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Fisheries and Oceans Canada
1420-401 Burrard Street, Vancouver, BC
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November 26, 2024

Subject: MCC response to draft 2024/2025 Pacific herring Food & Bait and Special Use Commercial Fishing Plans, and the full Integrated Fisheries Management Plan

Dear Hong,

The Pacific Marine Conservation Caucus (MCC) is submitting this letter in response to the draft 2024/2025 Pacific herring Food & Bait and Special Use (FB/SU) commercial fishery plans, as well as the draft Integrated Fisheries Management Plan.

Strait of Georgia

We have repeatedly expressed deep concern regarding the state of herring spawning in the Strait of Georgia (SoG; see Appendix I for an example). In short, spawning in the SoG has undergone substantial truncation in both spatial and temporal extent, such that spawning is now minimal south of Dodd Narrows and has become concentrated in the month of March (Figure 1).

The 2024 spawning season showed a continuation of these trends (Figure 1). While some small spawns were recorded in areas south of Dodd Narrows that had not seen spawning in recent years (e.g., Ganges Harbour), the overall spatial and temporal extents of spawning in 2024 were a continuation of trends of south-to-north loss of spawning, and a shortening of the spawning season. Indeed, for 2024, the temporal extent of spawning in the SoG was among the briefest on record (Figure 1).

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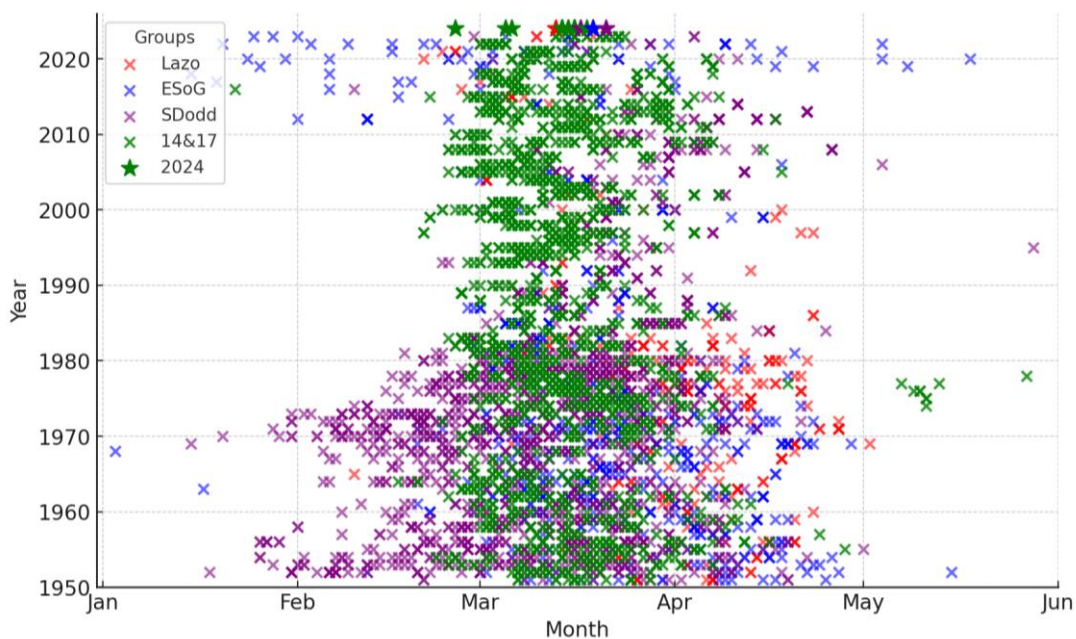


Figure 1. Strait of Georgia herring spawn start dates. Data: 1950-2023: (Government of Canada, 2023); 2024: (Cleary & Grinnell, 2024).

We believe that the spatial and temporal trends in SoG herring spawning are indicative of substantial and ongoing change in the interaction of herring with the SoG ecosystem, with fishery effects potentially exerting influence in certain periods and areas. We cannot assume that this ongoing change is neutral in its consequences for the future of SoG herring. First, the reduction in spatial and temporal diversity of spawn events means that the SoG herring spawn has become less distributed and more concentrated in both space and time, which in turn implies a loss of response diversity and a resulting loss of resilience – raising the potential for an unexpected downturn in the face of environmental variability. Second, as the spatial center of herring spawning shifts over time, herring are encountering new areas of potential spawning habitat and leaving those that they previously used – implying that the spawning dynamics associated with previous locations cannot be assumed to characterize spawning in novel habitats.

We have repeatedly raised these and associated concerns with DFO, as have others. The evidence for the loss of substantial herring spawning south of Dodd Narrows is incontrovertible, and the concentration of spawning in space and time is apparent in DFO's own data. The evidence is clear that SoG herring's spawning base has substantially changed and continues to change. However, DFO continues to develop harvest advice in the absence of any explicit consideration of these changes, or the drivers that are causing them.

Thus, for 2024/2025, we are once again presented with a suite of harvest options that, to our knowledge, have been developed as if these spatial and temporal changes have simply not happened and are not continuing to happen. In previous years we have recommended that DFO

adopt conservative harvest rates in the commercial fishery while also calling on DFO to fully engage with the realities of the spatial and temporal changes seen in this stock, and to inform their management of the fishery with an understanding of the drivers of these changes. To our knowledge, DFO's 2024/2025 harvest options once again do not engage with this reality, its drivers, or its implications for the SoG stock.

Furthermore, at this time we are developing a new set of analyses of SoG herring spawn data, and the results of these analyses – while still preliminary - add weight to our concerns about the spatial and temporal trends that have occurred over the past 70 years. Notably, the preliminary conclusions from these analyses raise our level of concern regarding the main migratory stock's spawning base, rather than the smaller spawns found in more distant parts of the SoG.

For these reasons, we have made the decision to not endorse any harvest options for SoG herring in 2024/2025.

This position does not indicate that we believe the proposed harvest options or recent exploitation rates are inherently unsustainable in and of themselves, or that cessation of commercial fishing will necessarily result in a reversal of the aforementioned spatial and temporal trends. Rather, we make this decision because we do not believe that DFO is fully engaging with the reality of SoG herring spawn changes, and until we see evidence that DFO is placing a high priority on understanding this issue and on incorporating it into fisheries management, we do not feel that we can endorse even those harvest options that are otherwise conservative.

For us to be confident in DFO's SoG herring decisions in the future, we will need to see evidence that DFO is directly engaging with the clear and ongoing changes to SoG herring spawning, and that DFO is deriving its harvest options with an understanding of the relevant trends and drivers. This should include publicly-available science that identifies and analyzes both trends and potential drivers, including spatially-explicit analyses of historical fishing effort of the different SoG herring fisheries.

Furthermore, we would like to call attention to recent calls for a "rebuilding plan" for herring south of Dodd Narrows. While we recognize that the regulatory triggers for a formal rebuilding plan or recovery plan may not be met due to the way in which the SoG stock is characterized and assessed, we feel that if the frame of reference is the ecosystem rather than the stock unit, it becomes essentially undeniable that the previously spawn-rich region of the southern Strait warrants a rebuilding lens. As a first step, and in conjunction with our previous recommendation of identifying and analyzing spawning trends and drivers, we recommend that DFO engage in an assessment of the potential to rebuild substantial herring spawning south of Dodd Narrows.

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Prince Rupert District and West Coast Vancouver Island

For Prince Rupert District (PRD) and West Coast Vancouver Island (WCVI), we urge DFO to adhere to the precautionary concept of “slow up, fast down” when considering harvest options, as recent increases in spawning biomass remain brief, relative to previous periods of sustained low biomass. Furthermore, for WCVI in particular, we note that La Niña conditions have been present in the North Pacific for most of the past five years, which corresponds to the period of sharply declining natural mortality and increasing biomass in WCVI herring. This unusually long period of La Niña conditions may have been particularly conducive to the growth and survival of WCVI herring – for example, the migratory offshore stock of Pacific hake, which is a major predator of herring, was largely absent from Canadian waters during this time. We therefore urge DFO to take a “slow up” view to potential harvest of WCVI herring in particular, in light of the potential for conditions to shift to a less-conducive phase.

Summary

For the SoG, we call on DFO herring fisheries science and management to directly engage with the SoG spawning issue by identifying its trends and drivers, addressing them in management, and assessing the potential for rebuilding the herring spawn south of Dodd Narrows. For PRD and WCVI, we urge DFO to adhere to a precautionary “slow up” approach when considering potential harvest options, in light of the brief and uncertain nature of these regions’ recent biomass increases.

We look forward to engaging with you and your DFO colleagues on these important issues throughout 2025.

Sincerely,

John Driscoll, PhD

Fisheries Science and Policy Analyst, David Suzuki Foundation
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Appendix I: 2023/2024 MCC response to draft Food & Bait and Special Use plans.

November 13, 2023

Subject: MCC response to draft 2023/2024 Pacific herring Food & Bait and Special Use Commercial Fishing Plans

Dear Marisa,

The Pacific Marine Conservation Caucus (MCC) is submitting this letter in response to the draft 2023/2024 Pacific herring Food & Bait and Special Use (FB/SU) commercial fishery plans.

While there are some encouraging trends coastwide, we are deeply concerned about the ongoing loss of herring spawning in the Strait of Georgia (SoG). In this region, a decades-long, south-to-north trend of spawning decline and cessation is evident, and the consequences for the SoG ecosystem are doubtlessly significant. However, Fisheries and Oceans Canada (DFO) is not actively addressing this issue: to our knowledge, DFO has not identified the drivers of this decline, and thus is managing SoG herring fisheries in the absence of a clear understanding of why this trend is occurring and what can be done to halt and reverse it.

1. Strait of Georgia spawning extent

For decades, the SoG has been losing herring spawning in a generally south-to-north direction (Figure 1, see also Figure 20 in Cleary & Grinnell, 2023). In the southern SoG, Area 19 has not hosted significant spawning since before 1950. Spawning in Area 18 underwent a sudden, severe, and persistent collapse in the 1980s, and has not recovered (Figure 1). Now, for the upcoming fishing season, we are specifically concerned about the status of spawning in Area 17, where spawning events have declined in recent years to their lowest recorded levels (Figure 2). The Area 17 spawning trends are troubling because they indicate that the south-to-north loss of spawning is continuing, the drivers of the trend remain unidentified and unmanaged, and the loss of spawning is now encroaching on the last remaining area of consistently high spawning activity in the Strait.

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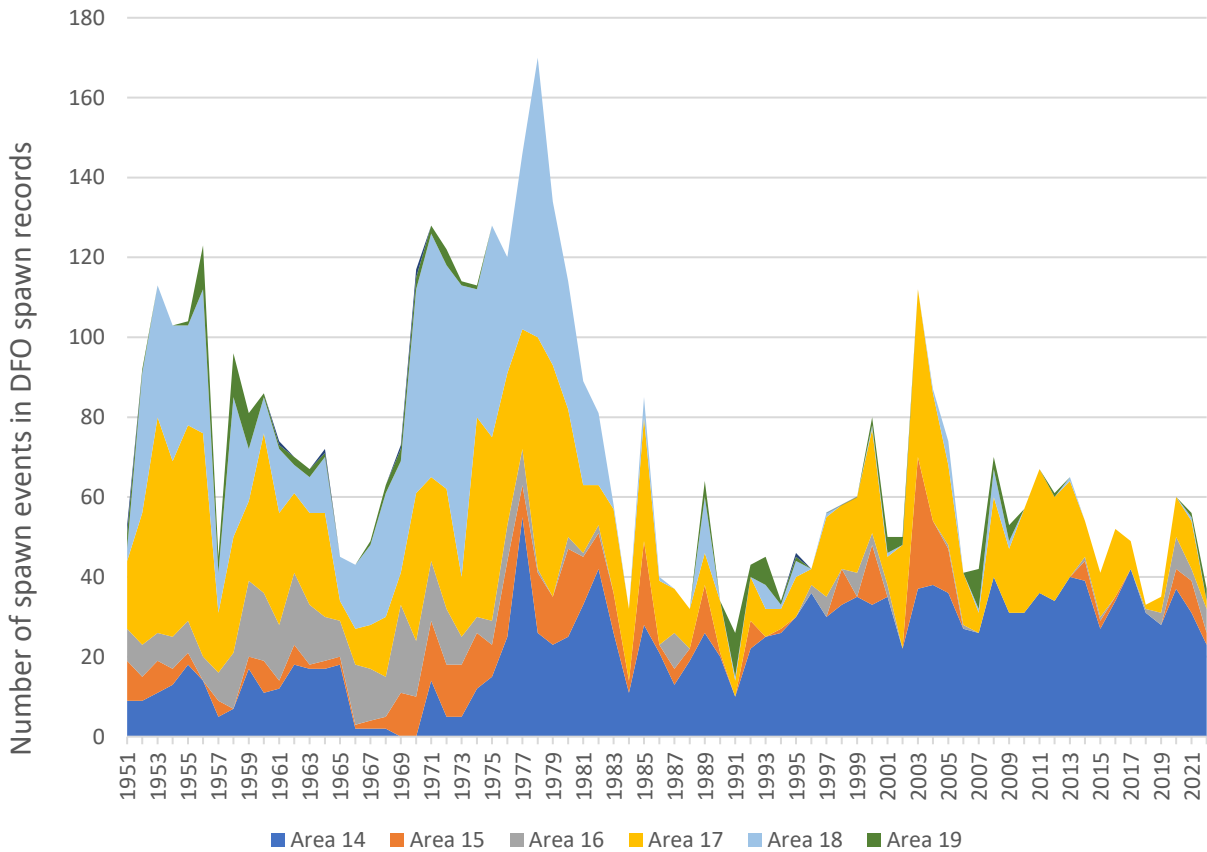


Figure 1. Number of SoG spawning events in DFO spawn data, by Area, 1951-2022.
Data source: (Government of Canada, 2023)

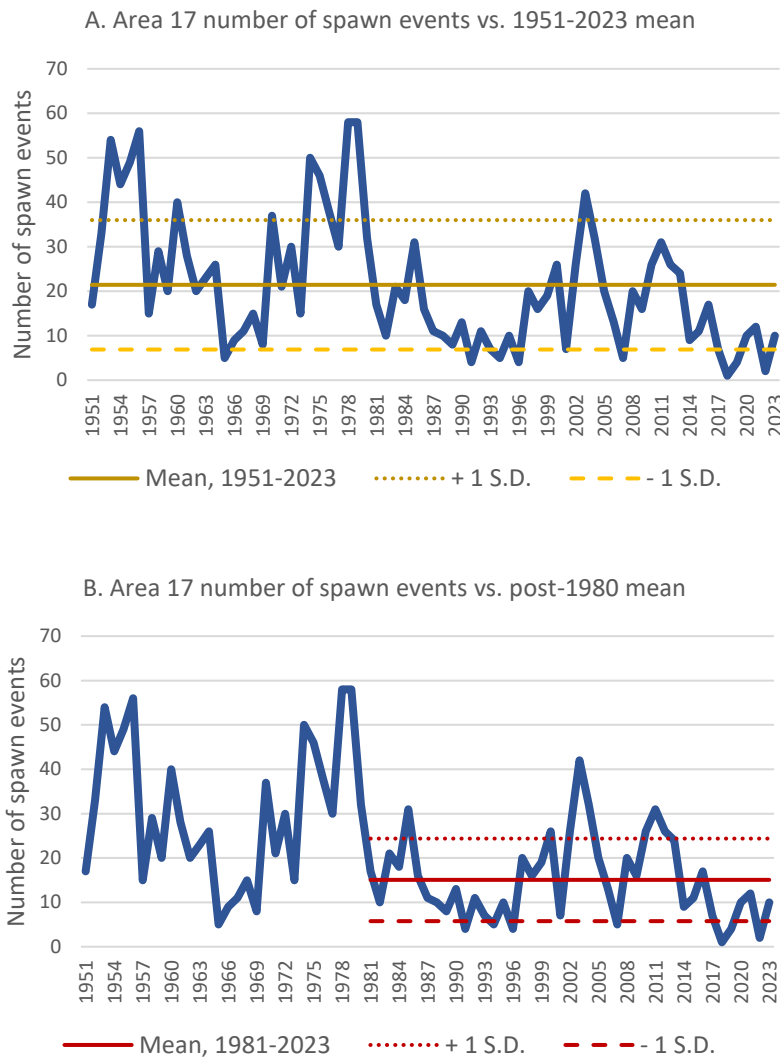


Figure 2. Annual number of herring spawning events in Area 17, relative to A) 1951-2023 mean, and B) 1981-2023 mean. Source for 1951-2022 data: (Government of Canada, 2023). Source for 2023 data: (Cleary & Grinnell, 2023)

As shown in Figure 2, the last several years have seen the number of spawning events annually recorded in Area 17 decline to their lowest levels in DFO’s spawning records. For Area 17, the average annual number of spawn events recorded from 2017 to 2023 (6.5 ± 4.3) is much lower than not only the long-term average (1951-2023: 21.4 ± 14.5 , Figure 2A), but also the post-1980 period of reduced spawning (1981-2023: 15.1 ± 9.3 , Figure 2B).

Thus, the current status of spawning frequency in Area 17 is at a critically low level, even when compared to already-diminished modern baselines, and appears to have substantially diverged from spawning trends in Area 14. When we view this in light of previous decades’ loss of spawning in Areas 19 and 18 – losses which persist to this day (Figure 1) - we are deeply concerned that Area 17 will be the next area to lose all significant herring spawning. We emphasize that this is not limited to those parts of Area 17 that are south of Dodd Narrows: in the last two years, spawning has been minimal from Nanaimo north to Lantzville (Figure 10 in

Cleary & Grinnell, 2022, and Figure 10 in Cleary & Grinnell, 2023), which raises concern that the ongoing loss of spawning is now encroaching on the last stronghold of consistent and significant herring spawning in the SoG, in the region north of Nanaimo.

Here, we note that to our knowledge, DFO has not identified the drivers of the south-to-north loss of herring spawning in the SoG, and therefore the SoG fisheries are being managed in the absence of an understanding of why this loss has occurred. As a result, we cannot assume that current management is informed by or is addressing these drivers. We therefore request an interim measure to immediately minimize direct human impact on herring throughout Area 17.

For these reasons, we are recommending that all remaining open subareas of Area 17 be closed to all commercial herring fisheries in the 2023/2024 season.

2. Strait of Georgia spawn diversity

As shown in Figure 1 (and see also Figure 20 in Cleary & Grinnell, 2023), herring spawning in the SoG has become highly concentrated in Area 14. Along with this spatial concentration, there has also been a concentration of spawn timing: whereas spawning in the 1950s, 1960s, and early 1970s was widely distributed across the months of February, March, and April, a sudden truncation occurred in the late 1970s, primarily affecting early spawning but also reducing later spawning (Figure 3). As a result, SoG spawning became highly concentrated in the month of March.

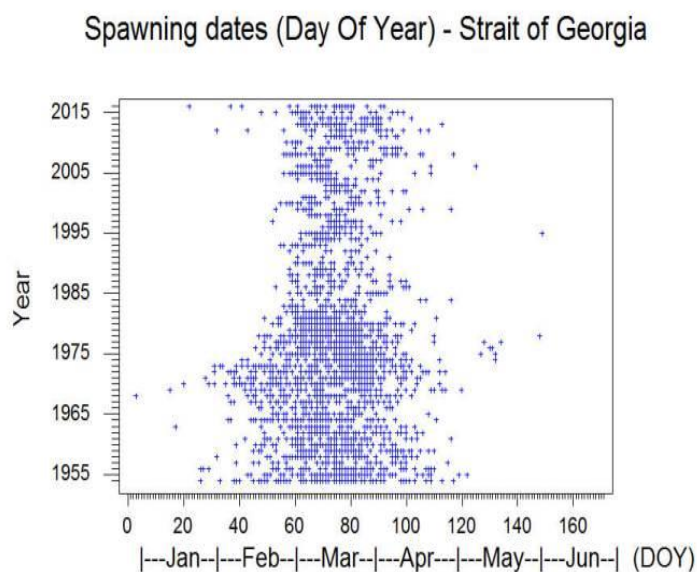


Figure 3. Spawning dates in the SoG. Figure from (DFO, 2016)

These concurrent spatial and temporal trends resulted in SoG herring spawning becoming increasingly concentrated in a smaller region (Area 14) and a briefer time period (the month of

March). There are two pathways by which this loss of temporal and spatial variation may result in a simplified – *i.e.*, a less diverse – spawning basis for the SoG herring population.

The first pathway relates to effects on sub-populations. The losses of temporal and spatial diversity in spawning may have had consequences for genetic diversity, as genetic differentiation in Pacific herring is associated with extremes in spawn timing, as well as differences in spatial location (e.g., mainland inlet spawners) (Petrou et al., 2021). The loss of spawning events at the extremes of the spawning season, the truncation of the primary part of the spawning season, and the loss of spawning in mainland inlets (e.g., Area 16 in Figure 1) suggest that genetically differentiated units of herring may have been affected.

The second pathway of simplification is via the distribution of spawning in the physical environment. The greater variety of spawning areas and spawn timings that previously characterized SoG herring spawning represented another sort of diversity – via physical variability in the exposure of SoG herring to different stressors, whether environmental, ecological, or anthropogenic. With the loss of this variety of spawning areas and timings, and the concentration of spawning in a smaller area and period of time, it is assumed that a greater share of SoG herring are now subjected to similar stressors.

Both of these possibilities – the potential loss of sub-population diversity, which is understood to confer resilience via the “portfolio effect” (Schindler et al., 2010), and the loss of physical diversity in spawn timing and location – may therefore affect the overall resilience of SoG herring to novel stressors. With record-breaking heat affecting much of the world’s oceans in 2023, and with an El Niño period recently emerging after several years of cooling La Niña conditions, Pacific herring may indeed be subject to increased stressors in the coming years. While past changes to herring spawning distribution may not be fully reversible, we must ensure that SoG fisheries do not contribute to continued simplification of SoG herring spawning – particularly at a time when the maintenance of resilience in the stock is of paramount importance.

To this end, we are concerned that the Food & Bait (F&B) fishery is proposed to receive 2,100 t of quota. Unlike the roe fishery, which is essentially assured of catching fish belonging to a specific (and assessed) spawning aggregation discrete in both space and time, the F&B fishery operates before herring have distributed to their spawning locations. As such, there is the possibility that this fishery intercepts herring that are ultimately bound for spawning locations outside the main migratory stock’s primary spawning areas, or outside the main spawning period. It is our understanding that DFO evaluates weight data from fishery samples to assess the similarity of F&B catches to roe catches (e.g., Figure 5 in Cleary & Grinnell, 2023), and uses this information, along with the temporal and spatial location of the F&B catches, to arrive at

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relative assuredness that the F&B fishery is exploiting the main migratory stock. While we agree that this approach likely ensures that most of the F&B catches are indeed from the main migratory stock, we are concerned that small catches of herring from outside the main migratory stock may still occur without meaningfully affecting the aggregate information – and that even small catches of such herring may represent important sources of mortality for any spawning herring that are highly differentiated in time and/or space.

Furthermore, we note that the lack of transparent, publicly-available information regarding the spatial locations of F&B catches continues to present a challenge to evaluating this fishery's dynamics over the years, and doubtlessly contributes to a high degree of uncertainty and distrust among many concerned stakeholders. This is exacerbated by the presence of winter (November-December) catches in Area 18 during the years immediately preceding its spawning collapse in the early 1980s, and in Area 17 in the years immediately preceding that Area's recent spawning decline. While other drivers may have exerted significant influence in these periods (e.g., the 1977 North Pacific regime shift, Anderson & Piatt, 1999), the simple fact is that the potential role of the F&B fishery in spawning decline remains an area of high uncertainty and distrust for many members of the public – and this is exacerbated by the lack of publicly-available information and analysis.

In short, catches in the F&B fishery are associated with a higher level of uncertainty regarding their ultimate impact. In keeping with the intent of the Precautionary Approach, situations with greater scientific uncertainty require greater caution. The need for a precautionary approach is only heightened in the SoG case, where many areas previously rich with spawning continue to see minimal to non-existent rebuilding even after years without spatially proximate fisheries.

On this basis, we are proposing a precautionary measure meant to minimize further risk, ideally to be in place only until a more complete assessment of historic F&B catches is publicly available. We propose that the maximum quota allocated to the F&B fishery be defined as a fixed proportion of the total SoG herring TAC, with the proportion determined by the ratio of the average annual F&B catches to total catches that occurred during a period of relatively high spawn occurrence and distribution across SoG Areas. We propose the 1998-2007 period as the reference period, selected because it a) represents a period of relatively high spawning events across multiple Areas during the “modern” (i.e., post-1980s decline) period in the SoG (Figure 1), and b) is within DFO's proposed “productive period” time frame for the SoG, and therefore represents fishery dynamics that occurred in conjunction with a period recognized by DFO for its productivity attributes. In the data to which we have access (DFO, n.d.), the ratio of average annual “winter” (September-December) catches to total catches during the 1998-2007 period was 0.087, or 8.7%.

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We therefore recommend that the 2023/2024 F&B catches be capped at 9% of the total SoG TAC.

3. Strait of Georgia harvest rate

In contrast to Area 17, spawning in Area 14 appears to be fluctuating within a consistent range of variability, and is not showing clear signs of significant decrease (Figure 4). When combined with this year's abundance estimates, as well as the positive spawning biomass production observed for 2022 (Figure 13 in DFO, 2023), this apparent consistency of spawning reduces our concerns regarding the status of herring in Area 14. It is from this perspective, and in conjunction with our request for a closure of Area 17, that we offer recommendations for harvest advice.

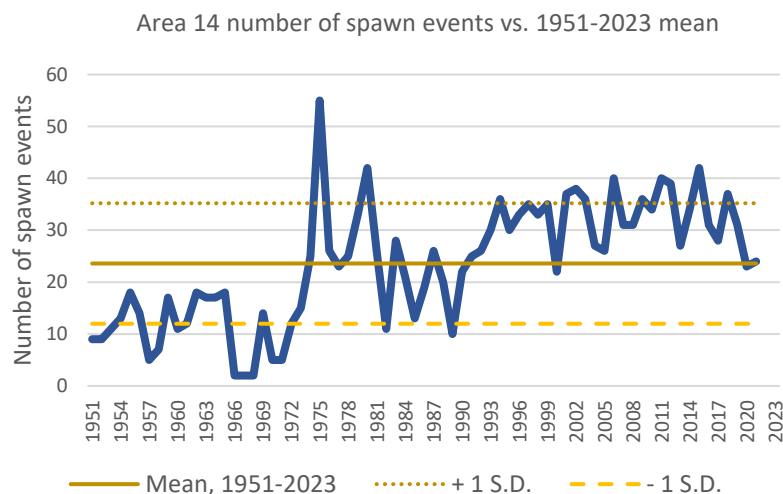


Figure 4. Annual number of spawn events in Area 14, relative to 1951-2023 mean. Data source: (Government of Canada, 2023)

For several years, the MCC has advocated for the adoption of the **HS30-60_HR10** management procedure. A key part of this procedure is the maximum 10% harvest rate. Setting the maximum harvest rate at 10% has been identified by DFO as the most effective management option for minimizing the effect of uncertainty in stock abundance, and thus reducing the risk that a given year's catches will exceed sustainable levels (DFO, 2022). Thus, for the upcoming fishing season, we emphasize that the SoG herring fishery, at the very least, must not exceed a harvest rate of 10%.

However, as defined by the **HS30-60_HR10** management procedure, a 10% harvest rate should only be applied if the stock's abundance is above 60% of its estimated unfished spawning biomass (SB_0). The 2023/2024 SoG herring stock is projected to be approximately 52% of SB_0 , which according to **HS30-60_HR10** requires that the maximum allowable fishery harvest rate be set at no more than 7%. The need to reduce the maximum allowable harvest rate from 10% to

7% is further supported by the extremely high uncertainty of the 2023/2024 spawning biomass estimate (5th and 95th percentile estimates of 29% and 87% of SB_0 , respectively), which implies a high probability that the actual harvest rate will be higher than the selected rate. This high degree of uncertainty creates the potential for unintentional overexploitation, which in turn warrants the selection of precautionary harvest rates, rather than the maximum possible options that appear to be allowable under department objectives.

For 2023-2024, we believe that **HS30-60_HR10**, and the associated 7% harvest rate, represents the maximum allowable management procedure for the Strait of Georgia. **HS30-60_HR10** is the only management procedure that achieves DFO's core conservation objective ($SB_t > 0.3SB_0$, with probability > 75%) across both reference and "robustness" scenarios of natural mortality, while still allowing for commercial harvest (DFO, 2023). Even then, **HS30-60_HR10** barely achieves the conservation objective in the robustness scenario ($P = 75\%$), underlining the need to view this management procedure as the maximum option during this period of increasing natural mortality. Thus, we reiterate that **HS30-60_HR10** represents the maximum allowable option for 2023-2024.

4. Summary

We reiterate our deep concern regarding the ongoing loss of herring spawning in the southern SoG, and we are specifically concerned about the status of spawning in Area 17. For 2023/2024, we see a clear need to protect any herring returning to Area 17 from direct human impacts. We are therefore requesting that all currently open subareas of Area 17 be closed to commercial fishing for the upcoming year.

Furthermore, in light of the continued lack of recovery of herring spawning throughout much of the SoG, and the higher level of uncertainty inherent in the F&B fishery, we request that the 2023/2024 F&B quota allocation be capped at 9% of the total SoG quota.

Finally, we reiterate our long-standing recommendation to implement the HS30-60_HR10 management option, which would result in maximum harvest rate of 7% for the upcoming fishing season.

Thank you for your time and consideration.

Sincerely,

John Driscoll, PhD

Fisheries Science and Policy Analyst, David Suzuki Foundation

Integrated Herring Harvest Planning Committee, MCC Representative

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References

- Anderson, P. J., & Piatt, J. F. (1999). Community reorganization in the Gulf of Alaska following ocean climate regime shift. *Marine Ecology Progress Series*, 189, 117–123.
- Cleary, J., & Grinnell, M. (2022). *Pacific herring preliminary data summary for Strait of Georgia 2022*. Fisheries and Oceans Canada.
- Cleary, J., & Grinnell, M. (2023). *Pacific herring preliminary data summary for Strait of Georgia 2023*. Fisheries and Oceans Canada.
- Cleary, J., & Grinnell, M. (2024). *Pacific herring preliminary data summary for Strait of Georgia 2024*. Fisheries and Oceans Canada.
- DFO. (n.d.). *Herring spawn summary, Region 5*. Retrieved September 23, 2023, from <https://www.pac.dfo-mpo.gc.ca/science/species-especes/pelagic-pelagique/herring-hareng/herspawn/tables/sogmapf-eng.html>
- DFO. (2016). *Herring spawning dates in six regions*. <https://www.pac.dfo-mpo.gc.ca/science/species-especes/pelagic-pelagique/herring-hareng/herspawn/pages/timereg-eng.html#5>
- DFO. (2022). *Stock status update with application of management procedures for Pacific herring (Clupea pallasii) in British Columbia: Status in 2022 and forecast for 2023* (Science Response 2022/046). Canadian Science Advisory Secretariat.
- DFO. (2023). *Stock status update with application of management procedures for Pacific herring (Clupea pallasii) in British Columbia: Status in 2023 and forecast for 2024* (Science Response 2023/000). Canadian Science Advisory Secretariat.
- Government of Canada. (2023). *Pacific herring spawn index data*. <https://open.canada.ca/data/en/dataset/d892511c-d851-4f85-a0ec-708bc05d2810>
- Petrou, E. L., Fuentes-Pardo, A. P., Rogers, L. A., Orobko, M., Tarpey, C., Jiménez-Hidalgo, I., Moss, M. L., Yang, D., Pitcher, T. J., Sandell, T., Lowry, D., Ruzzante, D. E., & Hauser, L. (2021). Functional genetic diversity in an exploited marine species and its relevance to fisheries management. *Proceedings of the Royal Society B: Biological Sciences*, 288(1945), 20202398. <https://doi.org/10.1098/rspb.2020.2398>
- Schindler, D. E., Hilborn, R., Chasco, B., Boatright, C. P., Quinn, T. P., Rogers, L. A., & Webster, M. S. (2010). Population diversity and the portfolio effect in an exploited species. *Nature*, 465(7298), 609–612. <https://doi.org/10.1038/nature09060>

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