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STOCK STATUS UPDATE WITH APPLICATION OF MANAGEMENT PROCEDURES FOR PACIFIC HERRING (*CLUPEA PALLASII*) IN BRITISH COLUMBIA: STATUS IN 2025 AND FORECAST FOR 2026

CONTEXT

Pacific Herring (*Clupea pallasii*) abundance in British Columbia (BC) is assessed using a statistical catch-age (SCA) model (Martell et al. 2011). In 2017, the Pacific Herring stock assessment included updates to the SCA model, a bridging analysis to support these changes (Cleary et al. 2019), and estimation of stock productivity and current stock status relative to the new limit reference point (LRP) of $0.3SB_0$ (Kronlund et al. 2017), where SB_0 is estimated unfished spawning biomass. In 2022, upper stock reference (USR) point options were introduced for the major stock assessment regions (SARs) and this assessment includes estimates of stock status relative to productive period USRs (DFO 2023a). The overall structure of the SCA model has not changed since 2017.

In 2016, Fisheries and Oceans Canada (DFO) committed to renewing the current management framework to address a range of challenges facing Pacific Herring stocks and fisheries in BC. Renewal of the management framework included engaging in a management strategy evaluation (MSE) process to evaluate the performance of candidate management procedures against a range of hypotheses about future stock and fishery dynamics. As part of the MSE process, a Canadian Science Advisory Secretariat (CSAS) regional peer review occurred in 2018, where performance of Pacific Herring management procedures (MPs) were assessed against conservation objectives for the Strait of Georgia (SoG) and West Coast of Vancouver Island (WCVI) SARs (DFO 2019). Steps included operating model (OM) development (Benson et al. 2022), fitting the OM to Pacific Herring stock and fishery monitoring data (OM conditioning), and closed-loop simulations of MP performance for alternative future natural mortality scenarios. In 2019, DFO initiated the MSE process for the Haida Gwaii (HG), Prince Rupert District (PRD), and Central Coast (CC) SARs (DFO 2020a). Updates to MP evaluations were then conducted for SoG and WCVI SARs in 2020 (DFO 2021a) and for PRD, CC, SoG, and WCVI in 2023 (DFO 2022, 2023a).

This assessment includes new science advice on choice of USR points for three of the five major Pacific Herring SARs: HG, CC, and WCVI. Note that the PRD and SoG SARs are assessed in DFO (In prep[1]) and DFO (In prep[2]) respectively, using a new modelling framework (Johnson et al. 2024). An analysis of USR options for PRD, CC, SoG, and WCVI was completed in 2022 (DFO 2023a) and provisional USRs based on productive periods identified for each

[1] DFO. In prep. Prince Rupert District Pacific Herring (*Clupea pallasii*) Stock Update in 2025. DFO Can. Sci. Advis Sec. Sci. Advis. Rep.

[2] DFO. In prep. Strait of Georgia Pacific Herring (*Clupea pallasii*) Stock Update in 2025. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep.

SAR were first implemented in the 2022/23 Integrated Fisheries Management Plan (IFMP). Note that Haida Gwaii USRs are developed in the HG rebuilding plan (DFO et al. 2025).

Since initiation of the Pacific Herring MSE process, MP evaluations have been included in the annual stock assessment as follows:

1. The 2018 stock assessment included MP recommendations for the SoG and WCVI SARs (DFO 2019).
2. The 2019 stock assessment included MP recommendations for the HG, PRD, and CC SARs, and implemented MP recommendations from previous years for the SoG and WCVI SARs (DFO 2020b).
3. The 2020 stock assessment included updated MP recommendations for the SoG and WCVI SARs, and implemented MP recommendations from previous years for the HG, PRD, and CC SARs (DFO 2021a).
4. The 2021 stock assessment included updated MP recommendations for the PRD and CC SARs, and implemented MP recommendations from previous years for the SoG and WCVI SARs (DFO 2021b).
5. The 2022 stock assessment included updated MP recommendations for the PRD, CC, SoG, and WCVI SARs (DFO 2022).
6. The 2023 stock assessment implemented MPs from previous years for the PRD, CC, SoG, and WCVI SARs (DFO 2024). Management measures to support long-term recovery of HG herring are developed through the HG rebuilding plan (DFO et al. 2025).
7. The 2024 stock assessment implemented MPs from previous years for the PRD, CC, and WCVI SARs (DFO 2025a).
8. The new SISCAH management framework (Johnson et al. 2024) was applied to SoG in 2024 (DFO 2025b) and updated for 2025.[2]
9. The new SISCAH management framework (Johnson et al. 2024) was applied to PRD in 2025.[1]
10. The new SISCAH management framework (Johnson et al. 2024) will be applied for HG, CC, and WCVI in 2026.

This 2025 stock assessment includes MP recommendations for CC and WCVI, derived in 2022 by updating herring OM conditioning (Benson et al. 2022) using the historic stock and fishery data from 1951 to 2021 (DFO 2022). There are no new MP evaluations for 2025 (all probability metrics reflect the MP evaluations presented in 2022).

Fisheries and Oceans Canada (DFO) Pacific Fisheries Management Branch requested that DFO Pacific Science Branch assess the status of British Columbia (BC) Pacific Herring stocks in 2025 and recommend harvest advice for 2026 using simulation-tested MPs to inform the development of the 2025/2026 IFMP, where appropriate. Estimated stock trajectories, current status of stocks for 2025, management procedure options, and harvest advice recommendations from those MPs for 2026 reflect methods of Cleary et al. (2019) and Benson et al. (2022) and, where applicable, recommendations from the aforementioned 2018, 2019, 2020, 2021, 2022, and 2023 MSE analyses (Section “Application of MPs and harvest options for 2026”).

This Science Response Report results from the regional peer review of September 22, 2025, Stock Status Update with Application of Management Procedures for Pacific Herring (*Clupea* *pallasii*) in British Columbia (Haida Gwaii, Central Coast, West Coast Vancouver Island stocks): Status in 2025 and Forecast in 2026.

BACKGROUND

Pacific Herring in BC are managed as five major and two minor SARs (Figure 1). The major SARs are Haida Gwaii (HG), Prince Rupert District (PRD), Central Coast (CC), Strait of Georgia (SoG), and West Coast of Vancouver Island (WCVI). The minor SARs are Area 27 (A27) and Area 2 West (A2W). We conduct formal analyses of stock trend information for the major SARs annually. Although PRD and SoG are assessed in DFO (In prep.)[1] and DFO (In prep.)[2] respectively, some tables and figures in this document include PRD and SoG data for completeness. For the minor SARs, we present available catch data, biological data, and spawn survey data (Section "Minor stock assessment regions"). Beginning in 2021 we include similar data for the special area, Area 10 (Section "Special areas"). Note that Area 10 is a subset of the Central Coast and is outside the SAR boundary. Formal analyses of stock trends are not included for minor SARs or special areas.

Description of the Fishery

There are several Pacific Herring fisheries in BC. After conservation, First Nations have priority access to fish for food, social, and ceremonial (FSC) purposes. Commercial fishing opportunities consist of four directed fisheries: food and bait (FB), special use (SU), spawn-on-kelp (SOK), and roe herring. There is also a small recreational fishery.

First Nations fish for whole herring, herring roe, and herring eggs for FSC purposes. Whole herring are fished by seine, gillnet, rake, dip net, and jig. Herring eggs are collected as spawn on seaweed such as kelp (i.e., SOK), or spawn on tree boughs placed in spawning locations. Indigenous harvest of herring for FSC purposes may occur coast wide where authorized by a communal licence.

In addition, treaty and Aboriginal commercial fisheries may occur in some specific management regions. Four modern treaties (Nisga'a, Tsawwassen, Maa-nulth, and Tla'amin) have been ratified in BC and articulate a treaty right to FSC harvest of fish. Five Nuu-chah-nulth First Nations located on the West Coast of Vancouver Island—Ahousaht, Ehattesaht, Hesquiaht, Mowachaht/Muchalaht, and Tla-o-qui-aht (the Five Nations)—have Aboriginal rights to fish for any species of fish, with the exception of Geoduck, within their Fishing Territories and to sell that fish. DFO developed a 2022/2023 Five Nations Multi-Species Fishery Management Plan (FMP). The FMP includes specific details about the fishery, such as allocation/access, licensing and designations, fishing area, harvesting opportunities, and fishery monitoring and catch reporting. Feedback provided by the Five Nations during consultations was considered and incorporated into the 2023/2024 FMP by DFO where possible. For further information see the 2023/2024 FMP.

On the Central Coast, Heiltsuk Nation have an Aboriginal right to commercially harvest Pacific Herring SOK. The Heiltsuk currently hold nine SOK licences in this area, and SOK is harvested using the preferred means of the Heiltsuk, which is open ponding. The DFO and Heiltsuk are also committed to annual development of a Joint Fisheries Management Plan for Pacific Herring in the Central Coast.

In 2024/2025, the primary Pacific Herring fisheries were seine roe and gillnet roe fisheries, with a combined coast wide catch of 7,074 tonnes (t). The FB seine fishery had a coast wide catch of 2,408 t. Roe fisheries operated in SoG and PRD this season, and FB and SU fisheries operated in SoG only. Commercial SOK fisheries operated both in the CC and WCVI in 2024/2025.

A complete dockside monitoring program exists for all Pacific Herring commercial fisheries and the resulting validated catch data are included in the annual stock assessment process for all fisheries, except SOK. The exclusion of SOK fishery data from the annual stock assessment process was identified as a key uncertainty in the most recent CSAS review of the stock assessment framework (Cleary et al. 2019). Recommendations for addressing this uncertainty require quantifying ponding mortality and removals (i.e., eggs) associated with SOK fisheries. Progress has been made in quantifying SOK mortality sources within the new modelling framework (DFO 2023b) implemented for PRD (DFO. In prep.)[1], and also within the HG rebuilding plan (DFO et al. 2025) however those approaches are not transferable to the SCA model (Martell et al. 2011) used here.

Description of the Stock Assessment Process

The SCA model is fitted to commercial catch data, fishery and survey proportion-at-age data, and a fishery-independent spawning biomass index to estimate total and spawning biomass, natural mortality, and recruitment. Observed annual weight-at-age is estimated external to the model, and maturity-at-age is a fixed input parameter. In 2017, an updated version of the SCA model was applied to assess each of the five major Pacific Herring SARs (Cleary et al. 2019). The main change from the SCA model used from 2011 to 2016 was partitioning variance between observation and process error to improve variance structure estimates (Cleary et al. 2019). A bridging analysis was used to validate the updated model which showed nearly identical parameter estimates and biomass trajectories from the new model compared to previous versions of the model, which supported adopting the updated model (Cleary et al. 2019).

A Bayesian framework is used to estimate time series of spawning biomass, instantaneous natural mortality, and age-2 recruitment from 1951 to 2025. Advice to managers for the major SARs includes posterior estimates of current stock status SB_{2025}, stock status relative to the LRP $0.3SB_0$, and spawning biomass in 2026, SB_{2026}, assuming no catch. Projected pre-fishery spawning biomass is based on the current year's recruitment deviations from average as predicted by the Beverton-Holt stock-recruit model, and estimated natural mortality and weight-at-age, both averaged over the last five years. The Markov chain Monte Carlo (MCMC) sampling procedure follows the same method implemented by Cleary et al. (2019).

Cleary et al. (2019) reported results from two SCA model fits with different assumptions about dive survey catchability q_2 (from 1988 to 2025): assessment model 1 (AM1) which estimates q_2 with a prior distribution; and assessment model 2 (AM2) where $q_2 = 1$. The assumptions that the dive survey spawn index represents all the spawn deposited and that no eggs are lost to predation are strong. However, there is little information in the stock assessment data to inform an estimate of q_2; examination of Bayes posteriors show that priors are not updated for the HG, CC, SoG, and WCVI SARs, and estimated values reflect prior means (Cleary et al. 2019, Appendix D). Assuming $q_2 = 1$ produces a "minimum" biomass estimate buffering any other assessment and management implementation errors (Martell et al. 2011; DFO 2012). Application of AM1 would remove such safeguards despite recent simulation evaluation showing that large (positive) assessment errors are produced by the current assessment model even with $q_2 = 1$ (DFO 2019). Scaling the assessment with values of $q_2 < 1$ is likely to result in larger absolute assessment errors than those estimated when $q_2 = 1$ (DFO 2019). For these reasons, advice presented here is based on the AM2 parameterization, supported also by comparisons presented in DFO (2016, Table A1), and Cleary et al. (2019, Appendix D).

ANALYSIS AND RESPONSE

Management Strategy Evaluation

Fisheries and Oceans Canada (DFO) has committed to renewing the current management framework to address a range of challenges facing Pacific Herring stocks and fisheries in BC. Renewal of the management framework for Pacific Herring uses MSE to evaluate the performance of candidate MPs against hypotheses about past and future stock and fishery dynamics. The purpose of the MSE process is to identify and eliminate MPs that incur unacceptable risks to a stock and identify MPs that provide acceptable outcomes related to conservation and fishery management objectives. Identifying preferred MPs requires measurable objectives that include reference points (typically categorized as limits and targets) and those related to catch, catch variability, and socio-cultural goals. MSE is an iterative and ongoing process conducted with the participation of First Nations, the fishing industry, as well as government and non-government organizations.

The first MSE cycles for the SoG and WCVI SARs were completed in 2018 (DFO 2019). Steps included OM development (Benson et al. 2022), fitting OMs and simulations of MP performance for various hypothesized natural mortality scenarios (DFO 2019). In 2019, the MSE process was extended to HG, PRD, and CC SARs and performance evaluation of SAR specific MPs (DFO 2020a), with subsequent updates outlined in Section “CONTEXT”. Management procedure evaluation tables were updated in 2022 (DFO 2022).

Currently, a core set of fisheries management objectives (DFO 2020a) have been drafted for each major SAR, however only the conservation objective (1) has been used in the selection of MPs:

1. Maintain spawning biomass at or above the LRP with at least 75% probability over three Pacific Herring generations (i.e., avoid a biomass limit; $P\ (SB_t \geq 0.3SB_0) \geq 0.75$), where generation time is estimated to be about five years (Cleary et al. 2010).
2. Maintain spawning biomass at or above the USR with at least 50% probability over three Pacific Herring generations (i.e., achieve a target biomass; $P\ (SB_t \geq SB_{targ}) \geq 0.50$).
3. Maintain average annual variability (AAV) in catch below 25% over three Pacific Herring generations (i.e., minimize catch variability; AAV < 0.25).
4. Maximize average annual catch over three Pacific Herring generations (i.e., maximize average catch).

A fully specified set of objectives has not yet been developed for each SAR. DFO will continue to collaborate with coastal First Nations to develop area-specific objectives specific for FSC and SOK fisheries. In addition, DFO will continue to engage with the herring industry, government, and non-government organizations to describe broader objectives related to conservation, stock rebuilding, economics, and access.

MPs for each SAR differ in the form of the harvest control rule (HCR) and choice of catch cap, but use the same type of monitoring data and assessment model (e.g., Cleary et al. 2019).

The current stock assessment model assumes natural mortality M is time-varying and this is reflected in the MSE as two hypotheses about future Pacific Herring natural mortality:

1. M is a time-varying, density-dependent process (DDM), and
2. M is a time-varying, density-independent process (DIM).

These two hypotheses are captured as operating model (OM) scenarios in Benson et al. (2022). The DDM scenario was identified as the reference OM scenario based on discussion at the 2018 CSAS review process (DFO 2020a), while the DIM scenario was identified as a robustness OM scenario.

On June 26 to 28, 2023, a regional peer review occurred for “Application of a new modelling framework for the assessment of Pacific Herring (*Clupea pallasii*) major stocks and implementation in the MSE process.” The details of the review process are summarized in DFO (2023b), and there were two key recommendations for implementation:

1. A process to implement the new assessment and operating model, update the MSE, and identify exceptional circumstances should be developed in a phased approach in consultation with managers, First Nations and other stakeholders.
2. A minimum three year cycle for MSE updates is recommended, unless new evidence reveals exceptional circumstances.

DFO has advanced these recommendations and has implemented the spatially integrated statistical catch at age herring (SISCAH) modelling framework for the SoG SAR beginning in 2024 (DFO 2025b) and the PRD SAR beginning in 2025 (DFO. In prep.)[1]. For the remaining three SARs (HG, CC, and WCVI) we implement MPs from the previously approved operating model (as per 2024).

Input Data

There are three types of input data used for the Pacific Herring stock assessment: catch data, biological data, and abundance data. These data are described in the following sections, and summarized in Table 1. Relative to the previous assessment, the only change to input data was to extend all the time series to include the 2024/2025 herring season (July 1 to June 30).

Note that we refer to ‘year’ instead of ‘herring season’ in this report; therefore 2025 refers to the 2024/2025 Pacific Herring season.

Catch data

For the purposes of stock assessment, catch data are summarized by gear type as described in Table 1 and presented in Figure 2. As in previous years, catch data for the stock assessment model does not include mortality from the commercial SOK fishery, nor any recreational fisheries or food, social, and ceremonial (FSC) harvest. Recreational fisheries and FSC harvest are considered minor relative to commercial harvest. The commercial SOK fishery is licensed based on pounds of validated SOK product (i.e., eggs adhered to kelp), not tonnes of fish used or spawned. Currently there is no basis to validate mortality imposed on the population by this fishery, however methods for estimating SOK mortality have been developed within the SISCAH modelling framework (DFO 2023b).

Combined commercial removals from 2016 to 2025 from the roe, food and bait, and special use fisheries appear in Table 2. Total SOK harvest (i.e., pounds of validated product) for the major SARs from 2016 to 2025 is presented in the Pacific Herring data summaries.

Biological data

Biological samples are collected as described in Cleary et al. (2019) and Table 1. Biological data inputs to the stock assessment are annual weight-at-age (Figure 3) and annual number-at-age, shown as proportion-at-age (Figure 4).

Declines in weight-at-age are evident for all major SARs from the mid-1980s to 2010. Declining weight-at-age may be due to a number of factors, including fishing effects (i.e., gear selectivity), environmental effects (e.g., changes in ocean productivity), or changes in sampling protocols (e.g., shorter time frame over which samples are collected). Declines in weight-at-age appear to have ceased since 2010.

Abundance data

The spawn index survey collects information on spatial extent of the spawn, number of egg layers, substrate type, and other data. There are two spawn survey periods defined by the predominant survey method: surface survey period from 1951 to 1987 and dive survey period from 1988 to 2025. Data from these surveys are used to calculate egg density in each spawn. Ultimately, we calculate the 'spawn index', the estimated biomass of mature spawners required to produce those eggs. The 2025 spawn survey followed standard dive survey protocols for the HG, PRD, CC, SoG, and WCVI SARs as described in Cleary et al. (2019). Time series of spawn index by major SAR from 1951 to 2025 are summarized in Figure 5 and Tables 3 to 5.

The surface survey methodology has been used on occasion from 1988 to 2025. Generally this occurs when spawns are observed in locations where a dive survey team is not available, or when spawns are early (e.g., January or February) or late (e.g., May) in the season. In these instances, spawning biomass estimates obtained from surface surveys for a given SAR and year are added to biomass estimates from dive surveys, and $q_2 = 1$ is assumed for the combined index. The Pacific Herring data summaries show the proportion of spawn survey data (i.e., spawn index) from the surface and dive survey methods by SAR and year. Due to the COVID-19 pandemic, only surface surveys were conducted for HG in 2020 and 2021, and for PRD in 2020. These surface survey observations are treated as dive survey observations and are assumed to be continuous with the dive survey time series. Methods for combining surface and dive survey observations are presented for the SISCAH modelling framework in DFO (2023b), but are not implemented here.

Spatial Spawn Distribution

Tables 3 through 5 summarize the spatial distribution of survey spawn biomass (i.e., the spawn index) by proportion over the last 10 years for the major SARs. For each SAR, spawn is summarized either by Group, or Statistical Area; the choice of spatial grouping reflects spawning behaviour and biology for each SAR based on the survey data and working group discussions with local First Nations.

Incidental Mortality

Incidental mortality is described in DFO (2024) and updated time series for each SAR can be found in Pacific Herring data summaries. These data are not currently included as removals in Herring stock assessments.

First Nations Observations

Data and observations for the 2025 herring spawning season were contributed by representatives of First Nations communities for each SAR and can be found in the Pacific Herring data summaries. These observations include contributions from the Haida Nation in Haida Gwaii; the Lax Kw'alaams Nations in Prince Rupert District; the Wuikinuxv and Kitasoo Xai'xais Nations in the Central Coast; the Tla'amin, Homalko, and Qualicum Nations in Strait of Georgia; and the Nuu-chah-nulth Nation on the West Coast of Vancouver Island. Observations include: Spawn distribution and abundance, access, FSC successes and challenges, fish behaviour, and comparison with previous seasons.

Stock Status Update

Analyses of stock trend information is presented following methods of Cleary et al. (2019) for the Pacific Herring major SARs. Markov chain Monte Carlo (MCMC) runs have a chain length of five million with a sample taken every one thousand iterations (i.e., thinning). Then the first one thousand samples are discarded (i.e., burn-in), leaving four thousand samples as posteriors. Perceptions of stock status based on outputs (i.e., posteriors) from SCA models are summarized for each SAR in a six-panel figure (e.g., Figure 8). The panels show:

1. Model fit to scaled spawn survey data,
2. Instantaneous natural mortality rate M estimates,
3. Number of age-2 recruits,
4. Spawning biomass SB_t and total catch C_t, with reference lines at model estimates of $0.3SB_0$,
5. Recruitment deviations (log scale) from the Beverton-Holt recruitment function, and
6. Spawning biomass production $P_t = SB_{t+1} - SB_t + C_{t+1}$ for the dive survey period, with reference lines at model estimates of $0.3SB_0$.

Note that spawn survey data (i.e., spawn index) is scaled to abundance in panel (a) by the spawn survey scaling parameter q. The spawn index has two distinct periods defined by the dominant survey method: surface surveys (1951 to 1987) and dive surveys (1988 to 2025). Thus, two q parameters are implemented in the estimation procedure: q_1 (1951 to 1987) with a weakly informative prior, and q_2 (1988 to 2025) with a strongly informative prior approximating 1.0.

Reference points

A biological LRP is defined for the major Pacific Herring SARs at $0.3SB_0$ (Kronlund et al. 2017). Candidate USRs were introduced in Cleary et al. (2019) and implemented as biomass objectives in simulation analyses for WCVI and SoG in 2018 (DFO 2019), and then for HG, PRD, and CC in 2019 (DFO 2020a). An analysis of USR options was undertaken in 2022 with results presented in DFO (2023a). In total, five USR options were evaluated:

1. Average spawning biomass during a productive period $\overline{SB}_{Prod}$ (i.e., a B_{MSY} proxy; Table 18),
2. $0.4SB_0$,
3. $0.5SB_0$,
4. $0.6SB_0$, and
5. Average spawning biomass from 1951 to 2025 $\overline{SB}$.

Implementing USRs as target biomass objectives within the simulation-evaluation process allows evaluation of MPs with respect to achieving USRs, including whether a given USR option can be achieved in the absence of commercial fisheries. In 2023, DFO Resource Management selected and implemented a provisional USR of $\overline{SB}_{Prod}$ through the 2022/2023 IFMP process. Stock status relative to assessment model estimates of $0.3SB_0$ (i.e., LRP) and USR options are presented in Tables 15 through 17.

LRPs and USRs relate stock status to the DFO PA Policy (DFO 2009), and the same calculations are used for each Pacific Herring SAR. There is an important distinction between reference points (e.g., LRP, USR) and operational control points (OCPs) of the HCR used to set catch limits. Specifically, OCPs define the inflection points of a HCR and identify biomass levels where management action is taken, whereas LRPs and USRs are management objectives.

Coast wide trends

Coast wide trends in Pacific Herring biomass, represented by adding estimated spawning biomass across all SARs, show an average increasing trend in estimated spawning biomass from mid-to-late 2000s to present. Catches have been declining over the last decade (Figure 6). Comparisons of total estimated biomass and spawning biomass are also included for each SAR (Figure 7); these trends are presented using median posterior estimates.

Haida Gwaii

Estimated spawning biomass historic lows occurred in the late 1960s predicated by high catches, low estimated recruitment and high estimated natural mortality (Figure 8). Under variable estimated recruitment, estimated spawning biomass recovered from that point through the early 1980s supported by declining rates of estimated natural mortality. As estimated natural mortality began increasing again in the mid 1990s, estimated biomass declined. A reprieve in estimated low biomass occurred following several years with above average estimated recruitment through the late 1990s, before biomass declined to persistent historic lows from 2000 to present, with a couple of low biomass peaks in 2013 and 2019 (Figure 8d). The increasing trend in the estimated natural mortality rate starting in 1980 (Figure 8b) largely absorbed any surplus production attributed to above average recruitment events (e.g., 1997, 2012, 2018; Figure 8c, d). Estimated natural mortality has been on a slow decline since the early 2000s but low estimated recruitment has failed to lead to higher productivity.

The HG stock persists in a low biomass state, with many years also showing low productivity which has largely precluded stock growth (Figure 8f). Above-average recruitment of age-2 fish in 2018 lead to increases in survey biomass in 2019 and 2020. Although this was a positive sign of growth, the average to below-average recruitment since then, which estimates negative productivity, has brought biomass back down to the LRP. The effective harvest rate Ut has been at or near zero since 2000 (Figure 12), with the last commercial roe fishery in 2002, and the last commercial SOK fishery in 2004.

Estimated unfished spawning biomass SB_0 is 21,725 t, and the LRP of $0.3SB_0$ is 6,518 t (posterior medians). Compared to last year, estimated spawning biomass increased from 5,849 (SB 2024) to 7,219 t (SB 2025, posterior median), and is equivalent to 32.9% of SB_0 (Tables 12 & 15). Spawning biomass in 2025 is estimated to be above the LRP with a 58.6% probability (Table 15). Management measures to support long-term recovery of herring stocks in Haida Gwaii are being developed through the rebuilding plan (DFO et al. 2025).

Central Coast

Estimated spawning biomass reached a historic high around 1980 preceded by low estimated natural mortality rates and the highest estimated recruitment on record (1979, Figure 9). From there a decline in estimated spawning biomass appears to be influenced initially by higher estimated natural mortality rates and highly variable estimated recruitment. Spawning biomass declined during the 1985–2008 period and an increase in estimated natural mortality led to historically low estimated biomass levels from 2006 to 2012. Decreasing estimated natural mortality lead to moderate increases in biomass through 2020. From 2021 to 2023, increasing estimated natural mortality caused a decrease in estimated biomass, which was mitigated in part by higher than average estimated recruitment in 2022 (Figure 9a, b, e). Model estimates show decreasing spawning biomass from 2020 to 2024, with an increase in 2025 (Table 13). The analysis of surplus production shows an estimated production close to neutral for 2021 and 2022, negative for 2023, and positive for 2024 (Figure 9f).

An examination of spawn biomass by herring section shows the recent decline in herring spawn to have largely occurred in Upper Spiller Channel (Section 078), Section 086, Kitasu Bay/East Higgins (Section 067), and Thompson/Stryker (Section 074; Figure 10). The occurrence of spawn in Thompson/Stryker from 2020 to 2022 represented the first significant spawns in this section in many years. The mechanisms driving spawn fluctuations in these smaller areas in the Central Coast occur throughout the time series and are not well understood.

From 1990 to 2006 the effective harvest rate Ut is estimated to fluctuate above and below the reference harvest rate of 20%, with median estimates exceeding 20% in some of these years (Figure 12). Occurrences of Ut exceeding 20% are due in part to positive assessment model errors and lags in detecting a directional change in the trend.

Following a commercial fishery closure from 2007 to 2013, the CC SAR was reopened to commercial fisheries: commercial roe fisheries occurred in 2014, 2015, and 2016. Commercial SOK fisheries have operated at some level most years since 2015 (see the Pacific Herring data summaries). SOK removals are not included in the estimation of U_t.

Estimated unfished spawning biomass SB_0 is 49,733 t, and the LRP of $0.3SB_0$ is 14,920 t (posterior medians). Compared to last year, estimated spawning biomass increased from 23,150 (SB_{2024}) to 25,025 t (SB_{2025}, posterior median), and is equivalent to 49.6% of SB_0 (Tables 13 & 16). Spawning biomass in 2025 is estimated to be above the LRP with a 94.6% probability (Table 16).

West Coast of Vancouver Island

The time series of estimated spawning biomass reached an estimated peak in the mid to late 1970s during a time period of lowest observed model estimates of natural mortality and variable estimated recruitment (Figure 11). From the late 1980s through to around 2008 an increase in estimated mortality and a generally variable but low estimated recruitment led to a declining trend, down from the peaks observed in the late 1970s to a slump in the mid 2000s to mid 2010s (Figure 11a, b, c).

In the last 5 years productivity has increased with mostly higher than average recruitment and declining natural mortality estimates resulting in increasing spawning biomass estimates not seen since the 1970s (Figure 11a, b, f). Biomass estimates are nearing the highest since 1951.

The absence of a commercial fishery since 2005 means the realized harvest rate has been near zero for the last 20 years (Figure 12).

Estimated unfished spawning biomass SB_0 is 46,720 t, and the LRP of $0.3SB_0$ is 14,016 t (posterior medians). Compared to last year, estimated spawning biomass increased from 52,578 (SB_{2024}) to 62,160 t (SB_{2025}, posterior median), and is equivalent to 131.0% of SB_0 (Tables 14 & 17). Spawning biomass in 2025 is estimated to be above the LRP with a 100.0% probability (Table 17).

Management Performance

Historic management procedure performance can be assessed using the time series of effective harvest rate U. Estimated effective harvest rate U in each year t is $U_t = C_t/(C_t + SB_t)$, where C_t is catch in year t, and SB_t is estimated spawning biomass in year t. Time series of U_t are presented in Figure 12, where U_t of 20% is used as a reference line only and is not indicative of annual management decisions on TAC for each SAR.

Application of MPs and Harvest Options for 2026

Harvest options for CC and WCVI for 2026 reflect application of simulation-tested MPs using the Herring OM (Benson et al. 2022). OM conditioning was updated in 2022 using historic stock and fishery data from 1951 to 2021; no MP updates were conducted for 2023 or 2024. MPs are not provided for HG because this is now conducted within the HG rebuilding plan (DFO et al. 2025).

MPs for SoG were updated in (DFO 2025b) and for PRD in (DFO. In prep.)[1]. MP updates for HG, CC and WCVI are planned for the 2026/27 fiscal year, and will be implemented in the SISCAH OM framework.

Haida Gwaii

The HG stock persisted in a low biomass state from approximately 2000–2018 (Figure 8). The stock was below the LRP for much of that period and shows little evidence of sustained stock growth despite the absence of commercial fisheries since 2002 (and since 2004 for the SOK fishery). Survey biomass increased from 2019 to 2020, remained stable in 2021, and declined from 2021 to 2023, with a slight increase in 2024. Results of the simulation-evaluations found that none of the proposed MPs, including the historical and no fishing MPs, maintained spawning biomass above the LRP with high probability (i.e., at least 75%, DFO 2009).[3]

In the absence of fishing, spawning biomass in 2026 SB_{2026} is forecast to be 7,194 t (posterior median; Table 15). Spawning biomass in 2026 is forecast to be below the LRP of $0.3SB_0$ (6,518 t) with a 42.9% probability, in the absence of fishing (Table 15 and Figure 13).

Given its prolonged low biomass state, a rebuilding plan was required for Haida Gwaii Pacific Herring. A comprehensive plan was co-developed by the Council of Haida Nation, Fisheries and Oceans Canada and Parks Canada and was finalized in April 2024 (DFO et al. 2025).

Guidance for developing rebuilding plans (DFO 2013) states that the primary objective of any rebuilding plan is to promote stock growth out of the Critical Zone (i.e., to grow the stock above the status-based LRP) by ensuring removals from all fishing sources are kept to the lowest possible level until the stock has cleared this zone with high probability. However, stock rebuilding does not end having met this goal, and one of the goals of the rebuilding plan will be to identify candidate threshold biomass levels greater than the LRP that are consistent with a rebuilt state.

Based on MP evaluations and the ongoing rebuilding plan, the harvest recommendation for the Haida Gwaii stock in 2026 is 0 t. All future MP evaluations will occur through the rebuilding plan.

Central Coast

The CC stock persisted in a low biomass, low productivity state from approximately 2005 to 2014. An increasing trend was observed from 2015 to 2020, followed by a decline from 2021 to 2024 (Figure 9a).

In the summer of 2022, we updated the conditioning of the MSE operating model for CC with 2021 spawn, catch, and biological data. These latest MP evaluations also appear in DFO (2023a). No new MPs were included, however probability metrics for the five USRs options (DFO 2023a) were estimated and have been added to the harvest options tables. The updated simulations show that MPs with harvest rates at 5% and 10% maintain spawning biomass above the LRP with 81 to 91% probability over both OM scenarios (Table 19). The mean

[3]"High" probability is defined as 75 to 95% by the DFO decision-making framework (DFO 2009).

effective harvest rate U_t for the past 10 years with non-zero catches (from 2001 to 2016) is 12% (Figure 12).

Harvest options listed in Table 19 reflect application of MPs to the 2026 forecast biomass for CC, whereby each MP meets the conservation objective with a minimum 75% probability under both DDM and DIM OM scenarios.

Since multiple MPs meet the conservation objective of maintaining spawning biomass above the LRP with at least 75% probability, other socio-economic objectives may drive the choice for a particular MP. Additionally, the current CC OM is unable to directly address Heilstuk Nation conservation objectives related to herring age and size, nor objectives on a finer spatial scale or those specific to SOK fisheries. These limitations exist for all five major SARs.

In the absence of fishing, spawning biomass in 2026 SB_{2026} is forecast to be 21,466 t (posterior median; Table 16). Spawning biomass in 2026 is forecast to be below the LRP of $0.3SB_0$ (14,920 t) with a 16.4% probability, in the absence of fishing (Table 16 and Figure 13).

Finally, DFO acknowledges commitment to the Heiltsuk Nation for the development of a Joint Fisheries Management Plan for Pacific Herring in the Central Coast in 2026. Results presented here may inform this ongoing commitment.

West Coast of Vancouver Island

The WCVI stock persisted in a low biomass, low productivity state from approximately 2004 to 2014. In recent years, biomass has increased above the LRP of $0.3SB_0$ and has sustained higher biomass since 2022.

In 2022, with updated 2021 data, closed-loop feedback simulations for WCVI show the conservation objective is met under the DDM OM scenario with between 80 and 84% probability, and the same MPs failed to meet the conservation objective under the DIM OM scenario, where natural mortality rates are most similar to the last 10 years (p between 61 to 65%).

In the absence of fishing, spawning biomass in 2026 SB_{2026} is forecast to be 55,432 t (posterior median; Table 17). Spawning biomass in 2026 is forecast to be below the LRP of $0.3SB_0$ (14,016 t) with a 0.0% probability, in the absence of fishing (Table 17 and Figure 13).

Harvest options for 2026, resulting from simulation-tested MPs, are presented in Table 20. These options reflect application of MPs to the 2026 forecast biomass for WCVI, under the two OM scenarios.

Ecosystem and Climate Change Considerations

Stock assessment models for Pacific Herring incorporate ecosystem and climate change indirectly via processes such as natural mortality and recruitment, both of which represent the foundations of historical stock productivity. Over the years, scientists and First Nations have expressed the need to examine the role of ecosystem changes in driving variation and trends in these Pacific Herring productivity processes, especially considering the importance of future productivity in evaluating harvest management procedures (i.e., as part of the management strategy evaluation process). This also aligns with DFOs commitment to advance Ecosystem Approaches to Fisheries Management.

Reference points

The ecosystem context of herring as a mid-trophic level (i.e., middle-of-the-food-chain) species is taken into account in the establishment of reference points. The biological LRP is set to a higher value compared to those recommended in the DFO sustainable fisheries policy (DFO 2009) and above the recommendation of $0.5B_{MSY}$ which is implemented in New Zealand fisheries (Shelton and Sinclair 2008). Candidate USRs (DFO 2023a) incorporate area-specific ecosystem considerations, including to reflect states (historical time frames) of higher stock biomass and variable levels of stock productivity. Both the LRP and USRs are included in the MSE process.

Haida Gwaii

Boldt et al. (2022) identified possible environmental and biological pressures that link to herring distribution, growth, and production. Environmental pressures include the timing, duration, and magnitude of upwelling, which can affect the amount of prey available to herring (Mackas et al. 2001; Boldt et al. 2018; Hourston and Thomson 2019), as well as predation and competition (Godefroid et al. 2019). Other physical environmental pressures include sea surface temperature (SST), salinity, sea level, river discharge, and Ekman transport (Tester 1948; Alderdice and Hourston 1985; Stocker et al. 1985; Stocker and Noakes 1985; Schweigert and Noakes 1990; Ware 1991; Zebdi and Collie 1995). These indicators are described in more detail in the 2023 Science Response (DFO 2024). Additional work is needed to incorporate mechanistic-linked indicators into the new modelling framework for HG herring.

West Coast of Vancouver Island

Uu-a-thluk Fisheries began a research program in 2020 to examine the role of

1. predation,
2. spawn distribution, and
3. life history characteristics in Pacific Herring productivity[4,5].

Those studies found relatively large changes in the predation regimes for Pacific Herring stocks that spend considerable parts of their life cycle in offshore oceanic habitats. Furthermore, the results also show that stock assessments at smaller spatial scales are able to more precisely model the spatial dynamics of Pacific Herring without drastic declines in statistical performance. Although the role of predation and ecosystem change varies among Pacific Herring stock assessment units, there are shared processes and commonalities among units in how ecosystems and climate affect productivity.

This section summarizes Pacific Herring productivity studies and their implications for the West Coast of Vancouver Island (WCVI) Pacific Herring stock assessment region.

Changing Predation Regimes

Ecosystem effects are included in Herring population dynamics models by linking historical (and future) predator consumption estimates to observed natural mortality (Doherty et al. 2024).

Predators include Humpback Whales (*Megaptera novaeangliae*), Harbour Seals (*Phoca vitulina*), Steller Sea Lions (*Eumetopias jubatus*), and Pacific Hake (*Merluccius productus*), which prey on herring throughout juvenile and adult stages (Figure 14).

Consumption of Pacific Herring by each predator is estimated via bio-energetics modeling (Chasco et al. 2018; Doherty et al. 2024), accounting for average predator size, estimated abundance, size preference, foraging days, diet composition, and the energy content of Pacific

[4] Uu-a-thluk Fisheries. 2021. [Ausmit] (taking care of herring) project.

[5] Uu-a-thluk Fisheries. 2025. [?aayaaqa] (herring) spawn dynamics.

Herring (Doherty et al. 2024). Estimates of stock biomass derived from these ecosystem-based models are consistent with corresponding estimates from models that use the implicit time-varying *M* approach, albeit with recruitment and age-2 mortality rates that have the same trend but at higher absolute values given the size-selection of predators (Figure 2 in Doherty et al. 2024).

While estimates of historical biomass, recruitment, and mortality derived from predation models are similar to corresponding estimates from the time-varying mortality model, the two approaches differ in their expectations of future biomass and productivity due to ecosystem impacts from predators.

The predation model estimates a lower unfished biomass for WCVI, which results in different perceptions of stock status (*B*/*B*[0]), despite both models having similar estimates of current biomass (Table 2 in Doherty et al. 2024). Expectations for future biomass growth for WCVI herring are smaller in comparison to previous assessments that do not model predator consumption due to higher rates of predation mortality in recent years and projected increases in future predator biomass. In contrast, the random walk projections of natural mortality used in the current assessment rely heavily on analyst choice about future trends, which influences the perception of risk when making fishing decisions under uncertainty (see implications section below for further discussion). Changing future productivity is expected for WCVI herring, where local knowledge and models suggest that predation is a driver of natural mortality. Total estimated consumption of herring by predators increased from 7 kt in the late 1990s to 13 kt in recent years (Figure 15) and is expected to increase further as the abundance of Steller Sea Lions (and possibly Humpback Whales) increases.

The key difference between the time-varying *M* approach and explicitly modeling *M* via predation lies in their implications for future trends in natural mortality. Projecting *M* via the implicit approach requires strong assumptions about the trends in *M*, while the predation approach involves modeling future trends in predator populations for which we have reasonable data and models. In general, some of these key predators may increase further in the future as the continue to recover from historical over-exploitation.

Spatial Dynamics and Spawn Distribution

The historical distribution of WCVI herring spawning abundance shows relatively consistent core areas within Statistical Area. Statistical Area 23 has the most consistent spawning in Section 232, while 242 and 245 are most consistent for Statistical Area 24, and Section 253 is the most consistent spawning area for Statistical Area 25 (Figure 16).

Based on these distinct areas, the single-stock stock assessment model data for WCVI herring was disaggregated into three independent stocks corresponding to Statistical Area 23, 24, and 25 to examine the potential for higher spatial resolution assessments[5] (Figure 17). Simulations of future average unfished biomass for the 3-stock model accounting for predation indicate that 2023 biomass in Statistical Areas 23, 24, and 25 is 91%, 140%, and 85% of unfished levels, respectively.[5] Statistical performance of the three-stock model was comparable to the single stock assessment and represents a potentially practical way to incorporate greater spatial detail in ecosystem processes and fisheries, and to represent Uu-a-thluk objectives.

Similar to WCVI, the historical distribution of HG and CC herring spawning abundance has shown relatively consistent core areas within Statistical Areas. Analyses carried out in the development of the HG rebuilding plan incorporated a finer-scale sub-stock structure dividing the DFO Management Sections within Statistical Areas 00 and 02 in HG into three sub-stocks. Approximately 80% of the annual herring spawning occurs in the Juan Perez/Skincuttle sub-stock (Sections 021 and 025) and 10% in each of the other 2 sub-stocks Cumshewa/Selwyn (Sections 023 and 024) and Louscoone Inlet (Section 006). Haida Traditional Knowledge has contributed greatly to understanding the spatial dynamics used to inform these finer spatial delineations and will continue to be used in the transition to the SISCAH OM framework planned for 2026.

Similar work is also underway with First Nations partners in the Central Coast, the Kitasoo and Heiltsuk Nations, including to inform transition to the SISCAH OM framework in 2026.

Life History Characteristics

Empirical analyses of data collected during herring spawn events found egg production per gram of bodyweight (fecundity) increases with age (Shelton et al. 2014). It has also been observed that older (larger) fish tend to spawn earlier and younger (smaller) fish spawning late (MacCall et al. 2018).

Implications for Science Advice

Changing ecosystems and climate are implicitly represented in historical science advice for Pacific Herring; however, their impact on future herring productivity is of most importance for management. Changes in natural mortality and recruitment are neither random nor independent of Pacific Herring or predator abundance (Doherty et al. 2024). This finding should be integrated into the MSE process.

Historical and future changes to Pacific Herring ecosystems imply a need to modify expectations for future biomass and fisheries, and to account for this in the choice of management objectives. For example, biomass targets (or upper stock reference points) recently proposed for WCVI herring were based on a productive period in the recent history (DFO 2023a): ‘maintain spawning stock biomass at or above a target biomass level equivalent to the average biomass from 1990 to 1999, with at least 50% probability over three herring generations’. This objective was updated from an earlier version proposed by the Nuu-chah-nulth Tribal Council that had a higher probability threshold of 75% that could not be achieved in simulations (DFO 2021a). Future MSE analyses should include scenarios with changing predation regimes that inhibit the stock’s ability to return to previous biomass levels.

CONCLUSIONS

The 2025 Science Response includes formal analyses of stock trend information for Pacific Herring major SARs using the stock assessment framework reviewed in Cleary et al. (2019) with data updated to include 2025.

DFO has committed to developing and implementing a rebuilding plan for Haida Gwaii Pacific Herring. Based on MP evaluations, the harvest recommendation for the HG SAR is 0 t.

The MSE process identifies a range of MPs that meet the conservation objective with at least 75% probability for the CC and WCVI SARs for the DDM reference OM scenario (DFO 2020a, 2021a). Harvest options and MP calculations for 2026 for these two SARs are combined with MP evaluations (probabilities) from the latest MSE update. Tables also include MP performance and harvest options for the DIM robustness OM scenario (Tables 19 and 20).

Science advice for the minor SARs is limited to presentation of catch data, biological data, and spawn survey data (Section “Minor stock assessment regions”). Similarly, science advice for the special area, Area 10 is limited to presentation of catch data, biological data, and spawn survey data (Section “Special areas”).

TABLES

Table 1. Input data for the 2025 Pacific Herring statistical catch-age model for the major SARs. The spawn index has two distinct periods defined by the dominant survey method: surface surveys (1951 to 1987) and dive surveys (1988 to 2025). Note: the 'spawn index' is not scaled by the spawn survey scaling parameter q.

Source	Data	Years
Roe gillnet fishery	Catch	1972 to 2025
Roe seine fishery	Catch	1972 to 2025
Other fisheries	Catch	1951 to 2025
Test fishery (seine)	Biological: number-at-age	1975 to 2025
Test fishery (seine)	Biological: weight-at-age	1975 to 2025
Roe seine fishery	Biological: number-at-age	1972 to 2025
Roe seine fishery	Biological: weight-at-age	1972 to 2025
Roe gillnet fishery	Biological: number-at-age	1972 to 2025
Other fisheries	Biological: number-at-age	1951 to 2025
Other fisheries	Biological: weight-at-age	1951 to 2025
Surface survey	Abundance: spawn index	1951 to 1987
Dive survey	Abundance: spawn index	1988 to 2025

Table 2. Total landed Pacific Herring catch in tonnes from 2016 to 2025 in the major stock assessment regions (SARs). Note that the PRD and SoG stocks are assessed in DFO (In prep.)[1] and DFO (In prep.)[2], respectively, but PRD and SoG data are included in this table for completeness. Legend: Haida Gwaii (HG), Prince Rupert District (PRD), Central Coast (CC), Strait of Georgia (SoG), and West Coast of Vancouver Island (WCVI). Note: 'WP' indicates that data are withheld due to privacy concerns.

Year	SAR				
	HG	PRD	CC	SoG	WCVI
2016	0	2,425	213	21,310	0
2017	0	2,849	0	25,279	0
2018	0	417	0	19,067	0
2019	0	0	0	21,419	0
2020	0	0	0	10,439	0
2021	0	0	0	14,396	0
2022	0	0	0	4,672	0
2023	0	168	0	6,002	0
2024	0	0	0	7,000	0
2025	0	0	0	9,482	0

Table 3. Haida Gwaii SAR: spawn index in tonnes for Pacific Herring and proportion of spawn index by Group from 2016 to 2025. Legend: 'Cumshewa/Selwyn' is Section 023 and 024; 'Juan Perez/Skincuttle' is Sections 021 and 025; and 'Louscoone' is Section 006. Note: the 'spawn index' is not scaled by the spawn survey scaling parameter q, and 'NA' indicates that data are not available.

		Proportion		
Year	Spawn index	Cumshewa/Selwyn	Juan Perez/Skincuttle	Louscoone
2016	6,888	0.053	0.947	0.000
2017	3,016	0.018	0.982	0.000
2018	4,588	0.234	0.766	0.000
2019	11,624	0.065	0.919	0.016
2020	20,423	0.077	0.923	0.000
2021	18,234	0.025	0.975	0.000
2022	5,281	0.150	0.850	0.000
2023	1,584	0.038	0.962	0.000

Year	Spawn index	Proportion		
		Cumshewa/Selwyn	Juan Perez/Skincuttle	Louscoone
2024	11,732	0.087	0.906	0.007
2025	8,947	0.092	0.908	0.000

Table 4. Central Coast SAR: spawn index in tonnes for Pacific Herring and proportion of spawn index by Statistical Area from 2016 to 2025. Note: the 'spawn index' is not scaled by the spawn survey scaling parameter q, and 'NA' indicates that data are not available.

Year	Spawn index	Proportion		
		06	07	08
2016	32,508	0.245	0.726	0.028
2017	23,517	0.359	0.584	0.057
2018	12,264	0.322	0.626	0.052
2019	46,255	0.323	0.641	0.036
2020	42,713	0.417	0.550	0.033
2021	28,674	0.257	0.697	0.045
2022	22,711	0.259	0.703	0.038
2023	17,551	0.152	0.766	0.081
2024	26,803	0.276	0.585	0.139
2025	32,504	0.196	0.770	0.033

Table 5. West Coast of Vancouver Island SAR: spawn index in tonnes for Pacific Herring and proportion of spawn index by Statistical Area from 2016 to 2025. Note: the 'spawn index' is not scaled by the spawn survey scaling parameter q, and 'NA' indicates that data are not available.

Year	Spawn index	Proportion		
		23	24	25
2016	20,528	0.577	0.266	0.157
2017	16,476	0.320	0.138	0.542
2018	28,107	0.331	0.194	0.475
2019	17,030	0.228	0.163	0.610
2020	18,761	0.562	0.288	0.150
2021	29,339	0.150	0.728	0.122
2022	23,707	0.243	0.503	0.254
2023	77,005	0.163	0.754	0.083
2024	86,308	0.361	0.460	0.179
2025	47,525	0.532	0.301	0.167

Table 6. Haida Gwaii SAR: key parameters in the Pacific Herring statistical catch-age model. Parameters are summarised by posterior (5th, 50th, and 95th percentile) and maximum posterior density (MPD) estimates. Legend: R_0 is unfished age-2 recruitment; h is steepness of the stock-recruitment relationship; M is instantaneous natural mortality rate; $\bar{R}$ is average age-2 recruitment from 1951 to 2025; $\bar{R}_{init}$ is average age-2 recruitment in 1950; ρ is the fraction of total variance associated with observation error; ϑ is the precision of total error; q is catchability for surface (1951 to 1987; q_1) and dive (1988 to 2025; q_2) survey periods; τ is the standard deviation of process error (i.e., recruitment); and σ is the standard deviation of observation error (i.e., survey index). Note: τ and σ are calculated values.

Parameter	5%	50%	95%	MPD
R_0	185.593	242.469	327.789	242.523
h	0.659	0.788	0.898	0.808
M	0.207	0.387	0.633	0.367
$\bar{R}$	127.579	152.219	179.732	158.499
$\bar{R}_{init}$	8.290	26.989	117.284	31.369

Parameter	5%	50%	95%	MPD
ρ	0.248	0.311	0.384	0.302
ϑ	0.753	0.909	1.088	0.976
q_1	0.355	0.430	0.528	0.425
q_2	0.982	0.999	1.016	0.999
τ	0.779	0.869	0.976	0.845
σ	0.516	0.584	0.662	0.557

Table 7. Central Coast SAR: key parameters in the Pacific Herring statistical catch-age model. Parameters are summarised by posterior (5th, 50th, and 95th percentile) and maximum posterior density (MPD) estimates. Legend: R_0 is unfished age-2 recruitment; h is steepness of the stock-recruitment relationship; M is instantaneous natural mortality rate; $\bar{R}$ is average age-2 recruitment from 1951 to 2025; $\bar{R}_{init}$ is average age-2 recruitment in 1950; ρ is the fraction of total variance associated with observation error; ϑ is the precision of total error; q is catchability for surface (1951 to 1987; q_1) and dive (1988 to 2025; q_2) survey periods; τ is the standard deviation of process error (i.e., recruitment); and σ is the standard deviation of observation error (i.e., survey index). Note: τ and σ are calculated values.

Parameter	5%	50%	95%	MPD
R_0	336.419	420.648	540.088	409.847
h	0.661	0.797	0.901	0.817
M	0.272	0.487	0.860	0.453
$\bar{R}$	254.373	283.590	320.088	284.854
$\bar{R}_{init}$	57.610	212.762	1,635.304	272.082
ρ	0.177	0.237	0.311	0.218
ϑ	1.042	1.256	1.492	1.327
q_1	0.271	0.317	0.362	0.320
q_2	0.983	0.999	1.016	0.999
τ	0.698	0.777	0.872	0.768
σ	0.376	0.434	0.504	0.406

Table 8. West Coast of Vancouver Island SAR: key parameters in the Pacific Herring statistical catch-age model. See Table 6 for description.

Parameter	5%	50%	95%	MPD
R_0	454.662	568.235	746.983	559.803
h	0.616	0.740	0.864	0.751
M	0.333	0.600	1.013	0.584
$\bar{R}$	334.742	381.658	436.407	387.102
$\bar{R}_{init}$	31.833	147.286	1,226.851	262.405
ρ	0.239	0.308	0.386	0.297
ϑ	1.107	1.352	1.620	1.455
q_1	0.717	0.854	1.010	0.857
q_2	0.982	1.000	1.016	0.999
τ	0.636	0.714	0.808	0.695
σ	0.419	0.476	0.545	0.452

Table 9. Haida Gwaii SAR: age-2 recruitment from 2016 to 2025 for the Pacific Herring statistical catch-age model. Recruitment in millions is summarised by posterior (5th, 50th, and 95th percentile) and maximum posterior density (MPD) estimates.

Year	5%	50%	95%	MPD
2016	107.562	154.988	224.822	160.633
2017	171.150	248.495	362.389	255.727

Year	5%	50%	95%	MPD
2018	320.433	463.627	668.264	474.510
2019	46.091	70.583	106.424	71.729
2020	25.396	38.390	57.011	39.239
2021	79.285	118.296	175.049	121.562
2022	76.579	117.440	176.667	120.727
2023	55.745	87.340	137.351	89.159
2024	71.604	117.196	194.616	119.857
2025	160.891	301.251	548.909	304.811

Table 10. Central Coast SAR: age-2 recruitment from 2016 to 2025 for the Pacific Herring statistical catch-age model. Recruitment in millions is summarised by posterior (5th, 50th, and 95th percentile) and maximum posterior density (MPD) estimates.

Year	5%	50%	95%	MPD
2016	147.418	194.409	251.799	196.235
2017	209.753	278.838	362.430	281.696
2018	836.222	1,094.765	1,425.652	1,120.110
2019	92.795	125.298	167.604	127.706
2020	348.367	462.223	615.324	474.578
2021	191.431	261.664	357.015	267.577
2022	680.269	928.318	1,259.515	947.750
2023	188.745	271.903	391.227	276.800
2024	359.791	562.311	865.006	564.629
2025	255.025	416.677	685.326	417.824

Table 11. West Coast of Vancouver Island SAR: age-2 recruitment from 2016 to 2025 for the Pacific Herring statistical catch-age model. See Table 9 for description.

Year	5%	50%	95%	MPD
2016	94.946	127.723	172.623	128.890
2017	96.859	134.000	180.403	135.081
2018	301.592	421.104	575.141	428.848
2019	218.783	301.999	415.909	308.612
2020	650.115	883.642	1,199.577	900.103
2021	546.170	752.592	1,028.833	765.605
2022	738.347	1,023.305	1,433.936	1,038.740
2023	387.919	559.621	794.967	562.170
2024	231.493	363.668	580.913	363.001
2025	291.650	463.640	749.303	465.934

Table 12. Haida Gwaii SAR: spawning biomass and depletion from 2016 to 2025 for the Pacific Herring statistical catch-age model. Spawning biomass and depletion are summarised by the posterior (5th, 50th, and 95th percentile) and maximum posterior density (MPD) estimates in thousands of tonnes. Note: depletion is relative spawning biomass SB_t/SB_0, where SB_t is spawning biomass in year t, and SB_0 is estimated unfished spawning biomass.

	Spawning Biomass				Depletion			
Year	5%	50%	95%	MPD	5%	50%	95%	MPD
2016	4.250	5.719	7.657	5.686	0.177	0.262	0.377	0.273
2017	5.392	7.282	9.873	7.304	0.226	0.335	0.493	0.351
2018	7.768	10.478	14.246	10.586	0.323	0.482	0.708	0.509
2019	9.110	12.325	16.769	12.479	0.377	0.570	0.836	0.600
2020	6.931	9.403	12.740	9.473	0.286	0.432	0.632	0.456

	Spawning Biomass				Depletion			
Year	5%	50%	95%	MPD	5%	50%	95%	MPD
2021	4.757	6.457	8.930	6.487	0.196	0.297	0.441	0.312
2022	4.510	6.240	8.813	6.233	0.190	0.288	0.433	0.300
2023	4.769	6.772	9.656	6.645	0.204	0.310	0.462	0.320
2024	3.813	5.849	8.904	5.662	0.167	0.268	0.421	0.272
2025	3.612	7.219	13.579	6.876	0.165	0.329	0.624	0.331

Table 13. Central Coast SAR: spawning biomass and depletion from 2016 to 2025 for the Pacific Herring statistical catch-age model. Spawning biomass and depletion are summarised by the posterior (5th, 50th, and 95th percentile) and maximum posterior density (MPD) estimates in thousands of tonnes. Note: depletion is relative spawning biomass SB_t/SB_0, where SB_t is spawning biomass in year t, and SB_0 is estimated unfished spawning biomass.

	Spawning Biomass				Depletion			
Year	5%	50%	95%	MPD	5%	50%	95%	MPD
2016	17.085	21.282	26.320	21.497	0.310	0.427	0.571	0.447
2017	16.962	21.226	26.211	21.483	0.307	0.425	0.569	0.446
2018	18.619	23.472	28.914	23.773	0.342	0.471	0.629	0.494
2019	25.602	32.289	40.051	32.897	0.470	0.648	0.870	0.684
2020	20.967	26.527	33.287	27.013	0.388	0.532	0.717	0.561
2021	15.926	20.484	26.254	20.738	0.296	0.411	0.559	0.431
2022	16.610	21.705	28.276	21.754	0.312	0.436	0.596	0.452
2023	17.968	23.910	31.556	23.773	0.343	0.480	0.664	0.494
2024	16.834	23.150	31.680	22.804	0.327	0.464	0.660	0.474
2025	15.151	25.025	40.132	24.398	0.295	0.496	0.812	0.507

Table 14. West Coast of Vancouver Island SAR: spawning biomass and depletion from 2016 to 2025 for the Pacific Herring statistical catch-age model. See Table 12 for description.

	Spawning Biomass				Depletion			
Year	5%	50%	95%	MPD	5%	50%	95%	MPD
2016	17.107	22.113	28.382	22.321	0.332	0.470	0.650	0.491
2017	13.409	17.443	22.668	17.648	0.261	0.372	0.513	0.388
2018	12.133	15.770	20.310	15.930	0.237	0.335	0.462	0.350
2019	12.599	16.349	21.130	16.514	0.247	0.346	0.479	0.363
2020	14.973	19.517	25.537	19.699	0.297	0.414	0.572	0.433
2021	19.624	26.121	34.770	26.200	0.393	0.555	0.771	0.576
2022	28.814	38.369	51.059	38.081	0.578	0.814	1.131	0.838
2023	33.566	44.645	59.198	44.027	0.674	0.946	1.311	0.969
2024	37.409	52.578	73.140	51.429	0.759	1.108	1.606	1.132
2025	37.507	62.160	95.986	60.572	0.783	1.310	2.111	1.333

Table 15. Haida Gwaii SAR: proposed reference points for the Pacific Herring statistical catch-age model. Reference points are summarised by posterior (5th, 50th, and 95th percentile) estimates. All biomass numbers are in thousands of tonnes. Legend: SB_0 is estimated unfished spawning biomass; $\overline{SB}_{Prod}$ is average spawning biomass during a productive period (Table 18); SB_t is spawning biomass in year t; P is probability; and SB_{2026} is projected spawning biomass in 2026 assuming no fishing. Note that the age-10 class is a 'plus group' which includes fish ages 10 and older.

Reference Point	5%	50%	95%
SB_0	17.355	21.725	28.014
$0.3SB_0$	5.206	6.518	8.404
$0.75\overline{SB}_{Prod}$	17.424	24.095	33.733

Reference Point	5%	50%	95%
SB_{2025}	3.612	7.219	13.579
SB_{2025} / SB_0	0.165	0.329	0.624
P (SB_{2025} < $0.3SB_0$)	–	0.414	–
P (SB_{2025} < $0.75\overline{SB}_{Prod}$)	–	0.999	–
SB_{2026}	3.053	7.194	17.874
SB_{2026} / SB_0	0.140	0.331	0.811
P (SB_{2026} < $0.3SB_0$)	–	0.429	–
P (SB_{2026} < $0.75\overline{SB}_{Prod}$)	–	0.980	–
Proportion aged 3	0.11	0.37	0.72
Proportion aged 4 to 10	0.18	0.42	0.71

Table 16. Central Coast SAR: proposed reference points for the Pacific Herring statistical catch-age model. Reference points are summarised by posterior (5th, 50th, and 95th percentile) estimates. All biomass numbers are in thousands of tonnes. Legend: SB_0 is estimated unfished spawning biomass; $\overline{SB}_{Prod}$ is average spawning biomass during a productive period (Table 18); SB_t is spawning biomass in year t; P is probability; and SB_{2026} is projected spawning biomass in 2026 assuming no fishing. Note that the age-10 class is a 'plus group' which includes fish ages 10 and older.

Reference Point	5%	50%	95%
SB_0	40.464	49.733	62.435
$0.3SB_0$	12.139	14.920	18.730
$\overline{SB}_{Prod}$	27.190	32.140	38.450
SB_{2025}	15.151	25.025	40.132
SB_{2025} / SB_0	0.295	0.496	0.812
P (SB_{2025} < $0.3SB_0$)	–	0.054	–
P (SB_{2025} < $\overline{SB}_{Prod}$)	–	0.805	–
SB_{2026}	11.802	21.466	40.962
SB_{2026} / SB_0	0.234	0.431	0.809
P (SB_{2026} < $0.3SB_0$)	–	0.164	–
P (SB_{2026} < $\overline{SB}_{Prod}$)	–	0.854	–
Proportion aged 3	0.08	0.26	0.57
Proportion aged 4 to 10	0.35	0.62	0.83

Table 17. West Coast of Vancouver Island SAR: proposed reference points for the Pacific Herring statistical catch-age model. See Table 15 for description.

Reference Point	5%	50%	95%
SB_0	38.501	46.720	59.700
$0.3SB_0$	11.550	14.016	17.910
$\overline{SB}_{Prod}$	27.921	34.392	42.432
SB_{2025}	37.507	62.160	95.986
SB_{2025} / SB_0	0.783	1.310	2.111
P (SB_{2025} < $0.3SB_0$)	–	0.000	–
P (SB_{2025} < $\overline{SB}_{Prod}$)	–	0.036	–
SB_{2026}	30.645	55.432	97.065
SB_{2026} / SB_0	0.650	1.169	2.085
P (SB_{2026} < $0.3SB_0$)	–	0.000	–
P (SB_{2026} < $\overline{SB}_{Prod}$)	–	0.104	–
Proportion aged 3	0.08	0.23	0.50
Proportion aged 4 to 10	0.44	0.69	0.86

Table 18. Year range for calculating proportion of average spawning biomass of Pacific Herring during a productive period $\overline{SB}_{Prod}$ in the major stock assessment regions (SARs). Note that the PRD and SoG stocks are assessed in DFO (In prep.)[1] and DFO (In prep.)[2], respectively, but PRD and SoG data are included in this table for completeness.

SAR	Years	Proportion
Haida Gwaii	1975 to 1985	0.75
Prince Rupert District	1983 to 1992	1.00
Central Coast	1990 to 1999	1.00
Strait of Georgia	1988 to 2007	0.80
West Coast of Vancouver Island	1990 to 1999	1.00

Table 19. Central Coast SAR: management procedure performance for the Pacific Herring statistical catch-age model. Performance metrics are given for two operating model (OM) scenarios: density-dependent natural mortality (DDM) and density-independent natural mortality (DIM). Performance criteria are calculated over three Pacific Herring generations (i.e., 15 years) from the start of the projection period for all objectives (Obj). MPs are ordered within each scenario by performance of achieving Objective 1. The recommended total allowable catch (TAC) and associated harvest rate (HR) in 2026 are calculated for each MP using posterior densities values. Legend: limit reference point (LRP); upper stock reference (USR); P is probability; maximum (Max); SB_t is spawning biomass in year t; SB_0 is estimated unfished spawning biomass; $\overline{SB}_{Prod}$ is average spawning biomass during a productive period (Table 18); average annual variability (AAV) in catch; and C is average annual catch. MPs are defined in DFO (2019) and DFO (2020a). Biomass and catch are in thousands of tonnes (t). Note: Dashes or 0.00 indicate that TAC and HR do not apply because the MP specifies no fishing. Also note that TAC and HR are median values calculated by the MP using posterior distributions of SB_{2026} and SB_0. The HR is derived according to the MP shape and is equivalent to TAC/SB_{2026}. In cases where MPs include a cap, the cap is constant regardless of estimated SB_{2026}, and higher SB_{2026} leads to lower HR.

Scenario		Conservation Obj 1 (LRP)	Biomass Obj 2 (USR)	Yield		2026	
OM	MP	$P \geq 75\%$ $SB_t \geq 0.3\overline{SB}_0$	P $SB_t \geq \overline{SB}_{Prod}$	Obj 3 $< 25\%$ AAV	Obj 4 Max $\bar{C}$	TAC	HR
DDM	NoFish_FSC	92%	69%	0.00	0.14	–	–
DDM	HS30-60_HR05	91%	64%	40.76	1.74	0.47	0.02
DDM	HS30-60_HR10_Cap5	90%	58%	38.83	2.92	0.93	0.04
DDM	MinE50_HR10	90%	58%	53.22	2.92	0.00	0.00
DIM	NoFish_FSC	85%	54%	0.00	0.14	–	–
DIM	HS30-60_HR05	83%	48%	50.38	1.38	0.47	0.02
DIM	MinE50_HR10	82%	43%	70.82	2.21	0.00	0.00
DIM	HS30-60_HR10_Cap5	81%	43%	52.19	2.45	0.93	0.04

Table 20. West Coast of Vancouver Island SAR: management procedure performance for the Pacific Herring statistical catch-age model. See Table 19 for description.

Scenario		Conservation Obj 1 (LRP)	Biomass Obj 2 (USR)	Yield		2026	
OM	MP	$P \geq 75\%$ $SB_t \geq 0.3\overline{SB}_0$	P $SB_t \geq \overline{SB}_{Prod}$	Obj 3 $< 25\%$ AAV	Obj 4 Max $\bar{C}$	TAC	HR
DDM	NoFish_FSC	84%	33%	0.00	0.14	–	–
DDM	HS30-60_HR10_Cap2	82%	27%	60.72	1.15	2.00	0.04
DDM	MinE30_HR05	82%	27%	59.45	1.01	2.77	0.05
DDM	HS50-60_HR10	82%	25%	89.73	1.28	5.54	0.10

Scenario		Conservation Obj 1 (LRP)	Biomass Obj 2 (USR)	Yield		2026	
				Obj 3	Obj 4		
OM	MP	$P \geq 75\%$ $SB_t \geq 0.3\overline{SB}_0$	P $SB_t \geq \overline{SB}_{Prod}$	$< 25\%$ AAV	Max $\bar{C}$	TAC	HR
DDM	HS30-60_HR15_Cap2	81%	27%	57.13	1.30	2.00	0.04
DDM	HS50-60_HR15	81%	23%	82.56	2.08	8.31	0.15
DDM	MinE30_HR10	80%	24%	75.21	1.87	5.54	0.10
DIM	NoFish_FSC	65%	17%	0.00	0.14	–	–
DIM	HS30-60_HR10_Cap2	63%	15%	71.81	0.79	2.00	0.04
DIM	MinE30_HR05	63%	15%	70.09	0.76	2.77	0.05
DIM	HS30-60_HR15_Cap2	62%	15%	80.94	0.83	2.00	0.04
DIM	HS50-60_HR10	62%	14%	96.54	0.72	5.54	0.10
DIM	MinE30_HR10	61%	13%	83.98	1.26	5.54	0.10
DIM	HS50-60_HR15	61%	12%	107.55	1.00	8.31	0.15

FIGURES

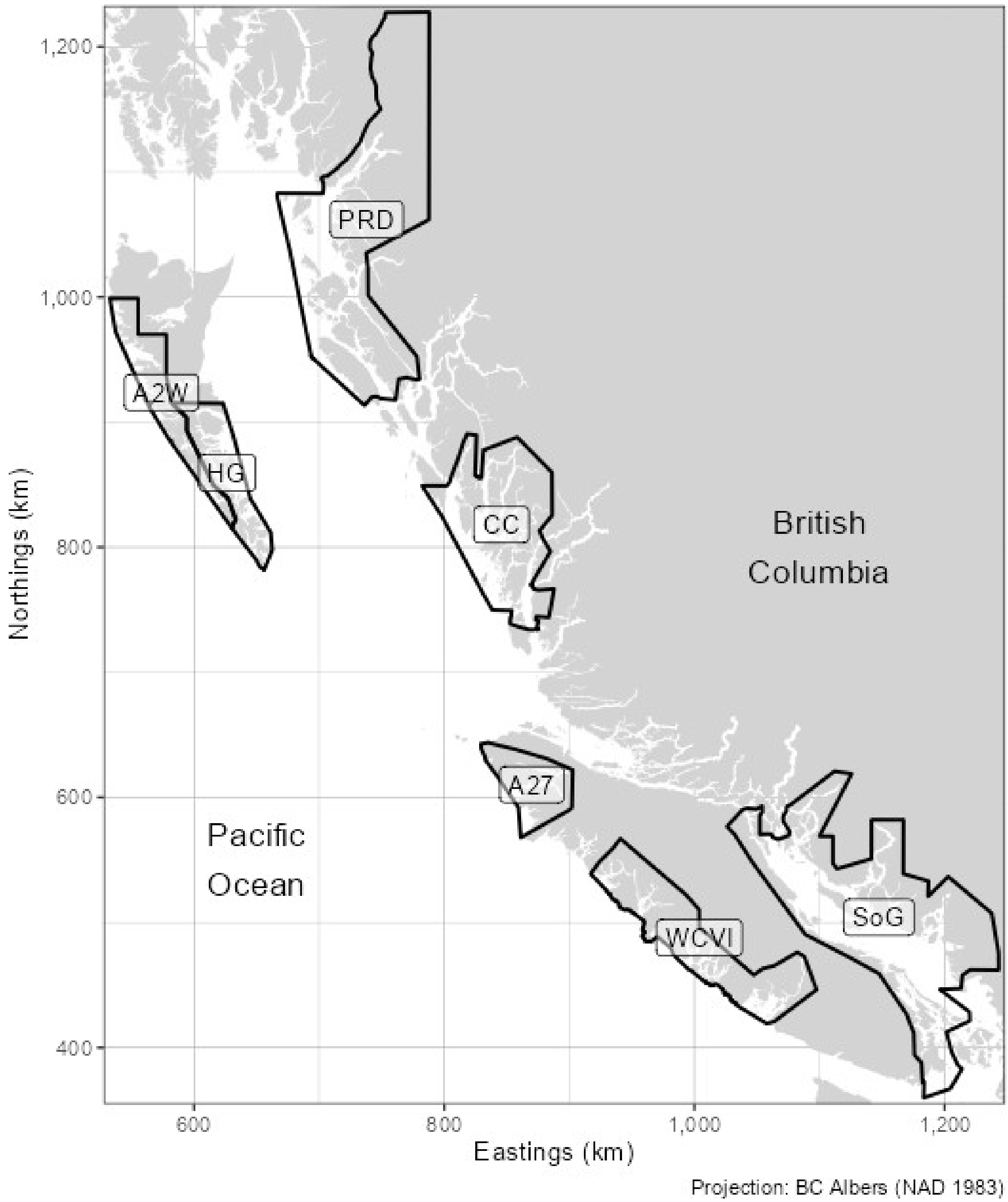

Figure 1. Boundaries for Pacific Herring SARs in British Columbia. The major SARs are Haida Gwaii (HG), Prince Rupert District (PRD), Central Coast (CC), Strait of Georgia (SoG), and West Coast of Vancouver Island (WCVI). The minor SARs are Area 27 (A27) and Area 2 West (A2W). Units: kilometres (km).

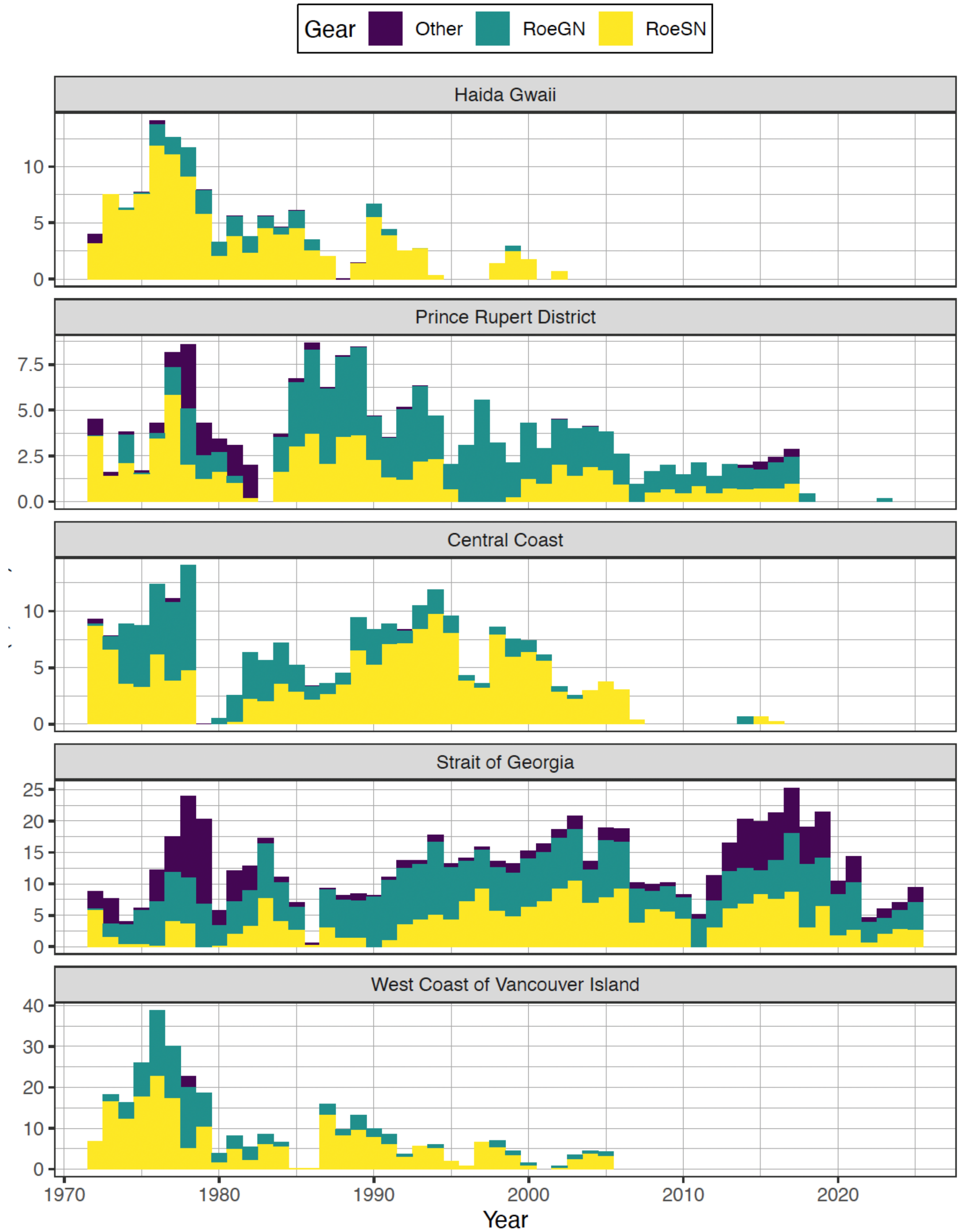

Figure 2. Total landed Pacific Herring catch in thousands of tonnes (t) from 1972 to 2025 in the major SARs. Note that the PRD and SoG stocks are assessed in DFO (In prep.)[1] and DFO (In prep.)[2], respectively, but PRD and SoG data are included in this figure for completeness. See Figures 8 to 11 for catches during the reduction period (1951 to 1971). Legend: 'Other' represents the reduction, the food and bait, as well as the special use fishery; 'RoeGN' represents the roe gillnet fishery; and 'RoeSN' represents the roe seine fishery.

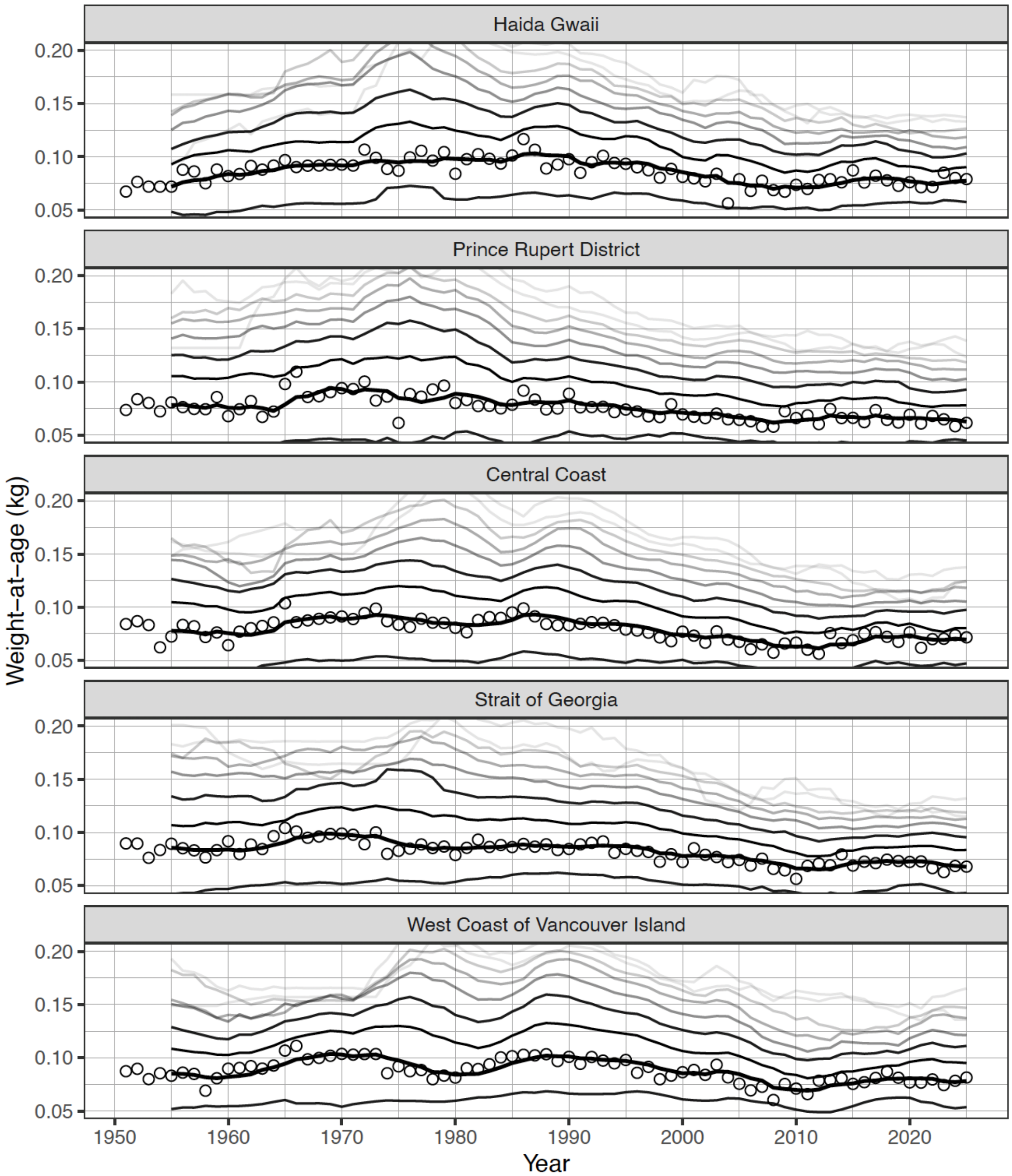

Figure 3. Mean weight-at-age for Pacific Herring in kilograms (kg) from 1951 to 2025 in the major SARs. Note that the PRD and SoG stocks are assessed in DFO (In prep.)[1] and DFO (In prep.)[2], respectively, but PRD and SoG data are included in this figure for completeness. Lines show 5-year running means for age-2 to age-10 herring, incrementing up from bottom line and shaded from darker to lighter, except thickest line shows age-3 herring. Circles show mean for age-3 herring. In years where there are no biological samples for an age class, values are imputed as the mean of the previous 5 years, except for the beginning of the time series which are imputed by extending the first non-missing value backwards. 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 includes fish ages 10 and older. Vertical axes are cropped at 0.05 to 0.20 kg.

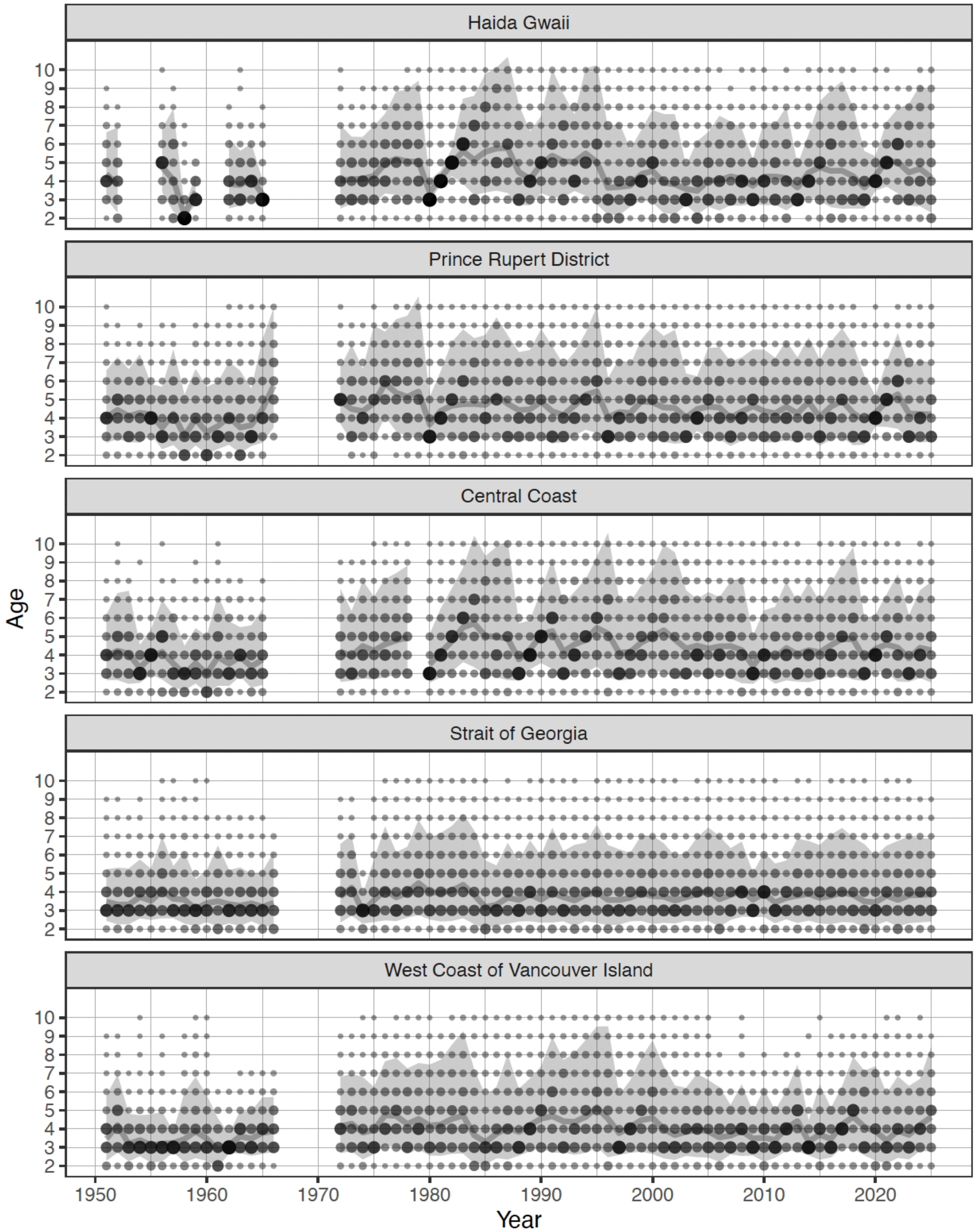

Figure 4. Proportion-at-age for Pacific Herring from 1951 to 2025 in the major SARs. Note that the PRD and SoG stocks are assessed in DFO (In prep.)[1] and DFO (In prep.)[2], respectively, but PRD and SoG data are included in this figure for completeness. Dot size and colour indicates age class proportion for the year; each year adds up to 1.0. The gray 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 plus class includes fish ages 10 and older.

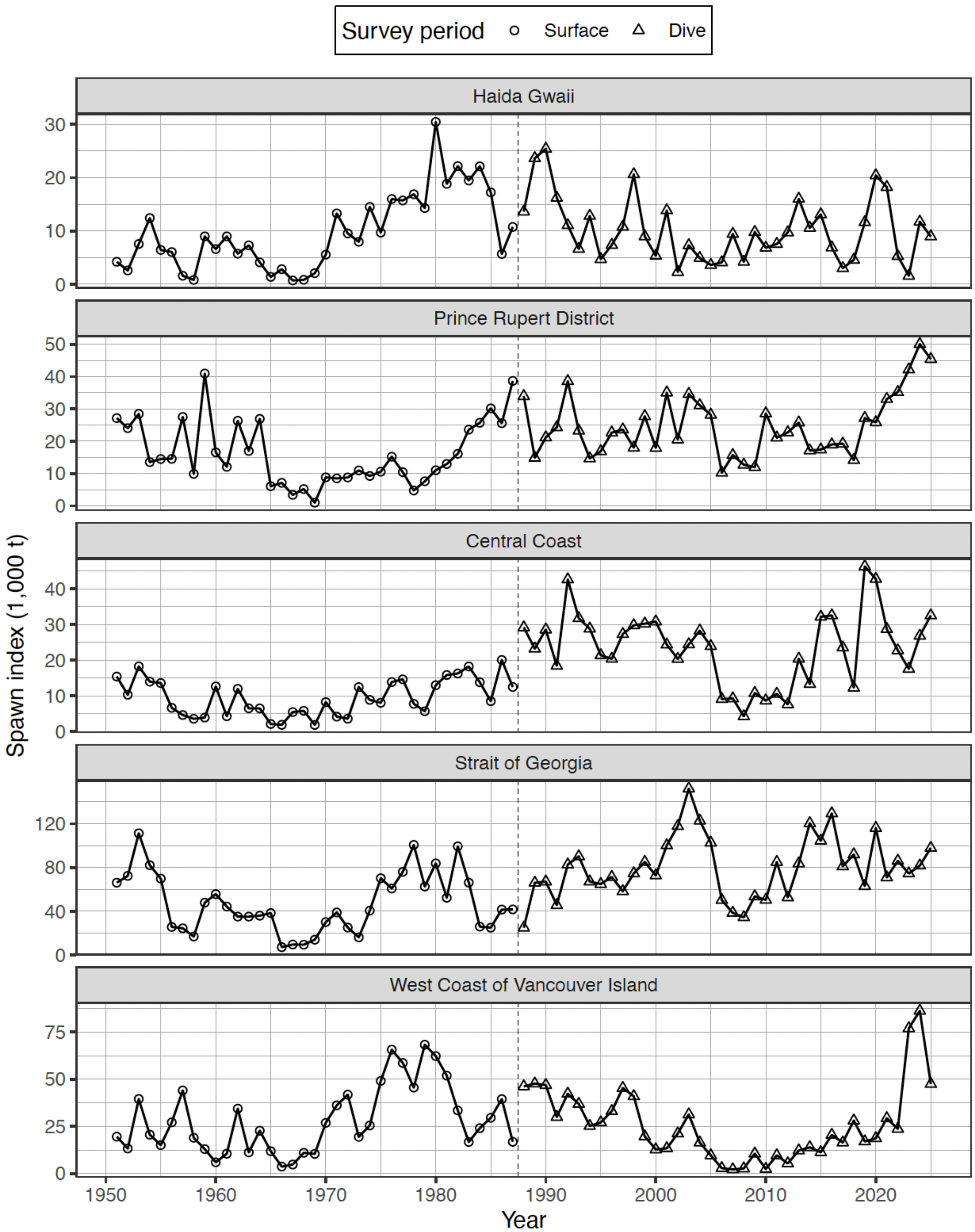

Figure 5. Spawn index in thousands of tonnes (t) for Pacific Herring from 1951 to 2025 in the major SARs. Note that the PRD and SoG stocks are assessed in DFO (In prep.)[1] and DFO (In prep.)[2], respectively, but PRD and SoG data are included in this figure for completeness. The dashed vertical line delineates between two periods defined by the dominant survey method: surface surveys (1951 to 1987), and dive surveys (1988 to 2025). Note: the 'spawn index' is not scaled by the spawn survey scaling parameter q.

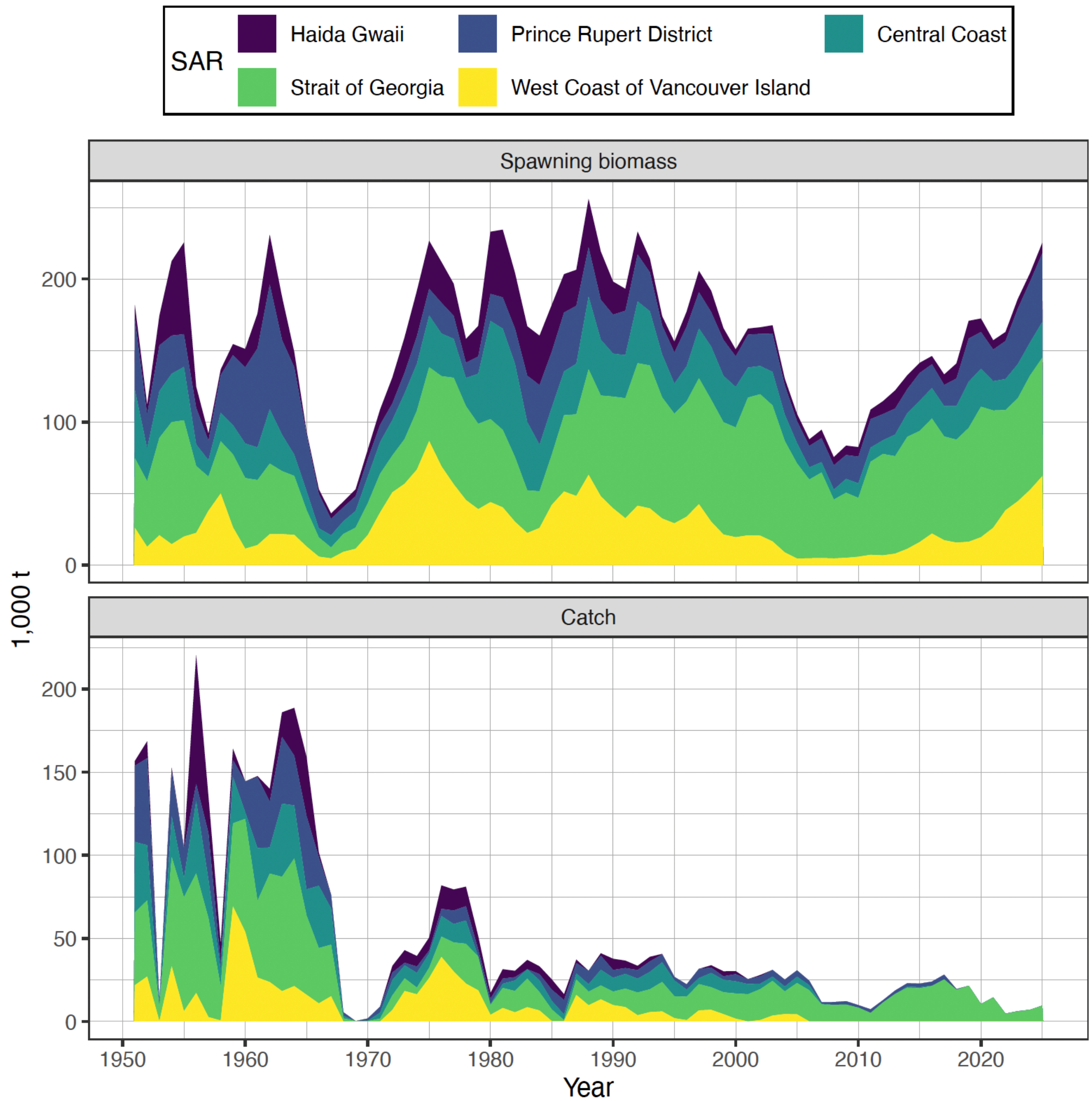

Figure 6. Spawning biomass and catch in thousands of tonnes (t) for Pacific Herring from 1951 to 2025 in the major SARs. Note that the PRD and SoG stocks are assessed in DFO (In prep.)[1] and DFO (In prep.)[2], respectively, but PRD and SoG data are included in this figure for completeness. Spawning biomass is represented by median posterior estimates.

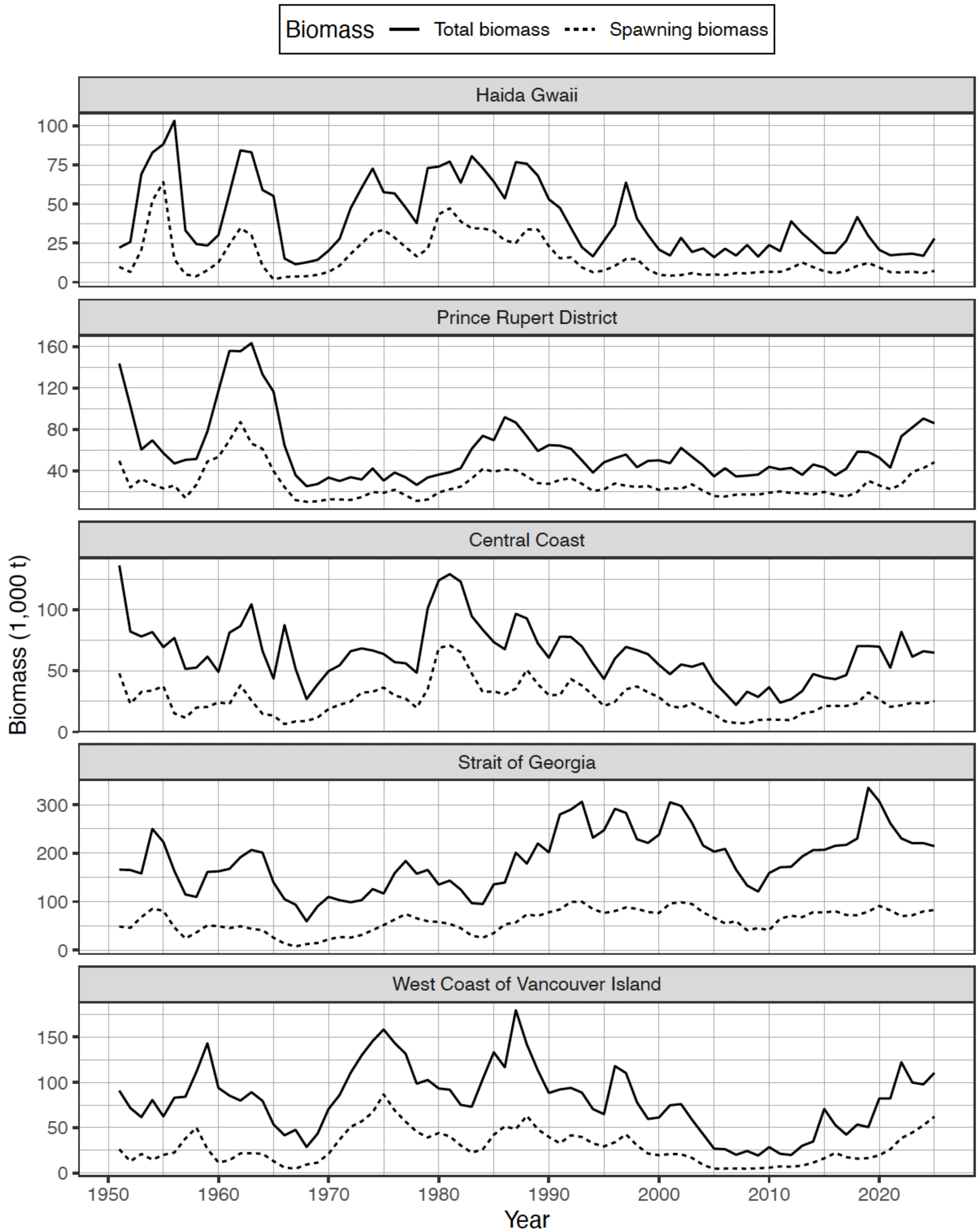

Figure 7. Total biomass and spawning biomass in thousands of tonnes (t) for Pacific Herring from 1951 to 2025 in the major SARs. Note that the PRD and SoG stocks are assessed in DFO (In prep.)[1] and DFO (In prep.)[2], respectively, but PRD and SoG data are included in this figure for completeness. Biomass is represented by median posterior estimates.

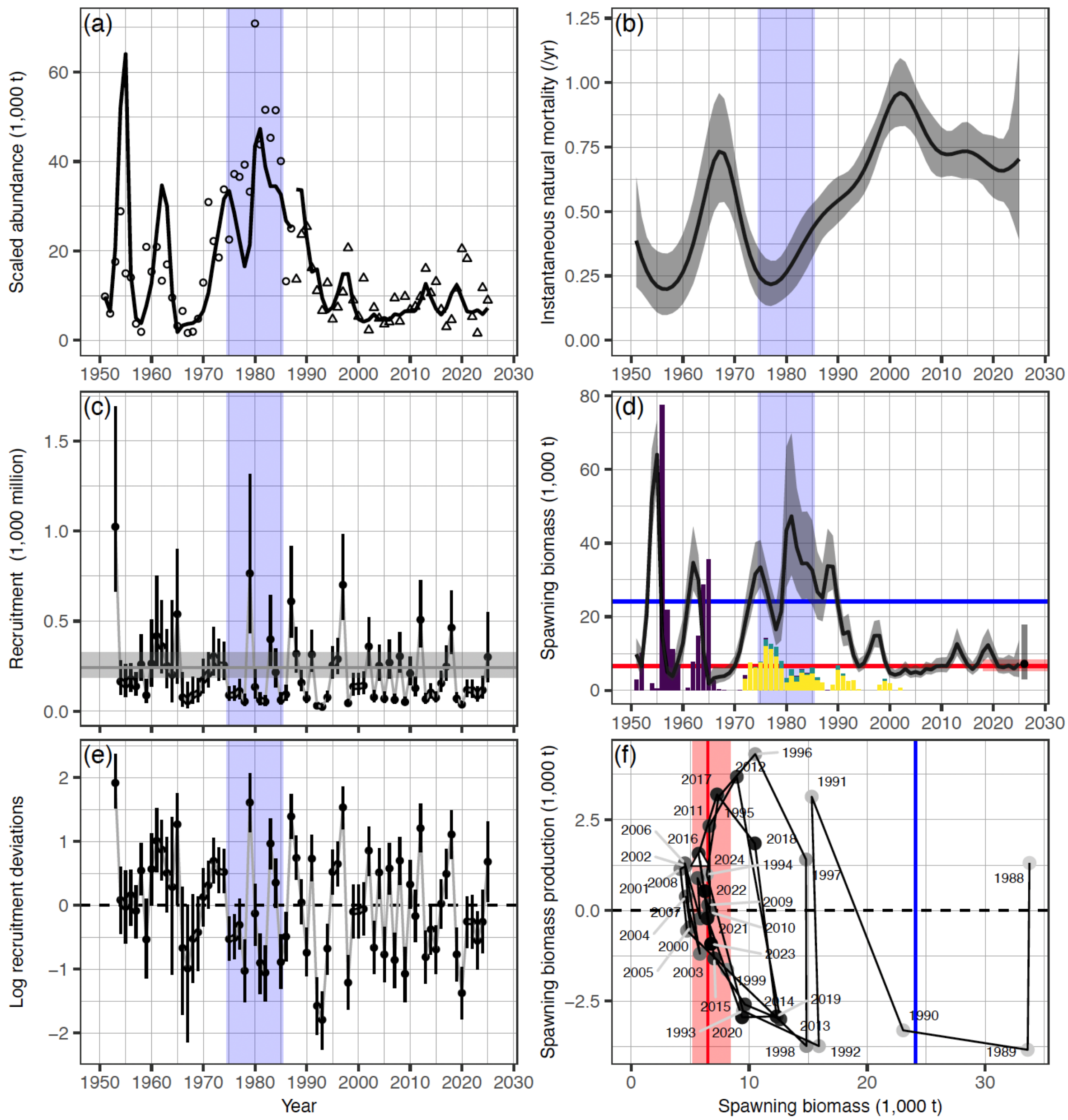

Figure 8. Haida Gwaii SAR: statistical catch-age model output for Pacific Herring from 1951 to 2025. ***Panel (a)****: Model fit (lines) to scaled abundance (points; Figure 5). Spawn index is scaled to abundance by the spawn index scaling parameter q.* ***Panel (b)****: Instantaneous natural mortality rate (year^{-1}).* ***Panel (c)****: Reconstructed number of age-2 recruits in thousands of millions from 1953 to 2025. Horizontal line indicates unfished age-2 recruitment R_0.* ***Panel (d)****: Spawning biomass (line), and forecast spawning biomass in 2026 in the absence of fishing (point). Coloured vertical bars indicate commercial catch (Figure 2).* ***Panel (e)****: Log recruitment deviations from 1953 to 2025.* ***Panel (f)****: Phase plot of spawning biomass production for the dive survey period (1988 to 2024). Points are chronologically shaded light to dark; triangle indicates 2024. Legend: biomass and catch are in thousands of tonnes (t); points and time-series lines are median posterior estimates; bands and error bars are 90% credible intervals; dashed horizontal lines indicate zero; blue circles and shaded regions indicate a productive period (Table 18); blue lines indicate proportion of spawning biomass during a productive period $0.75\overline{SB}_{Prod}$; and red lines indicate the median limit reference point $0.3SB_0$, where SB_0 is estimated unfished spawning biomass.*

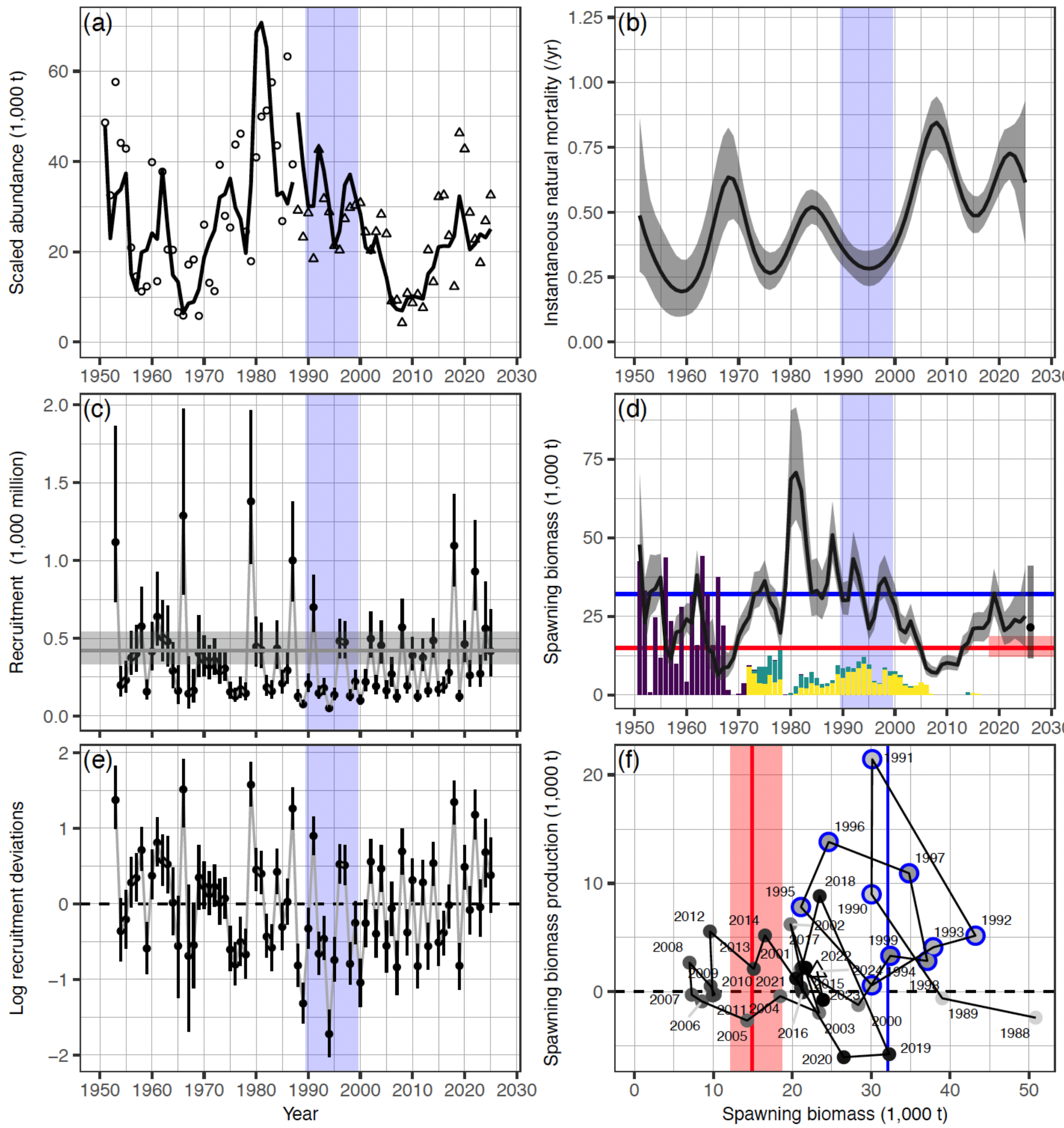

Figure 9. Central Coast SAR: statistical catch-age model output for Pacific Herring from 1951 to 2025. ***Panel (a)****: Model fit (lines) to scaled abundance (points; Figure 5). Spawn index is scaled to abundance by the spawn index scaling parameter q.* ***Panel (b)****: Instantaneous natural mortality rate (year^{-1}).* ***Panel (c)****: Reconstructed number of age-2 recruits in thousands of millions from 1953 to 2025. Horizontal line indicates unfished age-2 recruitment R_0.* ***Panel (d)****: Spawning biomass (line), and forecast spawning biomass in 2026 in the absence of fishing (point). Coloured vertical bars indicate commercial catch (Figure 2).* ***Panel (e)****: Log recruitment deviations from 1953 to 2025.* ***Panel (f)****: Phase plot of spawning biomass production for the dive survey period (1988 to 2024). Points are chronologically shaded light to dark; triangle indicates 2024. Legend: biomass and catch are in thousands of tonnes (t); points and time-series lines are median posterior estimates; bands and error bars are 90% credible intervals; dashed horizontal lines indicate zero; blue circles and shaded regions indicate a productive period (Table 18); blue lines indicate proportion of spawning biomass during a productive period $\overline{SB}_{Prod}$; and red lines indicate the median limit reference point $0.3SB_0$, where SB_0 is estimated unfished spawning biomass.*

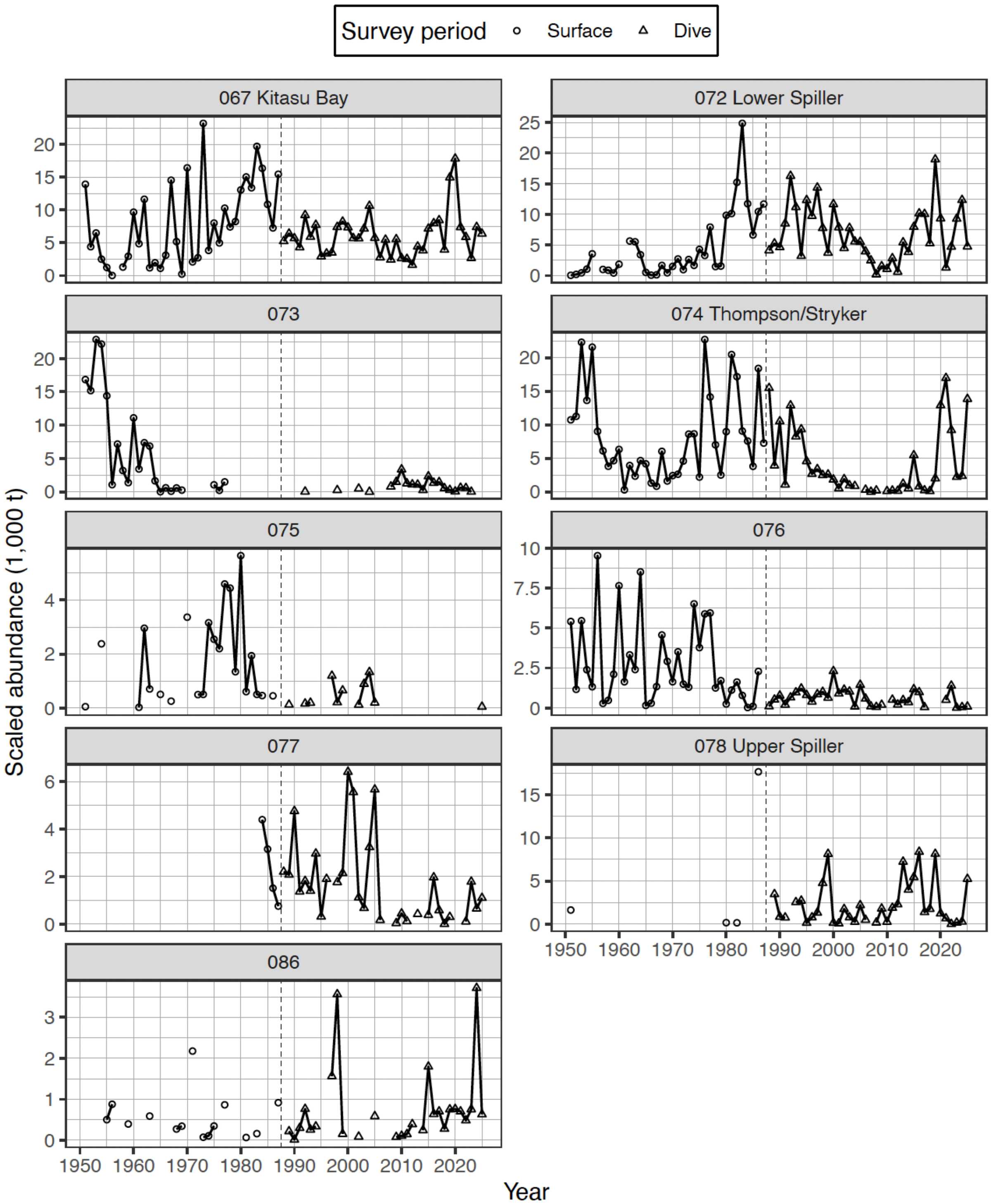

Figure 10. Central Coast SAR: scaled abundance in thousands of tonnes (t) of Pacific Herring in selected Sections from 1951 to 2025. The spawn index is scaled to abundance by the spawn survey scaling parameter q (median posterior estimate). The dashed vertical line delineates between two periods defined by the dominant survey method: surface surveys (1951 to 1987), and dive surveys (1988 to 2025).

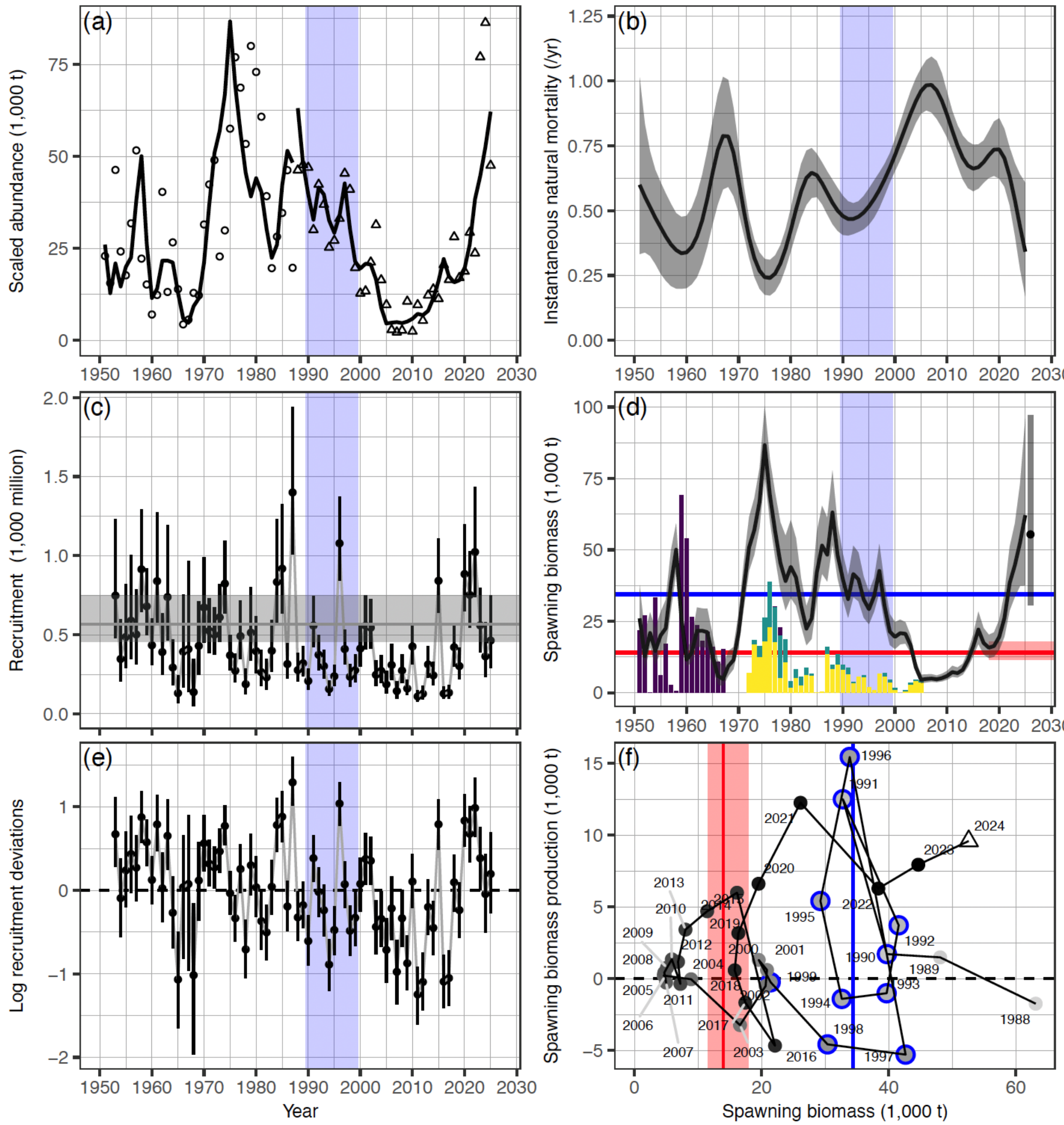

Figure 11. West Coast of Vancouver Island SAR: statistical catch-age model output for Pacific Herring from 1951 to 2025. ***Panel (a)****: Model fit (lines) to scaled abundance (points; Figure 5). Spawn index is scaled to abundance by the spawn index scaling parameter* q*.* ***Panel (b)****: Instantaneous natural mortality rate (year*$^{-1}$*).* ***Panel (c)****: Reconstructed number of age-2 recruits in thousands of millions from 1953 to 2025. Horizontal line indicates unfished age-2 recruitment* R_0*.* ***Panel (d)****: Spawning biomass (line), and forecast spawning biomass in 2026 in the absence of fishing (point). Coloured vertical bars indicate commercial catch (Figure 2).* ***Panel (e)****: Log recruitment deviations from 1953 to 2025.* ***Panel (f)****: Phase plot of spawning biomass production for the dive survey period (1988 to 2024). Points are chronologically shaded light to dark; triangle indicates 2024. Legend: biomass and catch are in thousands of tonnes (t); points and time-series lines are median posterior estimates; bands and error bars are 90% credible intervals; dashed horizontal lines indicate zero; blue circles and shaded regions indicate a productive period (Table 18); blue lines indicate proportion of spawning biomass during a productive period* $\overline{SB}_{Prod}$*; and red lines indicate the median limit reference point 0.3*SB_0*, where* SB_0 *is estimated unfished spawning biomass.*

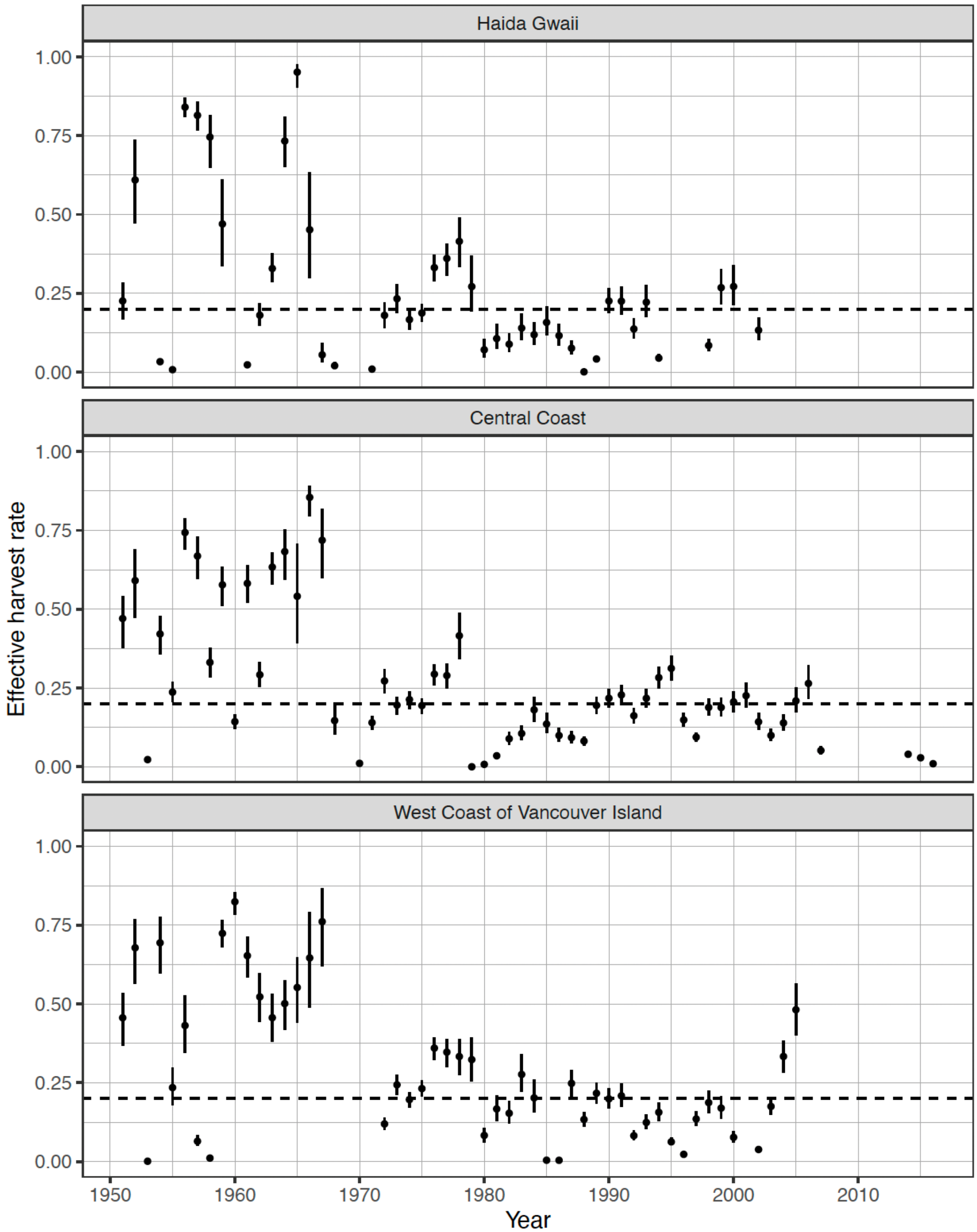

Figure 12. Effective harvest rate U_t for Pacific Herring from 1951 to 2025 in the major SARs. Effective harvest rate is $U_t = C_t/(C_t + SB_t)$ where C_t is catch in year t, and SB_t is estimated spawning biomass in year t. Points and vertical lines indicate medians and 90% credible intervals for U_t, respectively. Horizontal dashed lines indicate $U_t = 0.2$.

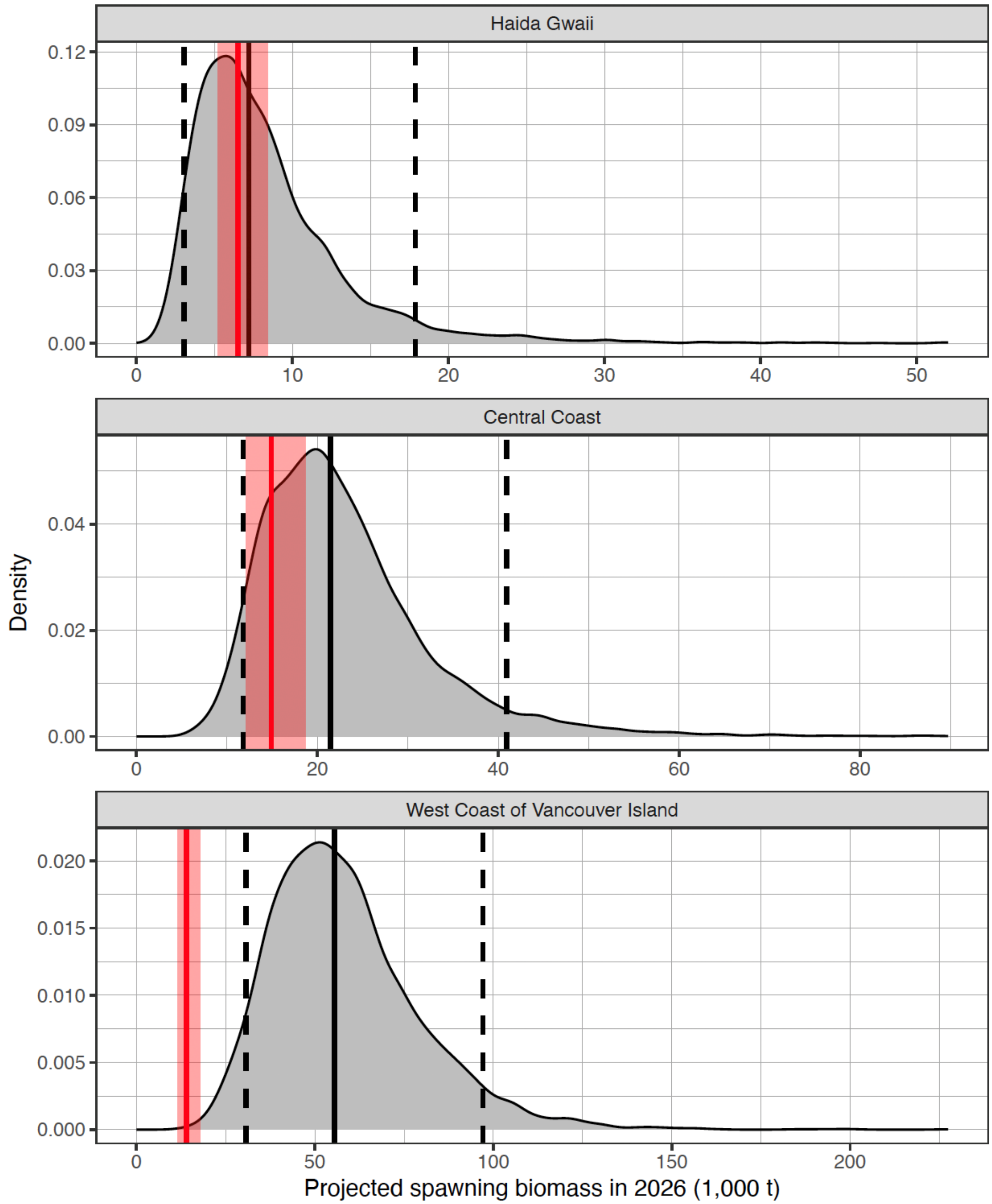

Figure 13. Projected spawning biomass of Pacific Herring assuming no fishing in 2026 SB_{2026} in thousands of tonnes (t) in the major SARs. Solid and dashed black lines indicate median posterior estimate and 90% credible intervals for SB_{2026}, respectively. Vertical red lines and shaded red areas indicate medians and 90% credible intervals for the limit reference point $0.3SB_0$, respectively, where SB_0 is estimated unfished spawning biomass.

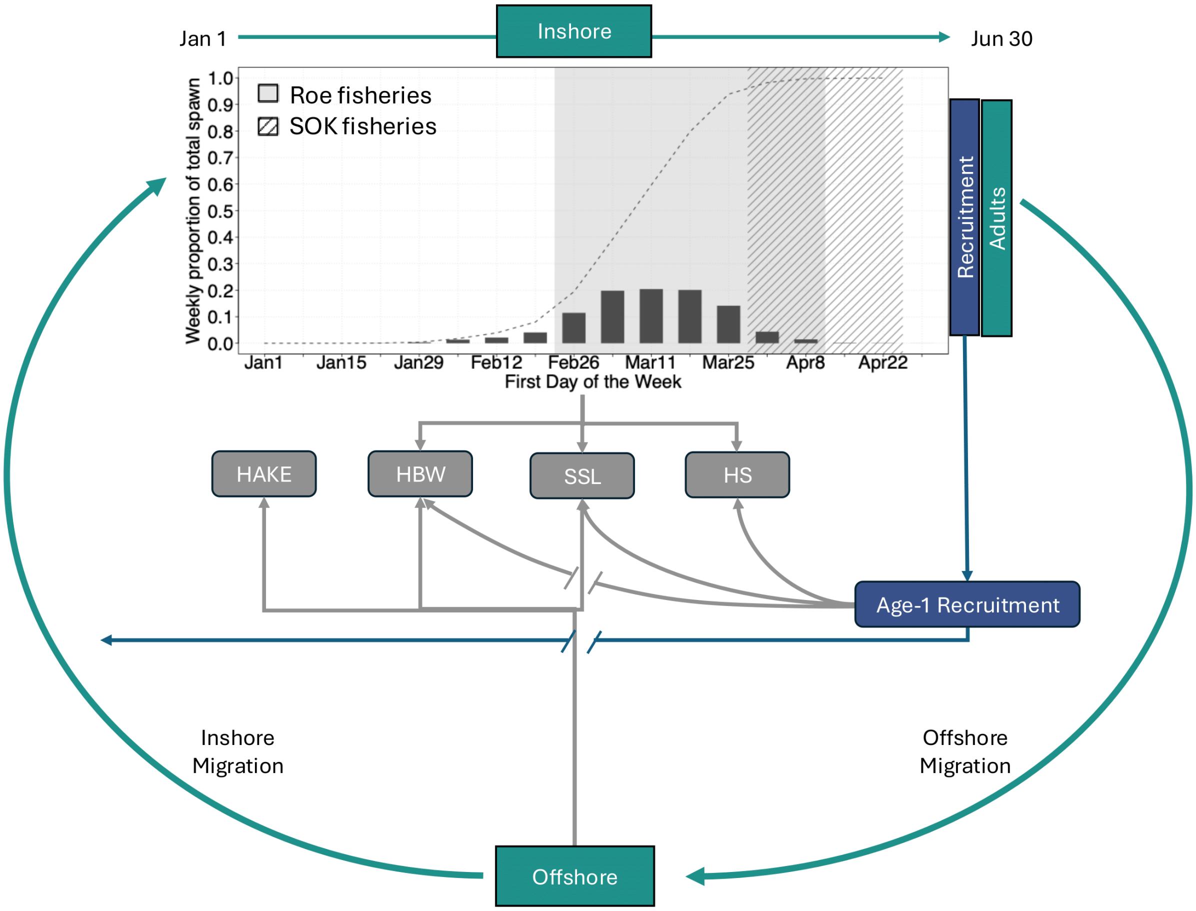

Figure 14. Conceptual model of the annual life cycle of Pacific Herring, including predation mortality in inshore and offshore regions, spawn timing (January to June), recruitment, and fisheries. Arrows to predator boxes (grey) indicate losses due to predation mortality from Pacific Hake (HAKE), Humpback Whales (HBW), Steller Sea Lions (SSL), and Harbour Seals (HS). Spawning occurs at the end of each year on June 30th. Arrows from recruitment boxes (blue) indicate recruitment of juveniles hatched from eggs deposited during the previous year's spawning events. Recruits do not migrate offshore during the feeding season but are subject to inshore predation before mixing with age-2+ herring returning from the offshore (green arrow on far left) during the spawning season. The top panel shows average weekly (vertical bars) and cumulative (dashed line) proportion of spawn for inshore spawning grounds, along with timing for roe and SOK fisheries.

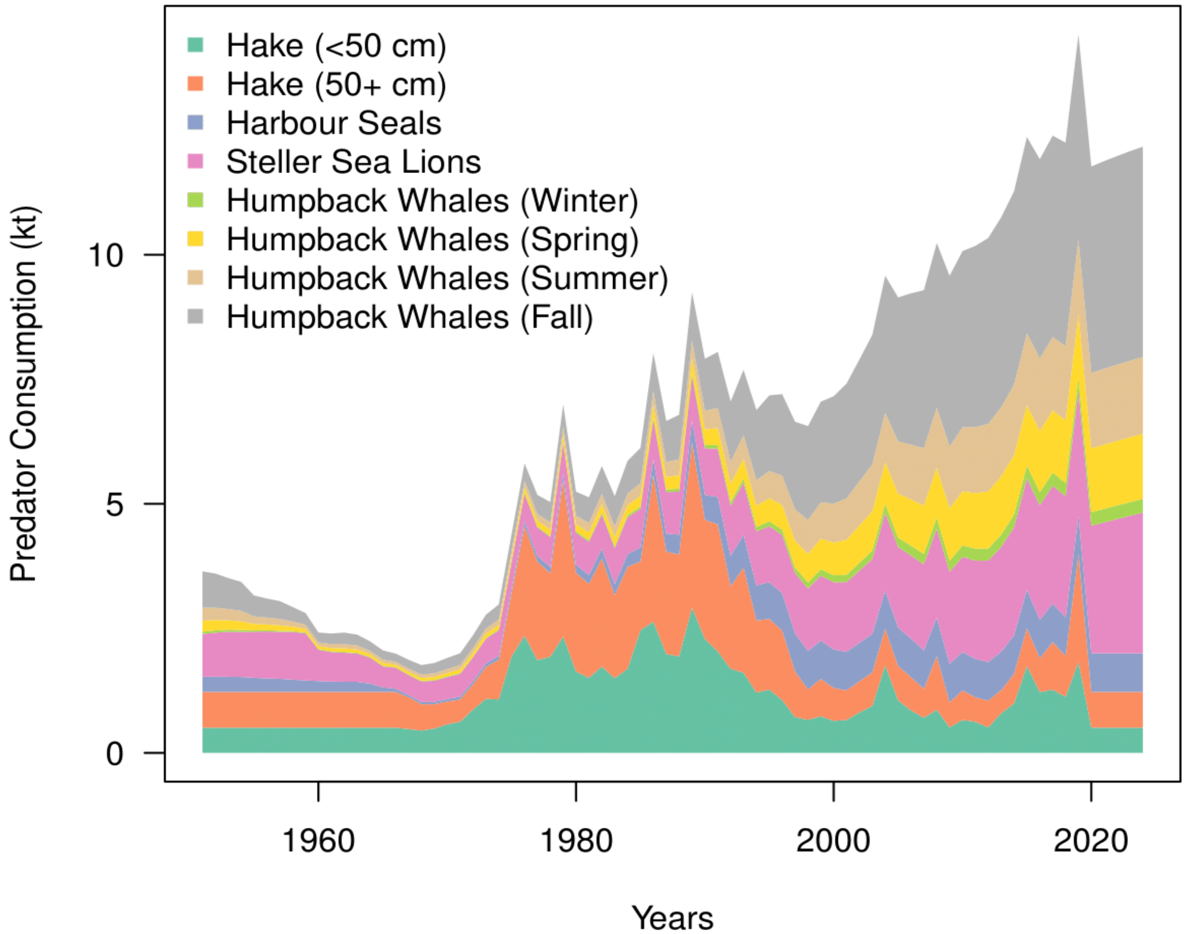

Figure 15. Estimated predator consumption of WCVI Herring from 1951 to 2024. Consumption is estimated in thousands of tonnes for each species, with Pacific Hake and Humpback Whales broken into two and four feeding groups, respectively. Feeding groups for hake differ in their Herring size preference, while Humpback Whale seasonal groups differ in size preference and spatio-temporal overlap with WCVI Herring.

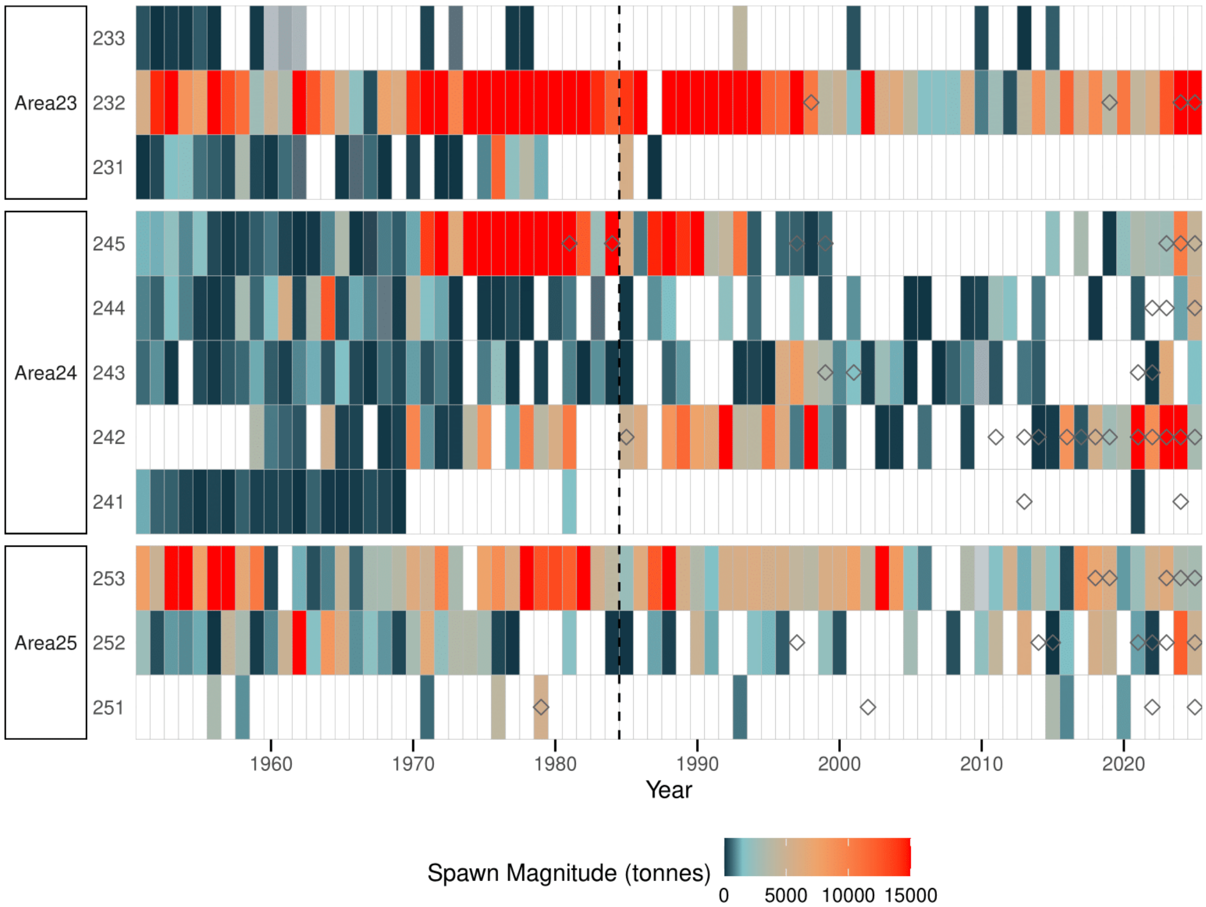

Figure 16. Spatial distribution of Pacific Herring spawn (blended index) from 1951 to 2025 for West Coast of Vancouver Island herring in Statistical Areas 23, 24, and 25 broken into individual sections. Diamonds indicate incomplete survey of spawning event, and colour gradients show spawning magnitude.

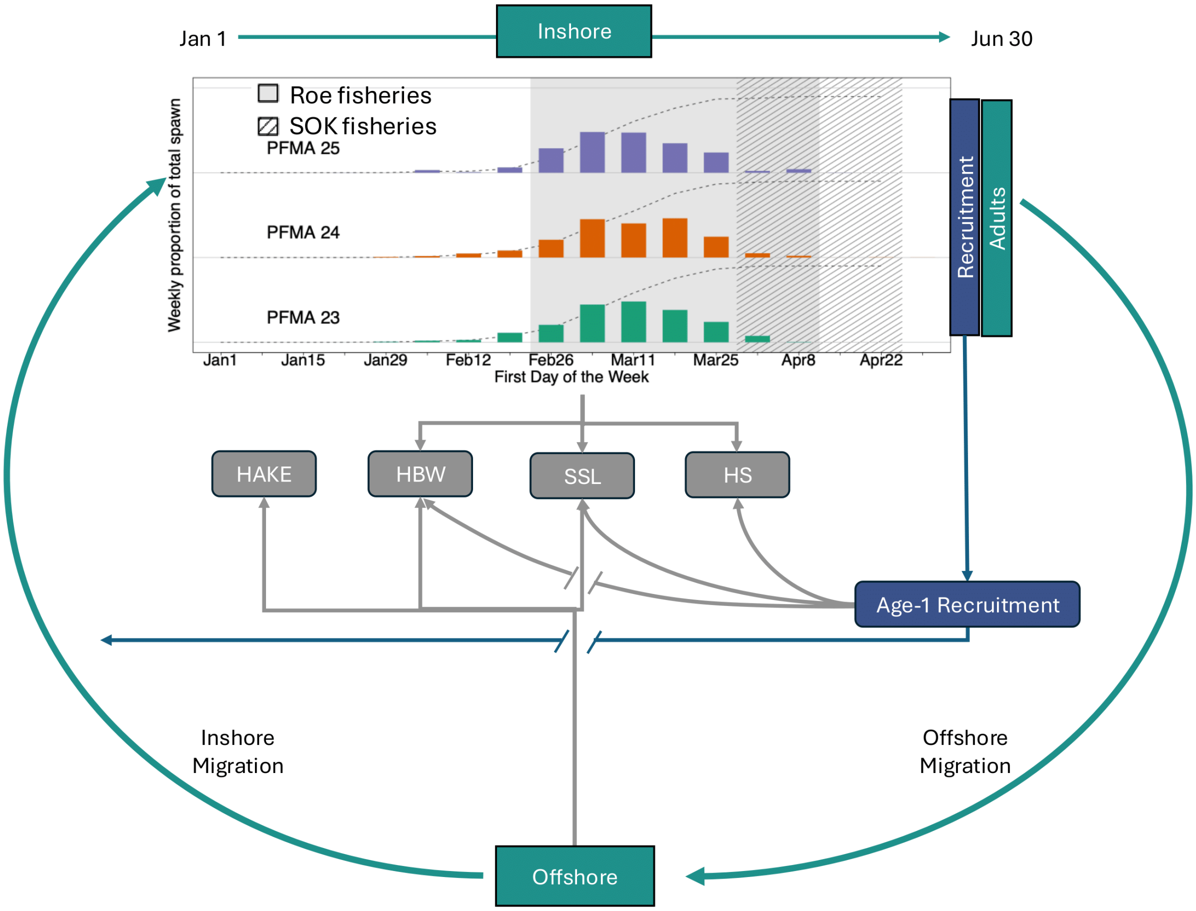

Figure 17. An annual time-step in the three-area Pacific Herring predation mortality model showing herring migrations between inshore spawning areas in Pacific Fishery Management Areas (PFMAs) and offshore feeding grounds, spawn timing (January to June), recruitment, fisheries, and predation. Arrows to predator boxes (grey) indicate losses due to predation mortality from Pacific Hake (HAKE), Humpback Whales (HBW), Steller Sea Lions (SSL), and Harbour Seals (HS). The annual time-step runs from July 1st to June 30th with spawning occurring at the end of each year. Arrows from recruitment boxes (blue) indicate recruitment of juveniles hatched from eggs deposited during the previous year's spawning events. Recruits do not migrate offshore during the feeding season, but are subject to inshore predation before mixing with age-2+ herring returning from the offshore (green arrow on far left) during the spawning season. The top panel shows average weekly (vertical bars) and cumulative (dashed line) proportion of spawn for inshore spawning grounds, along with timing for roe and SOK fisheries.

LIST OF MEETING PARTICIPANTS

Contributor	Affiliation
Jaclyn Cleary	DFO Science, Pacific
Matthew Grinnell	DFO Science, Pacific
Jennifer Boldt	DFO Science, Pacific
Samuel Johnson	Landmark Fisheries Research
Chris Rooper	DFO Science, Pacific
Bryan Rusch	DFO Fisheries Management, Pacific
Marisa Keefe	DFO Fisheries Management, Pacific
Sarah Hawkshaw	DFO Science, Pacific
Jessica Finney	DFO Science, Pacific
Miriam O	DFO Science, Pacific

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APPENDIX

Minor Stock Assessment Regions

DFO does not conduct formal analyses of stock trend information for the two Pacific Herring minor SARs: Area 27 (A27) and Area 2 West (A2W). However, DFO does provide landed commercial catch (Figure 18), biological data including weight-at-age (Figure 19) and proportion-at-age (Figure 20), as well as spawn index (Figure 21) from 1978 to 2025. DFO also provides the spawn index and proportion of spawn index by Section from 2016 to 2025 for A27 and A2W (Tables 21 and 22, respectively). For Area 27, spawn index by Section from 1978 to 2025 is also provided (Figure 22).

Special Areas

As is the case for the minor SARs, DFO does not conduct formal analyses of stock trend information for the Pacific Herring special area, Area 10 (A10; Figure 23). However, DFO provides biological data including weight-at-age (Figure 24) and proportion-at-age (Figure 25), as well as spawn index and proportion of spawn index by Section (Figure 26 and Table 23) from 1978 to 2025, where available. Note that Area 10 is a subset of the Central Coast and is outside the SAR boundary. In addition, note that there is no landed commercial catch or incidental mortality in finfish aquaculture activities in Area 10 from 1978 to 2025.

Tables

Table 21. Area 27 SAR: spawn index in tonnes for Pacific Herring and proportion of spawn index by Section from 2016 to 2025. See Table 3 for description.

		Proportion			
Year	**Spawn index**	**271**	**272**	**273**	**274**
2016	814	0.000	0.000	1.000	0.000
2017	26	0.000	0.000	1.000	0.000
2018	1,045	0.000	0.000	1.000	0.000
2019	192	0.000	0.000	1.000	0.000
2020	NA	0.000	0.000	0.000	0.000
2021	1,653	0.000	0.000	1.000	0.000
2022	NA	0.000	0.000	0.000	0.000
2023	13,511	0.000	0.000	1.000	0.000
2024	8,773	0.000	0.000	1.000	0.000
2025	NA	0.000	0.000	0.000	0.000

Table 22. Area 2 West SAR: spawn index in tonnes for Pacific Herring and proportion of spawn index by Section from 2016 to 2025. See Table 3 for description.

		Proportion				
Year	**Spawn index**	**001**	**002**	**003**	**004**	**005**
2016	3,001	0.000	1.000	0.000	0.000	0.000
2017	NA	0.000	0.000	0.000	0.000	0.000
2018	617	0.000	0.269	0.000	0.000	0.731
2019	2,884	0.000	1.000	0.000	0.000	0.000
2020	6,834	0.000	1.000	0.000	0.000	0.000
2021	1,377	0.000	1.000	0.000	0.000	0.000
2022	3,299	0.000	1.000	0.000	0.000	0.000
2023	1,192	0.000	1.000	0.000	0.000	0.000
2024	870	0.000	0.709	0.000	0.000	0.291

Year	Spawn index	Proportion				
		001	002	003	004	005
2025	1,612	0.000	1.000	0.000	0.000	0.000

Table 23. Area 10 special area: spawn index in tonnes for Pacific Herring and proportion of spawn index by Section from 2016 to 2025. See Table 3 for description.

Year	Spawn index	Proportion		
		101	102	103
2016	588	0.000	0.967	0.033
2017	2,206	0.000	1.000	0.000
2018	477	0.000	1.000	0.000
2019	570	0.000	1.000	0.000
2020	888	0.000	1.000	0.000
2021	350	0.000	1.000	0.000
2022	34	0.000	1.000	0.000
2023	503	0.000	1.000	0.000
2024	490	0.000	1.000	0.000
2025	NA	0.000	0.000	0.000

Figures

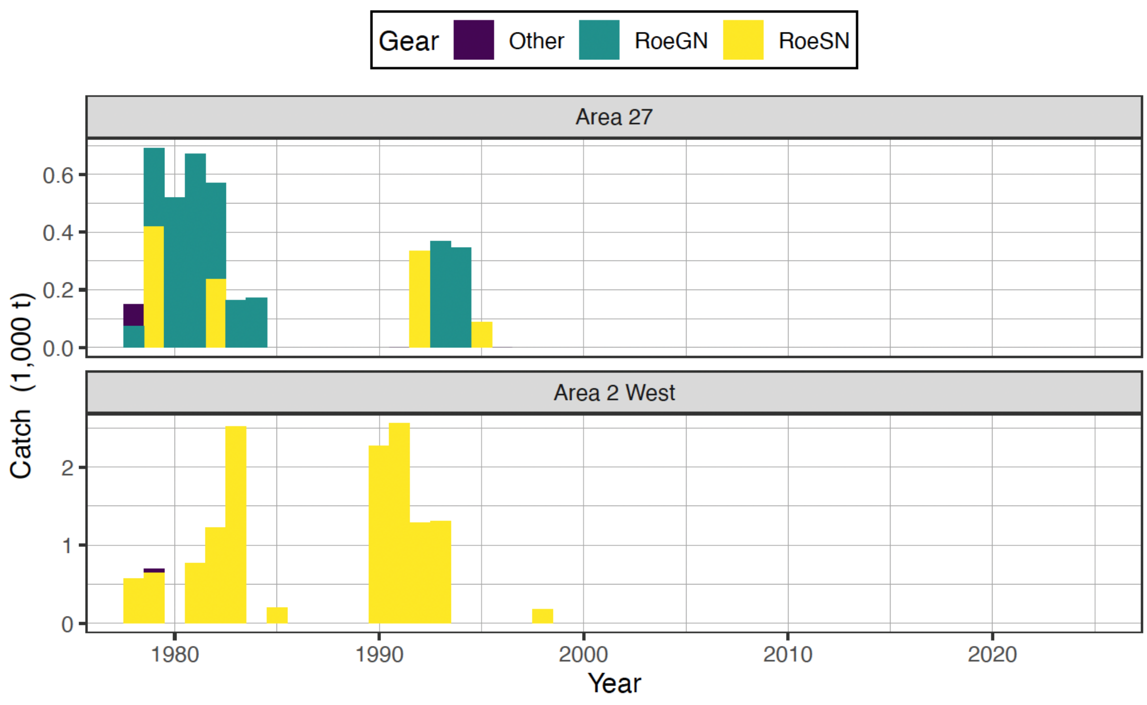

Figure 18. Total landed Pacific Herring catch in thousands of tonnes (t) from 1978 to 2025 in the minor SARs. See Figure 2 for description.

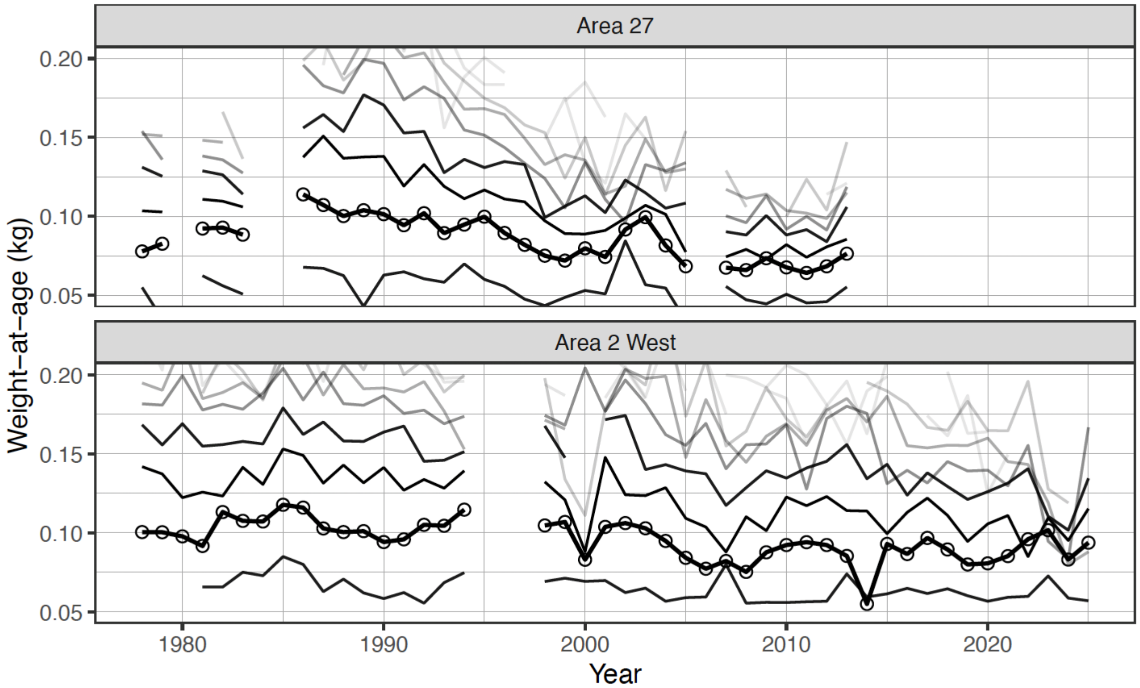

Figure 19. Mean weight-at-age for Pacific Herring in kilograms (kg) from 1978 to 2025 in the minor SARs. Circles show mean for age-3 herring. Lines show means for age-2 to age-10 herring, incrementing up from bottom line and shaded from darker to lighter. The thick line shows age-3 herring. Biological 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 includes fish ages 10 and older. Note: vertical axes are cropped at 0.05 to 0.20 kg.

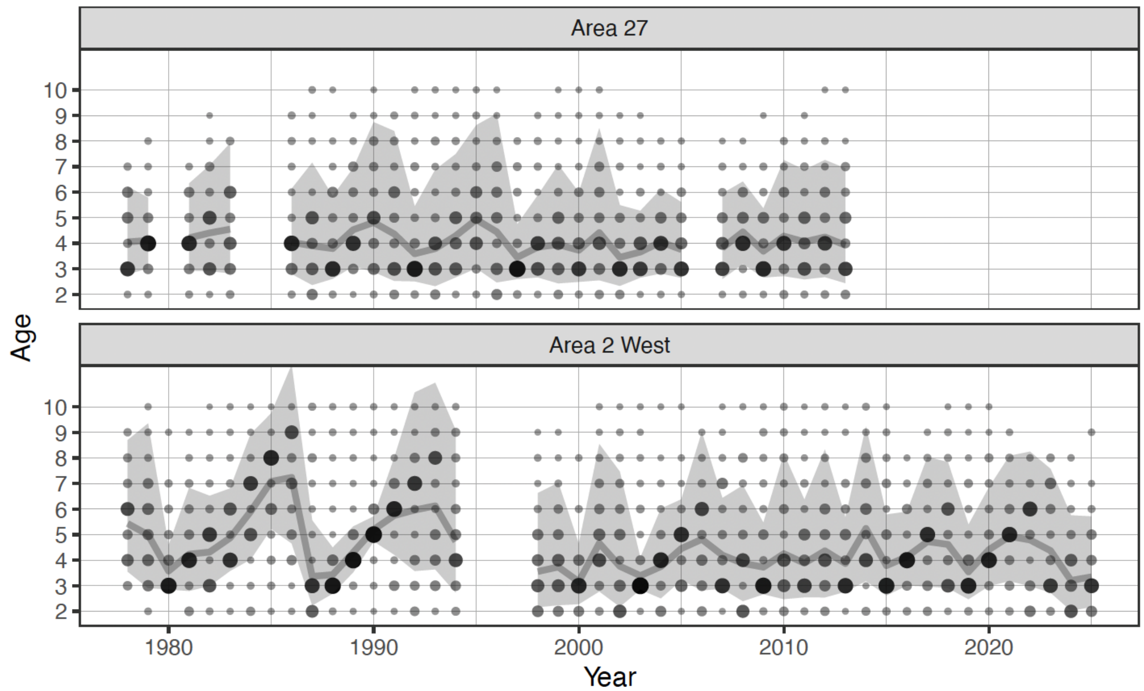

Figure 20. Proportion-at-age for Pacific Herring from 1978 to 2025 in the minor SARs. See Figure 4 for description.

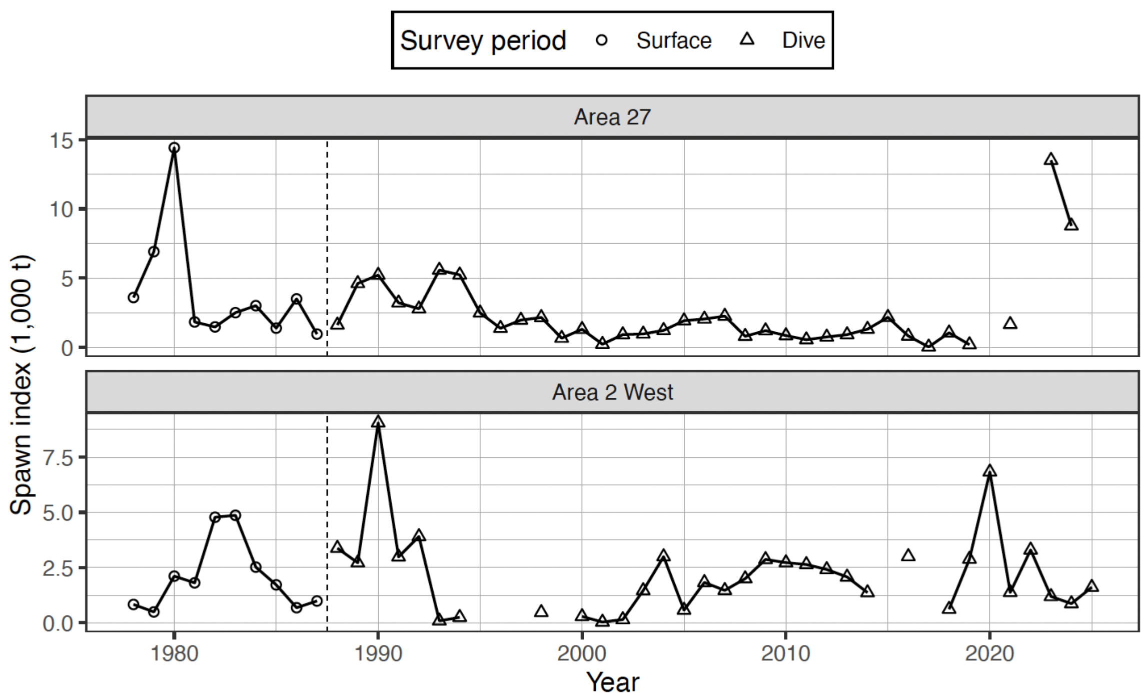

Figure 21. Spawn index in thousands of tonnes (t) for Pacific Herring from 1978 to 2025 in the minor SARs. See Figure 5 for description.

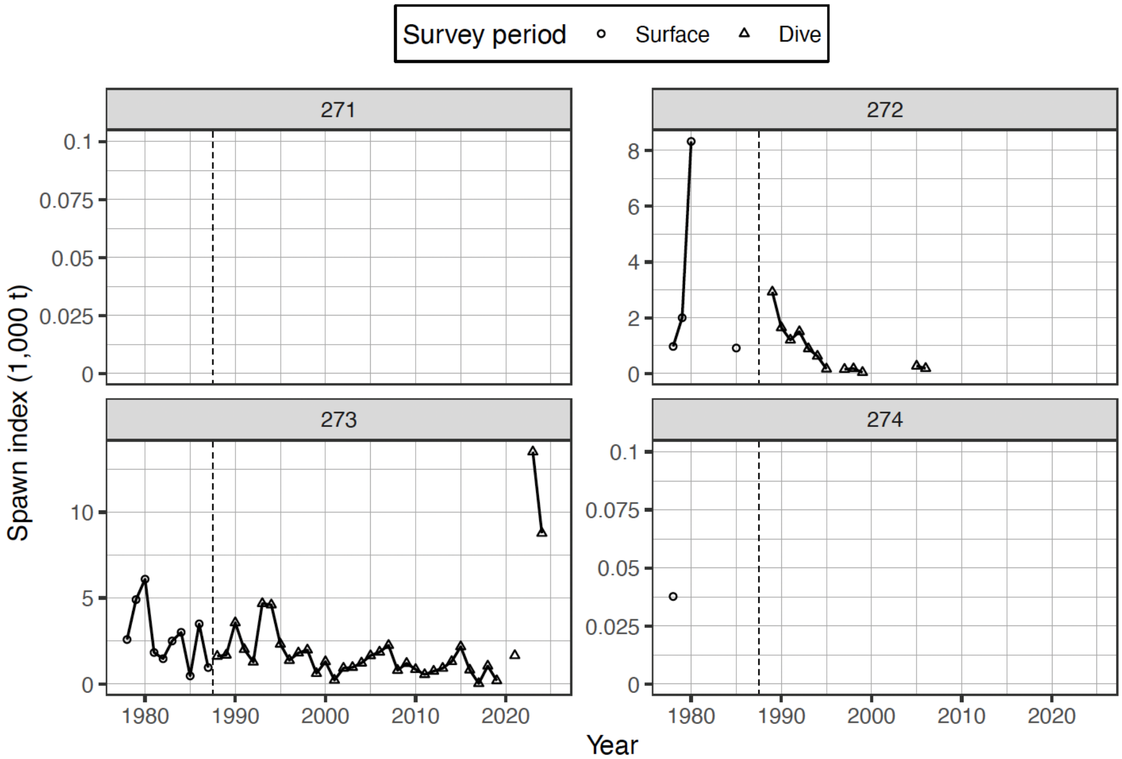

Figure 22. Area 27 SAR: spawn index in thousands of tonnes (t) of Pacific Herring by Section from 1978 to 2025. The dashed vertical line delineates between two periods defined by the dominant survey method: surface surveys (1951 to 1987), and dive surveys (1988 to 2025). Note: the 'spawn index' is not scaled by the spawn survey scaling parameter q.

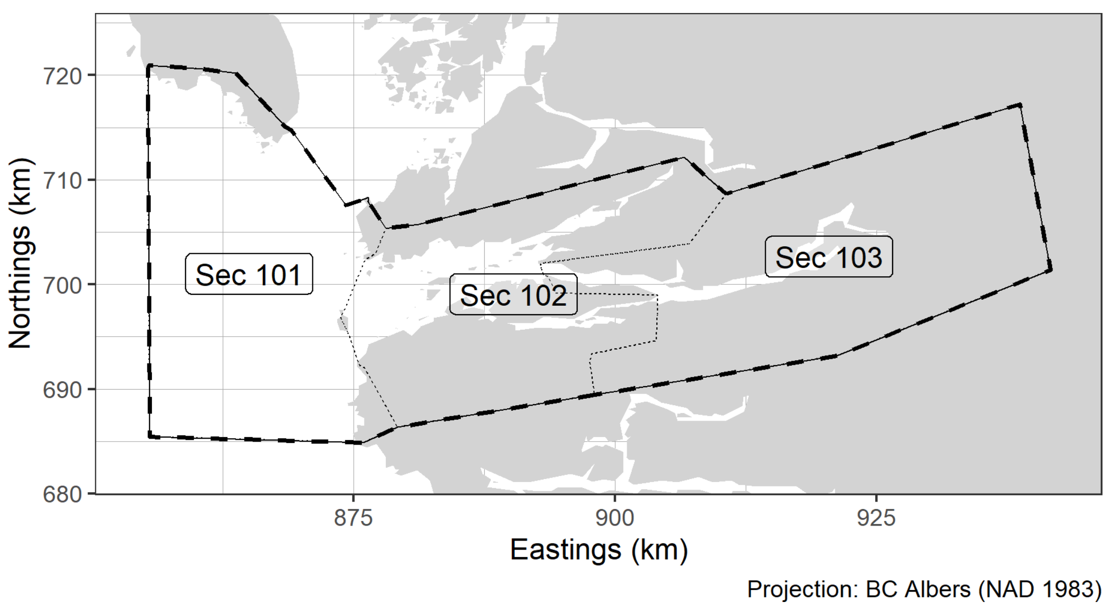

Figure 23. Sections (Sec) included in the Pacific Herring special area, Area 10 (A10). Note that special areas are not stock assessment regions (SARs); therefore they are excluded from regular monitoring and analyses. In addition, note that A10 is a subset of the Central Coast Sections that are outside the SAR boundary. Units: kilometres (km).

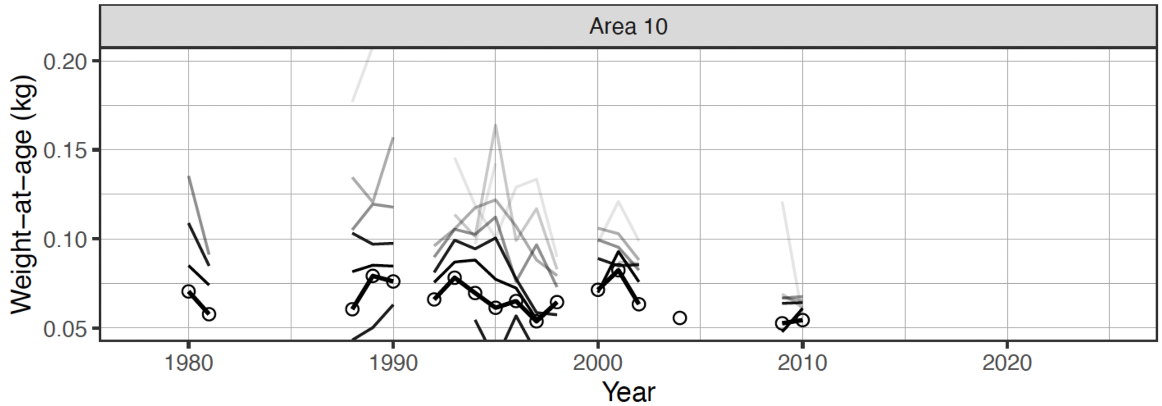

Figure 24. Mean weight-at-age for Pacific Herring in kilograms (kg) from 1978 to 2025 in the special area, Area 10. See Figure 19 for description.

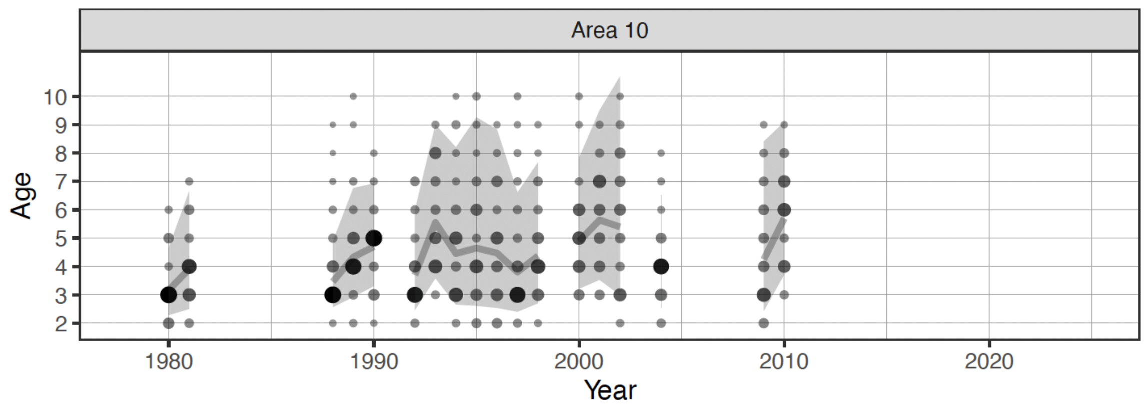

Figure 25. Proportion-at-age for Pacific Herring from 1978 to 2025 in the special area, Area 10. See Figure 4 for description.

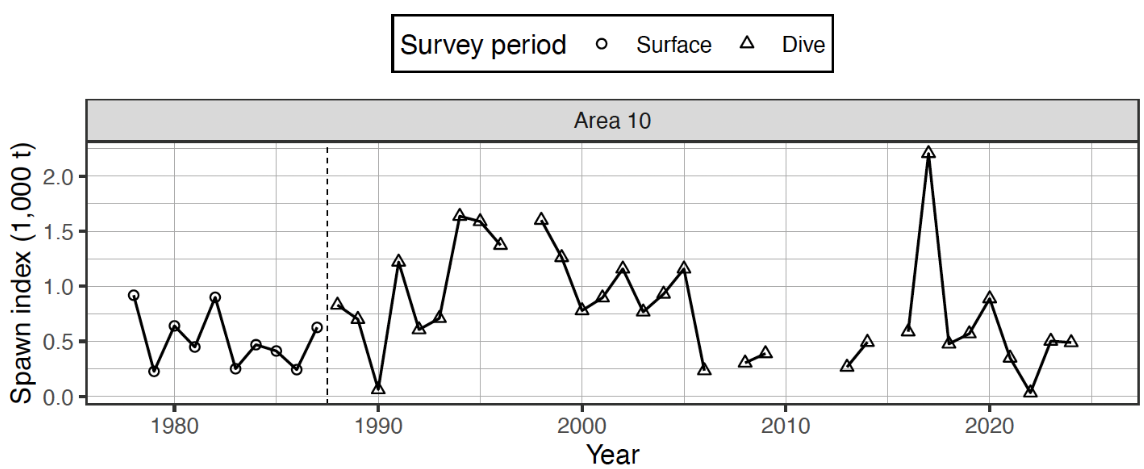

Figure 26. Spawn index in thousands of tonnes (t) for Pacific Herring from 1978 to 2025 in the special area, Area 10. See Figure 5 for description.

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3190 Hammond Bay Rd.
Nanaimo BC. V9T 6N7

E-Mail: DFO.PacificCSA-CASPacifique.MPO@dfo-mpo.gc.ca
Internet address: www.dfo-mpo.gc.ca/csas-sccs/

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