Report of the 16th Session of the IPHC Scientific Review Board (SRB016)

Meeting held electronically, 23-25 June 2020

Commissioners

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ACRONYMS

AM	Annual Meeting
ARIMA	Auto Regressive Integrated Moving Average
BS	Bering Sea
COVID-19	Novel Coronavirus 2019
CV	Coefficient of Variation
DMR	Discard Mortality Rate
DNA	Deoxyribonucleic Acid
FISS	Fishery-Independent Setline Survey
GOA	Gulf of Alaska
IPHC	International Pacific Halibut Commission
MSAB	Management Strategy Advisory Board
MSE	Management Strategy Evaluation
PCR	Polymerase Chain Reaction
SAA	Size-At-Age
SNP	Single Nucleotide Polymorphisms
SRB	Scientific Review Board
TCEY	Total Constant Exploitable Yield
U.S.A.	United States of America

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** (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 16th Session of the International Pacific Halibut Commission (IPHC) Scientific Review Board (SRB016) was held electronically from 23-25 June 2020. The meeting was opened by the Chairperson, Dr Sean Cox (Canada), and the Executive Director, Dr David Wilson, who welcomed participants.

The following are a subset of the complete recommendations/requests for action from the SRB016, which are provided in full at Appendix IV.

RECOMMENDATIONS

(para. 4) ***NOTING*** *that the core purpose of the SRB016 is to review progress on the IPHC science program, and to provide guidance for the delivery of products to the SRB017 in September 2020, the SRB* ***RECALLED*** *that formal recommendations to the Commission would not be developed at the present meeting, but rather, these would be developed at the SRB017.*

REQUESTS

IPHC Fishery-independent setline survey (FISS)

SRB016–Req.01 (para. 11) The SRB **NOTED** that many ecological processes that could be influencing the spatial distribution of the stock, and thus the performance of the FISS in providing a reliable index of relative abundance, are not adequately represented and uncertainty is underestimated when the spatial-temporal model is used to both simulate and analyse FISS data. One specific concern is that density-dependent habitat selection combined with preferential sampling of core habitat areas (to achieve cost goals) could lead to hyperstability in the index. As a first step, the SRB **REQUESTED** the IPHC Secretariat investigate the potential consequences and risk of FISS designs under density-dependent habitat selection (or other spatial processes) in future MSE work. Independent models could be developed for simulating FISS sampling data that could represent qualitatively different scenarios regarding ecological processes driving the spatial distribution of the stock.

SRB016–Req.02 (para. 12) The SRB **REQUESTED** that the IPHC Secretariat to develop a routine evaluation procedure following data collection to ensure that FISS designs adequately meet monitoring objectives (i.e. that projected FISS CVs represent realized future CVs).

Pacific halibut stock assessment: 2020

SRB016–Req.04 (para. 21) The SRB **AGREED** that data weighting approaches, including alternative error distributions (e.g. self-weighting), should be evaluated further in the context of the next full stock assessment, and should strive to make use of the best methods available, noting that there are a range of approaches in use for similar stock assessments. In particular, the SRB **REQUESTED** that the IPHC Secretariat investigate the feasibility of a logistic-normal distribution to incorporate correlated errors in age composition data (see Francis, R.I.C.C. 2014. Replacing the multinomial in stock assessment models: A first step. Fisheries Research 151: 70–84). This change may be technically challenging given the current assessment software, as well as having sexed age composition data, and could non-trivially affect the stock assessment estimates of biomass and recruitment. Therefore, the SRB does not expect new results until at least SRB018 in June 2021.

Management Strategy Evaluation: update

SRB016–Req.10 (para. 29) The SRB **NOTED** that the operating model includes decision-making variability or implementation uncertainty. This is an important addition to the MSE because, while some management procedures may perform reasonably well if fully implemented, large inter-annual adjustments could be made in practice in response to anticipated economic and social disruptions to the fishery. Thus, the SRB **REQUESTED** further investigation

of decision-making variability, including empirical analysis of the relationship between recommended and implemented harvest levels.

Migration and distribution

SRB016–Req.11 (para. 36) **NOTING** that the genetic data may be complimentary to data collected using other methods, for example, stock structure at the genetic level could be reflected in individual differences in otolith chemistry (if primary otolith annuli are interrogated), the SRB **REQUESTED** that a portion of individuals that are selected for otolith chemistry also be used for whole genome sequencing.

Reproductive assessment

SRB016–Req.13 (para. 38) The SRB **REQUESTED** a preliminary analysis of existing data on 'skipped spawning'.

Genetics and genomics

SRB016–Req.15 (para. 41) The SRB **NOTED** that the text in this section of paper IPHC-2020-SRB016-09 was not consistent. A high level of detail was provided in some areas and much less detail was provided in others. At one level, the SRB requires more information on (a) objectives and (b) methods to evaluate study design and the quality of data, however this was not possible given the information provided. For example in the first section on whole genome sequencing there was a major gap in methods. The SRB **REQUESTED** specific information on how the sequence data would be mapped to the reference genome.

Research integration

SRB016–Req.19 (para. 52) **NOTING** that a common theme in programmatic studies is a need to understand growth, the maturation process and size and age at sexual maturity, and to incorporate this understanding into the assessment and MSE programs. The SRB reiterated its previous **REQUEST** that the IPHC Secretariat hire a PhD-level life history modeller with expertise in the areas that include life history and quantitative genetics. The SRB was advised that at this point in time, the hiring of a life-history modeller is not financially feasible unless either 1) additional contributions were appropriated by the Contracting Parties, or 2) a current FTE was replaced with a life-history modeller.

1. OPENING OF THE SESSION

1. The 16th Session of the International Pacific Halibut Commission (IPHC) Scientific Review Board (SRB016) was held electronically from 23 to 25 June 2020. 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 (2020):

    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/16th-session-of-the-iphc-scientific-review-board-srb016.

3. IPHC PROCESS

3.1 SRB annual workflow

4. **NOTING** that the core purpose of the SRB016 is to review progress on the IPHC science program, and to provide guidance for the delivery of products to the SRB017 in September 2020, the SRB **RECALLED** that formal recommendations to the Commission would not be developed at the present meeting, but rather, these would be developed at the SRB017.

3.2 Update on the actions arising from the 15th Session of the SRB (SRB015)

5. The SRB **NOTED** paper IPHC-2020-SRB016-03, which provided the SRB with an opportunity to consider the progress made during the intersessional period, on the recommendations/requests arising from the SRB015.

6. The SRB **AGREED** to consider and revise the actions as necessary, and to combine them with any new actions arising from SRB016 into a consolidated list for future reporting.

3.3 Outcomes of the 96th Session of the IPHC Annual Meeting (AM096)

7. The SRB **NOTED** paper IPHC-2020-SRB016-04 which detailed the outcomes of the 96th Session of the IPHC Annual Meeting (AM096), 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** updates from the two science advisors, who provided brief overviews of some of the points of clarification being sought from the present SRB meeting. These included, but were not limited to: 1) COVID-19 impacts on the space-time model outputs and thus the stock assessment projects; 2) sex ratio data impacts on stock assessment; 3) MSE timelines; 4) Bioregion definitions; and 5) spatial dynamics of the stock.

4. IPHC FISHERY-INDEPENDENT SETLINE SURVEY (FISS)

4.1 2021-2023 FISS design evaluation

9. The SRB **NOTED** paper IPHC-2020-SRB016-05, which proposed designs for the 2021-23 IPHC Fishery-Independent Setline Survey (FISS), together with a summary of the process that led to the 2020 FISS design options adopted at the 96th Session of the IPHC Annual Meeting (AM096).

10. The SRB **NOTED** that more flexible forms of spatial dependency could be considered in future versions of the spatial-temporal model used to evaluate FISS sampling designs and analyse the data. In particular, the treatment of spatial dependency could be expanded to evaluate, for example, alternative environmental and ecological covariates, and other functional forms for spatial dependency (e.g. anisotropy and alternative models).

11. The SRB **NOTED** that many ecological processes that could be influencing the spatial distribution of the stock, and thus the performance of the FISS in providing a reliable index of relative abundance, are not adequately represented and uncertainty is underestimated when the spatial-temporal model is used to both simulate and analyse FISS data. One specific concern is that density-dependent habitat selection combined with preferential sampling of core habitat areas (to achieve cost goals) could lead to hyperstability in the index. As a first step, the SRB **REQUESTED** the IPHC Secretariat investigate the potential consequences and risk of FISS designs under density-dependent habitat selection (or other spatial processes) in future MSE work. Independent models could be developed for simulating FISS sampling data that could represent qualitatively different scenarios regarding ecological processes driving the spatial distribution of the stock.

12. The SRB **REQUESTED** that the IPHC Secretariat to develop a routine evaluation procedure following data collection to ensure that FISS designs adequately meet monitoring objectives (i.e. that projected FISS CVs represent realized future CVs).

13. The SRB **NOTED** paper IPHC-2020-SRB016-INF02, which provided background on and reviewed the methods for the IPHC's fishery-independent setline survey (FISS) rationalisation following the 2014-19 program of FISS expansions, along with discussion of the resulting FISS design proposals for the 2020-23 period.

14. The SRB **AGREED** with the proposed Compromise FISS design for 2021-2023. However, the SRB **NOTED** that the analyses presented in IPHC-2020-SRB016-INF02 were based on a pre-COVID-19 FISS sampling plan for 2020 that differs substantially from current 2020 sampling plans. Thus, the Compromise FISS design for 2021-2023 is likely no longer optimal from a purely scientific perspective. However, it does still appear to be reasonably justified given previous scientific work and within the context of the 3-tiered FISS objectives framework.

4.2 Methods for spatial setline survey modelling updates

15. The SRB **NOTED** paper IPHC-2020-SRB016-06, which provided an update on work related to space-time modelling of survey data undertaken or planned since SRB015.

16. The SRB **NOTED** the FISS Shiny app presentation and welcomed the idea of improving transparency and access and to FISS data, and looks forward to future developments in this arena.

5. PACIFIC HALIBUT STOCK ASSESSMENT: 2020

17. The SRB **NOTED** paper IPHC-2020-SRB016-07, which provided a summary of stock assessment development, including responses to previous SRB requests and an overview of the planned assessment activity and new data for 2020.

18. The SRB **AGREED** that the current approach for modelling the steepness of the stock-recruitment relationship, specifically the use of a fixed value of 0.75, provides a reasonable basis for the annual stock assessment models currently included in the ensemble. These models are mainly intended for short-term tactical biomass and recruitment estimation, whereas stock-recruitment steepness has a greater impact on long-term projections within the MSE process. The SRB supports continued investigation of the stock-recruitment relationship and its effect on uncertainties as presented in the decision table, particularly as part of the next full assessment.

19. The SRB **NOTED** the analysis of fleet-level impacts and its potential utility as an additional diagnostic to understand the effects of individual fisheries on the Pacific halibut stock, but cautions that it be interpreted mainly as a model diagnostic, as the analysis does not include the cumulative aspects of alternative historical management decisions.

20. The SRB **REQUESTED** that the IPHC Secretariat continue to update data weighting on an annual basis, even for updated stock assessments, in order to maintain internal model consistency and to best reflect changes in existing and new data as they arise.

21. The SRB **AGREED** that data weighting approaches, including alternative error distributions (e.g. self-weighting), should be evaluated further in the context of the next full stock assessment, and should strive to make use of the best methods available, noting that there are a range of approaches in use for similar stock assessments. In particular, the SRB **REQUESTED** that the IPHC Secretariat investigate the feasibility of a logistic-normal distribution to incorporate correlated errors in age composition data (see Francis, R.I.C.C. 2014. Replacing the multinomial in stock assessment models: A first step. Fisheries Research 151: 70–84). This change may be technically challenging given the current assessment software, as well as having sexed age composition data, and could non-trivially affect the stock assessment estimates of biomass and recruitment. Therefore, the SRB does not expect new results until at least SRB018 in June 2021.

22. The SRB **REQUESTED** that the Secretariat staff continue to evaluate whether the Stock Synthesis modelling framework is the most efficient for Commission needs, and to coordinate future development with the MSE framework as features and technical needs evolve together for the two efforts.

23. The SRB **REQUESTED** an update at SRB017 on all data available at that time and any additional changes anticipated for the final 2020 stock assessment.

6. MANAGEMENT STRATEGY EVALUATION: UPDATE

24. The SRB **NOTED** paper IPHC-2020-SRB016-08 Rev_1 which provided the SRB with an update of International Pacific Halibut Commission (IPHC) Management Strategy Evaluation (MSE) activities including the definition and development of a framework to evaluate management procedures for distributing the TCEY.

25. The SRB **NOTED** the substantial progress made on the spatial operating model and candidate management procedures.

26. The SRB **REQUESTED** that the IPHC Secretariat carefully (i.e. narrowly) scope the MSE work for 2020 to questions that are reasonably determined given the rapid expansion of uncertainties in a more complex model. The MSE timelines for delivery is short; therefore, results will need to be presented conditional on some parameters and processes remaining highly uncertain. For example, processes that remain highly uncertain be collected in a “reference grid” of plausible scenarios and a “robustness grid” of processes that currently lack evidence based on historical data.

27. The SRB **NOTED** that stochasticity in Pacific halibut productivity is driven substantially by extrinsic factors (i.e. processes independent of Pacific halibut population size, structure, distribution, etc.). While the current approach is reasonable at this early stage of operating model development, the SRB **REQUESTED** that the IPHC Secretariat investigate intrinsic drivers (e.g. compensatory and depensatory effect) for at least some of these processes. Further integration of the IPHC's biological and ecosystem sciences research plan into the MSE operating model development could be used to sensitivity-test such scenarios. Given the existing MSE timelines, however, more complex operating models could be delayed until SRB018 in June 2021.

28. The SRB **NOTED** autocorrelation structure in projected Pacific halibut weight-at-age in the spatial operating model. While such a structure adequately captures the smoothness of historical patterns, it is not clear whether it captures the correlation structure among ages. Therefore, the SRB **REQUESTED** that a multivariate normal distribution be investigated (for SRB018 June 2021) for weight-at-age deviations in which these are correlated among ages. This would involve fitting a multivariate time-series model instead of the ARIMA. Other forms of growth deviations (e.g. cohort-dependence) could also be used to better represent changes in weight-at-age over time.

29. The SRB **NOTED** that the operating model includes decision-making variability or implementation uncertainty. This is an important addition to the MSE because, while some management procedures may perform reasonably well if fully implemented, large inter-annual adjustments could be made in practice in response to anticipated economic and social disruptions to the fishery. Thus, the SRB **REQUESTED** further investigation of decision-making variability, including empirical analysis of the relationship between recommended and implemented harvest levels.

30. The SRB **NOTED** alternative specifications and additional features of the OM or general description of management procedures needed to evaluate management procedures related to coastwide scale and distribution of the TCEY in 2020.

7. BIOLOGICAL AND ECOSYSTEM SCIENCE PROGRAM RESEARCH UPDATES

7.1 Five-year research plan and management implications: update

31. The SRB **NOTED** paper IPHC-2020-SRB016-09 which provided the SRB with an update on current progress on research projects conducted and planned within the IPHC's five-year research plan (2017-21).

32. The SRB **NOTED** the temporal link of listed detailed outputs from the IPHC's five-year research plan (2017-21) with specific inputs into the Stock Assessment and Management Strategy Evaluation process.

33. The SRB **NOTED** peer review papers [*in review or in preparation*] supplementing paper IPHC-2020-SRB016-09 that provided the SRB with greater detail pertaining to research outcomes in several main areas of research currently underway by the IPHC Secretariat:

    a) Fish, T., Wolf, N., Harris, B.P., Planas, J.V. (*In Review*). A comprehensive description of oocyte developmental stages in Pacific halibut, *Hippoglossus stenolepis*. Journal of Fish Biology.

    b) Planas, J.V., Jasonowicz, A.J., Simeon, A., Rudy, D., Timmins-Schiffman, E., Nunn, B.L., Kroska, A., Wolf, N., Hurst, T.P. (*In Preparation*). Physiological signatures of temperature-induced growth manipulations in white skeletal muscle of juvenile Pacific halibut (*Hippoglossus stenolepis*).

    c) Sadorus, L.; Goldstein, E.; Webster, R.; Stockhausen, W.; Planas, J.V.; Duffy-Anderson, J. (*In Review*). Multiple life-stage connectivity of Pacific halibut (*Hippoglossus stenolepis*) across the Bering Sea and Gulf of Alaska. Fisheries Oceanography.

7.2 Progress on ongoing research projects

34. The SRB **NOTED** the progress on ongoing research projects contemplated within the IPHC's five-year research plan (2017-2021) involving:

a) **Migration and Distribution**. Studies are aimed at further understanding reproductive migration and identification of spawning times and locations as well as larval and juvenile dispersal.

b) **Reproduction**. Studies are aimed at providing information on the sex ratio of the commercial catch and to improve current estimates of maturity.

c) **Growth and Physiological Condition**. Studies are aimed at describing the role of some of the factors responsible for the observed changes in size-at-age and to provide tools for measuring growth and physiological condition in Pacific halibut.

d) **Discard Mortality Rates (DMRs) and Survival**. Studies are aimed at providing updated estimates of DMRs in both the longline and the trawl fisheries.

e) **Genetics and Genomics**. Studies are aimed at describing the genetic structure of the Pacific halibut population and at providing the means to investigate rapid adaptive changes in response to fishery-dependent and fishery-independent influences.

7.2.1 Migration and distribution

35. The SRB **AGREED** that it was difficult to interpret Table 1 in paper IPHC-2020-SRB016-09, and the wire tagging and recovery program results without having information on the time interval between first capture and recapture or season of first and second capture.

36. **NOTING** that the genetic data may be complimentary to data collected using other methods, for example, stock structure at the genetic level could be reflected in individual differences in otolith chemistry (if primary otolith annuli are interrogated), the SRB **REQUESTED** that a portion of individuals that are selected for otolith chemistry also be used for whole genome sequencing.

37. **NOTING** the issues of Gulf of Alaska (GOA) and Bering Sea (BS) connectivity relative to juvenile dispersal, the SRB **REQUESTED** that the IPHC Secretariat include individuals of different ages and locations in the GOA and BS in their whole genome sequencing analysis, including individuals from different places in GOA and BS.

7.2.2 Reproductive assessment

38. The SRB **REQUESTED** a preliminary analysis of existing data on ‘skipped spawning’.

39. The SRB **REQUESTED** that work on size- and age-specific fecundity be incorporated in the next 5-year research plan.

7.2.3 Somatic growth studies

40. The SRB **NOTED** that Size-at-Age (SAA) seems to be a pressing concern, and appreciated the IPHC Secretariat’s attention on the transcriptomics of growth from past studies. The data on transcriptome quality was prominently displayed in the report. However, the SRB **ENCOURAGED** the IPHC Secretariat to add individuals from the growth experiments that have transcriptomic data to use for sequencing. There are several hypotheses why there may be differential gene expression. One explanation is gene regulatory sequence variation. The other is sequence variation in the exons (transcribed regions) of genes that are shown to be differentially expressed. The IPHC Secretariat would be well advised to carefully select samples for whole genome sequencing. Likewise, if the IPHC Secretariat has samples of individuals that vary widely at SAA, these individuals would be useful for whole genome sequencing.

7.2.4 Discard mortality and survival assessment

No comments.

7.2.5 Genetics and genomics

41. The SRB **NOTED** that the text in this section of paper IPHC-2020-SRB016-09 was not consistent. A high level of detail was provided in some areas and much less detail was provided in others. At one level, the

SRB requires more information on (a) objectives and (b) methods to evaluate study design and the quality of data, however this was not possible given the information provided. For example in the first section on whole genome sequencing there was a major gap in methods. The SRB **REQUESTED** specific information on how the sequence data would be mapped to the reference genome.

42. **NOTING** the importance of genetically determined sex information to stock assessment, the SRB **REQUESTED** that the IPHC Secretariat conduct a pilot study to determine whether DNA and PCR amplification of sex-linked SNP loci can be obtained from archived otoliths of different collection periods to demonstrate feasibility to develop a more comprehensive spatial and temporal sex ratio data base.

8. RESEARCH INTEGRATION

43. The SRB **NOTED** that the IPHC Secretariat have embraced past SRB recommendations to integrate the research program with stock assessment and management strategy evaluation information needs.

44. The SRB **REQUESTED** an updated presentation on the plan and timelines for integrating research and results from biological and ecosystem science research plan into specific functions and parameters of the assessment and MSE.

45. The SRB **NOTED** that the IPHC Secretariat have placed increasing emphasis on applications of molecular genetic data that is currently available and which will be forthcoming based on the updates provided in IPHC-2020-SRB016-09. Considerable attention has been paid in IPHC-2020-SRB016-09 to demonstrate preliminary measures of quality of available current genomic resources (section 5—Genetics and Genomics section, Tables 2 and 3, Figure 2).

46. The SRB **NOTED** that methodology proposed in IPHC-2020-SRB016-09 for upcoming low coverage whole genome resequencing was provided, and appreciated the opportunity to comment on proposed work given the importance of the genomic data to the five (5) main research categories in the IPHC's 5-year Biological and Ecosystem Sciences Research Plan (2017-21), and the importance to stock assessment and management strategy evaluation.

47. The SRB **NOTED** that the growing genotyping information for Pacific halibut represent a potential high-impact resource. For example, recent advances incorporating genomics into stock assessment in the form of Close-Kin Mark-Recapture, sibling analyses, etc. Recent work in the Secretariat's Biological and Ecosystem Research group is quickly advancing toward this capability. The SRB, therefore, **ENCOURAGED** retention of highly-qualified personnel capable of supporting this important goal.

48. The SRB **NOTED** genome interrogation, assembly, and down-stream analyses are as follows:

    a) the general approach advocated by the IPHC Secretariat to use low coverage whole genomic sequencing for single nucleotide polymorphism (SNP) discovery. A primary objective is to obtain many loci to conduct 'standard' population genetics analyses, including analysis of spatial genetic diversity. Additional goals are to generate genomics data to address other IPHC questions, for example in areas of reproductive physiology, growth, maturation timing. Accordingly, the IPHC Secretariat goals dictate that genomic approaches that provide individual SNP genotypes are important;

    b) Sequencing coverage by at or above 5X to allow genotypes to be estimated with sufficient accuracy to avoid using likelihood-based methods of genotyping. Sequencing at 5X or greater coverage would also all estimation of population genetic statistics of relevance to the IPHC Secretariat stock assessment and management strategy evaluation needs;

    c) The genome is fairly small (600 MB), so the IPHC Secretariat should be able to place a fairly large number of individuals into a sequencing lane. No information was provided in IPHC-2020-SRB016-09 pertaining to available funding for the sequencing effort. Therefore, requested actions could not be provided concerning allocation of samples to each IPHC Secretariat research need;

d) **NOTING** the IPHC Secretariat desires to identify loci that may be under selection, the SRB **ENCOURAGED** that the IPHC Secretariat pursue this initiative rigorously. Identification of loci that are for example more highly differentiated spatially would add considerable power to analyses seeking to identify population structure (e.g. spawning stocks) and to place individuals at all ages and times of the year to spatial stocks.

49. The SRB **REQUESTED** that the IPHC Secretariat contact the National Center for Biological Information to annotate the genome. Subsequently, existing and newly discovered SNPs be mapped onto the existing Pacific halibut genome.

50. **RECOGNIZING** that full implementation of assessments using genetics data will rely heavily on availability of baseline information from all portions of the species range and appropriate sample size, sampling timing, and age distribution, the SRB **URGED** that the IPHC Secretariat summarize all sample holdings by year and time of collection, location, age(s), and sample type (e.g. tissue, fin, blood, otolith).

51. The SRB **URGED** that the IPHC Secretariat identify samples that could be used to (a) add critical samples to the upcoming sequencing to provide preliminary data for future research initiatives that are in line with pressing stock assessment and management strategy evaluation. A non-exclusive list of useful samples would be (i) samples from growth and reproductive studies where transcriptomics data are available, (ii) samples potential spawning areas that may provide recruits into IPHC management units (e.g. Russia, Canada (British Colombia), and the USA (Washington, Oregon, California), (iii) individuals of different ages that were collected at different times and locations. If indeed, stock allocations are possible, having sequencing data, even for a low number of individuals associated with each of several questions of importance would allow the IPHC Secretariat to allocate future priorities based on preliminary demonstration of feasibility.

52. **NOTING** that a common theme in programmatic studies is a need to understand growth, the maturation process and size and age at sexual maturity, and to incorporate this understanding into the assessment and MSE programs. The SRB reiterated its previous **REQUEST** that the IPHC Secretariat hire a PhD-level life history modeller with expertise in the areas that include life history and quantitative genetics. The SRB was advised that at this point in time, the hiring of a life-history modeller is not financially feasible unless either 1) additional contributions were appropriated by the Contracting Parties, or 2) a current FTE was replaced with a life-history modeller.

9. REVIEW OF THE DRAFT AND ADOPTION OF THE REPORT OF THE 16TH SESSION OF THE IPHC SCIENTIFIC REVIEW BOARD (SRB016)

53. The report of the 16th Session of the IPHC Scientific Review Board (IPHC-2020-SRB016-R) was **ADOPTED** on 25 June 2020, including the consolidated set of recommendations and/or requests arising from SRB016, provided at Appendix IV.

APPENDIX I
LIST OF PARTICIPANTS FOR THE 16TH SESSION OF THE IPHC SCIENTIFIC REVIEW BOARD (SRB016)

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APPENDIX II
AGENDA FOR THE 16TH SESSION OF THE IPHC SCIENTIFIC REVIEW BOARD (SRB016)

Date: 23-25 June 2020
Location: Electronic Meeting
Venue: Go-To-Meeting
Time: 12:00-17:00 (23rd), 09:00-17:00 (24-25th)
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 15th Session of the SRB (SRB015) (D. Wilson)
- 3.3. Outcomes of the 96th Session of the IPHC Annual Meeting (AM096) (D. Wilson)
- 3.4. Observer updates (e.g. Science Advisors)

4. IPHC FISHERY-INDEPENDENT SETLINE SURVEY (FISS)
- 4.1. 2021-2022 FISS design evaluation (R. Webster)
- 4.2. Methods for spatial setline survey modelling updates (R. Webster)

5. PACIFIC HALIBUT STOCK ASSESSMENT: 2020
- 5.1. Modelling updates (I. Stewart)

6. MANAGEMENT STRATEGY EVALUATION: UPDATE
- 6.1. Outcomes of the MSAB015 (A. Hicks)
- 6.2. Updates to MSE framework and closed-loop simulations (A. Hicks)
- 6.3. MSAB Program of Work and delivery timeline for 2020-21 (A. Hicks)

7. BIOLOGICAL AND ECOSYSTEM SCIENCE RESEARCH UPDATES
- 7.1. Five-year research plan and management implications: Update (J. Planas)
- 7.2. Progress on ongoing research projects (J. Planas)
  - 7.2.1. Migration and distribution (T. Loher, L. Sadorus)
  - 7.2.2. Reproductive assessment (J. Planas)
  - 7.2.3. Somatic growth studies (J. Planas)
  - 7.2.4. Discard mortality and survival assessment (C. Dykstra)
  - 7.2.5. Genetics and genomics (A. Jasonowicz)

8. REVIEW OF THE DRAFT AND ADOPTION OF THE REPORT OF THE 16TH SESSION OF THE IPHC SCIENTIFIC REVIEW BOARD (SRB016)

APPENDIX III
LIST OF DOCUMENTS FOR THE 16TH SESSION OF THE IPHC SCIENTIFIC REVIEW BOARD (SRB016)

Document	Title	Availability
IPHC-2020-SRB016-01	Agenda & Schedule for the 16th Session of the Scientific Review Board (SRB016)	✓ 25 Mar 2020 ✓ 24 May 2020 ✓ 23 Jun 2020
IPHC-2020-SRB016-02	List of Documents for the 16th Session of the Scientific Review Board (SRB016)	✓ 25 Mar 2020 ✓ 24 May 2020 ✓ 23 June 2020
IPHC-2020-SRB016-03	Update on the actions arising from the 15th Session of the SRB (SRB015) (IPHC Secretariat)	✓ 24 May 2020
IPHC-2020-SRB016-04	Outcomes of the 96th Session of the IPHC Annual Meeting (AM096) (D. Wilson)	✓ 15 May 2020
IPHC-2020-SRB016-05	2021-2023 FISS Design evaluation (R. Webster)	✓ 24 May 2020
IPHC-2020-SRB016-06	Methods for spatial survey modelling updates (R. Webster)	✓ 24 May 2020
IPHC-2020-SRB016-07	2020 Pacific halibut (*Hippoglossus stenolepis*) stock assessment: Development (I. Stewart, A. Hicks & P. Carpi)	✓ 22 May 2020
IPHC-2020-SRB016-08 Rev_1	An update on the IPHC Management Strategy Evaluation (MSE) process for SRB016 (A. Hicks, P. Carpi, S. Berukoff, & I. Stewart)	✓ 22 May 2020 ✓ 10 June 2020
IPHC-2020-SRB016-09	Report on current and future biological research activities (J. Planas, A. Jasonowicz, T. Loher, L. Sadorus, C. Dykstra, J. Forsberg)	✓ 24 May 2020
Information papers		
IPHC-2020-SRB016-INF01	Technical details of the IPHC MSE Framework (A. Hicks, P. Carpi & S. Berukoff)	✓ 19 June 2020
IPHC-2020-SRB016-INF02	DRAFT Review: Rationalisation of the FISS following 2014-19 expansion program (R. Webster)	✓ 19 June 2020

APPENDIX IV
CONSOLIDATED SET OF RECOMMENDATIONS AND REQUESTS OF THE 16TH SESSION OF THE IPHC SCIENTIFIC REVIEW BOARD (SRB016)

RECOMMENDATIONS

(para. 4) ***NOTING*** *that the core purpose of the SRB016 is to review progress on the IPHC science program, and to provide guidance for the delivery of products to the SRB017 in September 2020, the SRB* ***RECALLED*** *that formal recommendations to the Commission would not be developed at the present meeting, but rather, these would be developed at the SRB017.*

REQUESTS

IPHC Fishery-independent setline survey (FISS)

SRB016–Req.01 (para. 11) The SRB **NOTED** that many ecological processes that could be influencing the spatial distribution of the stock, and thus the performance of the FISS in providing a reliable index of relative abundance, are not adequately represented and uncertainty is underestimated when the spatial-temporal model is used to both simulate and analyse FISS data. One specific concern is that density-dependent habitat selection combined with preferential sampling of core habitat areas (to achieve cost goals) could lead to hyperstability in the index. As a first step, the SRB **REQUESTED** the IPHC Secretariat investigate the potential consequences and risk of FISS designs under density-dependent habitat selection (or other spatial processes) in future MSE work. Independent models could be developed for simulating FISS sampling data that could represent qualitatively different scenarios regarding ecological processes driving the spatial distribution of the stock.

SRB016–Req.02 (para. 12) The SRB **REQUESTED** that the IPHC Secretariat to develop a routine evaluation procedure following data collection to ensure that FISS designs adequately meet monitoring objectives (i.e. that projected FISS CVs represent realized future CVs).

Pacific halibut stock assessment: 2020

SRB016–Req.03 (para. 20) The SRB **REQUESTED** that the IPHC Secretariat continue to update data weighting on an annual basis, even for updated stock assessments, in order to maintain internal model consistency and to best reflect changes in existing and new data as they arise.

SRB016–Req.04 (para. 21) The SRB **AGREED** that data weighting approaches, including alternative error distributions (e.g. self-weighting), should be evaluated further in the context of the next full stock assessment, and should strive to make use of the best methods available, noting that there are a range of approaches in use for similar stock assessments. In particular, the SRB **REQUESTED** that the IPHC Secretariat investigate the feasibility of a logistic-normal distribution to incorporate correlated errors in age composition data (see Francis, R.I.C.C. 2014. Replacing the multinomial in stock assessment models: A first step. Fisheries Research 151: 70–84). This change may be technically challenging given the current assessment software, as well as having sexed age composition data, and could non-trivially affect the stock assessment estimates of biomass and recruitment. Therefore, the SRB does not expect new results until at least SRB018 in June 2021.

SRB016–Req.05 (para. 22) The SRB **REQUESTED** that the Secretariat staff continue to evaluate whether the Stock Synthesis modelling framework is the most efficient for Commission needs, and to coordinate future development with the MSE framework as features and technical needs evolve together for the two efforts.

SRB016–Req.06 (para. 23) The SRB **REQUESTED** an update at SRB017 on all data available at that time and any additional changes anticipated for the final 2020 stock assessment.

Management Strategy Evaluation: update

SRB016–Req.07 (para. 26) The SRB **REQUESTED** that the IPHC Secretariat carefully (i.e. narrowly) scope the MSE work for 2020 to questions that are reasonably determined given the rapid expansion of uncertainties in a more complex model. The MSE timelines for delivery is short; therefore, results will need to be presented conditional on some parameters and processes remaining highly uncertain. For example, processes that remain highly uncertain be collected in a "reference grid" of plausible scenarios and a "robustness grid" of processes that currently lack evidence based on historical data.

SRB016–Req.08 (para. 27) The SRB **NOTED** that stochasticity in Pacific halibut productivity is driven substantially by extrinsic factors (i.e. processes independent of Pacific halibut population size, structure, distribution, etc.). While the current approach is reasonable at this early stage of operating model development, the SRB **REQUESTED** that the IPHC Secretariat investigate intrinsic drivers (e.g. compensatory and depensatory effect) for at least some of these processes. Further integration of the IPHC's biological and ecosystem sciences research plan into the MSE operating model development could be used to sensitivity-test such scenarios. Given the existing MSE timelines, however, more complex operating models could be delayed until SRB018 in June 2021.

SRB016–Req.09 (para. 28) The SRB **NOTED** autocorrelation structure in projected Pacific halibut weight-at-age in the spatial operating model. While such a structure adequately captures the smoothness of historical patterns, it is not clear whether it captures the correlation structure among ages. Therefore, the SRB **REQUESTED** that a multivariate normal distribution be investigated (for SRB018 June 2021) for weight-at-age deviations in which these are correlated among ages. This would involve fitting a multivariate time-series model instead of the ARIMA. Other forms of growth deviations (e.g. cohort-dependence) could also be used to better represent changes in weight-at-age over time.

SRB016–Req.10 (para. 29) The SRB **NOTED** that the operating model includes decision-making variability or implementation uncertainty. This is an important addition to the MSE because, while some management procedures may perform reasonably well if fully implemented, large inter-annual adjustments could be made in practice in response to anticipated economic and social disruptions to the fishery. Thus, the SRB **REQUESTED** further investigation of decision-making variability, including empirical analysis of the relationship between recommended and implemented harvest levels.

Migration and distribution

SRB016–Req.11 (para. 36) **NOTING** that the genetic data may be complimentary to data collected using other methods, for example, stock structure at the genetic level could be reflected in individual differences in otolith chemistry (if primary otolith annuli are interrogated), the SRB **REQUESTED** that a portion of individuals that are selected for otolith chemistry also be used for whole genome sequencing.

SRB016–Req.12 (para. 37) **NOTING** the issues of Gulf of Alaska (GOA) and Bering Sea (BS) connectivity relative to juvenile dispersal, the SRB **REQUESTED** that the IPHC Secretariat include individuals of different ages and locations in the GOA and BS in their whole genome sequencing analysis, including individuals from different places in GOA and BS.

Reproductive assessment

SRB016–Req.13 (para. 38) The SRB **REQUESTED** a preliminary analysis of existing data on 'skipped spawning'.

SRB016–Req.14 (para. 39) The SRB **REQUESTED** that work on size- and age-specific fecundity be incorporated in the next 5-year research plan.

Genetics and genomics

SRB016–Req.15 (para. 41) The SRB **NOTED** that the text in this section of paper IPHC-2020-SRB016-09 was not consistent. A high level of detail was provided in some areas and much less detail was provided in others. At one level, the SRB requires more information on (a) objectives and (b) methods to evaluate study design and the quality of data, however this was not possible given the information provided. For example in the first section on whole genome sequencing there was a major gap in methods. The SRB **REQUESTED** specific information on how the sequence data would be mapped to the reference genome.

SRB016–Req.16 (para. 42) **NOTING** the importance of genetically determined sex information to stock assessment, the SRB **REQUESTED** that the IPHC Secretariat conduct a pilot study to determine whether DNA and PCR amplification of sex-linked SNP loci can be obtained from archived otoliths of different collection periods to demonstrate feasibility to develop a more comprehensive spatial and temporal sex ratio data base.

Research integration

SRB016–Req.17 (para. 44) The SRB **REQUESTED** an updated presentation on the plan and timelines for integrating research and results from biological and ecosystem science research plan into specific functions and parameters of the assessment and MSE.

SRB016–Req.18 (para. 49) The SRB **REQUESTED** that the IPHC Secretariat contact the National Center for Biological Information to annotate the genome. Subsequently, existing and newly discovered SNPs be mapped onto the existing Pacific halibut genome.

SRB016–Req.19 (para. 52) **NOTING** that a common theme in programmatic studies is a need to understand growth, the maturation process and size and age at sexual maturity, and to incorporate this understanding into the assessment and MSE programs. The SRB reiterated its previous **REQUEST** that the IPHC Secretariat hire a PhD-level life history modeller with expertise in the areas that include life history and quantitative genetics. The SRB was advised that at this point in time, the hiring of a life-history modeller is not financially feasible unless either 1) additional contributions were appropriated by the Contracting Parties, or 2) a current FTE was replaced with a life-history modeller.