Pacific Herring preliminary data summary for Central Coast 2019

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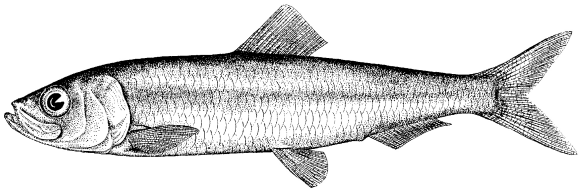

Pacific Herring (*Clupea pallasii*). Image credit: Fisheries and Oceans Canada.

Disclaimer This report contains preliminary data collected for Pacific Herring in 2019 in the 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 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.

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

2 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 19th to April 9th. 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. Nearshore herring samples were collected by Heiltsuk and Kitasoo staff as part of a pilot sampling program and on-going collaboration between CC First Nations and DFO. These nearshore biological samples were collected from spawning aggregations using cast nets.

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

- The "Pachena No.1" surveyed 17 days from April 2nd to April 18th,
- The "Ocean Cloud" surveyed 17 days from March 27th to April 12th, and
- The Kitasoo First Nations surveyed 5 days from April 1st to April 5th.

Three gillnet sounding vessels were operating 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.

2.1 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.

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 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 techincal report for calculations to convert SOK harvest to spawning biomass.

In 2019, 40 Pacific Herring biological samples were collected and processed for the Central Coast major SAR (Table 5, Table 6), and a total of 843 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). Some Statistical Areas tend to have larger fish at a given age (Figure 7, 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.

4 Spawn survey data

Pacific Herring spawn surveys were conducted at 46 individual locations in 2019 in the Central Coast major SAR (Table 9, and Figure 8). A summary of spawn from the last decade (2009 to 2018) is shown in Figure 9. Figure 10 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 11, Figure 12, Figure 13, Table 10, and Figure 14). We describe the calculations used to estimate the spawn index in the draft spawn index techincal report. In addition, spawn surveys estimate spawn depth by Statistical Area, and Section (Figure 15). 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 13b, Figure 16). For example, in 2019, Section 072 contributed the most to the spawn index (41%). As with Sections, some Statistical Areas contribute more than others to the total spawn index (Figure 13c, Figure 17). An animation shows the spawn index by spawn survey location from 1951 to 2019 (Figure 18).

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:

- The test boat encountered many small fish which appear to be predominantly 2 and 3 years old.
- The test boat caught a set that was exclusively juvenile fish near Cockle Bay.
- Spawns seemed to start quickly; no schooling or holding observed.
- Most major spawn locations finished by end of March; only a few isolated spawns were reported in April.
- Spawning biomass appeared to be stronger than last year, with some spawns in areas that had no spawn last year.
- Compared to last year, spawning was extensive (i.e., over a longer time period and area).
- Kynoch Inlet and Culpepper Lagoon saw extensive spawning this season.
- No spawns were reported in Kwakhume Inlet this season.
- Compared to last year, the number of sea lions and squid increased.

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, 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	06&07
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 2019 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 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 Central Coast major stock assessment region (SAR). See the draft spawn index techincal 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: '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	239,861	356
2015	169,470	252
2016	351,953	522
2017	392,747	583
2018	286,109	425
2019	356,042	528

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

	Number of samples		
Year	Commercial	Test	Total
2009	0	34	34
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

Table 6. Number and type of Pacific Herring biological samples processed in 2019 in the Central Coast major stock assessment region (SAR). Each sample is approximately 100 fish.

Type	Gear	Use	Number of samples
Commercial	Seine	SOK	2
Test	Other	Nearshore	28
Test	Seine	Test fishery	10

Table 7. Observed proportion-at-age for Pacific Herring from 2009 to 2019 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
2009	0.044	0.718	0.105	0.081	0.023	0.022	0.003	0.003	0.001
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

Table 8. Sample size for Pacific Herring weight-at-age analysis in 2019 in the Central Coast major stock assessment region (SAR) by Group from the most recent decade (2010 to 2019), and the previous decade (2000 to 2009), as displayed in Figure 7. 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	938	493
06&07	3	10,471	3,781
06&07	4	10,212	4,790
06&07	5	7,336	2,653
06&07	6	4,953	1,569
06&07	7	2,983	614
06&07	8	1,281	298
06&07	9	455	93
06&07	10	177	39
08	2	66	300
08	3	871	1,072
08	4	908	865
08	5	443	296
08	6	277	202
08	7	178	79
08	8	64	26
08	9	11	7
08	10	5	4

Table 9. Pacific Herring spawn survey locations, start date, and spawn index in metric tonnes (t) in 2019 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	Hartnell Pt	April 03	1,083
06	067	Kwakwa Cr	April 03	2,325
06	067	Marvin Is	March 24	1,462
06	067	Meyers Nrws	April 03	652
06	067	Meyers Psg	April 03	1,135
06	067	Milne Is	April 03	335
06	067	Osment Inlt	March 24	3,060
06	067	Parsons Anch	March 24	2,341
06	067	Thistle Psg	April 03	1
06	067	Wilby Pt	March 24	2,090
06	067	Wingate Pt	March 24	461
07	072	Balagny Pass	March 30	249
07	072	Berry Inlt	April 29	7
07	072	Branks It	March 30	8
07	072	Bullen Rk	March 29	537
07	072	Bush Pt	March 29	1,228
07	072	Don Lgn +	March 24	3,083
07	072	Don Pen	April 02	978
07	072	Dove Pt	March 24	1,427
07	072	Fisher Pt	March 29	221
07	072	Foote Islets	March 29	335
07	072	Mosquito Bay	March 24	3,926
07	072	Mouat Cv	March 29	74
07	072	Reid Pass	April 15	18
07	072	Shingle Rk	March 29	958
07	072	Spiller Chnl	March 24	3,698
07	072	Tankeeah River	March 30	1,162
07	072	Watch Is	March 30	525
07	072	Yeo Is	March 24	523
07	073	Troup Psg	March 26	269
07	074	Idol Pt	March 31	194
07	074	Norman Morrison Bay	March 24	1,796
07	077	E Higgins Pass	April 04	299
07	078	Culpepper Lgn	April 07	197
07	078	Ellerslie Bay	March 25	1,161
07	078	Gerald Pt	March 24	681
07	078	Kynoch Inlt	April 06	728
07	078	Neekas Cv	March 24	1,177

Table 9 continued

Statistical Area	Section	Location name	Start date	Spawn index (t)
07	078	Neekas Inlt	March 24	2,309
07	078	Spiller Chnl Hd	March 24	983
07	078	Spiller Inlt	March 24	903
08	085	Kwakume Pt	April 01	245
08	085	Pruth Bay	March 19	627
08	085	Whidbey Pt	April 01	29
08	086	Mustang Bay	March 31	719
08	086	Target Bay	April 01	33

Table 10. Summary of Pacific Herring spawn survey data from 2009 to 2019 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 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	70,980	31	1.4	10,771
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

7 Figures

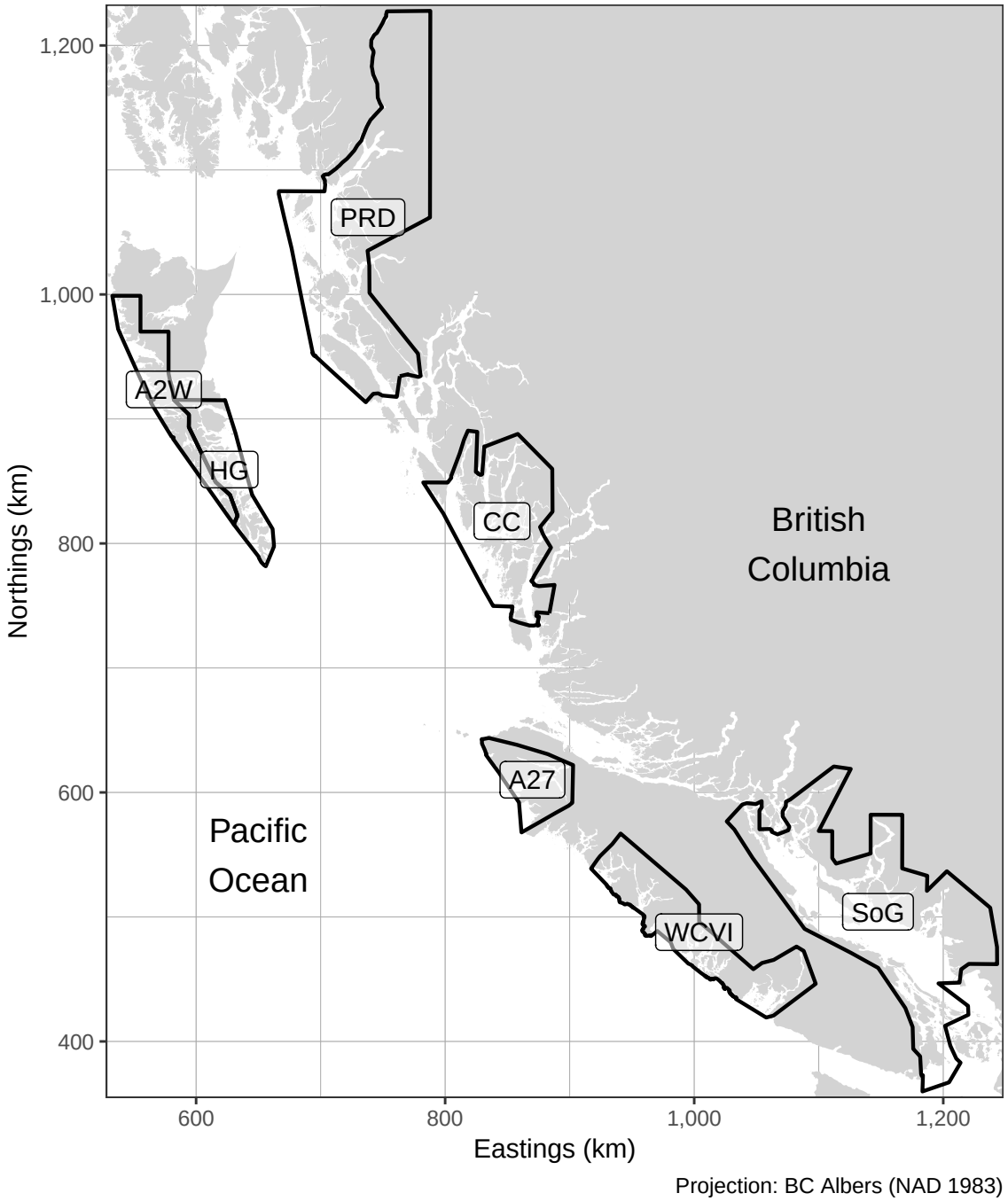

Figure 1. Boundaries for the Pacific Herring stock assessment regions (SARs) in British Columbia. There are 5 major SARs: Haida Gwaii (HG), Prince Rupert District (PRD), Central Coast (CC), Strait of Georgia (SoG), and West Coast of Vancouver Island (WCVI). There are 2 minor SARs: Area 27 (A27) and Area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

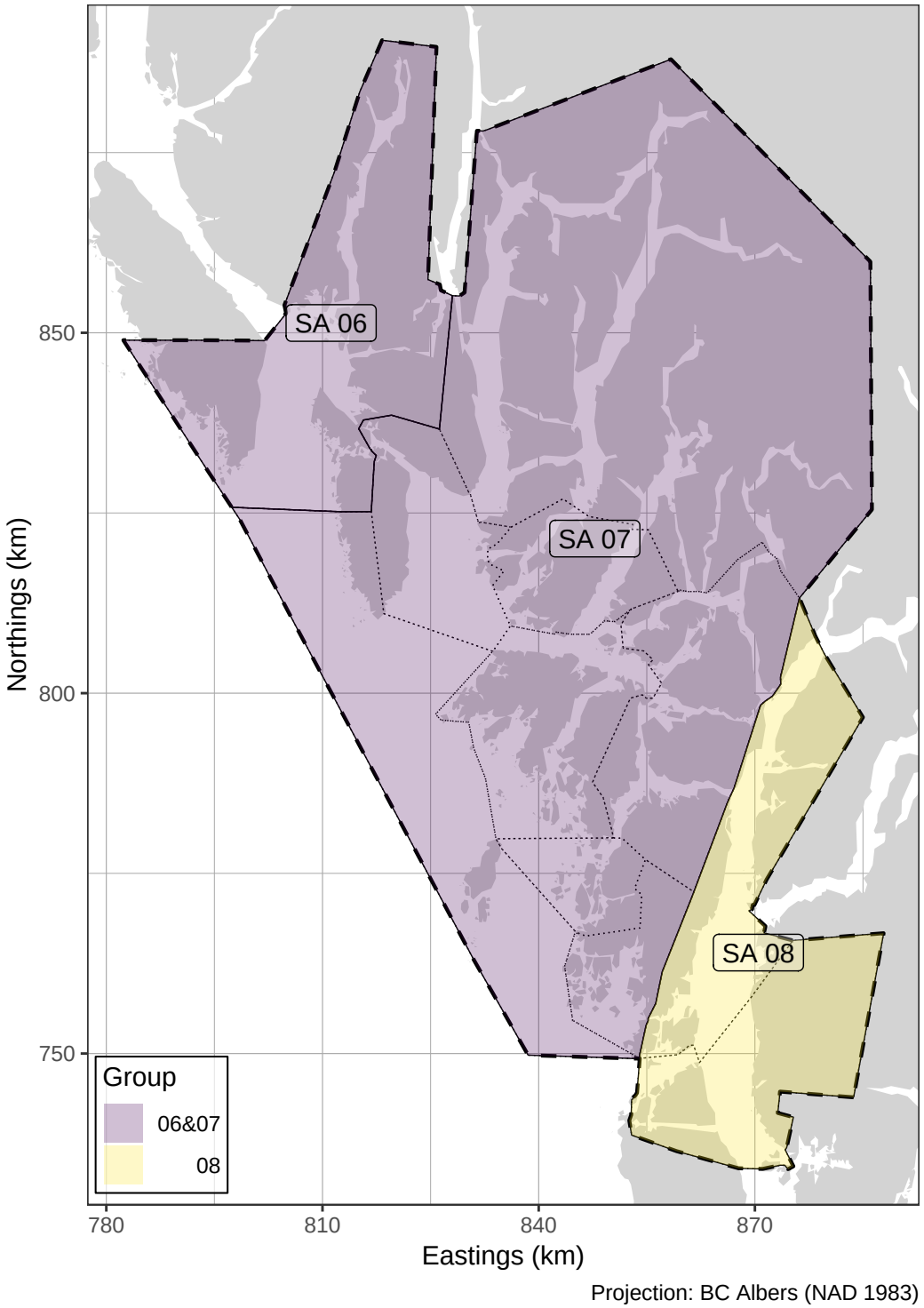

Figure 2. Boundaries for the Central Coast major stock assessment region (SAR; thick dashed lines), associated Statistical Areas (SA; thin solid lines), and associated Sections (thin dotted lines). Units: kilometres (km). Legend: '06&07' is Statistical Areas 06 and 07; and '08' is Statistical Area 08.

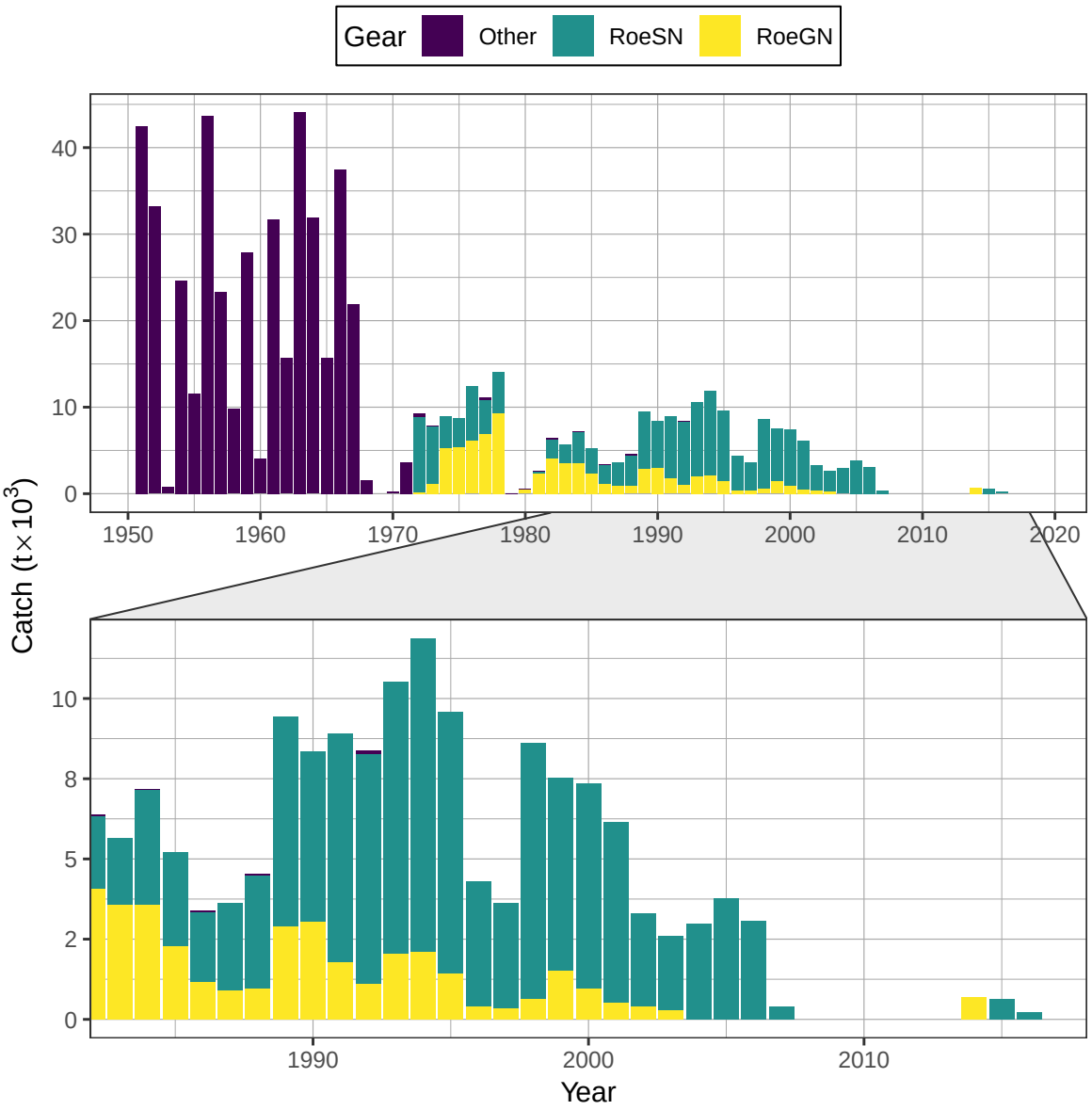

Figure 3. Time series of total landed catch in thousands of metric tonnes ($t \times 10^3$) of Pacific Herring by gear type from 1951 to 2019 in the Central Coast major stock assessment region (SAR). Legend: 'Other' represents the reduction, the food and bait, as well as the special use fishery; 'RoeSN'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

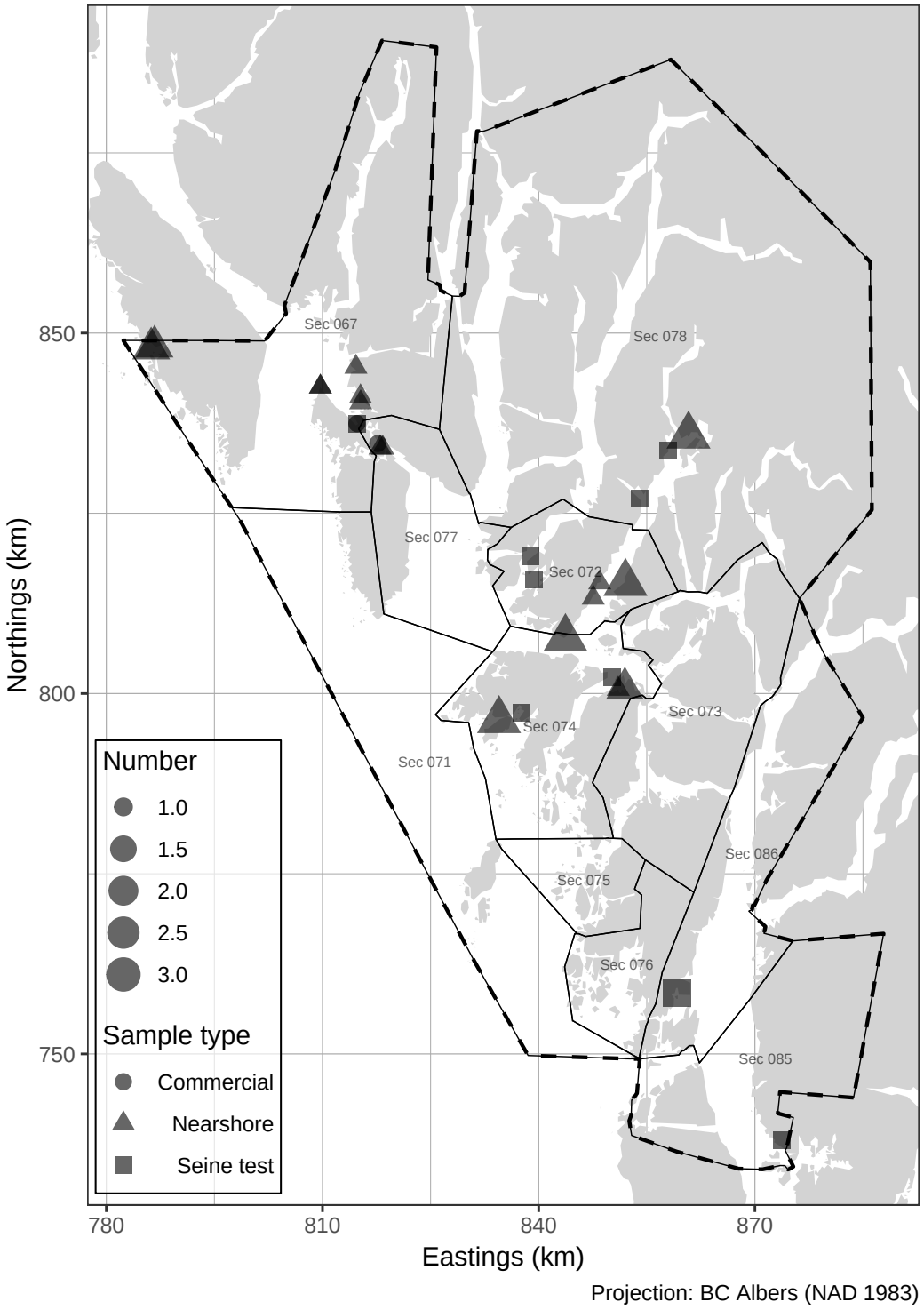

Figure 4. Location and type of Pacific Herring biological samples collected in 2019 in the Central Coast major stock assessment region (SAR; thick dashed lines), and associated Sections (Sec; thin solid lines). Units: kilometres (km).

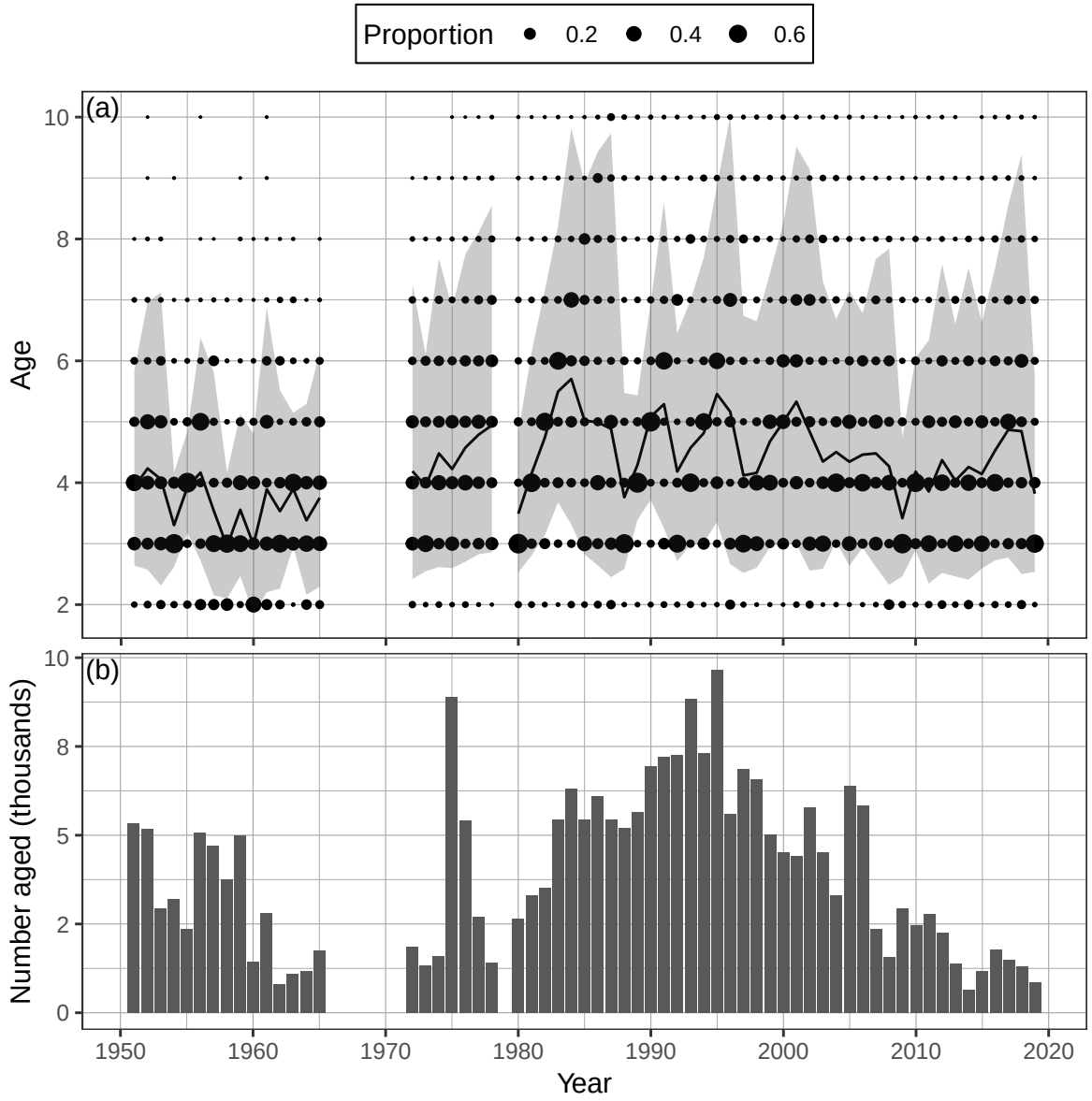

Figure 5. Time series of observed proportion-at-age (a) and number aged in thousands (c) of Pacific Herring from 1951 to 2019 in the Central Coast major stock assessment region (SAR). The black line is the mean age, and the shaded area is the approximate 90% distribution. Biological summaries only include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

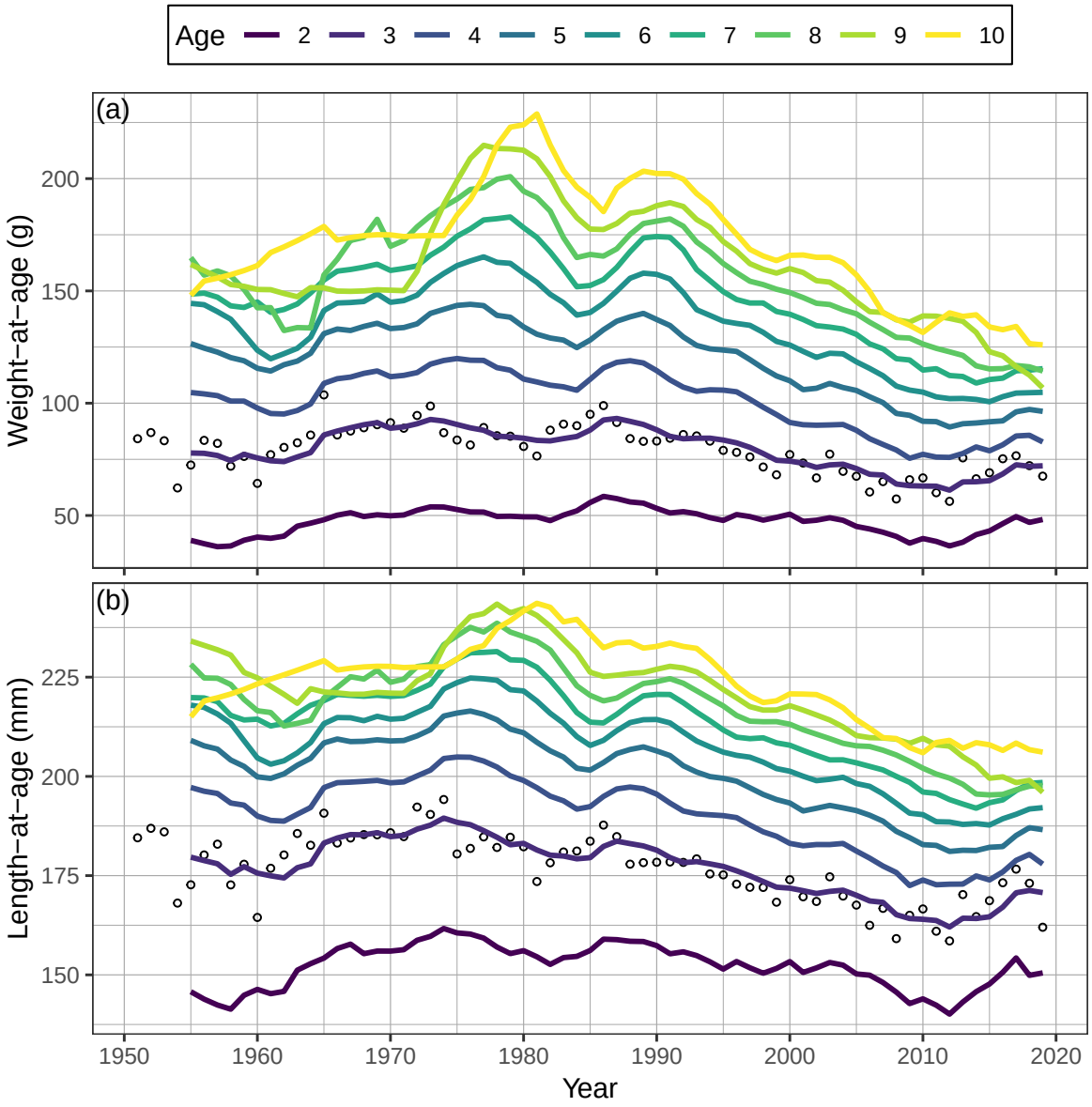

Figure 6. Time series of weight-at-age in grams (g; panel a) and length-at-age in milimetres (mm; panel b) for age-3 (circles) and 5-year running mean weight- and length-at-age (lines) for Pacific Herring from 1951 to 2019 in the Central Coast major stock assessment region (SAR). Missing weight- and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

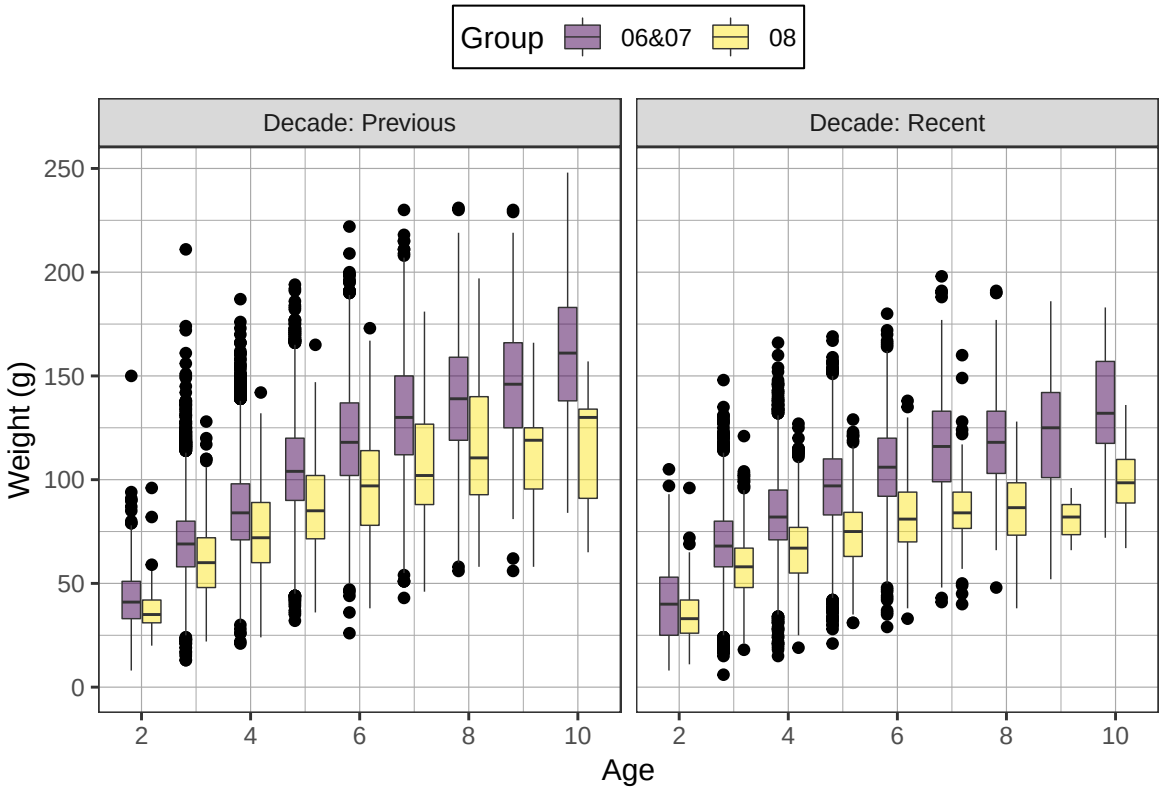

Figure 7. Weight-at-age in grams (g) of Pacific Herring in the Central Coast major stock assessment region (SAR) by Group from the most recent decade (2010 to 2019), and the previous decade (2000 to 2009). The outer edges of the boxes indicate the 25th and 75th percentiles, and the middle lines indicate 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.

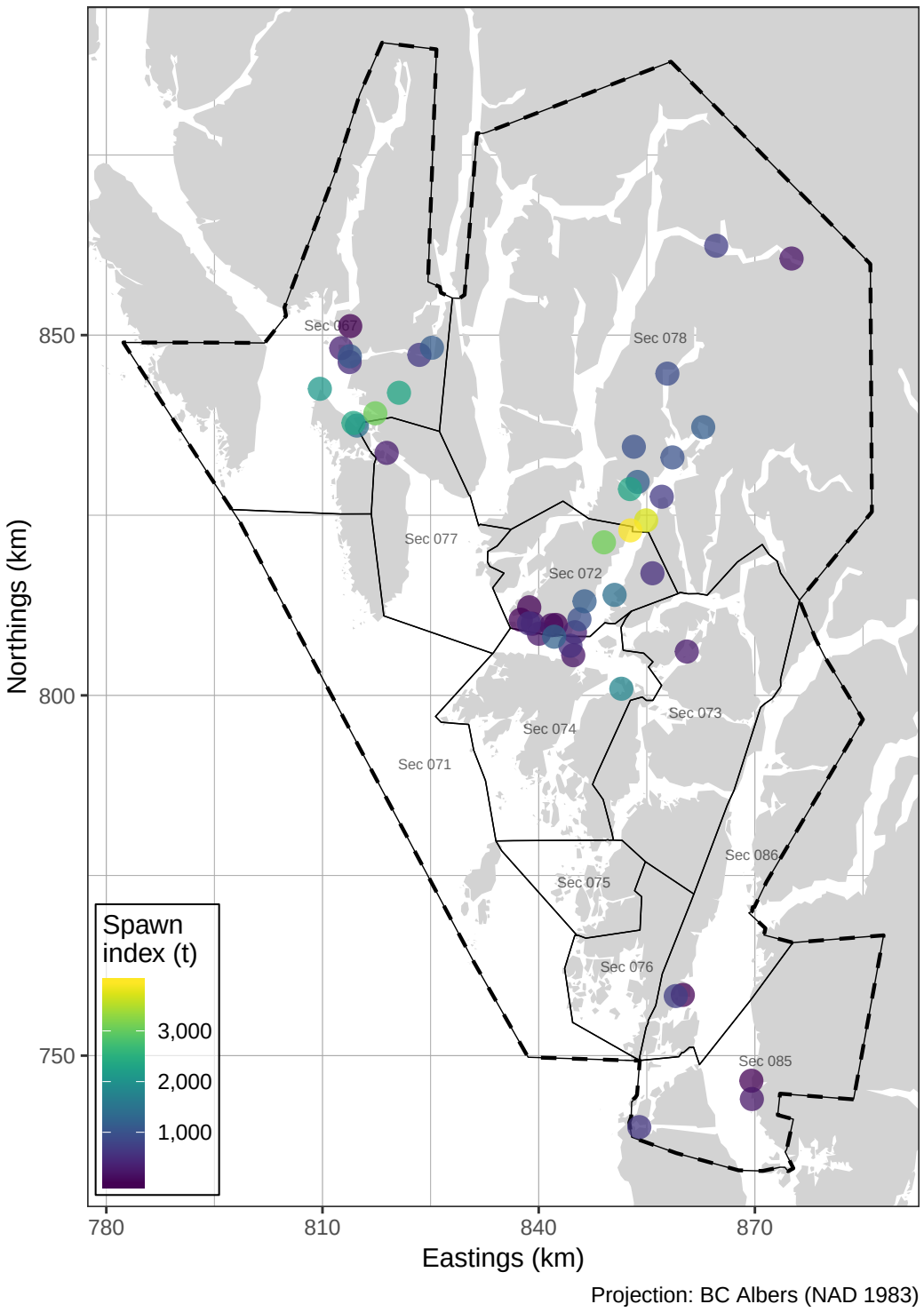

Figure 8. Pacific Herring spawn survey locations, and spawn index in metric tonnes (t) in 2019 in the Central Coast major stock assessment region (SAR; thick dashed lines), and associated Sections (Sec; thin solid lines). The 'spawn index' is not scaled by the spawn survey scaling parameter, q. Missing spawn index values (grey circles) indicate incomplete spawn surveys. Units: kilometres (km).

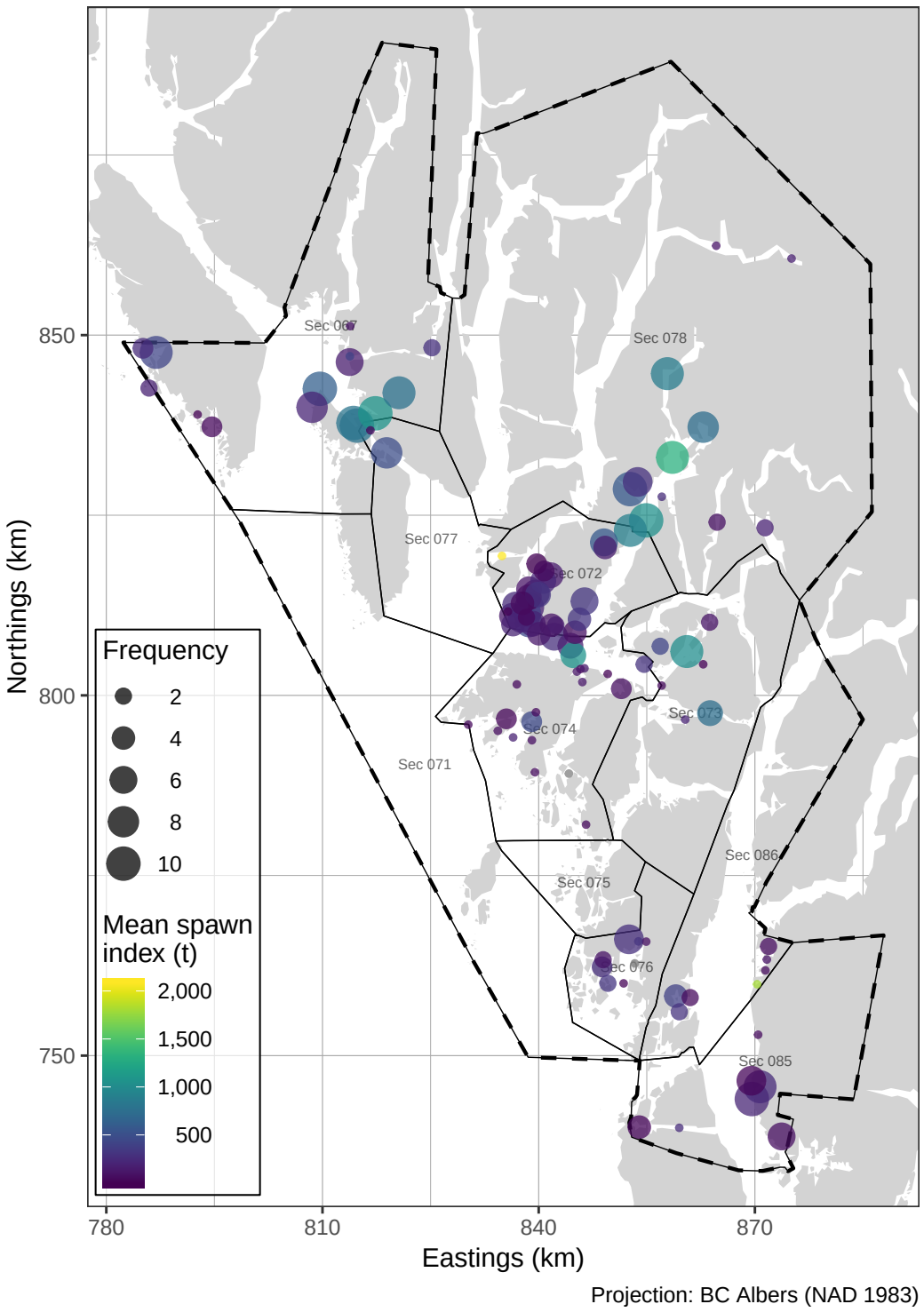

Figure 9. Pacific Herring spawn survey locations, mean spawn index in metric tonnes (t), and spawn frequency from 2009 to 2018 in the Central Coast major stock assessment region (SAR; thick dashed lines), and associated Sections (Sec; thin solid lines). The 'spawn index' is not scaled by the spawn survey scaling parameter, q. Missing spawn index values (grey circles) indicate incomplete spawn surveys. Units: kilometres (km).

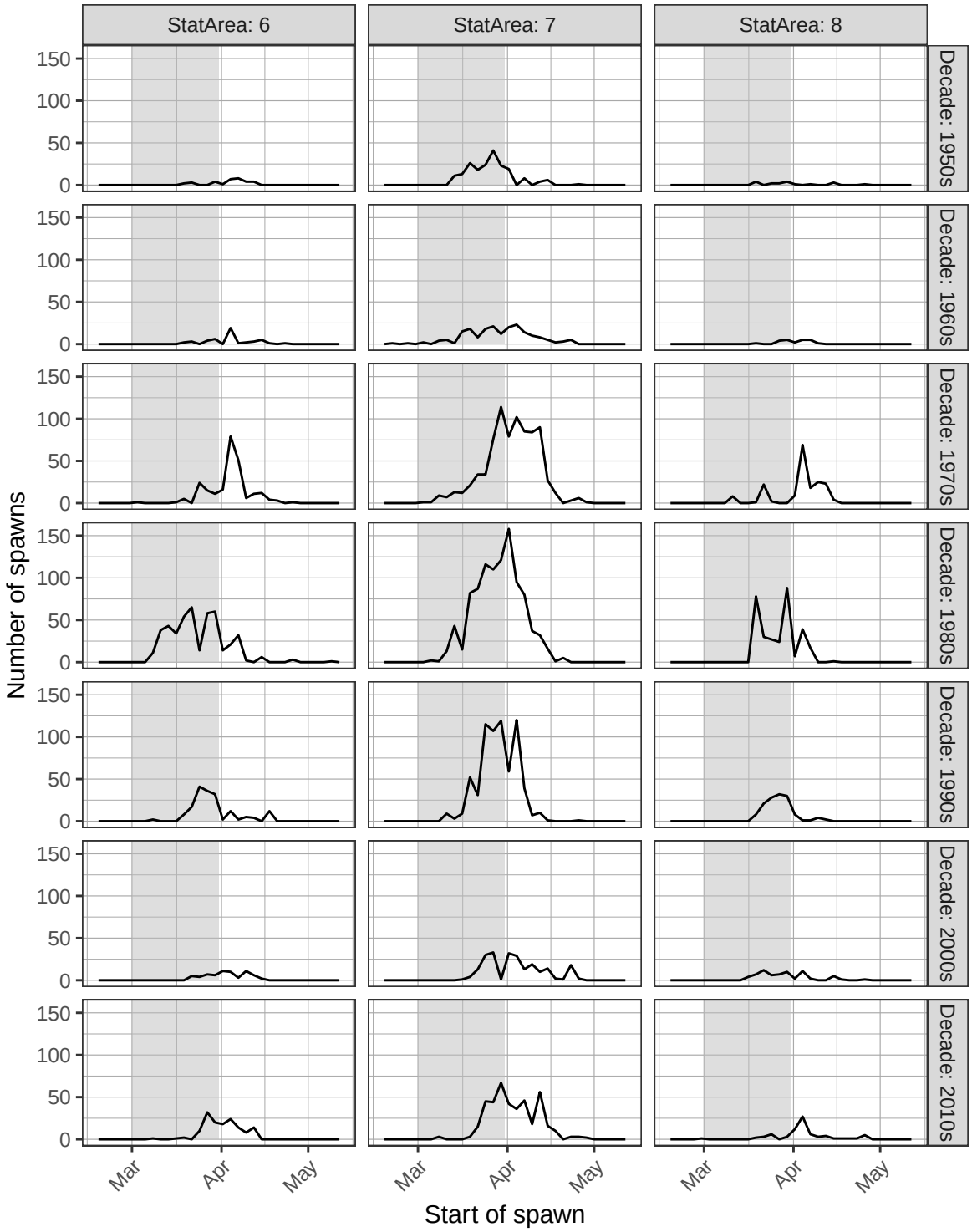

Figure 10. Pacific Herring spawn start date by decade and Statistical Area. Grey shaded regions indicate March 1st to 31st. Note that spawn size and intensity varies; therefore the number of spawns is not directly proportional to spawn extent or biomass.

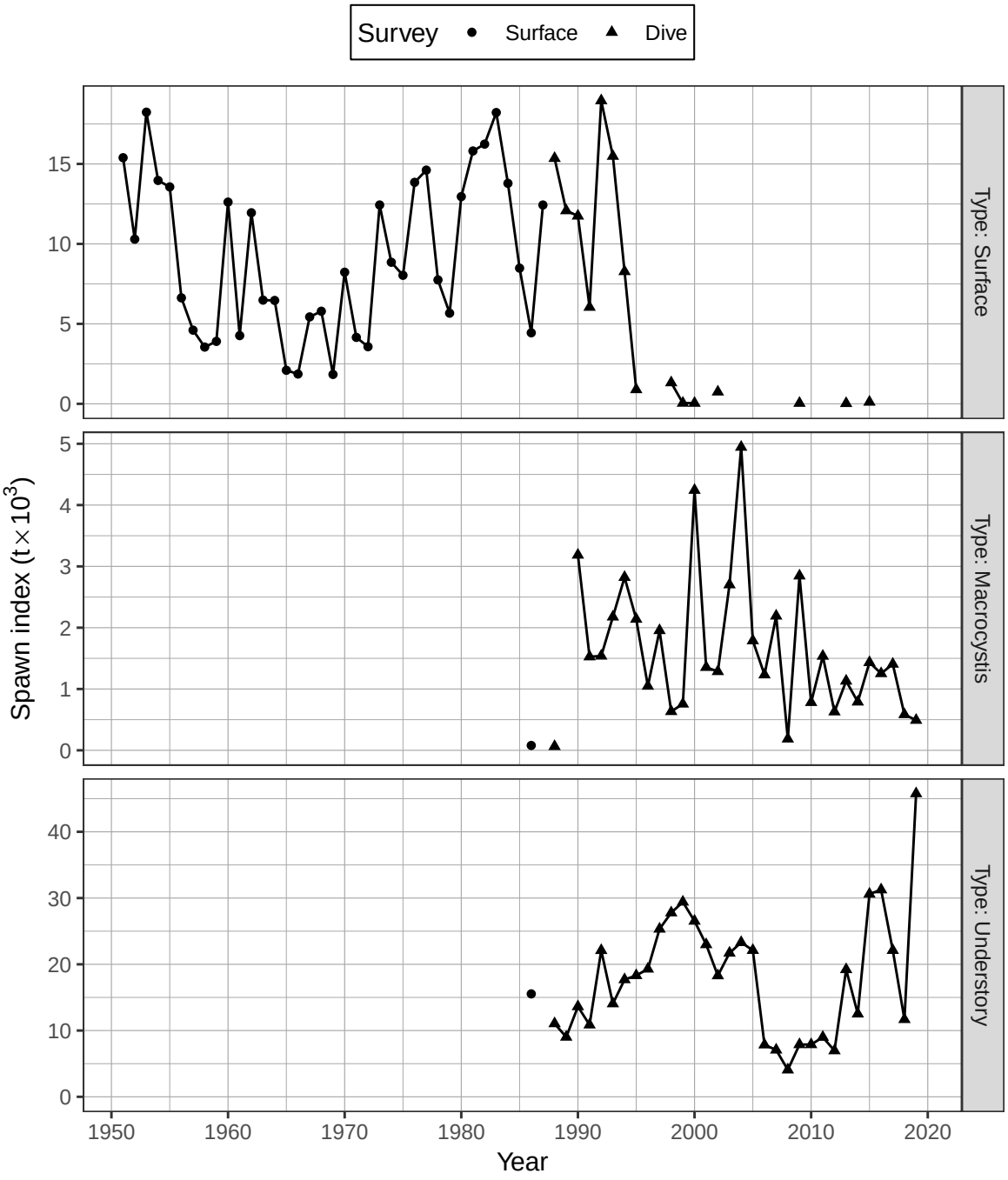

Figure 11. Time series of spawn index in thousands of metric tonnes ($t \times 10^3$) by type for Pacific Herring from 1951 to 2019 in the Central Coast major stock assessment region (SAR). There are three types of spawn survey observations: observations of spawn taken from the surface usually at low 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 2019).

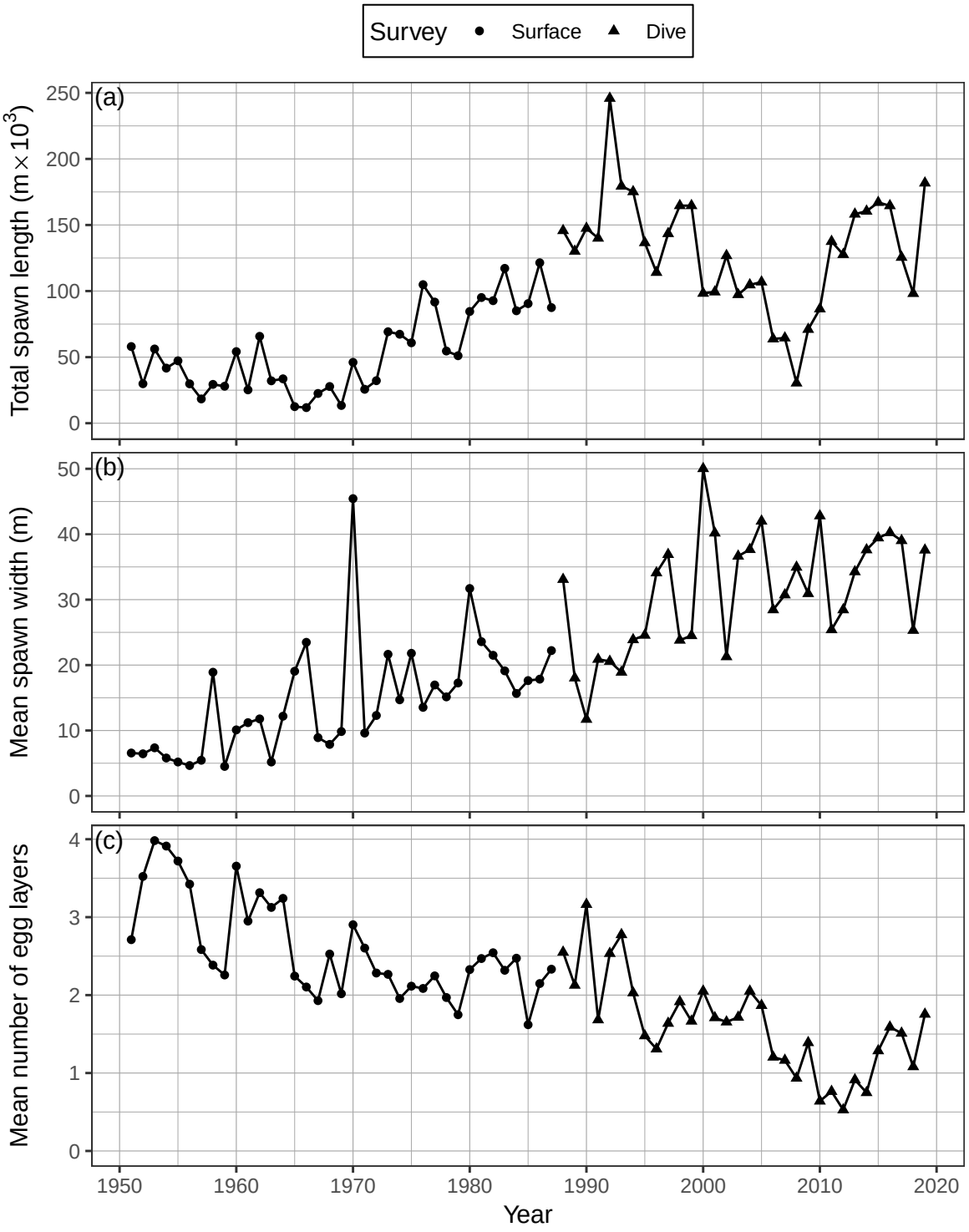

Figure 12. Time series of total spawn length in thousands of metres ($m \times 10^3$; panel a), mean spawn width in metres (b), and mean number of egg layers (c) for Pacific Herring from 1951 to 2019 in the Central Coast major stock assessment region (SAR). The spawn index has two distinct periods defined by the dominant survey method: surface surveys (1951 to 1987), and dive surveys (1988 to 2019).

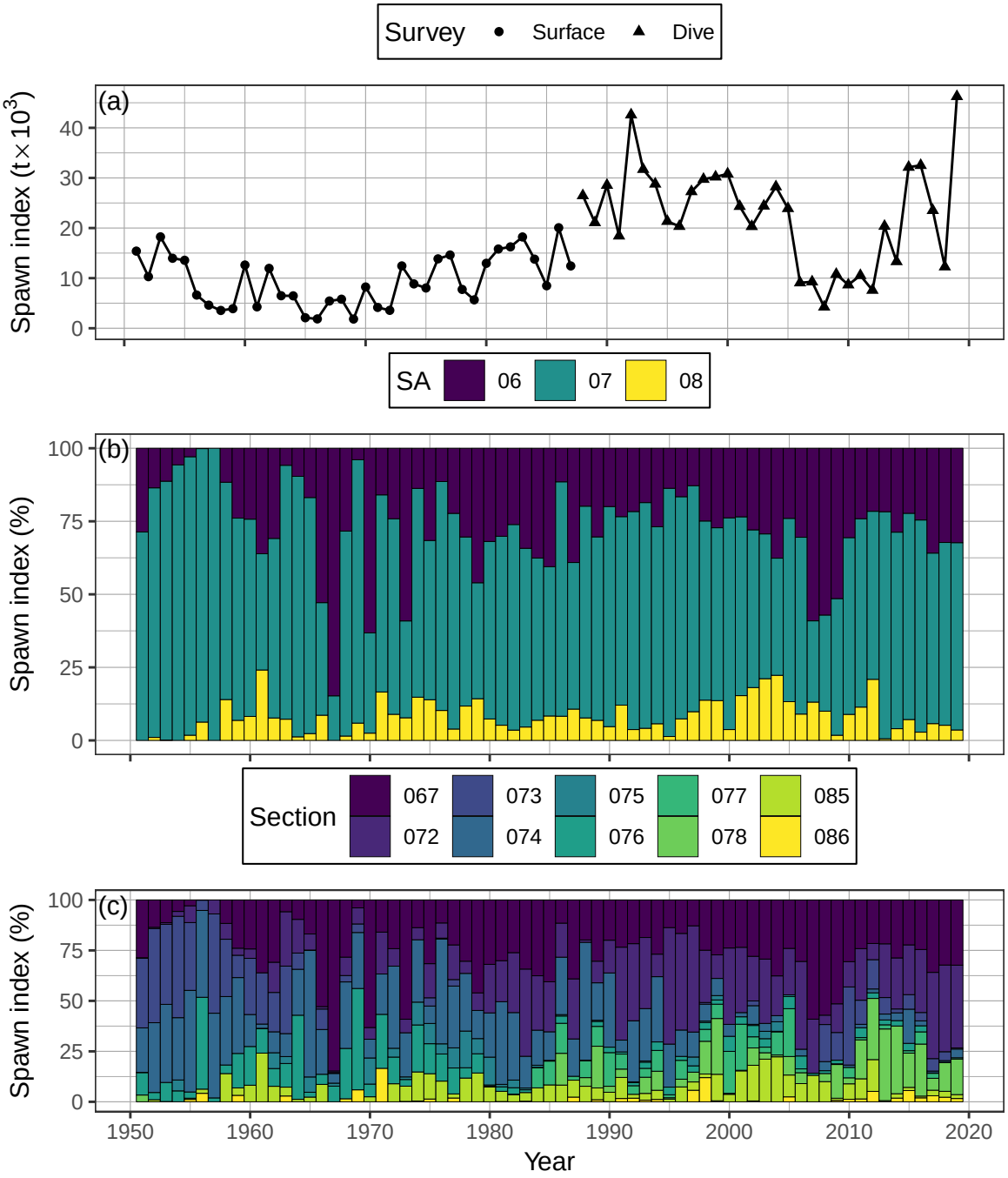

Figure 13. Time series of spawn index in thousands of metric tonnes ($t \times 10^3$) for Pacific Herring from 1951 to 2019 in the Central Coast major stock assessment region (SAR; panel a), as well as percent contributed by Statistical Area (SA), and Section (b, & c, respectively). The spawn index has two distinct periods defined by the dominant survey method: surface surveys (1951 to 1987), and dive surveys (1988 to 2019). 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.

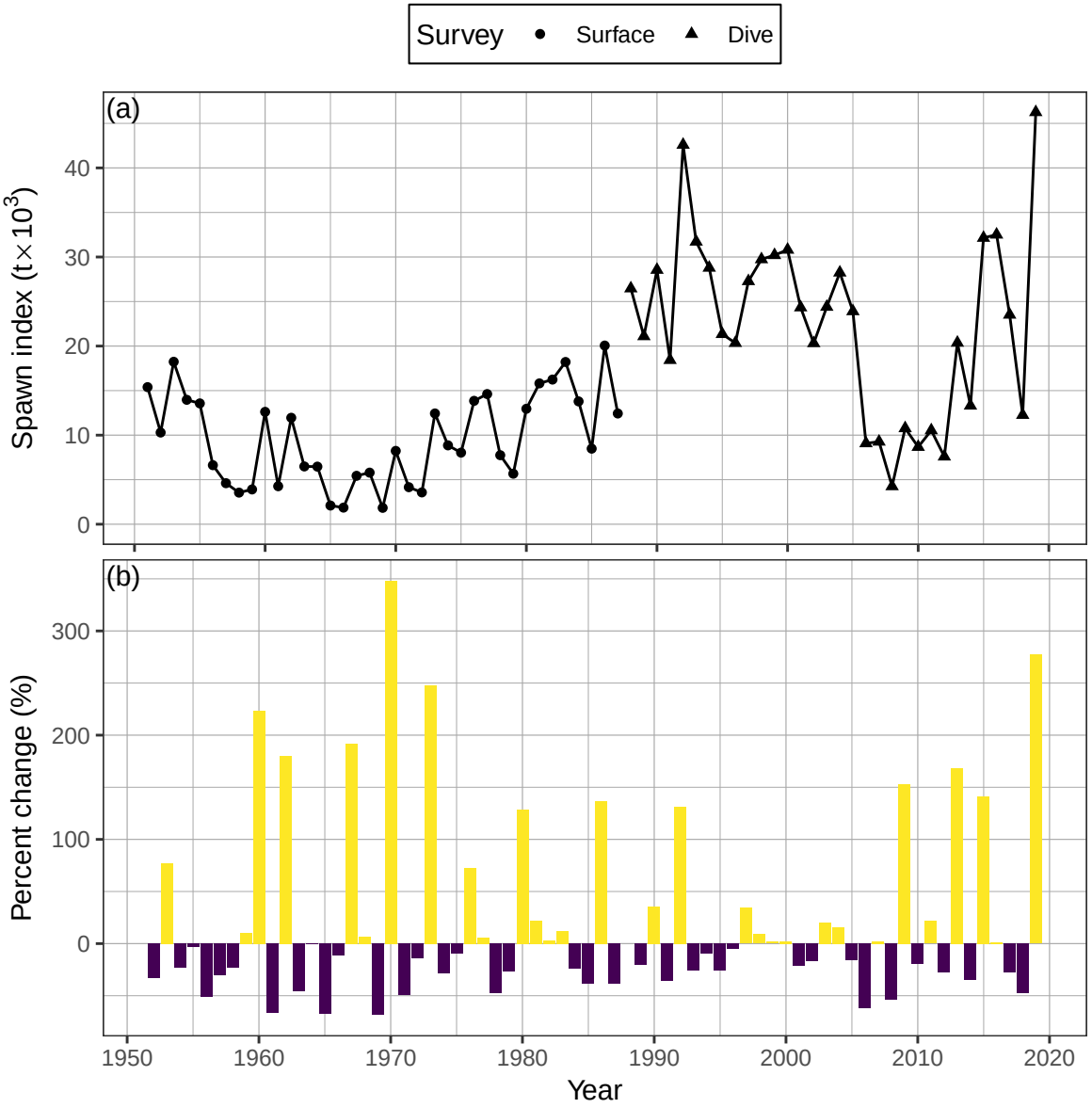

Figure 14. Time series of spawn index in thousands of metric tonnes ($t \times 10^3$) for Pacific Herring from1951 to 2019 in the Central Coast major stock assessment region (SAR; panel a), and percent change (b). We calculate percent change as $\delta_t = \frac{I_t - I_{t-1}}{I_{t-1}}$ where I_t is 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.

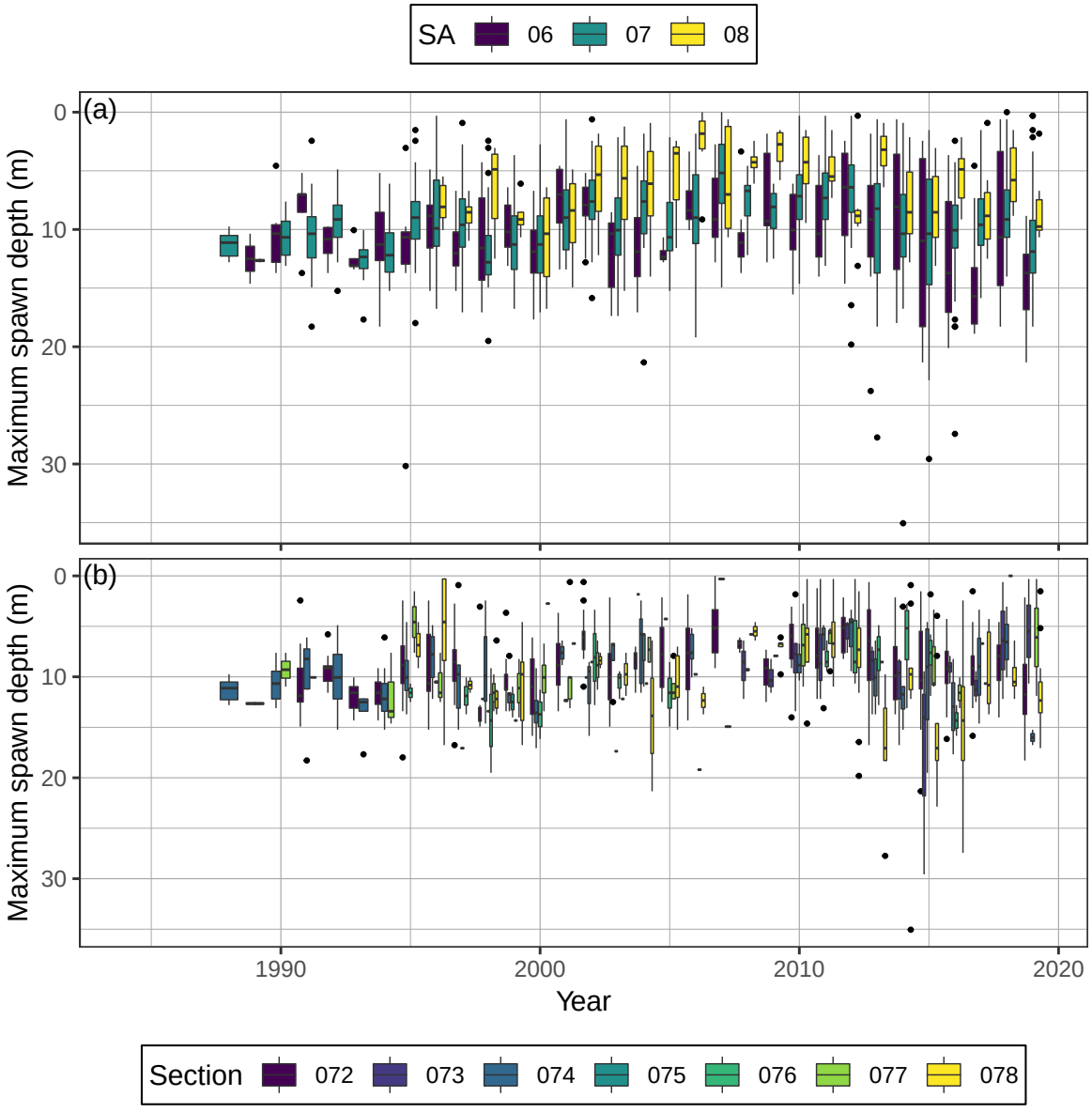

Figure 15. Time series of maximum spawn depth in metres (m) for Pacific Herring from 1984 to 2019 in the Central Coast major stock assessment region (SAR) by Statistical Area (SA; panel a), and Section (b). Note that depth is not corrected to the chart datum. The spawn index has two distinct periods defined by the dominant survey method: surface surveys (1951 to 1987), and dive surveys (1988 to 2019).

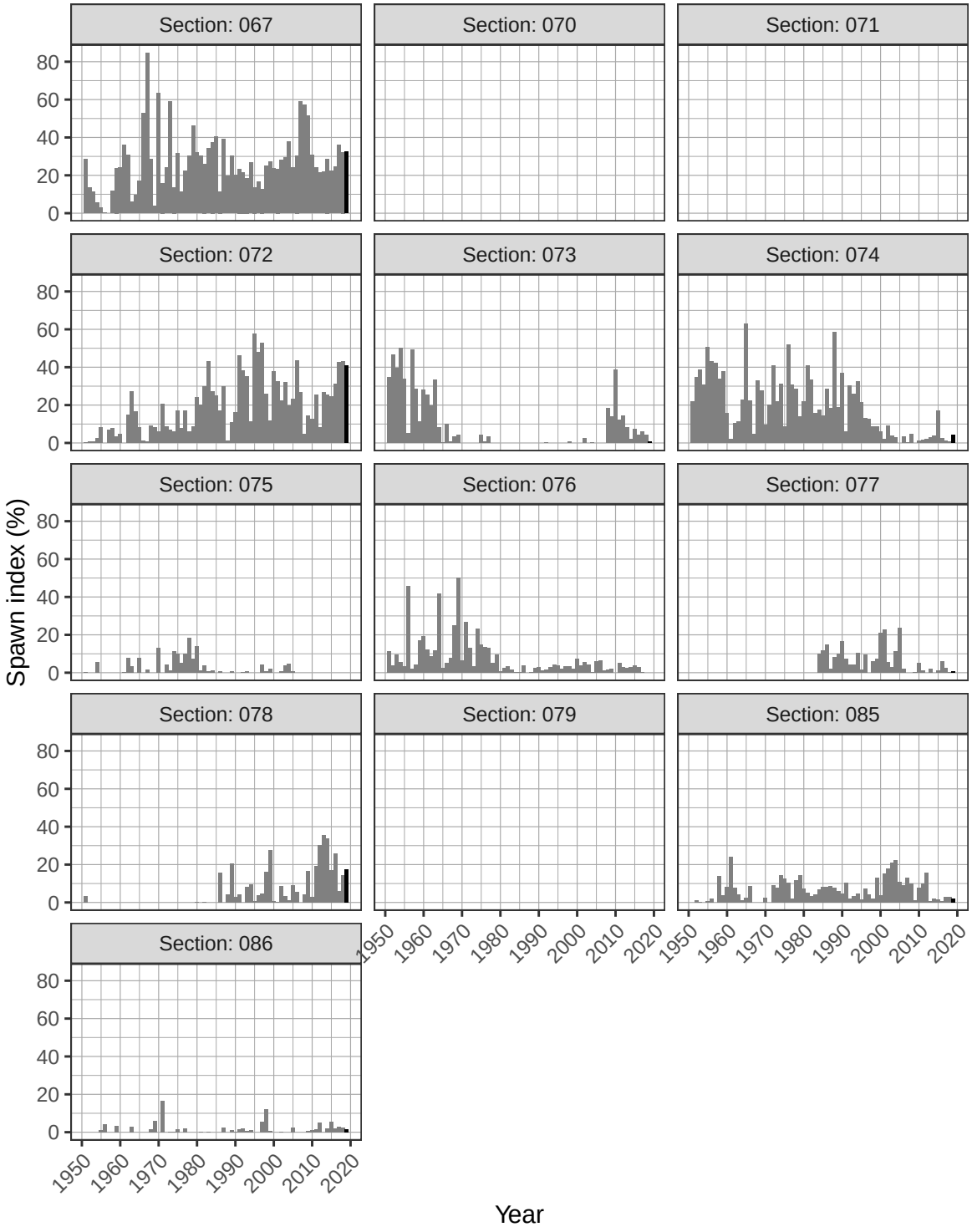

Figure 16. Time series of percent of spawn index by Section for Pacific Herring from 1951 to 2019 in the Central Coast major stock assessment region (SAR). The year 2019 has a darker bar to facilitate interpretation. The spawn index has two distinct periods defined by the dominant survey method: surface surveys (1951 to 1987), and dive surveys (1988 to 2019). The 'spawn index' is not scaled by the spawn survey scaling parameter, q.

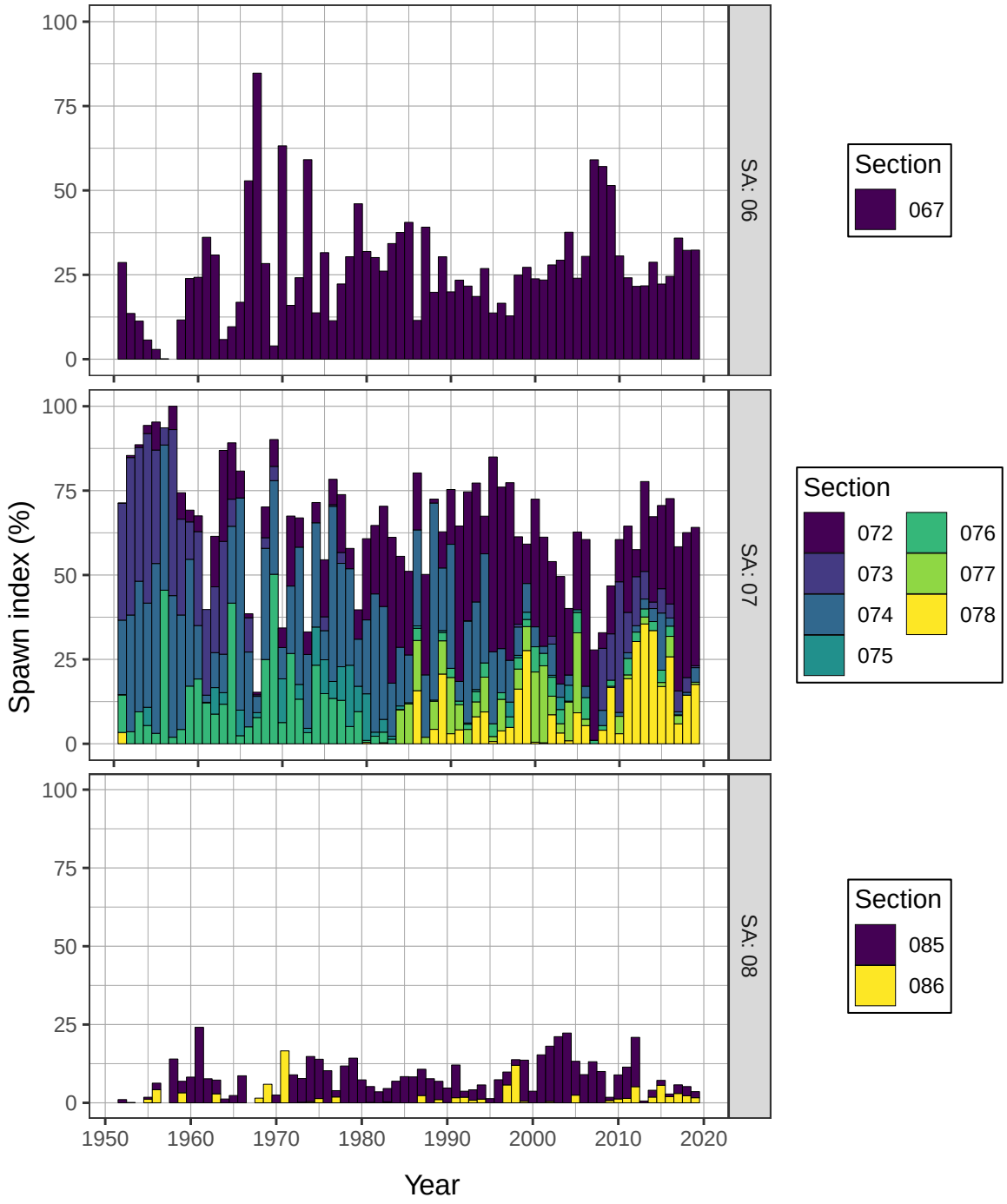

Figure 17. Time series of percent of spawn index by Statistical Area (SA) and Section for Pacific Herring from 1951 to 2019 in the Central Coast major stock assessment region (SAR). The spawn index has two distinct periods defined by the dominant survey method: surface surveys (1951 to 1987), and dive surveys (1988 to 2019). 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.

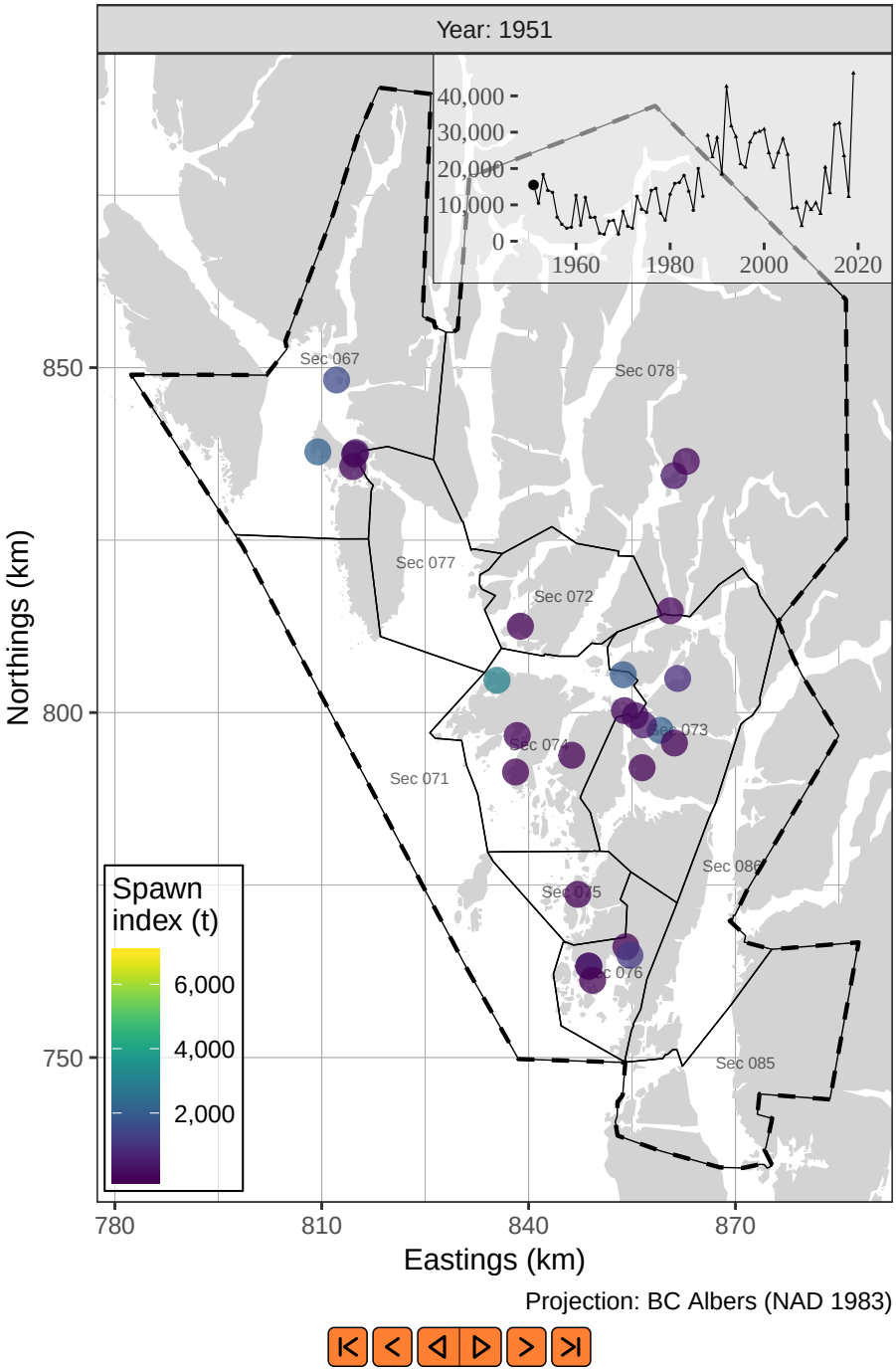

Figure 18. Animation of Pacific Herring spawn survey locations and spawn index in metric tonnes (t) from 1951 to 2019 in the Central Coast major stock assessment region (SAR; thick dashed lines), and associated Sections (Sec; thin solid lines). The spawn index has two distinct periods defined by the dominant survey method: surface surveys (1951 to 1987), and dive surveys (1988 to 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).