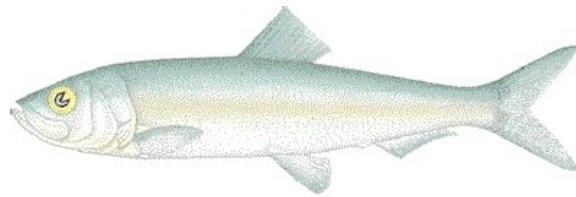# Pacific herring preliminary data summary for Central Coast 2016

DFO Science[*]

June 16, 2017

Pacific herring (*Clupea pallasii*). Image credit: Fisheries and Oceans Canada (`www.pac.dfo-mpo.gc.ca`).

Disclaimer This report contains preliminary data. Therefore, the data may differ from data used and presented in the final Pacific herring stock assessment for Central Coast 2016.

---

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 2016. 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 herring biomass to plan harvesting activities. In-season acoustic soundings are not used by stock assessment to inform the estimation of spawning biomass.

[*]Jaclyn Cleary (email: `Jaclyn.Cleary@dfo-mpo.gc.ca`)

The following is a description of data collected for Pacific herring in the Central Coast major SAR in 2016 (Figure 2). Data collected outside the SAR boundary are not included in this summary, and are not used for the purposes of stock assessment. Note that we refer to 'year' instead of 'herring season' in this report; therefore 2016 refers to the 2015/2016 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 two vessels, the seine test charter "Franciscan No.1" for 10 days from March 1st to March 10th, and the seine charter vessel "Proud Canadian" for 21 days from March 14th to April 3rd. 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.

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

- The charter vessel "Pachena No.1" surveyed 21 days from April 2nd to April 22th.

- The charter vessel "Ocean Cloud" surveyed 12 days from March 30th to April 10th.

- The Kitasoo First Nations conducted 5 days of dive survey on spawn in Clifford Bay (Area 06).

Three gillnet sounding vessels were operating by the Heiltsuk Nation this season - two primarily in Area 07 and one primarily in Area 08 to assist the location of fish for the 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

There were commercial fishing opportunities for seine roe and spawn on kelp (SOK) in 2016 in the Central Coast major stock area. The total landed commercial catch of Pacific herring from all fisheries in 2016 in the Central Coast major SAR was 213 t, which is 66% less than last year (Table 2 and Figure 3). The total harvested spawn on kelp (SOK) in 2016 in the Central Coast major SAR was 351,953 lb, which is associated with an estimated spawning biomass of 2,928 t (Table 3). We use the following equation to convert SOK harvest to spawning biomass [ref?]

$$SB = SOK \cdot 0.00832 \tag{1}$$

where SOK is SOK harvest in pounds, and SB is spawning biomass in tonnes.

In 2016, 20 Pacific herring biological samples were collected and processed for the Central Coast major SAR (Table 4, Table 5), and a total of 1,769 Pacific herring were aged in 2016. The locations in which the biological samples were collected are presented in Figure 4. Included herein are biological summaries of observed proportion-, number-, and weight-at-age (Figure 5, Table 6, and Figure 6, respectively). Some Statistical Areas tend to have larger fish at a given age (Figure 7, Table 7). Biological summaries only include samples collected using seine nets (commercial and test) due to size-selectivity of other gear types such as gillnet.

4 Spawn survey data

Herring spawn surveys were conducted at 55 locations in 2016 in the Central Coast major SAR (Table 8, Figure 8). Spawn surveys are conducted to estimate the spawn length, width, number of layers, and substrate type, and these data are used to estimate the index of spawning biomass (i.e., the spawn index; Figure 9, Figure 10, Figure 11, Figure 12, and Table 9). In addition, spawn surveys estimate spawn depth below surface by Statistical Area, and Section (Figure 13). The 'spawn index' represents the raw survey data only, and 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 (1951–1987), and dive surveys (1988–2016).

Some 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 2016, Section 072 contributed the most to the spawn index (31%). As with Sections, some Statistical Areas contribute more than others to the total spawn index (Figure 12c, Figure 15).

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 addition of a second test charter vessel (one of which commenced in early March) to the Central Coast in 2016 was needed to support data collection in Areas 06, 07, and 08 given the estimated stock biomass has increased since 2012.

- Herring seemed to arrived later than usual this year in the CC.

- Stat Area 06: Squid were spawning at the same time as herring around Kitasu Bay.

- Stat Area 06: Charter skipper reported fungal eggs in Clifford Bay area. Fewer overall reports of fungal eggs in the CC as compared with 2015.

- Stat Area 07: Deeper spawn was reported around the boundary of Spiller Channel and Spiller Inlet. A couple of layers of spawn was observed on bedrock past 30 m.

- Stat Area 07: Tankeeah and Shingle Rock: dive transects were moved to avoid interaction with SOK lines. Moving transects may have an impact on spawn width for this area.

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. Total landed commercial catch of Pacific herring in metric tonnes (t) by fishery in 2016 in the Central Coast major stock assessment region (SAR).

Fishery	Use	Catch (t)
Seine	Roe	213

Table 3. Total harvested Pacific herring spawn on kelp (SOK) in pounds (lb), and the associated estimate of spawning biomass in metric tonnes (t) from 2006 to 2016 in the Central Coast major stock assessment region (SAR).

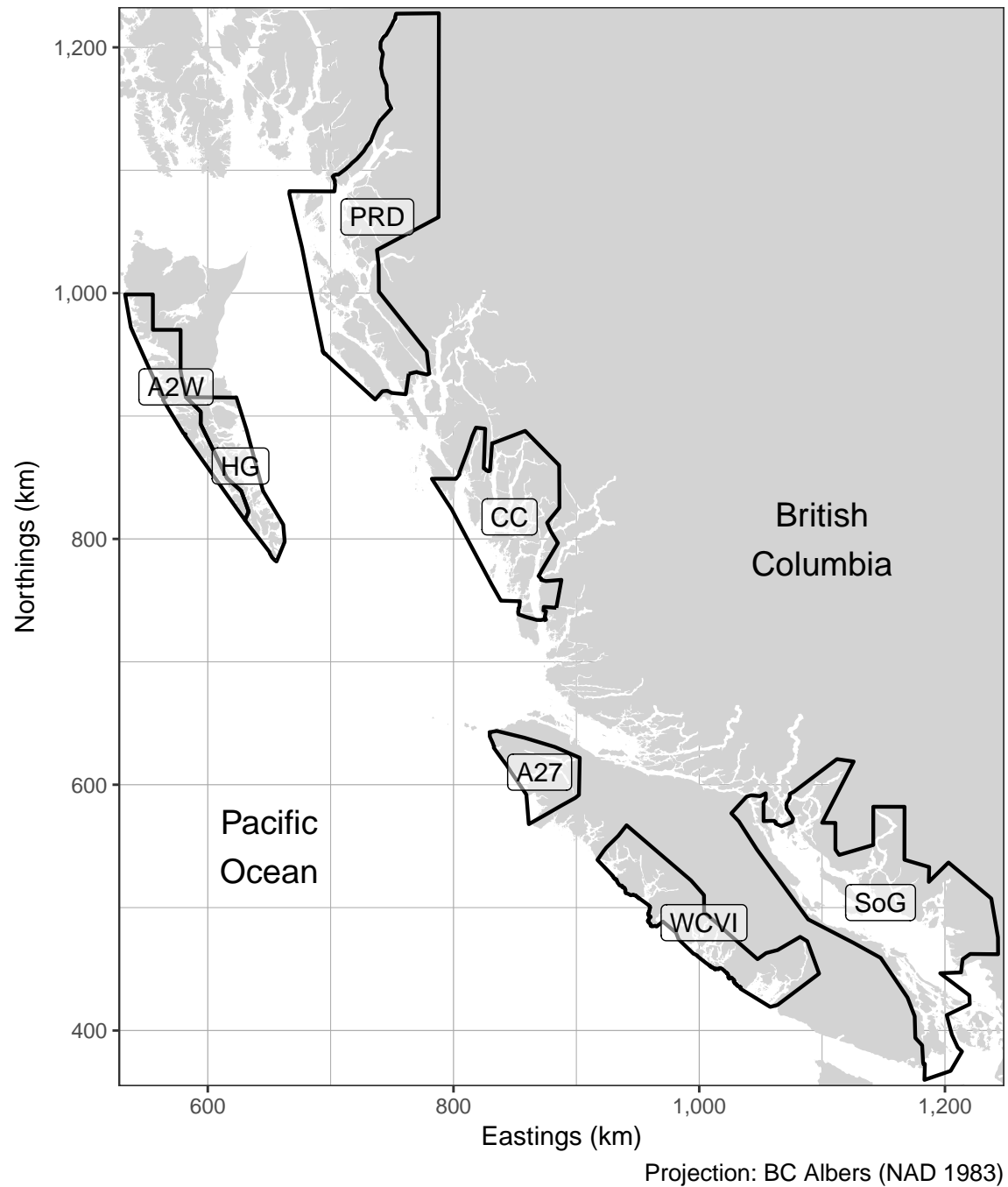| Year	Harvest (lb)	Spawning biomass (t)
2006	422,850	3,518
2007	130,596	1,086
2008	0	0
2009	0	0
2010	0	0
2011	0	0
2012	0	0
2013	0	0
2014	239,861	1,995
2015	169,470	1,410
2016	351,953	2,928

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). Units: kilometres (km). Also see Table 1.
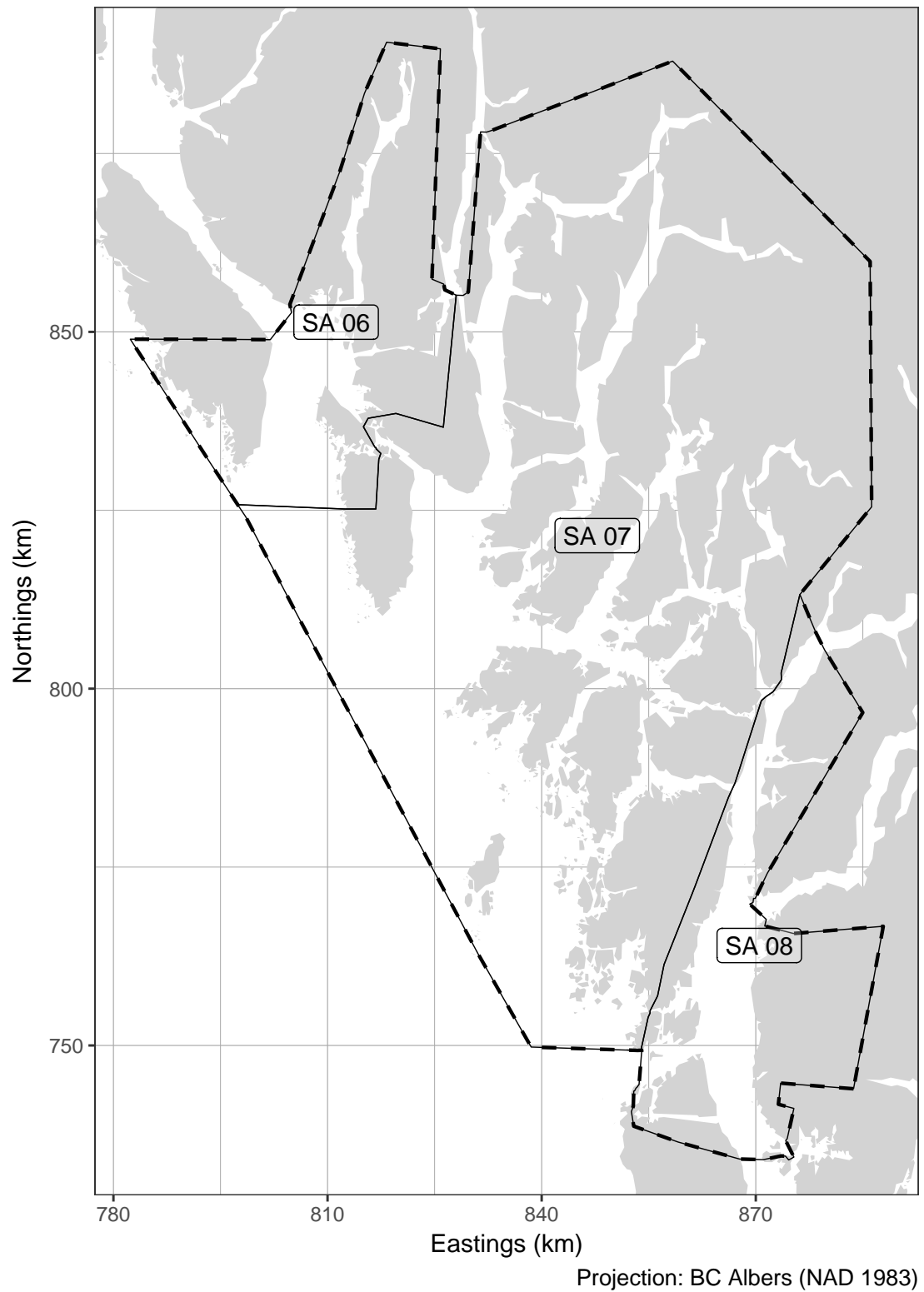
Figure 2. Boundaries for the Central Coast major stock assessment region (SAR; thick dashed lines), and associated Statistical Areas (SA; thin solid lines). Units: kilometres (km).
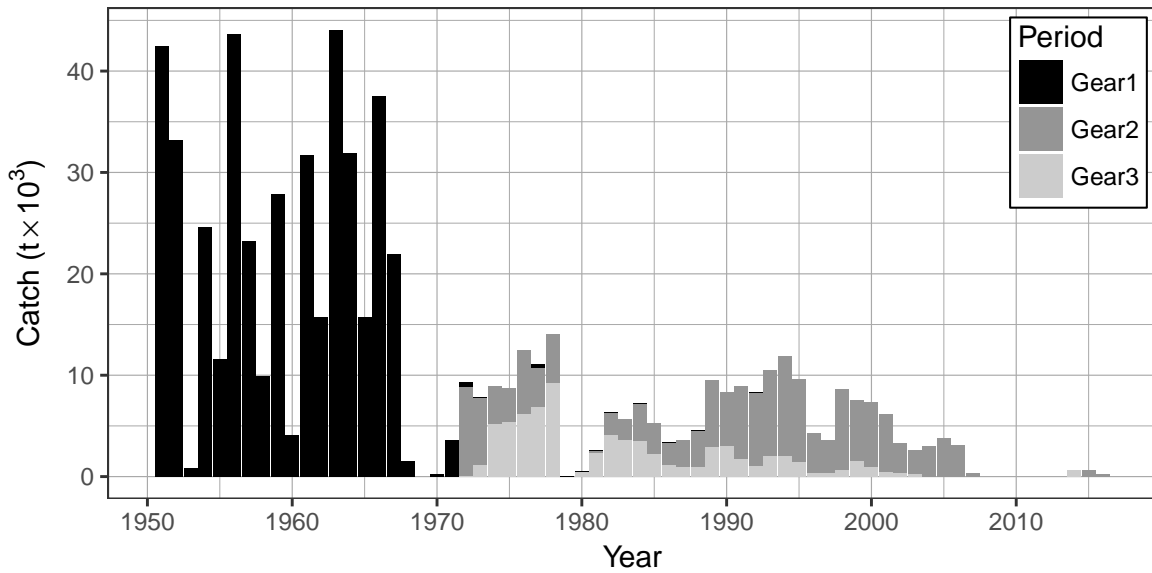
Figure 3. Time series of total landed catch in thousands of metric tonnes ($t \times 10^3$) of Pacific herring by gear type from 1951 to 2016 in the Central Coast major stock assessment region (SAR). Legend: 'Gear1' represents the reduction, the food and bait, as well as the special use fishery; 'Gear2' represents the roe seine fishery; and 'Gear3' represents the roe gillnet fishery.

Table 4. Number of Pacific herring biological samples processed from 2006 to 2016 in the Central Coast major stock assessment region (SAR). Each sample is approximately 100 fish.

	Number of samples		
Year	Commercial	Test	Total
2006	8	56	64
2007	13	13	26
2008	0	17	17
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

Table 5. Number and type of Pacific herring biological samples processed in 2016 in the Central Coast major stock assessment region (SAR). Each sample is approximately 100 fish.

Type	Gear	Use	Number of samples
Commercial	Seine	Other	2
Commercial	Seine	Roe Fishery	3
Test	Seine	Test Fishery	15

Table 6. Observed proportion-at-age for Pacific herring from 2006 to 2016 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
2006	0.009	0.120	0.556	0.100	0.166	0.034	0.008	0.005	0.001
2007	0.014	0.299	0.190	0.316	0.081	0.079	0.016	0.004	0.001
2008	0.142	0.103	0.419	0.117	0.156	0.028	0.027	0.005	0.001
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
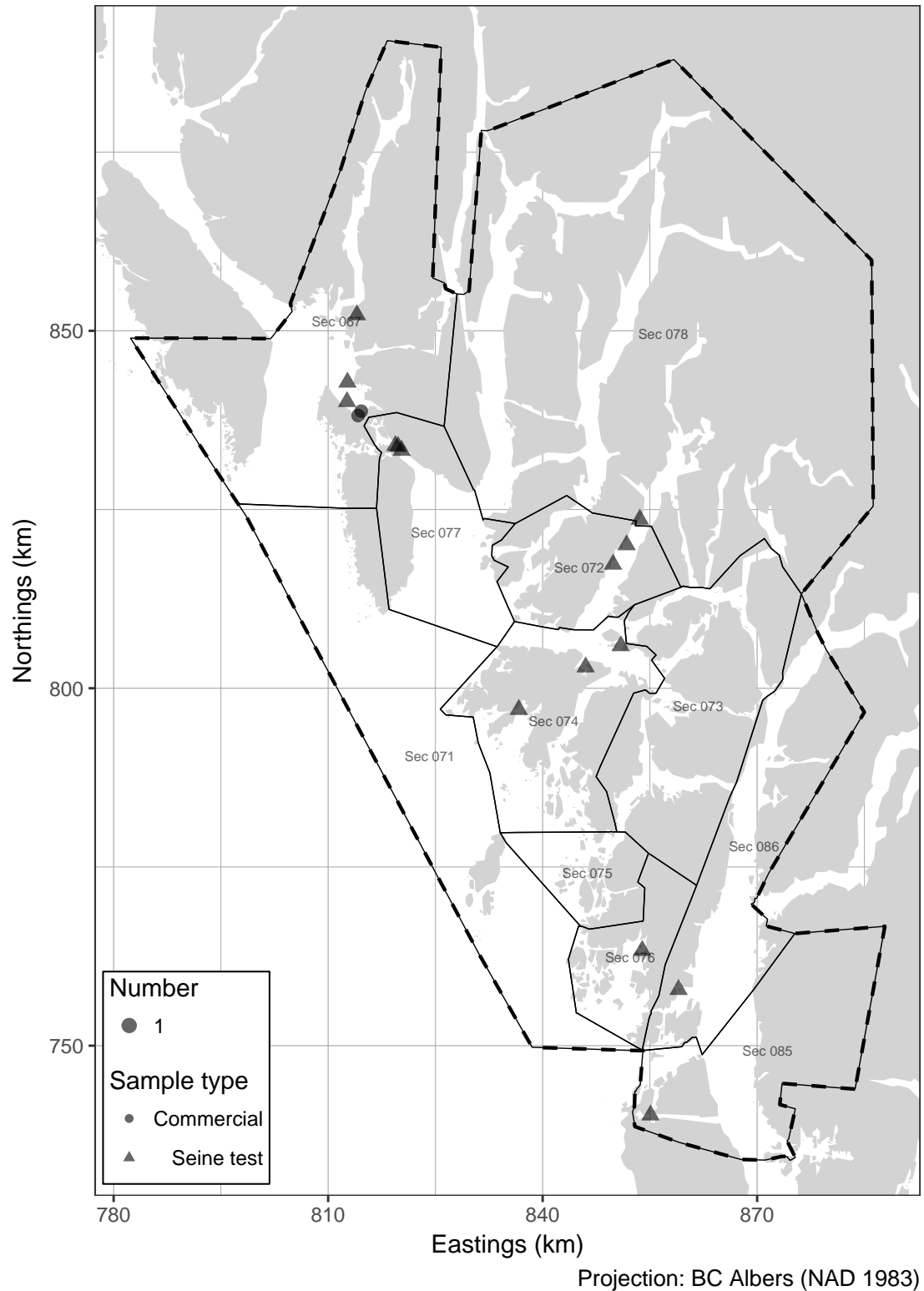
Figure 4. Location and type of Pacific herring biological samples collected in 2016 in the Central Coast major stock assessment region (SAR; thick dashed lines), and associated Sections (Sec; thin solid lines). Units: kilometres (km).
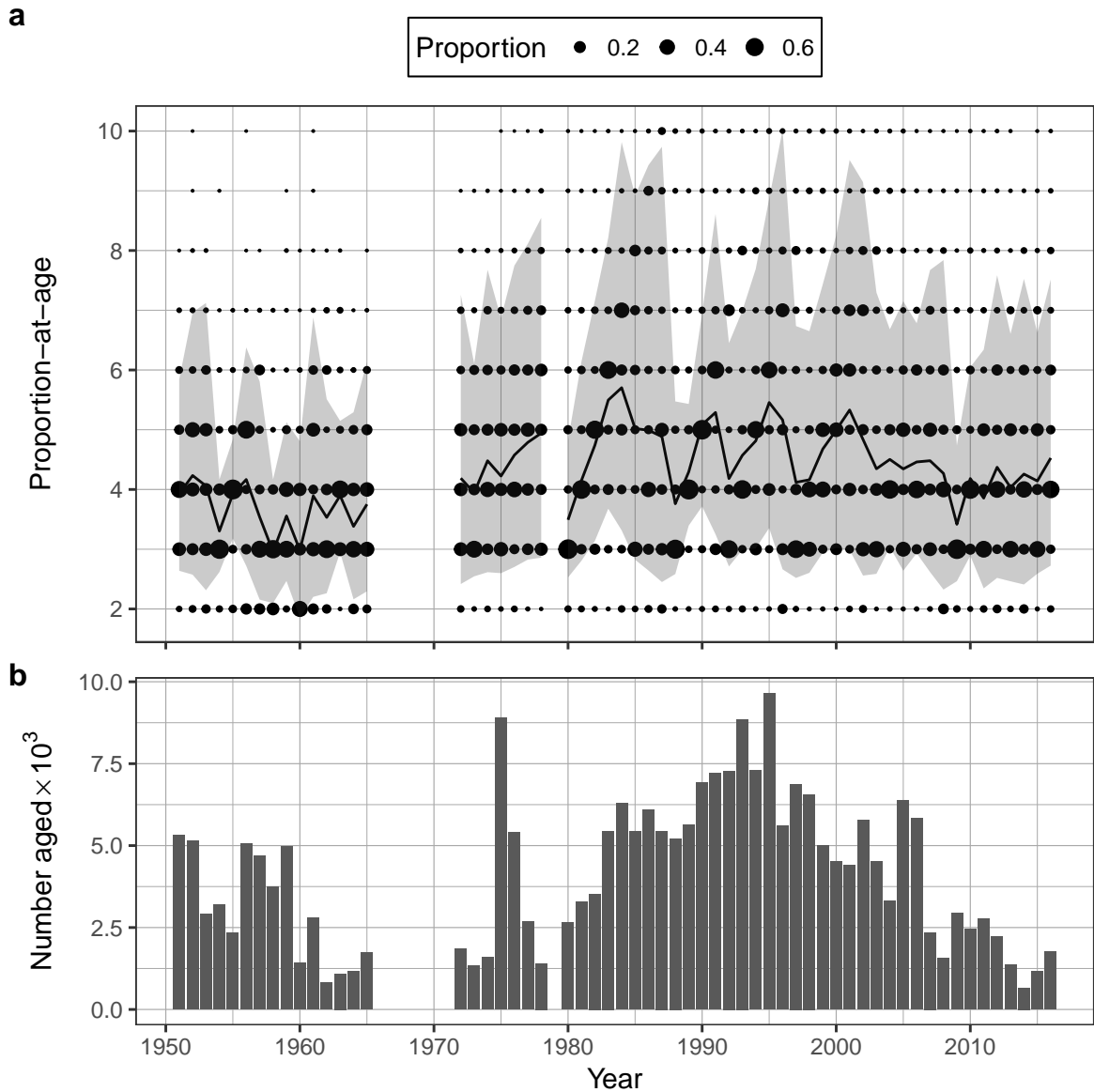
a

b

Figure 5. Time series of observed proportion-at-age (a) and number aged (b) of Pacific herring from 1951 to 2016 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.
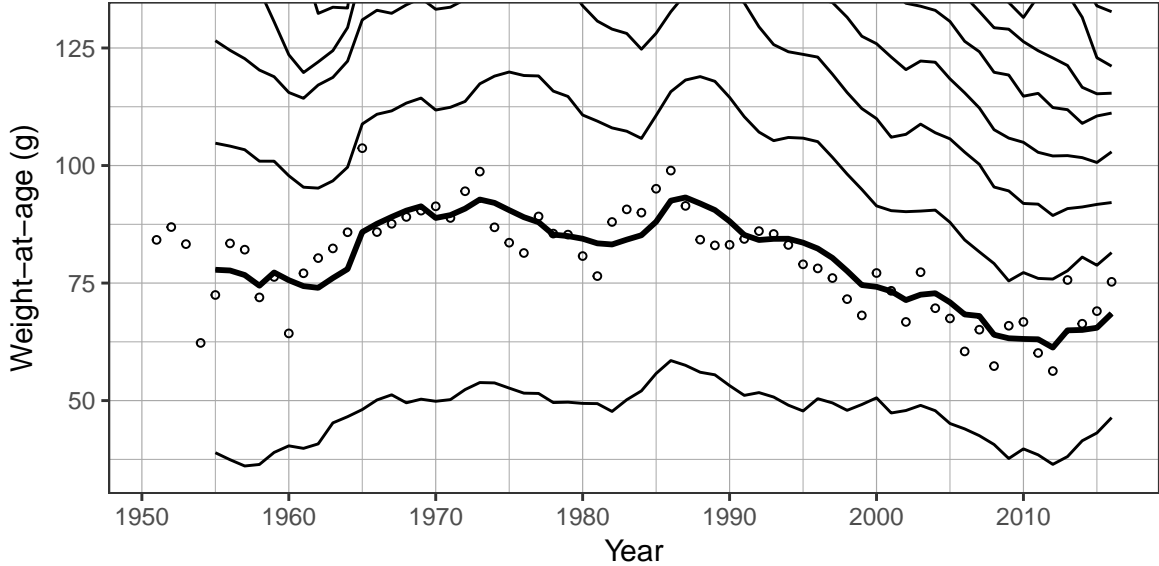
Figure 6. Time series of weight-at-age in grams (g) for age-3 (circles) and 5-year running mean weight-at-age (lines) for Pacific herring from 1951 to 2016 in the Central Coast major stock assessment region (SAR). Lines show 5-year running means for age-2 to age-10 herring (incrementing higher from the lowest line); the thick black line highlights age-3 herring. Missing weight-at-age values (i.e., years where there are 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.
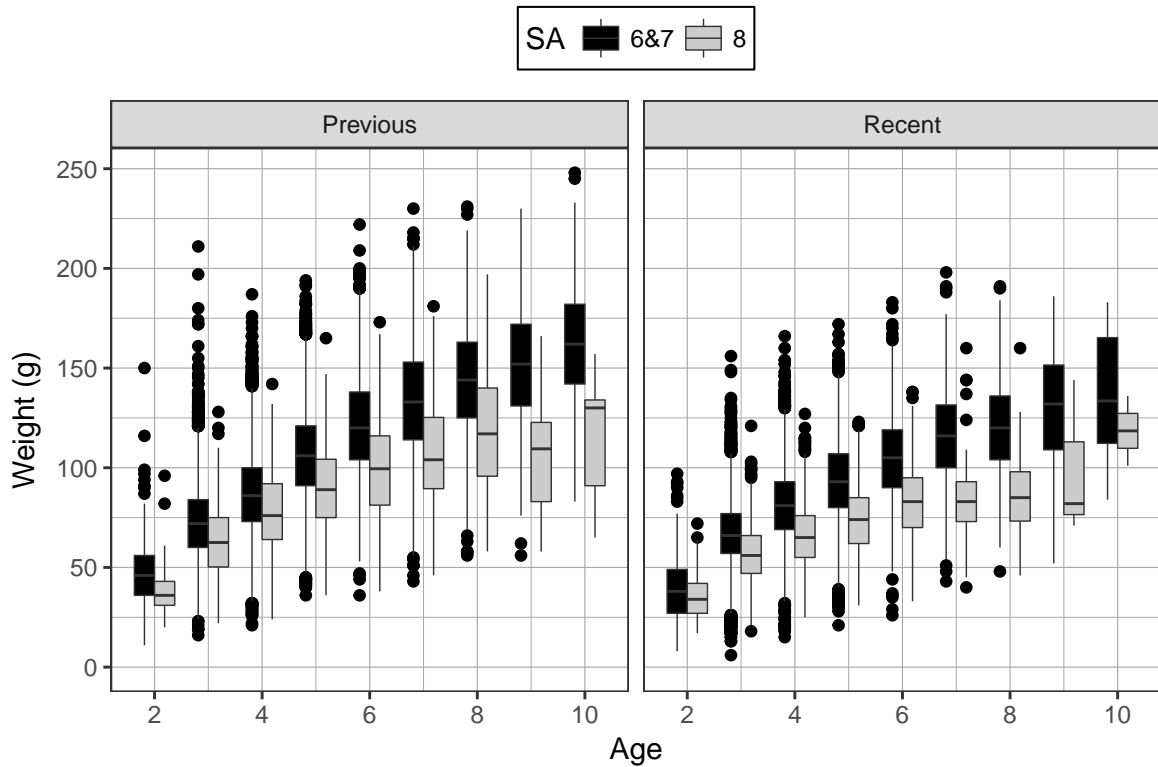
Figure 7. Weight-at-age in grams (g) of Pacific herring in the Central Coast major stock assessment region (SAR) by Statistical Area (SA) from the most recent decade (2007 to 2016), and the previous decade (1997 to 2006). The outer edges of the boxes indicate the 25th and 75th percentiles, and the middle 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 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.

Table 7. Sample size for Pacific herring weight-at-age analysis in 2016 in the Central Coast major stock assessment region (SAR) by Statistical Area (SA) from the most recent decade (2007 to 2016), and the previous decade (1997 to 2006), 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.

		Sample size	
SA	Age	Previous decade	Recent decade
6&7	2	772	737
6&7	3	14,134	5,797
6&7	4	14,827	5,567
6&7	5	8,642	2,906
6&7	6	5,364	1,545
6&7	7	3,254	659
6&7	8	2,072	289
6&7	9	819	87
6&7	10	325	30
8	2	65	272
8	3	966	1,031
8	4	979	923
8	5	488	304
8	6	266	167
8	7	172	53
8	8	72	14
8	9	14	3
8	10	5	2

Table 8. Pacific herring spawn survey locations and spawn index in metric tonnes (t) in 2016 in the Central Coast major stock assessment region (SAR). The 'spawn index' represents the raw survey data only, and is not scaled by the spawn survey scaling parameter, q. Missing spawn index values (i.e., NA) indicate incomplete spawn surveys.

Statistical Area	Section	Location code	Location name	Spawn index (t)
06	067	424	Meyers Psg	425
06	067	425	Parsons Anch	1,034
06	067	430	Marvin Is	1,364
06	067	432	Osment Inlt	1,869
06	067	433	Wilby Pt	736
06	067	434	Kwakwa Cr	1,254
06	067	436	Wingate Pt	325
06	067	1842	Clifford Bay	472
06	067	1862	Abrams Is	302
06	067	3079	Woodcock Is	199
07	072	457	Spiller Chnl	2,327
07	072	467	Watch Is	1,030
07	072	469	Balagny Pass	775
07	072	471	Berry Inlt	54
07	072	480	Powell Anch	519
07	072	481	Shingle Rk	282
07	072	489	Lake Is	9
07	072	491	Cecilia Is	40
07	072	496	Lambard Inlt	183
07	072	499	Lady Trutch Pass	41
07	072	529	Reid Pass	549
07	072	1537	Port Blackney	231
07	072	1618	Boat Inlt	15
07	072	1688	King Cv	4
07	072	1692	Oliver Cv	549
07	072	1693	Leighton Is	227
07	072	1864	Foote Islets	91
07	072	1875	Fisher Pt	405
07	072	1876	Bush Pt	844
07	072	1907	Mouat Cv	330
07	072	1909	Mosquito Bay	256
07	072	1929	Branks It	184
07	072	1933	Cameron Pt	14
07	072	1943	Tankeeah River	847
07	072	1987	Bullen Rk	304
07	072	3025	Bird Pt	34
07	073	454	Gunboat Pass	1,298
07	073	500	Dumas Pt	48

Table 8 continued				
Statistical Area	Section	Location code	Location name	Spawn index (t)
07	074	1749	Little Thompson Bay	790
07	076	564	Goodlad Bay	982
07	077	1748	E Higgins Pass	1,968
07	078	515	Roscoe Inlt	313
07	078	516	Ellerslie Bay	980
07	078	517	Spiller Chnl Hd	3,596
07	078	518	Spiller Inlt	2,927
07	078	519	Briggs Inlt	157
07	078	1846	Neekas Inlt	40
07	078	1949	Neekas Cv	366
08	085	575	Kwakume Inlt	124
08	085	576	Illahie Inlt	111
08	085	603	Pruth Bay	24
08	085	1363	Kwakume Pt	9
08	085	1529	Whidbey Pt	11
08	086	497	Mustang Bay	589
08	086	2086	Unknown Sec 086	50

Table 9. Summary of spawn survey data from 2006 to 2016 in the Central Coast major stock assessment region (SAR). The spawn index has two distinct periods defined by the dominant survey method: surface surveys (1951–1987), and dive surveys (1988–2016). The 'spawn index' represents the raw survey data only, and is not scaled by the spawn survey scaling parameter, q. Units: metres (m), and metric tonnes (t).

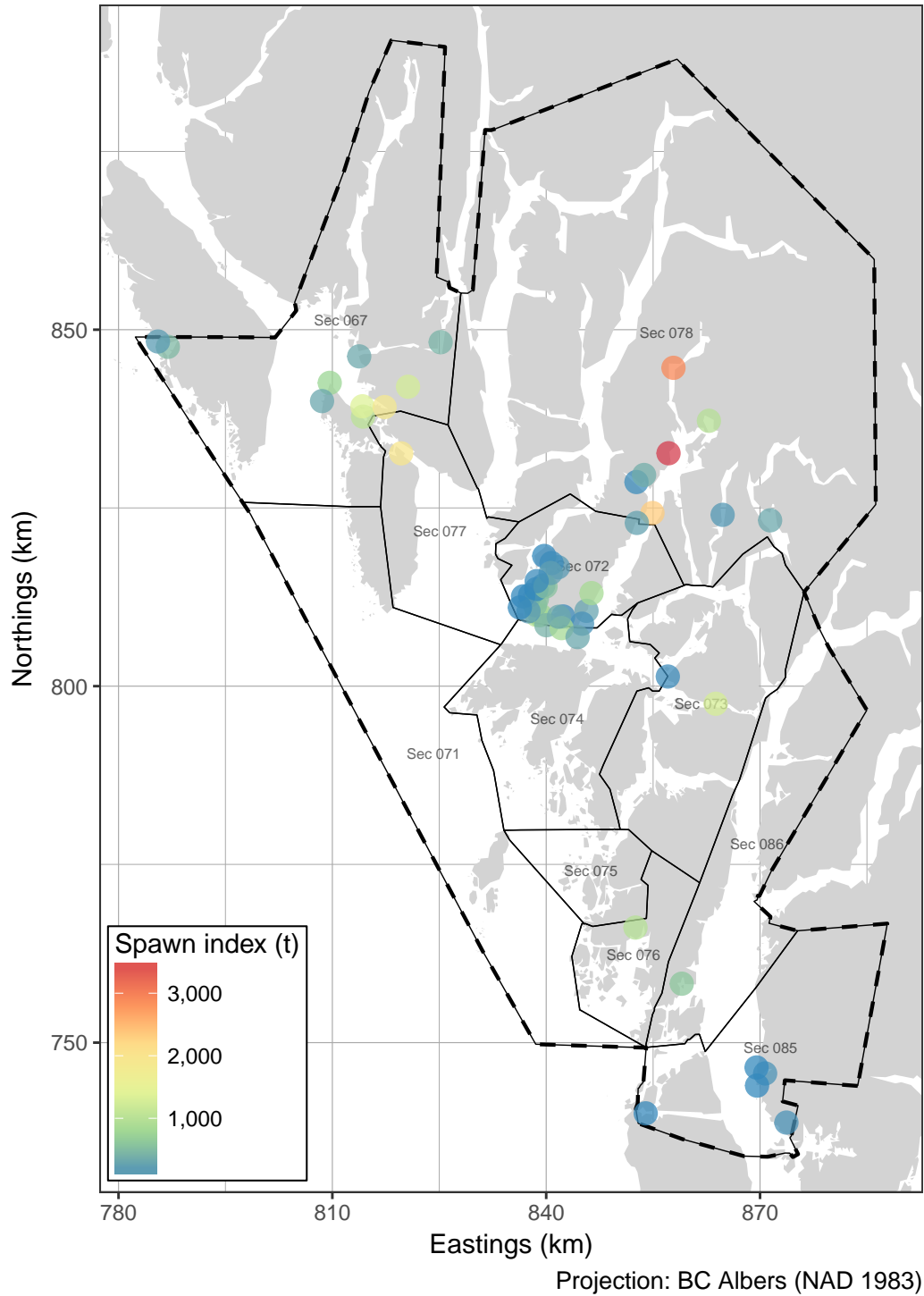| Year	Total length (m)	Mean width (m)	Mean number of layers	Spawn index (t)
2006	63,775	28	1.204	9,081
2007	64,500	31	1.163	9,264
2008	30,390	35	0.934	4,255
2009	70,980	31	1.390	10,771
2010	86,490	43	0.640	8,671
2011	137,530	25	0.763	10,534
2012	127,632	28	0.527	7,592
2013	158,205	34	0.913	20,369
2014	160,450	38	0.749	13,309
2015	167,060	39	1.285	32,146
2016	164,575	40	1.589	32,508

Figure 8. Location of Pacific herring spawning locations in 2016 in the Central Coast major stock assessment region (SAR; thick dashed lines), and associated Sections (Sec; thin solid lines). The 'spawn index' represents the raw survey data only, and is not scaled by the spawn survey scaling parameter, q. Missing spawn index values (grey circles) indicate incomplete spawn surveys. Units: kilometres (km), and metric tonnes (t).
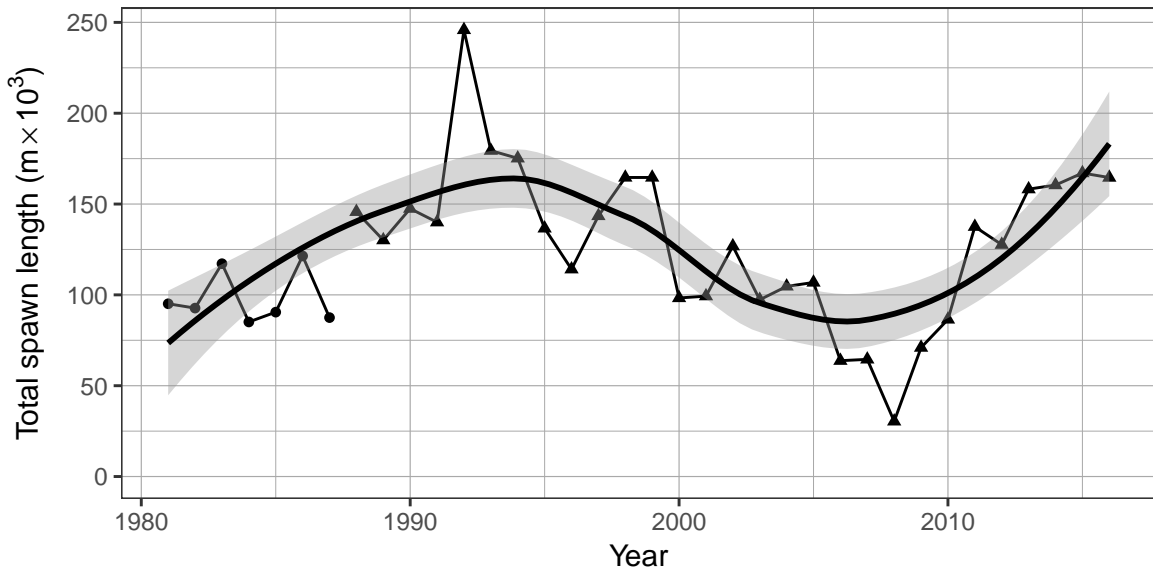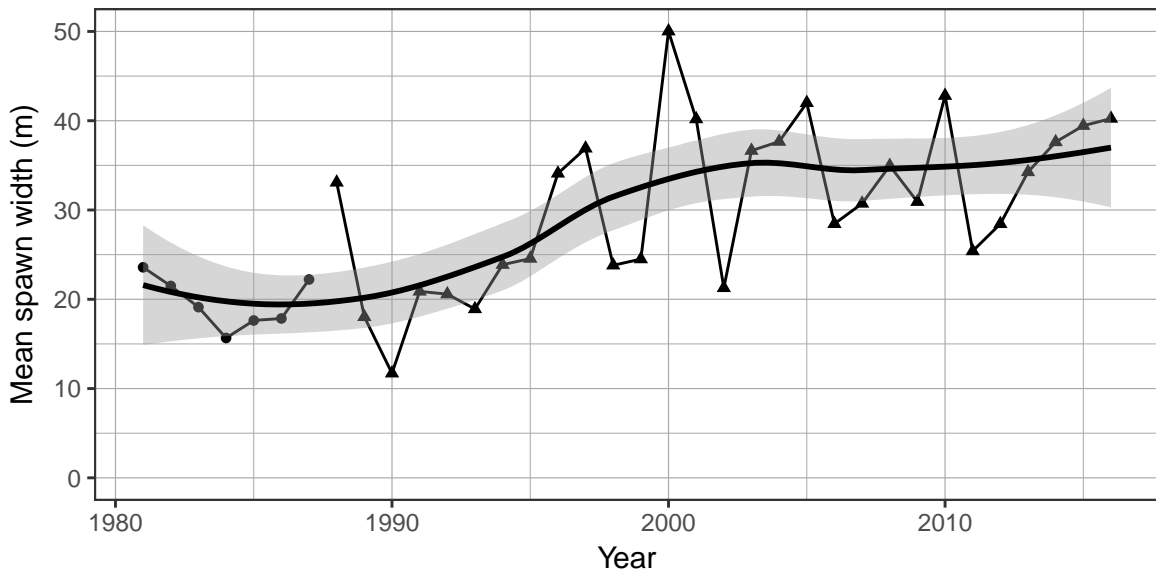
Figure 9. Time series of total spawn length in thousands of metres (m × 10³) for Pacific herring from 1981 to 2016 in the Central Coast major stock assessment region (SAR). The thick black line is a loess curve, and the shaded area is the 90% confidence interval. The spawn index has two distinct periods defined by the dominant survey method: surface surveys (1951–1987), and dive surveys (1988–2016).

Figure 10. Time series of mean spawn width in metres (m) for Pacific herring from 1981 to 2016 in the Central Coast major stock assessment region (SAR). The thick black line is a loess curve, and the shaded area is the 90% confidence interval. The spawn index has two distinct periods defined by the dominant survey method: surface surveys (1951–1987), and dive surveys (1988–2016).
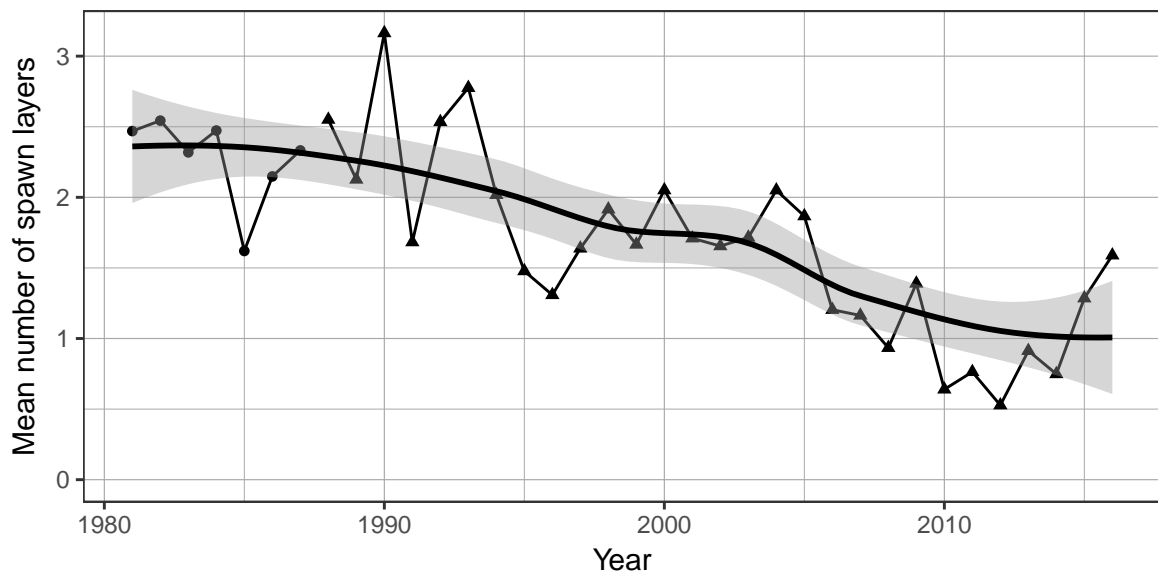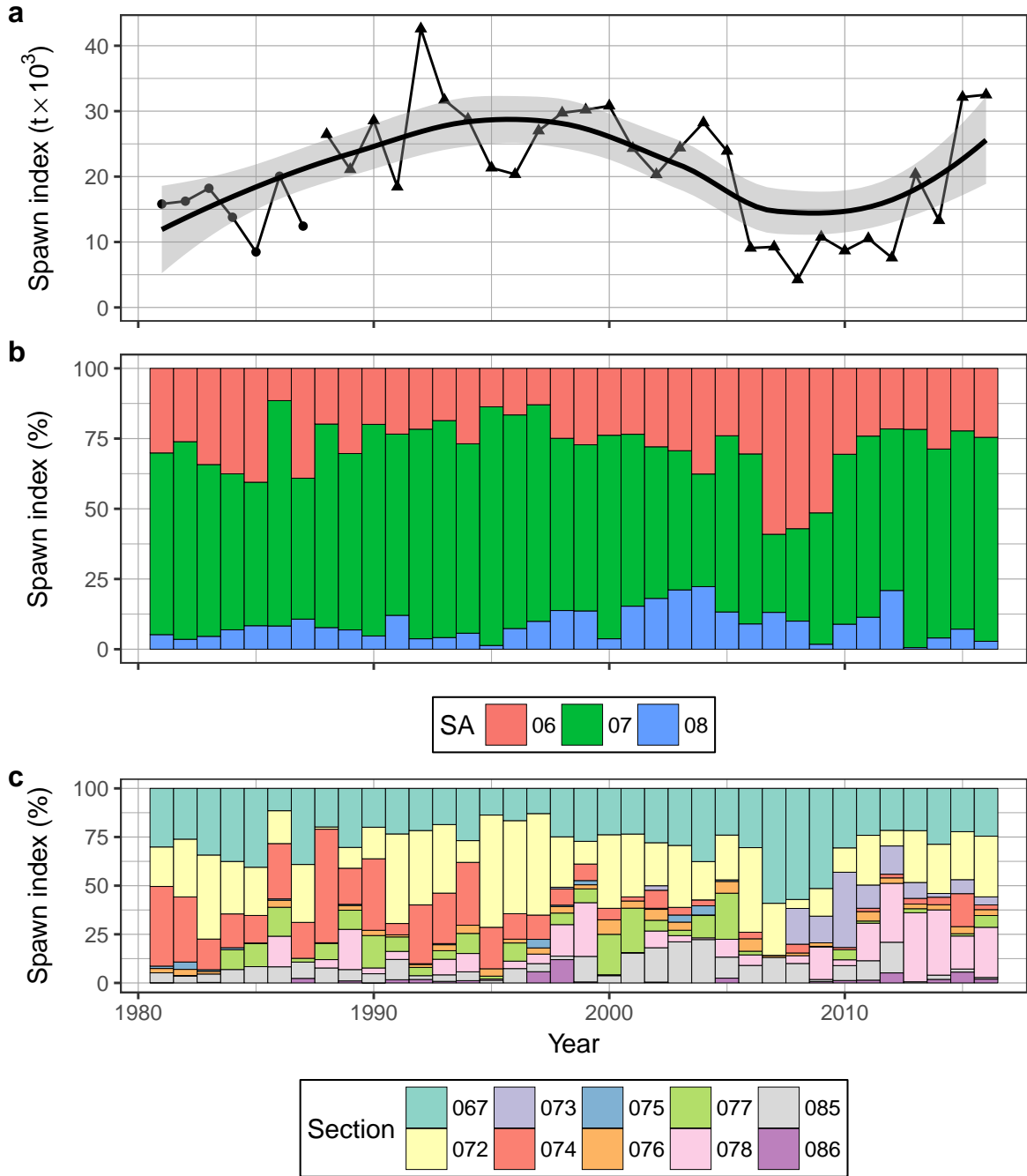
Figure 11. Time series of mean number of spawn layers for Pacific herring from 1981 to 2016 in the Central Coast major stock assessment region (SAR). The thick black line is a loess curve, and the shaded area is the 90% confidence interval. The spawn index has two distinct periods defined by the dominant survey method: surface surveys (1951–1987), and dive surveys (1988–2016).

Figure 12. Time series of spawn index in thousands of metric tonnes ($t \times 10^3$) for Pacific herring from 1981 to 2016 in the Central Coast major stock assessment region (SAR; a), as well as percent contributed by Statistical Area (SA), and Section (b, & c, respectively). The thick black line is a loess curve, and the shaded area is the 90% confidence interval. The spawn index has two distinct periods defined by the dominant survey method: surface surveys (1951–1987), and dive surveys (1988–2016). The 'spawn index' represents the raw survey data only, and is not scaled by the spawn survey scaling parameter, q.
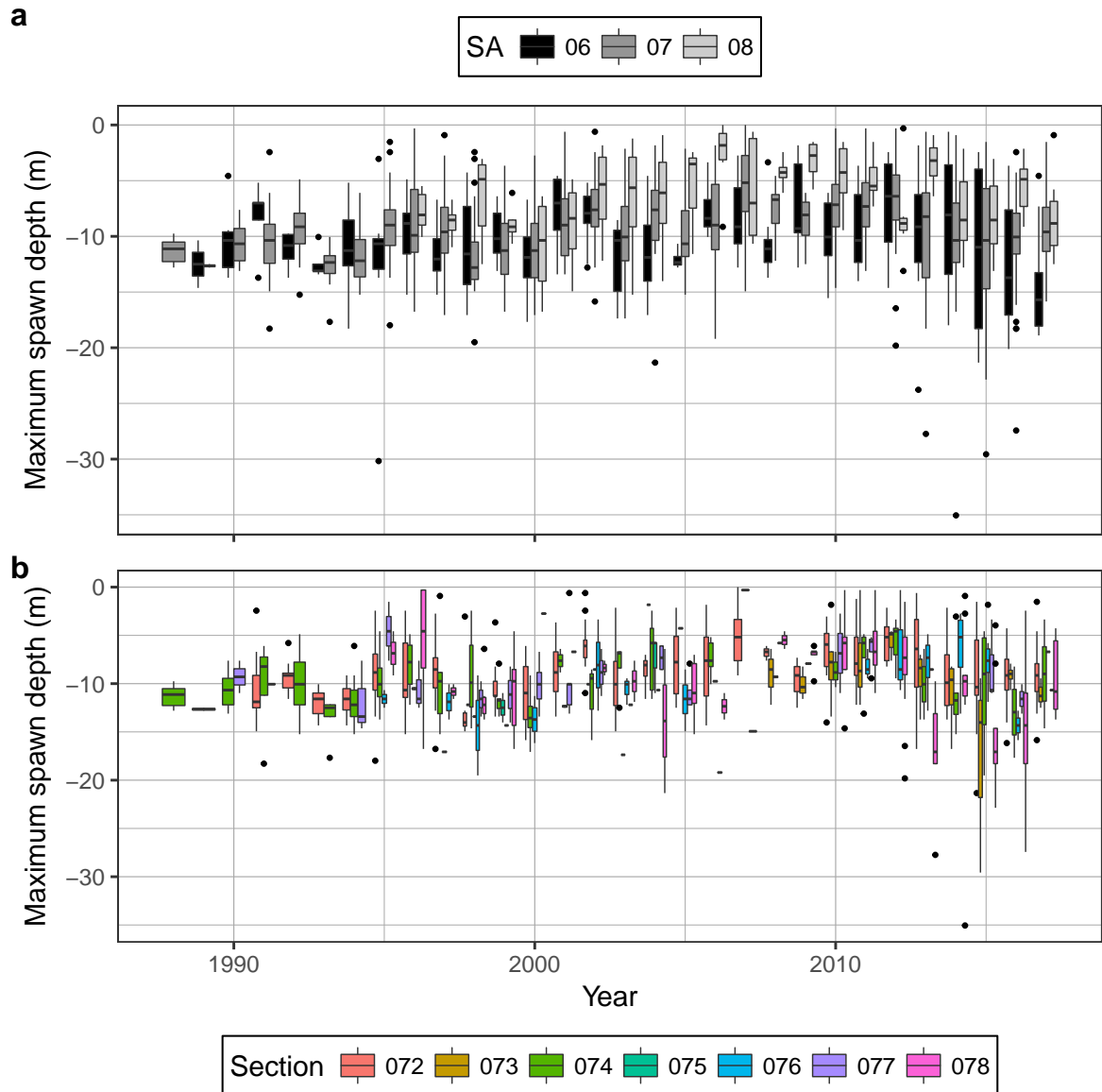
Figure 13. Time series of maximum spawn depth below surface in metres (m) for Pacific herring from 1981 to 2016 in the Central Coast major stock assessment region (SAR) by Statistical Area (SA; a), and Section (b). Note that depth is not corrected to the chart datum. The spawn index has two distinct periods defined by the dominant survey method: surface surveys (1951–1987), and dive surveys (1988–2016).
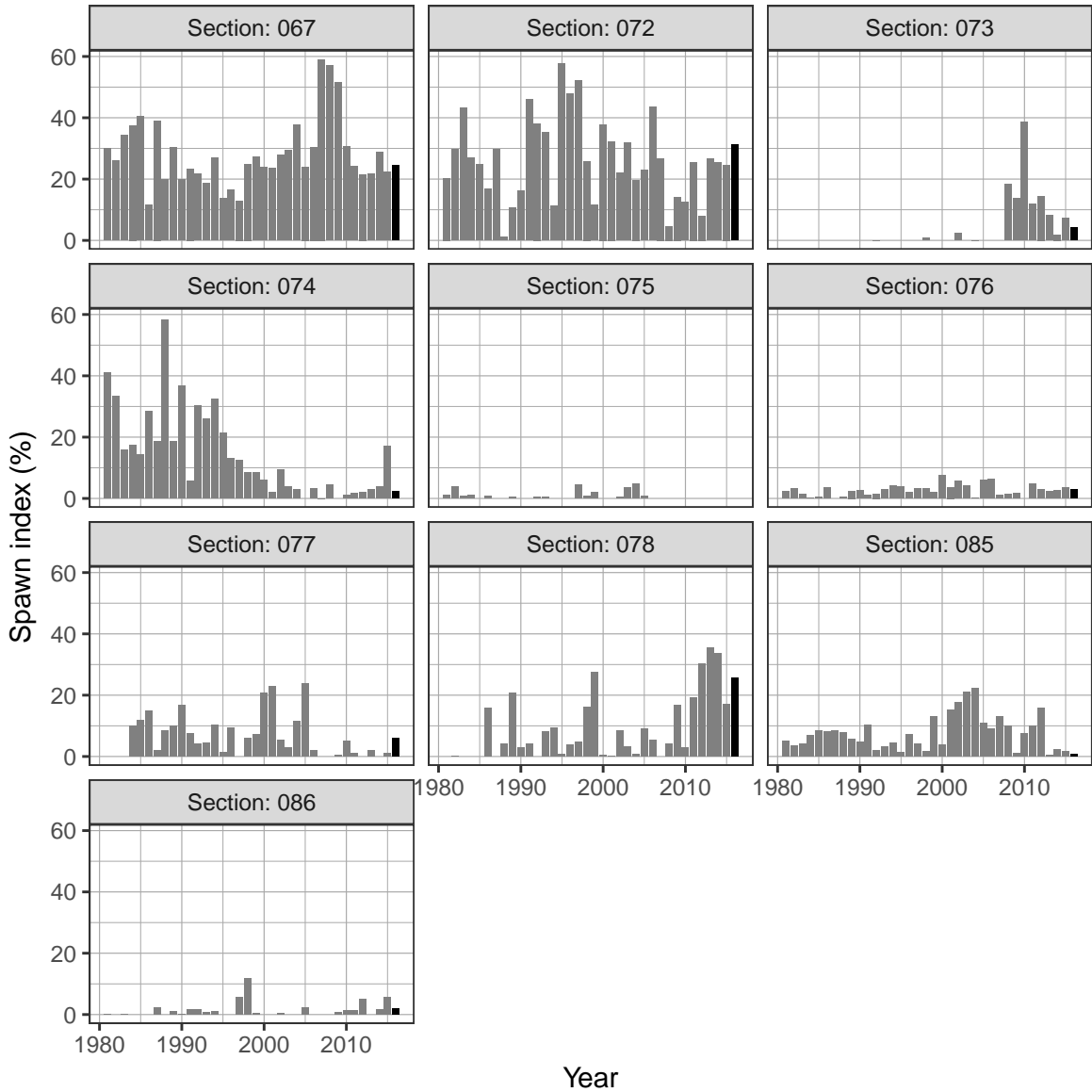
Figure 14. Time series of percent of spawn index by Section for Pacific herring from 1981 to 2016 in the Central Coast major stock assessment region (SAR). The year 2016 has a darker bar to facilitate interpretation. The spawn index has two distinct periods defined by the dominant survey method: surface surveys (1951–1987), and dive surveys (1988–2016). The 'spawn index' represents the raw survey data only, and is not scaled by the spawn survey scaling parameter, q.
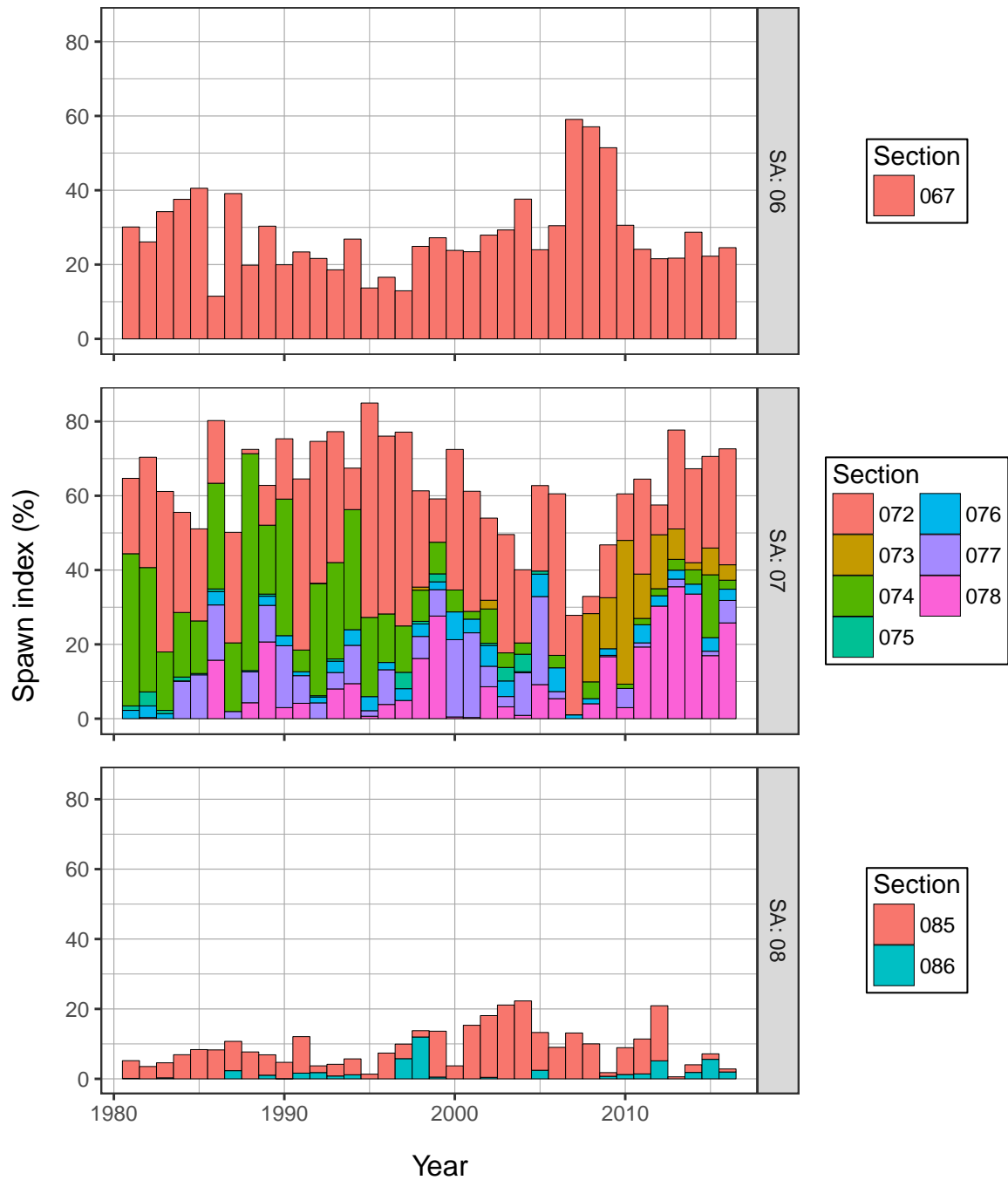
Figure 15. Time series of percent of spawn index by Statistical Area (SA) and Section for Pacific herring from 1981 to 2016 in the Central Coast major stock assessment region (SAR). The spawn index has two distinct periods defined by the dominant survey method: surface surveys (1951–1987), and dive surveys (1988–2016). The 'spawn index' represents the raw survey data only, and is not scaled by the spawn survey scaling parameter, q.