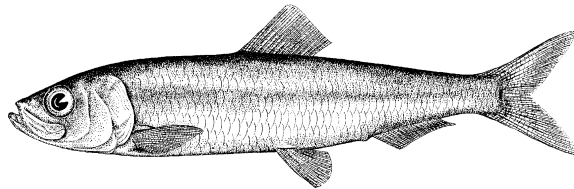


Pacific Herring preliminary data summary for Area 2 West 2021

Jaclyn Cleary*

Matthew Grinnell†

July 26, 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 Area 2 West minor stock assessment region (SAR). These data may differ from data used and presented in the final stock assessment.

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.

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

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

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 Area 2 West minor 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 the “Queens Reach”, a seine test charter vessel funded by DFO. The “Queens Reach” collected biological samples from main bodies of herring, identified from soundings. The “Atlas” completed an 8 day surface survey charter in Area 2 West from April 5th to 12th. Both 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 Area 2 West minor 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, 4 Pacific Herring biological samples were collected and processed for the Area 2 West minor SAR (Table 5, Table 6), and a total of 361 Pacific Herring were aged in 2021. 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). 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 1 individual location in 2021 in the Area 2 West minor SAR (Table 8, and Figure 9). A summary of spawn from the last decade (2011 to 2020) is shown in Figure 10. Figure 11 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 12, Figure 13, Figure 14, Figure 15, Table 9, and Figure 16). 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 15b, Figure 17). For example, in 2021, Section 002 contributed the most to the spawn index (100%). As with Sections, some Statistical Areas contribute more than others to the total spawn index (Figure 15c, Figure 18). An animation shows the spawn index by spawn survey location from 1951 to 2021 (Figure 19).

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:

- Despite very poor weather conditions in Area 2W during both the test seine charter

and spawn surface survey, the primary stock assessment goals were achieved.

- Despite observations of herring aggregations throughout Port Louis all of the observed spawning seemed to be limited to Otard Bay. This was thought to be due to prevailing strong westerly winds and a resulting large swell into much of Port Louis. The spawn in Otard Bay was very heavy and observations suggested that all of the herring in the area had spawned there.
- No other spawns were observed in Area 2W other than amounts of trace spawn at the head of Kano Inlet and a small spot spawn in Dawson Inlet.
- There was a large abundance of both Stellars and California Sea Lions as well as several Humpback whales in the Port Louis area in 2021.

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 Area 2 West minor stock assessment region (SAR).

Region	Statistical Area	Section
Area 2 West	00	000
Area 2 West	00	001
Area 2 West	00	002
Area 2 West	00	003
Area 2 West	00	004
Area 2 West	00	005

Table 3. Total landed commercial catch of Pacific Herring in metric tonnes (t) by gear type in 2021 in the Area 2 West minor 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 Area 2 West minor 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	WP	WP
2013	WP	WP
2014	WP	WP
2015	0	0
2016	0	0
2017	0	0
2018	0	0
2019	0	0
2020	46,189	68
2021	0	0

Table 5. Number of Pacific Herring biological samples processed from 2011 to 2021 in the Area 2 West minor stock assessment region (SAR). Each sample is approximately 100 fish.

Year	Number of samples		
	Commercial	Test	Total
2011	0	10	10
2012	0	5	5
2013	1	6	7
2014	3	0	3
2015	0	4	4
2016	0	5	5
2017	0	6	6
2018	0	6	6
2019	0	6	6
2020	0	4	4
2021	0	4	4

Table 6. Number and type of Pacific Herring biological samples processed in 2021 in the Area 2 West minor stock assessment region (SAR). Each sample is approximately 100 fish.

Type	Gear	Use	Number of samples
Test	Seine	Test fishery	4

Table 7. Observed proportion-at-age for Pacific Herring from 2011 to 2021 in the Area 2 West minor stock assessment region (SAR). The age-10 class is a ‘plus group’ which includes fish ages 10 and older.

Year	Proportion-at-age								
	2	3	4	5	6	7	8	9	10
2011	0.022	0.499	0.183	0.232	0.016	0.035	0.007	0.004	0.001
2012	0.072	0.192	0.372	0.148	0.159	0.015	0.030	0.004	0.008
2013	0.003	0.612	0.085	0.183	0.062	0.048	0.000	0.006	0.001
2014	0.053	0.004	0.438	0.068	0.208	0.106	0.094	0.011	0.019
2015	0.036	0.689	0.028	0.122	0.010	0.070	0.026	0.016	0.003
2016	0.036	0.096	0.715	0.027	0.105	0.017	0.004	0.000	0.000
2017	0.065	0.124	0.085	0.602	0.030	0.064	0.023	0.007	0.000
2018	0.013	0.390	0.105	0.070	0.361	0.022	0.022	0.015	0.002
2019	0.038	0.662	0.186	0.027	0.023	0.055	0.006	0.002	0.002
2020	0.027	0.066	0.673	0.098	0.040	0.037	0.053	0.003	0.003
2021	0.036	0.089	0.083	0.620	0.100	0.028	0.033	0.011	0.000

Table 8. Pacific Herring spawn survey location, start date, and spawn index in metric tonnes (t) in 2021 in the Area 2 West minor 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	002	Otard Bay	April 05	1,377

Table 9. Summary of Pacific Herring spawn survey data from 2011 to 2021 in the Area 2 West minor 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	14,130	30	2	2,641
2012	19,704	14	2	2,416
2013	14,965	11	2	2,076
2014	12,050	27	1	1,368
2015	NA	NA	NA	NA
2016	15,800	27	3	3,001
2017	NA	NA	NA	NA
2018	20,800	18	2	617
2019	11,740	19	4	2,884
2020	20,102	11	5	6,834
2021	5,605	25	6	1,377

8 Figures

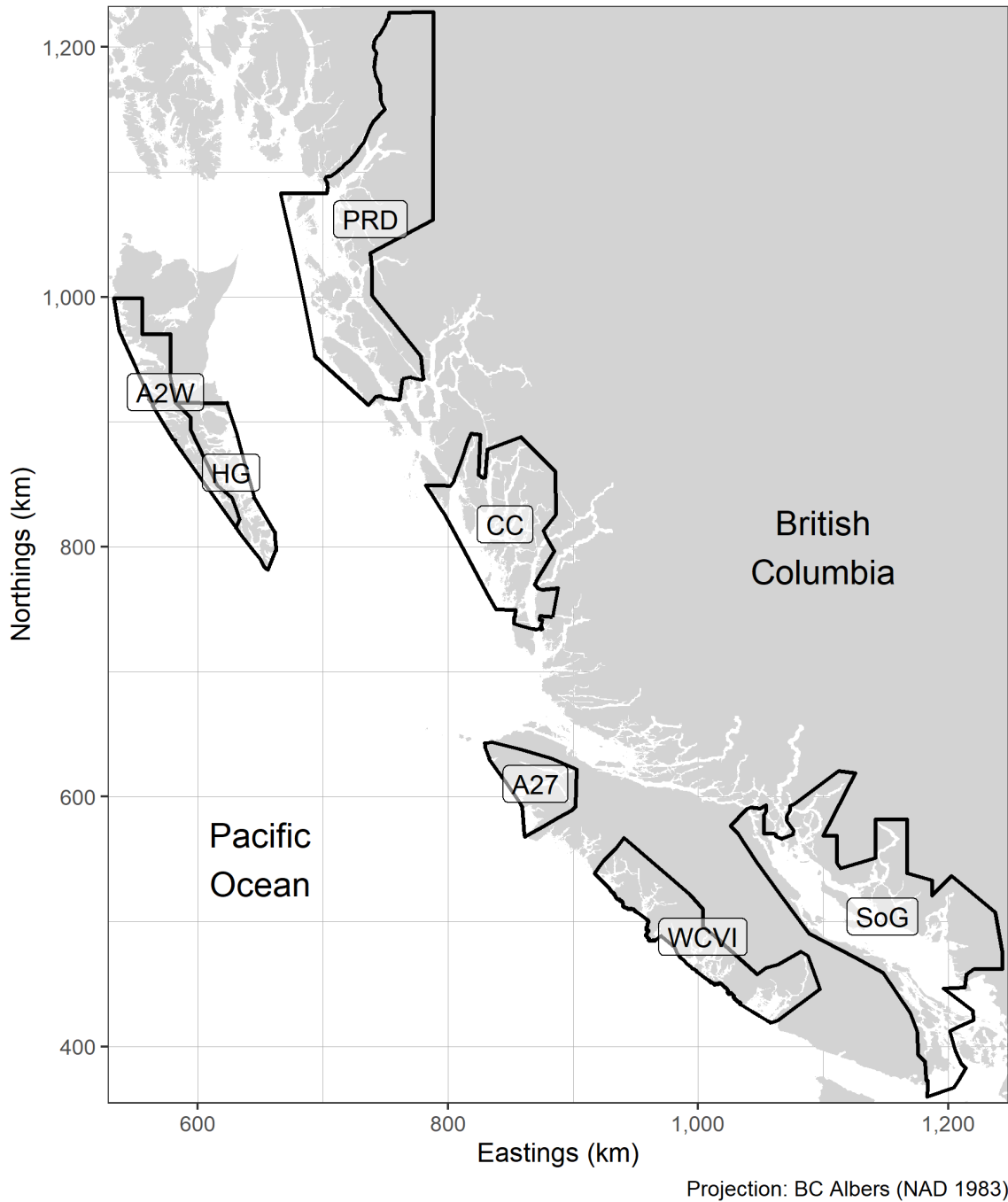


Figure 1. Boundaries for the Pacific Herring stock assessment regions (SARs) in British Columbia. There are 5 major SARs: Haida Gwaii (HG), Prince Rupert District (PRD), Central Coast (CC), Strait of Georgia (SoG), and West Coast of Vancouver Island (WCVI). There are 2 minor SARs: Area 27 (A27) and Area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

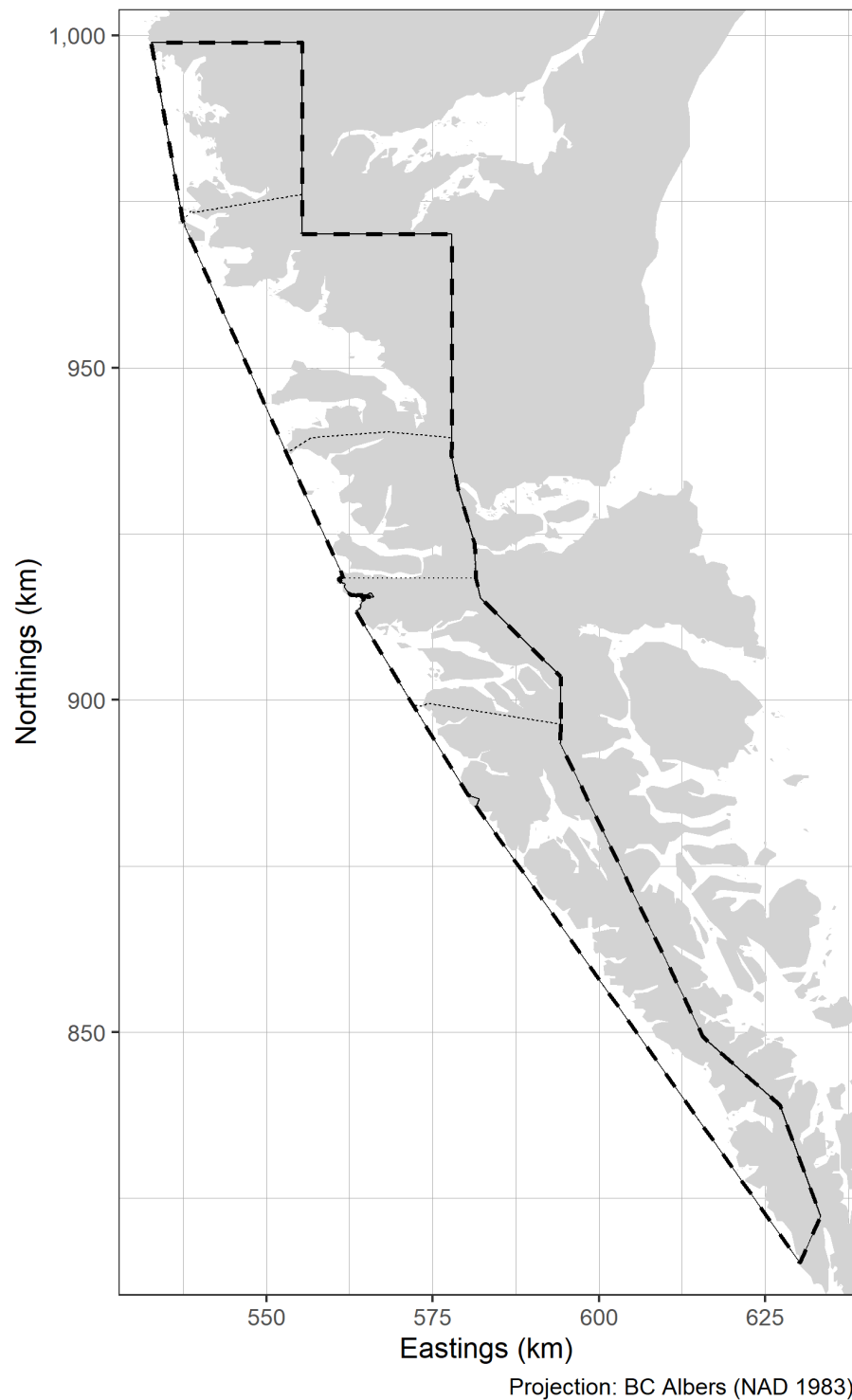


Figure 2. Boundaries for the Area 2 West minor stock assessment region (SAR; thick dashed lines), associated Statistical Areas (SA; thin solid lines), and associated Sections (thin dotted lines). Units: kilometres (km).

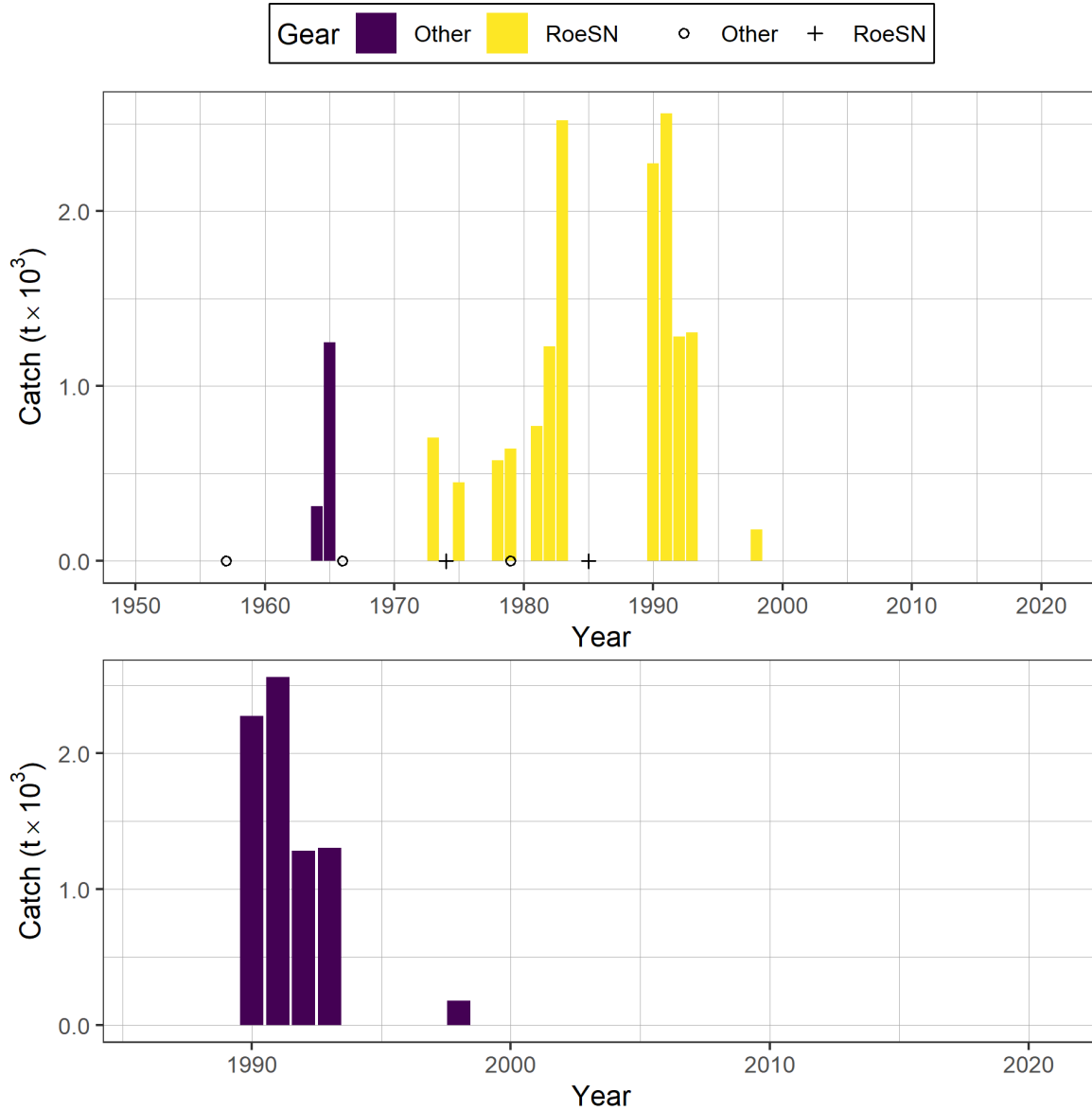


Figure 3. Time series of total landed catch in thousands of metric tonnes ($t \times 10^3$) of Pacific Herring by gear type from 1951 to 2021 in the Area 2 West minor stock assessment region (SAR). Legend: ‘Other’ represents the reduction (1951 to 1970 only), the food and bait, as well as the special 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) is withheld due to privacy concerns.

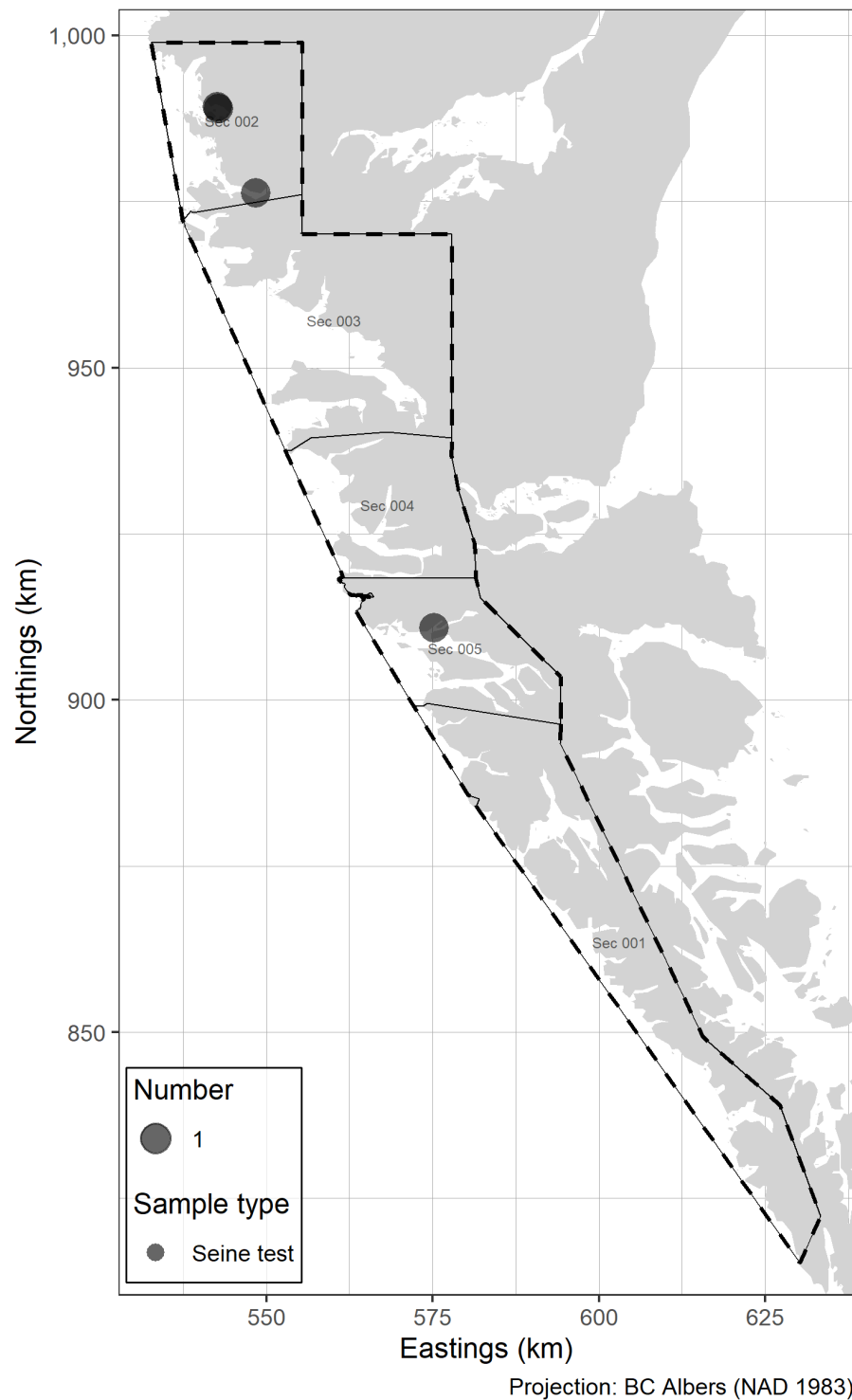


Figure 4. Location and type of Pacific Herring biological samples collected in 2021 in the Area 2 West minor stock assessment region (SAR; thick dashed lines), and associated Sections (Sec; thin solid lines). Units: kilometres (km).

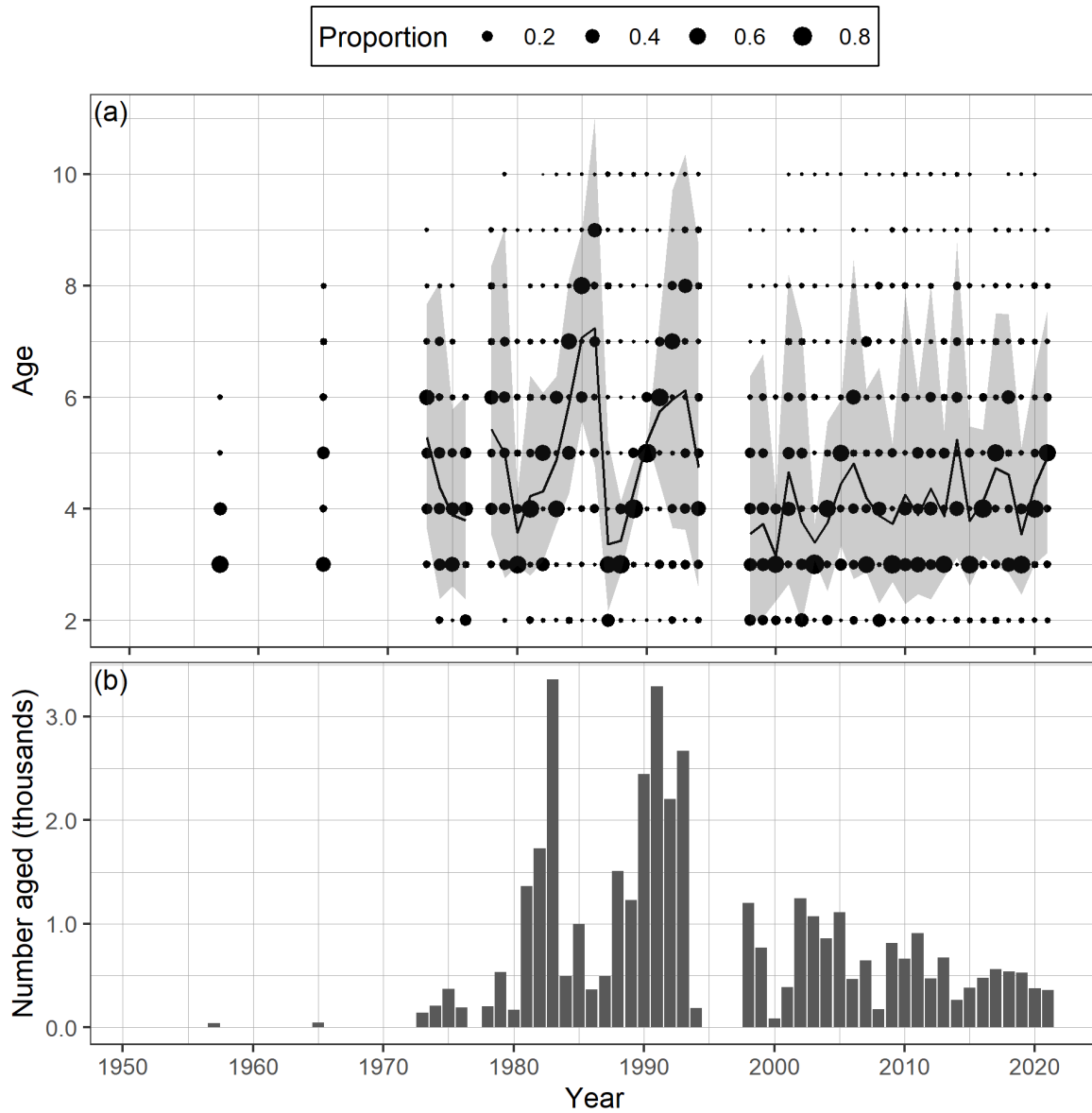


Figure 5. Time series of observed proportion-at-age (a) and number aged in thousands (b) of Pacific Herring from 1951 to 2021 in the Area 2 West minor stock assessment region (SAR). The black line is the mean age, and the shaded area is the approximate 90% distribution. Biological summaries only include 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.

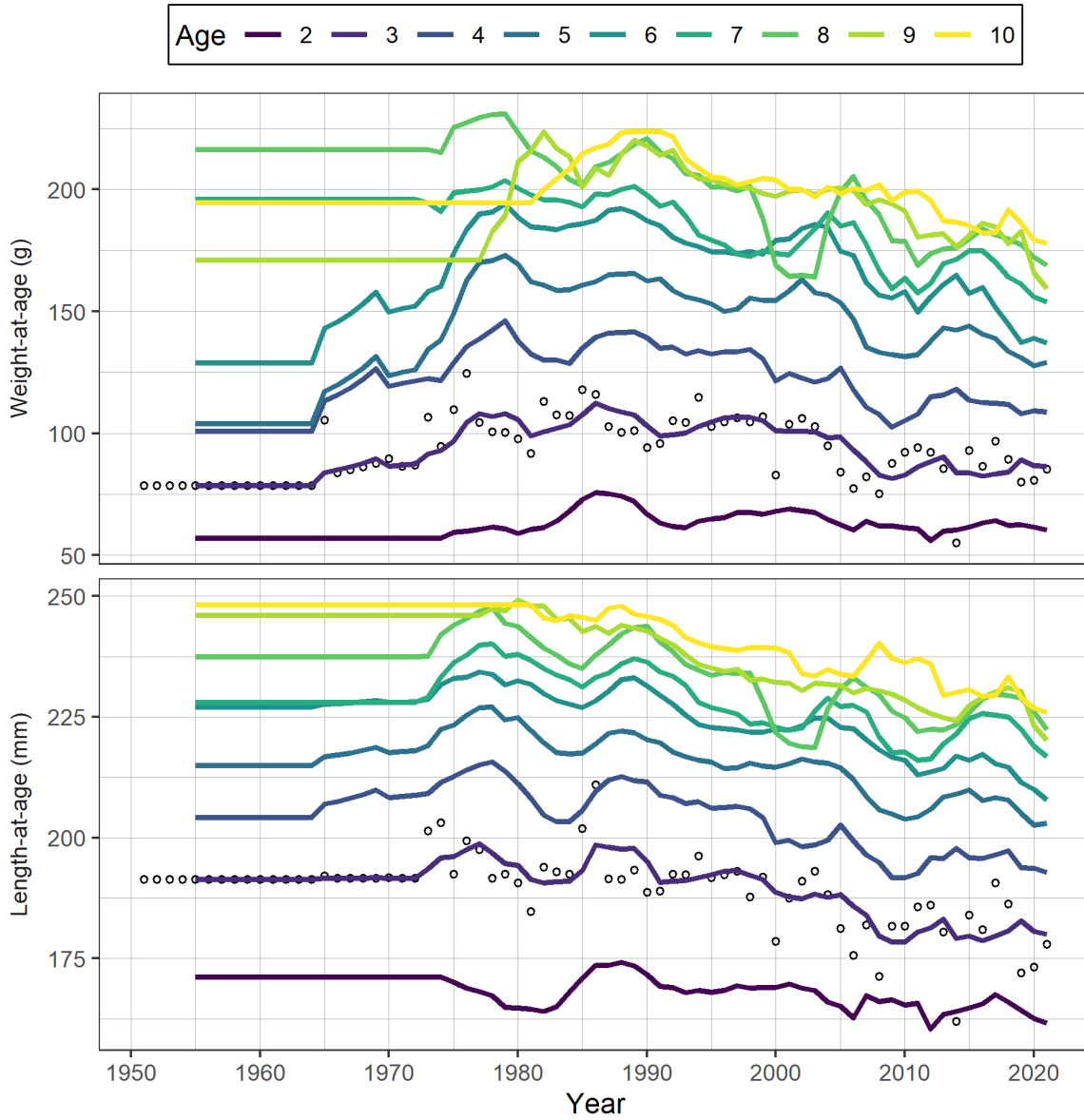


Figure 6. Time series of weight-at-age in grams (g) and length-at-age in millimetres (mm) for age-3 (circles) and 5-year running mean weight- and length-at-age (lines) for Pacific Herring from 1951 to 2021 in the Area 2 West minor stock assessment region (SAR). Missing weight- and length-at-age values (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.

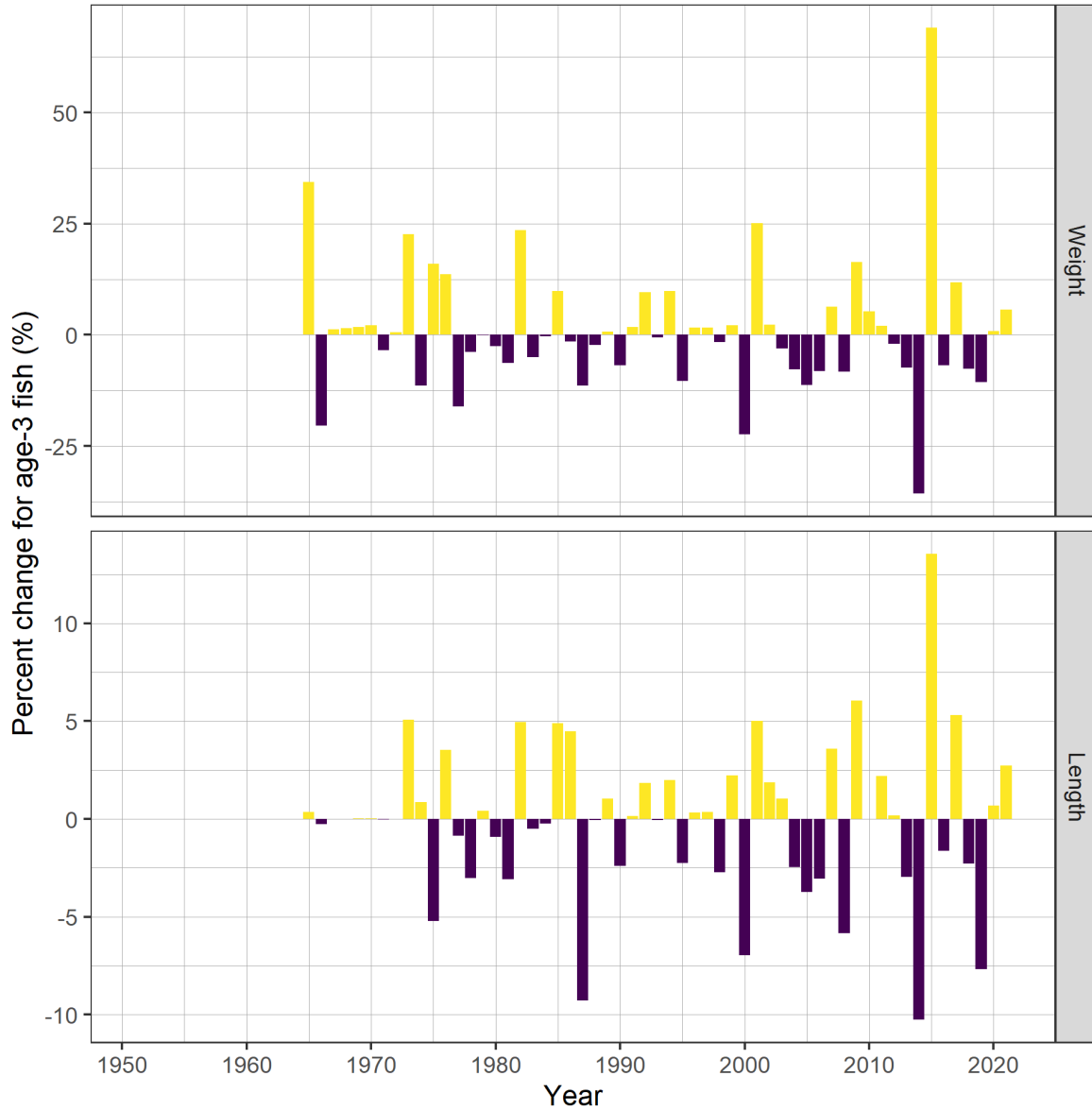


Figure 7. Time series of percent change (%) in weight and length for age-3 fish for Pacific Herring from 1951 to 2021 in the Area 2 West minor stock assessment region (SAR). Percent change is $\delta_t = \frac{\alpha_t - \alpha_{t-1}}{\alpha_{t-1}}$ where α_t is the weight and length of age-3 fish, respectively, 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.

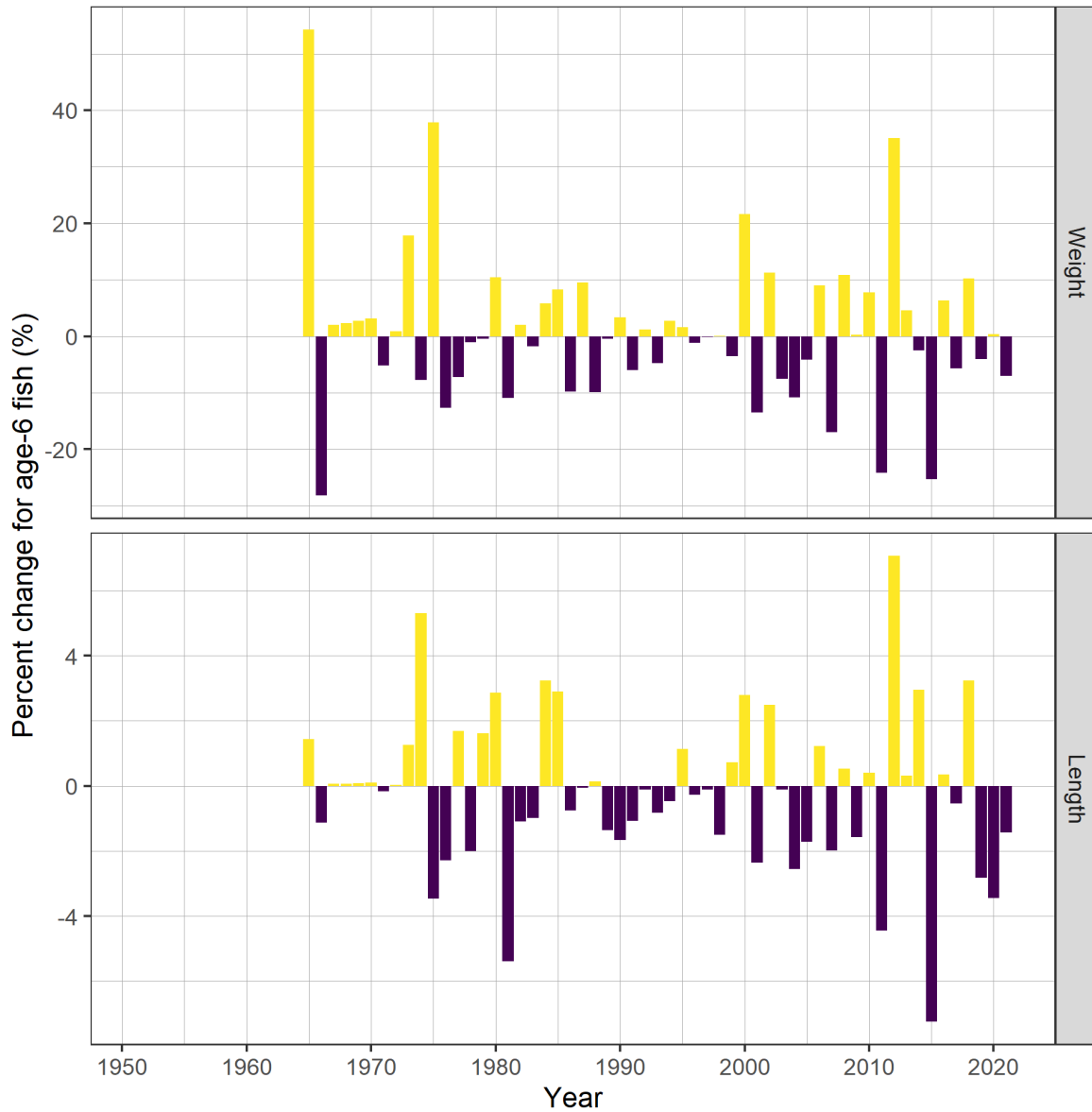


Figure 8. Time series of percent change (%) in weight and length for age-6 fish for Pacific Herring from 1951 to 2021 in the Area 2 West minor stock assessment region (SAR). Percent change is $\delta_t = \frac{\alpha_t - \alpha_{t-1}}{\alpha_{t-1}}$ where α_t is the weight and length of age-6 fish, respectively, 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.

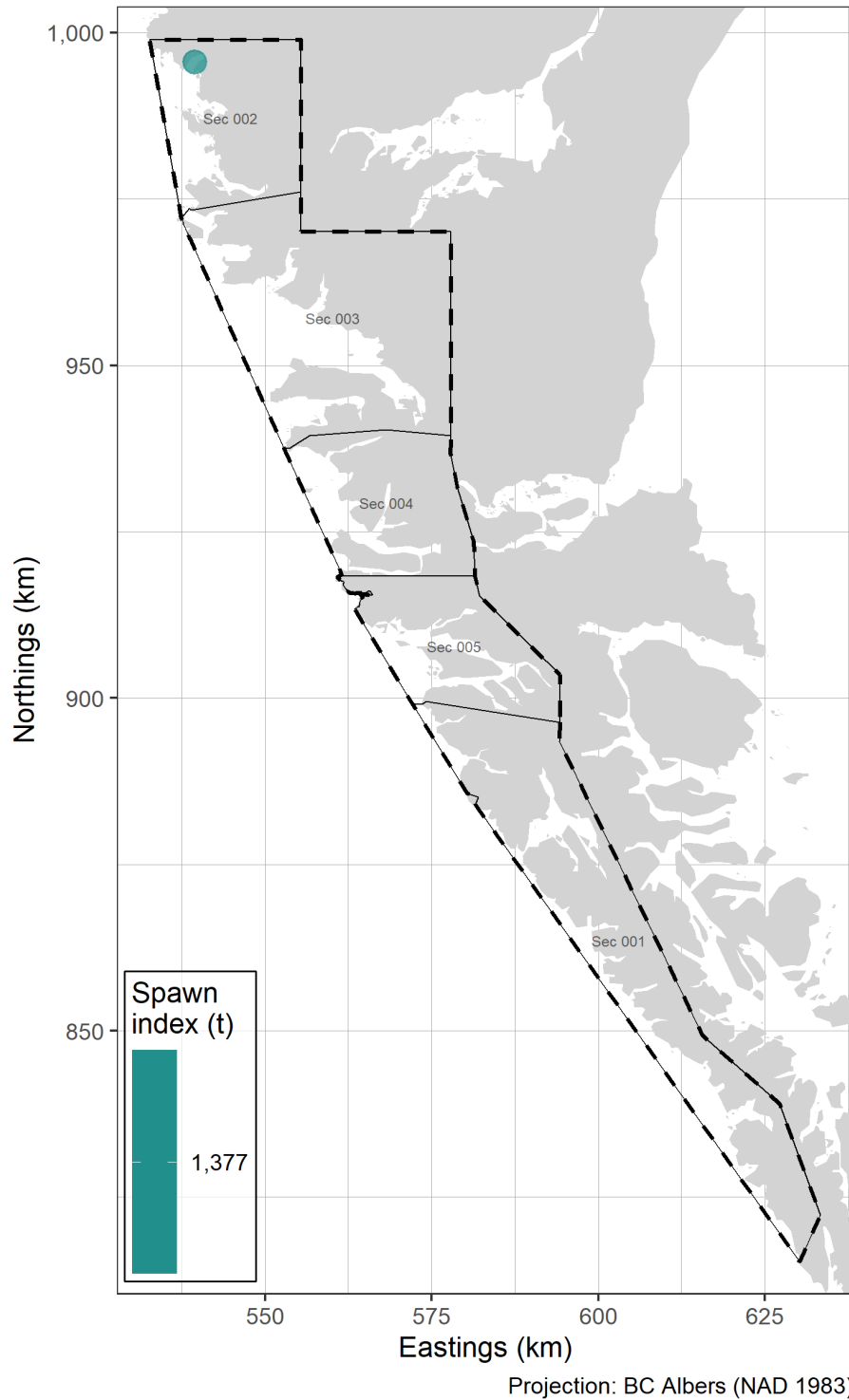


Figure 9. Pacific Herring spawn survey location, and spawn index in metric tonnes (t) in 2021 in the Area 2 West minor stock assessment region (SAR; thick dashed lines), and associated Sections (Sec; thin solid lines). The ‘spawn index’ is not scaled by the spawn survey scaling parameter, q . Missing spawn index values (grey circles) indicate incomplete spawn surveys. Units: kilometres (km).

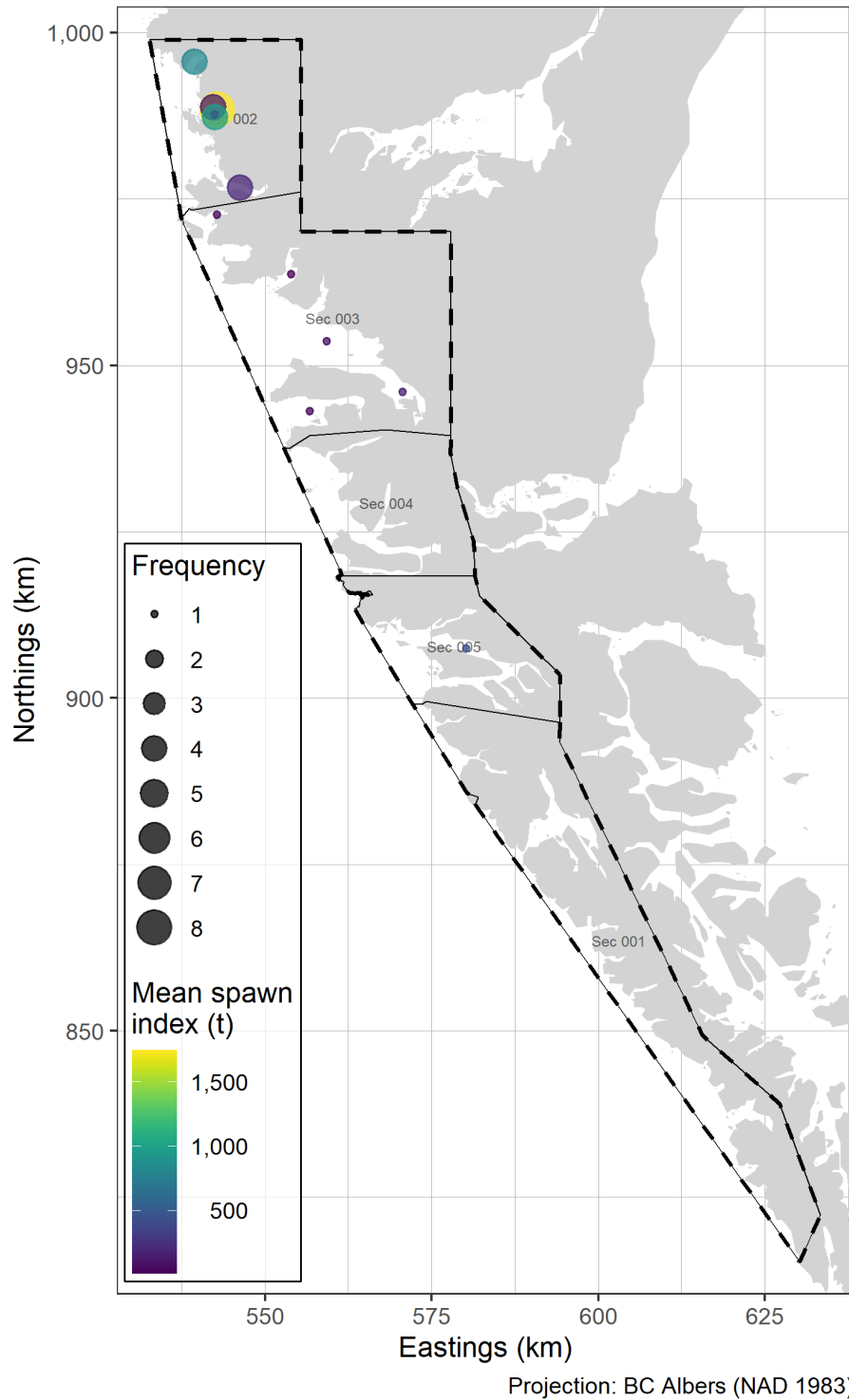


Figure 10. Pacific Herring spawn survey location, mean spawn index in metric tonnes (t), and spawn frequency from 2011 to 2020 in the Area 2 West minor stock assessment region (SAR; thick dashed lines), and associated Sections (Sec; thin solid lines). The ‘spawn index’ is not scaled by the spawn survey scaling parameter, q . Missing spawn index values (grey circles) indicate incomplete spawn surveys. Units: kilometres (km).

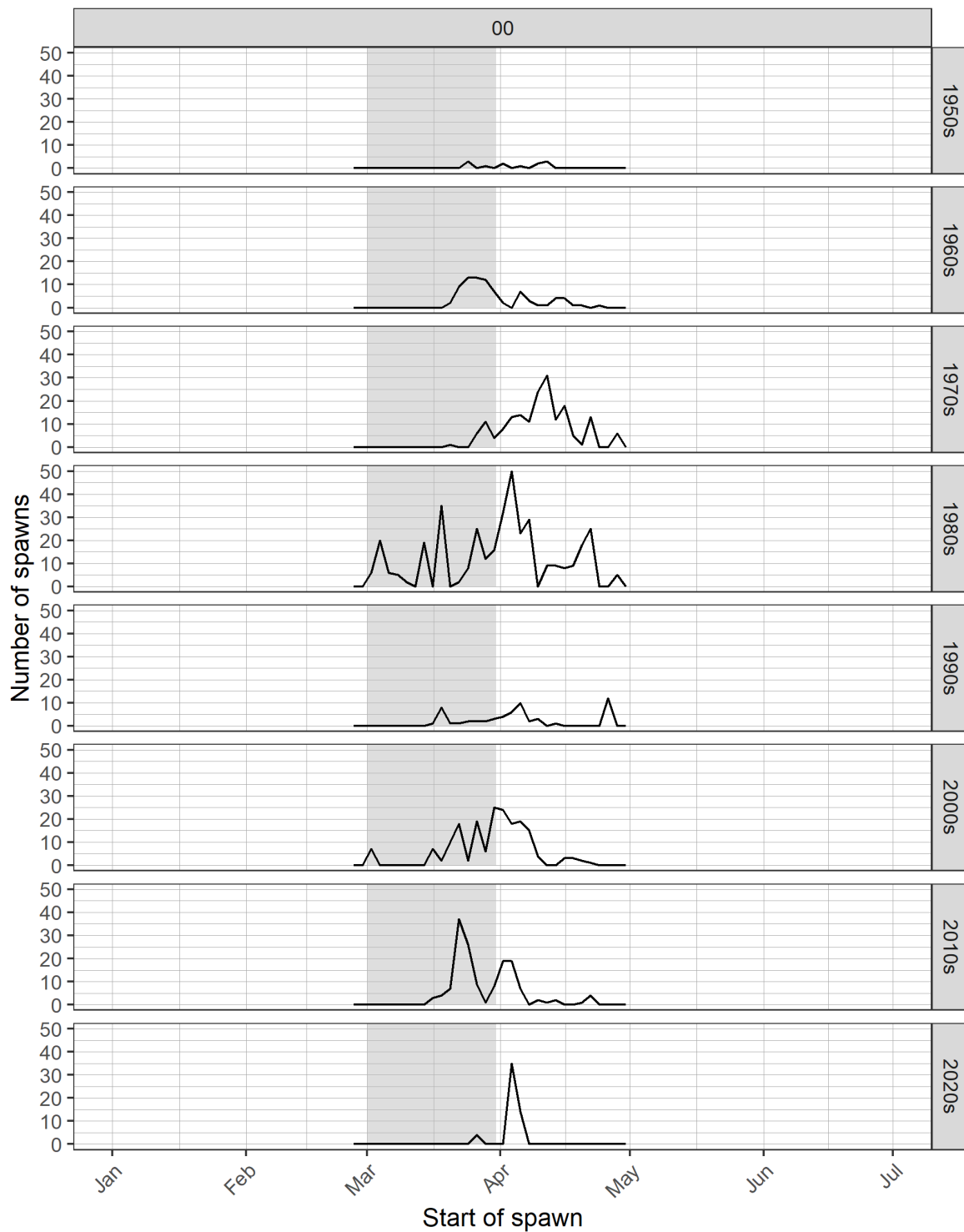


Figure 11. Pacific Herring spawn start date by decade and Statistical Area. Grey shaded regions indicate March 1st to 31st. Note that spawn size and intensity varies; therefore the number of spawns is not directly proportional to spawn extent or biomass.

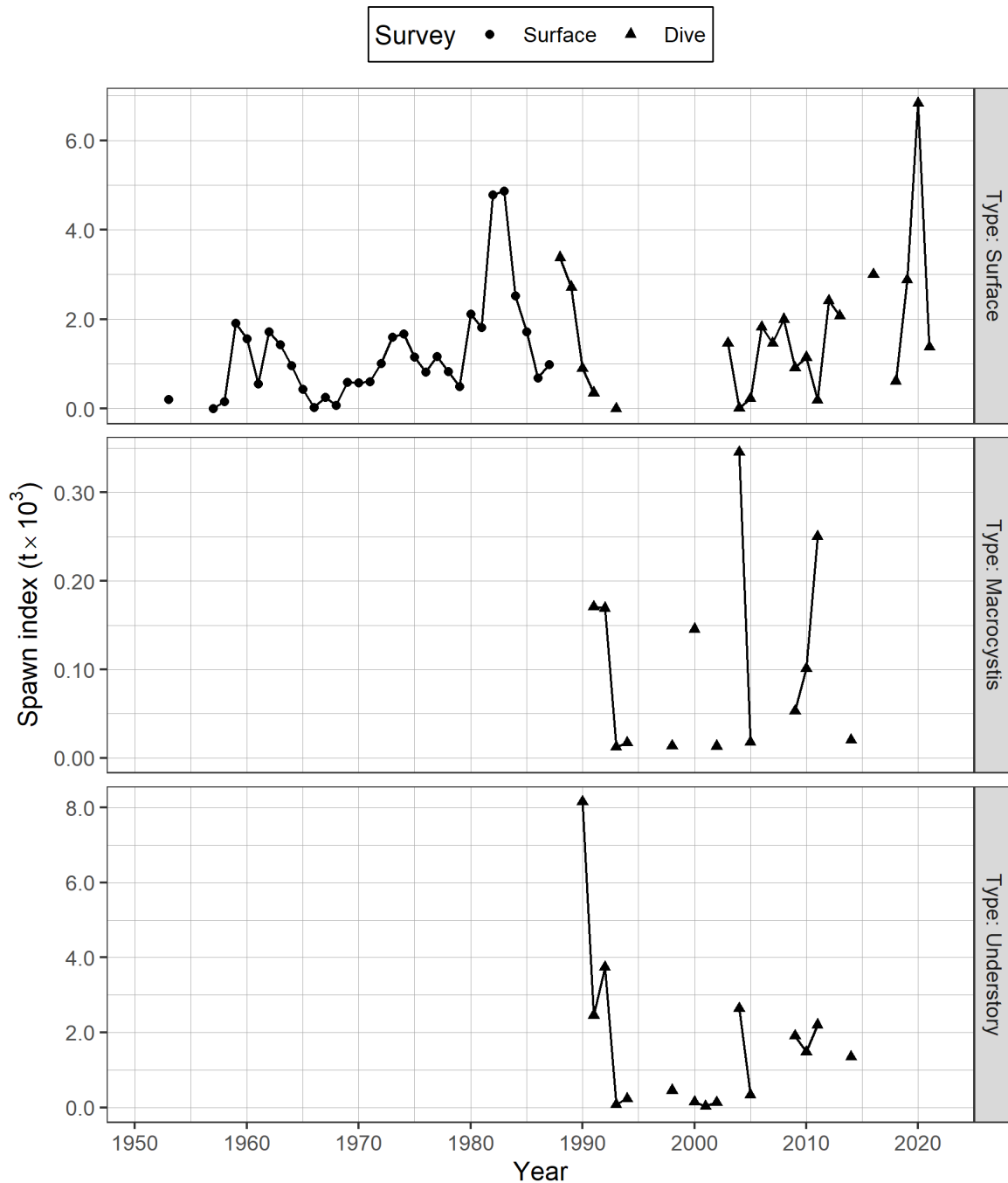


Figure 12. Time series of spawn index in thousands of metric tonnes ($t \times 10^3$) by type for Pacific Herring from 1951 to 2021 in the Area 2 West minor stock assessment region (SAR). There are three types of spawn survey observations: observations of spawn taken from the surface usually at low tide, underwater observations of spawn on giant kelp, *Macrocytistis* (*Macrocytistis* 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).

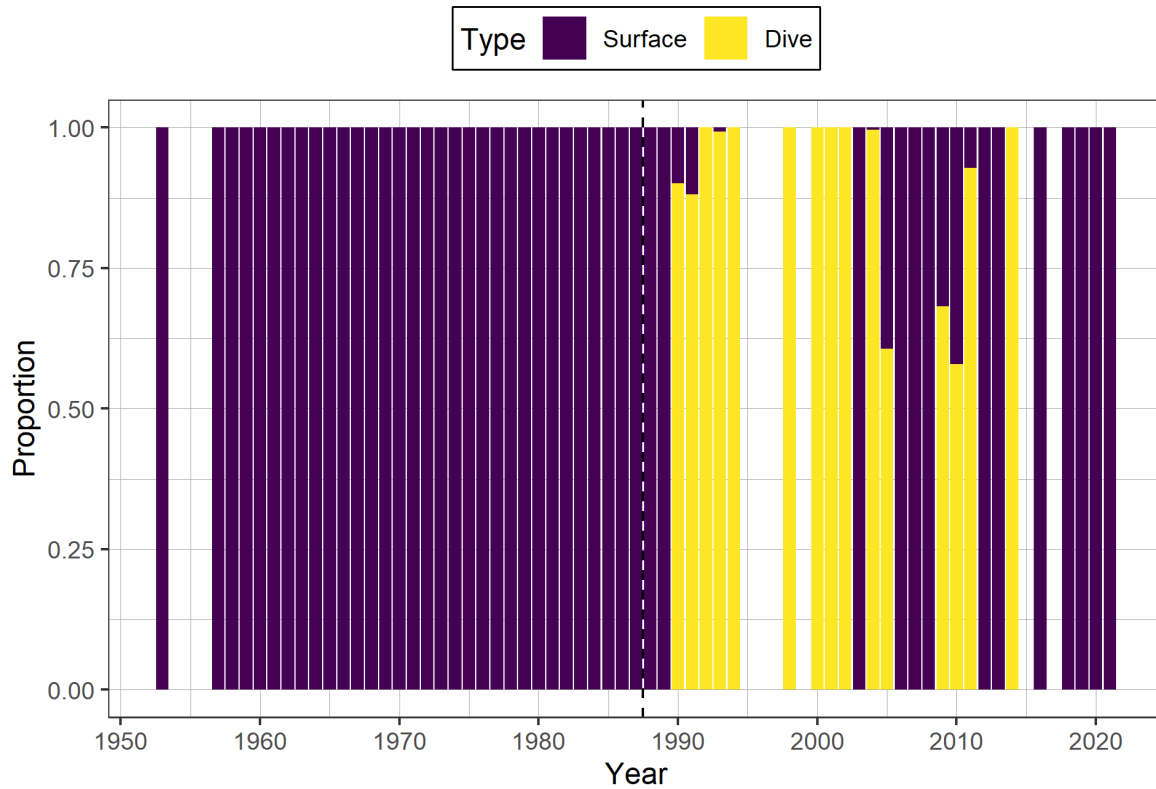


Figure 13. Time series of proportion of spawn index by surface and dive surveys for Pacific Herring from 1951 to 2021 in the Area 2 West minor stock assessment region (SAR). The spawn index has two distinct periods defined by the dominant coastwide survey method: surface surveys (1951 to 1987), and dive surveys (1988 to 2021).

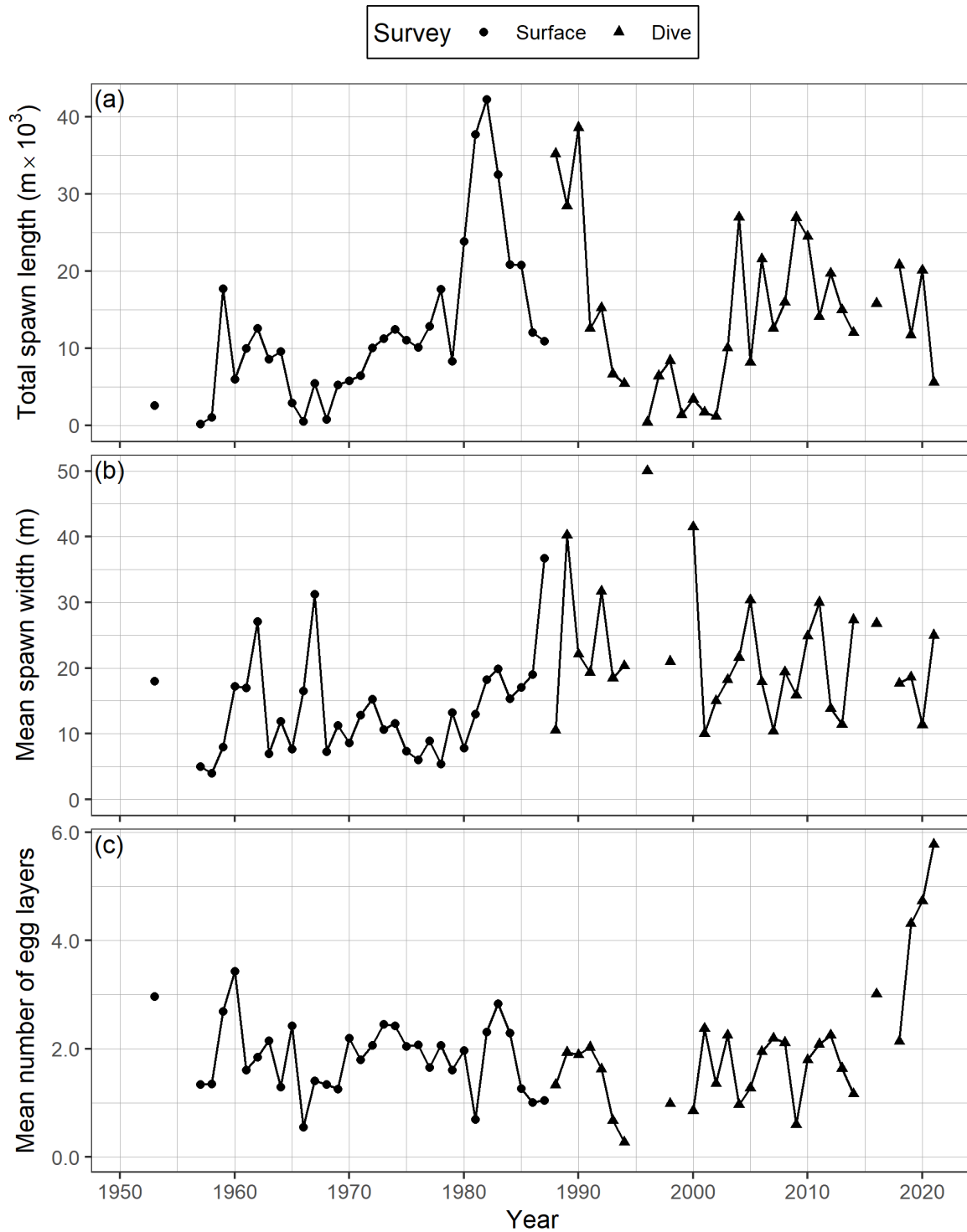


Figure 14. Time series of total spawn length in thousands of metres ($m \times 10^3$; panel a), mean spawn width in metres (b), and mean number of egg layers (c) for Pacific Herring from 1951 to 2021 in the Area 2 West minor stock assessment region (SAR). The spawn index has two distinct periods defined by the dominant coastwide survey method: surface surveys (1951 to 1987), and dive surveys (1988 to 2021).

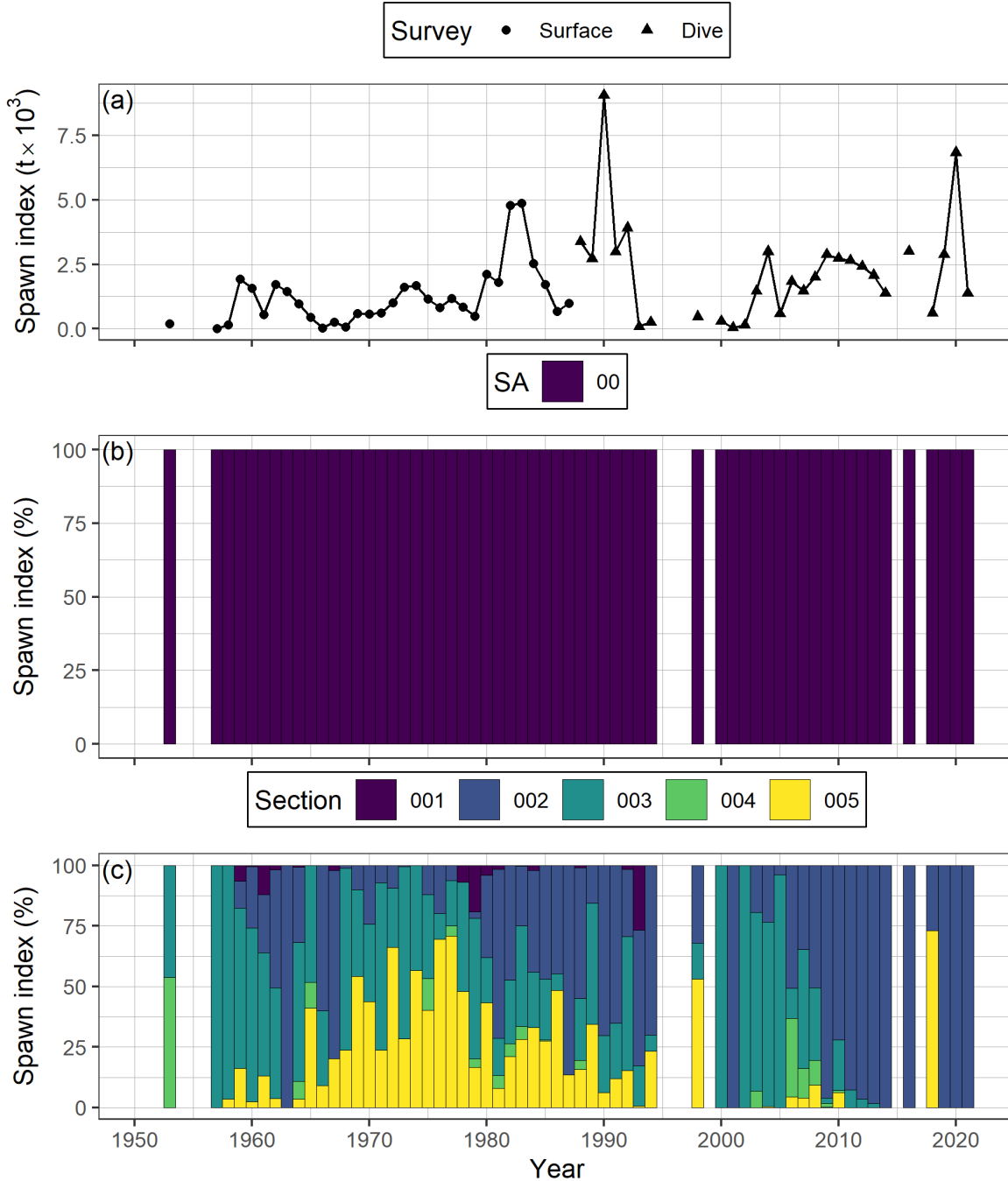


Figure 15. Time series of spawn index in thousands of metric tonnes ($t \times 10^3$) for Pacific Herring from 1951 to 2021 in the Area 2 West minor stock assessment region (SAR; panel a), as well as percent contributed by Statistical Area (SA), and Section (b, & c, respectively). The spawn index has 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 12 and 13). The ‘spawn index’ is not scaled by the spawn survey scaling parameter, q .

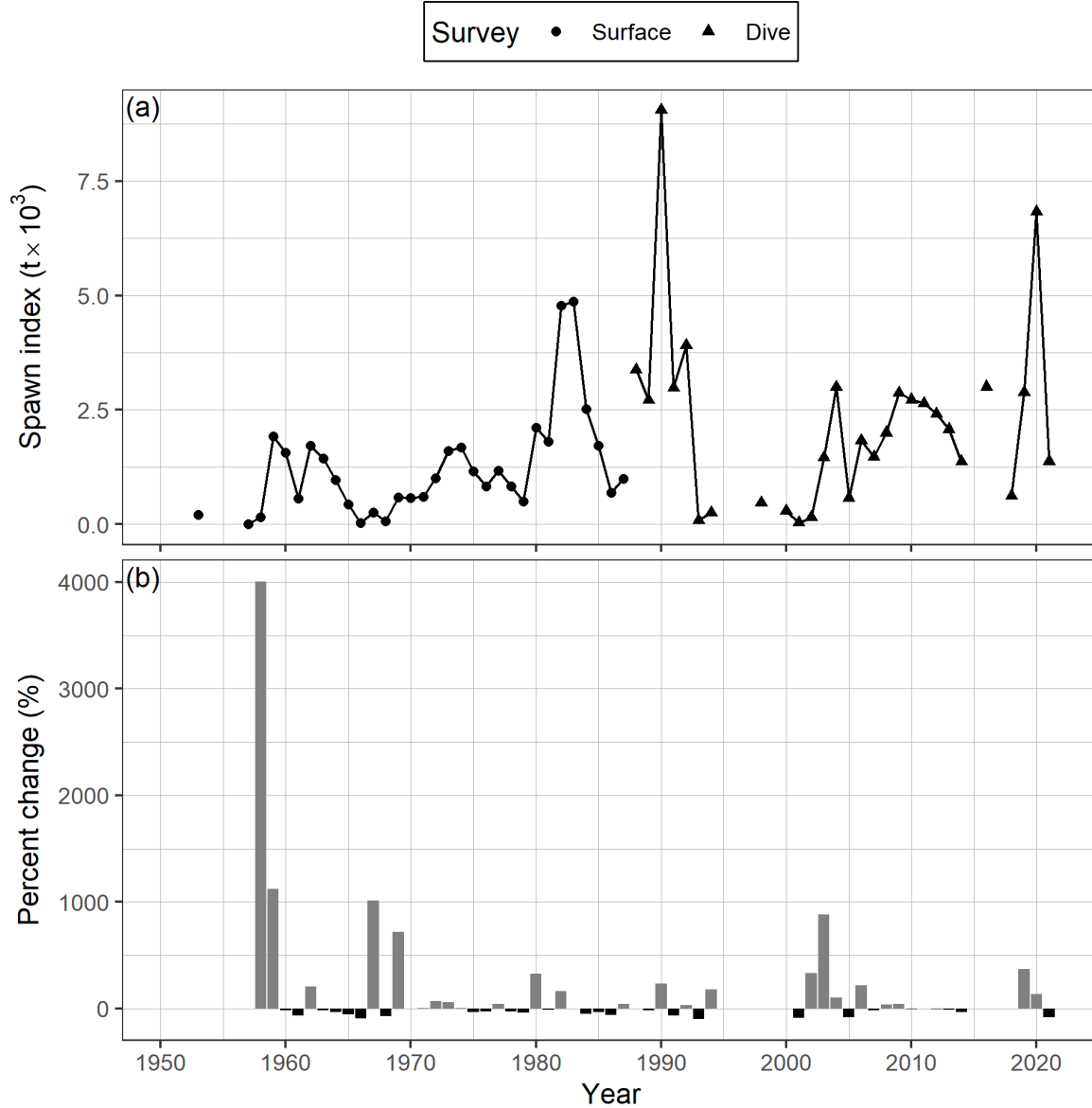


Figure 16. Time series of spawn index in thousands of metric tonnes ($t \times 10^3$) for Pacific Herring from 1951 to 2021 in the Area 2 West minor stock assessment region (SAR; panel a), and percent change (b). Percent change is $\delta_t = \frac{\alpha_t - \alpha_{t-1}}{\alpha_{t-1}}$ where α_t is 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 12 and 13).

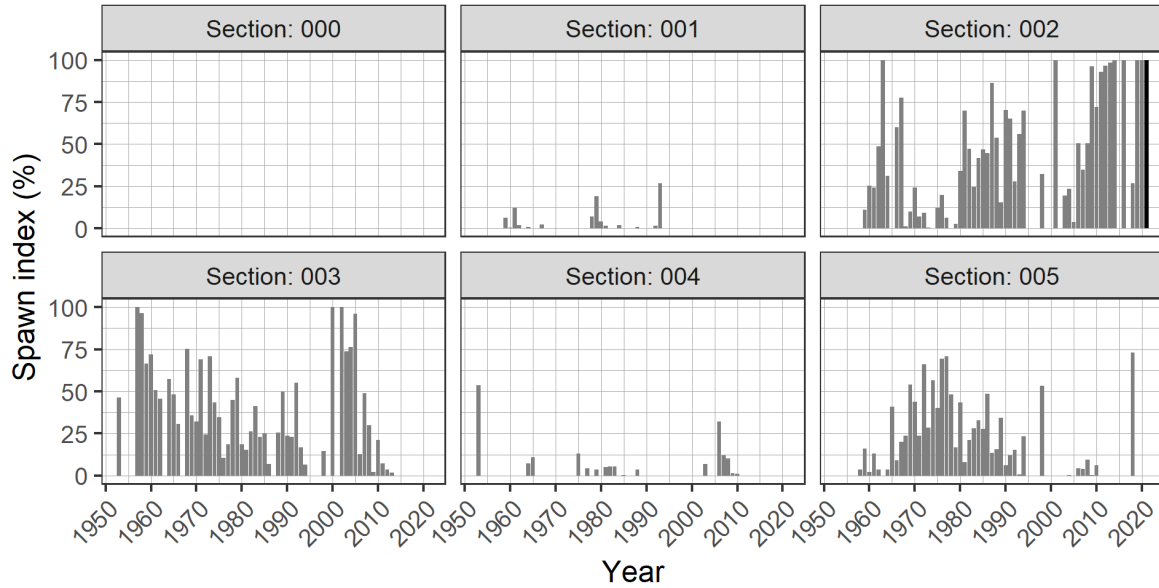


Figure 17. Time series of percent of spawn index by Section for Pacific Herring from 1951 to 2021 in the Area 2 West minor stock assessment region (SAR). The year 2021 has a darker bar to facilitate interpretation. The spawn index has two distinct periods defined by the dominant coastwide survey method: surface surveys (1951 to 1987), and dive surveys (1988 to 2021). The ‘spawn index’ is not scaled by the spawn survey scaling parameter, q .

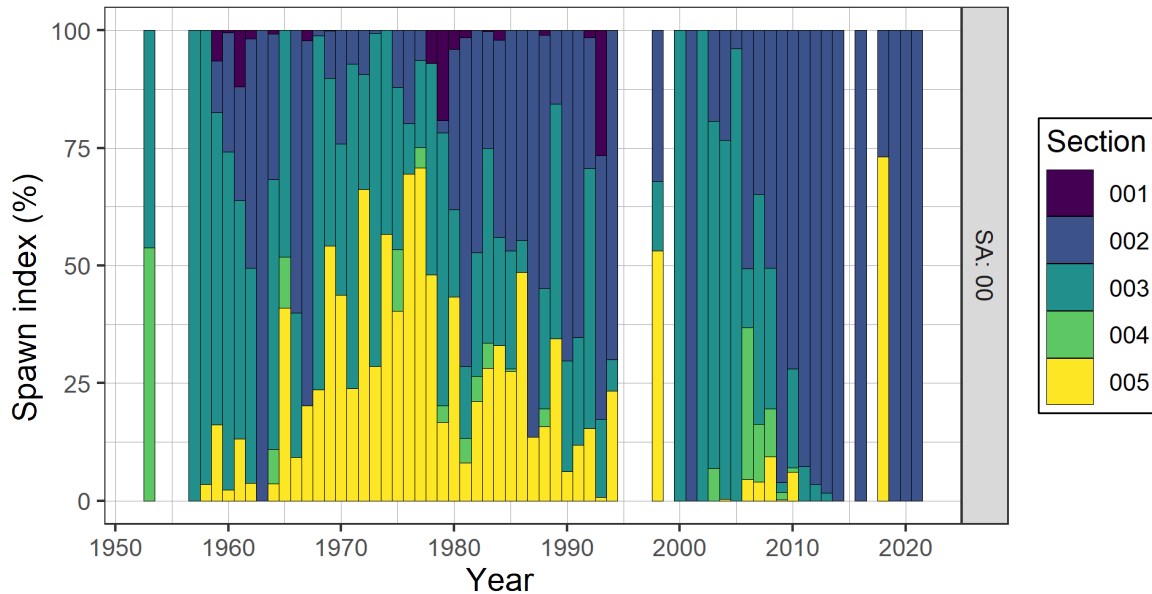


Figure 18. Time series of percent of spawn index by Statistical Area (SA) and Section for Pacific Herring from 1951 to 2021 in the Area 2 West minor stock assessment region (SAR). The spawn index has two distinct periods defined by the dominant coastwide survey method: surface surveys (1951 to 1987), and dive surveys (1988 to 2021). The ‘spawn index’ is not scaled by the spawn survey scaling parameter, q .

Figure 19. Animation of Pacific Herring spawn index in metric tonnes (t) by Location from 1951 to 2021 in the Area 2 West minor 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 PDF, open it with Adobe, enable JavaScript, and click the “play” button.