INTERNATIONAL PACIFIC HALIBUT COMMISSION

IPHC–2023–SRB022–R

Report of the 22nd Session of the IPHC Scientific Review Board (SRB022)

Meeting held in Seattle, WA, USA, 20-22 June 2023

Commissioners

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INTERNATIONAL PACIFIC HALIBUT COMMISSION

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ACRONYMS

AM	Annual Meeting
CV	Coefficient of Variation
FISS	Fishery-Independent Setline Survey
IPHC	International Pacific Halibut Commission
MAF	Minor allele frequency
MP	Management Procedure
MSA	Mixed stock analysis
MSAB	Management Strategy Advisory Board
MSE	Management Strategy Evaluation
OM	Operating Model
PCA	Principle component analyses
PDO	Pacific Decadal Oscillation
SNP	Single nucleotide polymorphisms
SRB	Scientific Review Board
TCEY	Total Constant Exploitation Yield
U.S.A.	United States of America
WPUE	Weight-Per-Unit-Effort

DEFINITIONS

A set of working definitions are provided in the IPHC Glossary of Terms and abbreviations: https://www.iphc.int/the-commission/glossary-of-terms-and-abbreviations

HOW TO INTERPRET TERMINOLOGY CONTAINED IN THIS REPORT

This report has been written using the following terms and associated definitions so as to remove ambiguity surrounding how particular paragraphs should be interpreted.

Level 1: **RECOMMENDED**; **RECOMMENDATION; ADOPTED** (formal); **REQUESTED; ENDORSED; ACCEPTED** (informal): A conclusion for an action to be undertaken, by a Contracting Party, a subsidiary (advisory) body of the Commission and/or the IPHC Secretariat.

Level 2: **AGREED**: Any point of discussion from a meeting which the Commission considers to be an agreed course of action covered by its mandate, which has not already been dealt with under Level 1 above; a general point of agreement among delegations/participants of a meeting which does not need to be elevated in the Commission's reporting structure.

Level 3: **NOTED/NOTING**; **CONSIDERED**; **URGED**; **ACKNOWLEDGED**: General terms to be used for consistency. Any point of discussion from a meeting which the Commission considers to be important enough to record in a meeting report for future reference. Any other term may be used to highlight to the reader of an IPHC report, the importance of the relevant paragraph. Other terms may be used but will be considered for explanatory/informational purposes only and shall have no higher rating within the reporting terminology hierarchy than Level 3.

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EXECUTIVE SUMMARY

The 22nd Session of the International Pacific Halibut Commission (IPHC) Scientific Review Board (SRB022) was held in Seattle, WA, USA from 20 to 22 June 2023. The meeting was opened by the Chairperson, Dr Sean Cox (Canada), and the Executive Director, Dr David Wilson.

The following are a subset of the complete recommendations/requests for action from the SRB022, which are provided in full at Appendix IV.

RECOMMENDATIONS

Management strategy evaluation

SRB022–Rec.03 (para. 25) To improve comparability of MPs in performance achieving TCEY objectives, the SRB **RECOMMENDED** equalizing MP performance on one of the conservation objectives.

SRB022–Rec.04 (para. 26) The SRB **RECOMMENDED** that reconditioning the operating model should be limited to situations where the stock assessment has changed significantly. This likely means a three-year schedule for reconditioning the operating model in the year following each full stock assessment.

SRB022–Rec.05 (para. 27) The SRB **RECOMMENDED** that the Secretariat consider using explicit informative priors for conditioning the operating model to make fitting constraints more explicit.

SRB022–Rec.06 (para. 28) The SRB **RECOMMENDED** that exceptional circumstance (i) be evaluated annually based on comparisons between the simulation distribution (e.g. a 95% interval) of FISS values from MSE simulations to the realized FISS estimates; and (ii) be clearly distinguished from "unusual conditions". For example, exceptional circumstances should have a high threshold for persistent (i.e. more than a single year) deviation from MSE simulations.

SRB022–Rec.07 (para. 29) The SRB **RECOMMENDED** that an initial response to a suspected "exceptional circumstance" should include presentation at the next SRB meeting to establish whether the situation meets the definition of an "exceptional circumstance" and to formulate a response.

Biology and ecology

SRB022–Rec.08 (para. 32) The SRB **NOTED** that the current maturity sampling design does not determine whether the high rate of individuals at the cortical alveoli stage in the southeastern portion of the study area is a function of differences in seasonal reproductive timing or in size/age at maturity. The SRB **RECOMMENDED** additional investigations on the region-specific seasonal reproductive cycles and evaluating the extent to which differences among regions can be explained by size or age of the sampled individuals.

SRB022–Rec.10 (para. 36) **NOTING** that in terms of bioinformatic quality filtering to exclude loci, filtering based on sequencing depth alone may not be sufficient to exclude mitochondrial sequences, the SRB **RECOMMENDED** that loci be mapped to the published Pacific halibut mitochondrial genome to ensure that non-autosomal loci are included in analyses. Filtering based on sequencing depth alone is likely not sufficient to exclude regions of the genome that represent repetitive elements. Suggest sites be checked for repetitive elements.

SRB022–Rec.11 (para. 37) The SRB **RECOMMENDED** that the Secretariat include other genome-wide summary measures of diversity. Measures could include (a) measures of genome size, (b) percentages of genome as singleton and duplicated loci, (c) other summary measures of diversity including (i) number of loci with minor allele frequency (MAF)>0.01, (ii) number of loci with MAF>0.05, (iii) a measure of deviation of observed and expected heterozygosity (Fis), (iv) observed heterozygosity (Ho) and expected heterozygosity (He).

SRB022–Rec.12 (para. 38) The SRB **RECOMMENDED** that the Secretariat evaluate multiple 'windows' and inter-window 'spacing' to summarize diversity and differentiation. The SRB is unsure why a 15 Kb 'window was used with 7.5 Kb space for producing Manhattan plots. The size of the window will affect estimates of significance based on a measures of Fst significance. Specifically, the larger the 'window' likely the larger the standard deviation across a greater number of sites. Window size is also likely to affect levels of linkage disequilibrium and down-stream analyses based on it.

SRB022–Rec.13 (para. 39) **NOTING** that different outlier tests are based on different assumptions and statistical approaches, the SRB **RECOMMENDED** that the Secretariat implement more than one method. Selection of specific markers would appropriately be based on concordant designation of highly population discriminatory loci identify across methods. The Secretariat is likely to have greater confidence in assignment of 'outliers' based on principles of concordance using multiple and semi-independent software packages and statistical approaches.

SRB022–Rec.14 (para. 40) The SRB **RECOMMENDED** that after statistical significance of SNP loci has been established, the Secretariat use gene set enrichment analyses to establish functional annotations for genes associated with SNPs.

SRB022–Rec.20 (para. 47) The SRB **RECOMMENDED**:

a) that the Secretariat move forward to stock discrimination to satisfy the Secretariat objective of using genetic data to define spatial structuring including unsupervised clustering methods (e.g. K-means, Structure, etc.) as well as PCA-based clustering (e.g. Discriminant Analysis of Principle Component) clustering;

b) using assignment testing and mixture analyses such as leave-one-out cross-validation simulations to assess the potential accuracy of mixed stock analysis (MSA).

Management Supporting Information

SRB022–Rec.21 (para. 52) The SRB **NOTED** the presentation demonstrating how secondary FISS objectives influence choices for future FISS designs that may have already been endorsed by the SRB based only on primary objectives. The SRB **RECOMMENDED** that the MSE include some scenarios in which the FISS is skipped (as also requested above in para. 30) because of occasional (or persistent) economic constraints on executing full FISS designs. Such simulation scenarios would provide some indication of the potential scale of impacts on MP performance of maintaining long-term revenue neutrality of the FISS.

REQUESTS

International Pacific Halibut Commission 5-year program of integrated research and monitoring (2022-26)

SRB022–Req.01 (para. 16) The SRB **REQUESTED** that during the next update of the Plan, consider specifying the role and timing of input from the SRB in developing and reviewing project methods, performance metrics.

Pacific halibut stock assessment

SRB022–Req.02 (para. 18) **NOTING** that analysis of whale depredation has clarified that the potential scale of removals from depredation is relatively small, except in IPHC Regulatory Area 4A, the SRB **REQUESTED** that updated analysis using USA observer data be presented at SRB023 to evaluate whether incorporation of whale depredation in the stock assessment is warranted.

Management strategy evaluation

SRB022–Req.03 (para. 30) The SRB **NOTED** that situations in which critical data streams (e.g. FISS index or age data) are unavailable for one or more years does not constitute an "exceptional circumstance" and **REQUESTED** that the MSE include evaluation of such missing FISS data scenarios for the SRB023.

FISS design evaluation

SRB022–Req.04 (para. 50) The SRB **NOTED** that IPHC Regulatory Area 4B will not be sampled in 2023 and **REQUESTED** that the Secretariat present an analysis of the predicted CV for unsampled and partially sampled IPHC Regulatory Areas in 2024.

1. OPENING OF THE SESSION

1. The 22nd Session of the International Pacific Halibut Commission (IPHC) Scientific Review Board (SRB022) was held in Seattle, WA, USA from 20 to 22 June 2023. The list of participants is provided at Appendix I. The meeting was opened by the Chairperson, Dr Sean Cox (Canada), and the Executive Director, Dr David Wilson.

2. The SRB **RECALLED** its mandate, as detailed in Appendix VIII, Sect. I, para. 1-3 of the IPHC Rules of Procedure (2023):

    1. *The Scientific Review Board (SRB) shall provide an independent scientific peer review of Commission science/research proposals, programs, and products, including but not limited to:*
        a. *Data collection;*
        b. *Historical data sets;*
        c. *Stock assessment;*
        d. *Management Strategy Evaluation;*
        e. *Migration;*
        f. *Reproduction;*
        g. *Growth;*
        h. *Discard survival;*
        i. *Genetics and Genomics.*
    2. *Undertake periodic reviews of science/research strategy, progress, and overall performance.*
    3. *Review the recommendations arising from the MSAB and the RAB.*

2. ADOPTION OF THE AGENDA AND ARRANGEMENTS FOR THE SESSION

3. The SRB **ADOPTED** the Agenda as provided at Appendix II. The documents provided to the SRB are listed in Appendix III. Participants were reminded that all documents for the meeting were published on the IPHC website, 30 days prior to the Session: https://www.iphc.int/venues/details/22nd-session-of-the-iphc-scientific-review-board-srb022.

3. IPHC PROCESS

3.1 SRB annual workflow

4. **NOTING** that the core purpose of the SRB022 is to review progress on the IPHC's research and monitoring activities, and to provide guidance for the delivery of products to the SRB023 in September 2023, the SRB **RECALLED** that formal recommendations to the Commission would not necessarily be developed at the present meeting, but rather, these would be developed and finalised at SRB023.

3.2 Update on the actions arising from the 21st Session of the SRB (SRB021)

5. The SRB **NOTED** paper IPHC-2023-SRB022-03, that provided the SRB with an opportunity to consider the progress made during the intersessional period on the recommendations/requests arising from the SRB021.

6. The SRB **AGREED** to consider and revise the actions as necessary, and to combine them with any new actions arising from SRB022 into a consolidated list for future reporting.

3.3 Outcomes of the 99th Session of the IPHC Annual Meeting (AM099)

7. The SRB **NOTED** paper IPHC-2023-SRB022-04 that detailed the outcomes of the 99th Session of the IPHC Annual Meeting (AM099), relevant to the mandate of the SRB, and **AGREED** to consider how best to provide the Commission with the information it has requested, throughout the course of the current SRB meeting.

3.4 Observer updates

8. The SRB **NOTED** the following updates (paraphrased) from the Canadian science advisor:

*a) **Fishery-Independent Setline Survey (FISS)***

- *Two main concerns: 1) longer term financial viability of the FISS, and 2) how changes made to the FISS design endorsed by the SRB each year in order to meet secondary & tertiary objectives impact science;*
- *In order to address these two concerns, there is interest in exploring the impact on both scientific and economic value of making changes to FISS design such as: 1) changing (relaxing) the target CV of 15%, and 2) not sampling in every charter/Regulatory Area in every year.*

9. The SRB **NOTED** the following updates (paraphrased) from the USA science advisor:

*a) **Stock Assessment:***

- *How can the Commission be better prepared to respond to changes in the stock assessment model structure and the potential magnitude of changes in the outcomes (e.g. sex-ratio, natural mortality)?;*
- *Could communication of upcoming model changes and the potential impacts be improved?*

4. INTERNATIONAL PACIFIC HALIBUT COMMISSION 5-YEAR PROGRAM OF INTEGRATED RESEARCH AND MONITORING (2022-26)

10. The SRB **NOTED** paper IPHC-2023-SRB022-05 that provided the SRB with the IPHC 5-year Program of Integrated Research and Monitoring (2022-26), including a draft research tracking tool, which takes into consideration the recommendation from the previous SRB meeting (ref. IPHC-2022-SRB021-R; SRB021–Rec.01).

11. The SRB **RECALLED** that:

a) the IPHC Secretariat conducts activities to address key issues identified by the Commission, its subsidiary bodies, the broader stakeholder community, and the IPHC Secretariat;

b) the process of identifying, developing, and implementing the IPHC's science-based activities involves several steps that are circular and iterative in nature, but result in clear project activities and associated deliverables;

c) the process includes developing and proposing projects based on direct input from the Commission, the experience of the IPHC Secretariat given its broad understanding of the resource and its associated fisheries, and concurrent consideration by relevant IPHC subsidiary bodies (including the SRB), and where deemed necessary, including by the Commission, additional external peer review;

d) the IPHC Secretariat commenced implementation of the new Plan in 2022 and will keep the Plan under review on an ongoing basis.

12. The SRB **RECALLED** that an overarching goal of the IPHC 5-year Program of Integrated Research and Monitoring (2022-26) is to promote integration and synergies among the various research and monitoring activities of the IPHC Secretariat in order to improve knowledge of key inputs into the Pacific halibut stock assessment, and Management Strategy Evaluation (MSE) processes, thereby providing the best possible advice for management decision making processes.

13. The SRB **RECALLED** that at SRB021 in September 2022, the SRB made the following recommendation:

    SRB021–Rec.01 (para. 14) *The SRB RECOMMENDED that the Secretariat and Commission take a more deliberate and explicit approach in deciding which research programs to fund internally or externally, since internally funded research can: (i) utilize milestones and interim evaluations as possible "kill points" where a project may be discontinued if the marginal costs outweigh the benefits of a particular research stream or project; (ii) provide pilot data to support external research proposals; and (iii) support critical applied research that falls outside typical funding agency interests.*

14. The SRB **NOTED** that at the 13th Special Session of the Commission (SS013; IPHC-2023-SS013-R), the Commission provided the following directive to the Secretariat based on their interpretation of SRB021-Rec.01:

    Budget Estimates: FY2024 (for approval): Fund 20 – Research: Biological and Ecosystem Sciences annual reporting

    SS013-Req.01 (para. 9) *The Commission REQUESTED that, as part of the annual reporting to the Commission on the Biological and Ecosystem Science Branch activities, that the Secretariat provide a summary table that incorporates the following elements for Commission review:*

    a) Current project abstract, including objectives, links to IPHC's core mandate and how it will inform Commissioner's decisions;

    b) Related Commission decisions and directives;

    c) Timeline for deliverables;

    d) Funding sources;

    e) Progress report.

15. The SRB **NOTED** the reporting table draft provided by the Contracting Parties (Appendix A of paper IPHC-2023-SRB022-05) and **RECOMMENDED** further modification by adding the following and as shown in Table 1 below:

    a) New Column: Brief description of the project and how it relates to the core mandate of the Commission;

    b) Description of the problem being addressed;

    c) Objective: List of concise objectives (research and how the results will be incorporated);

    d) Impact scale and timing;

    e) Interim performance/evaluation metrics.

Table 1. Proposed template for summary of research program

Project start/end year	General area	Topic	Problem	Relevance to General Area	Study objectives and rationale	Anticipated results/application	Expected Impact	Impact timing	Funding details (amount required per year, funding source)	Commissioner decision	Status
E.g. 1, 2, 3	*Stock assessment or MSE*		*E.g. similar to typical science abstract to summarize project, with links to IPHC core mandate and decision-making*		*a list of concise project objectives including main research objectives and rationale for why the results are important to the General Area*	*Results and application in SA or MSE*	*High-Med-Low*	*expected timeframe in which the Impact will occur. These are labeled Short1 (within 1 year), Med2-4 (2-4 years), and Long6+ (more than 6 years)*	*E.g. 2023: $XX,XXX; 2024:...;*	*E.g. Adopted, Not adopted, supported by US only, supported by CAN only*	*E.g. Specify status similar to what is done to report on PR; status to be linked to milestones*
NEW PROJECTS - FOR DECISION											
...											
PREVIOUSLY PITCHED PROJECTS (including adopted and not adopted)											
...											

16. The SRB **REQUESTED** that during the next update of the Plan, consider specifying the role and timing of input from the SRB in developing and reviewing project methods, performance metrics.

4.1 Research

4.1.1 Pacific halibut stock assessment

17. The SRB **NOTED** paper IPHC-2023-SRB022-08, which provided a response to recommendations and requests made during SRB021 (IPHC-2022-SRB021-R) and to provide an update of the 2023 stock assessment development.

18. **NOTING** that analysis of whale depredation has clarified that the potential scale of removals from depredation is relatively small, except in IPHC Regulatory Area 4A, the SRB **REQUESTED** that updated analysis using USA observer data be presented at SRB023 to evaluate whether incorporation of whale depredation in the stock assessment is warranted.

19. **NOTING** that the scale of impact from different model weighting approaches presented here is small relative to the impact of other factors in the MSE (e.g. two- vs. three-year assessment intervals and TCEY), the SRB **RECOMMENDED** that the Secretariat continue using the equal weighting approach for model averaging.

4.1.2 Management strategy evaluation

20. The SRB **NOTED** paper IPHC-2023-SRB022-07 which provided the SRB with an update on MSE progress in 2023 and potential tasks for 2023–2025.

21. The SRB **NOTED** that additional simulations beyond those presented at MSAB017 resulted in more precise values of the performance metrics, but the relative comparisons between management procedures remained the same.

22. The SRB **NOTED** that different PDO regimes (i.e. always high or always low):

    a) had little effect on the priority conservation objective, but low PDO resulted in low TCEYs and high PDO resulted in high TCEYs;

    b) affected the long-term distribution of spawning biomass differently in each Biological Region; and

    c) may have as much or a larger effect on the long-term distribution of spawning biomass in each Biological Region than fishing with the current interim harvest strategy policy does.

23. The SRB **ENDORSED** the process for developing and conditioning the 2023 OM.

24. The SRB **NOTED** that the spatial structure objective could be better addressed through a criterion that compares biomass in each region to unfished biomass in the same region rather than using proportions of the total stock-wide biomass.

25. To improve comparability of MPs in performance achieving TCEY objectives, the SRB **RECOMMENDED** equalizing MP performance on one of the conservation objectives.

26. The SRB **RECOMMENDED** that reconditioning the operating model should be limited to situations where the stock assessment has changed significantly. This likely means a three-year schedule for reconditioning the operating model in the year following each full stock assessment.

27. The SRB **RECOMMENDED** that the Secretariat consider using explicit informative priors for conditioning the operating model to make fitting constraints more explicit.

28. The SRB **RECOMMENDED** that exceptional circumstance (i) be evaluated annually based on comparisons between the simulation distribution (e.g. a 95% interval) of FISS values from MSE simulations to the realized FISS estimates; and (ii) be clearly distinguished from "unusual conditions". For example, exceptional circumstances should have a high threshold for persistent (i.e. more than a single year) deviation from MSE simulations.

29. The SRB **RECOMMENDED** that an initial response to a suspected "exceptional circumstance" should include presentation at the next SRB meeting to establish whether the situation meets the definition of an "exceptional circumstance" and to formulate a response.

30. The SRB **NOTED** that situations in which critical data streams (e.g. FISS index or age data) are unavailable for one or more years does not constitute an "exceptional circumstance" and **REQUESTED** that the MSE include evaluation of such missing FISS data scenarios for the SRB023.

4.1.3 Biology and ecology

31. The SRB **NOTED** paper IPHC-2023-SRB022-09 which provided the SRB with a description of progress towards research activities described in the IPHC's five-year Program of Integrated Research and Monitoring (2022-2026).

32. The SRB **NOTED** that the current maturity sampling design does not determine whether the high rate of individuals at the cortical alveoli stage in the southeastern portion of the study area is a function of differences in seasonal reproductive timing or in size/age at maturity. The SRB **RECOMMENDED** additional investigations on the region-specific seasonal reproductive cycles and evaluating the extent to which differences among regions can be explained by size or age of the sampled individuals.

33. The SRB **NOTED** that the habitat mapping research is a good example of a project that could benefit from explicitly defining research goals, connections to stock assessment or MSE, methods, timelines, etc. as specified in Appendix A of the paper.

34. The SRB **NOTED** that research on whale depredation includes (i) reducing the uncertainty around the scale of impacts on total mortality used in the stock assessment and (ii) reducing the impacts of depredation on the fishery.

35. The SRB **NOTED** the presentation on whale depredation avoidance devices and **RECOMMENDED** that the Secretariat pursue external funding opportunities for expanding this research and testing one or more devices in the presence of whales.

36. **NOTING** that in terms of bioinformatic quality filtering to exclude loci, filtering based on sequencing depth alone may not be sufficient to exclude mitochondrial sequences, the SRB **RECOMMENDED** that loci be mapped to the published Pacific halibut mitochondrial genome to ensure that non-autosomal loci are included in analyses. Filtering based on sequencing depth alone is likely not sufficient to exclude regions of the genome that represent repetitive elements. Suggest sites be checked for repetitive elements.

37. The SRB **RECOMMENDED** that the Secretariat include other genome-wide summary measures of diversity. Measures could include (a) measures of genome size, (b) percentages of genome as singleton and duplicated loci, (c) other summary measures of diversity including (i) number of loci with minor allele frequency (MAF)>0.01, (ii) number of loci with MAF>0.05, (iii) a measure of deviation of observed and expected heterozygosity (Fis), (iv) observed heterozygosity (Ho) and expected heterozygosity (He).

38. The SRB **RECOMMENDED** that the Secretariat evaluate multiple 'windows' and inter-window 'spacing' to summarize diversity and differentiation. The SRB is unsure why a 15 Kb 'window was used with 7.5 Kb space for producing Manhattan plots. The size of the window will affect estimates of significance based on a measures of Fst significance. Specifically, the larger the 'window' likely the larger the standard deviation across a greater number of sites. Window size is also likely to affect levels of linkage disequilibrium and down-stream analyses based on it.

39. **NOTING** that different outlier tests are based on different assumptions and statistical approaches, the SRB **RECOMMENDED** that the Secretariat implement more than one method. Selection of specific markers would appropriately be based on concordant designation of highly population discriminatory loci identify

across methods. The Secretariat is likely to have greater confidence in assignment of 'outliers' based on principles of concordance using multiple and semi-independent software packages and statistical approaches.

40. The SRB **RECOMMENDED** that after statistical significance of SNP loci has been established, the Secretariat use gene set enrichment analyses to establish functional annotations for genes associated with SNPs.

41. The SRB **APPRECIATED** that the Secretariat estimated Tajima's D as recommended (IPHC-2022-SRB021-R), and **RECOMMENDED** that:

    a) the Secretariat be cautious with filtering SNP loci based on minor allele frequency (MAF) at levels as low as 0.01 as employed in results described in IPHC-2023-SRB022-09, as this may affect values of Tajima's D; and

    b) a range of values be explored.

42. The SRB **NOTED** that samples that form the basis for statistical comparisons of levels of genetic differentiation among IPHC reporting regions are composed of collections from multiple years. The representation of different age classes differs between collection years. There is also evidence for genetic differences between individuals collected in different years that often appear to be part of different year cohort. These findings warrant further attention.

43. The SRB **RECOMMENDED** looking for genome regions (more than 2 or more co-located 'significant' SNPS) with high divergence as indication of regions containing structural variants. Measures of linkage disequilibrium can also be profitably used to identify structural variants.

44. The SRB **RECOMMENDED** plotting levels of heterozygosity as Manhattan plots across chromosomal regions.

45. **NOTING** that use of high-throughput low-coverage DNA sequencing data can lead to biased estimates of the site frequency spectrum (SFS) due to high levels of uncertainty in genotyping, the SRB **RECOMMENDED** exploring other derivations from Secretariat proposed work described in IPHC-2023-SRB022-09 including visualisations of SFS in multi-dimensional space.

46. **NOTING** that one of the primary objectives of the Pacific halibut genome project is to provide spatial discrimination of 'populations' (IPHC reporting regions) and to assign individuals to these groups, and that the Secretariat described genetic relationships among individuals from different IPHC reporting region and years of collection based on multivariate ordination using principle component analyses (PCA), and that levels of variability explained associated with PCA axes projects is low, the SRB **RECOMMNEDED**:

    a) conducting additional analyses to evaluate statistical significance of measures of inter-population differentiation (Fst); and

    b) re-analysis using only outlier loci.

47. The SRB **RECOMMENDED**:

    a) that the Secretariat move forward to stock discrimination to satisfy the Secretariat objective of using genetic data to define spatial structuring including unsupervised clustering methods (e.g. K-means, Structure, etc.) as well as PCA-based clustering (e.g. Discriminant Analysis of Principle Component) clustering;

    b) using assignment testing and mixture analyses such as leave-one-out cross-validation simulations to assess the potential accuracy of mixed stock analysis (MSA).

4.2 Monitoring

4.2.1 Fishery-dependent data

Nil.

4.2.2 Fishery-independent data

4.2.2.1 2024 FISS design evaluation

48. The SRB **NOTED** paper IPHC-2023-SRB022-06, which proposed designs for the IPHC's Fishery-Independent Setline Survey (FISS) for the 2024-26 period, and an evaluation of those designs, for review by the Scientific Review Board.

49. The SRB **NOTED** the full FISS sampling grid which consists of 1890 stations (Fig. 1) from which an optimal subset of stations can be selected when devising annual FISS designs. In the Bering Sea, the full FISS design does not provide complete spatial coverage, and FISS data are augmented with calibrated data from NOAA-Fisheries and Alaska Department of Fish and Game (ADFG) trawl surveys (stations vary by year based on the full designs shown in Fig. 1).

50. The SRB **NOTED** that IPHC Regulatory Area 4B will not be sampled in 2023 and **REQUESTED** that the Secretariat present an analysis of the predicted CV for unsampled and partially sampled IPHC Regulatory Areas in 2024.

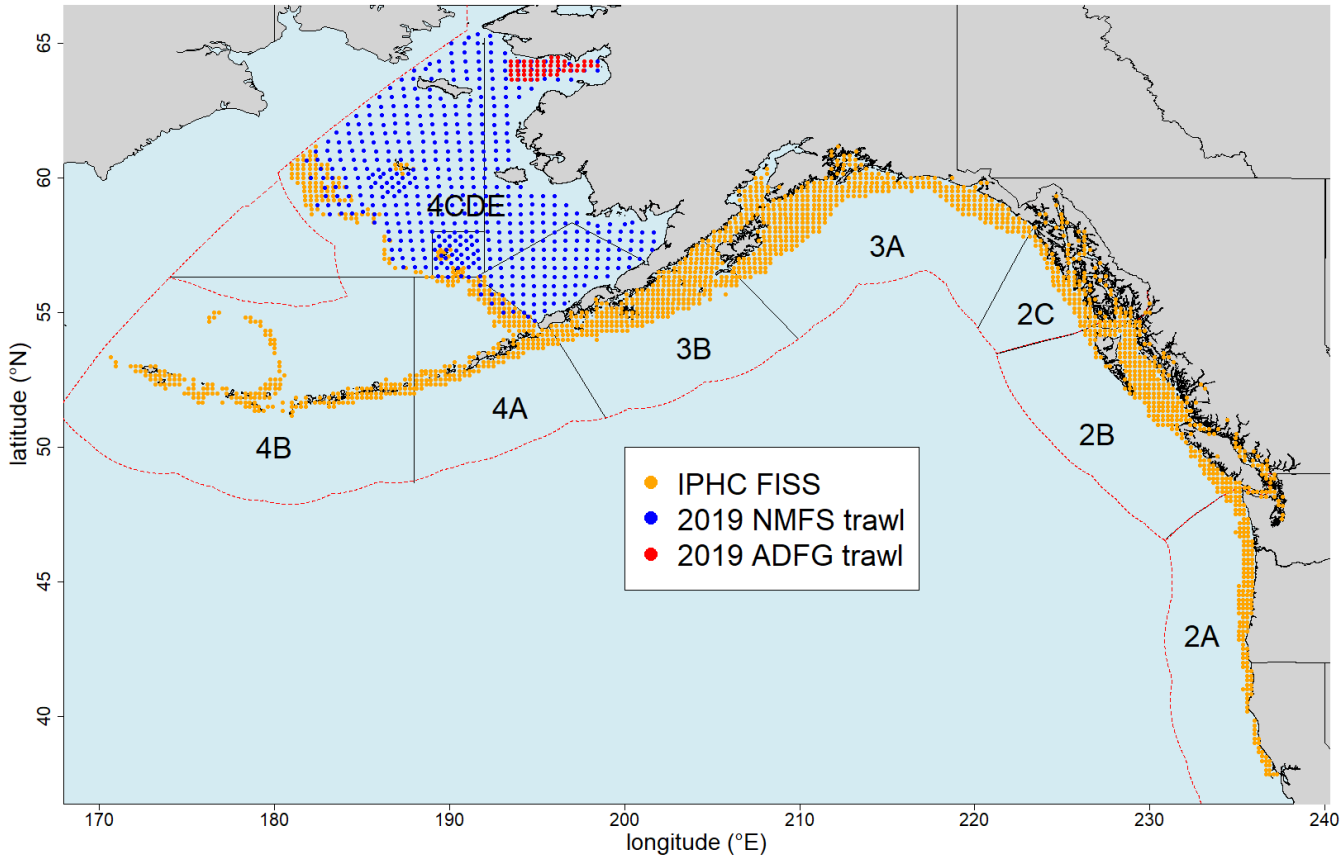

Figure 1. Map of the full 1890 station FISS design, with orange circles representing stations available for inclusion in annual sampling designs, and other colours representing trawl stations from 2019 NMFS and ADFG surveys used to provide complementary data for Bering Sea modelling.

4.2.2.2 Updates to space-time modelling

51. The SRB **NOTED** Table 4 in paper IPHC-2023-SRB022-06 showing that observed CVs for the 2022 O32 WPUE for IPHC Regulatory Areas 2A was 2% higher than expected based on space-time model projections.

5. MANAGEMENT SUPPORTING INFORMATION

52. The SRB **NOTED** the presentation demonstrating how secondary FISS objectives influence choices for future FISS designs that may have already been endorsed by the SRB based only on primary objectives. The SRB **RECOMMENDED** that the MSE include some scenarios in which the FISS is skipped (as also requested above in para. 30) because of occasional (or persistent) economic constraints on executing full FISS designs. Such simulation scenarios would provide some indication of the potential scale of impacts on MP performance of maintaining long-term revenue neutrality of the FISS.

53. The SRB **NOTED** that the 15% CV threshold for each regulatory area is more important for stock distribution than it is for coastwide assessment.

6. REVIEW OF THE DRAFT AND ADOPTION OF THE REPORT OF THE 22ND SESSION OF THE IPHC SCIENTIFIC REVIEW BOARD (SRB022)

54. The SRB **NOTED** the list of highly qualified candidates for SRB membership in the areas of Fish Population Genomics and Life History and Population Ecology and would appreciate these additions to the SRB.

55. The SRB **NOTED** the continuing gap within the Secretariat of research scientist expertise in both population genomics and life history modelling. In terms of prioritizing future hires, e.g. re-opening previous hiring attempts for a research scientist life history modeller, the SRB **RECOMMENDED** prioritizing a research scientist position in population genomics given the investments and future potential contribution of this research to the overall goals of the Commission.

56. The SRB **NOTED** that the 23rd Session of the IPHC Scientific Review Board (SRB023) will be held from 25-27 September 2023, in Seattle, WA, USA.

57. The report of the 22nd Session of the IPHC Scientific Review Board (IPHC-2023-SRB022-R) was **ADOPTED** on 22 June 2023, including the consolidated set of recommendations and/or requests arising from SRB022, provided at Appendix IV.

APPENDIX I
LIST OF PARTICIPANTS FOR THE 22ND SESSION OF THE IPHC SCIENTIFIC REVIEW BOARD (SRB022)

SRB Members

Dr Sean **Cox**:	spcox@sfu.ca; Professor, School of Resource and Environmental Management, Simon Fraser University, 8888 University Dr., Burnaby, B.C., Canada V5A 1S6
Dr Olaf **Jensen:**	olaf.p.jensen@gmail.com; Associate Professor, Center for Limnology, University of Wisconsin - Madison, 680 N Park St., Madison, WI 53706
Dr Kim **Scribner**:	scribne3@msu.edu; Professor, Department of Fisheries and Wildlife, Michigan State University, 2E Natural Resources Building, East Lansing, MI, U.S.A., 48824

Observers

Canada	United States of America
Ms Ann-Marie **Huang**: Ann-Marie.Huang@dfo-mpo.gc.ca	Mr Pete **Hulson:** pete.hulson@noaa.gov
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IPHC Secretariat

Name	Position	Email
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APPENDIX II
AGENDA FOR THE 22ND SESSION OF THE IPHC SCIENTIFIC REVIEW BOARD (SRB022)

Date: 20-22 June 2023
Location: Seattle, WA, USA, & Electronic Meeting
Venue: IPHC HQ & Adobe Connect
Time: 12:30-17:00 (20th), 09:00-17:00 (21-22nd) PDT
Chairperson: Dr Sean Cox (Simon Fraser University)
Vice-Chairperson: Nil

1. OPENING OF THE SESSION

2. ADOPTION OF THE AGENDA AND ARRANGEMENTS FOR THE SESSION

3. IPHC PROCESS

3.1. SRB annual workflow (D. Wilson)
3.2. Update on the actions arising from the 21st Session of the SRB (SRB021) (D. Wilson)
3.3. Outcomes of the 99th Session of the IPHC Annual Meeting (AM099) (D. Wilson)
3.4. Observer updates (e.g. Science Advisors)

4. INTERNATIONAL PACIFIC HALIBUT COMMISSION 5-YEAR PROGRAM OF INTEGRATED RESEARCH AND MONITORING (2022-26)

4.1. RESEARCH

4.1.1. Pacific halibut stock assessment
4.1.2. Management strategy evaluation
4.1.3. Biology and ecology

4.2. MONITORING

4.2.1. Fishery-dependent data
4.2.2. Fishery-independent data

- IPHC Fishery-Independent Setline Survey (FISS)
  - 2024 FISS design evaluation (R. Webster)
  - Updates to space-time modelling (R. Webster)

5. MANAGEMENT SUPPORTING INFORMATION

6. REVIEW OF THE DRAFT AND ADOPTION OF THE REPORT OF THE 22nd SESSION OF THE IPHC SCIENTIFIC REVIEW BOARD (SRB022)

APPENDIX III
LIST OF DOCUMENTS FOR THE 22ND SESSION OF THE IPHC SCIENTIFIC REVIEW BOARD (SRB022)

Document	Title	Availability
IPHC-2023-SRB022-01	Agenda & Schedule for the 22nd Session of the Scientific Review Board (SRB022)	✓ 13 Mar 2023
IPHC-2023-SRB022-02	List of Documents for the 22nd Session of the Scientific Review Board (SRB022)	✓ 17 May 2023
IPHC-2023-SRB022-03	Update on the actions arising from the 21st Session of the SRB (SRB021) (IPHC Secretariat)	✓ 17 May 2023
IPHC-2023-SRB022-04	Outcomes of the 99th Session of the IPHC Annual Meeting (AM099) (D. Wilson)	✓ 17 May 2023
IPHC-2023-SRB022-05	International Pacific Halibut Commission 5-Year program of integrated research and monitoring (2022-26) (D. Wilson, J. Planas, I. Stewart, A. Hicks, R. Webster, & B. Hutniczak)	✓ 17 May 2023
IPHC-2023-SRB022-06	2023-25 FISS design evaluation (R. Webster)	✓ 20 May 2023
IPHC-2023-SRB022-07	IPHC Secretariat MSE Program of Work (2023) and an update on progress (A. Hicks & I. Stewart)	✓ 18 May 2023
IPHC-2023-SRB022-08	Development of the 2023 Pacific halibut (*Hippoglossus stenolepis*) stock assessment (I. Stewart & A. Hicks)	✓ 18 May 2023
IPHC-2023-SRB022-09	Report on current and future biological and ecosystem science research activities (J. Planas)	✓ 17 May 2023
Information papers		
Nil to-date	Nil to-date	-

APPENDIX IV
CONSOLIDATED SET OF RECOMMENDATIONS AND REQUESTS OF THE 22ND SESSION OF THE IPHC SCIENTIFIC REVIEW BOARD (SRB022)

RECOMMENDATIONS

International Pacific Halibut Commission 5-year program of integrated research and monitoring (2022-26)

SRB022–Rec.01 (para. 15) The SRB **NOTED** the reporting table draft provided by the Contracting Parties (Appendix A of paper IPHC-2023-SRB022-05) and **RECOMMENDED** further modification by adding the following and as shown in Table 1 below:

a) New Column: Brief description of the project and how it relates to the core mandate of the Commission;

b) Description of the problem being addressed;

c) Objective: List of concise objectives (research and how the results will be incorporated);

d) Impact scale and timing;

e) Interim performance/evaluation metrics.

Pacific halibut stock assessment

SRB022–Rec.02 (para. 19) **NOTING** that the scale of impact from different model weighting approaches presented here is small relative to the impact of other factors in the MSE (e.g. two- vs. three-year assessment intervals and TCEY), the SRB **RECOMMENDED** that the Secretariat continue using the equal weighting approach for model averaging.

Management strategy evaluation

SRB022–Rec.03 (para. 25) To improve comparability of MPs in performance achieving TCEY objectives, the SRB **RECOMMENDED** equalizing MP performance on one of the conservation objectives.

SRB022–Rec.04 (para. 26) The SRB **RECOMMENDED** that reconditioning the operating model should be limited to situations where the stock assessment has changed significantly. This likely means a three-year schedule for reconditioning the operating model in the year following each full stock assessment.

SRB022–Rec.05 (para. 27) The SRB **RECOMMENDED** that the Secretariat consider using explicit informative priors for conditioning the operating model to make fitting constraints more explicit.

SRB022–Rec.06 (para. 28) The SRB **RECOMMENDED** that exceptional circumstance (i) be evaluated annually based on comparisons between the simulation distribution (e.g. a 95% interval) of FISS values from MSE simulations to the realized FISS estimates; and (ii) be clearly distinguished from "unusual conditions". For example, exceptional circumstances should have a high threshold for persistent (i.e. more than a single year) deviation from MSE simulations.

SRB022–Rec.07 (para. 29) The SRB **RECOMMENDED** that an initial response to a suspected "exceptional circumstance" should include presentation at the next SRB meeting to establish whether the situation meets the definition of an "exceptional circumstance" and to formulate a response.

Biology and ecology

SRB022–Rec.08 (para. 32) The SRB **NOTED** that the current maturity sampling design does not determine whether the high rate of individuals at the cortical alveoli stage in the southeastern portion of the study area is a function of differences in seasonal reproductive timing or in size/age at maturity. The SRB **RECOMMENDED** additional investigations on the region-specific

seasonal reproductive cycles and evaluating the extent to which differences among regions can be explained by size or age of the sampled individuals.

SRB022–Rec.09 (para. 35) The SRB **NOTED** the presentation on whale depredation avoidance devices and **RECOMMENDED** that the Secretariat pursue external funding opportunities for expanding this research and testing one or more devices in the presence of whales.

SRB022–Rec.10 (para. 36) **NOTING** that in terms of bioinformatic quality filtering to exclude loci, filtering based on sequencing depth alone may not be sufficient to exclude mitochondrial sequences, the SRB **RECOMMENDED** that loci be mapped to the published Pacific halibut mitochondrial genome to ensure that non-autosomal loci are included in analyses. Filtering based on sequencing depth alone is likely not sufficient to exclude regions of the genome that represent repetitive elements. Suggest sites be checked for repetitive elements.

SRB022–Rec.11 (para. 37) The SRB **RECOMMENDED** that the Secretariat include other genome-wide summary measures of diversity. Measures could include (a) measures of genome size, (b) percentages of genome as singleton and duplicated loci, (c) other summary measures of diversity including (i) number of loci with minor allele frequency (MAF)>0.01, (ii) number of loci with MAF>0.05, (iii) a measure of deviation of observed and expected heterozygosity (Fis), (iv) observed heterozygosity (Ho) and expected heterozygosity (He).

SRB022–Rec.12 (para. 38) The SRB **RECOMMENDED** that the Secretariat evaluate multiple 'windows' and inter-window 'spacing' to summarize diversity and differentiation. The SRB is unsure why a 15 Kb 'window was used with 7.5 Kb space for producing Manhattan plots. The size of the window will affect estimates of significance based on a measures of Fst significance. Specifically, the larger the 'window' likely the larger the standard deviation across a greater number of sites. Window size is also likely to affect levels of linkage disequilibrium and down-stream analyses based on it.

SRB022–Rec.13 (para. 39) **NOTING** that different outlier tests are based on different assumptions and statistical approaches, the SRB **RECOMMENDED** that the Secretariat implement more than one method. Selection of specific markers would appropriately be based on concordant designation of highly population discriminatory loci identify across methods. The Secretariat is likely to have greater confidence in assignment of 'outliers' based on principles of concordance using multiple and semi-independent software packages and statistical approaches.

SRB022–Rec.14 (para. 40) The SRB **RECOMMENDED** that after statistical significance of SNP loci has been established, the Secretariat use gene set enrichment analyses to establish functional annotations for genes associated with SNPs.

SRB022–Rec.15 (para. 41) The SRB **APPRECIATED** that the Secretariat estimated Tajima's D as recommended (IPHC-2022-SRB021-R), and **RECOMMENDED** that:

a) the Secretariat be cautious with filtering SNP loci based on minor allele frequency (MAF) at levels as low as 0.01 as employed in results described in IPHC-2023-SRB022-09, as this may affect values of Tajima's D; and

b) a range of values be explored.

SRB022–Rec.16 (para. 43) The SRB **RECOMMENDED** looking for genome regions (more than 2 or more co-located 'significant' SNPS) with high divergence as indication of regions containing structural variants. Measures of linkage disequilibrium can also be profitably used to identify structural variants.

SRB022–Rec.17 (para. 44) The SRB **RECOMMENDED** plotting levels of heterozygosity as Manhattan plots across chromosomal regions.

SRB022–Rec.18 (para. 45) **NOTING** that use of high-throughput low-coverage DNA sequencing data can lead to biased estimates of the site frequency spectrum (SFS) due to high levels of uncertainty in genotyping, the SRB **RECOMMENDED** exploring other derivations from Secretariat proposed work described in IPHC-2023-SRB022-09 including visualisations of SFS in multi-dimensional space.

SRB022–Rec.19 (para. 46) **NOTING** that one of the primary objectives of the Pacific halibut genome project is to provide spatial discrimination of 'populations' (IPHC reporting regions) and to assign individuals to these groups, and that the Secretariat described genetic relationships among individuals from different IPHC reporting region and years of collection based on multivariate ordination using principle component analyses (PCA), and that levels of variability explained associated with PCA axes projects is low, the SRB **RECOMMNEDED**:

a) conducting additional analyses to evaluate statistical significance of measures of inter-population differentiation (Fst); and

b) re-analysis using only outlier loci.

SRB022–Rec.20 (para. 47) The SRB **RECOMMENDED**:

c) that the Secretariat move forward to stock discrimination to satisfy the Secretariat objective of using genetic data to define spatial structuring including unsupervised clustering methods (e.g. K-means, Structure, etc.) as well as PCA-based clustering (e.g. Discriminant Analysis of Principle Component) clustering;

d) using assignment testing and mixture analyses such as leave-one-out cross-validation simulations to assess the potential accuracy of mixed stock analysis (MSA).

Management Supporting Information

SRB022–Rec.21 (para. 52) The SRB **NOTED** the presentation demonstrating how secondary FISS objectives influence choices for future FISS designs that may have already been endorsed by the SRB based only on primary objectives. The SRB **RECOMMENDED** that the MSE include some scenarios in which the FISS is skipped (as also requested above in para. 30) because of occasional (or persistent) economic constraints on executing full FISS designs. Such simulation scenarios would provide some indication of the potential scale of impacts on MP performance of maintaining long-term revenue neutrality of the FISS.

Other business

SRB022–Rec.22 (para. 55) The SRB **NOTED** the continuing gap within the Secretariat of research scientist expertise in both population genomics and life history modelling. In terms of prioritizing future hires, e.g. re-opening previous hiring attempts for a research scientist life history modeller, the SRB **RECOMMENDED** prioritizing a research scientist position in population genomics given the investments and future potential contribution of this research to the overall goals of the Commission.

REQUESTS

International Pacific Halibut Commission 5-year program of integrated research and monitoring (2022-26)

SRB022–Req.01 (para. 16) The SRB **REQUESTED** that during the next update of the Plan, consider specifying the role and timing of input from the SRB in developing and reviewing project methods, performance metrics.

Pacific halibut stock assessment

SRB022–Req.02 (para. 18) **NOTING** that analysis of whale depredation has clarified that the potential scale of removals from depredation is relatively small, except in IPHC Regulatory Area 4A, the SRB **REQUESTED** that updated analysis using USA observer data be presented at SRB023 to evaluate whether incorporation of whale depredation in the stock assessment is warranted.

Management strategy evaluation

SRB022–Req.03 (para. 30) The SRB **NOTED** that situations in which critical data streams (e.g. FISS index or age data) are unavailable for one or more years does not constitute an "exceptional circumstance" and **REQUESTED** that the MSE include evaluation of such missing FISS data scenarios for the SRB023.

FISS design evaluation

SRB022–Req.04 (para. 50) The SRB **NOTED** that IPHC Regulatory Area 4B will not be sampled in 2023 and **REQUESTED** that the Secretariat present an analysis of the predicted CV for unsampled and partially sampled IPHC Regulatory Areas in 2024.