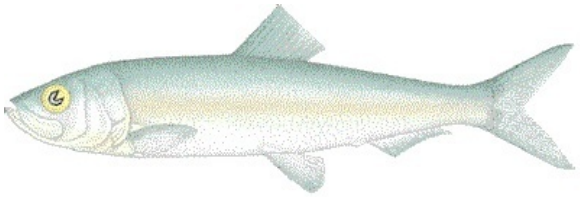
Pacific herring preliminary data summary for West Coast of Vancouver Island 2017

DFO Science*

September 7, 2017



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

Disclaimer This report contains preliminary data, which may differ from data used and presented in the final Pacific herring stock assessment for West Coast of Vancouver Island 2017.

---

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 2017. 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 West Coast of Vancouver Island major SAR in 2017 (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 2017 refers to the 2016/2017 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 11th. 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 "Canadian Shore" surveyed 15 days from March 5th to March 20th. This vessel mainly covered Areas 24 and 25. The charter vessel "Seaveyor", surveyed 17 days from late February through early April. The "Seaveyor" covered Areas 23, 24, 25, and 27 along with a couple days in the Strait of Georgia. All three charter vessels were funded by DFO, through a contract to the Herring Conservation Research Society.

3 Catch and biological samples

Landed commercial catch of Pacific herring by year and fishery is shown in Table 2 and Figure 3. Total harvested spawn on kelp (SOK) in 2017 in the West Coast of Vancouver Island major SAR is shown in Table 3; we also calculate the estimated spawning biomass associated with SOK harvest. See calculations to convert SOK to spawning biomass in Appendix A, page 21.

In 2017, 19 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 1,059 Pacific herring were aged in 2017. There are differences between biological data collected from two sampling protocols regarding the number-, proportion-, and weight-at-age for Pacific herring in 2017 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 24 individual locations in 2017 in the West Coast of Vancouver Island major SAR (Table 10, and Figure 7). A summary of spawn from the last decade (2007 to 2016) is shown in Figure 8. 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 9, Figure 10, Figure 11, Figure 12, 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 (1988–2017).

Some herring Sections contribute more than others to the total spawn index, and the percentage contributed by Section varies yearly (Figure 12b, Figure 13). For example, in 2017, Section 253 contributed the most to the spawn index (57%). As with Sections, some Statistical Areas contribute more than others to the total spawn index (Figure 12c, Figure 14).

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:

- Compared to 2016, the spatial extent of the spawn in Area 23 appeared to be reduced.
- Early spawns in Hesquiat Harbour continue to be observed and reported.
- Surface surveys form a significant proportion of the spawn survey data in Area 24.
- As in recent years, significant gray whale feeding was observed in Hesquiat Harbour throughout the season.
- The test boat reported spawned-out fish in test sample from Nootka Sound, but no spawn was observed or reported.
- New spawning areas in Esperanza in Louie Bay and Hixson Bluff.

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 gear type in 2017 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. Data from the spawn-on-kelp (SOK) fishery is not included. Note: 'WP' indicates that data are withheld due to privacy concerns.

Period	Catch (t)
Gear1	0
Gear2	0
Gear3	0

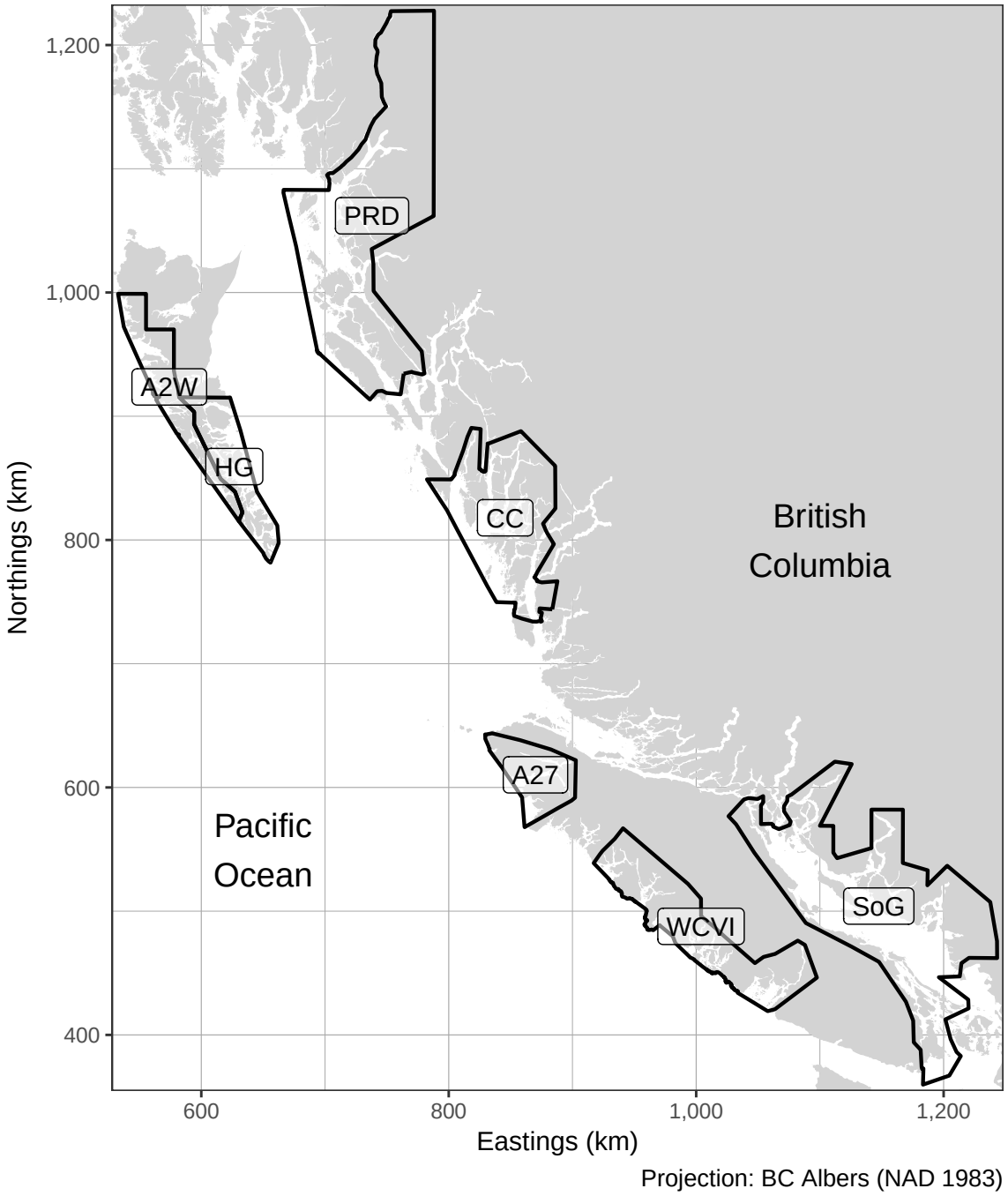


Figure 1. Boundaries for the Pacific herring stock assessment regions (SARs) in British Columbia: there are 5 major SARs (HG, PRD, CC, SoG, and WCVI), and 2 minor SARs (A27 and A2W; Table 1). Units: kilometres (km).

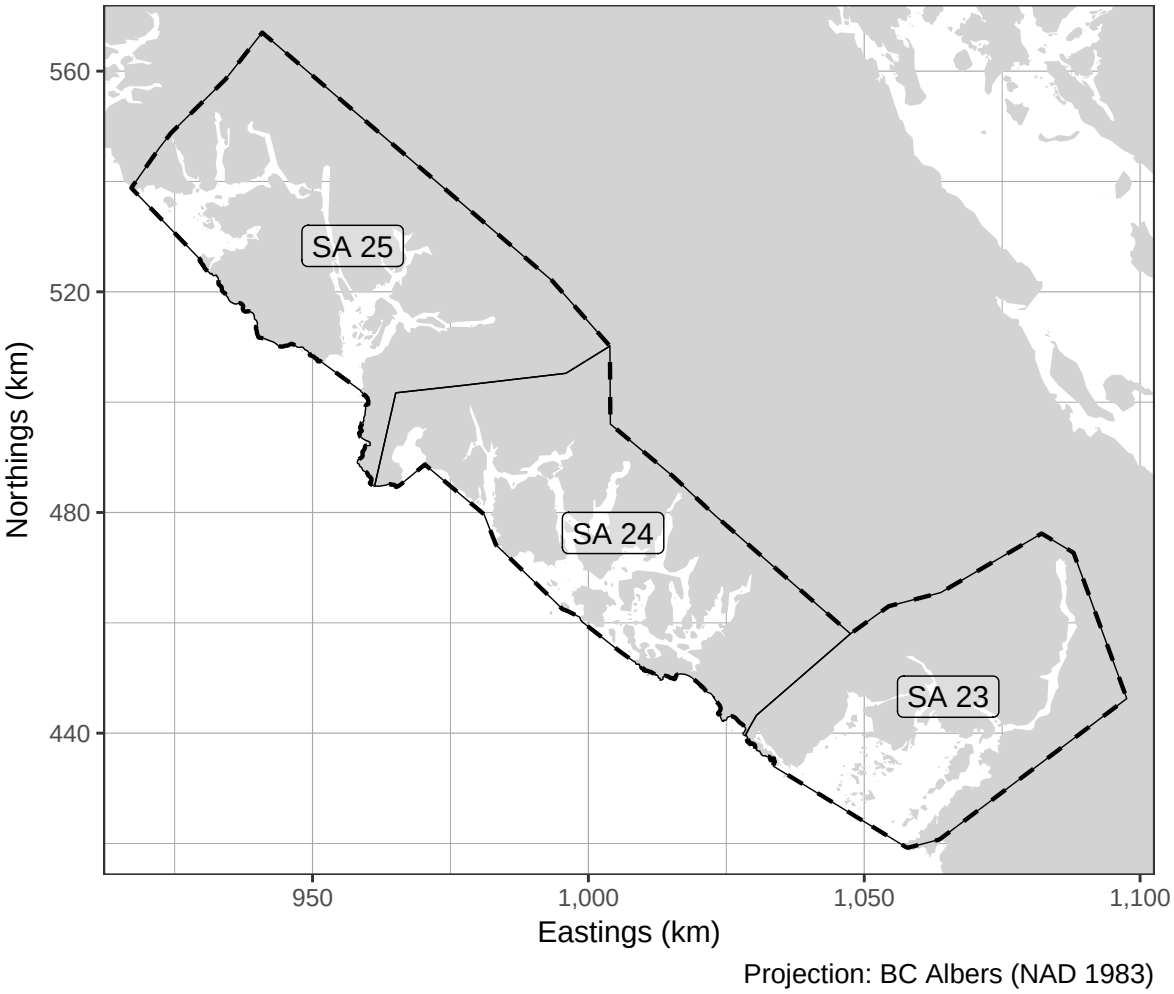


Figure 2. Boundaries for the West Coast of Vancouver Island major stock assessment region (SAR; thick dashed lines), and associated Statistical Areas (SA; thin solid lines). Units: kilometres (km).

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 2007 to 2017 in the West Coast of Vancouver Island major stock assessment region (SAR). See calculations to convert SOK to spawning biomass in Appendix A, page 21. Note: 'WP' indicates that data are withheld due to privacy concerns.

Year	Harvest (lb)	Spawning biomass (t)
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
2017	0	0

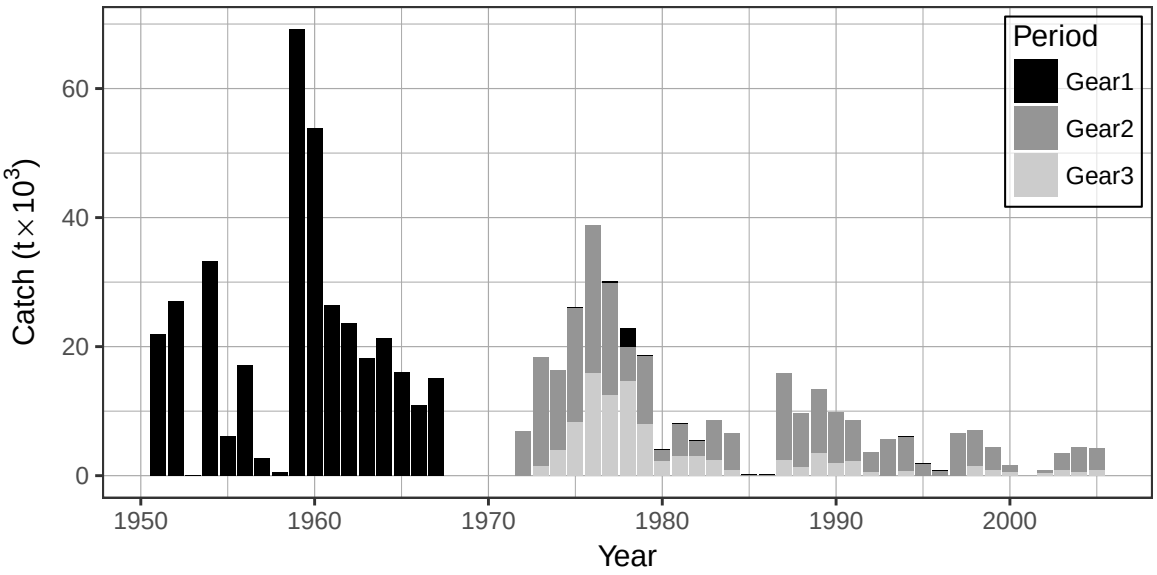


Figure 3. Time series of total landed catch in thousands of metric tonnes ($t \times 10^3$) of Pacific herring by gear type from 1951 to 2017 in the West Coast of Vancouver Island major stock assessment region (SAR). Legend: 'Gear1' represents the reduction, the food and bait, as well as the special use fishery; 'Gear2' represents the roe seine fishery; and 'Gear3' represents the roe gillnet fishery. Data from the spawn-on-kelp (SOK) fishery is not included.

Table 4. Number of Pacific herring biological samples processed from 2007 to 2017 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
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
2017	0	19	19

Table 5. Number and type of Pacific herring biological samples processed in 2017 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	7
Test	Seine	Test Fishery	12

Table 6. Observed number-at-age of Pacific herring by sample type in 2017 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	43	56	355	89	64	4	0	0	0
Seine test	27	81	703	140	87	17	2	2	0
Total	70	137	1058	229	151	21	2	2	0

Table 7. Observed proportion-at-age of Pacific herring by sample type in 2017 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	0.070	0.092	0.581	0.146	0.105	0.007	0.000	0.000	0.000
Seine test	0.025	0.076	0.664	0.132	0.082	0.016	0.002	0.002	0.000
Total	0.042	0.082	0.634	0.137	0.090	0.013	0.001	0.001	0.000

Table 8. Observed weight-at-age in grams (g) of Pacific herring by sample type in 2017 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	57.9	70.3	85.3	91.1	94.2	97.5	NA	NA	NA
Seine test	65.4	81.0	94.6	102.0	109.9	118.9	136.5	121.0	NA
Total	60.8	76.7	91.5	97.8	103.3	114.8	136.5	121.0	NA

Table 9. Observed proportion-at-age for Pacific herring from 2007 to 2017 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
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
2017	0.025	0.076	0.664	0.132	0.082	0.016	0.002	0.002	0.000

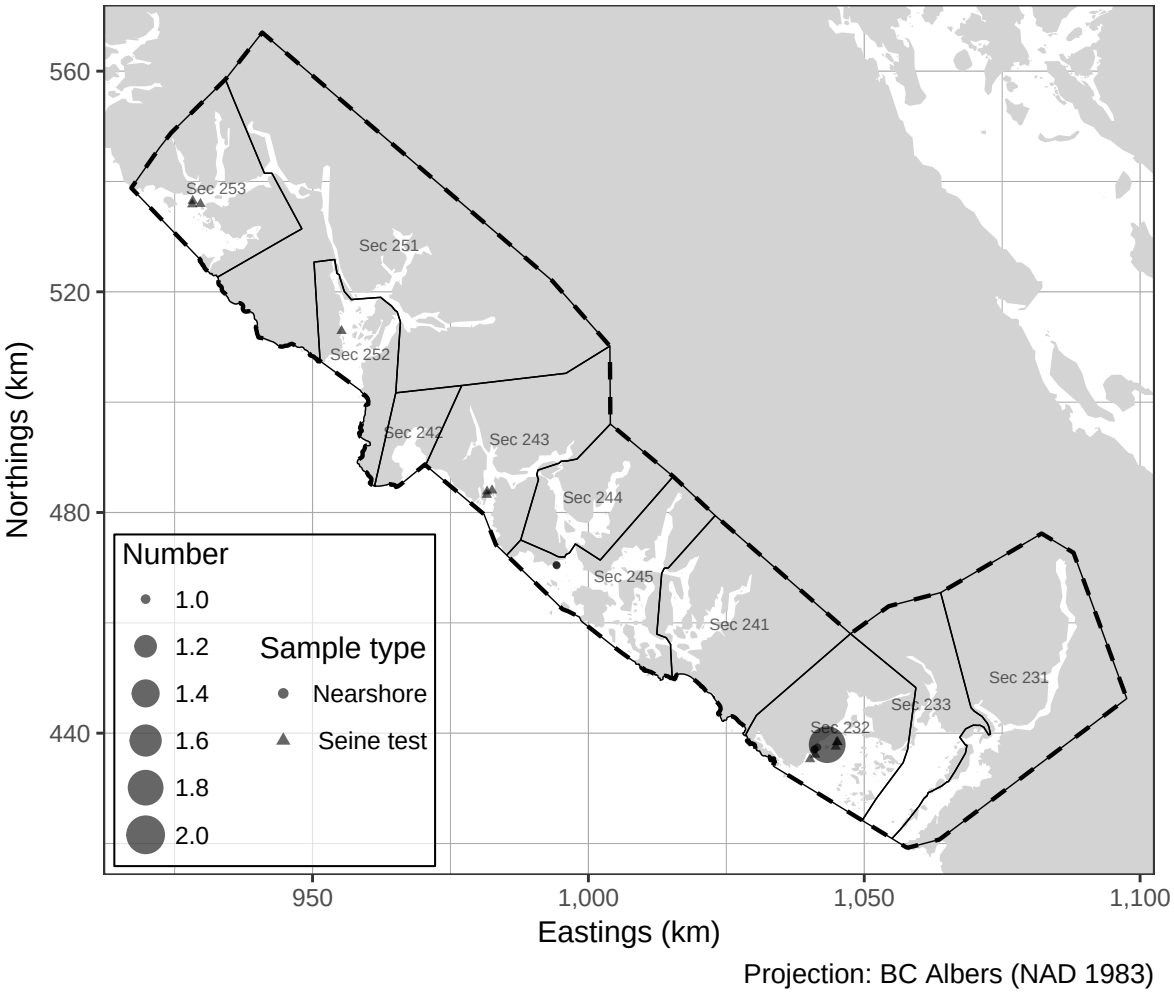


Figure 4. Location and type of Pacific herring biological samples collected in 2017 in the West Coast of Vancouver Island major stock assessment region (SAR; thick dashed lines), and associated Sections (Sec; thin solid lines). Units: kilometres (km).

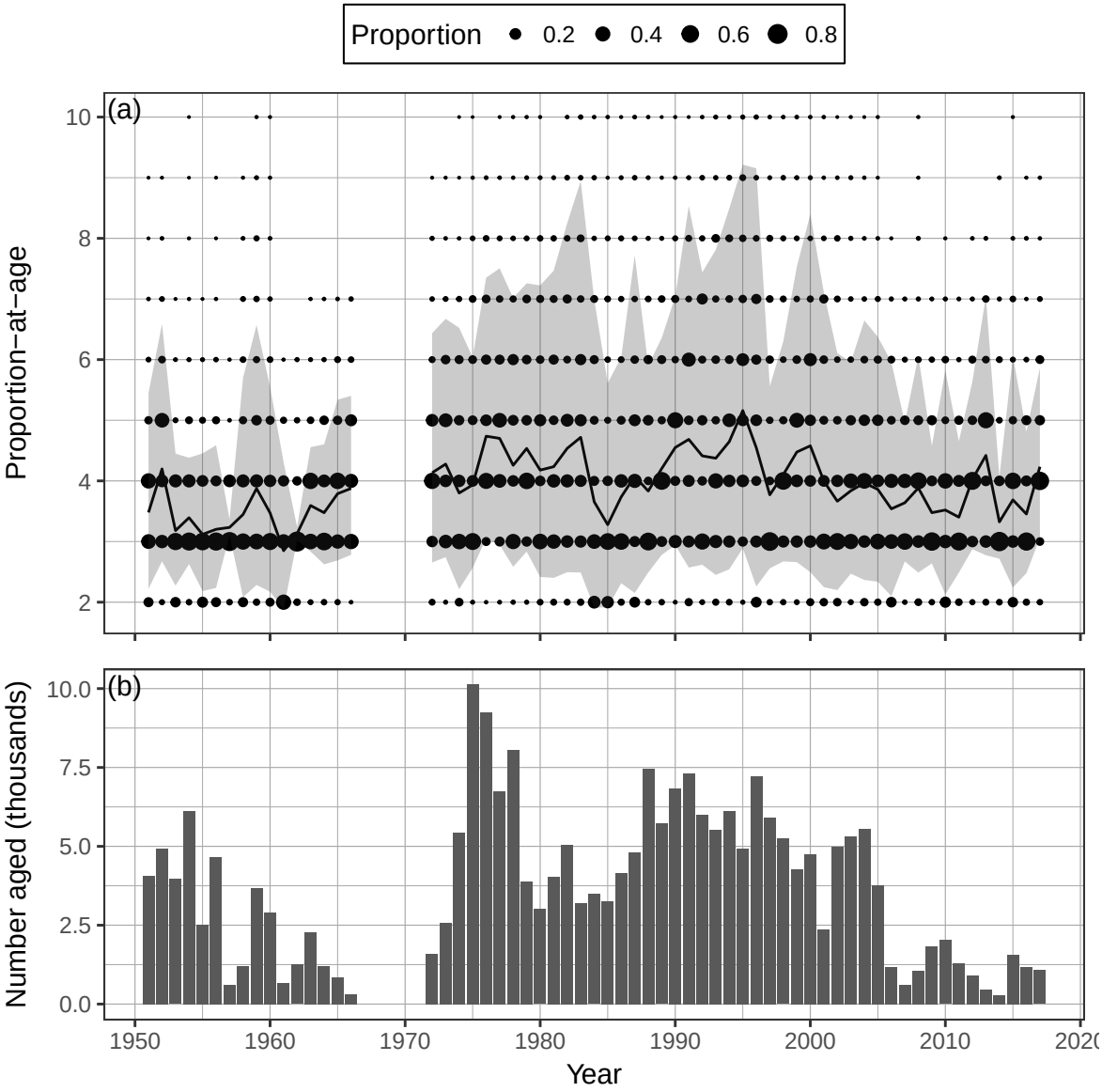


Figure 5. Time series of observed proportion-at-age (a) and number aged in thousands (b) of Pacific herring from 1951 to 2017 in the West Coast of Vancouver Island major stock assessment region (SAR). The black line is the mean age, and the shaded area is the approximate 90% distribution. Biological 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.

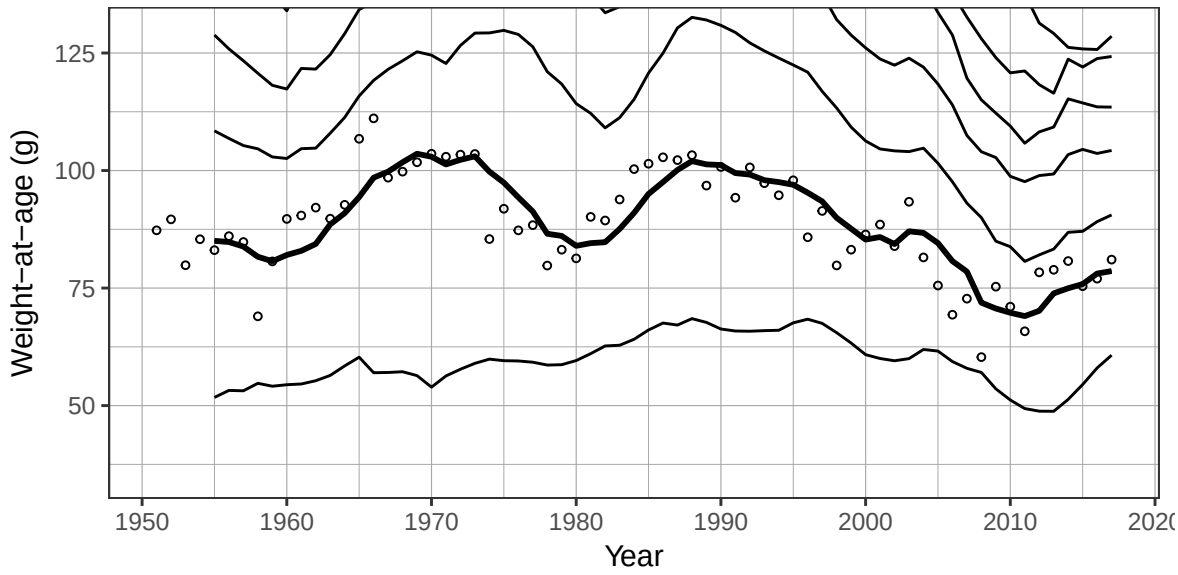


Figure 6. Time series of weight-at-age in grams (g) for age-3 (circles) and 5-year running mean weight-at-age (lines) for Pacific herring from 1951 to 2017 in the West Coast of Vancouver Island major stock assessment region (SAR). Lines show 5-year running means for age-2 to age-10 herring (incrementing 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 2017 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 +	1,659
23	232	1144	Macoah Pass	141
23	232	1145	Forbes Is	1,236
23	232	1146	Amphitrite Pt	653
23	232	1150	David Is	248
23	232	1755	Newcombe Chnl	1,338
24	242	1217	Hesquiat Hrbr	307
24	242	1603	Antons Spit	6
24	242	1604	Rondeault Pt	NA
24	242	1605	Leclaire Pt	NA
24	242	1788	Hesquiat Pt	NA
24	242	1812	Hesquiat Hrbr Hd	NA
24	242	1886	Matlahaw Pt	NA
24	244	1861	Chetarpe Reserve	133
24	245	1222	Epper Pass	65
24	245	1658	Whitesand Cv	502
24	245	3020	Clifford Pt	514
25	253	1261	Catala Is	116
25	253	1262	Port Langford	1,268
25	253	1268	Outer Nuchatlitz	5,202
25	253	1657	Inner Nuchatlitz	1,051
25	253	1794	Louie Bay	1,173
25	253	2253	Unknown Sec 253	122
25	253	3053	Rolling Roadstead	2

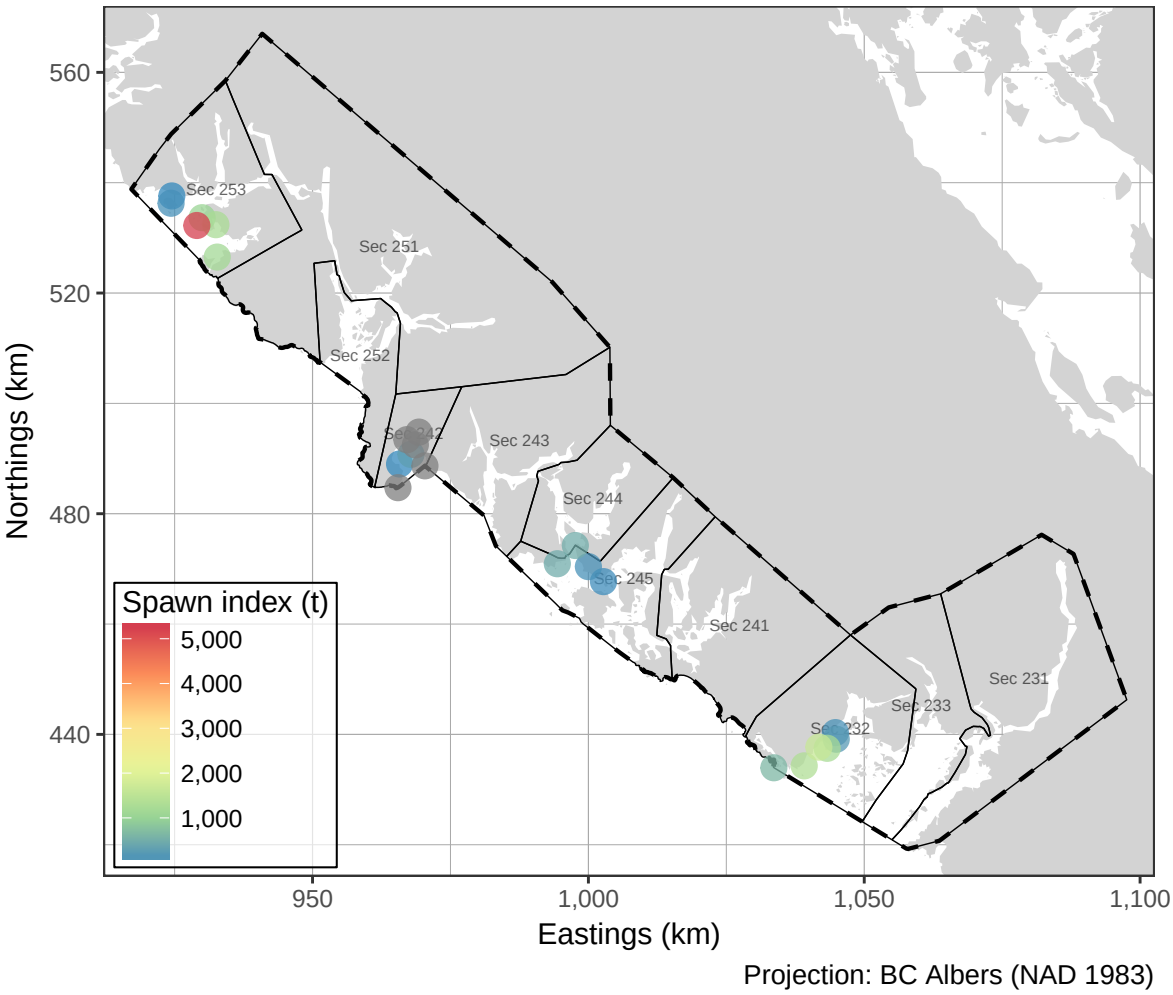


Figure 7. Pacific herring spawn survey locations, and spawn index in metric tonnes (t) in 2017 in the West Coast of Vancouver Island major stock assessment region (SAR; thick dashed lines), and associated Sections (Sec; thin solid lines). The 'spawn index' represents the raw survey data only, and is not scaled by the spawn survey scaling parameter, q. Missing spawn index values (grey circles) indicate incomplete spawn surveys. Units: kilometres (km).

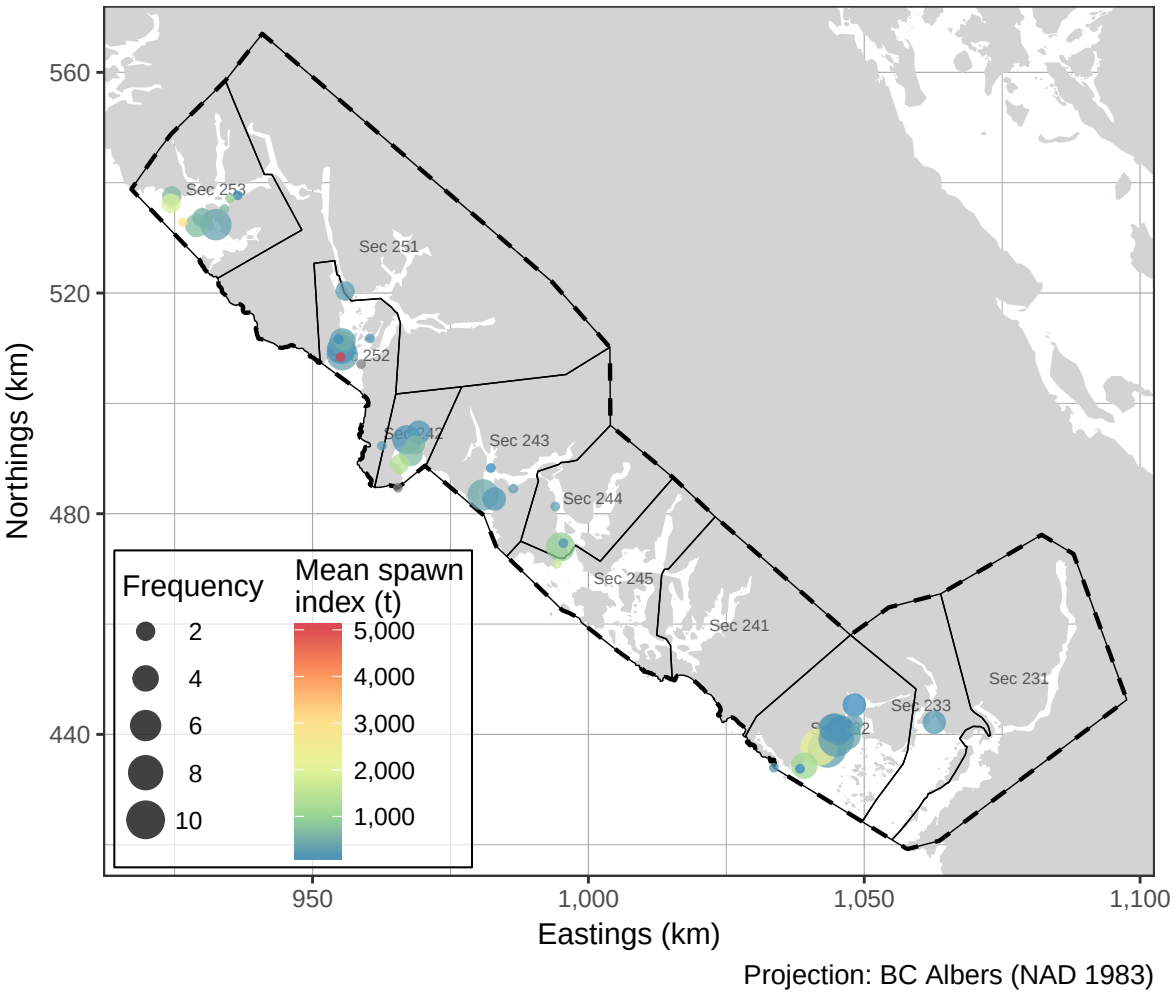


Figure 8. Pacific herring spawn survey locations, mean spawn index in metric tonnes (t), and spawn frequency from 2007 to 2016 in the West Coast of Vancouver Island major stock assessment region (SAR; thick dashed lines), and associated Sections (Sec; thin solid lines). The 'spawn index' represents the 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).

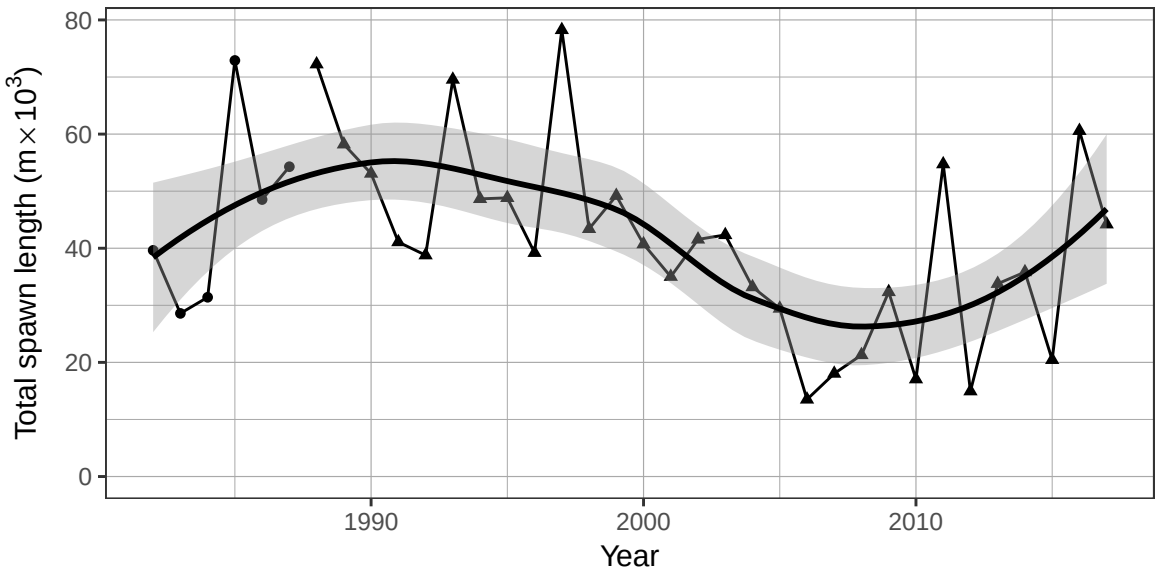


Figure 9. Time series of total spawn length in thousands of metres ($m \times 10^3$) for Pacific herring from 1982 to 2017 in the West Coast of Vancouver Island major stock assessment region (SAR). The thick black line is a loess curve, and the shaded area is the 90% confidence interval. The spawn index has two distinct periods defined by the dominant survey method: surface surveys (1951–1987), and dive surveys (1988–2017).

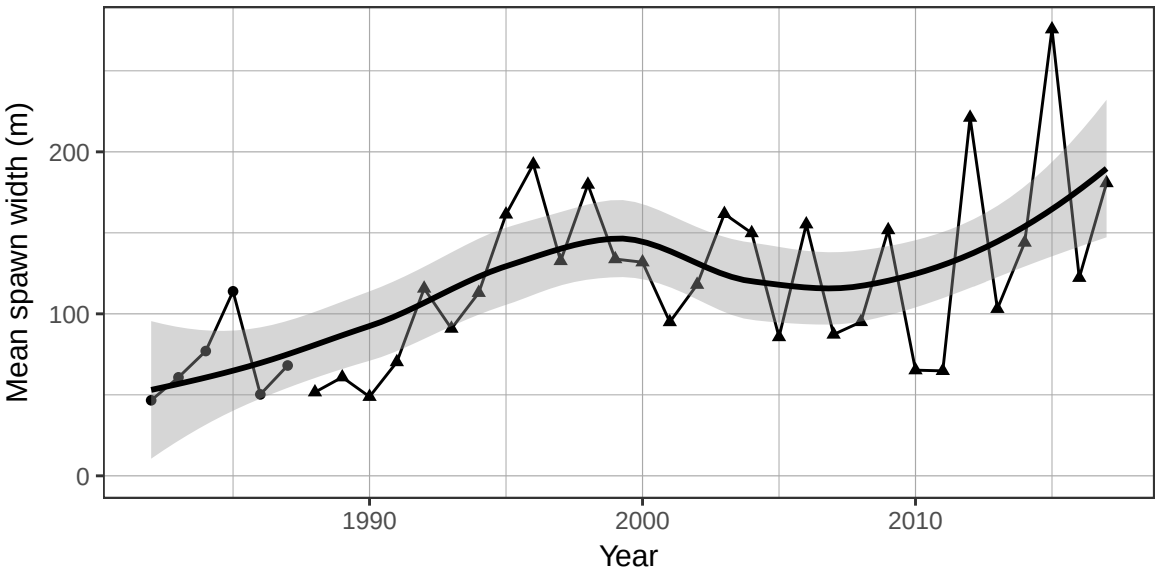


Figure 10. Time series of mean spawn width in metres (m) for Pacific herring from 1982 to 2017 in the West Coast of Vancouver Island major stock assessment region (SAR). The thick black line is a loess curve, and the shaded area is the 90% confidence interval. The spawn index has two distinct periods defined by the dominant survey method: surface surveys (1951–1987), and dive surveys (1988–2017).

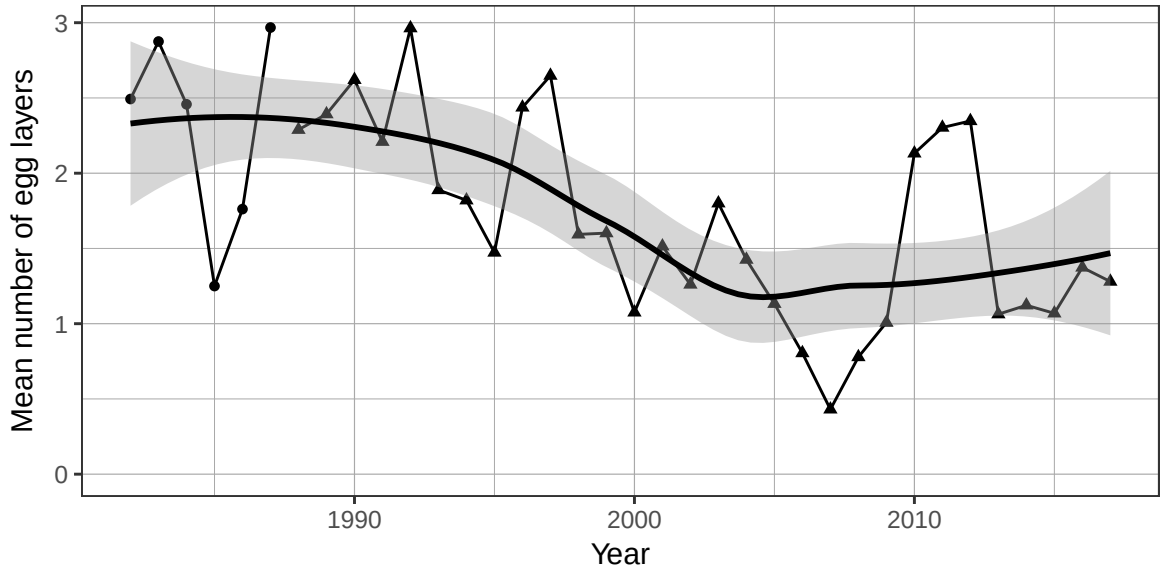


Figure 11. Time series of mean number of egg layers for Pacific herring from 1982 to 2017 in the West Coast of Vancouver Island major stock assessment region (SAR). The thick black line is a loess curve, and the shaded area is the 90% confidence interval. The spawn index has two distinct periods defined by the dominant survey method: surface surveys (1951–1987), and dive surveys (1988–2017).

Table 11. Summary of spawn survey data from 2007 to 2017 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 (1988–2017). 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 egg layers	Spawn index (t)
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
2017	44,200	181	1.280	15,734

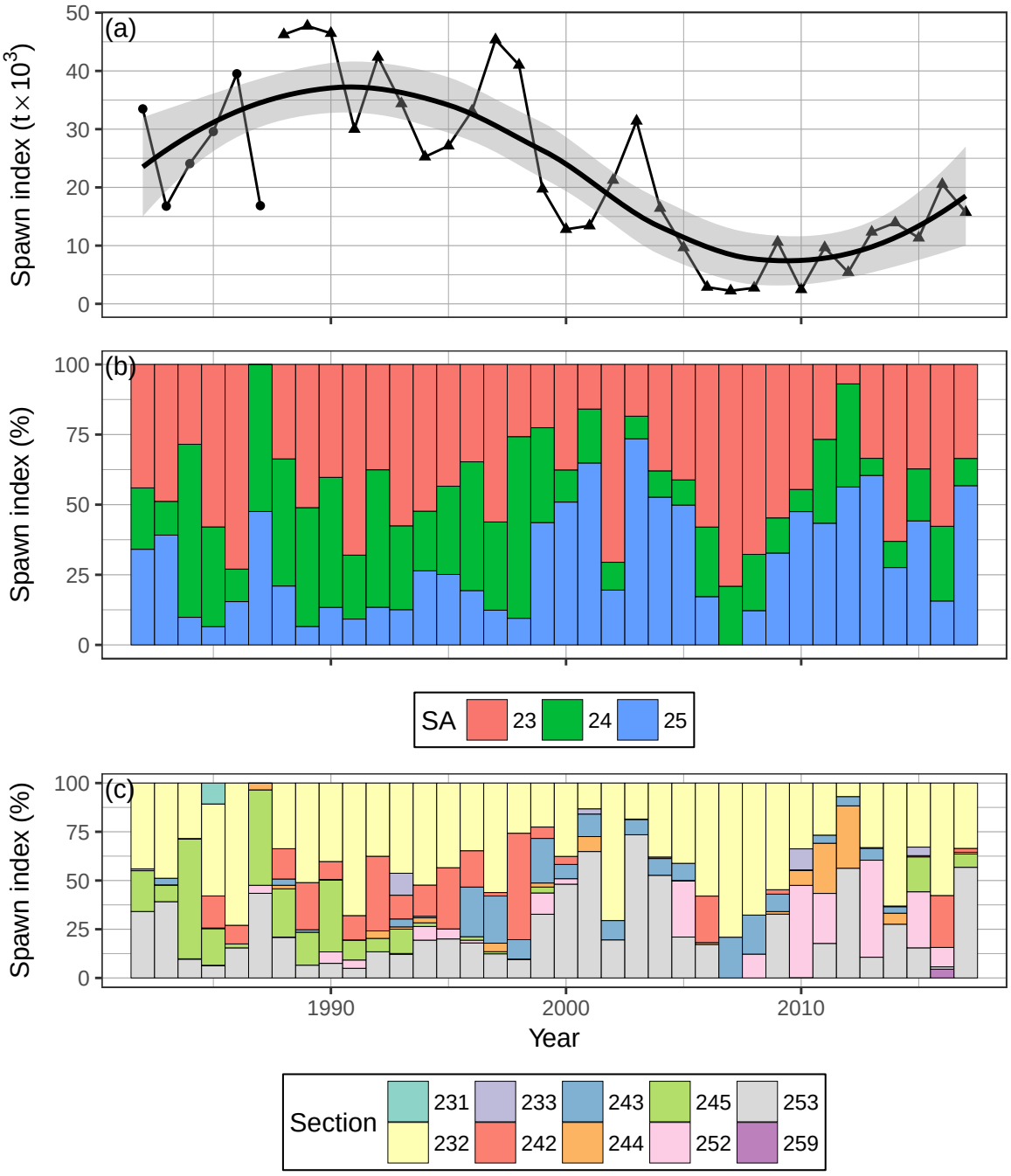


Figure 12. Time series of spawn index in thousands of metric tonnes ($t \times 10^3$) for Pacific herring from 1982 to 2017 in the West Coast of Vancouver Island major stock assessment region (SAR; a), as well as percent contributed by Statistical Area (SA), and Section (b, & c, respectively). The thick 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 (1988–2017). The 'spawn index' represents the raw survey data only, and is not scaled by the spawn survey scaling parameter, q.

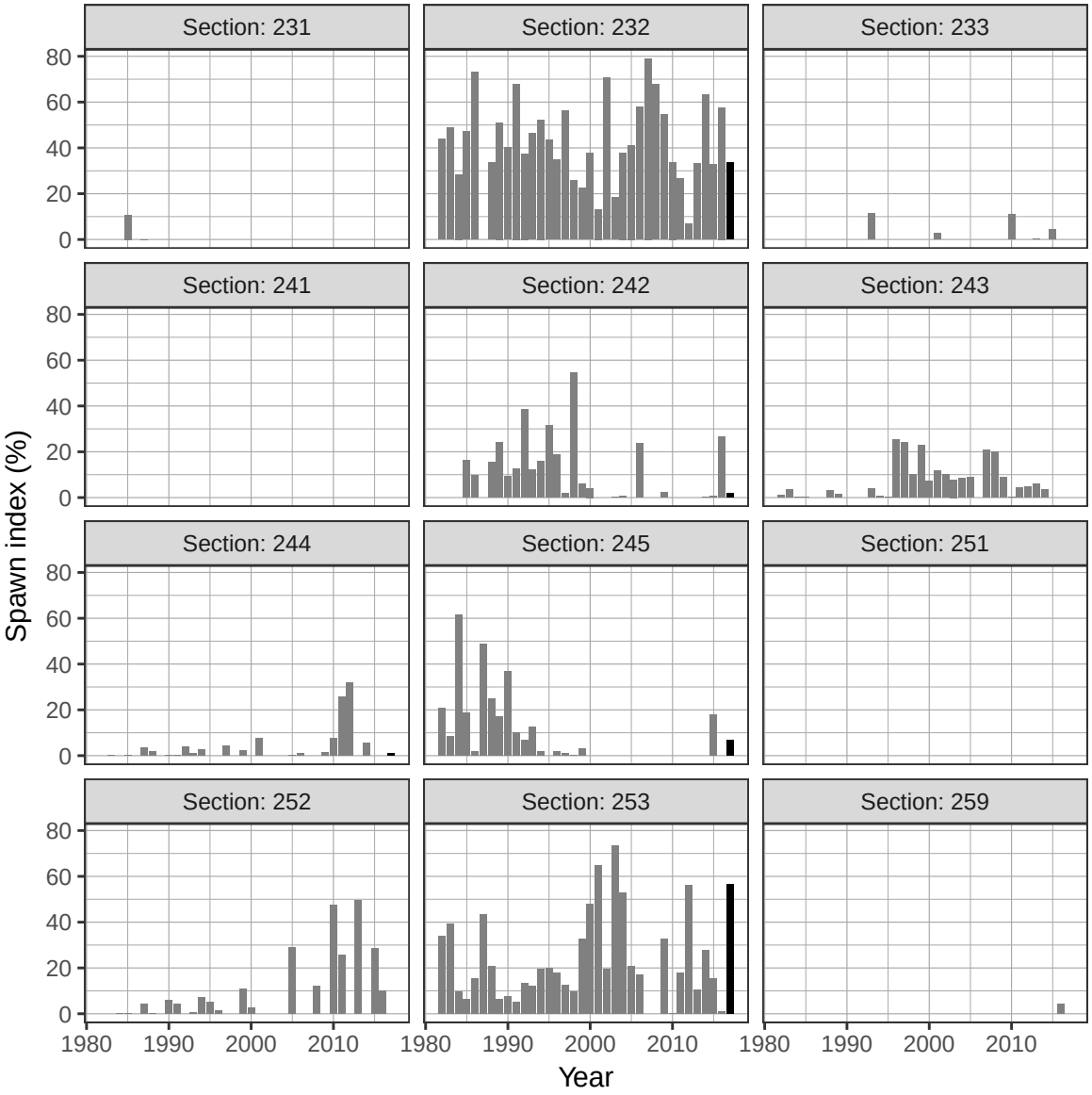


Figure 13. Time series of percent of spawn index by Section for Pacific herring from 1982 to 2017 in the West Coast of Vancouver Island major stock assessment region (SAR). The year 2017 has a darker bar to facilitate interpretation. The spawn index has two distinct periods defined by the dominant survey method: surface surveys (1951–1987), and dive surveys (1988–2017). The 'spawn index' represents the raw survey data only, and is not scaled by the spawn survey scaling parameter, q.

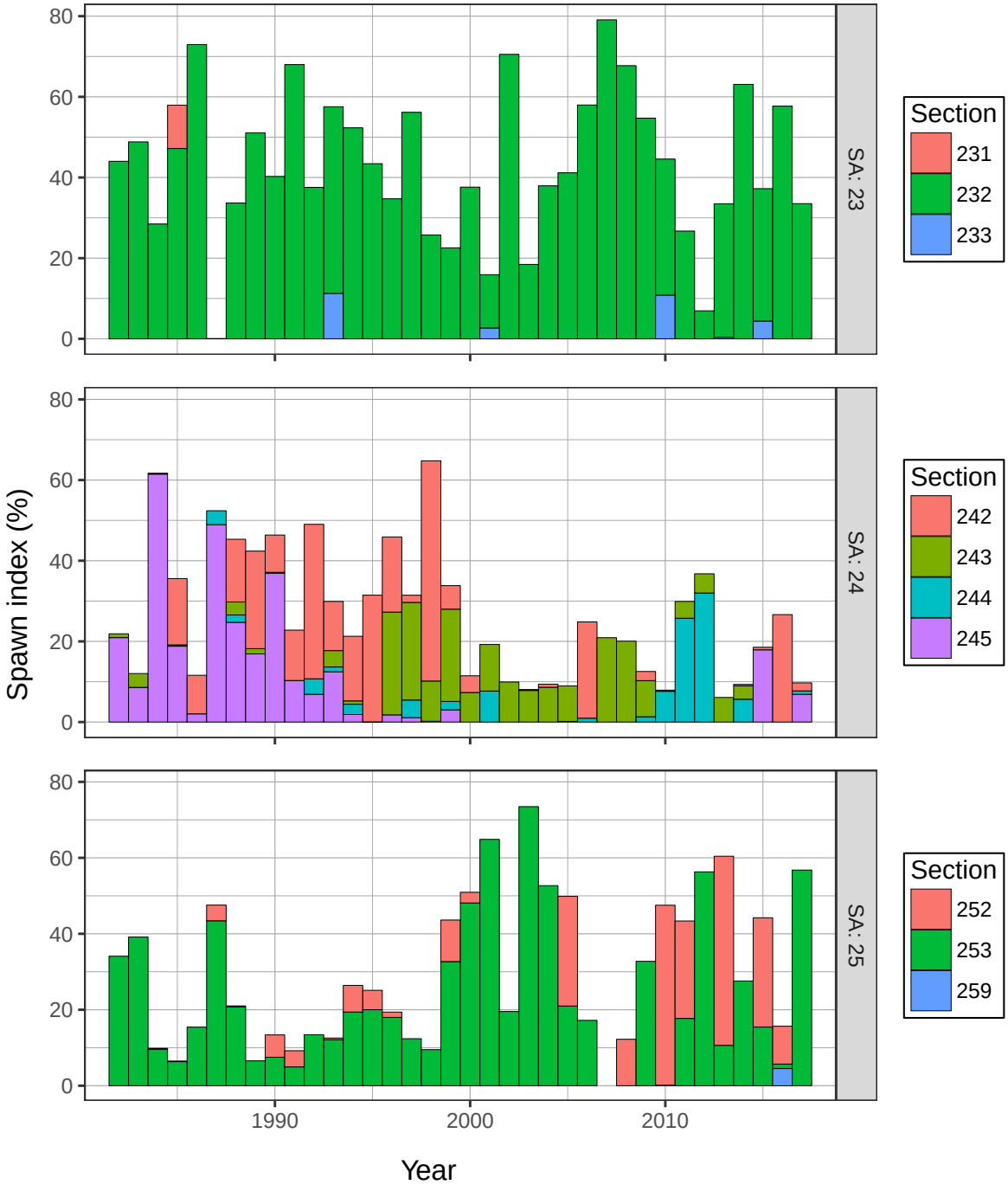


Figure 14. Time series of percent of spawn index by Statistical Area (SA) and Section for Pacific herring from 1982 to 2017 in the West Coast of Vancouver Island major stock assessment region (SAR). The spawn index has two distinct periods defined by the dominant survey method: surface surveys (1951–1987), and dive surveys (1988–2017). The 'spawn index' represents the raw survey data only, and is not scaled by the spawn survey scaling parameter, q.

Appendix A Spawn on kelp

Female Pacific herring produce an average of approximately 200,000 eggs per kilogram, kg of total body weight (Hay 1985; Hay and Brett 1988). We assume that females account for 50% of spawners, and we use the following egg conversion factor, *ECF* to convert eggs to tonnes, t of spawners

$$ECF = fecundity \cdot pFemale \cdot \frac{10^3 \text{ kg}}{\text{t}} \tag{1}$$

where *fecundity* is the number of eggs per kilogram of total female body weight in $\text{eggs} \cdot \text{kg}^{-1}$, *pFemale* is the proportion of spawners that are female, and *ECF* is in $\text{eggs} \cdot \text{t}^{-1}$. Thus, we convert eggs to spawning biomass in tonnes by dividing the number of eggs by $ECF = \text{eggs} \cdot 10^8 \cdot \text{t}^{-1}$. Although Pacific herring productivity is affected by environmental variability and other factors (Tanasichuk and Ware 1987; Hay and Brett 1988), we assume that bias from using Equation 1 is insignificant in most areas and years (Schweigert 1993).

Shields et al. (1985) collected information on the relationship between the number of egg layers in SOK product, and the proportion of the product weight that consisted of eggs and kelp. They determined that kelp represented an average of 12% of the total product weight. Since SOK product is universally brined at the time of harvest, it is necessary to also consider the uptake of salt by the eggs, which increases the overall product weight. However, there is uncertainty in the degree of brining that occurs prior to weighing the product. Nevertheless, Whyte and Englar (1977) determined that following a 24 hour brining period, the wet product weight increased about 13% due to salt uptake. However, by osmosis, the brining would also draw some water from the eggs; unfortunately this cannot be accounted for at this time. The last factor to consider is the mean fertilized egg weight, which was determined by Hay and Miller (1982) as $2.38 \cdot 10^{-6}$ kg. We estimate spawning biomass removed from the population by the SOK fishery as

$$SB = \frac{SOK \cdot eggKelpProp \cdot eggBrineProp}{eggWt \cdot ECF} \tag{2}$$

where *SOK* is the weight in kilograms of herring SOK harvest, *eggKelpProp* is the proportion of the SOK product that is eggs, not kelp (0.88), *eggBrineProp* is the proportion of SOK product that is eggs after brining (0.87), *eggWt* is the average weight in kilograms of a fertilized egg ($\text{kg} \cdot \text{egg}^{-1}$), and *SB* is the estimated spawning biomass in tonnes, based on Equation 1.

References

Hay, D.E. 1985. Reproductive biology of Pacific herring (*Clupea harengus pallasi*). *Canadian Journal of Fisheries and Aquatic Sciences* **42**(S1): 111–126. DOI: 10.1139/f85-267

Hay, D.E., and Brett, J.R. 1988. Maturation and fecundity of Pacific herring (*Clupea harengus pallasi*): An experimental study with comparisons to natural populations. *Canadian Journal of Fisheries and Aquatic Sciences* **45**(3): 399–406. DOI: 10.1139/f88-048

Hay, D.E., and Miller, D.C. 1982. A quantitative assessment of herring spawn lost by storm action in French Creek, 1980. Canadian Manuscript Report of Fisheries and Aquatic Sciences 1636, Department of Fisheries and Oceans. URL `http://cat.fsl-bsf.scitech.gc.ca/record=b3849753~S1`

Schweigert, J.F. 1993. A review and evaluation of methodology for estimating Pacific herring egg deposition. *Bulletin of Marine Science* **53**(2). URL `www.ingentaconnect.com/content/umrsmas/bullmar/1993/00000053/00000002/art00019`

Shields, T.L., Jamieson, G.S., and Sprout, P.E. 1985. Spawn-on-kelp fisheries in the Queen Charlotte Islands and northern British Columbia coast - 1982 and 1983. Canadian Technical Report of Fisheries and Aquatic Sciences 1372, Department of Fisheries and Oceans. URL `http://cat.fsl-bsf.scitech.gc.ca/record=b1319605~S1`

Tanasichuk, R.W., and Ware, D.M. 1987. Influence of interannual variations in winter sea temperature on fecundity and egg size in Pacific herring (*clupea harengus pallasi*). *Canadian Journal of Fisheries and Aquatic Sciences* **44**(8): 1485–1495. DOI: 10.1139/f87-178

Whyte, J.N.C., and Englar, J.R. 1977. Aspects of the production of herring roe on *Macrocystis integrifolia* in Georgia Strait locations. Fisheries and Marine Service Technical Report 751, Fisheries and Marine Service. URL `http://cat.fsl-bsf.scitech.gc.ca/record=b1115904~S1`