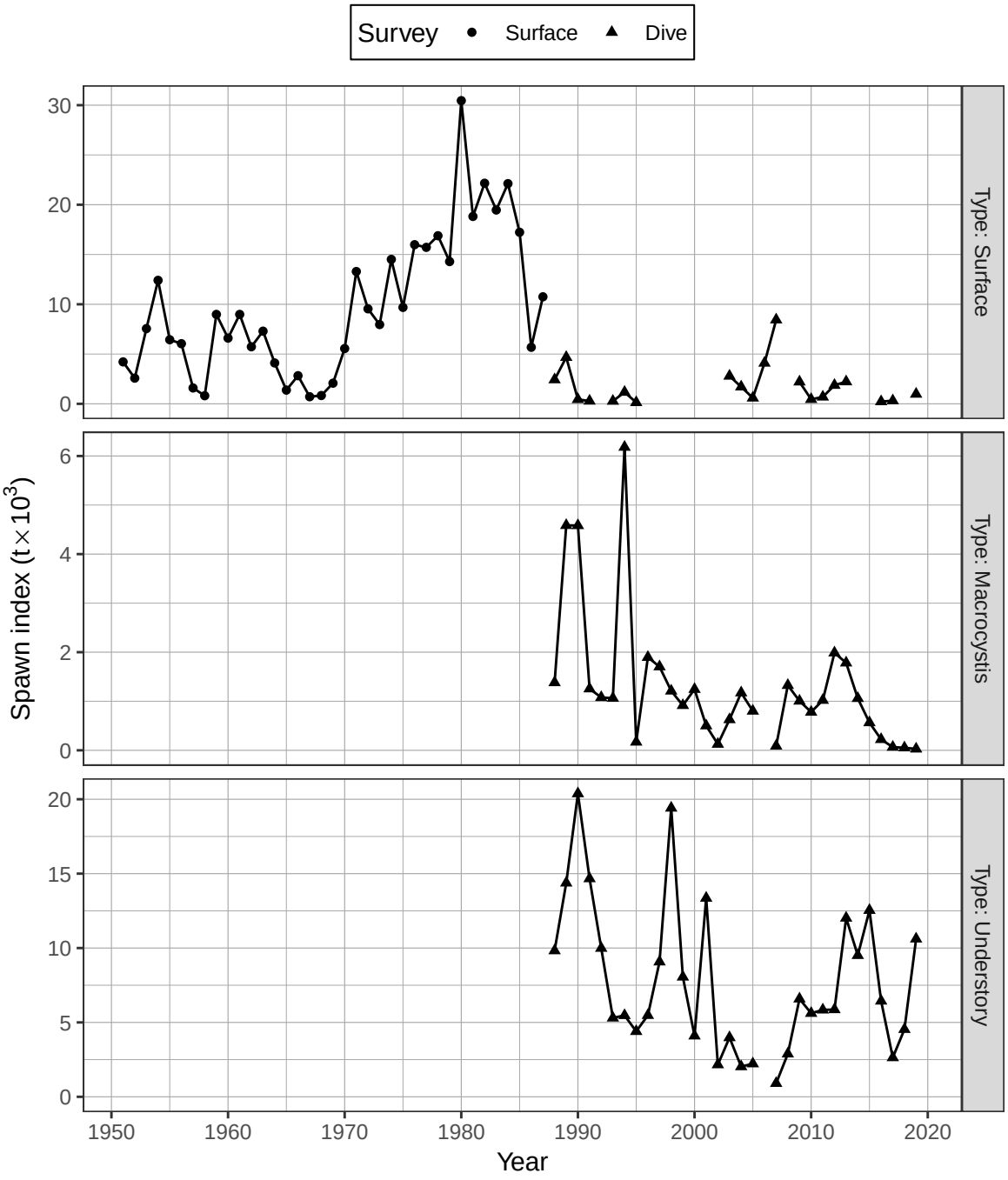

Figure 10. Time series of spawn index in thousands of metric tonnes ($t \times 10^3$) by type for Pacific Herring from 1951 to 2019 in the Haida Gwaii major stock assessment region (SAR). There are three types of spawn survey observations: observations of spawn taken from the surface usually at low tide,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

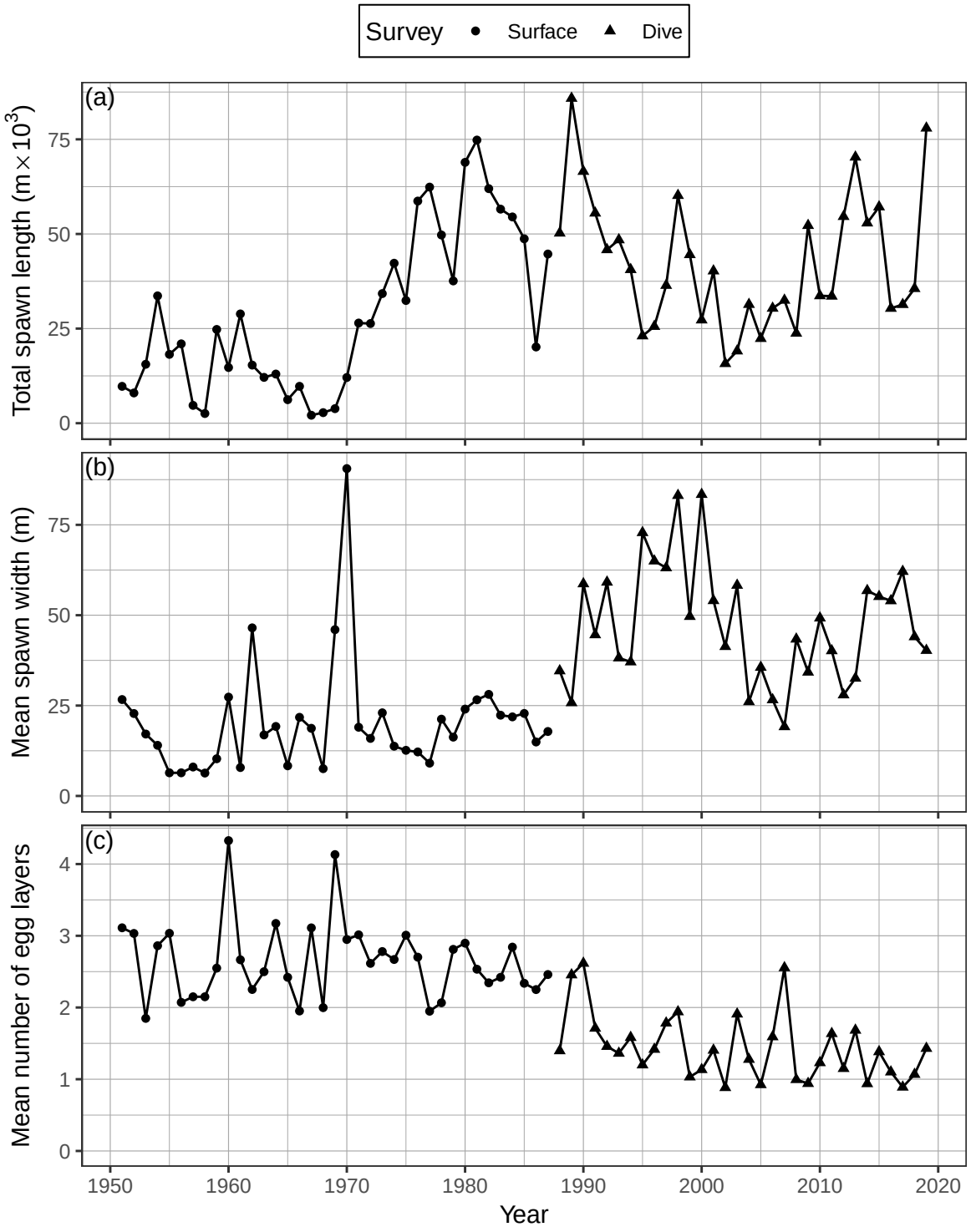

Figure 11. Time series of total spawn length in thousands of metres ($m \times 10^3$; panel a), mean spawn width in metres (b), and mean number of egg layers (c) for Pacific Herring from 1951 to 2019 in the Haida Gwaii major stock assessment region (SAR). The spawn index has two distinct periods defined by the dominant survey method: surface surveys (1951 to 1987), and dive surveys (1988 to 2019).

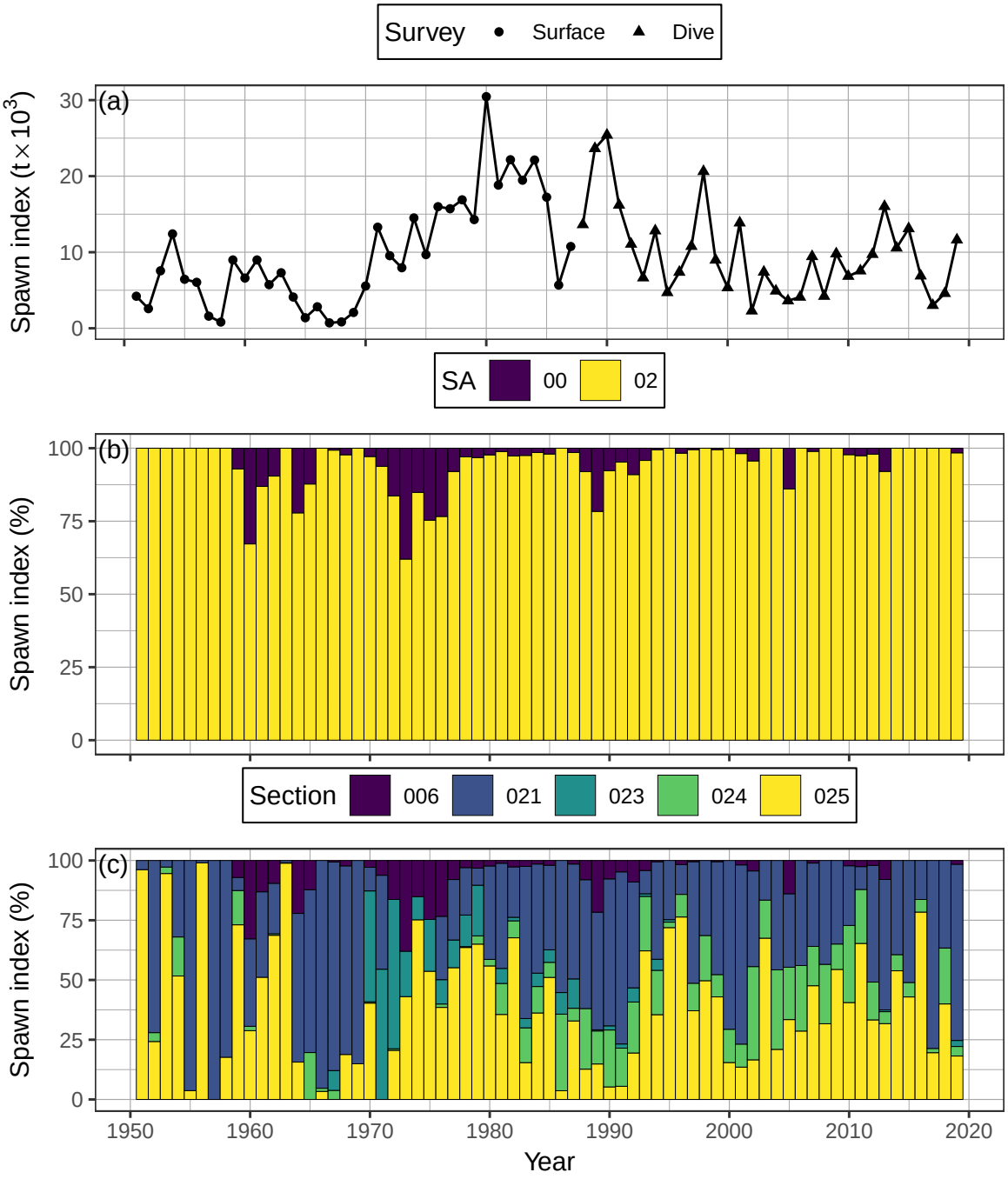

Figure 12. Time series of spawn index in thousands of metric tonnes ($t \times 10^3$) for Pacific Herring from 1951 to 2019 in the Haida Gwaii major stock assessment region (SAR; panel a), as well as percent contributed by Statistical Area (SA), and Section (b, & c, respectively). The spawn index has two distinct periods defined by the dominant survey method: surface surveys (1951 to 1987), and dive surveys (1988 to 2019). The 'spawn index' is not scaled by the spawn survey scaling parameter, q.

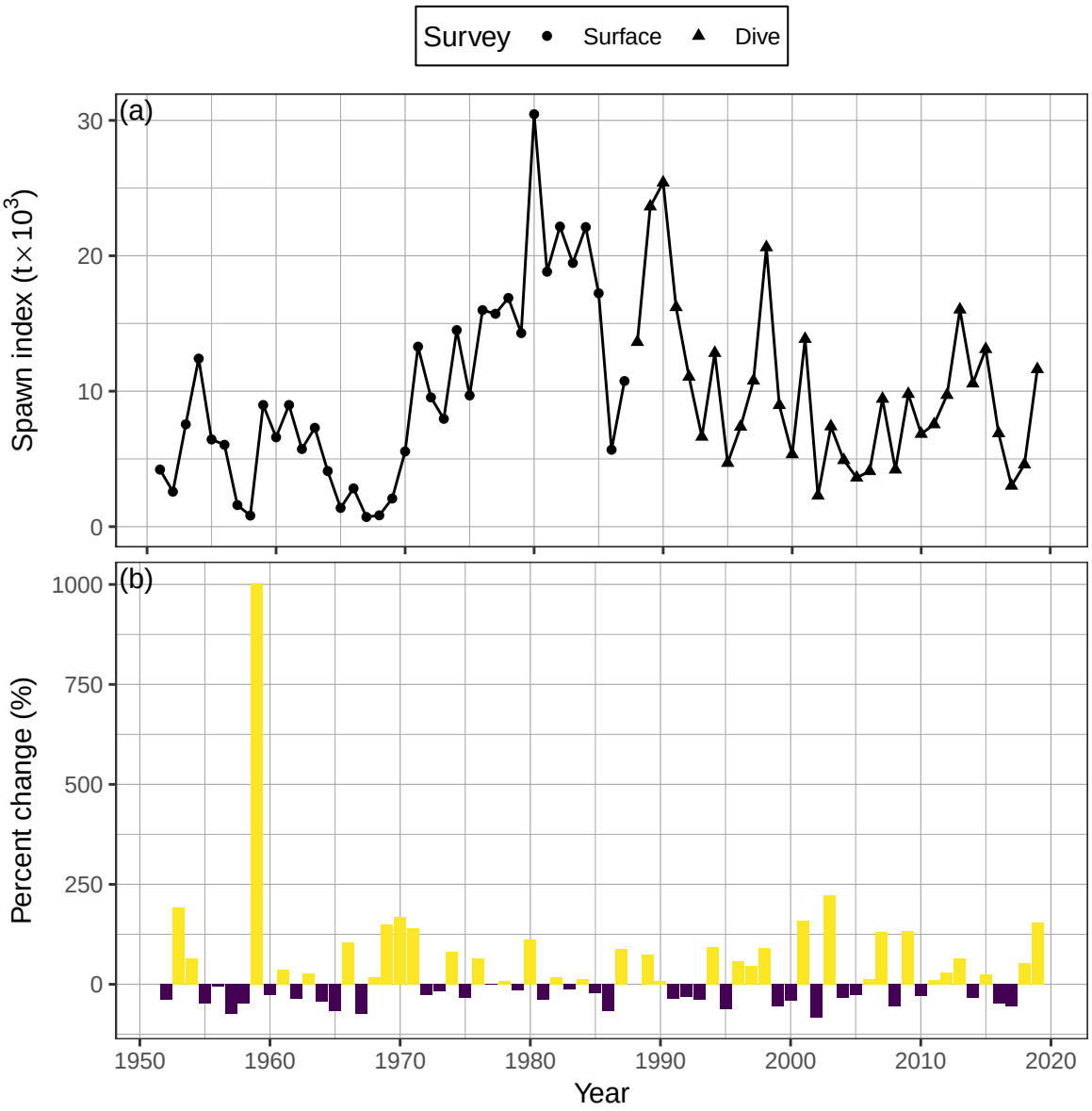

Figure 13. Time series of spawn index in thousands of metric tonnes ($t \times 10^3$) for Pacific Herring from1951 to 2019 in the Haida Gwaii major stock assessment region (SAR; panel a), and percent change (b). We calculate percent change as $\delta_t = \frac{I_t - I_{t-1}}{I_{t-1}}$ where I_t is the spawn index in year t. The spawn index has two distinct periods defined by the dominant survey method: surface surveys (1951 to 1987), and dive surveys (1988 to 2019). The 'spawn index' is not scaled by the spawn survey scaling parameter, q.

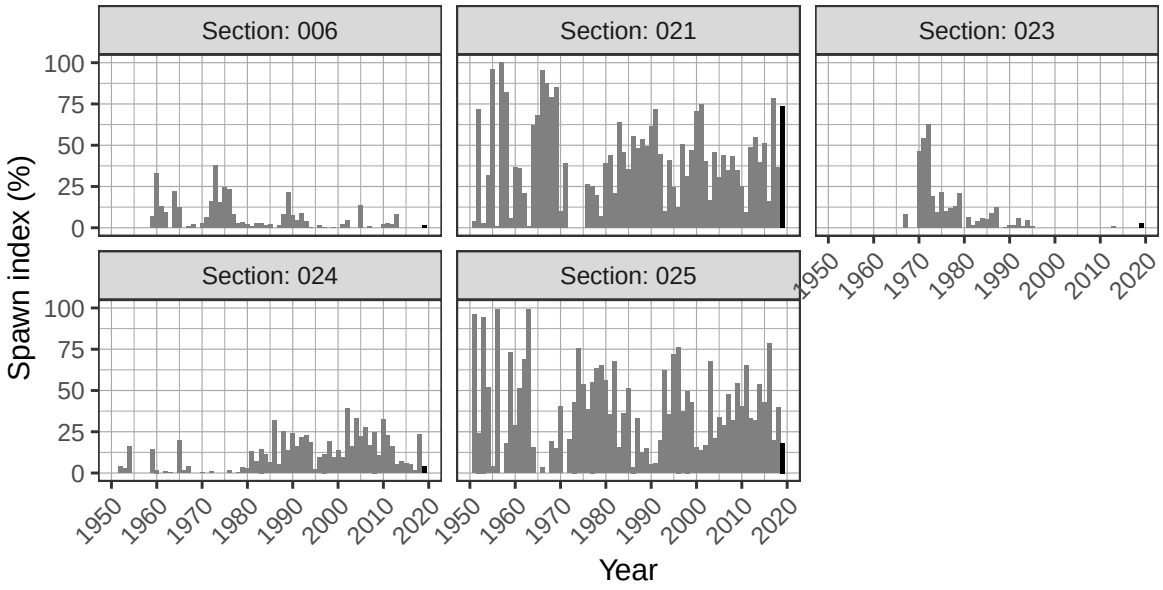

Figure 14. Time series of percent of spawn index by Section for Pacific Herring from 1951 to 2019 in the Haida Gwaii major stock assessment region (SAR). The year 2019 has a darker bar to facilitate interpretation. The spawn index has two distinct periods defined by the dominant survey method: surface surveys (1951 to 1987), and dive surveys (1988 to 2019). The 'spawn index' is not scaled by the spawn survey scaling parameter, q.

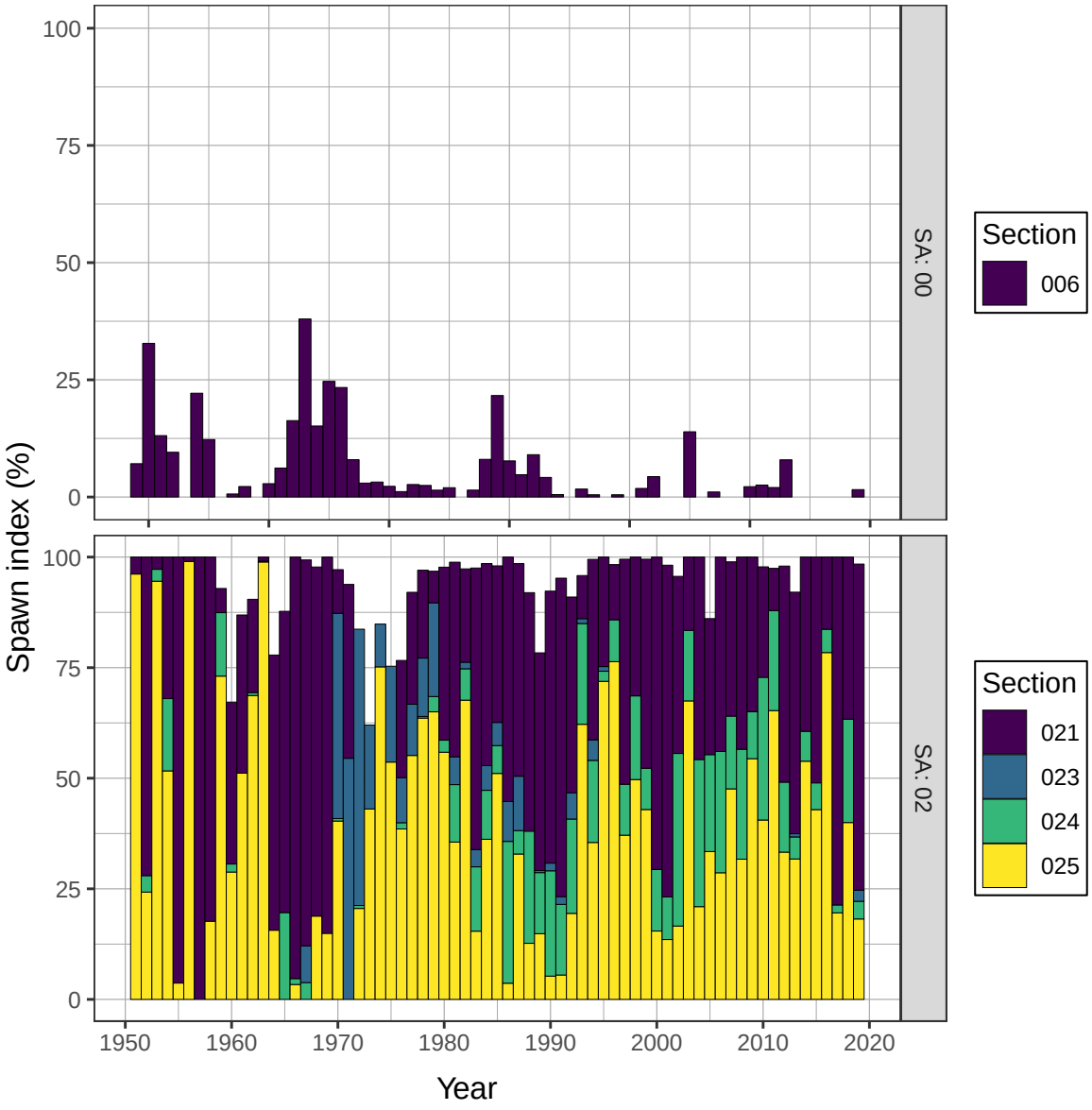

Figure 15. Time series of percent of spawn index by Statistical Area (SA) and Section for Pacific Herring from 1951 to 2019 in the Haida Gwaii major stock assessment region (SAR). The spawn index has two distinct periods defined by the dominant survey method: surface surveys (1951 to 1987), and dive surveys (1988 to 2019). The 'spawn index' is not scaled by the spawn survey scaling parameter, q.

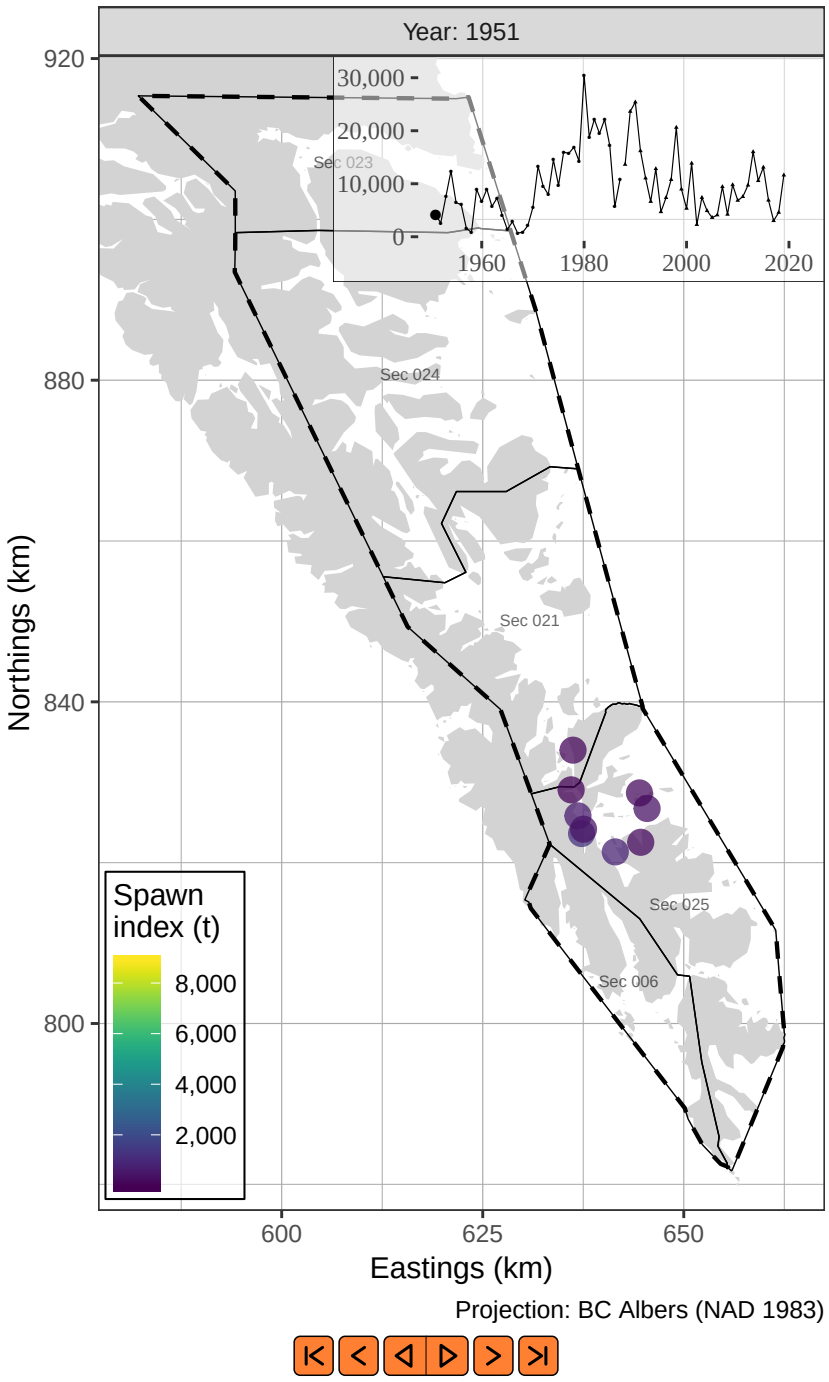

Figure 16. Animation of Pacific Herring spawn survey locations and spawn index in metric tonnes (t) from 1951 to 2019 in the Haida Gwaii major stock assessment region (SAR; thick dashed lines), and associated Sections (Sec; thin solid lines). The spawn index has two distinct periods defined by the dominant survey method: surface surveys (1951 to 1987), and dive surveys (1988 to 2019). The 'spawn index' is not scaled by the spawn survey scaling parameter, q. Missing spawn index values (grey circles) indicate incomplete spawn surveys. The inset shows the total spawn index by year. Units: kilometres (km).