Report by Independent Science Expert for the 2nd Performance Review of the IPHC

Prepared by Kevin Stokes
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EXECUTIVE SUMMARY

This review is intended as a standalone, independent review of IPHC science processes and provision of scientific advice to the Commission. While standalone, it is also intended to provide input to the 2nd Performance Review of the IPHC (PRIPHC02).

The review was developed primarily as a desk exercise but benefited from a brief site visit for discussions with IPHC Secretariat staff and the IPHC's Scientific Review Board (SRB), teleconferences with USA and, separately, Canadian Commissioners, and discussions with the PRIPHC02 panel.

The review covers five objectives: i) consideration of progress against relevant recommendations made by the first Performance Review of the IPHC (PRIPHC01); ii) assessment of the IPHC science processes compared to international best practice; iii) evaluation of strengths, weaknesses, opportunities, and risks; iv) assessment of consistency between scientific advice and management measures adopted by the Commission; and v) making recommendations on how to improve the IPHC science process to meet or exceed international best practice.

The review finds that:

i) progress against PRIPHC01 recommendations has been carefully considered and is impressive;
ii) when considered across criteria related to peer review, relevance, integrity, objectivity and reliability, plus communication, the IPHC science processes meets or exceeds best practice standards;
iii) the IPHC science capability and capacity is strong and trusted with a variety of strengths and few relative weaknesses, but clear opportunity for improved communication to enable effective stakeholder engagement; and
iv) scientific decision-support is at the heart of Commission decision-making and that decisions taken are respectful of the science.

A number of **recommendations** are made as follows:

1. Maintain the existing, highly credible science capacity and capability of the Secretariat, while strengthening as appropriate to meet specific future needs (e.g. in economics).
2. When revisiting PRIPHC01 Recommendation 3.1 on unifying subsidiary bodies, treat the CB and PAB as non-science process and maintain separated RAB and MSAB at least until 2021 adoption and implementation of a new management strategy.
3. Ensure continued support for high quality stakeholder engagement through the science-focused subsidiary bodies (RAB and MSAB) or any future subsidiary bodies.
4. Consider development of simplified materials for RAB and especially MSAB use, including training/induction materials. The RAB and MSAB mechanisms are robust but the members need to be fully supported to enable successful engagement.
5. Convene a science communication meeting annually (e.g., ED to chair with subsidiary body chairs, selected Commissioners and selected science staff) to agree on

stakeholder and Commission communication needs and develop an annual science communication and training plan for stakeholders and Commissioners.

6. Consider options for simple graphical summary (phase plot equivalents) of fishing intensity and spawning stock biomass OR provide an explanation to the Commission of why such a plot cannot be used for Pacific halibut.
7. Maintain the current strategic approach to biological and ecosystem research, with clear pathways to stock assessment and MSE. Note that MSE might be used to identify the cost-benefits of future research.
8. Ensure continued high-quality peer review through the SRB mechanism and appropriate membership. The SRB mechanism itself does not guarantee the quality and credibility of IPHC science but is also dependent on its membership. The current membership of the SRB is of a high standard with complementary attributes; this standard should be maintained and strengthened as necessary. However, consideration should be given to amending the Rules of Procedure to include fixed terms of service to ensure peer review remains independent and fresh; a fixed term of three years seems appropriate, perhaps with no more than one renewal.
9. Complement SRB provided peer review through occasional, fully independent external subject specific reviews. Current candidates for review are data quality and standards, the FISS, MSE, and the biological program. Review of MSE prior to adoption is advised.
10. Encourage, where appropriate, converting internal science documents to primary literature publications to further enhance peer review.
11. Continue development of MSE to underpin multi-annual (strategic) decision-making and, as multi-annual decision making is implemented, current Secretariat capacity usage for annual stock assessments should be refocused on research to investigate MSE operating model development (including consideration of biological and fishery uncertainties) for future MSE iterations and regularized multi-annual stock assessments.
12. Seek opportunities to engage with eastern Pacific halibut science and management agencies to strengthen science links and appropriate data exchange. Specifically, consider options to investigate pan Pacific stock structure and migration of Pacific halibut.

CRITERIA AND PROCESS

This report is intended as a standalone, independent review of IPHC science processes and provision of scientific advice to the Commission. While standalone, it is also intended to provide input to the 2nd Performance Review of the IPHC (PRIPHC02).

This standalone review was carried out remotely but benefited from a concurrent review by the same reviewer of the IPHC stock assessment (IPHC, 2019j) and an informal site visit from 17-20 June 2019 to meet IPHC Secretariat staff; discuss a range of issues, primarily focused on the stock assessment but also on science process; identify key documents; and understand the

IPHC website structure and content. The site visit provided an opportunity for discussions with IPHC Secretariat staff and members of the IPHC Scientific Review Board (SRB) but not with stakeholder advisory bodies or Commissioners. The site visit was not initially planned and I am grateful to the IPHC Secretariat staff who made time and contributed to it, including repeating presentations already made to the 1st session of PRIPHC02. In addition to the site visit, as part of the concurrent PRIPHC02 process, panel discussions were held with Canadian and, separately, United States of America (USA) Commissioners, a number of whom have served or serve on advisory panels (Conference Board, CB; Research Advisory Board, RAB; and Management Strategy Advisory Board, MSAB).

This review is structured to consider five objectives:

1) *Review the recommendations relevant to the science process arising from the first performance review of the IPHC, notably through the tables/matrix prepared by the IPHC Secretariat;*
2) *Carry out an assessment of the current IPHC science process, compared against the mandate detailed in the IPHC Convention, and also in comparison to international best practice;*
3) *Evaluate the strengths, weaknesses, opportunities and risks to the organization from the current science processes;*
4) *Assess the consistency between scientific advice and management measures adopted by the Commission;*
5) *Make recommendations on how to improve the IPHC science process to meet or exceed international best practice.*

While the reviewer is *free to comment on any aspects of the IPHC's science processes*, the work is also intended to assist in consideration of criteria to be addressed by PRIPHC02, as set out below.

i. Status of living marine resources

- *Status of Pacific halibut stock under the purview of the IPHC in relation to relevant biological standards.*
- *Trends in the status of the stock.*
- *Status of species that belong to the same ecosystems as, or are associated with or dependent upon, Pacific halibut (hereinafter "nontarget species").*
- *Trends in the status of non-target species.*

ii. Quality and provision of scientific advice

- *Extent to which the IPHC receives and/or produces the best scientific advice relevant to the fish stocks and other living marine resources under its purview, as well as to the effects of fishing on the marine environment.*
- *Extend to which the IPHC obtains and evaluates scientific advice, reviews the status of the stock, promotes the conduct of relevant scientific research, and disseminates the results thereof.*

iii. Data collection and sharing

- *Extent to which the IPHC has agreed formats, specifications and timeframes for data submission, taking into account UNFSA Annex I.*
- *Extent to which IPHC Contracting Parties, individually or through the IPHC, collect and share complete and accurate fisheries data concerning target stocks and non-target species and other relevant data in a timely manner.*
- *Extent to which fishing data and fishing vessel data are gathered by the IPHC and shared among Contracting Parties and other relevant bodies.*
- *Extent to which the IPHC is addressing any gaps in the collection and sharing of data as required.*
- *Extent to which the IPHC has set standards for the collection of socioeconomic data from the fisheries; and extent to which this information is used to inform decisions by the Commission.*
- *Extent to which the IPHC has set security and confidentiality standards and rules for sharing of sensitive science and operational/compliance data.*

iv. Consistency between scientific advice and fishery Regulations adopted

- *Extent to which the IPHC has adopted fishery Regulations for both Pacific halibut, and proposed regulations for non-target species to relevant bodies, that ensure the long-term sustainability of the ecosystem as well as of such stocks and species and are based on the best scientific evidence available.*
- *Extent to which the IPHC has applied the precautionary approach as set forth in UNFSA Article 6 and the Code of Conduct for Responsible Fisheries Article 7.5, including the application of precautionary reference points and harvest control rules.*
- *Extent to which the IPHC has adopted and implemented effective rebuilding plans for depleted or overfished stocks.*
- *Extent to which the IPHC has taken due account of the need to conserve marine biological diversity and minimise harmful impacts of fisheries on living marine resources and marine ecosystems.*
- *Extent to which the IPHC has adopted measures to minimise pollution, waste, discards, catch by lost or abandoned gear, catch of non-target species, both fish and non-fish species, and impacts on associated or dependent species, in particular endangered species, through measures including, to the extent practicable, the development and use of selective, environmentally safe and cost-effective fishing gear and techniques.*

v. Compatibility of management measures

- *Extent to which measures have been adopted as reflected in UNFSA Article 7.*

vi. Fishing allocations and opportunities

- *Extent to which the IPHC agrees on the allocation of allowable catch or levels of fishing effort, including taking into account requests for participation from new Contracting Parties or participants as reflected in UNFSA Article 11.*

Of the listed criteria, not all are directly related to the objectives of this review. This report is therefore structured to reflect the five review objectives; it does not explicitly address the individual criteria but remains cognizant of them.

CONSIDERATION OF REVIEW OBJECTIVES

OBJECTIVE 1) Review the recommendations relevant to the science process arising from the first performance review of the IPHC, notably through the tables/matrix prepared by the IPHC Secretariat.

IPHC (2018), prepared by the IPHC Secretariat and available at: https://www.iphc.int/uploads/pdf/im/2018im/iphc-2018-im094-13.pdf), provides a review of progress against recommendations made by the first IPHC Performance Review (PRIPHC01). The review is in the form of tables and is referred to as "*the matrix*". The matrix includes 39 recommendations split into 12 areas. Nine of the Recommendations relate to science process and the provision of advice. These nine are considered below with PRIPHC01 text in *maroon italics* and the Secretariat responses in the matrix shown in *red italics*.

3.1 [*Governance; Revisit Stakeholder Engagement Structure;* assigned **Medium priority]
PRIPHC01 recommended the IPHC *Adopt a multi-step process over the next two years to transition the current stakeholder advisory arrangement into a unified, integrated body*. The Secretariat comments that *[Completed] The Commission assessed that it would be better served by retaining the current CB, PAB, and RAB structures, and decided against consolidating its subsidiary bodies into one*.

The Secretariat does not elaborate on the reasoning for the Commission's decision but the Commission's intent with respect to stakeholder engagement and opportunity to comment on advice is clear from its 2014 Progress report (against PRIPHC01 Recommendations) which states: *The Commission also continues to solicit comment and advice from stakeholders on its ongoing performance review process.*
(see:https://www.iphc.int/uploads/pdf/iphc-2014-performancereviewprogressreport.pdf). Based on discussion with Commissioners as part of the PRIPHC02 process, the decision not to unify subsidiary bodies was considered to be of lower importance than other matters at that time but that revisiting the recommendation should still be considered.

The Secretariat's comment on progress includes the Research Advisory Board (RAB) but the PRIPHC01 recommendation relates primarily to the Conference Board (CB) and Processor Advisory Board (PAB), not to the RAB nor to advisory bodies set up after the first review (i.e. the Management Strategy Advisory Board, MSAB).

From a science process and advisory perspective, the IPHC is unusual in that opportunities are provided for stakeholder engagement during all stages. Informally, Secretariat scientific staff are in frequent contact while sampling or visiting ports and during the extensive annual Fishery-Independent Setline Survey (FISS) which typically contracts 14-18 Canadian and USA vessels each year. Formally, both the RAB (see; e.g.: https://www.iphc.int/uploads/pdf/rab/2019/iphc-2019-rab020-r.pdf) and MSAB (see also Recommendation 8, and e.g.: https://www.iphc.int/uploads/pdf/msab/msab13/iphc-2019-msab013-r.pdf), are standing bodies

with multi-sector representation, clear mandates set out by the Commission, and operating under the IPHC Rules of Procedure (see: https://www.iphc.int/the-commission) which include clear terms of reference for each board. The RAB meets annually and the MSAB meets twice a year. The RAB mandate provides opportunity to make inputs directly to the Secretariat in the development of research plans and also directly to the independent Scientific Review Board (SRB), itself mandated in the Rules of Procedure, as well as reporting to the Annual Meeting (AM) alongside the RAB, MSAB and other subsidiary boards. All RAB, MSAB and SRB activities are transparent. Materials provided to the meetings and meeting reports are all available online. The MSAB provides critical input to the development and testing of management strategies with direct consequences for future harvest strategy and fishing opportunities. The SRB provides independent scientific peer review of all science-related matters including review of recommendations from the RAB and MSAB.

The IPHC is an unusual RFMO in that it deals with a single, high value stock but especially in that it has only two Contracting Parties with contiguous fisheries, a common language, and a long history of cooperation and data collection (96+ years). For RFMOs which are highly multilateral, enabling stakeholder engagement is logistically and practically difficult. The IPHC has taken advantage of its relative simplicity and other advantages and has provided for extensive stakeholder engagement. The use of multiple subsidiary boards allows wide engagement but also relevant expertise and interest within focused areas within the separate boards. The functions of the CB, PAB, RAB and (since 2PRIPHC01) MSAB are set out in the IPHC Rules of Procedure. The CB is mandated very generally to advise the Commission on matters relating to conservation measures and Pacific halibut management, including on review of Secretariat reports and recommendations and regulatory proposals received by the Commission. The PAB is mandated to advise the Commission on issues related to the management of the Pacific halibut resource in the Convention Area and to encourage stability and growth of the North American Pacific halibut industry. In contrast to the RAB and MSAB, and while important for advising on objectives, neither the CB nor PAB are part of the science processes as such. The RAB is mandated to suggest research ideas and make recommendations to the SRB concerning research plans and priorities. The MSAB mandate is more specific with its primary role being to advise the Commission on the Management Strategy Evaluation (MSE) process, including advising on objectives.

Unifying all bodies would potentially remove opportunities for critical engagement in specific areas of interest and expertise and potentially could hinder the aim of separating policy and science (see also PRIPHC01 Recommendation 8). Unifying the bodies or re-combining them could also lead to unwieldy groups. Counter to this view, however, is that the large number of advisory bodies can in principle create conflicting recommendations to the Commission and that there are natural synergies and overlaps between the bodies which may not be fully investigated by separate bodies. With MSE development in progress and expected to be completed by 2021, the need for clarity as to Commission objectives is paramount. The primary advisory body for MSE development is the MSAB but all advisory bodies have natural overlaps with the MSAB. For example, the PAB mandate includes encouraging fishery stability and growth, potentially competing objectives that need to be made operational for MSE work. MSE

is used to develop robust approaches to management but is also a tool for cost-benefit analysis of research options, creating an interaction with the RAB and research planning. Arguably, MSE development will only have high utility and obviate annual decision-making if allocation decisions are embedded within evaluated and adopted multi-year management strategies, requiring CB (and Commission) involvement. The SRB is mandated to peer review all science and science planning and to review recommendations made by the MSAB and RAB, but not integration of recommendations by the CB and PAB.

With all bodies meeting on different schedules and reporting separately to the Commission there is potential for inconsistency which requires careful management or coordination. See also Objective 3.

This review does not make comment on unifying the CB and PAB; it may or may not still have merit. Unifying the RAB with those bodies would seem counterproductive given the mandate of the RAB. Unifying the science boards, the RAB and MSAB, would also not obviously create overall benefits. The RAB is long-standing and provides an opportunity for discussion of ideas and how these might be included in relevant research programs to meet stock assessment (SA) and Management Strategy Evaluation (MSE) needs. It does not necessarily require participants to have in-depth understanding of the technical aspects of SA and MSE or to focus on management objectives and performance measurement. The MSAB serves a very different purpose and through time is likely to wax and wane in intensity as MSE work cycles through development, testing and implementation phases. Participants in the MSAB need to be helped to engage effectively in a highly complex and technical subject area (see also comments on Objective 2 *Relevance*).

Considering the quality of current functioning of the science-related stakeholder advisory bodies (RAB and MSAB) to meet distinct needs, the decision by the Commission in 2014 to retain separation appears sound. The recommendation by PRIPHC01 has been considered and appropriate action has been completed.

However, with the establishment since PRIPHC01 of the MSAB and SRB, and current focus on MSE, revisiting the PRIPHC01 recommendation would be timely. This report suggests (see Objective 5) that the CB and PAB are not part of science processes and that currently it would be best to maintain separate RAB and MSAB. However, the MSE work is scheduled to lead to implementation of a new management procedure in 2021 and revisiting the science advisory board structure would be appropriate at that time.

4.1 [*Research; Develop Strategic Approach to Research*; assigned **High priority]**
PRIPHC01 recommended the IPHC *Develop a strategic Five Year Research Plan that links research projects to Commission objectives, with an accompanying and predictable budget. The Research Plan should address the specific organizing questions that structure the research, as well as the timeline of projects and deliverables. The Research Plan should also address*

specific objectives of cooperative research. Some specific topics to address may include size at age, migration, and impacts of bycatch, but these should be revised and confirmed as the Research Plan is drafted. The Secretariat comments that *[Completed] The IPHC Secretariat continues to refine the Commission's research planning and execution, to include clear linkage between the 5-Year Research Plan and annual planning. In addition, the annual research planning process has been revised to add rigor and strengthen its connection to long-term research goals and priorities.*

Three Secretariat branches (*Biological & Ecosystem Sciences Branch, Quantitative Sciences Branch*, and *Fisheries Statistics & Services Branch*) work effectively together to ensure relevant research is conducted to support fundamental understanding of Pacific halibut but with a focus on the needs to inform SA and MSE. The current 5-year research plan (IPHC, 2019a) is informed and influenced by the RAB and the MSAB, enabling informed research prioritisation to meet Commission needs and facilitating communication between the Secretariat science staff and stakeholders. The SRB provides independent scientific peer review of the plan. The Plan lays out clearly the linkage between biological research and analytical approaches (stock assessment and MSE) and their use in informing policy decisions (see, e.g., Appendices II and III of IPHC, 2019a, at: https://www.iphc.int/uploads/pdf/besrp/2019/iphc-2019-besrp-5yp.pdf).

The plan includes cooperative research and covers five main topics (migration, reproduction, growth, discard survival, and genetics and genomics). The recommendation by PRIPHC01 has been considered and appropriate action has been completed.

4.2 [*Research; Develop Strategic Approach to Research*; assigned **High priority]**
PRIPHC01 recommended the IPHC *Bolster and formalize RAB. The RAB currently lacks any written Protocols/Rules of Procedure nor does it have any formal composition. Consistent with the steps outlined above to have clear guidelines and balanced participation, we recommend the Commission take steps to formally establish the RAB with associated objectives, participation criteria and other operational aspects.* The Secretariat comments that *[Completed] IPHC Rules of Procedure (2017) adopted at the 93rd Session of the Commission.*

This recommendation is superficially inconsistent with the PRIPHC01 Recommendation 3.1 to unify advisory bodies though that recommendation does not mention the RAB explicitly; the Secretariat response includes the RAB. Notwithstanding, the Rules of Procedure include that they should be reviewed for their consistency and appropriateness at least biennially. The Secretariat provided IPHC (2017a) in January 2017 which suggested changes to the Rules of Procedure, clearly marked using track changes, and for consideration at the 93rd Session of the Commission. While that paper makes extensive suggestions for change to various advisory bodies, it does not appear to suggest changes to the Rules of Procedure for the RAB. Because the IPHC website does not include links to documents for Sessions prior to the 93rd, it is difficult to trace changes in Rules of Procedure for the RAB but, according to the Secretariat, none were made between 2014 and 2017. Nevertheless, the Rules of Procedure as of January 2017

include clear specifications for the RAB at Appendix VII, including on Terms of Reference at VII(I) and Representation at VII(II).

The recommendation by PRIPHC01 has been considered and appropriate action has been completed. However, noting comments on PRIPHC01 Recommendation 3.1, revisiting the mandates of all advisory bodies, and possible simplification might be in order.

4.3 [*Research; Develop Strategic Approach to Research*; assigned **Medium priority]**
PRIPHC01 recommended the IPHC *Consider periodic peer review. As the Commission moves forward, it should consider the need for periodic peer review of its long-term and annual research plan. We also recommend it expand commitments to pursue cooperative research.*
The Secretariat comments that *[Completed] The IPHC Scientific Review Board (SRB) was formalized in the IPHC Rules of Procedure (2017) and contain peer review elements by independent experts in a range of fields covering IPHC research and assessment activities.*

See also comments at PRIPHC01 Recommendation 4.1, above. As for the RAB, the Rules of Procedure cover the functioning of the SRB which provides continuous, not just periodic, independent peer review of the research plan and all other science-related matters. The IPHC has also commissioned independent peer review of the stock assessment (IPHC, 2019j) which includes consideration of the current 5-year research plan (IPHC, 2019a). That plan lays out clearly the linkage between biological research and analytical approaches (stock assessment and MSE) and their use in informing policy decisions (see, e.g., Appendices II and III of IPHC, 2019a, at: https://www.iphc.int/uploads/pdf/besrp/2019/iphc-2019-besrp-5yp.pdf). The plan also shows a high degree of cooperative research with fisheries agencies and universities. Notable cooperation exists, for example, between the IPHC and NOAA Fisheries with reciprocal use of survey information across stock assessments (e.g., use of the NOAA Alaska groundfish survey in IPHC stock assessments and use of the IPHC FISS to inform NOAA stock assessments of Pacific cod in the Gulf of Alaska (see: https://www.afsc.noaa.gov/REFM/Docs/2018/GOA/GOApcod.pdf).

The recommendation by PRIPHC01 has been considered and appropriate action has been completed.

5.1 [*Stock Assessment; Strengthen stock Assessment Processes*; assigned **Medium priority]**
PRIPHC01 recommended the IPHC *Foster regular peer review of stock assessment model and outputs, as well as the associated apportionment process.*
5.2 [*Stock Assessment; Strengthen stock Assessment Processes*]
PRIPHC01 recommended the IPHC *Ensure adequate time and predictable process for stakeholder and Commissioner discussion of proposed changes to the assessment model and the associated apportionment methodology.*
At Recommendations 5.1 and 5.2, the Secretariat comments that *[Completed] The Commission has instituted the SRB as a regular ongoing peer-review mechanism, and has adopted a regular*

sequence of annual SRB meetings to support the assessment, the management strategy evaluation, and the research program. As an indication of the state of IPHC science, IPHC scientists are regularly invited to present and instruct on assessment modeling and methods at international conferences.

The SRB was instituted and first met in 2013. Since then it has met twice annually and in June 2019 held its 15th Session. As noted at PRIPHC 01 Recommendations 4.2 and 4.3, the Rules of Procedure (at Appendix VIII) clearly specify the function of the SRB as an ongoing, independent scientific peer review body. From discussions with Secretariat staff and SRB members, and from consideration of papers to the SRB and responses in its reports, it is clear that the interactions are productive. The SRB process is transparent with all documentation available online, as well as full audio recordings of meetings. The SRB Terms of Reference/objectives are clearly laid out and include specific direction to *support and strengthen the stock assessment process*. Of note with respect to Recommendation 5.1 is that the first task and report from the SRB was on the apportionment process (see: https://www.iphc.int/uploads/pdf/srb/iphc-2013-srb01-01.pdf).

Recommendation 5.1 by PRIPHC01 has been considered and appropriate action has been completed. However (see Objective 2, Peer Review), there may be scope for further use of external, independent review.

PRIPHC01 Recommendation 5.2 needs to be considered in light of the timing of that review, when concerns about regular changes in the stock assessment had caused concern amongst stakeholders over some years. Since 2013, however, the stock assessment approach has been reasonably constant and has been used to provide a consistent basis for advice. In 2019 a new "full" assessment is being carried out and a separate, independent review (IPHC, 2019j) has been commissioned, along with ongoing SRB review. The independent review of the 2019 stock assessment suggested continued use of the recent stock assessment approach and the SRB at its June 2019 (14th Session) meeting did not suggest any change in approach. Given the lack of changes in stock assessment since 2013, Recommendation 5.2 would possibly not now be made. However, some further comments are pertinent.

Stock assessment and 'apportionment' methodology, and annual advice, is fully transparent. For all stock assessments used to inform decision-making, discussion of methodologies to help understanding, credibility and confidence in use of estimates/results is potentially difficult given the complex mathematics/statistics and need to accommodate often conflicting signals from different data sources, make assumptions which impact outcomes, and confront uncertainty of many forms. However good and impartial is the science, decision-making in a commercial, multi-sector, and political context means that communication of the underlying science is often fraught. This is considered also at Recommendations 8.1 and 8.2. This Recommendation is specific about ensuring adequate time and predictable process for stakeholder and Commissioner discussion of proposed changes to the assessment model and the associated apportionment methodology. What is adequate is context and individual specific but specific

process can be designed to provide the best opportunities for discussion and confidence building.

Formal opportunities to discuss changes in methodologies with stakeholders and Commissioners (or their advisors) exist in principle at the CB but most particularly at the Annual Meeting (AM) of the Commission for which full stock assessment documentation and SRB commentary is available. I note that AM and CB timing is such that the same materials could be considered by the CB and that the CB does use the online mortality projection tool (see: https://iphc.int/data/projection-tool). There are no obvious instances in recent CB reports (e.g., the 88th and 89th Sessions) of consideration of changes to the stock assessment model and the mortality projection tool, just usage of the tool. In recent AM reports (e.g., of the 95th Session), the stock assessment and considerable ancillary information is presented, though the focus for the Commission is clearly on catch allocation and use of the online mortality projection tool.

The lack of consideration in recent years of stock assessment specific issues possibly suggests a level of confidence in the scientific basis for decision-making that may not have existed at the time of PRIPHC01. This is perhaps also reflected in the comments made by some Commissioners during PRIPHC02 interviews. One general comment on IPHC progress against the PRIPHC01 Recommendations was that the Secretariat had made "*pretty impressive progress*", while another, from a CB and AM perspective, was positive about the "*change in process and atmosphere to a now open system*." Positive comments were made about the online mortality projection tool and about the "*excellent communication of IPHC science staff when interacting with the public and subsidiary bodies*". One comment noted that *"between long-term and new staff this is the strongest science ever*". Though comments have been very positive, some concern still seems to exist that terminology can be difficult and some "*cartooning down*" of the stock assessment and mortality projection tool would be appreciated to assist stakeholder understanding. Similar comments were made regarding communication of assessment results with respect to stock status.

While there seems currently to be less concern about changes to assessment and apportionment methodology, more general concerns still exist about communication of science, both as relates to enabling stakeholder understanding of what is done and as relates to communicating science outputs to the Commission. While it is recognized by Commissioners that the IPHC is "*fortunate to have such good science communicators*…" there is still some concern that in a transparent, science-based decision-making setting, stakeholder and Commissioner understanding is increasingly important and needs to be supported. Further comments are made below at Objective 2 (*Relevance*).

Recommendation 5.2 by PRIPHC01 is arguably now redundant given changes in staff and progress towards more stable stock assessments. However, general concerns about the communication of science still exist (see Objective 2, Relevance).

5.3 [*Stock Assessment; Strengthen stock Assessment Processes*]
PRIPHC01 recommended the IPHC *Augment Secretariat assessment staff.* The Secretariat comments that *[Completed] Since the 1st Performance Review, the Secretariat has hired top-level assessment and harvest policy scientists. The Commission has also brought in the services of graduate interns at appropriate points in the analytical process, and has budgeted for programming support of the management strategy evaluation.*

See also comments on PRIPHC01 Recommendation 5.2, above. The Secretariat has strengthened its internal science capacity which is highly regarded internationally and by stakeholders and Commissioners. As noted in the recent review of the 2019 stock assessment (IPHC, 2019j): "*The stock assessment is ... carried out by world class analysts, supported within the IPHC by statistics and biology teams and by the independent SRB, and embedded in the fertile Seattle stock assessment and methods community. The quality of analysis is excellent and aimed purposefully at providing science-based risk assessment to support IPHC decision-making*".

Recommendation 5.3 by PRIPHC01 has been considered and appropriate action has been completed.

8.1 [*Advice; Structure Staff Advice to Strengthen the Delineation Between Scientific Analysis and Policy Options*]
PRIPHC01 recommended the IPHC *Clarify the respective roles and responsibilities of Commissioners and staff for each step of the analysis and policy development cycle.*
8.2 [*Advice; Structure Staff Advice to Strengthen the Delineation Between Scientific Analysis and Policy Options*]
PRIPHC01 recommended the IPHC *Present options for Commission consideration.*
At Recommendations 8.1 and 8.2, the Secretariat comments that *[Completed] The Commission noted that the approach to delineation between science advice and policy options should follow accepted national and international best practices, and that as a first step towards implementation, an approach should be developed for risk-based harvest advice. The Commission has adopted a new structure for harvest advice proposed by the IPHC Secretariat, including a decision-table presentation format to support risk-based decision-making. This new advice structure clearly separates the scientific analysis from the management decisions, and was thoroughly examined and revised as part of the stock assessment review by outside scientific reviewers. The Commission also decided to implement the MSE process to better inform its policy analysis and choices, and chartered the MSAB in 2013 to oversee the MSE process and to advise the Commission and IPHC Secretariat on the development and evaluation of candidate objectives and strategies for managing the fishery.*

The Secretariat has identified the Commission's response made to PRIPHC01. That response predates documentation available online (which starts with the 2015 91st Session of the AM) and is therefore taken as read. From discussion with IPHC scientific staff during the site visit, it is clear that the separation of policy and science responsibilities has been a major driving force

for stock assessment-based advice since 2013. This is also reflected in the first task of the SRB, as noted at Recommendation 5.1, which was to report on the 'apportionment' process (see: https://www.iphc.int/uploads/pdf/srb/iphc-2013-srb01-01.pdf).

The approach adopted, as pointed out by the Secretariat, has been to develop clear risk-based harvest advice with a separation of stock assessment supported by biological and ecosystem research to inform a separate decision-support tool for use by stakeholders and Commissioners - the online mortality projection tool in 2018 and 2019 (see: https://iphc.int/data/projection-tool). The stock assessment does not choose a single base case but uses an ensemble of four models using coastwise or smaller areas and longer or shorter data series. The four models are equally weighted to develop the annual decision tables and to underpin the online mortality projection tool. All allocation decisions can be explored by stakeholders and the Commission using the tool; the Secretariat science staff have no role in making the policy decisions, only in providing the basis for those decisions.

In any modelling exercise, decisions need to be made which might introduce biases. The stock assessment as currently used, however, has been developed with close scrutiny by the SRB and has been subject to internal deliberations and external, independent review. The independent 2019 review (IPHC, 2019j) concluded:

"*The provision of risk assessment advice to the IPHC uses all four, structurally different models, in a way which is slightly unconventional. Most stock assessment-based advice is based on a single assessment and associated sensitivity runs to portray uncertainty. While that approach may provide risk assessments that include uncertainty associated with data and model fitting to data, it does not address uncertainty due to the structural differences between models - all of which are valid. Selecting a single model as a basis for risk assessment would put a key part of the risk decision into the science process rather than the IPHC Annual Meeting process. In order to separate risk decisions in science and policy to the greatest extent possible, the IPHC approach is to assess risks associated with any decisions on future mortalities using an ensemble of all four models. Selection of the four models is rational and science-based and use of all four removes the necessity to focus on any one model.*

Of course, different models could be selected and risk assessments could be affected. The rationales for model development are, however, science based and credible. In order to provide a consistent basis for advice this review concludes that continued use of the four individual models is appropriate. This leaves open the issue of whether the four models might be weighted equally, as in recent years, or differentially. There is no right way to weight the models and even equal weighting is arbitrary. Equal weighting also makes models with lower biomass scales influential in assessing risks. The issue of weighting is considered in the review and at this stage it is advised to maintain equal weighting."

As noted by the Secretariat, the Commission also decided to implement the MSE process to better inform its policy analysis and choices, and chartered the MSAB in 2013 to oversee the MSE process and to advise the Commission and IPHC Secretariat on the development and

evaluation of candidate objectives and strategies for managing the fishery. The MSAB first met in June 2013 and in October 2019 will hold its 14th Session. The Terms of Reference for MSAB are contained in the Rules of Procedure at appendix V, and membership *includes individuals representing harvesters (commercial, sport, and subsistence), fisheries managers, processors, IPHC Staff, science advisors and other experts as required may be represented*. The MSAB is tasked with Proposing fishery objectives, articulating management procedures, and proposing performance measures in order to recommend fishery management strategies for Commission consideration.

From discussions during the site visit and consideration of MSAB reports it is clear that considerable progress has been made with iterative discussions between IPHC scientific staff and the MSAB making recommendations on objectives and performance measures to the Commission. Experience around the world on MSE and Management Procedure development has shown clearly the difficulty of ensuring good interaction to enable distinction of roles, between science and policy. The high quality of IPHC internal scientific capability and extensive stakeholder advisory bodies, with increasing trust of the science support for decision-making, is at the forefront of MSE and MP work.

Recommendations 8.1 and 8.2 by PRIPHC01 have been considered and appropriate action has been completed.

OBJECTIVE 2) Carry out an assessment of the current IPHC science process, compared against the mandate detailed in the IPHC Convention, and also in comparison to international best practice.

The 1979 Convention (*The Protocol amending the Convention for the Preservation of the Halibut Fishery of the Northern Pacific Ocean and Bering Sea)* and other basic texts of the IPHC including the current Rules of Procedure and Fishery Regulations are available at: https://www.iphc.int/the-commission.

The Convention does not include any specification of science processes. The Rules of Procedure (see: https://www.iphc.int/uploads/pdf/basic-texts/iphc-2019-rules-of-procedure.pdf) also do not specify science processes as such but do set out procedures for the establishment, membership, chairing, and operation of subsidiary bodies, including three of relevance to science processes: the Management Strategy Advisory Board (MSAB); the Research Advisory Board (RAB); and the Scientific Review Board (SRB). The MSAB and RAB are stakeholder advisory Boards that meet twice annually and annually, respectively. The SRB is an independent scientific review board that meets twice annually. The MSAB and SRB were both set up following PRIPHC01.

Other RFMOs have adopted a wide variety of approaches to providing scientific advice. Approaches taken vary from using full-time science staff and analysts employed directly (e.g., IATTC, ICCAT, IOTC) or contracted (e.g., WCPFC) to conduct analyses, or relying entirely on

national delegations to conduct analyses (e.g., CCAMLR, SPRFMO, CCSBT). In all cases, advice is developed by scientific committees comprised of national scientific delegations, sometimes also depending on inter-sessional working parties (e.g., IOTC). Some RFMOs contract independent chairs for the scientific committee (e.g., CCSBT) while others draw from delegations. The IPHC model of employing "in-house" quantitative and biological staff is not unique but the employed capacity is much larger than any other RFMO. Unlike other RFMOs, the IPHC does not have a separate scientific committee. Rather, the Secretariat is directly responsible for the provision of advice. Given the history of the IPHC (96+ years), but especially its size, with just two Contracting Parties and one stock, this is practical and makes good sense (though see comments below).

The use of regular stakeholder groups (MSAB and RAB) and especially the twice annual independent science peer review provided by the SRB is potentially able to underpin key aspects of best practice science processes. The SRB is unique in providing integrated peer review, though the CCSBT does contract a standing group of experts that participates in annual scientific committee meetings to facilitate and effectively peer review all research, including stock assessments and management procedure testing (similar to MSE).

In the absence of an international standard for best practice, and in the face of high variability in approaches taken by RFMOs, this review considers IPHC science processes using a more general framework developed and used for New Zealand fisheries quality assurance which itself drew on practices elsewhere. The New Zealand Research and Science Information Standard (MPI, 2011) defines key principles for science information quality, noting that it relates to i) relevance, ii) integrity, iii) objectivity and iv) reliability. The New Zealand standard further notes that the primary, internationally accepted mechanism for evaluating the quality of research and science information is v) peer review and, as such, peer review is both a principle and a mechanism. It is not suggested that these five key principles necessarily be adopted formally by IPHC but they are used here to carry out an assessment of the current IPHC science process. The descriptions of the principles given in MPI (2011) are repeated here in *blue italics*.

Peer Review: *Is the principal process used to ensure that the quality of scientific methods, results and conclusions meet the accepted standards and best practices of the science community. Peer review is an organised process that uses peer scientists with appropriate expertise and experience to evaluate the quality of research and science information.*
Following PRIPHC01, the Commission instituted the SRB in 2013 as a regular and continuous peer-review mechanism and has adopted a sequence of twice annual SRB meetings to support stock assessment, management strategy evaluation, and research planning. Since inception in 2013, the SRB membership has been consistent, interactions with the Secretariat scientists have been iterative, and the full process is transparent through the IPHC website. All materials presented are available online, as are SRB reports and audio recordings of meetings. The three long-standing SRB members have high international credibility and all have relevant experience and knowledge. During 2019, an additional member with complementary expertise and review experience has been appointed to the SRB to further broaden and strengthen peer review capability.

In addition, the Commission has contracted separate independent peer review of the stock assessment, the most recent being in 2019 (IPHC, 2019j). As for all IPHC reports, the independent stock assessment review is available online. It is debatable whether the Commission should additionally contract independent reviews on other matters. The SRB mechanism is in principle sufficient but while it is independent, it is also internalized and could potentially be perceived as institutionalized. Stakeholder, Commissioner and public trust may be enhanced by judicious contracting of occasional, additional external peer reviews. With respect to the MSE, timely review would be prior to finalization and decision-making on implementation. Other areas for potential review are the FISS, the biological research program, and catch data quality and standards. Opportunities to publish in the primary literature could also be taken advantage of, providing a highly visible form of peer review.

During discussion with Commissioners and in PRIPHC02, comments were made that the SRB could be more responsive and assist in strengthening internal engagement of members. Careful consideration is needed of the SRB role and whether it could be widened to serve such purposes. As mandated through the Rules of Procedure it has an independent, scientific peer review function. Any move to widen that function could undermine it and perceptions of independence. To meet best practice standards, a clear peer review mechanism is required. The current functioning of the SRB and occasional external review meets those standards.

Less formally, the IPHC employs world-class analysts and biologists and exists in what might best be termed a fisheries center of excellence; Seattle provides a fertile ground for informal scientific peer review and the interactions between permanent IPHC scientists and the wider scientific northwest Pacific fisheries science community further ensure continuous scrutiny.

The key principle of Peer Review is met. Informal but especially rigorous and regular Commission-adopted formalized peer review provisions are of the highest caliber.

Relevance: *Scientific research must be relevant to the fisheries management question(s) being addressed, contributing directly to answering those management questions and addressing management objectives for that fishery.*

As described in the Convention, the Commission's purpose is to maintain the stock at a level able to support optimal yield. Objectives in the Convention or that can be inferred from the history of the Commission include supporting research to improve knowledge of the biology and life history of Pacific halibut, improving the analytical basis of assessing stock status, and improving the capability to provide robust decision-making support materials. The Commission needs to receive information in support of decision-making about setting catch limits, amending regulations, supporting research programs, and other matters. It has to make decisions on the nature and extent of future catches, including their allocation, with a clear understanding of how its decisions are likely to impact on Pacific halibut stock status and future fishing opportunities.

Biological and Ecosystem Sciences Research

The IPHC has a long history of data collection, biological research, and stock assessment. The current 5-year research plan (IPHC, 2019a) lays out clearly the linkage between biological research and analytical approaches (stock assessment and MSE) and their use in informing policy decisions (see, e.g., Appendices II and III of IPHC, 2019a). The successful pursuit of the objectives detailed in the 5-year research plan are aligned with the Commission's strategic goals to position IPHC as a global leader in scientific excellence and science-based decision making and to foster collaboration within Contracting Parties (CP) and internationally to enhance IPHC's science and management advice. Individual research projects and results are published in meeting papers of the IPHC's subsidiary bodies, in the scientific literature, and on the IPHC website (see: https://www.iphc.int/management/science-and-research/biological-and-ecosystem-science-research-program-bandesrp).

An overarching goal of the 5-year research plan is to promote integration and synergies among the various research activities led by the IPHC in order to improve knowledge of key biological inputs that feed into the stock assessment and MSE processes. The goals of the main activities of the plan are aligned and integrated with the IPHC stock assessment and MSE processes (at Appendix II) and with specific timelines (at Appendix III). The Secretariat proposes new and continuing projects annually, designed to address key biological issues based on the Secretariat's own input as well as input from the IPHC Commissioners, stakeholders and particularly from subsidiary bodies to the IPHC, including the SRB and the RAB. Proposed research projects are evaluated and presented to IPHC Commissioners for feedback and potential approval.

The IPHC biological sciences and ecosystem research program is wide ranging but clearly focused on management needs. Analyses are well focused and are supported by full documentation. Presentations to Annual Meetings (e.g., IPHC, 2019b) are succinct and cover all aspects of research pertinent to decision-making.

One fundamental concern raised in discussion with Commissioners about the relevance of the stock assessment is that the stock definition and area of assessment may be inappropriate. If so, this would of course have potential ramifications for cooperative research and stock assessment, but also management and even potential IPHC membership. Pacific halibut are distributed across the coastal North Pacific Ocean from Hokkaido (Japan) to California (USA) but life history and genetic studies to date are inconclusive as to distinction between western and eastern North Pacific stocks (see, e.g., Laius et al, 2019). The 5-year research plan includes work on migration within the IPHC Convention Area but does not include anything on stock definition. The issue is raised in Stewart and Hicks (2019) under research priorities and further consideration is encouraged in the independent review of the stock assessment IPHC (2019j). More generally, opportunities for liaison between IPHC and scientists working on eastern north Pacific halibut should be explored and encouraged.

Stock assessment

Stock assessment (e.g., Stewart and Hicks, 2019) and MSE work (e.g., Hicks and Stewart, 2019) show clear understanding by IPHC analysts of Commission tactical and strategic decision-making needs. Separate RAB, MSAB and SRB reporting to the Commission at Annual Meetings ensures both focus on relevant matters and a further independent voice on the science outputs and required direction. The annual stock assessment provides advice on status with respect to agreed objectives (as SPR%) and decision tables and catch allocation tools that can be used by the Commission to make risk-based decisions informed by robust, unbiased science (see also *Objectivity* and *Reliability*, below).

Stock assessment is conducted annually using data from the FISS, commercial and other Pacific halibut fisheries, bycatch fisheries, and biological information from the IPHC's research program. The stock assessment includes the Pacific halibut resource in the IPHC Convention Area, covering the Exclusive Economic Zones of Canada and the USA. Data sources are updated each year to reflect the most recent scientific information available for use in management decision making. Stock assessment results are used as inputs for harvest strategy calculations, including catch tables for the upcoming year that reflect the IPHCs harvest strategy policy and other considerations, as well as the harvest decision table which provides a direct tool for the management process. The harvest decision table uses the probability distributions from short-term (three year) assessment projections to evaluate the trade-offs between alternative levels of potential yield (catch) and the associated risks to the stock and fishery. The most recent stock assessment files are available on each Annual Meeting page, as well as the Stock assessment page on the IPHC website (see: https://www.iphc.int/management/science-and-research/stock-assessment).

Harvest Strategy Policy and Management Strategy Evaluation

The draft Harvest Strategy Policy (IPHC, 2019i) provides a framework for applying a science-based approach to setting harvest levels for Pacific halibut throughout the Convention Area. It defines biological and economic objectives that apply to the development of a harvest strategy for Pacific halibut. It also identifies reference points for use in achieving and monitoring the Commission's stated objectives. This policy, together with the Convention, provides the basis to manage the risk to Pacific halibut fisheries and the Pacific halibut population.

At its 89th Annual Meeting in 2013, the Commission endorsed the development of a program of Management Strategy Evaluation (MSE) for the Pacific halibut resource occurring within the Convention Area. In doing so, the Commission approved the formation of a Management Strategy Advisory Board (MSAB), tasked with overseeing and advising the IPHC Secretariat staff on the Management Strategy Evaluation (MSE) process. The latest progress and documents relating to the MSE process may be located on the MSAB meeting pages (see: https://www.iphc.int/library/documents/meeting-documents/iphc-meeting-index).

Communication

In order to be treated as relevant and used, science and scientific advice also needs to be understood and trusted. The high degree of stakeholder engagement allowed for in IPHC processes requires continuously comprehensive and comprehensible communication to provide understanding and enable effective engagement in research planning, MSE development, and annual catch limit decision-making. The general view of Secretariat science communication is highly positive but two areas for potential further work emerged during discussions with Commissioners. First, assisting advisory bodies to understand science and engage effectively in stakeholder processes. Second, providing a simple graphical update of stock status for use by the Commission.

The first is a must and an ongoing challenge. It is not the role of this review to suggest specific topics or means of training, but a regularly updated training needs analysis is advisable. It is recommended that an annual communication meeting be chaired by the Secretariat with participation of science advisory board chairs, selected Commissioners and selected Secretariat science staff.

The second issue requires careful consideration given the use of an ensemble approach combining models with dynamic and different reference points to provide risk-based advice, which does not naturally enable use of methods such as simple phase plots showing conservation and exploitation status, and as commonly used in many domestic and RFMO settings.

There seems to be some concern that despite the materials provided for annual decision-making, no simple graphical summary of fishing intensity and spawning biomass is presented, as is common for many fisheries and in other management settings as a “phase plot” or “Kobe Plot”. Given the ensemble model approach adopted, and the use of dynamic reference points in some of the ensemble models, a single, synthesized “phase plot” of fishing intensity and spawning biomass could be misleading. Indeed, apparently similar phase plots used elsewhere need to be very carefully interpreted and arguably misleading if not. Materials presented at AM (e.g., to the 2019 AM; IPHC, 2019k), do include graphical and tabular information on trends and scales of fishing intensity and spawning biomass; though the materials are complex they are carefully constructed to be correct and the text summary in the AM report (IPHC, 2019b), though brief, does capture well the best available information on fishing intensity and spawning biomass with clear statements that the stock is neither overfished not experiencing overfishing. The issue seems to be that while the science is appropriate and carefully presented, the outputs used to communicate status do not conform to those used elsewhere. Some consideration might be given to developing a more typical phase plot analogue or explaining to the Commission why such a plot is not used for Pacific halibut.

The key principle of Relevance is met. Biological, stock assessment and MSE work is integrated and focused on meeting management objectives and needs.

Integrity: *Refers to the security of information, and to the protection of information from inappropriate alteration, selective interpretation or selective presentation. It must be ensured that the information is not compromised or biased, particularly with regards to presenting the uncertainty of that information, to ensure that information remains complete throughout the science-to-decision process.*

NOTE: There are potential overlaps in the consideration of *Integrity*, *Objectivity* and *Reliability*. Integrity and Objectivity in particular overlap. For consideration here, integrity is interpreted as the protection of data, information and scientific advice from influences external to scientific considerations. Objectivity is interpreted as the protection of data, information and advice within scientific considerations. Reliability is treated as a consideration of reproducibility, validation, verification, and utility to decision-making processes.

Considered from the perspective of external influences on science processes, it must be acknowledged that in order to provide fit-for-purpose advice, interactions with users of the advice and stakeholders affected by decisions are necessary; science that informs decision-making and provides risk-based analyses cannot exist without context and policy objectives. IPHC science processes therefore include formal points of interaction with stakeholders through the RAB and MSAB in particular. The RAB and MSAB multi-stakeholder boards operate with clear terms of reference and responsibilities set out in the IPHC Rules of Procedure (see Objective 1, consideration of PRIPHC01 Recommendation 3.1). All RAB and MSAB activities are fully documented and transparent and any recommendations made are considered also by the SRB, the independent science peer review board which itself has clear terms of reference and responsibilities set out in the Rules of Procedure (see Objective 1, consideration of PRIPHCo1 Recommendation 5.2, and Objective 2, *Peer Review*).

Importantly (see Objective 1, consideration of PRIPHC01 Recommendation 8.2), the IPHC has adopted an approach to providing risk-based harvest advice which uses stock assessment supported by biological and ecosystem research to inform a separate decision-support tool for use by stakeholders and Commissioners - the online mortality projection tool (see: https://iphc.int/data/projection-tool). The stock assessment does not choose a single base case but uses an ensemble of four models using coastwise or smaller areas and longer or shorter data series. The four models are equally weighted to develop the annual decision tables and to underpin the online mortality projection tool. All allocation decisions can be explored by stakeholders and the Commission using the tool; the Secretariat science staff have no role in making the policy decisions, only in providing the basis for those decisions. Further, while in any modelling exercise, decisions need to be made by scientists which might introduce biases, the stock assessment as currently used has been developed with close scrutiny by the SRB and has been subject to internal deliberations and external, independent review.

Underpinning the credibility and utility of any models is trust in the quality of data. Stewart and Hicks (2019) and Stewart and Webster (2019) make recommendations related both to estimates of discard mortality in directed fisheries and bycatch mortality in other fisheries. The independent review (IPHC, 2019j) comments on these in the context of the stock assessment

and MSE. Issues with underlying data quality are transparent and considered in analyses and advice and data integrity through national agencies and the IPHC is not in question.

However, during discussion with Commissioners and in PRIPHC02, comments were made that reveal concerns about data quality, particularly as it relates to adequate observer coverage of bycatch fisheries in areas of higher fishing effort. It is unclear if this is an issue that undermines the perceived integrity of the assessment but as noted above the stock assessment and MSE processes can and do deal with uncertainty in mortality data. This review recommends consideration of an independent review of catch data systems and possible standard setting.

The key principle of Integrity is met. The IPHC science processes are well designed and operated to ensure high integrity with clear points of contact, roles, and continuous internalized peer review.

Objectivity: *Refers to whether the information presented is accurate, impartial and unbiased. Objective interpretations or conclusions do not depend upon the personal assumptions, prejudices, viewpoints or values of the person presenting or reviewing the information. Scientific methods must be used in the collection and analysis of data, and science processes must be free of undue non-scientific influences and considerations. Data must be obtained from credible and reliable sources. To the extent possible, data and analyses must be accurate and unbiased.*

The independent review of the stock assessment (IPHC, 2019j), including consideration of relevant data and biological research, noted:
"*The SA paper by Stewart and Hicks (2019) is notable for its careful and logical elaboration of the in-development stock assessment. It is unusually and exceptionally clear with a focus on explaining why as well as how models have been developed - from an historical perspective, given data, and in the IPHC decision-making context. While many SA documents focus on model fitting, Stewart and Hicks (2019) is about modelling but with full consideration of model fitting nested appropriately, comprehensively and clearly. It is an excellent document but for review needs to be read in conjunction with Stewart and Webster (2019) which elaborates on data available for the SA. It also needs to be considered in the context of its purpose which is to provide a scientifically rigorous, but value-free, risk assessment to aid the Commission in its annual deliberations.*

In addition to the in-development SA document, a wide range of papers and materials were made available for the review in electronic form, either in advance, during the informal site visit, or through the IPHC website. In advance, these included detailed input and output files for the individual models (see ToR bullet 2) used in the ensemble (see ToR bullet 3); the excellent, annually updated, overview of data sources up to November 2018 (Stewart and Webster, 2019; ToR bullet 1); previous model documentation; and relevant papers/manuscripts on the assessment, most notably as relevant to ToR bullets 2 and 3. The overall quality of documentation from all IPHC sources is of the highest quality with exceptional care taken in preparation."

The review considered in detail the individual models and ensemble approach used to provide risk-based advice for decision-making and noted the care taken by IPHC science staff to develop robust and well-considered science-based analyses to inform decision-making. All data inputs and supporting analyses, model assumptions and developments are fully transparent and carefully considered. Stewart and Hicks (2019) on stock assessment, and Stewart and Webster (2019) on data, provide detailed explanations to support decisions and include extensive consideration of research that might assist future objective analyses. Consideration of current biological and ecological concerns such as understanding of migration, changes in growth, and impacts of environmental change is transparent in the data and stock assessment documents and research on these issues is included in the 5-Year BSERP.

As noted at Objective 1 (consideration of PRIPHC Recommendation 5.3), the Secretariat has strengthened its internal science capacity which is highly regarded internationally and by stakeholders and Commissioners (see comments at Objective 1, Recommendation 5.1). As noted by (IPHC, 2019j): "*The stock assessment is ... carried out by world class analysts, supported within the IPHC by statistics and biology teams and by the independent SRB, and embedded in the fertile Seattle stock assessment and methods community. The quality of analysis if excellent and aimed purposefully at providing science-based risk assessment to support IPHC decision-making*".

Objectivity is further enhanced by the continuous peer review provided by the SRB (see Objective 1, consideration of PRIPHC01 Recommendation 5.2, and Objective 2, *Peer Review*) and occasional independent peer review (IPHC, 2019j).

The key principle of Objectivity is met. The IPHC science processes are well designed and operated to ensure high Objectivity. Secretariat staff are of the highest calibre and the internal and external peer review processes further ensure Objectivity.

Reliability: *Relates to the accuracy and reproducibility of information. Research and science information must be accurate, reflecting the true value of the results being reported within an acceptable level of imprecision or uncertainty appropriate to the data and analytical methods used. Information should not be biased and should not suffer from such a high level of imprecision that the results and conclusions are rendered meaningless. Methods and models used to produce science information must be verified and validated to the extent necessary to demonstrate that results may be reliably reproduced by an independent scientific expert using the same data and analytical methods.*

Validation is concerned with determining whether a conceptual model such as a stock assessment is an accurate representation of the system under study, while verification is the process whereby a program or process is determined to perform as intended (e.g., the software used to fit a stock assessment model; see, e.g., Law and Kelton, 1991). The end point of the IPHC science processes is risk-based advice to the Commission; the utility of that advice relates primarily to the validity of the data, assumptions and models used and the characterization of

uncertainty. It also relates to verification in that the tools used to develop the scientific advice need to work as expected and intended.

All data used in developing advice are subject to scrutiny by Contracting Party agencies, the IPHC Secretariat, or both. Methods used to analyse data are subject to extensive verification by developers and through collaborative usage. Notable amongst methods and software used is the stock assessment software, Stock Synthesis (Methot et al 2019), which is subject to continuous and rigorous verification. Other statistical software used is subject to similar ongoing scrutiny through collaborative mechanisms. Verification of correct implementation is through internal collaboration and internal and external peer review. The stock assessment (Stewart and Hicks, 2019) includes careful "bridging" analyses to check on potential influences of software changes.

The key issue in considering the reliability of science processes is validity, including the characterisation of uncertainty that affects risk-based decision-making. Stock assessments are caricatures that can only capture a small subset of real-world complexity. They model biological and fishery aspects at scales supported by data and research but cannot capture the fine-grained aspects that determine many aspects of fishery-stock interactions. Depending on models, data and assumptions, advice can vary and selection of stock assessment models as base cases for providing advice is often contentious. As noted already at Objective 1 (consideration of PRIPHC Recommendation 8.2):

In any modelling exercise, decisions need to be made which might introduce biases. The stock assessment as currently used, however, has been developed with close scrutiny by the SRB and has been subject to internal deliberations and external, independent review. As already noted at Objective 1 (consideration of PRIPHC01 Recommendation 8.2), the independent 2019 review (IPHC, 2019j) concluded:

"*The provision of risk assessment advice to the IPHC uses all four, structurally different models, in a way which is slightly unconventional. Most stock assessment-based advice is based on a single assessment and associated sensitivity runs to portray uncertainty. While that approach may provide risk assessments that include uncertainty associated with data and model fitting to data, it does not address uncertainty due to the structural differences between models - all of which are valid. Selecting a single model as a basis for risk assessment would put a key part of the risk decision into the science process rather than the IPHC Annual Meeting process. In order to separate risk decisions in science and policy to the greatest extent possible, the IPHC approach is to assess risks associated with any decisions on future mortalities using an ensemble of all four models. Selection of the four models is rational and science-based and use of all four removes the necessity to focus on any one model.*

Of course, different models could be selected and risk assessments could be affected. The rationales for model development are, however, science based and credible. In order to provide a consistent basis for advice this review concludes that continued use of the four individual models is appropriate. This leaves open the issue of whether the four models might be weighted

equally, as in recent years, or differentially. There is no right way to weight the models and even equal weighting is arbitrary. Equal weighting also makes models with lower biomass scales influential in assessing risks. The issue of weighting is considered in the review and at this stage it is advised to maintain equal weighting."

The current IPHC stock assessment approach and supporting science is excellent. It carefully constructs an objective risk analysis that includes consideration of structurally different caricatures of Pacific halibut and its fisheries. All models are carefully tuned such that fitting of multiple data sources to the model components results in a balance of observation and process errors and the uncertainty in estimates of interest from each model is then used jointly to provide a basis for risk-based advice. Tuning is currently carried out manually for the large majority of stock assessments internationally and requires both statistical understanding but also guile.

All model development and tuning decisions are transparent and are fully reported (e.g., Stewart and Hicks, 2019). Similarly, all data and analyses used in stock assessment are reported (e.g., Stewart and Webster, 2019; and online). All input and output files from assessments are available and technical choices are fully transparent, enhancing reproducibility.

The key principle of Reliability is met. The IPHC science processes are well implemented to ensure verification and reproducibility. Validity is enhanced through careful model development and fitting and the use of the ensemble approach to confront model uncertainty. The risk-based analyses provided for decision-making are reliable.

OBJECTIVE 3) Evaluate the strengths, weaknesses, opportunities and risks to the organization from the current science processes.

Strengths:

1. Trust in scientific advice from the Commission is currently strong.
2. The IPHC conducts its own research and annual fishery-independent setline survey, enabling cooperative research and informal stakeholder interactions.
3. Stakeholder interaction with science occurs formally and regularly through the RAB and MSAB which are clearly mandated in the IPHC Rules of Procedure. Comments made as part of the PRIPHC02 process generally signal satisfaction with progress in this respect.
4. There is a strong strategic approach to biological and ecosystem research, with clear pathways to stock assessment and MSE. The RAB plays an important role in this.
5. Stock assessments are of the highest quality by international standards. Annual scientific advice is relevant, has integrity, is objective and reliable; it forms a clear basis for distinct policy analysis and decision-making.
6. MSE is well supported by the Commission and Secretariat with strong stakeholder interactions through the MSAB. The interplay of MSE/development, MSAB and the Commission as seen through Reports of Annual Meetings suggests a high degree of confidence in adopting the approach in 2021 or soon after.

7. The SRB provides a critical peer review role in ensuring IPHC science remains relevant while having integrity, objectivity and reliability. The use of occasional, independent external peer review enhances this but the continuous nature of the SRB is fundamental to ensuring continued quality and credibility of science processes and science outputs.
8. One superficial weakness in the system is that the Harvest Strategy remains in draft form. However, this needs to be viewed positively in the context of the Harvest Strategy Policy as an overarching document for consideration as part of the ongoing MSE development, with regular MSAB and Commission involvement.

Weaknesses:

Compared against international best practice there are no significant weaknesses in the IPHC science processes; indeed, the processes have been modified and strengthened since PRIPHC01 to the point where one Commissioner commented that "[There has been a] *95% improvement since 2012 and there is not a lot more to squeeze. It's in a pretty good place.*"

Science processes are robust and implementation as evidenced by transparent documentation and reports is excellent with most improvements occurring after 2016.

Nevertheless, relative weaknesses include:

1. While the multiple advisory bodies are clearly mandated in the Rules of Procedure and serve distinct functions, they potentially all have a role in shaping objectives for management (see Objective 1, PRIPHC01 Recommendation 3.1), with potential for incompatible requirements of MSE not articulated through the MSAB.
2. A continuing need to communicate complex science and advice to stakeholders, Commissioners and the public. Given the array of needs and diverse level of engagement and expertise, this is a challenge.
3. Some concerns exist about the underlying stock definition assumptions, data quality and changing biological/ecological environment.

Opportunities:

1. Coordination of advisory bodies to work through MSAB to ensure clear expectations of future management procedures.
2. All stakeholder boards, including the RAB and MSAB, serve an important role and members need to remain well-informed to enable effective engagement. While comments on science communication by the Secretariat to stakeholders are highly complimentary, there may still be opportunity to provide more simplified materials to enhance effectiveness.
3. It is unclear whether there is any form of induction training for new RAB and MSAB members but developing training materials for all aspects of IPHC science and science process might be considered given the high degree of ongoing stakeholder engagement.
4. Assisting the Commission to understand the technical basis of the SA and annual advice, in particular why it is of a different form that many participants experience elsewhere.

5. The SRB is expert and functions well as a peer review body but formal procedures (fixed, renewable terms) to ensure continuity and turnover would provide greater confidence in SRB independence.
6. IPHC decision-making is annual (tactical), based on objective and currently trusted science. Past experience of a changing scientific base has led to the adoption of a consistent ensemble model approach to providing the scientific basis for decision-making. This is good but potentially (though not currently) could lead to stagnation in the stock assessment area. The move towards strategic decision-making and management based on Management Strategy Evaluation (MSE) and a clear Harvest Strategy Policy is a major opportunity to reduce tactical and contentious decision-making and hence also to free up capacity and capability used in the intensive annual stock assessment processes. Using that capacity and capability for more forward-looking research and stock assessment development would likely lead to further improved scientific advice long-term.
7. Transparency is a strong attribute of all IPHC work, particularly since 2017. The scope and quality of science documentation is impressive. However, as is common in fisheries, the science products are generally restricted to internal ("grey literature") documents. There is considerable opportunity for much of the IPHC science to be published in primary literature, providing further peer review and credibility but also motivation for Secretariat staff.
8. While the 5-year research plan includes work on migration within the IPHC Convention Area it does not include anything on stock definition. As noted in the independent review of the IPHC stock assessment (IPHC, 2019j), opportunities for liaison between the IPHC and scientists working on eastern Pacific halibut should be explored and encouraged.

Risks:

1. The IPHC currently has high caliber, motivated science staff working on biological and ecosystem research, survey and other analyses, stock assessment, and MSE. Staff work collaboratively within IPHC and with outside agencies. Comments made as part of the PRIPHC02 process signal high respect for and trust in science staff. The current high level of trust is a function of processes *per se* but also of staff and staff leadership. No signals of staff dissatisfaction have been noted but staff retention is critical to continued quality and trust by stakeholders and Commissioners. Further comment would impact on management more than process.
2. Similar to *Risks* (1), the SRB provides a key function of peer review to ensure the relevance, integrity, objectivity and reliability of the science outputs. Ensuring continuity is critical though needs to be balanced against potential perceptions of the SRB as an internal, collegiate science advisory body. The recent strengthening of the SRB is a positive step and signal of Secretariat understanding and oversight of the processes that needs to be maintained. Nevertheless, the lack of a formal means of ensuring a balance between continuity and turnover of SRB membership is a risk that should be mitigated.
3. The stakeholder and Commission in MSE development, together with exceptional Secretariat capability and SRB oversight, puts the IPHC in a strong position to develop and implement strategic management options. The full power of MSE will be gained if

multi-annual allocation decisions are embedded into developed management strategies. If they are not, then the need for annual decision-support tools will remain, potentially putting at risk not just management gains but also the credibility of science processes and motivation of science staff.

4. Lack of engagement between IPHC and eastern Pacific halibut science and management agencies could undermine the relevance (see Objective 2) of science carries out and advice provided.

OBJECTIVE 4) Assess the consistency between scientific advice and management measures adopted by the Commission.

IPHC Fishery Regulations are updated annually. The latest regulations are available at: *https://www.iphc.int/the-commission/fishery-regulations/*. Assessing the consistency between scientific advice and management measures adopted into the regulations involves consideration of the advice made through proposals and subsequent decisions by the Commission, which can be seen through reports of Annual Meetings. Note that the IPHC is not a management agency and the Fishery Regulations are given effect by the Contracting Parties. No consideration is made here of implementation of measures by Contracting Parties and whether those are consistent with the regulations; that is considered a matter of compliance rather than science process.

Proposals for amendment of the regulations are made by the Secretariat, national agencies, and stakeholders. All proposals are publicly available. For the 94th (2018) and 95th (2019) Sessions of the Annual Meetings, proposals are in individual files and are available at:
2018:*https://www.iphc.int/venues/details/95th-session-of-the-iphc-annual-meeting-am095*
2019:*https://www.iphc.int/venues/details/94th-session-of-the-iphc-annual-meeting-am094*

For the 93rd Session (2017), proposals were merged into a single paper (IPHC, 2017c), supported by a presentation available at: https://www.iphc.int/uploads/pdf/am/2017am/iphc-2017-am093-10-p.pdf

Most proposals are minor and do not involve scientific advice. Non-minor proposals other than related to catch limits are few. In 2017, the Secretariat proposed a regulatory change to require Pacific halibut are landed with heads on, primarily to improve the estimate of total removals. Advice was provided and the Commission adopted the proposal (IPHC, 2017; para 48), a clear example of consistency between science-based advice and adoption of a management measure.

In 2017 the Secretariat also proposed removal of a closed area in the Bering Sea on the basis that there is no scientific basis for the purported intent of protecting a nursery area. The closed area has considerable history and was reviewed in the late 1990s and again between 2011 and 2013. At its 2017 Annual meeting the Commission did not adopt the proposal, noting differing

views of the PAB and CB. The Secretariat provided further information in its 2018 proposals but the Commission did not adopt the proposed changes, though noting the closed area is not currently meeting its intended objective of protecting juvenile Pacific halibut while it is open to non-directed fisheries (managed by the North Pacific Fisheries Management Council, NPFMC). Noting ongoing work by the NPFMC, the Commission agreed the closed area proposal should be reconsidered at subsequent meetings of the Commission, but no later than in 2020. No proposals were therefore made, or information provided to the 2019 Annual Meeting. Lack of progress on the closed area proposal should not be construed as a lack of consistency between scientific advice and management measures. The advice is that there is no scientific basis for retaining the closure, but scientific advice that the closure should be removed is yet to be presented. Further, there is a set of competing commercial and other interests, and inter-agency responsibilities that impact on decision-making.

With regard to catch limits, as commented above at Objective 1 (Recommendation 8.2) and Objective 2 (Relevance), the Secretariat has followed the recommendation of PRIPHC01 and has successfully delineated between scientific analysis and policy options. Stock assessments provide a consistent and robust foundation for provided decision-support materials. For the 2019 Annual Meeting, provided reports include the stock assessment (IPHC, 2019d), fishery status (IPHC, 2019e), the mortality projection tool (IPHC, 2019f), and additional information papers on the treatment of and projection consequences for dealing with discard and bycatch mortality (IPHC, 2019g; IPHC, 2019h). In addition, the Commission is also guided by the Harvest Strategy Policy (IPHC, 2019i).

Commission discussions on catch limits and allocation are extensively reported in the reports of Annual Meetings and in 2018 no decision was made, with 2017 limits being carried over. Discussions in 2019 were lengthy but a decision was made with clear reference to the decision-support materials, including information papers. Also apparent in the consolidated recommendations in the 2019 Annual report (at IPHC, 2019b, Appendix IX) is that the issue of unaccounted discarding of small and bycaught fish is creating tension at a time when catch limits are declining. Despite such tensions, and the complex underlying structure of fishery interests, the Commission has also made recommendations on MSE and to the MSAB, with a clear signal of intent with respect to the use of science-based and well-ordered future decision-making.

Because the IPHC science branches provide decision-support materials rather than definitive advice, it is difficult to assess comprehensively or categorically whether there is consistency between scientific advice and management measures adopted by the Commission.

From the evidence available, however, it is clear that scientific decision-support is at the heart of Commission decision-making and that decisions taken are respectful of the science. There is no evidence of any systematic departure from scientific advice.

OBJECTIVE 5) Make recommendations on how to improve the IPHC science process to meet or exceed international best practice.

As noted above, compared against international best practice there are no significant weaknesses in the IPHC science processes; indeed, the processes have been modified and strengthened since PRIPHC01 to the point where one Commissioner commented that "[There has been a] *95% improvement since 2012 and there is not a lot more to squeeze. It's in a pretty good place.*" Only one interviewee has suggested further gains in transparency and stakeholder engagement might be made, primarily by provision of simplified communication.

The IPHC Secretariat science staff are trusted and the science processes are robust. Implementation, as evidenced by transparent documentation and reports, and interviews with Secretariat staff, the SRB and Commissioners, is good. International best practice is already met (see Objective 2) and it is arguable that the IPHC is at the forefront of RFMO science processes. A key strength is in the provision for extensive stakeholder engagement, made possible by the single stock, two CP, common language and contiguous fisheries nature of the IPHC. Other RFMOs provide various forms of science process but none include such strong stakeholder engagement. The robustness and credibility of the IPHC science processes and science products is further strengthened by the unique peer review mechanism (the SRB) that ensures the science remains relevant and has integrity, objectivity and reliability.

At its heart, the IPHC science processes have strong capacity and high caliber science capability within the Secretariat. Secretariat scientists have access to data, internal and external research opportunities, and a dedicated annual survey to inform stock assessment. The Secretariat provides high quality and relevant tools to inform decision-making with a clear separation of the science from policy decisions.

Recommendations below are fundamentally to maintain current practice.

Recommendations

1. Maintain the existing, highly credible science capacity and capability of the Secretariat, while strengthening as appropriate to meet specific future needs (e.g. in economics).
2. When revisiting PRIPHC01 Recommendation 3.1 on unifying subsidiary bodies, treat the CB and PAB as non-science process and maintain separated RAB and MSAB at least until 2021 adoption and implementation of a new management strategy.
3. Ensure continued support for high quality stakeholder engagement through the science-focused subsidiary bodies (RAB and MSAB) or any future subsidiary bodies.
4. Consider development of simplified materials for RAB and especially MSAB use, including training/induction materials. The RAB and MSAB mechanisms are robust but the members need to be fully supported to enable successful engagement.
5. Convene a science communication meeting annually (e.g., ED to chair with subsidiary body chairs, selected Commissioners and selected science staff) to agree

on stakeholder and Commission communication needs and develop an annual science communication and training plan for stakeholders and Commissioners.

6. Consider options for simple graphical summary (phase plot equivalents) of fishing intensity and spawning stock biomass OR provide an explanation to the Commission of why such a plot cannot be used for Pacific halibut.
7. Maintain the current strategic approach to biological and ecosystem research, with clear pathways to stock assessment and MSE. Note that MSE might be used to identify the cost-benefits of future research.
8. Ensure continued high-quality peer review through the SRB mechanism and appropriate membership. The SRB mechanism itself does not guarantee the quality and credibility of IPHC science but is also dependent on its membership. The current membership of the SRB is of a high standard with complementary attributes; this standard should be maintained and strengthened as necessary. However, consideration should be given to amending the Rules of Procedure to include fixed terms of service to ensure peer review remains independent and fresh; a fixed term of three years seems appropriate, perhaps with no more than one renewal.
9. Complement SRB provided peer review through occasional, fully independent external subject specific reviews. Current candidates for review are data quality and standards, the FISS, MSE, and the biological program. Review of MSE prior to adoption is advised.
10. Encourage, where appropriate, converting internal science documents to primary literature publications to further enhance peer review.
11. Continue development of MSE to underpin multi-annual (strategic) decision-making and, as multi-annual decision making is implemented, current Secretariat capacity usage for annual stock assessments should be refocused on research to investigate MSE operating model development (including consideration of biological and fishery uncertainties) for future MSE iterations and regularized multi-annual stock assessments.
12. Seek opportunities to engage with eastern Pacific halibut science and management agencies to strengthen science links and appropriate data exchange. Specifically, consider options to investigate pan Pacific stock structure and migration of Pacific halibut.

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