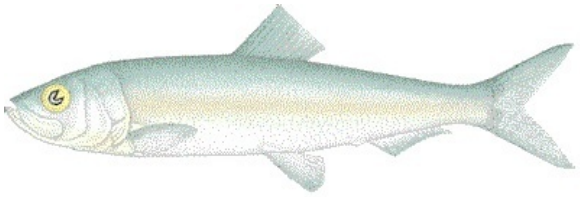
Pacific herring preliminary data summary for West Coast of Vancouver Island 2016

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 West Coast of Vancouver Island 2016.

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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 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.

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The following is a description of data collected for Pacific herring in the West Coast of Vancouver Island 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

Biological samples were collected by the seine charter vessel "Proud Canadian" for 20 days from February 20th to March 10th. The primary purpose of the test charter vessel was to collect biological samples from main bodies of herring from Areas 23, 24, and 25. Nearshore herring samples were collected by the Nuu-chah-nulth staff in Area 23 as part of a pilot sampling program (a collaboration between WCVI First Nations and DFO). These nearshore biological samples were collected from spawning aggregations using cast nets. WCVI First Nations were involved in the collection of spawn observations via surface surveys (in Hesquiat Harbour, Area 24), reporting spawning locations in Areas 23, 24, and 25, and the collection of biological samples in Area 24.

Herring spawn locations were primarily identified with fixed-wing overflights conducted by DFO Resource Management Area staff. Twelve flights were conducted this season from February to April. Two dive charter vessels operated on the WCVI. The charter vessel "Waterbear" surveyed 14 days from March 4th to March 24th (plus a 3-day extension). This vessel covered Areas 24 and 25, with 3 days survey work in the Strait of Georgia. The charter vessel "Seaveyor", surveyed 20 days from late February through early April. The "Seaveyor" covered Areas 23 and 27, with 3 days in the Strait of Georgia. The "Seaveyor" also went to Area 24, however no spawn was observed in the areas assessed. All three charter vessels were funded by DFO, through a contract to the Herring Conservation Research Society.

3 Catch and biological samples

There were no seine, gillnet, or spawn on kelp (SOK) commercial fishing opportunities in 2016 in the West Coast of Vancouver Island major stock area. The total landed commercial catch of Pacific herring from all fisheries in 2016 in the West Coast of Vancouver Island major SAR was 0 t, which is the same as last year (Table 2 and Figure 3). The total harvested spawn on kelp (SOK) in 2016 in the West Coast of Vancouver Island major SAR was 0 lb, which is associated with an estimated spawning biomass of 0 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, 25 Pacific herring biological samples were collected and processed for the West Coast of Vancouver Island major SAR (Table 4, Table 5), and a total of 1,164 Pacific herring were aged in 2016. There are differences between biological data collected

from two sampling protocols regarding the number-, proportion-, and weight-at-age for Pacific herring in 2016 in the West Coast of Vancouver Island major SAR (Table 6, Table 7, and Table 8, respectively). The nearshore sampling program is a multi-year pilot study (using cast nets), therefore only biological data from the seine samples were used for the purposes of stock assessment. 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 9, and Figure 6, respectively). Biological summaries only include samples collected using seine nets (commercial and test) due to size-selectivity of other gear types such as gillnet.

4 Spawn survey data

Herring spawn surveys were conducted at 28 locations in 2016 in the West Coast of Vancouver Island major SAR (Table 10, Figure 7). 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 8, Figure 9, Figure 10, Figure 11, and Table 11). 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 11b, Figure 12). For example, in 2016, Section 232 contributed the most to the spawn index (58%). As with Sections, some Statistical Areas contribute more than others to the total spawn index (Figure 11c, Figure 13).

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:

- Area 23: Spawn was more spread out though the shoreline and islands of the northwest side of Barkley Sound compared with 2015.
- Area 25: Spawn observed in Nootka Sound throughout the Spanish Pilot Group islands which are not easily observed from the regular flight path.
- Area 25: Spawns on the outside of Nootka Island (Beano in 2015, Bajo in 2016) are difficult to find a weather window to survey due to their exposed location.
- Area 25: The test vessel caught unspawned herring in Esperanza Inlet after the small spawn in Nuchatlitz occurred, however no further spawning was detected in

Esperanza Inlet. In addition to the spawn flights, the First Nation charter was on the grounds looking for spawn and staff from the NTC and Nuchatlaht First Nation also spent many days on the water looking for spawning activity.

- Area 24: A spawn was observed at Whitesand Cove by the First Nation Charter with reported spawn on bough harvest but when the Seaveyor arrived to survey the area they didnt find any spawn.
- Significant numbers (≥ 20) of gray whales were observed on multiple flights feeding in Hesquiat Harbour. On one flight, an estimated 100 gray whales were observed around Bajo Reefs after the herring spawning event in the area. Whales were observed infrequently in Barkley Sound in 2016.
- Area 24: Surface surveys in Hesquiat Harbour were performed on Jan 7$^{\text{th}}$, Feb 1$^{\text{st}}$, Feb 7$^{\text{th}}$, Feb 16$^{\text{th}}$, and Mar 1$^{\text{st}}$. These represent some of the earliest recorded spawning events, however, the Hesquiaht First Nation reports these early spawning events as 'not uncommon'. DFO records do show a number of early spawns in Hesquiat starting from mid-January into late February, with the earliest spawn in DFO records observed on January 16$^{\text{th}}$.
- Area 24: Deep spawn was observed on two transects on Verdia Island (Area 24) below 15 m to 20 m.

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 West Coast of Vancouver Island major stock assessment region (SAR).

Fishery	Use	Catch (t)
NA	NA	0

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 West Coast of Vancouver Island major stock assessment region (SAR).

Year	Harvest (lb)	Spawning biomass (t)
2006	0	0
2007	0	0
2008	0	0
2009	0	0
2010	0	0
2011	0	0
2012	0	0
2013	0	0
2014	0	0
2015	0	0
2016	0	0

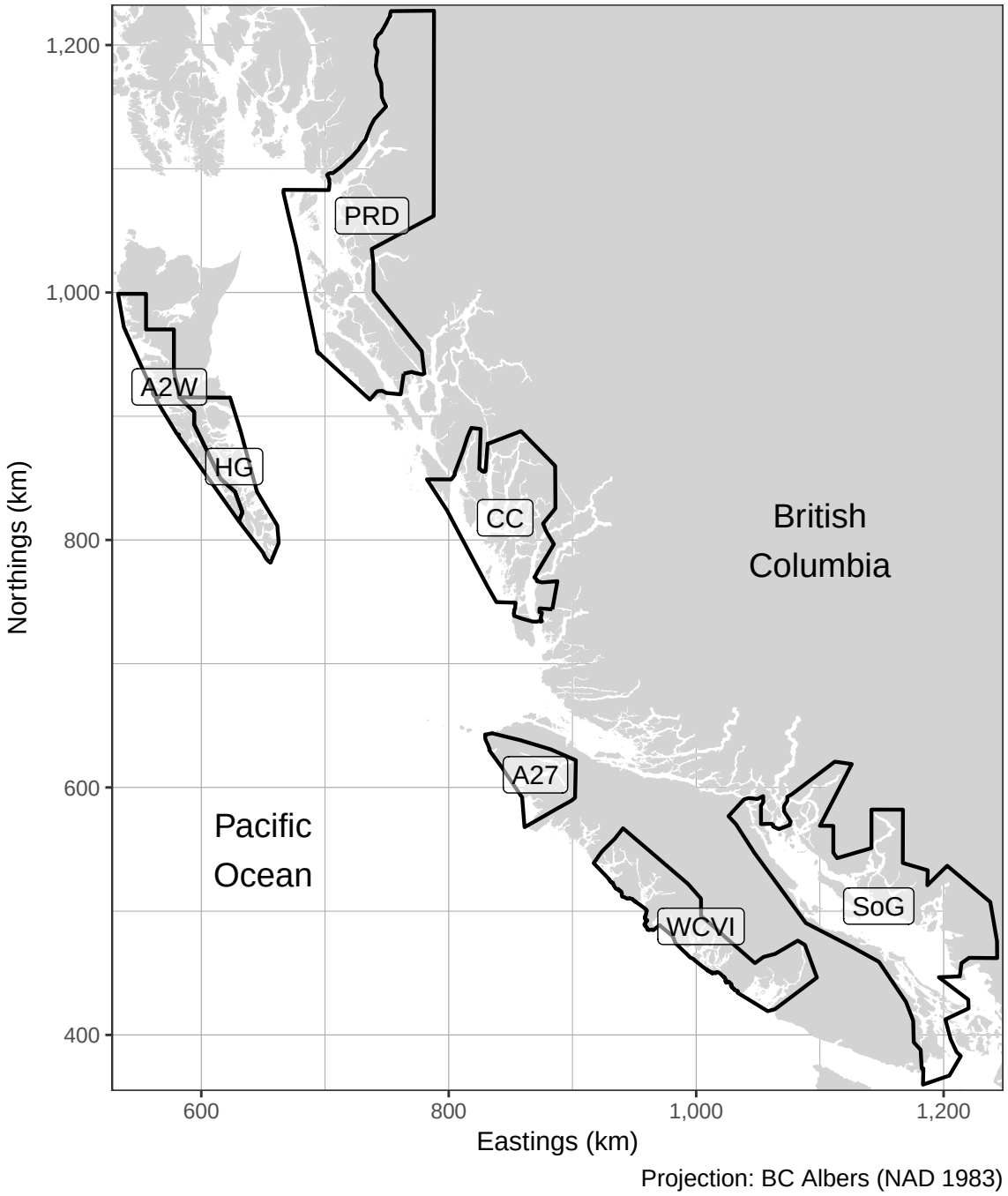

Figure 1. Boundaries for the Pacific herring stock assessment regions (SARs) in British Columbia: there are 5 major SARs (HG, PRD, CC, SoG, and WCVI), and 2 minor SARs (A27 and A2W). Units: kilometres (km). Also see Table 1.

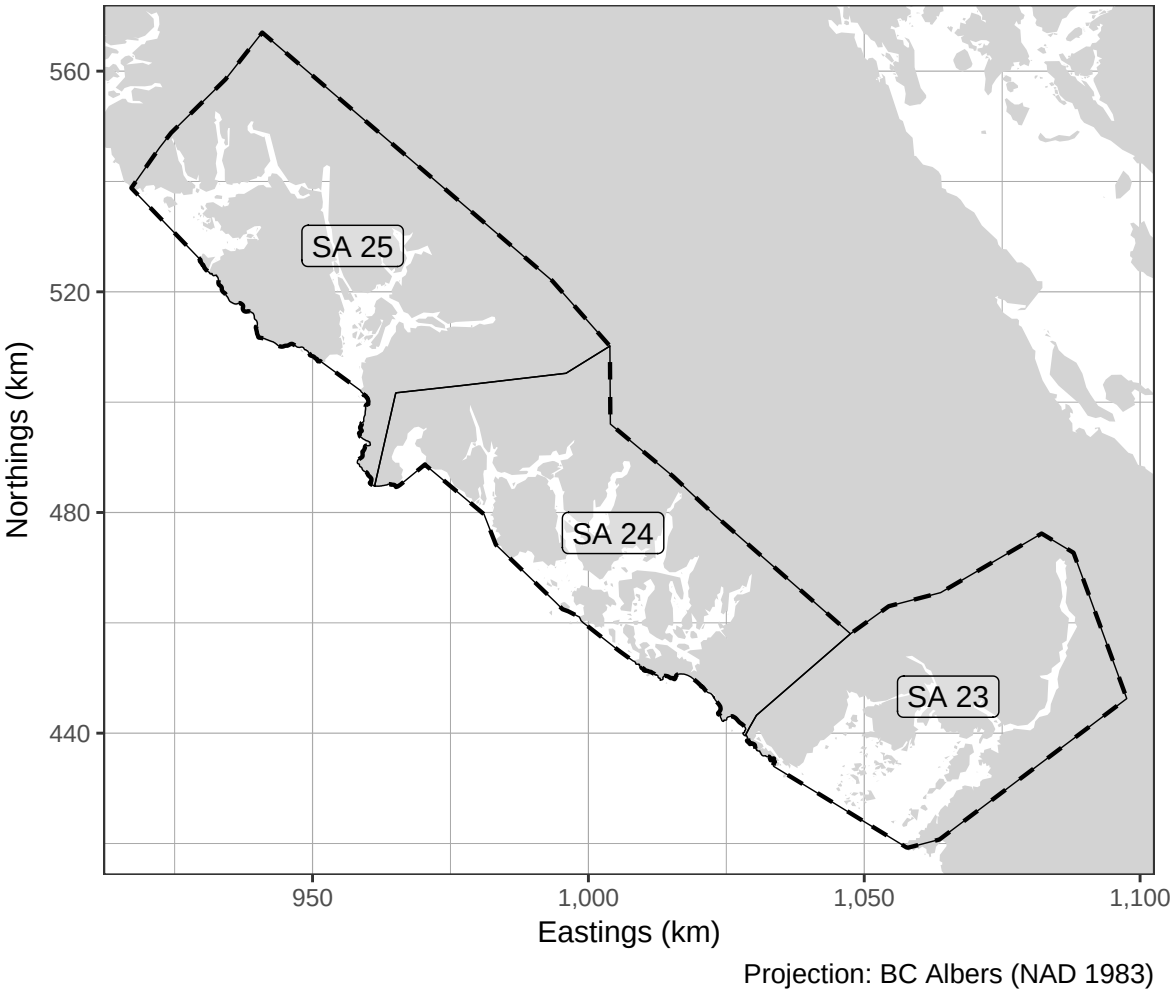

Figure 2. Boundaries for the West Coast of Vancouver Island major stock assessment region (SAR; thick dashed lines), and associated Statistical Areas (SA; thin solid lines). Units: kilometres (km).

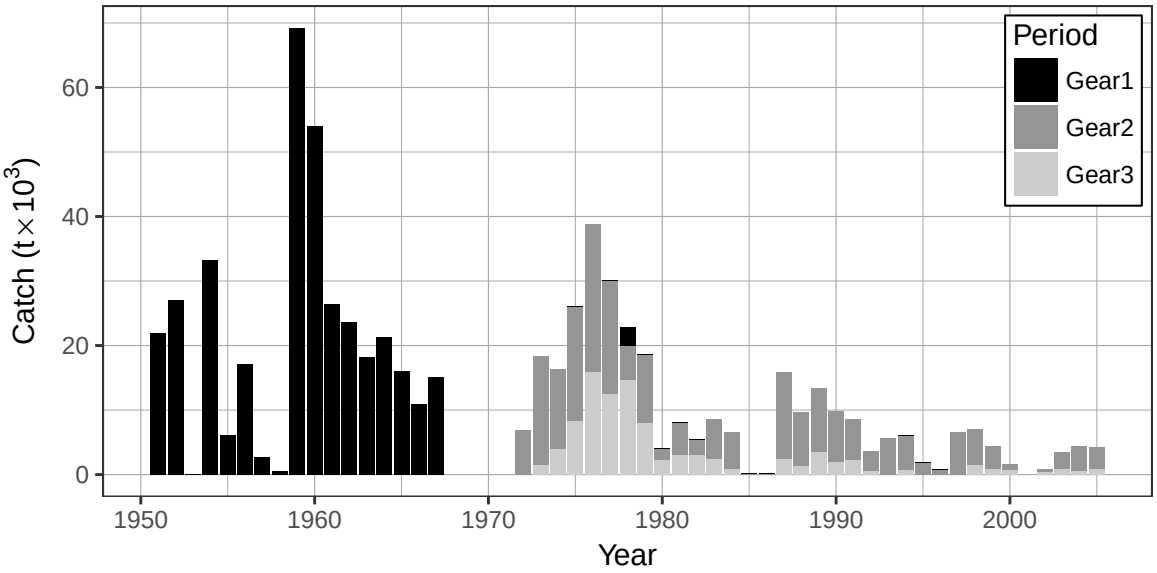

Figure 3. Time series of total landed catch in thousands of metric tonnes ($t \times 10^3$) of Pacific herring by gear type from 1951 to 2016 in the West Coast of Vancouver Island major stock assessment region (SAR). Legend: 'Gear1' represents the reduction, the food and bait, as well as the special 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 West Coast of Vancouver Island major stock assessment region (SAR). Each sample is approximately 100 fish.

	Number of samples		
Year	Commercial	Test	Total
2006	0	23	23
2007	0	10	10
2008	0	22	22
2009	0	29	29
2010	0	27	27
2011	0	28	28
2012	0	10	10
2013	0	5	5
2014	0	4	4
2015	0	20	20
2016	0	25	25

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

Type	Gear	Use	Number of samples
Test	Other	Nearshore	10
Test	Seine	Test Fishery	15

Table 6. Observed number-at-age of Pacific herring by sample type in 2016 in the West Coast of Vancouver Island major stock assessment region (SAR). The age-10 class is a 'plus group' which includes fish ages 10 and older. Legend: 'Nearshore' refers to samples collected using cast nets as part of a pilot study with WCVI First Nations.

	Number-at-age								
Sample type	2	3	4	5	6	7	8	9	10
Nearshore	32	537	161	122	13	3	2	0	0
Seine test	46	754	195	144	16	3	5	1	0
Total	78	1291	356	266	29	6	7	1	0

Table 7. Observed proportion-at-age of Pacific herring by sample type in 2016 in the West Coast of Vancouver Island major stock assessment region (SAR). The age-10 class is a 'plus group' which includes fish ages 10 and older. Legend: 'Nearshore' refers to samples collected using cast nets as part of a pilot study with WCVI First Nations.

	Proportion-at-age								
Sample type	2	3	4	5	6	7	8	9	10
Nearshore	0.037	0.617	0.185	0.140	0.015	0.003	0.002	0.000	0.000
Seine test	0.040	0.648	0.168	0.124	0.014	0.003	0.004	0.001	0.000
Total	0.038	0.635	0.175	0.131	0.014	0.003	0.003	0.000	0.000

Table 8. Observed weight-at-age in grams (g) of Pacific herring by sample type in 2016 in the West Coast of Vancouver Island major stock assessment region (SAR). The age-10 class is a 'plus group' which includes fish ages 10 and older. Legend: 'Nearshore' refers to samples collected using cast nets as part of a pilot study with WCVI First Nations.

	Weight-at-age (g)								
Sample type	2	3	4	5	6	7	8	9	10
Nearshore	48.8	66.4	72.1	81.0	87.7	82.7	88.0	NA	NA
Seine test	63.3	77.0	82.4	92.0	94.5	121.3	135.4	146.0	NA
Total	57.3	72.6	77.7	87.0	91.4	102.0	121.9	146.0	NA

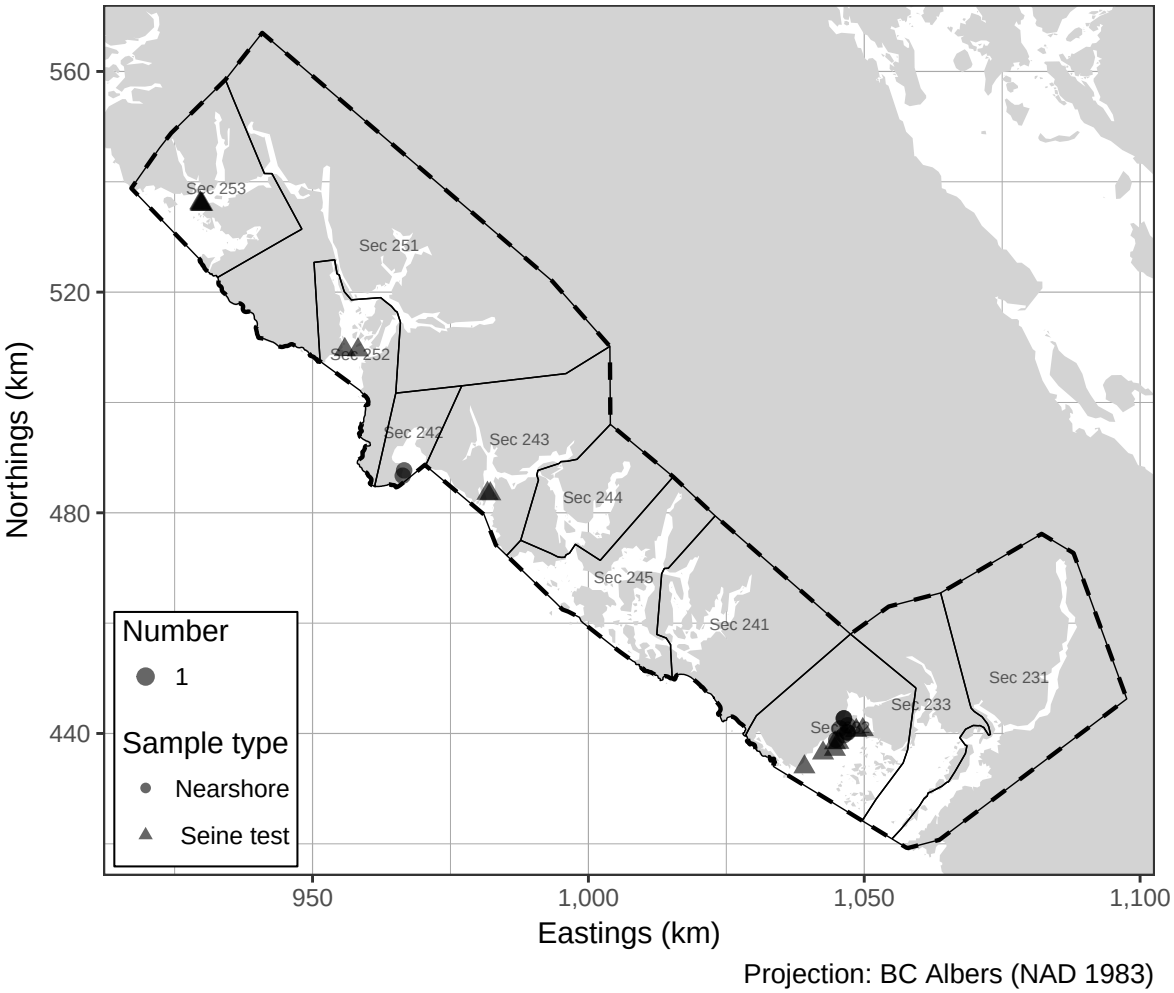

Figure 4. Location and type of Pacific herring biological samples collected in 2016 in the West Coast of Vancouver Island major stock assessment region (SAR; thick dashed lines), and associated Sections (Sec; thin solid lines). Units: kilometres (km).

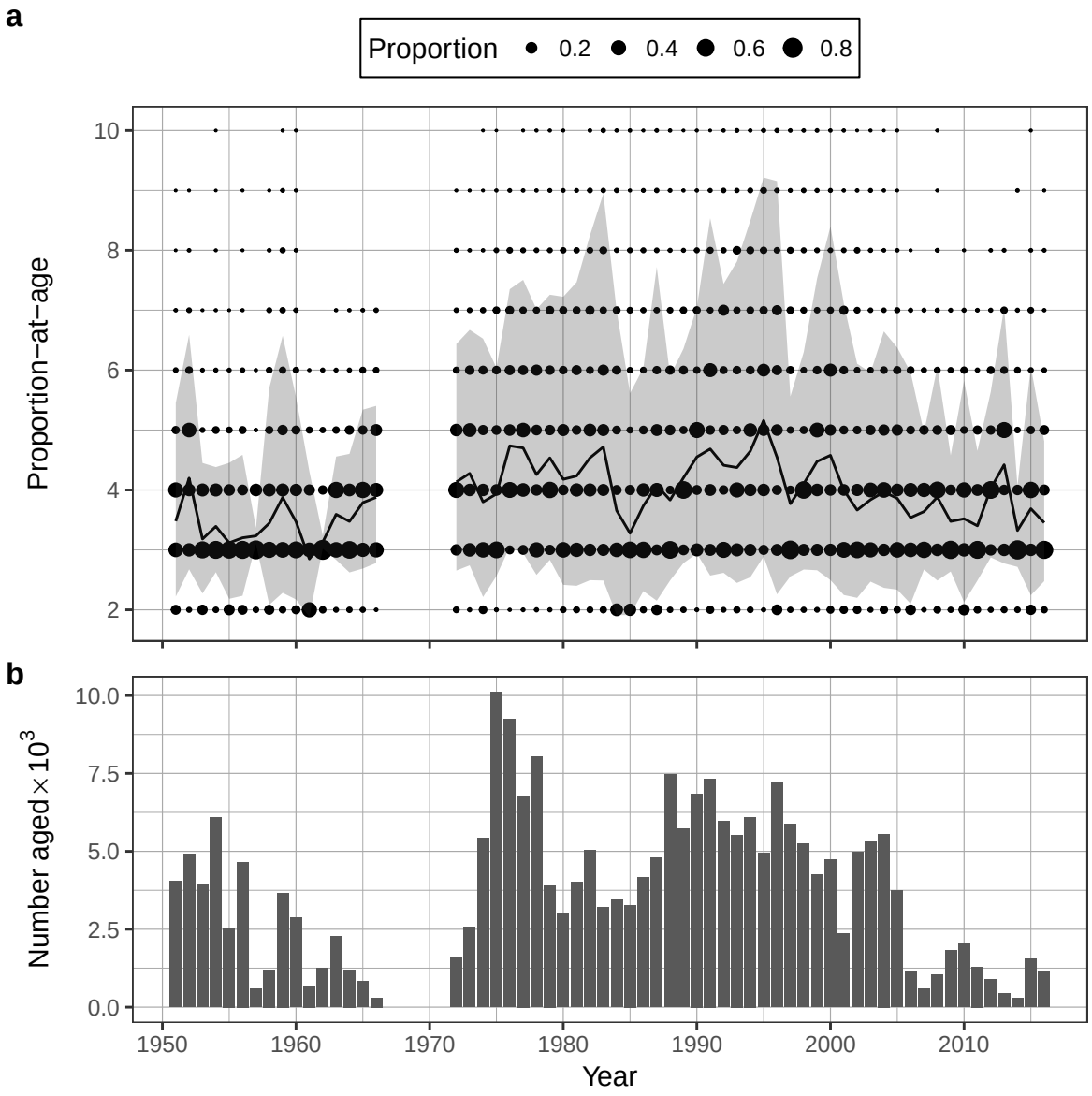

Figure 5. Time series of observed proportion-at-age (a) and number aged (b) of Pacific herring from 1951 to 2016 in the West Coast of Vancouver Island major stock assessment region (SAR). The black line is the mean age, and the shaded area is the approximate 90% distribution. Biological summaries only 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.

Table 9. Observed proportion-at-age for Pacific herring from 2006 to 2016 in the West Coast of Vancouver Island 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	0.151	0.373	0.335	0.079	0.054	0.008	0.001	0.000	0.000
2007	0.012	0.503	0.350	0.110	0.018	0.007	0.000	0.000	0.000
2008	0.052	0.246	0.540	0.115	0.031	0.008	0.006	0.001	0.001
2009	0.024	0.664	0.157	0.127	0.023	0.006	0.000	0.000	0.000
2010	0.176	0.295	0.424	0.052	0.045	0.007	0.001	0.000	0.000
2011	0.048	0.630	0.211	0.096	0.009	0.005	0.000	0.000	0.000
2012	0.021	0.186	0.621	0.103	0.059	0.007	0.003	0.000	0.000
2013	0.034	0.241	0.150	0.475	0.050	0.045	0.005	0.000	0.000
2014	0.029	0.752	0.147	0.029	0.032	0.007	0.000	0.004	0.000
2015	0.140	0.238	0.505	0.068	0.017	0.028	0.004	0.000	0.001
2016	0.040	0.648	0.168	0.124	0.014	0.003	0.004	0.001	0.000

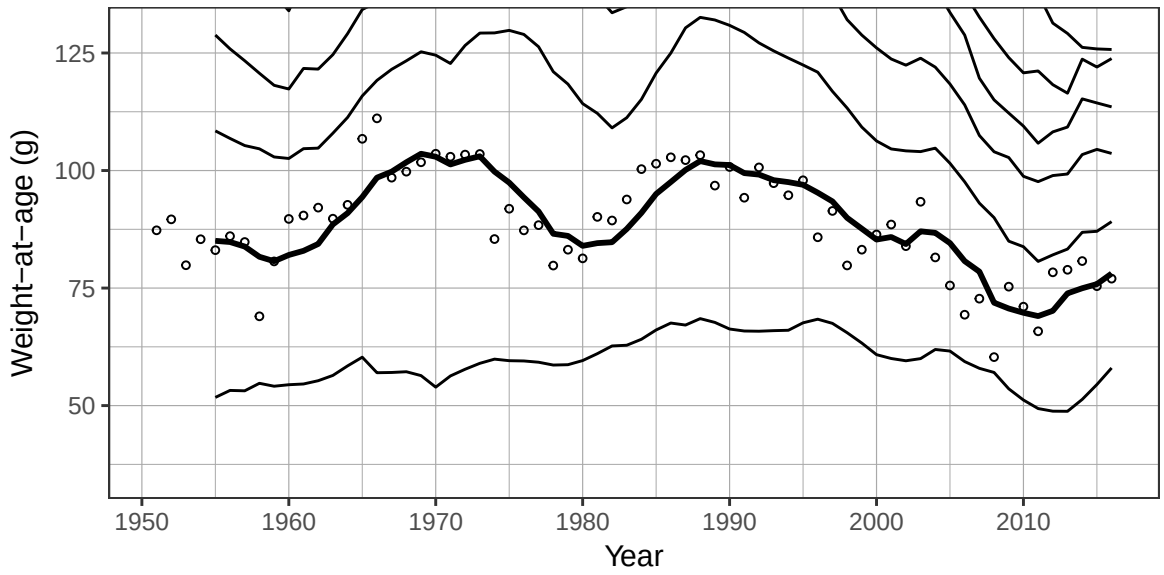

Figure 6. Time series of weight-at-age in grams (g) for age-3 (circles) and 5-year running mean weight-at-age (lines) for Pacific herring from 1951 to 2016 in the West Coast of Vancouver Island major stock assessment region (SAR). Lines show 5-year running means for age-2 to age-10 herring (incrementing 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.

Table 10. Pacific herring spawn survey locations and spawn index in metric tonnes (t) in 2016 in the West Coast of Vancouver Island 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)
23	232	1131	Two Rivers +	4,198
23	232	1132	Larkin Is	141
23	232	1142	Stopper Is	500
23	232	1143	Toquart Bay	25
23	232	1144	Macoah Pass	1,453
23	232	1145	Forbes Is	220
23	232	1150	David Is	718
23	232	1153	Maggie Rvr	473
23	232	1155	Spilling Islet	361
23	232	1156	Ottaway Islet	435
23	232	1159	St Ines Is	1,430
23	232	1755	Newcombe Chnl	1,889
24	242	1217	Hesquiat Hrbr	1,324
24	242	1603	Antons Spit	2,683
24	242	1604	Rondeault Pt	656
24	242	1605	Leclaire Pt	125
24	242	1791	Hesquiat Pen	306
24	242	1812	Hesquiat Hrbr Hd	372
24	242	1886	Matlahaw Pt	NA
25	252	1246	Pantoja Is	64
25	252	1253	Spouter Is	168
25	252	1277	McKay Psg	209
25	252	1281	Santa Gertrudis Cv	10
25	252	1282	Friendly Cv	113
25	252	1283	Strange Is	615
25	252	2252	Unknown Sec 252	866
25	253	1262	Port Langford	243
25	259	1522	Bajo Rf	927

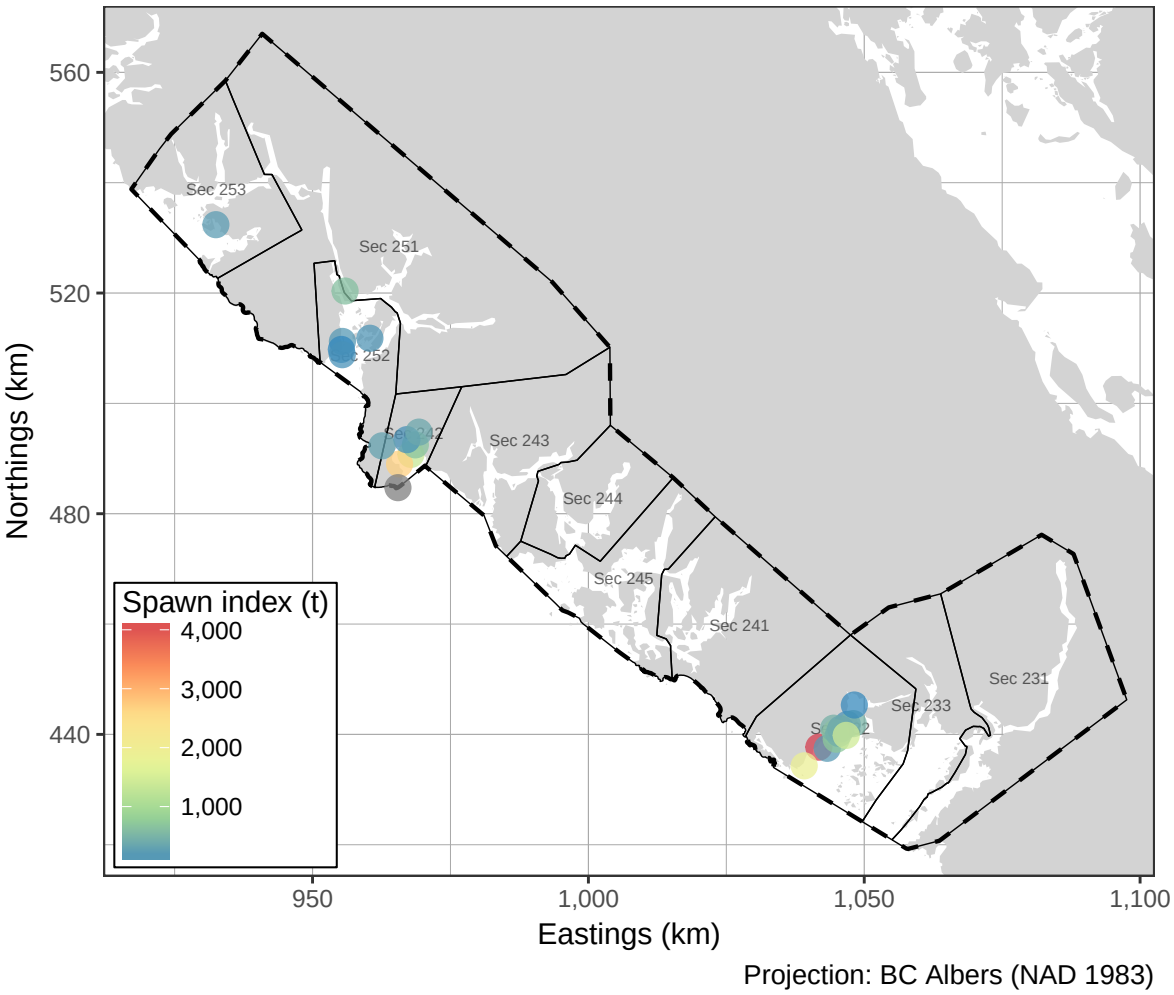

Figure 7. Location of Pacific herring spawning locations in 2016 in the West Coast of Vancouver Island major stock assessment region (SAR; thick dashed lines), and associated Sections (Sec; thin solid lines). The 'spawn index' represents the raw survey data only, and is not scaled by the spawn survey scaling parameter, q. Missing spawn index values (grey circles) indicate incomplete spawn surveys. Units: kilometres (km), and metric tonnes (t).

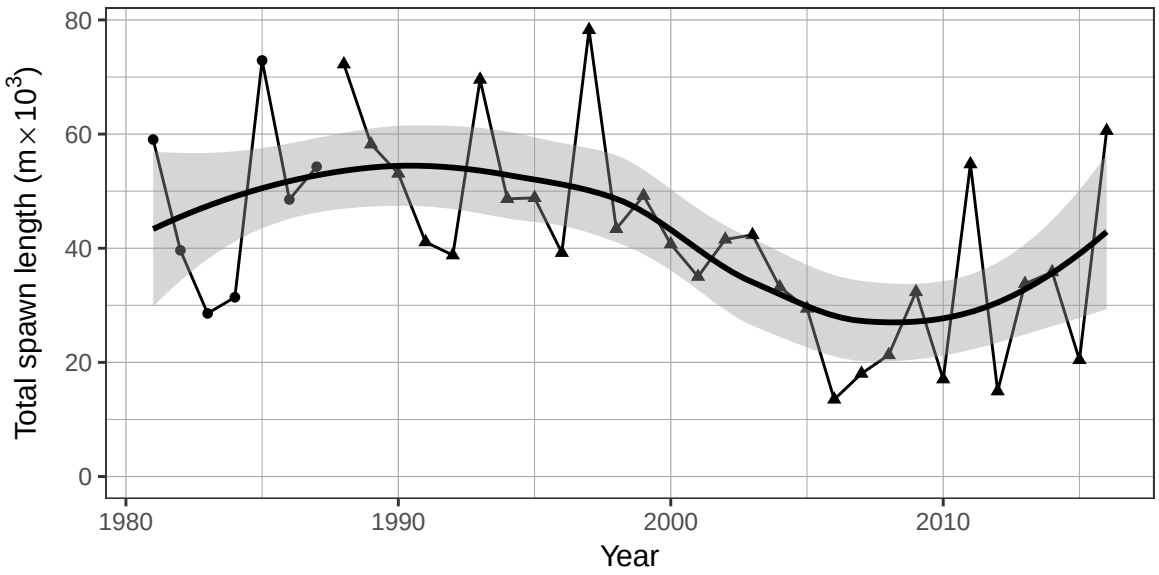

Figure 8. Time series of total spawn length in thousands of metres ($m \times 10^3$) for Pacific herring from 1981 to 2016 in the West Coast of Vancouver Island major stock assessment region (SAR). The thick black line is a loess curve, and the shaded area is the 90% confidence interval. The spawn index has two distinct periods defined by the dominant survey method: surface surveys (1951–1987), and dive surveys (1988–2016).

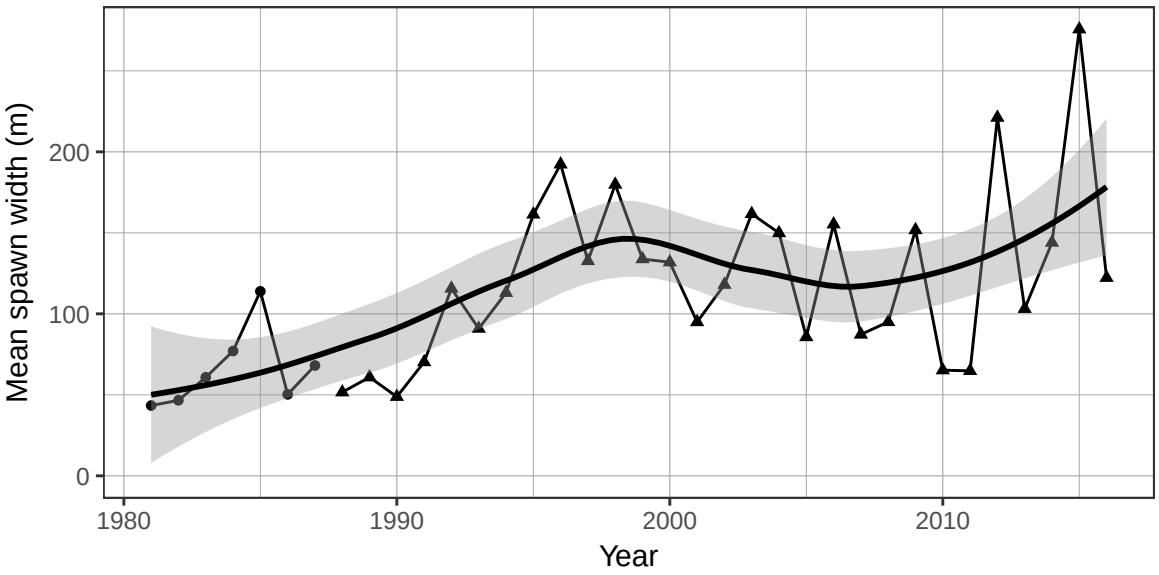

Figure 9. Time series of mean spawn width in metres (m) for Pacific herring from 1981 to 2016 in the West Coast of Vancouver Island major stock assessment region (SAR). The thick black line is a loess curve, and the shaded area is the 90% confidence interval. The spawn index has two distinct periods defined by the dominant survey method: surface surveys (1951–1987), and dive surveys (1988–2016).

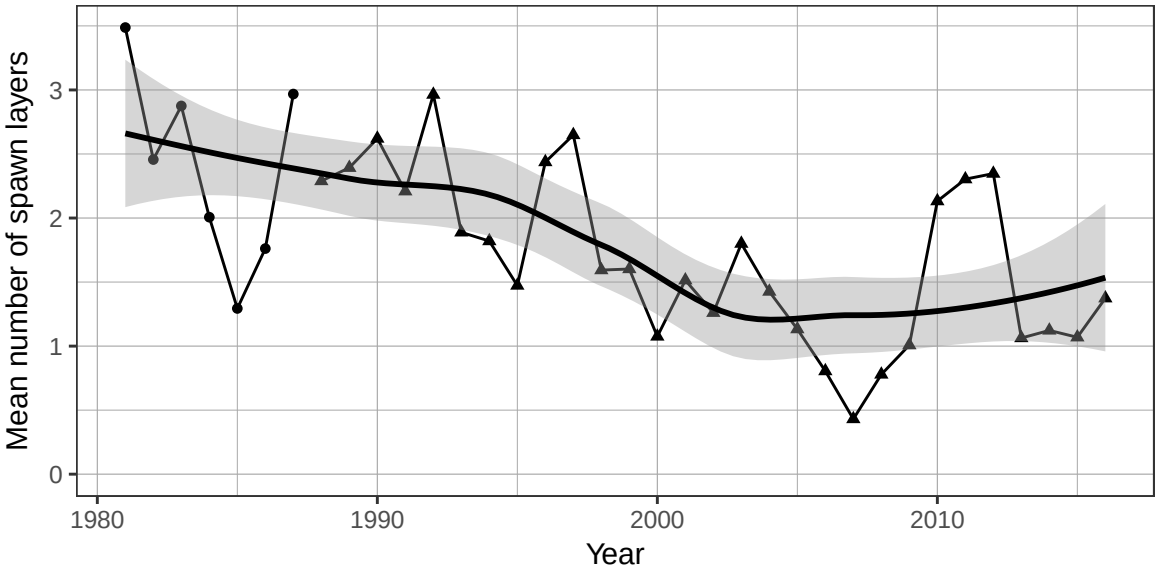

Figure 10. Time series of mean number of spawn layers for Pacific herring from 1981 to 2016 in the West Coast of Vancouver Island major stock assessment region (SAR). The thick black line is a loess curve, and the shaded area is the 90% confidence interval. The spawn index has two distinct periods defined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

Table 11. Summary of spawn survey data from 2006 to 2016 in the West Coast of Vancouver Island 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	13,510	155	0.805	2,875
2007	18,040	87	0.431	2,246
2008	21,300	95	0.779	2,739
2009	32,340	152	1.008	10,607
2010	17,055	65	2.132	2,464
2011	54,735	65	2.303	9,663
2012	14,953	221	2.347	5,407
2013	33,775	103	1.063	12,342
2014	35,825	144	1.122	13,937
2015	20,450	276	1.069	11,323
2016	60,575	122	1.374	20,528

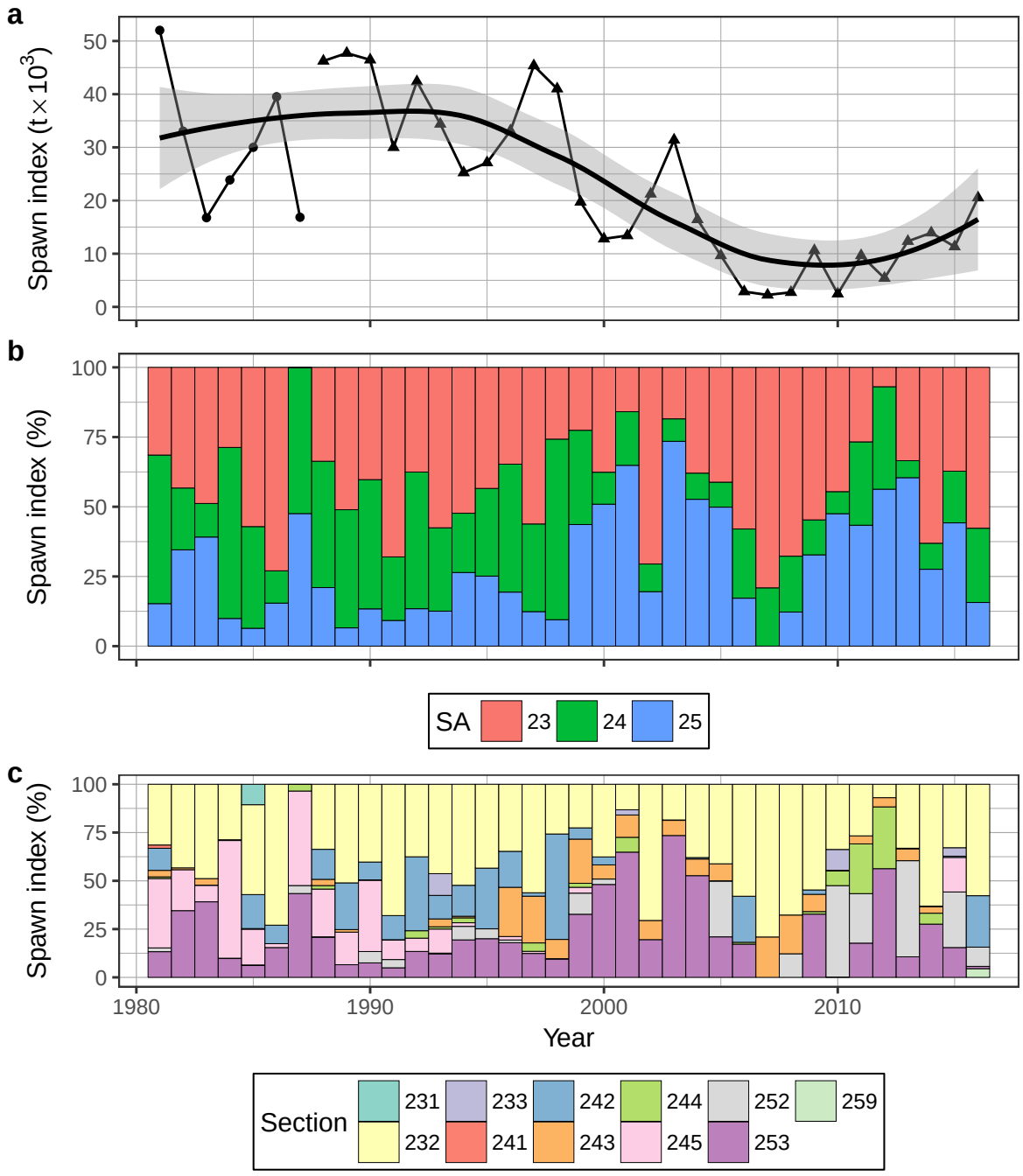

Figure 11. Time series of spawn index in thousands of metric tonnes ($t \times 10^3$) for Pacific herring from 1981 to 2016 in the West Coast of Vancouver Island major stock assessment region (SAR; a), as well as percent contributed by Statistical Area (SA), and Section (b, & c, respectively). The thick 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.

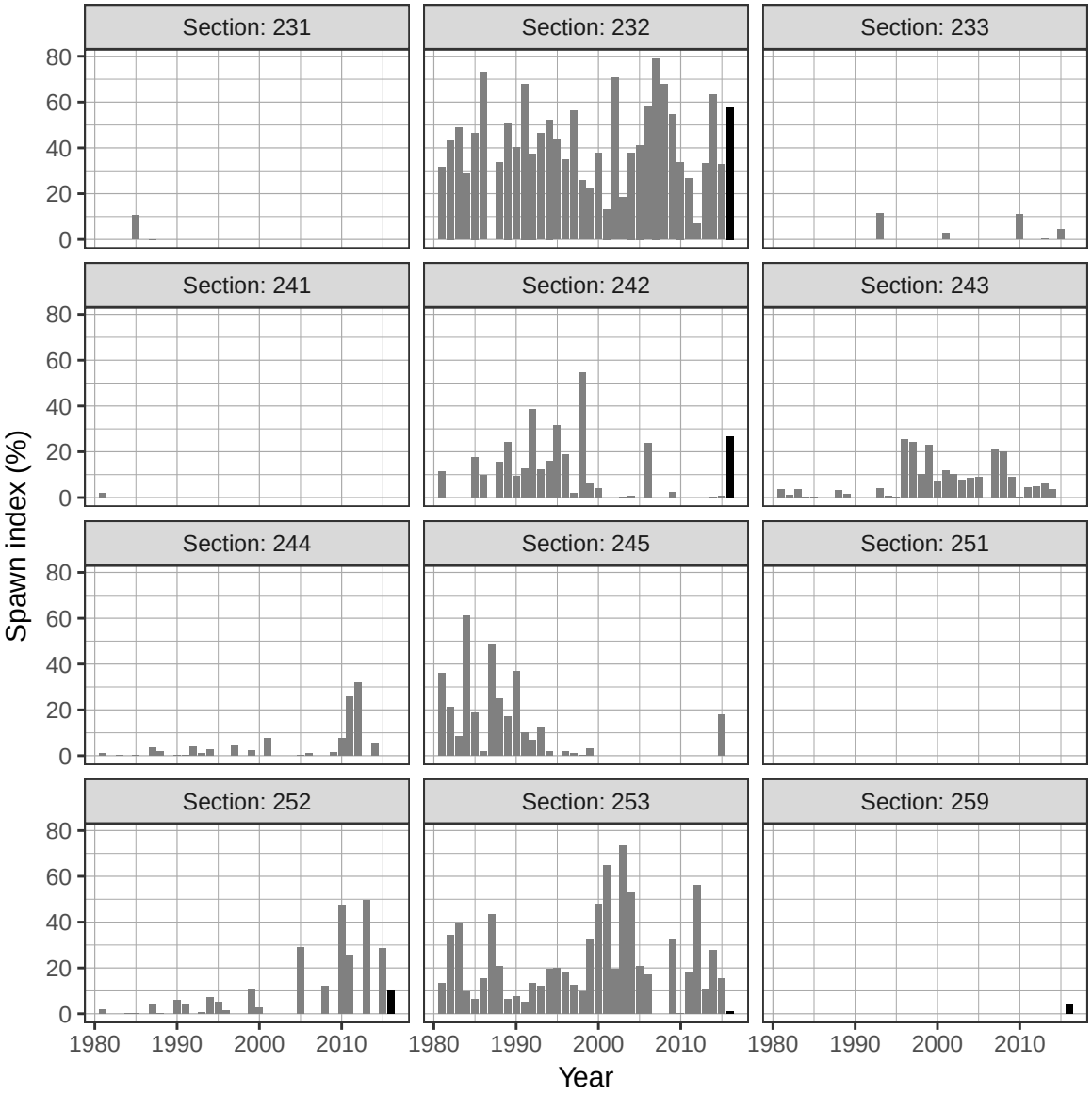

Figure 12. Time series of percent of spawn index by Section for Pacific herring from 1981 to 2016 in the West Coast of Vancouver Island major stock assessment region (SAR). The year 2016 has a darker bar to facilitate interpretation. The spawn index has two distinct periods defined by the dominant survey 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.

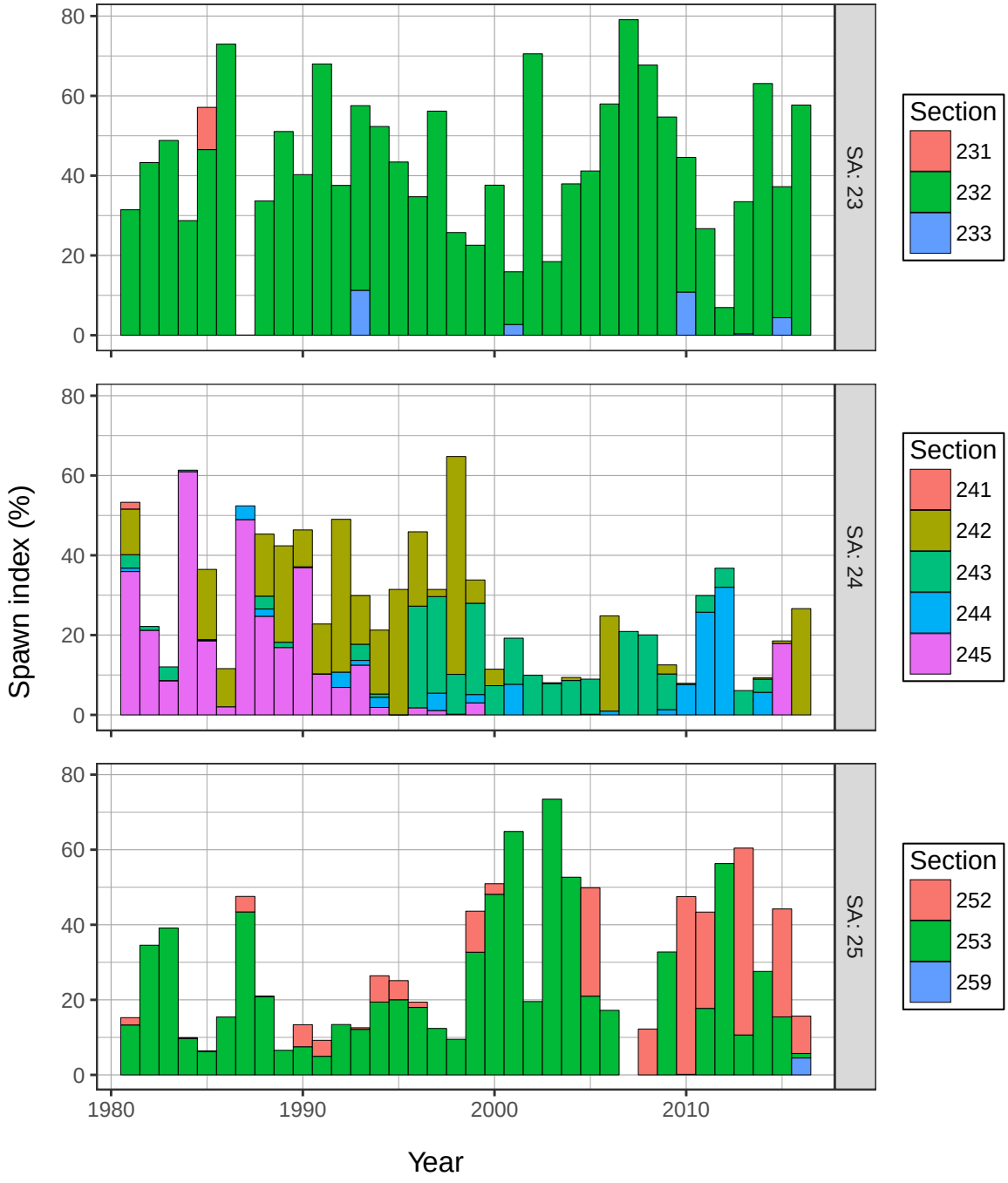

Figure 13. Time series of percent of spawn index by Statistical Area (SA) and Section for Pacific herring from 1981 to 2016 in the West Coast of Vancouver Island major stock assessment region (SAR). The spawn index has two distinct periods defined by the dominant survey method: surface surveys (1951–1987), 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.