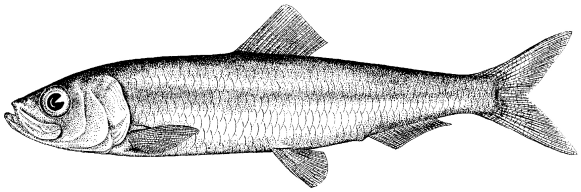
Pacific Herring preliminary data summary for Central Coast 2020

Jaclyn Cleary* Matthew Grinnell†

September 21, 2020



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

Disclaimer This report contains preliminary data collected for Pacific Herring in 2020 in the Central Coast major stock assessment regions (SAR). These data may differ from data used and presented in the final stock assessment.

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1 COVID-19 pandemic

The COVID-19 pandemic impacted our ability to collect and analyse Pacific Herring data throughout British Columbia in 2020. The pandemic and associated provincial response changed rapidly during the Pacific Herring field program season. Despite these challenges, surveyors assessed all major observed spawns in the 5 major stock assessment regions (SARs). However, these changes impacted our ability to assess spawn in SARs with later spawns more than SARs with earlier spawns. For example, spawns were surveyed by surface surveys instead of underwater dive surveys in Prince Rupert District and Haida Gwaii.

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

Although Pacific Herring biological samples were collected as usual, the pandemic delayed the analysis of biological data for all SARs. This delay is most notable for age data which are analysed at the sclerochronology lab at the Pacific Biological Station. This lab closed on March 16th, and resumed limited ageing analysis on July 6th. This has resulted in delayed provision of age data for Pacific Herring and many other species. To address this backlog efficiently, senior science staff and fisheries managers at DFO prioritized species to analyse in the sclerochronology lab.

We now have biological data for Pacific Herring in 2020. This updated version of the report contains biological data that was absent from the previous version. We appreciate your patience and understanding as we continue to work from home in these uncertain and changing times.

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 2020. 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 2020 in the Central Coast 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). For the Central Coast major SAR, we use another level of spatial aggregation which we refer to as a 'Group'. Note that we refer to 'year' instead of 'herring season' in this report; therefore 2020 refers to the 2019/2020 Pacific Herring season.

3 Data collection programs

The data collection program in the Central Coast reflected a number of collaborations between DFO, the Heiltsuk Nation, and the Herring Industry. Biological samples were collected by the seine test charter vessel "Windward Isle" for 22 days from March 14th to April 4th. The primary purpose of the test charter vessel was to collect biological samples from main bodies of herring in Statistical Areas 06, 07, and 08, identified from soundings. Due to COVID-19, no nearshore cast net herring samples were collected by Heiltsuk or Kitasoo in 2020.

Herring spawn locations were primarily identified with fixed-wing overflights conducted by DFO Resource Management Area staff. Four spawn flights were conducted this season, in late March and early April. Two dive charter vessels operated in the CC:

- The "Pachena No.1" surveyed 17 days from April 2nd to April 18th, and
- The "Ocean Cloud" surveyed 17 days from March 27th to April 12th.

Three gillnet sounding vessels were operated by the Heiltsuk Nation this season: two primarily in Statistical Area 07, and one primarily in Statistical Area 08 to assist in locating fish for spawn on kelp (SOK) operations.

3.1 Biological samples in Statistical Area 08

In the Central Coast major SAR, Pacific Herring in Statistical Area (SA) 08 tend to be smaller than fish in other areas. In addition, fewer biological samples are typically collected from SA 08 compared to the other areas. For example, between 1994 and 2013, on average $\sim 7\%$ of biological samples came from SA 08. In 2014 and 2015, additional resources were available to collect biological samples in SA 08, which consequently received more sampling effort than previous years, compared to the other areas. In order to avoid using non-representative biological data in the Central Coast stock assessment model, biological samples from SA 08 in 2014 and 2015 are weighted by the average historic proportion of samples in that area (i.e., $\sim 7\%$). Biological data presented in this report (e.g., proportion-at-age, weight-at-age) reflect these weights, and are considered to be representative of the Central Coast major SAR.

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 2020 in the Central Coast 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 2020, 12 Pacific Herring biological samples were collected and processed for the Central Coast major SAR (Table 5, Table 6), and a total of 1,084 Pacific Herring were

aged in 2020. 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). Some Statistical Areas tend to have larger fish at a given age (Figure 9, Table 8). 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 50 individual locations in 2020 in the Central Coast major SAR (Table 9, and Figure 10). A summary of spawn from the last decade (2010 to 2019) 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 10, and Figure 17). See the draft spawn index technical report for calculations to convert SOK harvest to spawning biomass. In addition, spawn surveys estimate spawn depth by Statistical Area, and Section (Figure 18). 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 2020).

Some Pacific Herring Sections contribute more than others to the total spawn index, and the percentage contributed by Section varies yearly (Figure 16b, Figure 19). For example, in 2020, Section 067 contributed the most to the spawn index (42%). As with Sections, some Statistical Areas contribute more than others to the total spawn index (Figure 16c, Figure 20). An animation shows the spawn index by spawn survey location from 1951 to 2020 (Figure 21).

6 General observations

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

- As planned, two dive charters did the spawn survey this year.
- The Heiltsuk First Nation made the difficult decision to cancel their commercial SOK fishery due to COVID-19 concerns; FSC fisheries proceeded. The Kitasoo Xai'xais commercial SOK fishery proceeded and successful FSC fisheries were also reported.

- Because of limited overflights, dive boats spent a lot of time searching for spawn. A small boat charter to map spawn at low tide, as in Haida Gwaii, is recommended for future surveys.
- Overall it seemed like more spawn year than last year.
- Spawn was broadly distributed throughout the area, and all observed spawns were surveyed. However, some deep spawn in upper Spiller Channel may have been missed.
- Spawn quality in several areas was very good, and was similar to last year. For example, divers reported over a dozen layers of eggs, and spawn at depths beyond where the divers can survey.
- There was spawn in areas that had not spawned much or at all in recent years, such as Stryker Bay, Thompson Bay, and Weeteeum Bay.
- Other areas did not receive a lot of spawn like they did last year, for example Norman Morison Bay.
- The fish seemed to hold a long time and were not in a hurry to spawn.
- Macrocystis abundance seemed low this year compared to previous years.
- There was a little more wildlife activity (such as Humpback Whales and sea lions) than last season.

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, Sections, and Groups for Pacific Herring in the Central Coast major stock assessment region (SAR). Legend: '06&07' is Statistical Areas 06 and 07; and '08' is Statistical Area 08.

Region	Statistical Area	Section	Group
Central Coast	06	067	06&07
Central Coast	07	070	06&07
Central Coast	07	071	06&07
Central Coast	07	072	06&07
Central Coast	07	073	06&07
Central Coast	07	074	06&07
Central Coast	07	075	06&07
Central Coast	07	076	06&07
Central Coast	07	077	06&07
Central Coast	07	078	06&07
Central Coast	07	079	NA
Central Coast	08	085	08
Central Coast	08	086	08

Table 3. Total landed commercial catch of Pacific Herring in metric tonnes (t) by gear type in 2020 in the Central Coast 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 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 2010 to 2020 in the Central Coast major stock assessment region (SAR). See the draft spawn index technical report for calculations to convert SOK harvest to spawning biomass. Harvest does not include the 2,411 lbs of spawn on egregia in 2018. Note: data may be withheld due to privacy concerns (WP).

Year	Harvest (lb)	Spawning biomass (t)
2010	0	0
2011	0	0
2012	0	0
2013	0	0
2014	239,861	355
2015	169,470	251
2016	351,953	521
2017	392,747	582
2018	286,109	424
2019	356,042	528
2020	44,857	66

Table 5. Number of Pacific Herring biological samples processed from 2010 to 2020 in the Central Coast major stock assessment region (SAR). Each sample is approximately 100 fish.

	Number of samples		
Year	Commercial	Test	Total
2010	0	26	26
2011	0	30	30
2012	0	24	24
2013	0	15	15
2014	14	12	26
2015	6	14	20
2016	5	15	20
2017	4	40	44
2018	4	30	34
2019	2	38	40
2020	0	12	12

Table 6. Number and type of Pacific Herring biological samples processed in 2020 in the Central Coast major stock assessment region (SAR). Each sample is approximately 100 fish.

Type	Gear	Use	Number of samples
Test	Seine	Test fishery	12

Table 7. Observed proportion-at-age for Pacific Herring from 2010 to 2020 in the Central Coast 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
2010	0.017	0.157	0.650	0.054	0.077	0.021	0.021	0.001	0.002
2011	0.045	0.491	0.154	0.243	0.031	0.023	0.007	0.006	0.001
2012	0.077	0.106	0.484	0.119	0.167	0.024	0.016	0.005	0.003
2013	0.026	0.480	0.129	0.243	0.056	0.057	0.004	0.003	0.001
2014	0.095	0.146	0.467	0.089	0.141	0.028	0.029	0.004	0.000
2015	0.008	0.454	0.156	0.249	0.055	0.064	0.009	0.004	0.001
2016	0.040	0.091	0.549	0.094	0.146	0.028	0.039	0.011	0.003
2017	0.029	0.170	0.132	0.446	0.089	0.092	0.024	0.012	0.007
2018	0.090	0.168	0.174	0.147	0.295	0.066	0.041	0.014	0.005
2019	0.012	0.616	0.178	0.053	0.053	0.059	0.024	0.002	0.002
2020	0.028	0.028	0.739	0.101	0.045	0.029	0.021	0.007	0.002

Table 8. Sample size for Pacific Herring weight-at-age analysis in 2020 in the Central Coast major stock assessment region (SAR) by Group from the most recent decade (2011 to 2020), and the previous decade (2001 to 2010), as displayed in Figure 9. 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. Legend: '06&07' is Statistical Areas 06 and 07; and '08' is Statistical Area 08.

		Sample size	
Group	Age	Previous decade	Recent decade
06&07	2	958	475
06&07	3	10,013	3,492
06&07	4	11,206	4,013
06&07	5	5,949	2,641
06&07	6	3,998	1,439
06&07	7	2,771	599
06&07	8	1,279	265
06&07	9	416	97
06&07	10	141	35
08	2	71	307
08	3	851	1,004
08	4	1,021	846
08	5	393	285
08	6	236	192
08	7	178	74
08	8	65	30
08	9	11	9
08	10	6	4

Table 9. Pacific Herring spawn survey locations, start date, and spawn index in metric tonnes (t) in 2020 in the Central Coast 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)
06	067	Abrams Is	March 26	127
06	067	Clifford Bay	April 02	19
06	067	Kwakwa Cr	March 27	3,759
06	067	Marvin Is	March 26	1,364
06	067	Meyers Nrws	April 02	1,328
06	067	Osment Inlt	March 27	3,792
06	067	Parsons Anch	March 26	2,670
06	067	Weeteeam Bay	March 31	1,522
06	067	Wilby Pt	March 26	2,028
06	067	Wingate Pt	March 30	1,215
07	072	Balagny Pass	March 27	117
07	072	Berry Inlt	March 27	300
07	072	Bird Pt	March 29	28
07	072	Blair Inlt	March 27	418
07	072	Bullen Rk	March 27	291
07	072	Bush Pt	March 27	701
07	072	Don Lgn +	March 27	1,469
07	072	Fisher Pt	March 30	122
07	072	Foote Islets	March 27	43
07	072	Mosquito Bay	March 27	1,970
07	072	Mouat Cv	March 27	334
07	072	Port Blackney	March 27	118
07	072	Powell Anch	March 27	47
07	072	Shingle Rk	March 27	310
07	072	Spiller Chnl	March 27	2,374
07	072	Tankeeah River	March 27	685
07	073	Troup Psg	April 07	48
07	074	Ardmillan Bay	March 31	278
07	074	Boddy Pass Nrws	March 21	873
07	074	Cree Pt	March 20	159
07	074	Kynumpt Hrbr	March 31	1,382
07	074	Little Thompson Bay	March 20	581
07	074	Norman Morrison Bay	March 23	157
07	074	Odin Cv	March 31	136
07	074	Ormidale Hrbr	March 31	1,024
07	074	Potts Is	March 20	942
07	074	Princess Alice Is	March 20	474
07	074	Quinoot Pt	March 21	3,752

Table 9 continued

Statistical Area	Section	Location name	Start date	Spawn index (t)
07	074	Stryker Bay	March 31	3,060
07	074	Waskesiu Pass	March 18	61
07	078	Kynoch Inlt	April 09	111
07	078	Neekas Inlt	March 27	1,114
08	085	Keith Anch	March 22	369
08	085	Koeye Pt	March 30	7
08	085	Kwakume Pt	March 30	180
08	085	Whidbey Pt	March 30	96
08	086	Hergest Pt	April 04	200
08	086	Mustang Bay	April 04	100
08	086	Target Bay	April 04	232
08	086	Warrior Cv	March 22	229

Table 10. Summary of Pacific Herring spawn survey data from 2010 to 2020 in the Central Coast 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 2020). 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)
2010	86,490	43	0.6	8,671
2011	137,530	25	0.8	10,534
2012	127,632	28	0.5	7,592
2013	158,205	34	0.9	20,369
2014	160,450	38	0.7	13,309
2015	167,060	39	1.3	32,146
2016	164,575	40	1.6	32,508
2017	125,525	39	1.5	23,517
2018	98,149	25	1.1	12,264
2019	181,750	38	1.8	46,255
2020	160,625	39	2.0	42,713

8 Figures

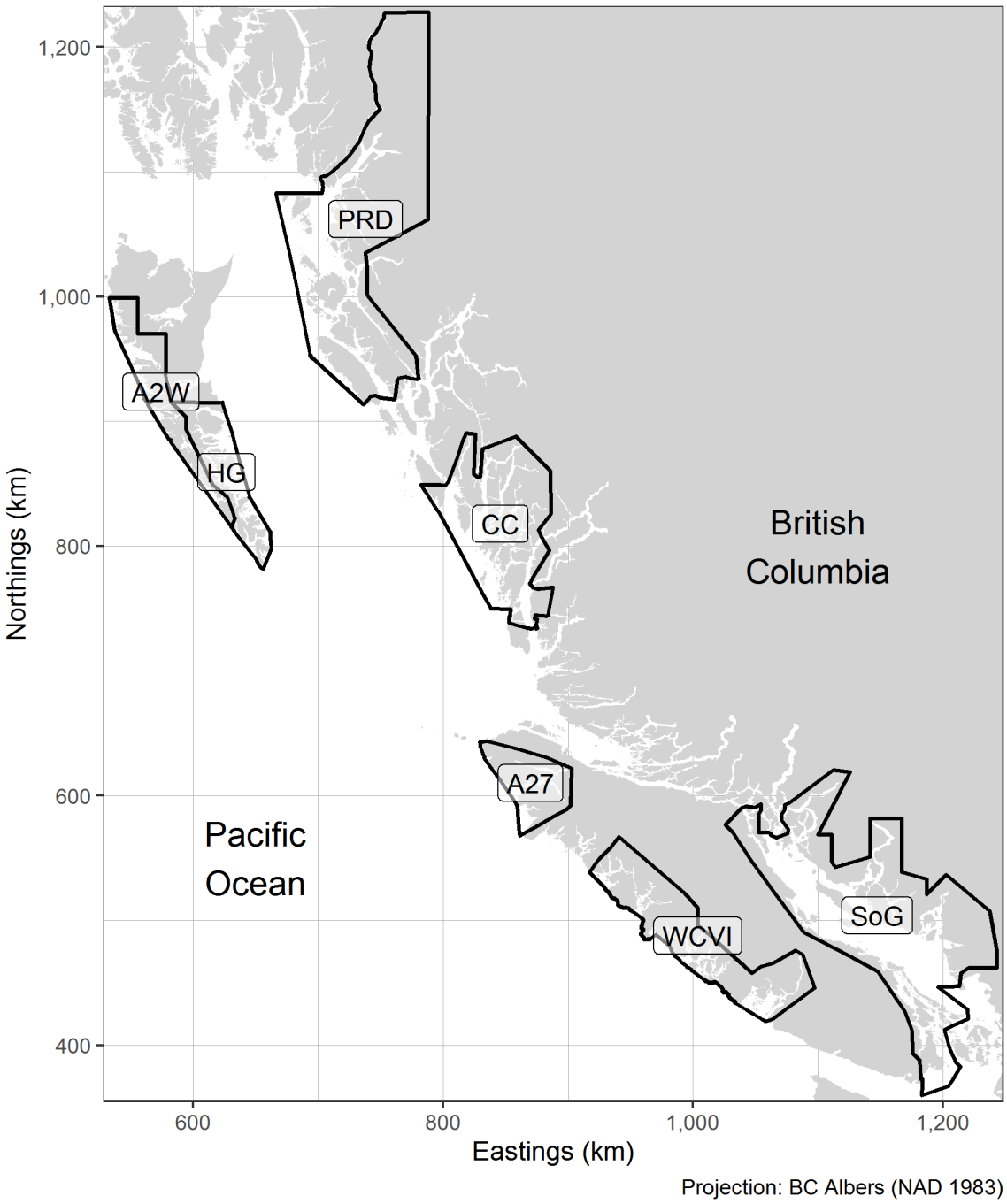

Figure 1. Boundaries for the Pacific Herring stock assessment regions (SARs) in British Columbia. There are 5 major SARs: Haida Gwaii (HG), Prince Rupert District (PRD), Central Coast (CC), Strait of Georgia (SoG), and West Coast of Vancouver Island (WCVI). There are 2 minor SARs: Area 27 (A27) and Area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

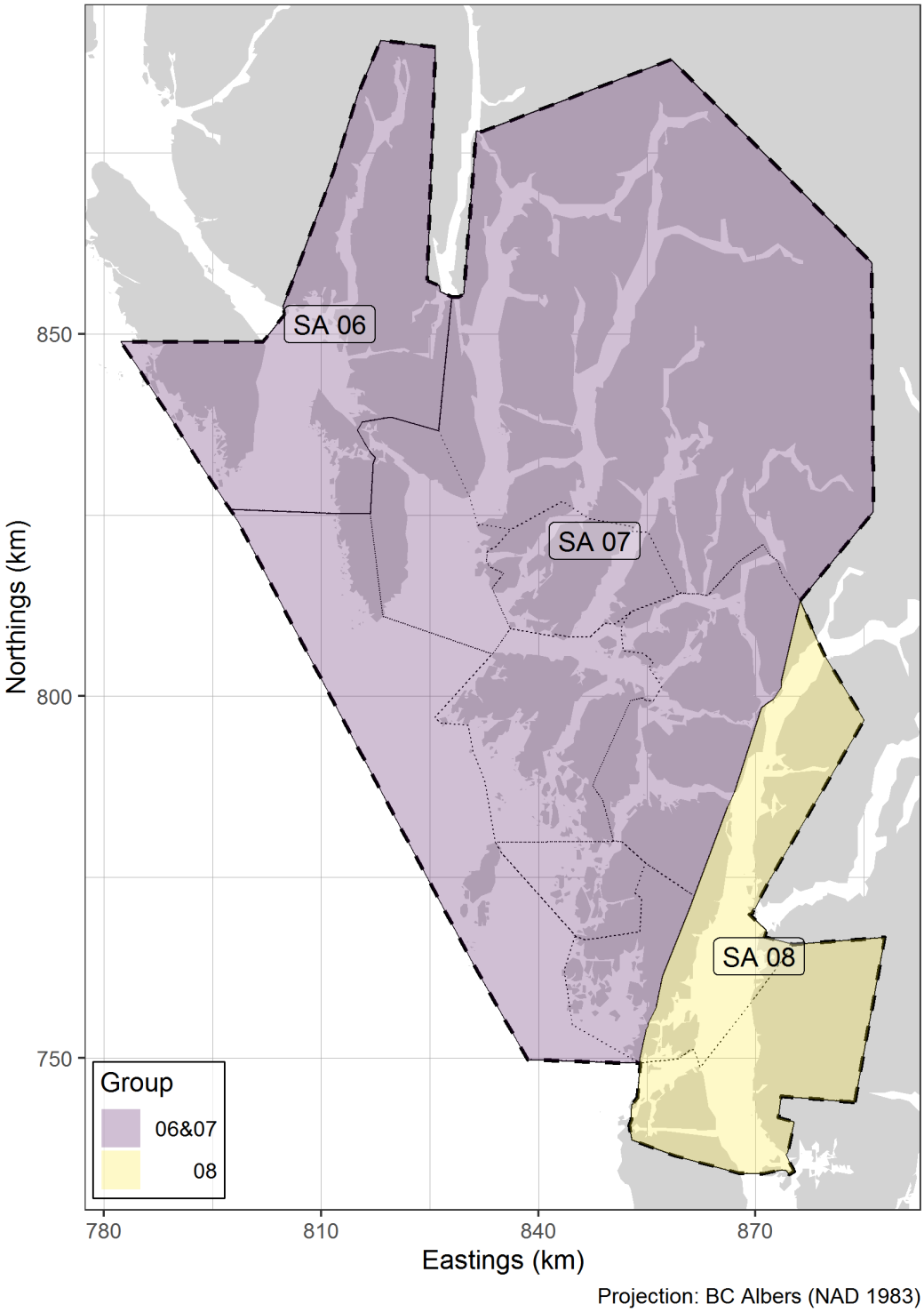

Figure 2. Boundaries for the Central Coast major stock assessment region (SAR; thick dashed lines), associated Statistical Areas (SA; thin solid lines), and associated Sections (thin dotted lines). Units: kilometres (km). Legend: '06&07' is Statistical Areas 06 and 07; and '08' is Statistical Area 08.

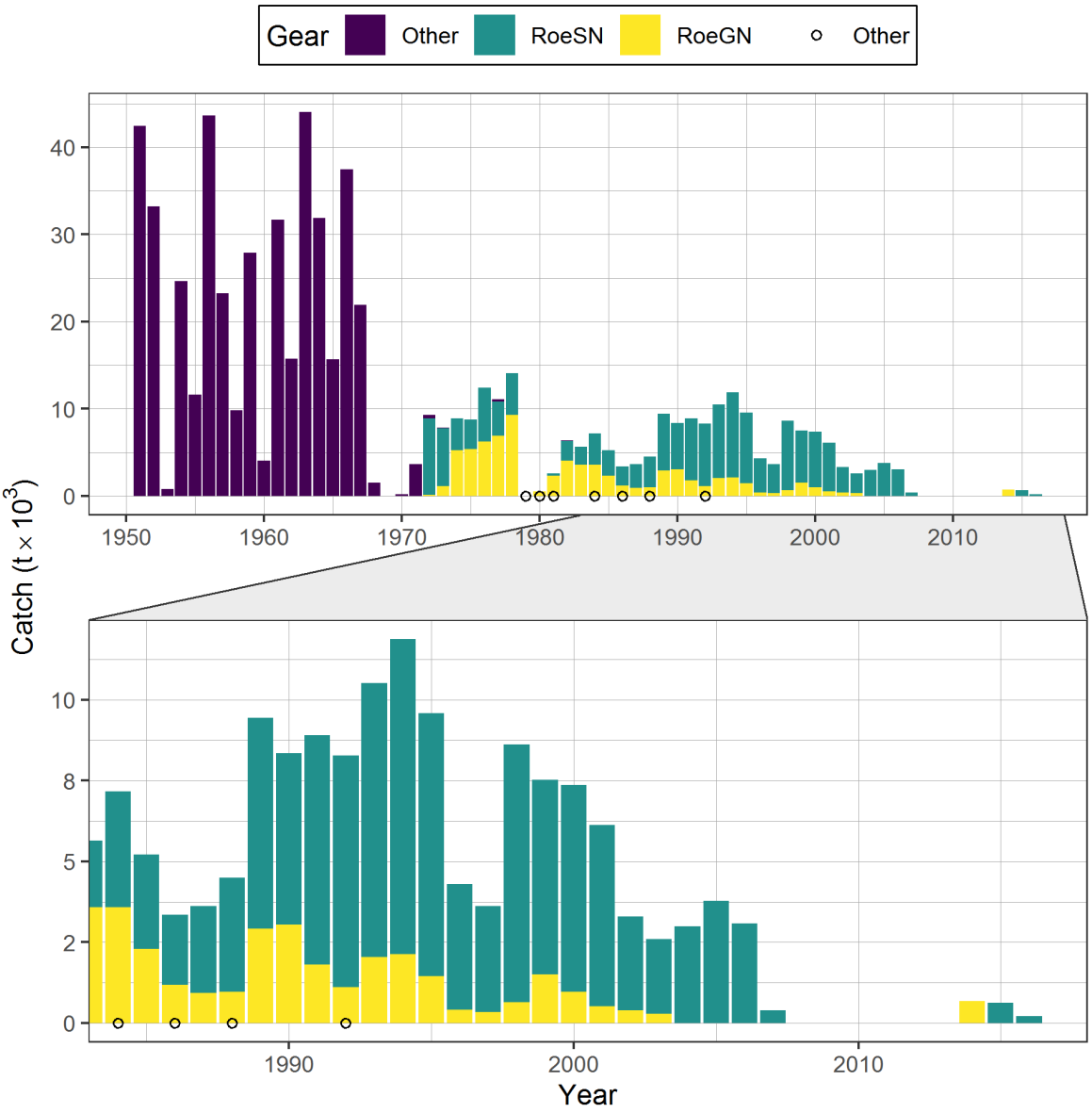

Figure 3. Time series of total landed catch in thousands of metric tonnes ($t \times 10^3$) of Pacific Herring by gear type from 1951 to 2020 in the Central Coast major stock assessment region (SAR). Legend: 'Other' represents the reduction, the food and bait, as well as the special use fishery; 'RoeSN' represents the roe seine fishery; and 'RoeGN' represents the roe gillnet fishery. Data from the spawn-on-kelp (SOK) fishery are not included. Note: symbols indicate years in which catch by gear type (i.e., Other, RoeSN, RoeGN) is withheld due to privacy concerns.

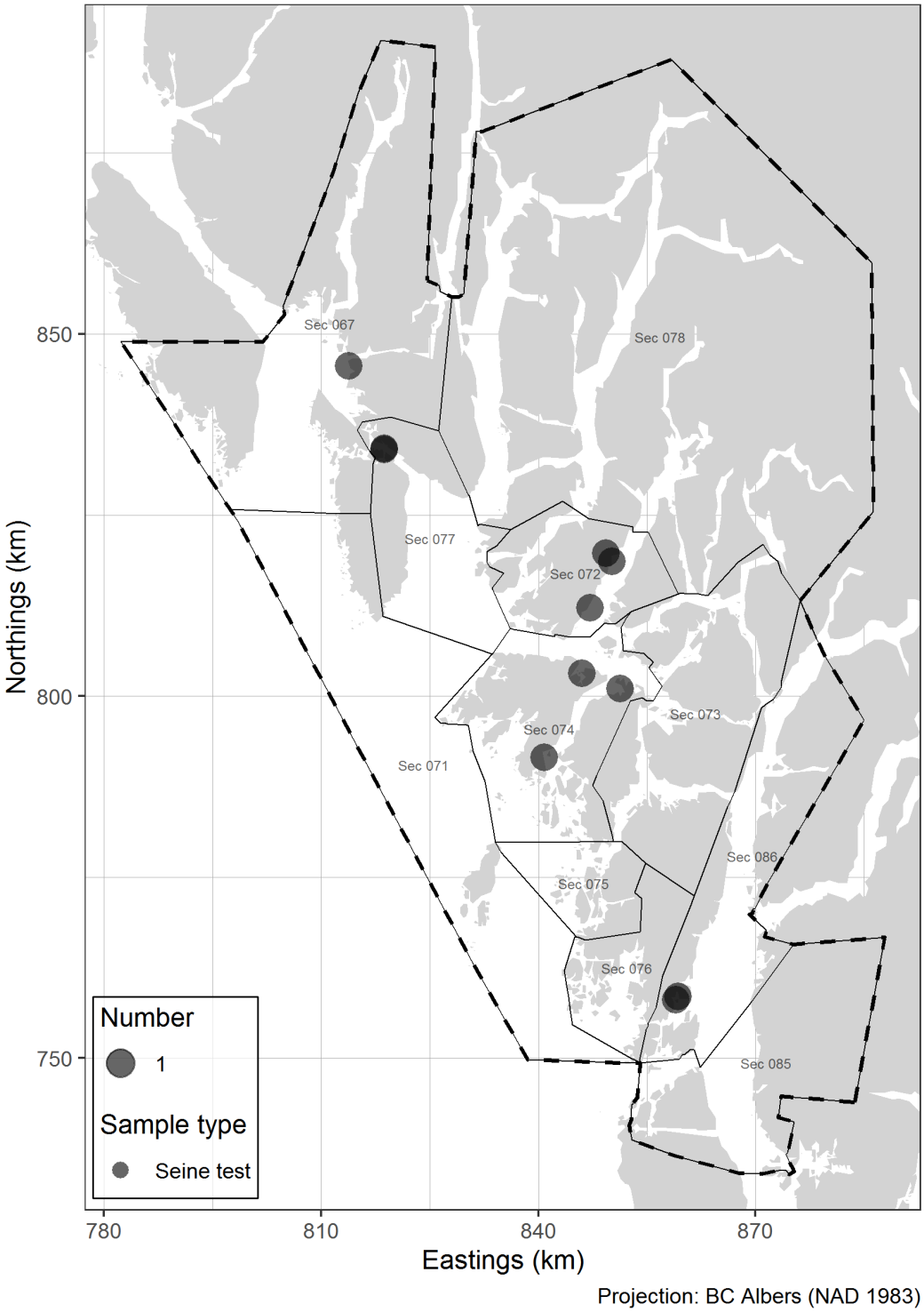

Figure 4. Location and type of Pacific Herring biological samples collected in 2020 in the Central Coast major stock assessment region (SAR; thick dashed lines), and associated Sections (Sec; thin solid lines). Units: kilometres (km).

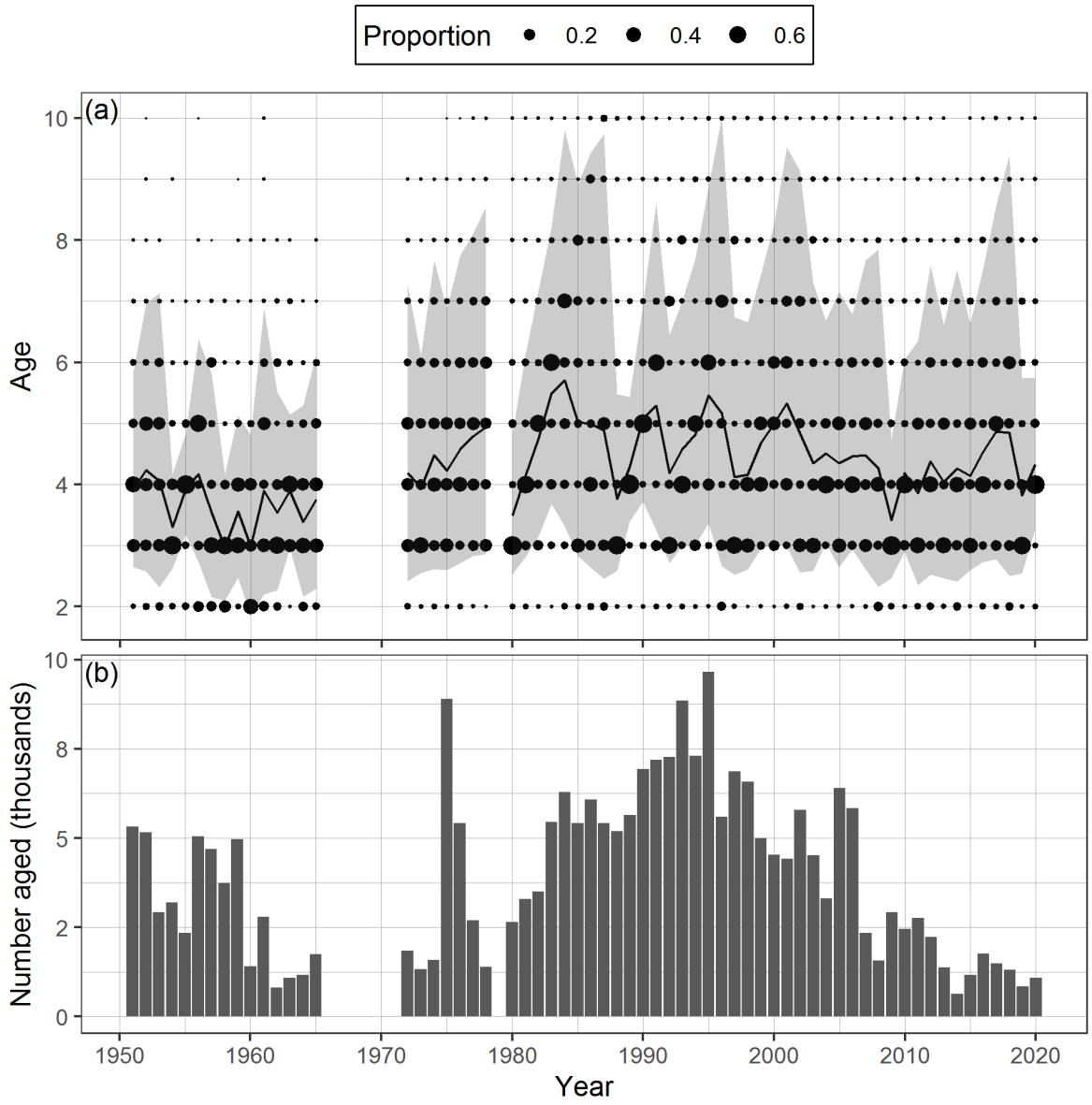

Figure 5. Time series of observed proportion-at-age (a) and number aged in thousands (c) of Pacific Herring from 1951 to 2020 in the Central Coast major stock assessment region (SAR). The black line is the mean age, and the shaded area is the approximate 90% distribution. Biological summaries only include samples collected using seine nets (commercial and test) due to size-selectivity of other gear types such as gillnet. The age-10 class is a 'plus group' which includes fish ages 10 and older.

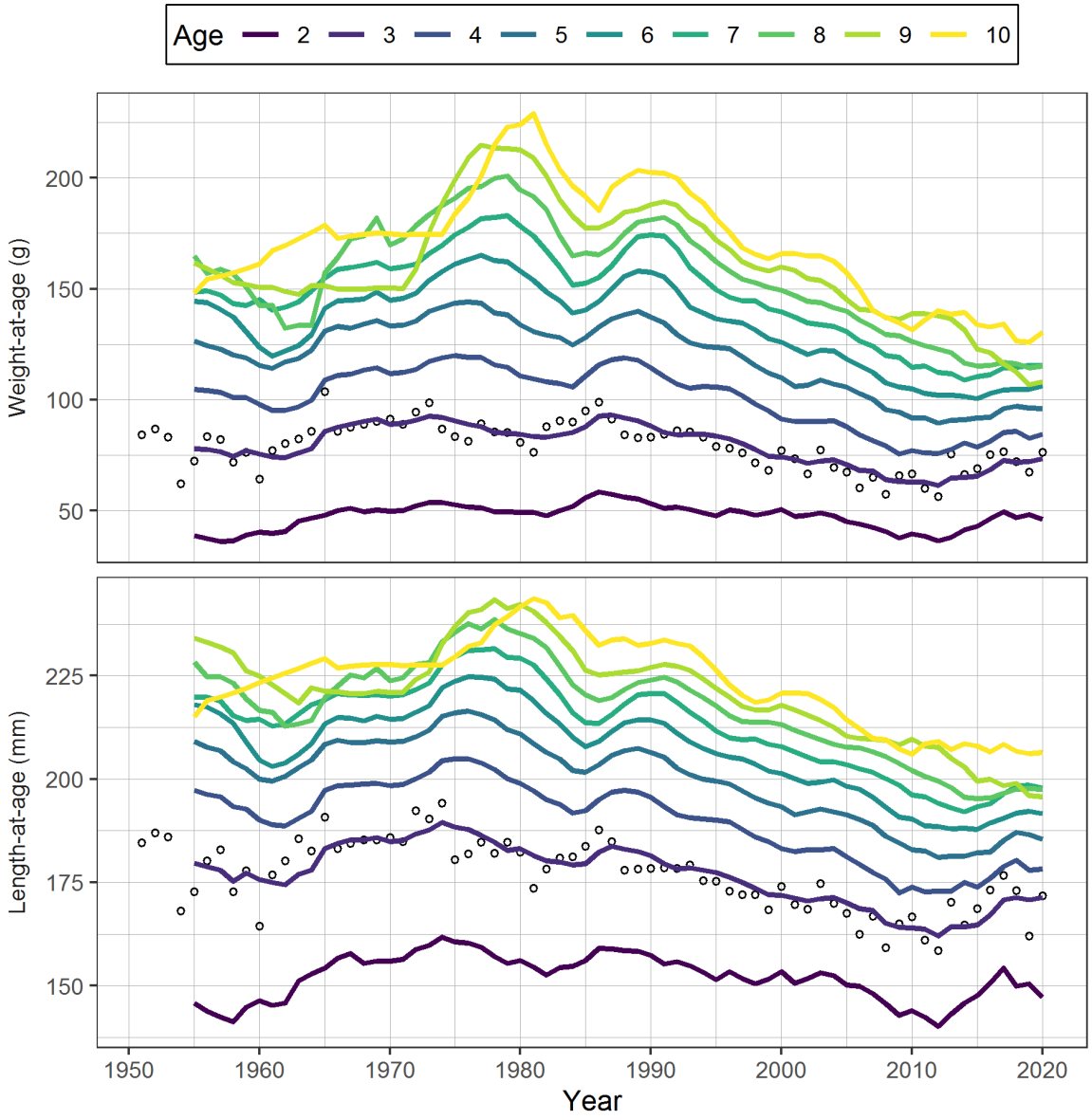

Figure 6. Time series of weight-at-age in grams (g) and length-at-age in milimetres (mm) for age-3 (circles) and 5-year running mean weight- and length-at-age (lines) for Pacific Herring from 1951 to 2020 in the Central Coast major stock assessment region (SAR). Missing weight- and length-at-age values (i.e., years with no biological samples) are imputed using one of two methods: missing values at the beginning of the time series are imputed by extending the first non-missing value backwards; other missing values are imputed as the mean of the previous 5 years. Biological summaries only include samples collected using seine nets (commercial and test) due to size-selectivity of other gear types such as gillnet. The age-10 class is a 'plus group' which includes fish ages 10 and older.

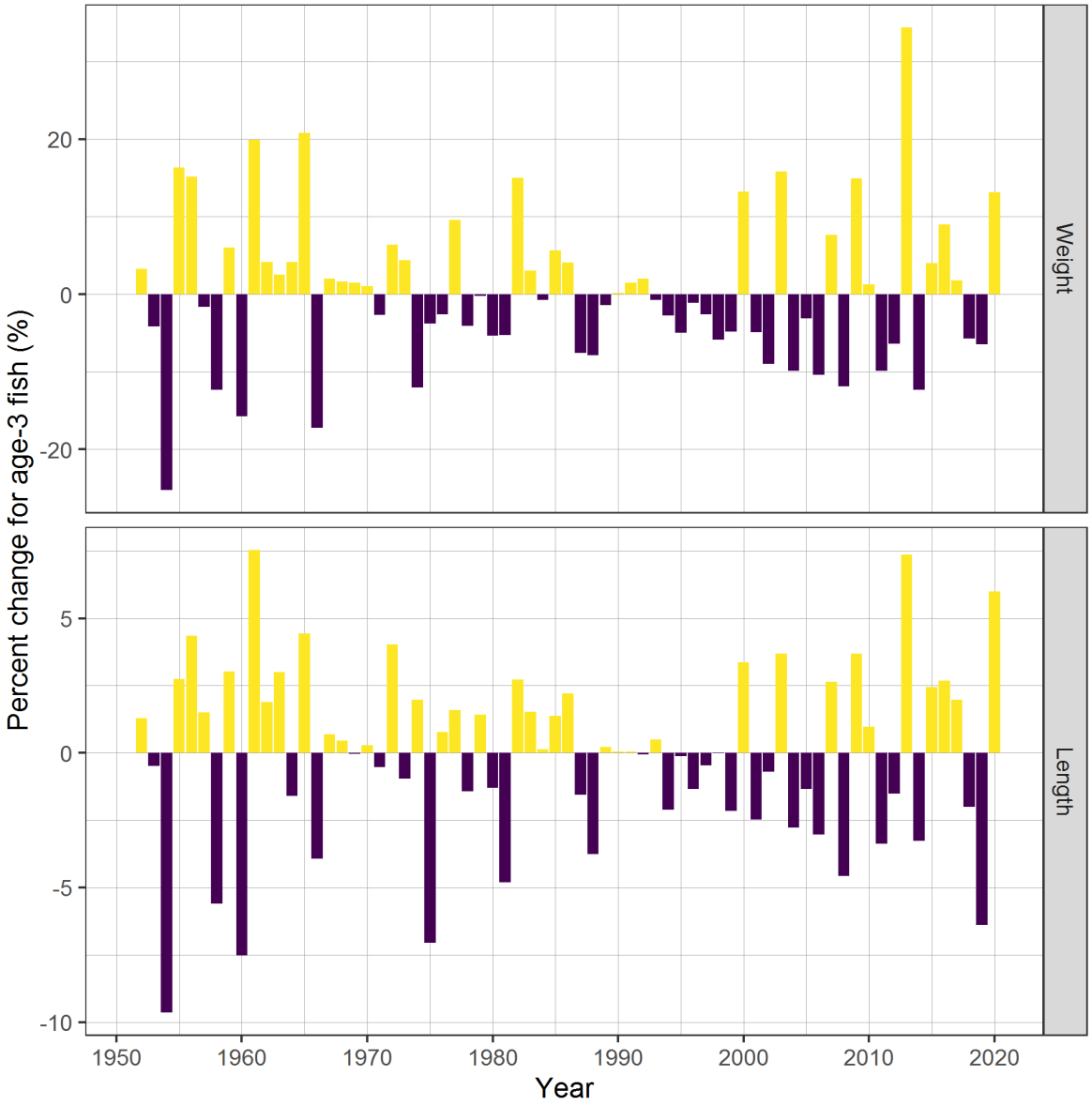

Figure 7. Time series of percent change (%) in weight and length for age-3 fish for Pacific Herring from 1951 to 2020 in the Central Coast major stock assessment region (SAR). Percent change is $\delta_t = \frac{\alpha_t - \alpha_{t-1}}{\alpha_{t-1}}$ where α_t is the weight and length of age-3 fish, respectively, in year t. Biological summaries only include samples collected using seine nets (commercial and test) due to size-selectivity of other gear types such as gillnet.

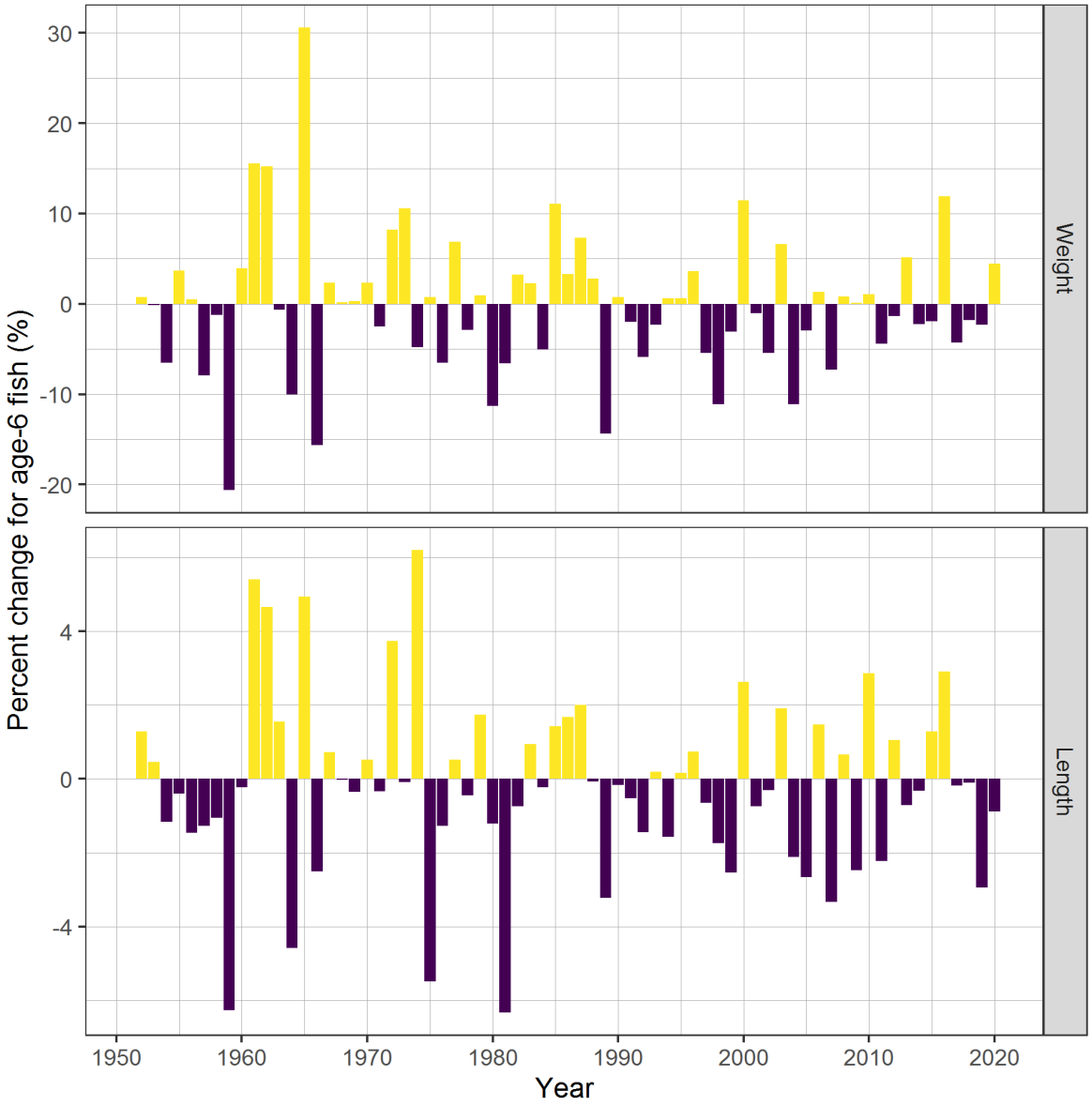

Figure 8. Time series of percent change (%) in weight and length for age-6 fish for Pacific Herring from 1951 to 2020 in the Central Coast major stock assessment region (SAR). Percent change is $\delta_t = \frac{\alpha_t - \alpha_{t-1}}{\alpha_{t-1}}$ where α_t is the weight and length of age-6 fish, respectively, in year t. Biological summaries only include samples collected using seine nets (commercial and test) due to size-selectivity of other gear types such as gillnet.

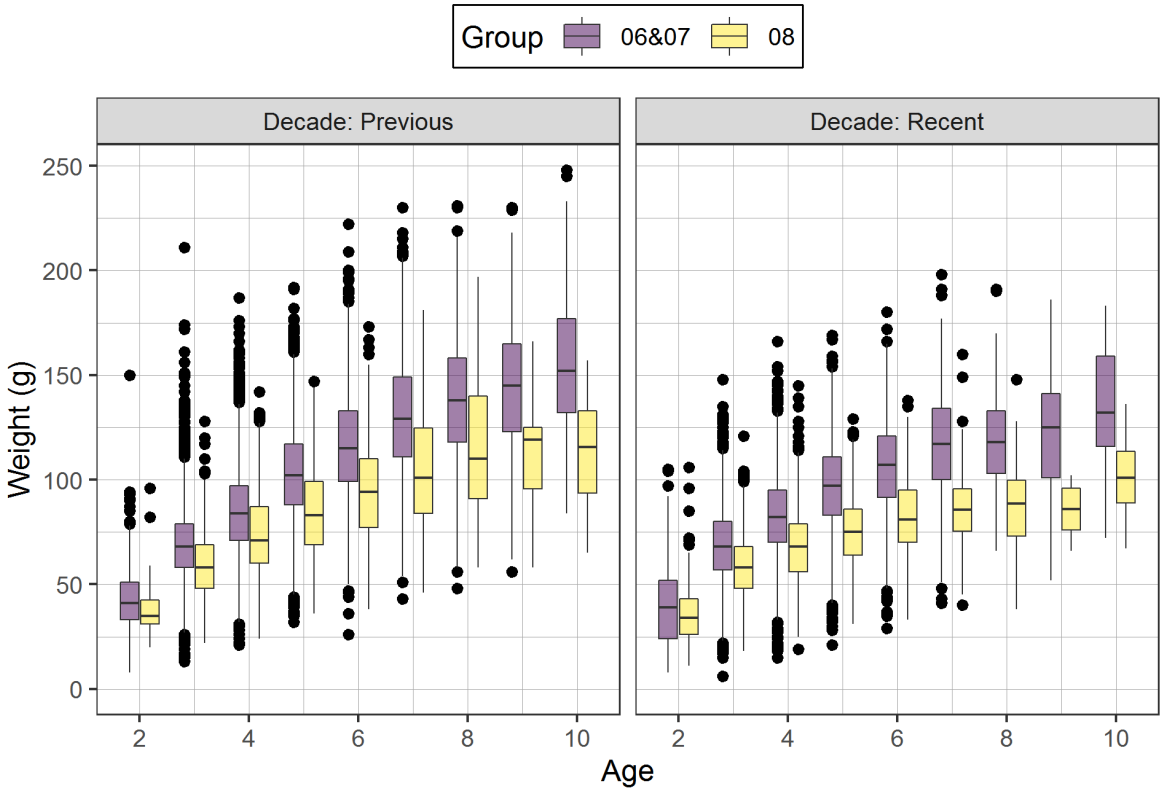

Figure 9. Weight-at-age in grams (g) of Pacific Herring in the Central Coast major stock assessment region (SAR) by Group from the most recent decade (2011 to 2020), and the previous decade (2001 to 2010). The outer edges of the boxes indicate the 25th and 75th percentiles, and the middle lines indicate the 50th percentiles (i.e., medians). The whiskers extend to 1.5 $\times$ IQR, where IQR is the distance between the 25th and 75th percentiles, and dots indicate outliers. Sample sizes are given in Table 8. 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. Legend: '06&07' is Statistical Areas 06 and 07; and '08' is Statistical Area 08.

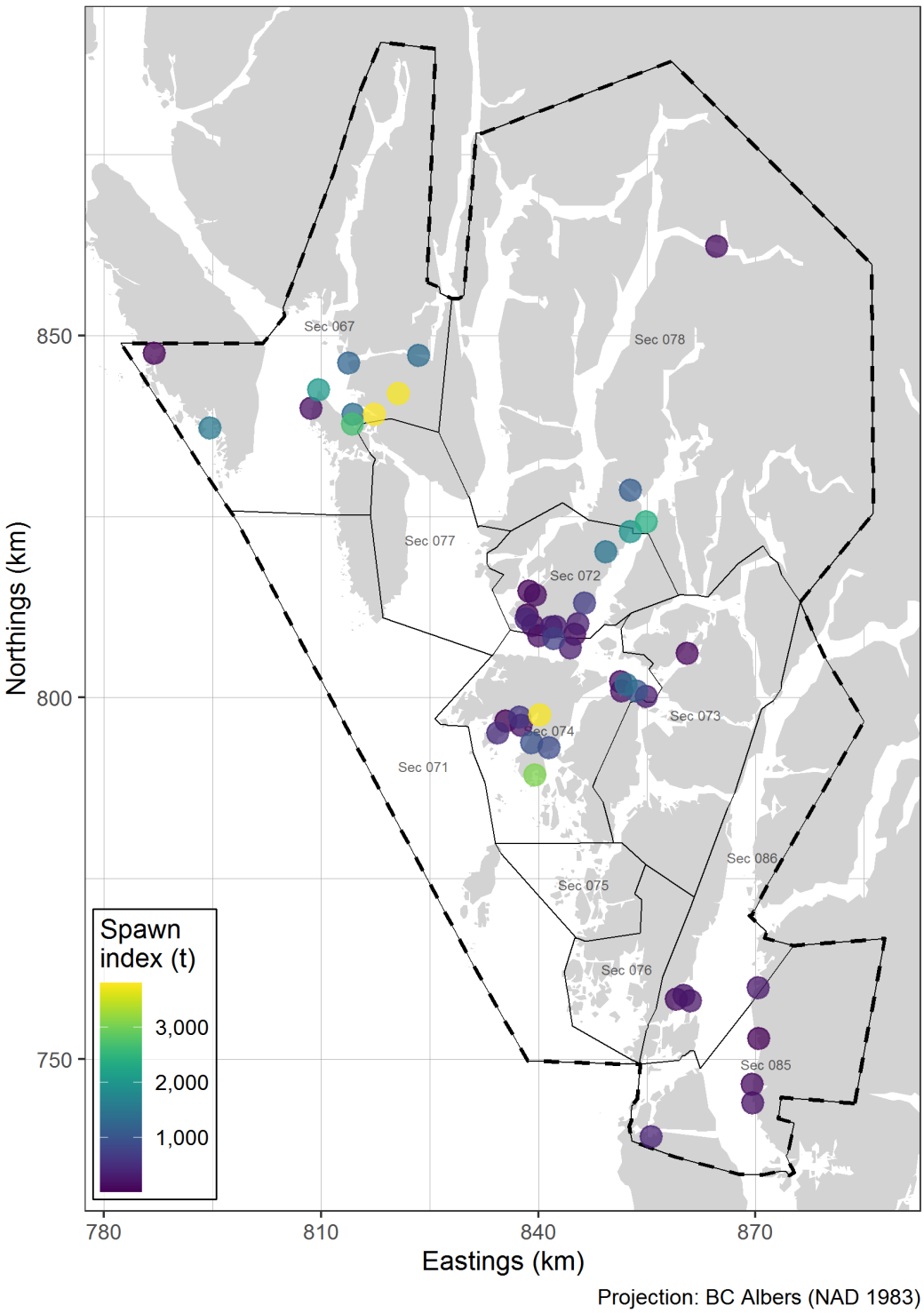

Figure 10. Pacific Herring spawn survey locations, and spawn index in metric tonnes (t) in 2020 in the Central Coast major stock assessment region (SAR; thick dashed lines), and associated Sections (Sec; thin solid lines). The 'spawn index' is not scaled by the spawn survey scaling parameter, q. Missing spawn index values (grey circles) indicate incomplete spawn surveys. Units: kilometres (km).

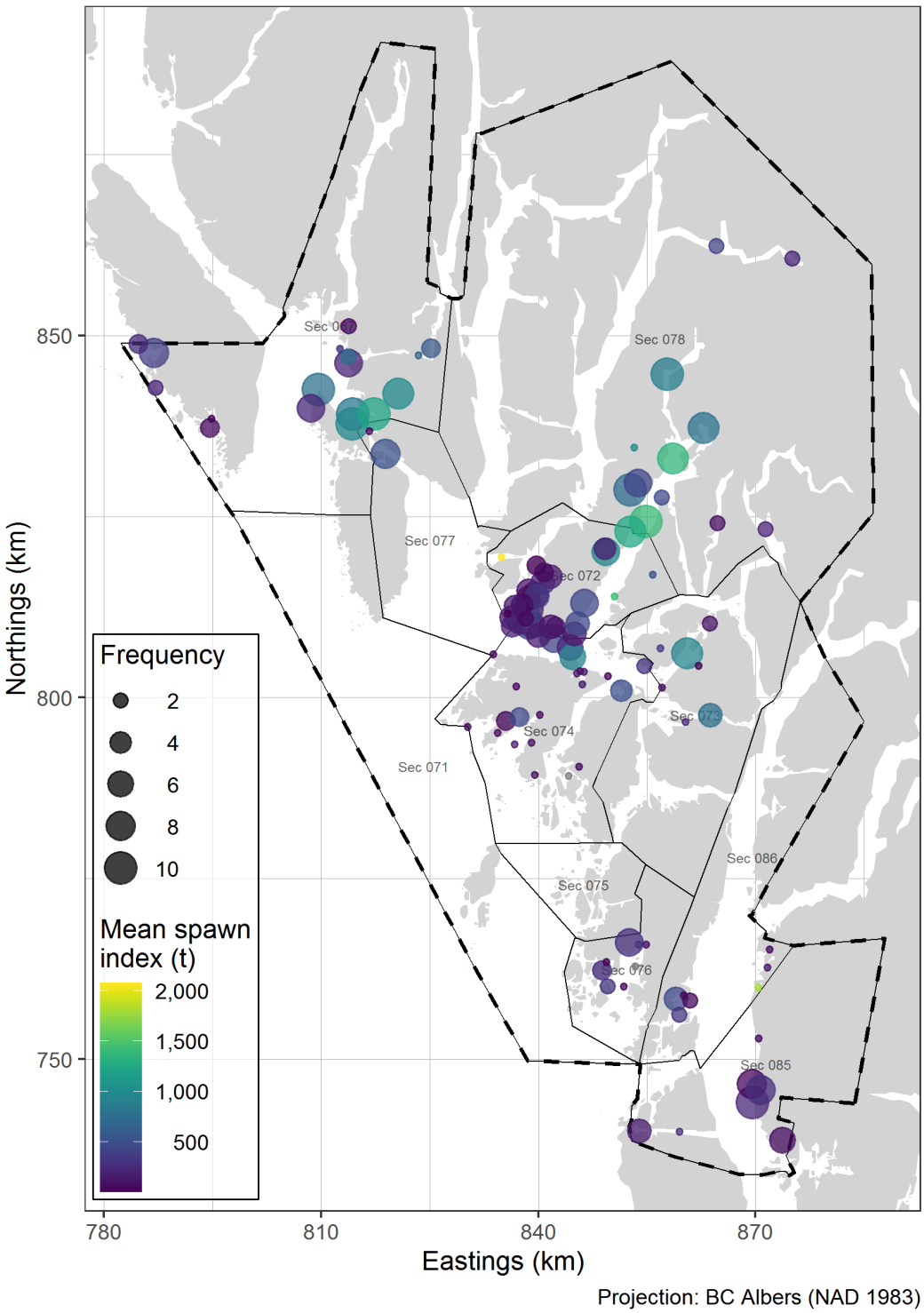

Figure 11. Pacific Herring spawn survey locations, mean spawn index in metric tonnes (t), and spawn frequency from 2010 to 2019 in the Central Coast major stock assessment region (SAR; thick dashed lines), and associated Sections (Sec; thin solid lines). The 'spawn index' is not scaled by the spawn survey scaling parameter, q. Missing spawn index values (grey circles) indicate incomplete spawn surveys. Units: kilometres (km).

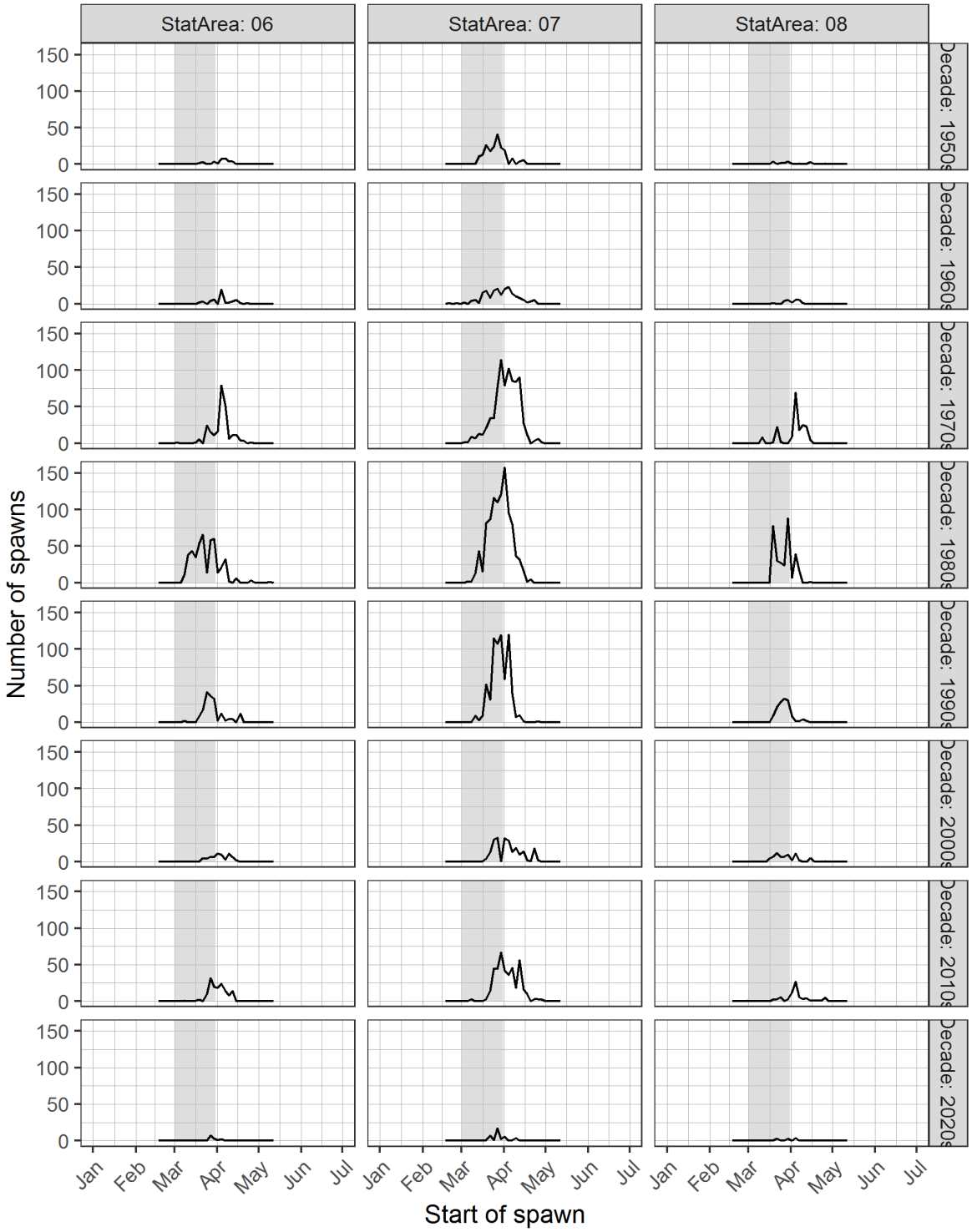

Figure 12. Pacific Herring spawn start date by decade and Statistical Area. Grey shaded regions indicate March 1st to 31st. Note that spawn size and intensity varies; therefore the number of spawns is not directly proportional to spawn extent or biomass.

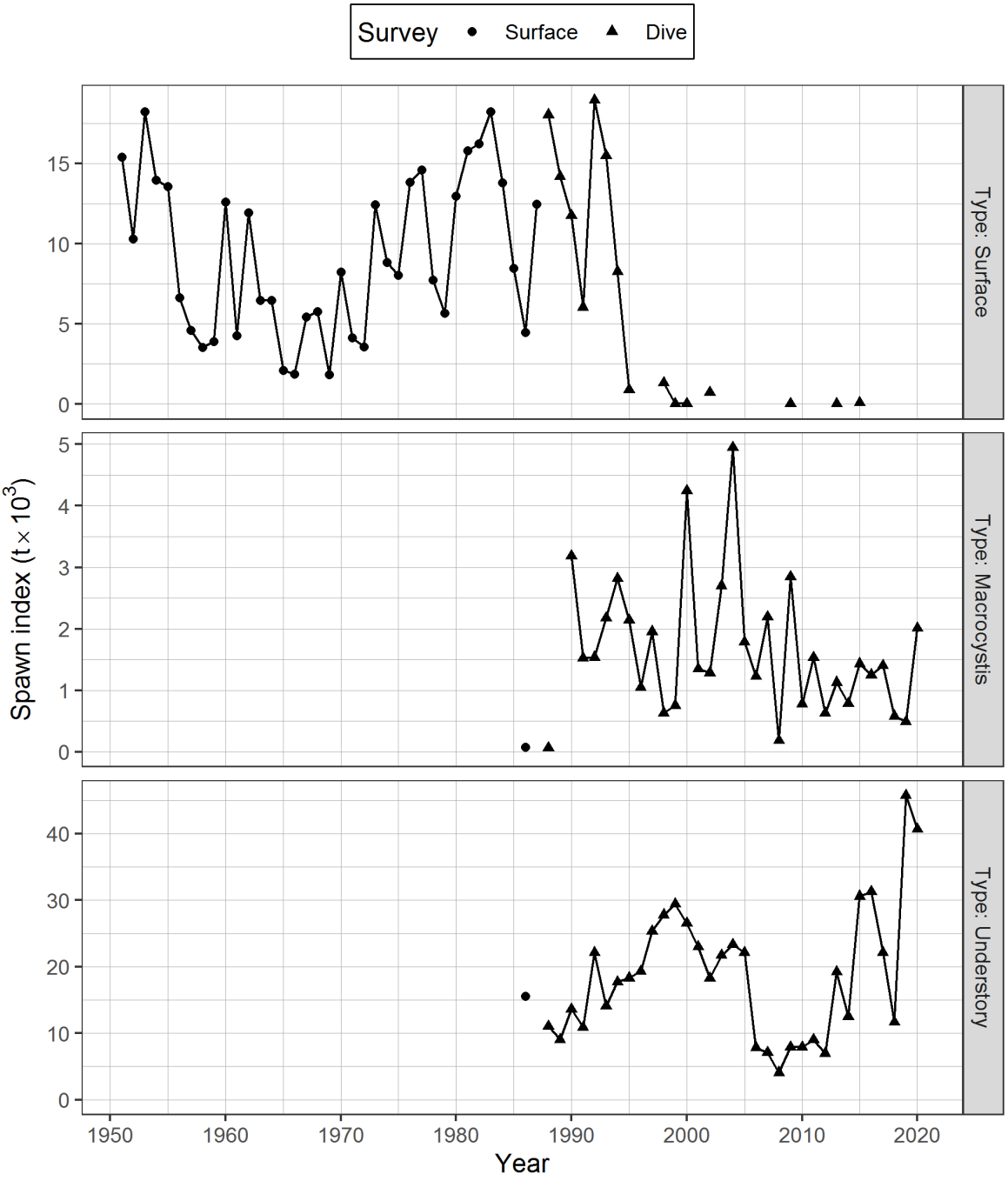

Figure 13. Time series of spawn index in thousands of metric tonnes ($t \times 10^3$) by type for Pacific Herring from 1951 to 2020 in the Central Coast major stock assessment region (SAR). There are three types of spawn survey observations: observations of spawn taken from the surface usually at low 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 2020).

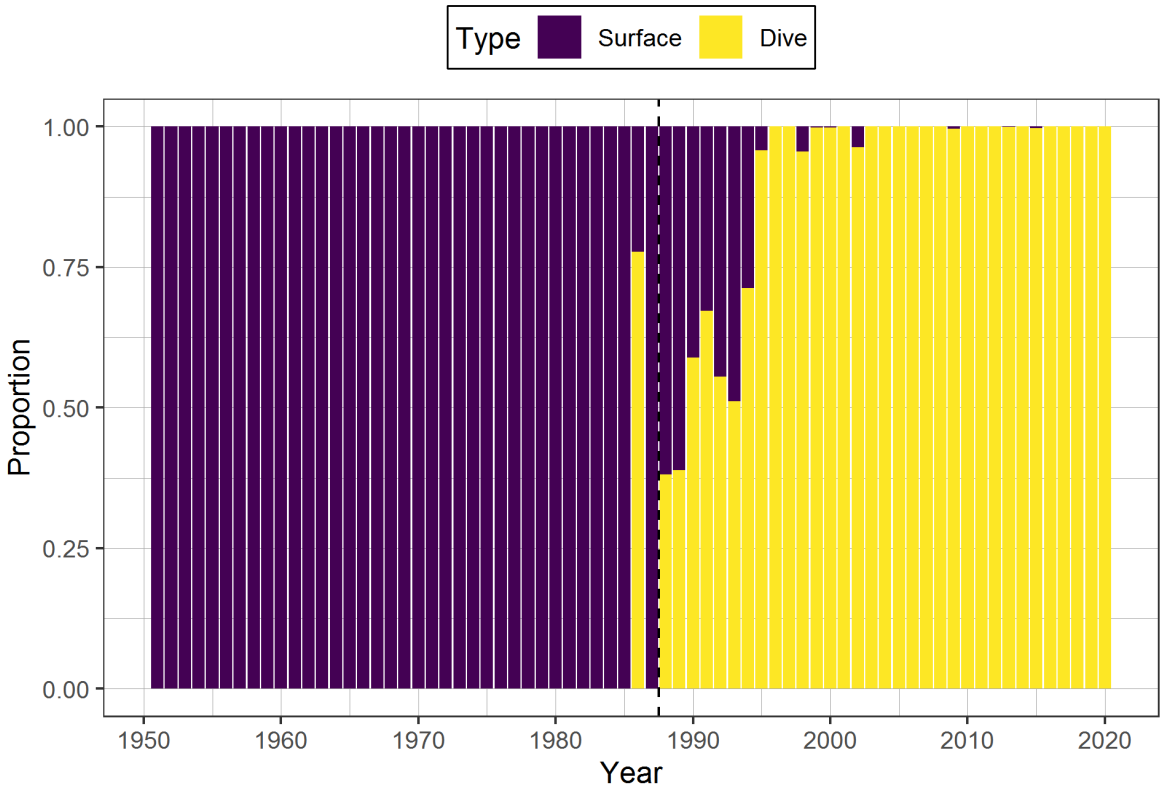

Figure 14. Time series of proportion of spawn index by surface and dive surveys for Pacific Herring from 1951 to 2020 in the Central Coast major stock assessment region (SAR). The spawn index has two distinct periods defined by the dominant survey method: surface surveys (1951 to 1987), and dive surveys (1988 to 2020).

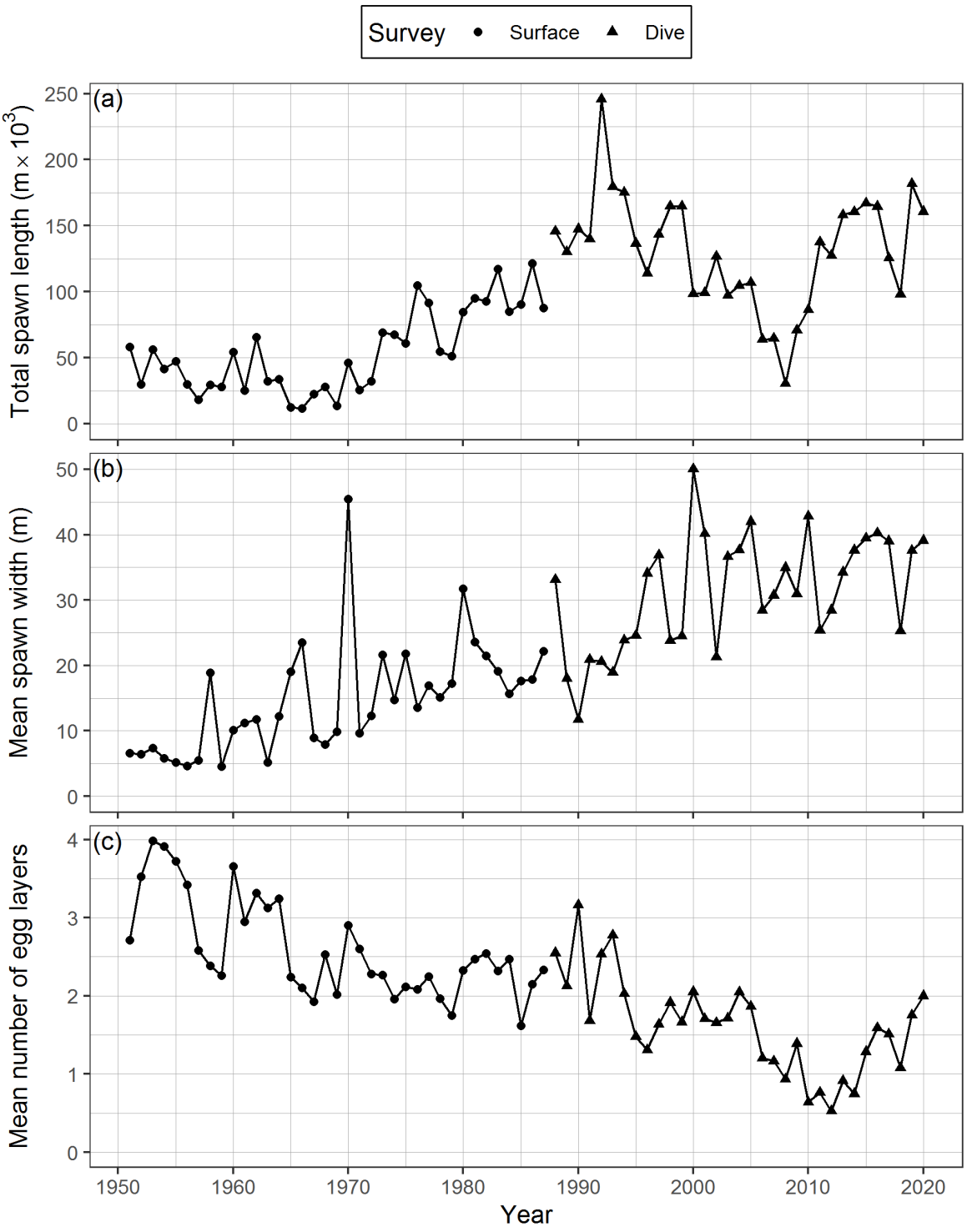

Figure 15. Time series of total spawn length in thousands of metres ($m \times 10^3$; panel a), mean spawn width in metres (b), and mean number of egg layers (c) for Pacific Herring from 1951 to 2020 in the Central Coast major stock assessment region (SAR). The spawn index has two distinct periods defined by the dominant survey method: surface surveys (1951 to 1987), and dive surveys (1988 to 2020).

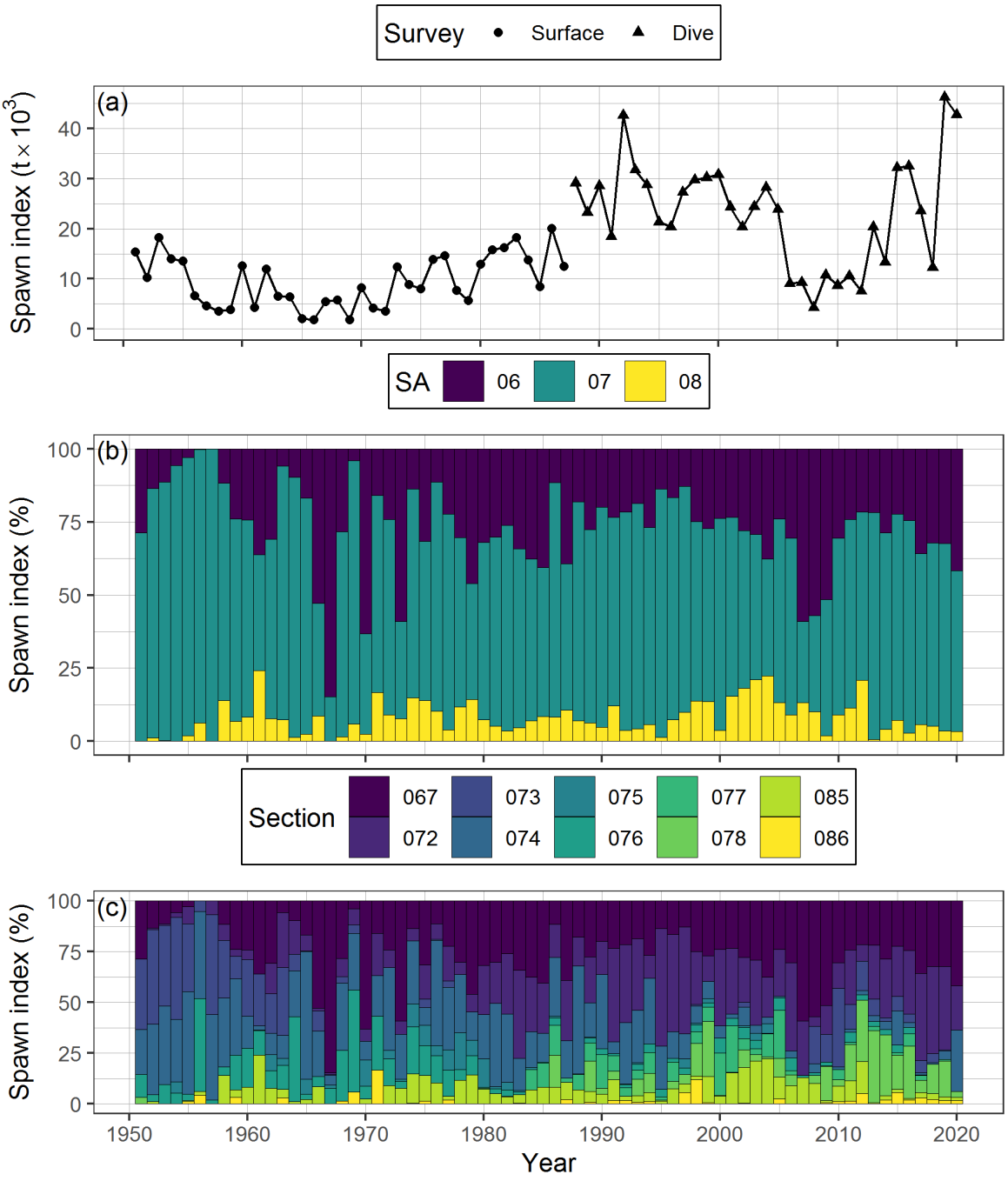

Figure 16. Time series of spawn index in thousands of metric tonnes ($t \times 10^3$) for Pacific Herring from 1951 to 2020 in the Central Coast major stock assessment region (SAR; panel a), as well as percent contributed by Statistical Area (SA), and Section (b, & c, respectively). The spawn index has two distinct periods defined by the dominant survey method: surface surveys (1951 to 1987), and dive surveys (1988 to 2020). The 'spawn index' is not scaled by the spawn survey scaling parameter, q. Legend: '06&07' is Statistical Areas 06 and 07; and '08' is Statistical Area 08.

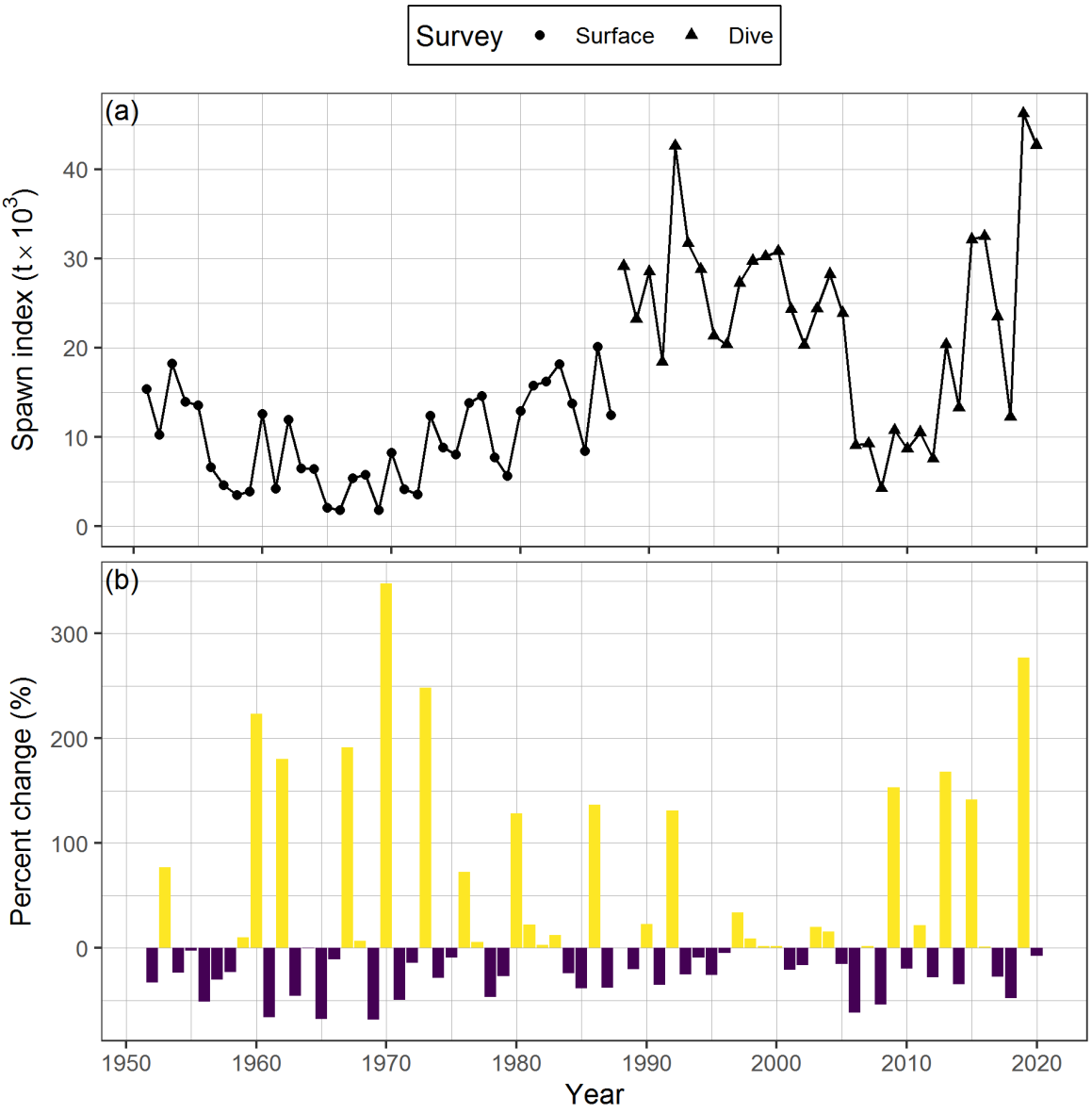

Figure 17. Time series of spawn index in thousands of metric tonnes ($t \times 10^3$) for Pacific Herring from1951 to 2020 in the Central Coast major stock assessment region (SAR; panel a), and percent change (b). Percent change is $\delta_t = \frac{\alpha_t - \alpha_{t-1}}{\alpha_{t-1}}$ where α_t is the spawn index in year t. The spawn index has two distinct periods defined by the dominant survey method: surface surveys (1951 to 1987), and dive surveys (1988 to 2020). The 'spawn index' is not scaled by the spawn survey scaling parameter, q.

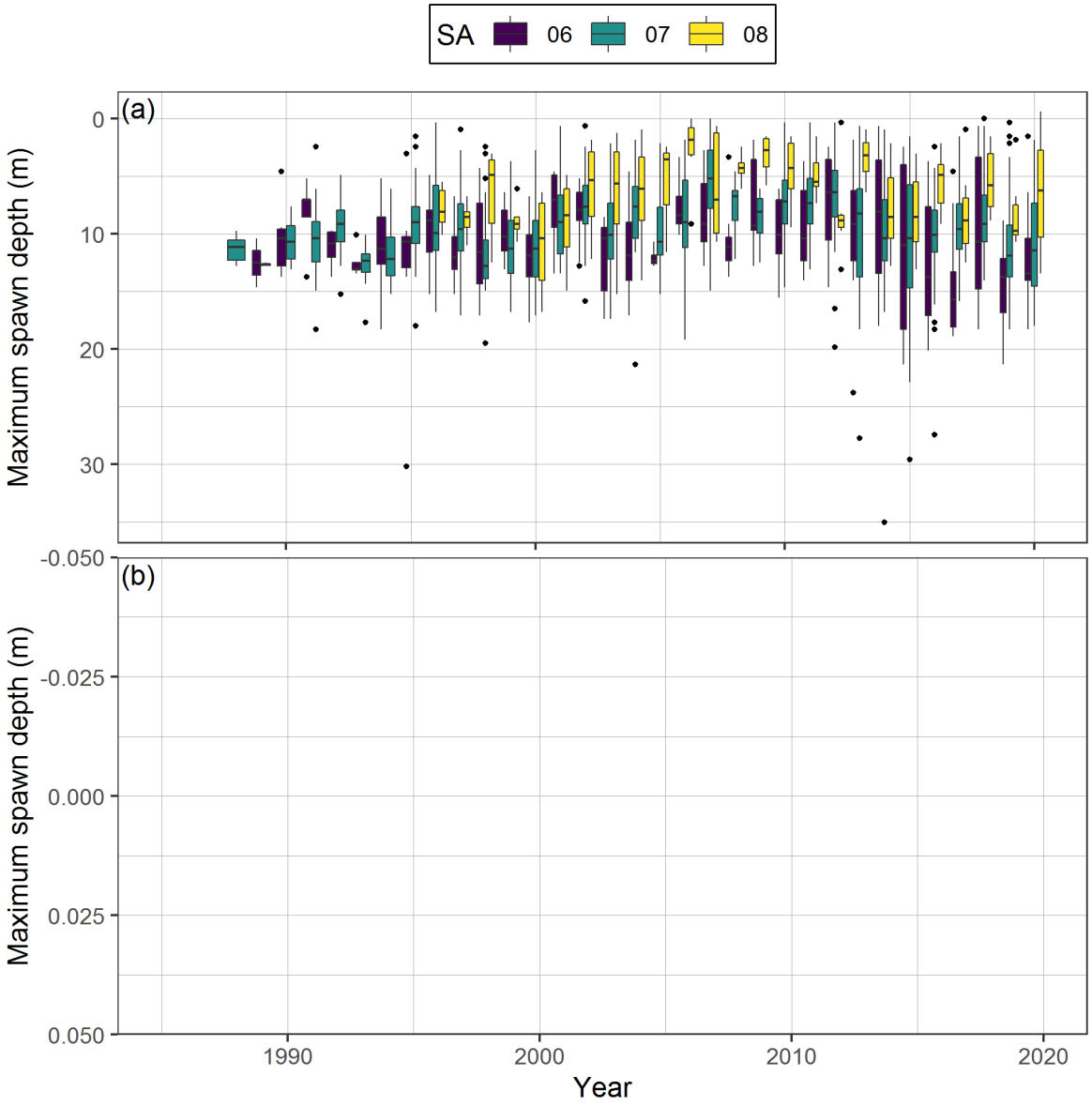

Figure 18. Time series of maximum spawn depth in metres (m) for Pacific Herring from 1985 to 2020 in the Central Coast major stock assessment region (SAR) by Statistical Area (SA; panel a), and Section (b). Note that depth is not corrected to the chart datum. The spawn index has two distinct periods defined by the dominant survey method: surface surveys (1951 to 1987), and dive surveys (1988 to 2020).

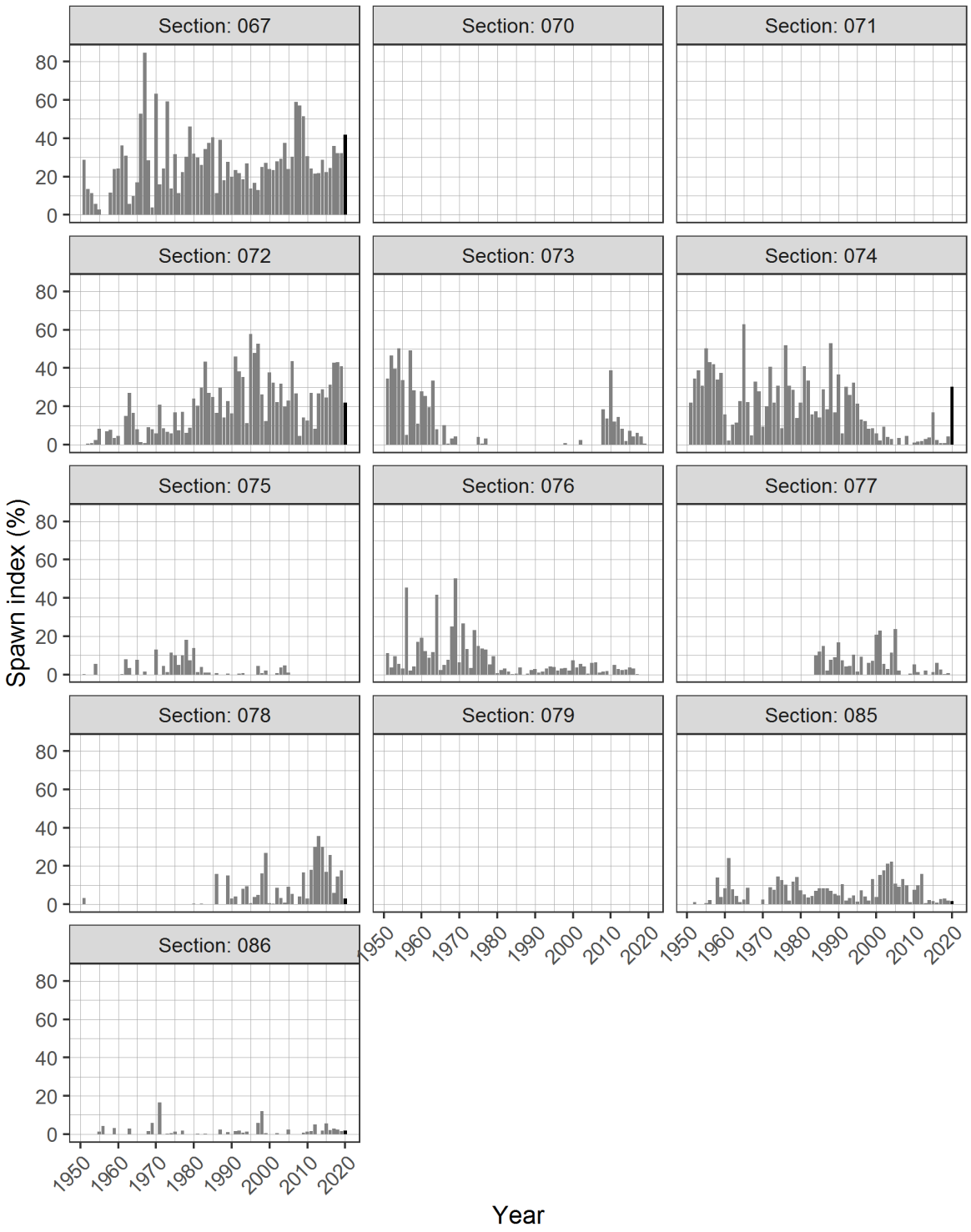

Figure 19. Time series of percent of spawn index by Section for Pacific Herring from 1951 to 2020 in the Central Coast major stock assessment region (SAR). The year 2020 has a darker bar to facilitate interpretation. The spawn index has two distinct periods defined by the dominant survey method: surface surveys (1951 to 1987), and dive surveys (1988 to 2020). The 'spawn index' is not scaled by the spawn survey scaling parameter, q.

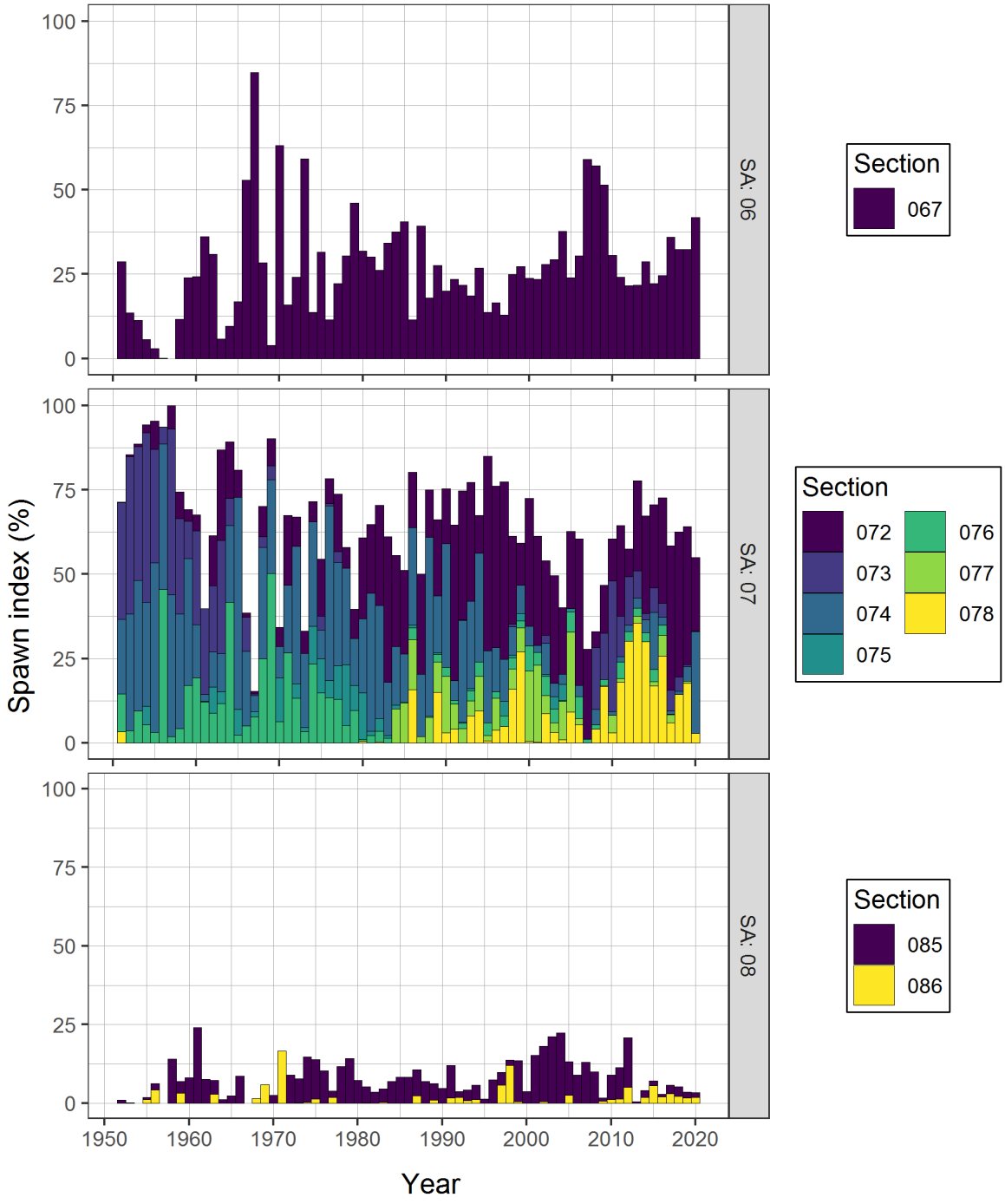

Figure 20. Time series of percent of spawn index by Statistical Area (SA) and Section for Pacific Herring from 1951 to 2020 in the Central Coast major stock assessment region (SAR). The spawn index has two distinct periods defined by the dominant survey method: surface surveys (1951 to 1987), and dive surveys (1988 to 2020). The 'spawn index' is not scaled by the spawn survey scaling parameter, q. Legend: '06&07' is Statistical Areas 06 and 07; and '08' is Statistical Area 08.

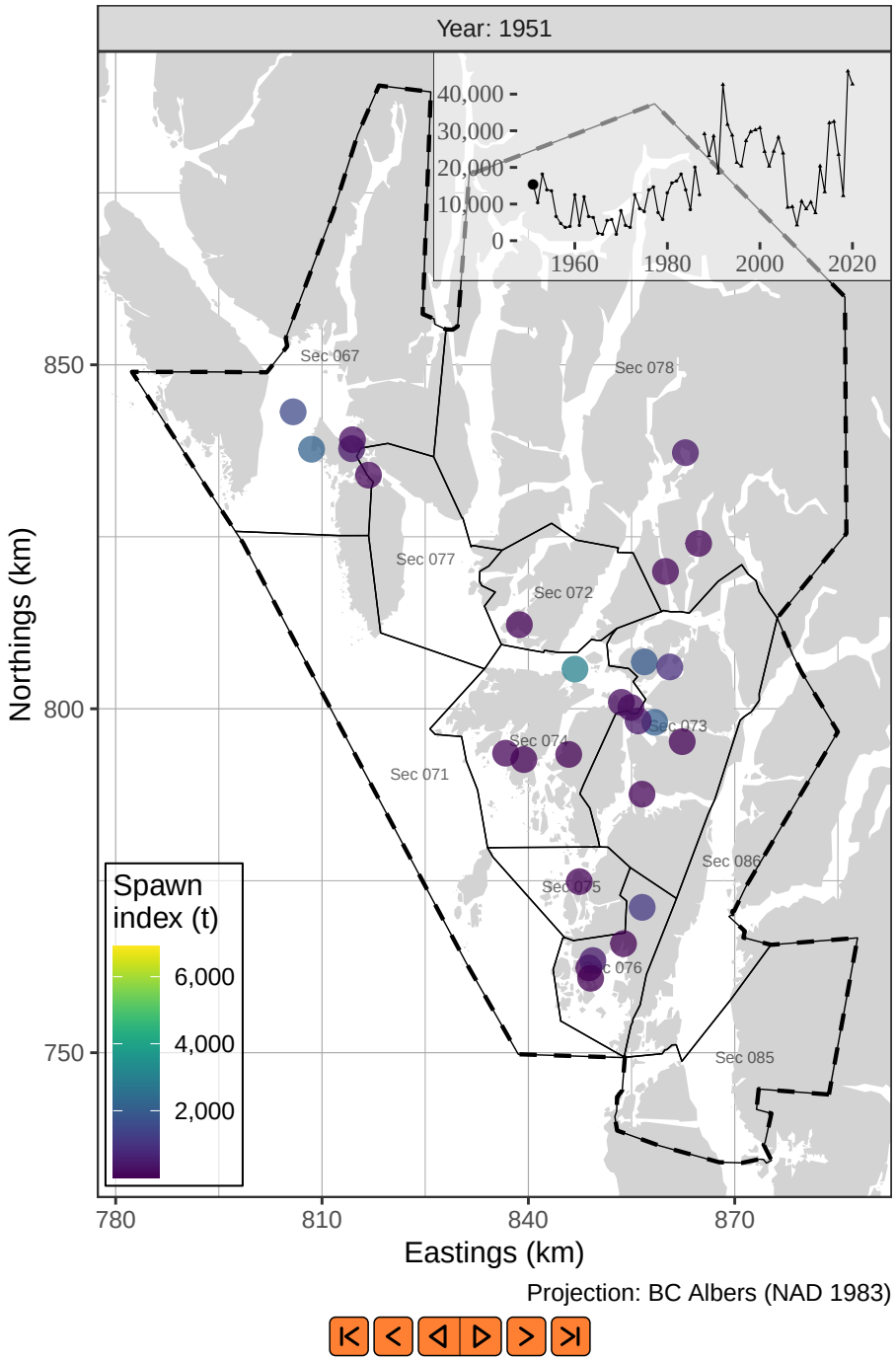

Figure 21. Animation of Pacific Herring spawn index in metric tonnes (t) by Location from 1951 to 2020 in the Central Coast major stock assessment region (SAR; thick dashed lines), and associated Sections (Sec; thin solid lines). The spawn index has two distinct periods defined by the dominant survey method: surface surveys (1951 to 1987), and dive surveys (1988 to 2020). 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).