Executive Secretary's Summary of Decisions

31st Annual Meeting

February 8-12, 2016; Vancouver, B.C.

The Pacific Salmon Commission held its 31st Annual Meeting from February 8-12, 2016 at the Hyatt Regency Hotel in Vancouver, B.C., and discussed a number of topics (see attached agenda).

The Commission AGREED:

1. The minutes from January 2016 are approved as edited by the National Sections.

2. The Concept Paper regarding perspectives on renewal of Chapter 3 is approved as edited.

3. The February 10, 2016 Chinook Interface Group (CIG) action plan for transition to the new Chinook model is approved.

4. The metrics for use in the Chinook model calibration assessment, as provided by the Chinook Interface Group on February 10, 2016, are approved.

5. The Executive Secretary's proposal regarding enhancement activities reporting is approved, namely: a) the Commission confirms that Article V reporting requirements are met through the current electronic exchange of data; b) communication between the Parties, the Commission, and the Panels already occurs through established channels; and c) a revised annual work plan template is adopted to highlight new issues for the Commission's attention.

6. The proposal for Commission engagement on the Larry Rutter Memorial Award is approved, pending input from the Joint Fund Committee and any associated edits.

7. The February 11, 2016 proposal from the CIG for a process to provide PSC guidance on Very High Priority Chinook Projects for 2017 and 2018 is approved.

8. The CTC shall provide timely strategic advice and cost estimates for 2017 Very High Priority Chinook Projects. The Executive Secretary shall arrange a virtual meeting for the Commission to discuss associated guidance on 2017 funding needs and priorities to transmit to the Joint Fund Committee.

9. The Committee on Scientific Cooperation's February 10, 2016 proposed tasks to monitor environmental anomalies deserve further attention, and will be reconsidered at the 2016 Fall Meeting. In the meantime, the CSC is directed to begin on Task 1 and the Pacific Salmon Foundation will contribute financial assistance to facilitate task 1a and 1b (documenting 2015 anomalies) to guide Commission decisions at the 2016 Fall Meeting.

10. The report of the Standing Committee on Finance and Administration is accepted, including the budget for fiscal year 2016/2017.

11. The U.S. Section will provide Canada a report on the 2015 Southeast Alaska (SEAK) Chinook fishery.

12. The recommendations from the Chinook Interface Group are accepted, namely: 1) the CTC will revise the maturity rates and environmental variables used in the Chinook model consistent with the findings in PSC report TCCHINOOK (16)-01 for use in the 2016 management cycle; and 2) the report of the *ad hoc* CTC subcommittee on the winter troll model shall be revised for technical errors and subsequently posted as part of this meeting's attendant documents.

ATTENDANCE

PACIFIC SALMON COMMISSION
ANNUAL MEETING
FEBRUARY 8-12, 2016
HYATT REGENCY VANCOUVER
VANCOUVER, B.C.

COMMISSIONERS

UNITED STATES	CANADA
P. Anderson (Chair)	S. Farlinger (Vice Chair)
W.R. Allen	B. Assu
W. Auger	J. McCulloch
M. Clark	M. Ned
R. Klumph	R. Reid
M. Oatman	B. Rezansoff
C. Swanton	B. Riddell
B. Turner	P. Sprout

Agenda
31st Annual Meeting
February 8-12, 2016
Vancouver, B.C.

1. Adoption of Agenda

2. Approval of minutes: January 2016

3. Executive Secretary's report

Action Items Pending

4. Chinook

   a. Perspectives on renewal of Chapter 3 (based on exchange of documents in January 2016)

      1. Concept paper

      2. Paragraph-by-paragraph paper

   b. Model improvement tasks (from October 2015 direction to CTC)

      1. Final report on maturation rates and environmental variable analyses/recommendations

      2. Progress on Chapter 3 performance evaluation

   c. CIG action plan on transition to new Chinook model

      1. Approve action plan

      2. Transition task 1: finalize list of metrics for use in calibration assessment

   d. Very High Priority Chinook Projects: 2017-2018 process options

   e. Update on Canadian WCVI troll fishery mitigation program (Annex IV, Ch. 3, par. 4)

5. Update from Fraser Strategic Review Committee

6. Enhancement activities reporting

   a. Data availability and comparability

   b. Website links

7. Larry Rutter Award: proposal for implementation

Reports from Panels and Committees

8. Annual Reports on Work Plans – Panels and Technical Committees

9. Selective Fisheries Evaluation Committee: Lessons Learned report

10. CSC progress report on environmental indicator data

11. Joint Fund Committee

12. Standing Committee on Finance and Administration

Other Business

14. Public comments as needed

Agenda Item 4.a.1. Chinook, Perspectives on renewal of Chapter 3, Concept paper

Final: Adopted in Bilateral Commissioner, February 10, 2016

Pacific Salmon Treaty
Chapter 3 - Chinook Salmon

Commission's Perspective on Renewal of Chapter 3

1. Introduction

The provisions of Annex IV Chapter 3: Chinook Salmon apply for the period 2009 through 2018. This paper describes the Parties' joint perspective on the process for renewing the chapter and the provisions that may be in need of amendment and is intended to assist in the development a mutually-agreed approach to negotiations.

2. Factors Guiding the Parties in the Negotiations

The Parties have identified a number of factors that will guide its negotiations on the renewal of Chapter 3.

Conservation and Sustainable Use - The Parties are interested in an outcome that addresses management of conservation concerns in both countries and supports long term sustainable harvests by both parties.[1]

Consistency – Adoption of a consistent approach in responding to similar issues/circumstances in both countries (e.g., limiting the interceptions of one party in response to conservation concerns regarding stocks originating in the other party's waters) to achieve balanced outcomes with respect to both parties responding to conservation concerns and benefitting from the actions taken.

Ability to Implement – Provisions of Chapter 3 must be both technically and financially feasible.

Working Relationship – A renewed chapter should foster a positive working relationship between Canada and the USA and encourage collaboration.

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[1] The Parties are committed to the Treaty principal of "conservation and rational management" but have found domestic constituencies define "conservation" in a variety of ways. The Parties seek to avoid in this document an opportunity for dispute about the definition of conservation by focusing this sentence on "management."

Comprehensiveness – A comprehensive approach will be taken to renew chapters (i.e., all chapters will remain under negotiation until an overall agreement is reached).

Flexibility – There should be flexibility to adjust the renewed Chinook chapter in the future before it expires, subject to bilateral agreement.

Environmental Conditions – Climate change is anticipated to result in increased variability in ocean conditions, stock abundances and stock distribution. The Parties commit to explore avenues by which a renewed chapter can account for this type of uncertainty and avoid unwarranted escalation of chinook mortalities.

3. Overall Approach to Negotiations

It would be helpful to review the performance of the current chapter to inform the upcoming negotiations. In particular, the Parties are interested in understanding the extent to which Chapter 3 has benefitted naturally spawning Chinook stocks under the jurisdiction of the chapter. Presently, some stocks are producing at levels below their potential and cannot sustain fisheries observed previously. A review could also be helpful in identifying provisions of Chapter 3 that are difficult to interpret or have proven impractical to implement.

The Parties support maintaining the abundance-based coast wide Chinook management regime which includes a combination of AABM responsibilities based on stock aggregation and ISBM obligations.

In addition, the Parties suggest that potential improvements to Chapter 3 should focus on the following:
   a) Responding to a common understanding of the performance of the Chapter. The Parties have agreed that the Performance Review is the vehicle for providing that information and commit to completing the Review as soon as possible.
   b) Taking coordinated bilateral action to maintain a viable coast-wide Coded Wire Tag (CWT) system as required by a 1985 Memorandum of Understanding between the United States and Canada;
   c) Improving the accuracy, reliability and timeliness of abundance estimates generated by the Chinook model;
   d) Clarifying provisions of the chapter that are difficult to interpret and removing provisions that are not practicable to implement; and,
   e) Collaborating on funding arrangements to implement the provisions of Chapter 3.

The overall approach recognizes conservation concerns associated with many natural Chinook salmon stocks originating in both countries and harvested in fisheries. In addition, the suggested approach reflects recent PSC discussions regarding a range of technical, operational and financial matters.

February 10, 2016

From: Bilateral Chinook Interface Group

To: Pacific Salmon Commission

RE: Development of action plan regarding the anticipated process and potential timeline for continued use of the current PSC Chinook model and the needed evaluation and subsequent transition to relying on the new revised PSC Chinook model.

Charge: <u>The CIG will develop an action plan for consideration in January 2016 by the Pacific Salmon Commission that includes:</u>

(1) *Consideration, if appropriate, of performance standards for evaluation of the new PSC Chinook model.*
   a. *The performance of the new model will be assessed using two general procedures:*

      i. *Calibration Assessment. A comparison of how well estimates from the new and the current model match-up with other stock assessment information.*

      ii. *Hindcasting Assessment. A comparison of the performance of preseason and postseason predictions of abundance indices (and other indices as recommended by the Chinook Technical Committee) for the new and the current model.*

   b. *The calibration assessment will be completed for the years 1999 through 2015 and will compare model performance for metrics such as catch distribution (model and CWT), terminal runs (model and run reconstruction), brood and fishery exploitation rates (model and CWT), and stock composition (model and genetic, as appropriate). Statistical measures may include mean percent error, mean absolute percent error, and/or mean squared error.*

   c. *The hindcasting assessment will be completed for the years 2004 through 2015 and will include comparisons for the new and old model of:*

      i. *the similarity of preseason and postseason predictions of abundance indices;*

      ii. *time series of the postseason predictions of abundance indices for the new and current models; and*

      iii. *the similarity of preseason and postseason abundance indices with independent estimates of abundance or indices of abundance.*

1

(2) General description of the tasks associated with supporting the transition to reliance on the new Chinook model.

Task 1. CTC, CIG, PSC Commissioners. Finalize list of metrics for use in calibration assessment (Appendix A).

Task 2. CTC. Complete base period calibration with new stock groups (Phase 1), fisheries (Phase 2), and a review of the base period data, taking into consideration the requirements of Phase 3.

Task 3. CTC. Complete preliminary calibration assessment as described in 1(b) with a detailed assessment of the performance of each model, the identification of deviations between the models, and views of why those deviations occur.

Task 4. CTC. To identify any changes to calibration procedures or model structure that are intended to improve model performance or management utility in the short-term (prior to June 2017) or long-term (including the implementation of Phase 3).

Task 5. CTC. Complete final calibration assessment as described in 1(b) with a detailed assessment of the performance of each model, the identification of deviations between the models, and views of why those deviations occur.

Task 6. CTC. Complete hindcasting assessment as described in 1(c) with a detailed assessment of the performance of each model, the identification of deviations between the models, and views of why those deviations occur.

Task 7. CTC, CIG, Commissioners. Determine the appropriate method of translating Table 1 of the agreement from the current model to the new model.

Task 8. Commissioners. Determine role of new and/or current model during the remainder of the negotiations.

Task 9. Commissioners. Determine the role of the new and/or current model in implementation of the updated Chinook Chapter.

Task 10. CTC. Complete a written report that includes all data, methods, and programs used for the base period calibration.

(3) Develop a potential timeline describing the continued use of the existing PSC Chinook model and subsequent transition to use of the new PSC Chinook model.

Task 1. 2016 Annual Meeting. Task 1. CTC provides to the CIG and Commissioners a list of recommended metrics that will be used in the calibration assessment. CIG and Commissioners identify final list of metrics.

Task 2. October 2016 PSC Executive Meeting. CTC completes Phase 1 and Phase 2 of the base period calibration.

Task 3. October 2016 PSC Executive Meeting. CTC completes preliminary calibration assessment and provides briefing to CIG and PSC Commissioners.

Task 4. October 2016 PSC Executive Meeting. CTC recommends changes to calibration procedures or model structure. Commissioners provide direction regarding short and long-term implementation.

Task 5. January 2017 PSC Post-Season Meeting. CTC completes final calibration assessment and provides briefing to CIG and PSC Commissioners.

Task 6. January 2017 PSC Postseason Meeting. CTC completes hindcasting assessment completed and provides briefing to CIG and PSC Commissioners.

Task 7. June 2017. CTC recommends appropriate method of translating Table 1 of the agreement from the current model to the new model.   Commissioners provide preliminary direction regarding translation methods for remainder of negotiations.

Task 8. June 2017. Commissioners provide direction regarding the role of new and/or current model during the remainder of the negotiations.

Task 9. January 2018 PSC Postseason Meeting. Commissioners provide direction on the role of the new and/or current model in implementation of the updated Chinook Chapter in 2019.

Task 10. June 2018. CTC provides to Commissioners written documentation of calibration of model used in negotiating updated Chinook Chapter.

Appendix A. Task 1 Response – CTC Model Phase 2 Comparison/Evaluation Diagnostics

1. **Abundance Indices**
2. **Retrospective Exercise**
3. **Brook-year exploitation rate by stock, age and fishery between models and CWTs.**
   a. **Evaluate by terminal and pre-terminal**
4. **Comparison of stock composition between models.**
   a. **Compare to GSI data where available.**
5. **Comparison of terminal runs and escapement.**
6. **Cohort sizes.**
7. **Catches.**
8. **EVs**
   a. **Time series.**
   b. **Correlation with CWT survival indices.**

Proposal for sharing enhancement data as per the Pacific Salmon Treaty

Prepared by the Secretariat

February 3, 2016

<u>**Treaty requirements on enhancement reporting**</u>

Reporting enhancement activities is a requirement under Article V of the Pacific Salmon Treaty.

"*Article V: Salmon Enhancement Programs*

1. *Salmon enhancement programs that may be established by the Parties shall be conducted subject to the provisions of Article III.*

2. *Each year each Party shall provide to the other Party and to the Commission information pertaining, inter alia, to: (a) operations of and plans for existing projects; (b) plans for new projects; and(c)its views concerning the other Party's salmon enhancement projects.*

The Commission shall forward this information to the appropriate Panels.

3. *The Panels shall examine the information and report their views to the Commission in light of the obligations set forth in Article III.*

4. *The Commission shall review the reports of the Panels and may make recommendations to the Parties."*

<u>**Recent Commission discussions regarding Article V**</u>

At its October 2015 and January 2016 meetings, the Commission considered the history of reporting under Article V (see Attachment 1). It was agreed that transmission of enhancement data through written reports was obsolete in light of online electronic databases now maintained by each Party. Commissioners expressed concern over possible bilateral inconsistencies in terminology and data formats, and directed the Executive Secretary to coordinate with the Data Sharing Technical Committee to develop a proposal on the matter. This document responds to that directive.

<u>**Status of national databases and data sharing**</u>

Each Party maintains online data reports of hatchery activities (enhancement plans, species, numbers, release stage, release strategy, etc.). There is also a bilateral data exchange process and

both countries maintain databases containing the full set of information exchanged under agreed protocols. The Canadian data base is known as the Mark Recovery Program Information System (MRP) and is maintained by Fisheries and Oceans Canada. The U.S. database is known as the Regional Mark Information System (RMIS) and is maintained by the Pacific States Marine Fisheries Commission via its Regional Mark Processing Center (RMPC). Only RMIS can be accessed through an online query tool. Links to key programs are listed in Attachment 2.

According to the Data Sharing Technical Committee, a query to either MRP or the RMIS online database should be sufficient for purposes of the Coho Technical, Chinook Technical, and Selective Fisheries Evaluation Committee members.

Bilateral data exchange of enhancement information is coastwide according to standard format specifications. Canadian data for all species is complete and recent U.S. reports of releases of Chinook and Coho to the RMIS are believed to be complete. Historic U.S. data for Chinook and Coho is the best available, although it is acknowledged that some historic data may be missing or incomplete. Nonetheless, the RMIS data is sufficient for current assessment needs and historical gaps are not considered to be catastrophic.

The two data fields likely to be most problematic for cross-agency consistency are release stage and release strategy. The bi-lateral data sharing exchange formats allow agencies to select from multiple choices for these fields but neither fields are required, and since 1989 (see PSC report TCDS 89-1), it has been accepted bi-laterally that interpretation of release stage is agency-specific.

Proposal

The spirit of Article V in the Pacific Salmon Treaty is to:

1. ensure that the Parties regularly share their plans and data for national enhancement activities;
2. prompt the Panels to consider this information on an ongoing basis; and
3. direct the Panels to alert the Commission to any relevant issues that may affect bilateral Treaty implementation.

Given the accessibility and bilateral nature of the current data exchange process, it seems clear that the Parties are meeting Article V's first objective. The Parties could meet the second and third objectives without developing a new procedure for the Panels and the Commission. Specifically, the Commission could direct the Panels to consider enhancement issues (as informed by the RMIS and MRP, e.g.) through their annual work plans and report to the Commission as appropriate each February (at the annual meeting, as usual). The PSC work plan template could be amended slightly to "flag" enhancement as an area of interest (as shown in Attachment 3).

The Secretariat recommends that the Commission:

- Confirm that national reporting under Article V is currently accomplished through the RMIS online database or the MRP;
- Continue resolution of any issues around data definitions within the Data Sharing Technical Committee;
- Confirm that communication between the Parties, the Commission, and the Panels (as a principle in Article V) already occurs through established channels; and
- Adopt a revised work plan template for Panels and Committees to report annually as appropriate on enhancement activities.

History of reporting under Article V

1. **1986**: The Parties exchanged their first enhancement reports.

2. **1988**: The Commission formed a committee to develop recommendations for the pre- and post-season and enhancement report formats. In summary, the committee proposed that:

   - detailed reports on existing enhancement facilities of the type produced in 1987 be prepared every four years;

   - the Parties will annually update information on eggs taken, fry or smolts released, and adults taken to facilities. Significant changes in facility mission or production will be highlighted in narratives; and

   - the Parties will provide periodic reports through the appropriate Panels on new enhancement plans.

3. **1989-2003**: Enhancement reports were exchanged annually. The last enhancement report submitted by the U.S. was for the year 2003. The last enhancement report submitted by Canada was for 2005.

4. In the years during which enhancement reports were exchanged, the practice was to table the reports annually at a Commission meeting. Report executive summaries were included in each PSC Annual Report.

5. **2004**:

   - At the October 2004 Commission meeting, the U.S. Section raised concerns about the usefulness of the enhancement reports. The U.S. believed that while both Parties put a lot of effort into compiling the reports, it was unclear about how the information was being used and by whom.

   - Canada agreed and the Commission instructed the Southern Panel to conduct a review of the Parties' enhancement reports as described in Article V of the Treaty. The Panel was directed to provide recommendations about how to modify or refine the format and content of the reports in order to ensure that they provided value and that the process of compiling the reports was streamlined.

6. **2005**:

   - At the February 2005 meeting, the Southern Panel Chair and Vice Chair reported that the Panel was in the process of reviewing the enhancement reports and hoped to make them more useful because at that time, the Panel believed that they provide little utility.

   - At the October 2005 meeting, the Commission learned that the Southern Panel had generated some recommendations about the annual enhancement report process, focusing on improving the utility of the reports and determining if there

was a better process to follow in providing information on enhancement activities annually.

- The Commission agreed that the Southern Panel's recommendations would be passed on to the Commission's other three Panels (Transboundary, Northern, and Fraser River). Those Panels would review and comment on the recommendations. If the Panels concurred with the Southern Panel's suggested approach, the Southern Panel would more fully develop recommendations for the Commission's consideration.

7. **2006**:

- At the February 2006 meeting, the Southern Panel presented "Southern Panel Enhancement Report Recommendations." (Attached)

- The Southern Panel had consolidated the comments from the other three Panels about the utility of the annual enhancement reports. The Panels concurred that the reports should be condensed, made more useable and more consistent on both sides, and that they should center upon issues of major significant change. The result would be more useable and understandable annual enhancement reports.

8. The Commission adopted the Southern Panel Enhancement Report Recommendation.

Since this 2006 agreement, neither Party has submitted a report to the Commission on their enhancement activities. At the February 2015 Annual Meeting, the Southern Panel raised questions about its role or mandate to review enhancement data under Article V. The Commission considered the issue in January 2016 and directed the Secretariat to develop a proposal on the matter. Specifically, in conjunction with the Data Sharing Technical Committee, the Secretariat was to propose how the Parties may best meet the requirements of Article V in light of accessible electronic databases, consistent national terminology, and Panel/Committee needs.

Attachment 2

Online sources of national enhancement activities

Bilateral – Regional Mark Processing Center

- http://www.rmpc.org

Canada

Salmonid Enhancement Program (SEP)

- http://www.pac.dfo-mpo.gc.ca/sep-pmvs/ifmp-pgip-eng.html
- http://www.pac.dfo-mpo.gc.ca/sep-pmvs/data-donnees/SC&NC-IFMP-2015-PSR.htm

United States

Columbia Basin Fish Passage Center

- http://www.fpc.org/
- http://www.fpc.org/hatchery/Hatchery_Queries_v2.html

Alaska

- http://mtalab.adfg.alaska.gov/CWT/reports/default.asp

Revised PSC Work Plan Template (see highlighted revision in brackets)

Panel / Committee:

Identify the name of the Panel/Committee as well as who it reports to.

e.g. Transboundary Technical Committee reports to the Transboundary Panel.

Date: *This is the date of the Commission meetings where the Work Plan will be presented (Annual Meeting), updated (Executive Session) and reported (Post Season).*

Update on Bi-lateral Tasks Assigned Under Current PSC Agreement:

List the Tasks and provide a brief update (up to 20 lines) on each.

Obstacles to Completing above Bi-lateral Tasks:

Note the Task and the issue preventing the completion the Task, along with recommendations, where appropriate, for how the Commission can remove these obstacles.

Outline of Other Panel / Committee Tasks or Emerging Issues:

Highlight issues that have significance to the Treaty and that may have to be considered by this Panel/Committee in future work plans.

Potential Issues for Commissioners, including enhancement activities reported under Article V:

Highlight any issues that the Panel/Committee has identified that may come to the attention of the Commissioners for resolution.

Potential Issues for Committee on Scientific Cooperation

Highlight any scientific issues that the Panel/Committee believes may benefit from CSC input or collaboration.

Proposed Meeting Dates and Draft Agendas:

Note the meeting schedule for the year and how the schedule of these meetings and the work in the intervening periods will lead to the completion of the assigned Tasks.

Status of Technical or Annual Reports: *Note the reports scheduled for completion during the year and the progress toward completing them. Identify any impediments to completing these reports where not included in "Obstacles to Completing above Bi-Lateral Tasks", above.*

Comments: *Include any additional comments not included above that you think that would be useful to the Commissioners.*

Memorandum

From: PSC Chair and Vice Chair, Phil Anderson and Susan Farlinger
To: Joint Fund Committee; PSC Commissioners
Subject: Larry Rutter Memorial Award for Pacific Salmon Conservation – Pacific
           Salmon Commission initiative

The Pacific Salmon Commission (PSC) commends the Joint Fund Committee (JFC) for initiating the Larry Rutter Memorial Award for Pacific Salmon Conservation in 2016 and further accepts the JFC's offer that the PSC takes ownership of the initiative in 2017 and beyond. At its 31st Annual Meeting, the PSC will consider the below proposal to implement the award as a PSC initiative, which was jointly developed by the PSC's Chair and Vice Chair, Phil Anderson and Susan Farlinger. The PSC welcomes the JFC's review and comment on the below proposal concurrent with or following the PSC's subject discussion at its 31st Annual Meeting.

PSC proposal to implement the Larry Rutter Memorial Award for Pacific Salmon
Conservation in 2017 and beyond:

In its below proposal, the PSC considers three annual responsibilities for implementing the Larry Rutter Memorial Award for Pacific Salmon Conservation as a PSC initiative in 2017 and beyond: 1) award selection; 2) award presentation; and 3) budget.

Award Selection:
The PSC proposes to convene an Award Selection Committee composed of balanced representation between the PSC and JFC, composed of two designees from the PSC, one or two individuals from the JFC, and the Executive Secretary. The Award Selection Committee would be charged with the tasks of:
   1) Soliciting nominations (fall); and
   2) Reviewing nominations and selecting a nominee to the award (January), annually.

The Award Selection Committee would convene its business virtually regarding nomination reviews and selection of a nominee.

The PSC would either update and adopt the nomination form used by the JFC in 2016 (attached) or direct the Award Selection Committee to review and adopt the form inclusive of revised selection criteria, as appropriate. The selection criteria used in 2016 are excerpted below:

> "The award will be granted annually to an individual or organization that has:
>   1. Significantly advanced U.S./Canadian understanding of salmon biology
>   or ecology;
>   2. Made notable contributions to resolving U.S./Canadian issues or
>   disputes regarding salmon management;
>   3. Increased public awareness of salmon conservation, the Pacific Salmon
>   Treaty, the PSC, and related initiatives; or

4. Otherwise helped ensure a sustainable and resilient Pacific salmon resource for the people of Canada and the United States."

Award Presentation:
Consistent with the timing of award presentation for 2016, the PSC would present the 2017 and subsequent awards at its Annual Meeting. The PSC proposes to incorporate presentation of the award into a bilateral session of its Annual Meeting, which would be inclusive of opening remarks and an opportunity for the awardee to speak or present to the PSC on their achievement. All of the Committees and Panels of the PSC would be invited to the award presentation, to be held in a large ballroom. The Secretariat would consider options of a no-host bar or a coffee station following the award presentation. The awardee may also be invited to join a dinner reservation with PSC Chair, Vice Chair, interested Commissioners, and the Executive Secretary for an evening celebration.

Budget:
The PSC proposes that the initiative should not burden the Parties, JFC, or Secretariat Office budgets. As such, the only costs assumed would be payment of travel and per diem for the awardee to attend the award presentation (the Party from whence the winner originates), payment for the award or plaque by the Secretariat, and the award presentation as described above would proceed.

Recommendation:
Following comment by the JFC, adopt proposal, confirm list of members to the Award Selection Committee, and verify its process and criteria for award selection.

Attachment: 2016 Nomination Form

**Nomination Form
for the 1st Annual Larry Rutter Memorial Award for
Pacific Salmon Conservation**

_____

Background

Larry Rutter was a fixture in Pacific salmon conservation and management for more than three decades until his untimely death in 2014. It is difficult to describe fully the impact Larry's work had on the institutions and people involved with this valuable resource. From the early 1970's until 1997, he worked for and with the Treaty Indian Tribes of the U.S. Pacific Northwest to advance their interests and ideas as salmon co-managers. From 1997 until his passing, Larry worked for the U.S. National Marine Fisheries Service/NOAA Fisheries on salmon issues ranging from Endangered Species Act listings to Pacific Salmon Treaty negotiations. He served the last 12 years of that career as the U.S. Federal Commissioner to the Pacific Salmon Commission (PSC), as well as a "founding member" of the Southern Boundary Restoration and Enhancement Fund (SEF) Committee. Near the end of his career, Larry was convinced that substantial, multi-year funding was needed to study early marine survival of salmon stocks utilizing the Salish Sea. His foresight and dedication led to a $5 million, five-year SEF commitment for the bilateral Salish Sea Marine Survival Project. It is safe to say that Larry was a leading influence in how the Tribes, the United States, and Canada approached salmon management and research during the turn of the 21st century.

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The Northern Boundary and Transboundary Rivers Restoration and Enhancement Fund Committee and the Southern Boundary Restoration and Enhancement Fund Committee (together, the Joint Fund Committee) wishes to help memorialize Larry's lifetime of work including his leadership in the PSC, the Southern Fund Committee, and beyond. Accordingly, the Joint Fund Committee has established the <u>Larry Rutter Memorial Award in Pacific Salmon Conservation</u>.

The award will be granted annually to an individual or organization that has:

5. Significantly advanced U.S./Canadian understanding of salmon biology or ecology;
6. Made notable contributions to resolving U.S./Canadian issues or disputes regarding salmon management;
7. Increased public awareness of salmon conservation, the Pacific Salmon Treaty, the PSC, and related initiatives; or
8. Otherwise helped ensure a sustainable and resilient Pacific salmon resource for the people of Canada and the United States.

<u>Selection</u>

The Joint Fund Committee is soliciting nominations for the 2016 award (see attached form). The successful recipient will be notified the week of January 11, 2016, with an invitation to receive their award, expenses paid, in person at an evening reception during the PSC's 31st Annual Meeting in Vancouver (February 8-12, 2016; Hyatt Regency Vancouver).

All nomination forms must be received at the PSC Secretariat no later than January 4, 2016. Please email an electronic copy of the nomination form to Ms. Clare Rochfort at the PSC Secretariat at <u>rochfort@psc.org</u>. Questions about the award or the process can be conveyed to Mr. John Field, PSC Executive Secretary, at <u>field@psc.org</u> or 604 684 8081 ext. 622.

NOMINATION FORM
LARRY RUTTER MEMORIAL AWARD FOR PACIFIC SALMON
CONSERVATION

Nominee
Name:
Affiliation:
Address:
Phone:
Email:

Submitted by
Name:
Affiliation:
Address:
Phone:
Email:

<u>Narrative</u>
Please provide a concise justification (500 words or less) for the nominee, highlighting how they contributed to Pacific salmon conservation in one or more of the ways listed below:

1. *Significantly advanced U.S./Canadian understanding of salmon biology or ecology;*
2. *Made notable contributions to resolving U.S./Canadian issues or disputes regarding salmon management;*
3. *Increased public awareness of salmon conservation, the Pacific Salmon Treaty, the PSC, and related initiatives; or*
4. *Otherwise helped ensure a sustainable and resilient Pacific salmon resource for the people of Canada and the United States.*

Annual Report of the
Southern Boundary Restoration and Enhancement Fund and the
Northern Boundary and Transboundary Rivers Restoration and Enhancement Fund
for the year 2015.

Introduction

In June of 1999, the United States and Canada reached a comprehensive new agreement (the "1999 Agreement") under the 1985 Pacific Salmon Treaty. Among other provisions, the 1999 Agreement established two bilateral funds: the Northern Boundary and Transboundary Rivers Restoration and Enhancement Fund (Northern Fund); and the Southern Boundary Restoration and Enhancement Fund (Southern Fund). The purpose of the two funds is to support activities in both countries that develop improved information for fishery resource management, rehabilitate and restore marine and freshwater habitat, and enhance wild stock production through low technology techniques. The United States agreed to capitalize the Northern and Southern Funds in the amounts of $75 million U.S. and U.S. $65 million respectively. Canada also contributed CAN $500,000. The 1999 Agreement also established a Northern Fund Committee and a Southern Fund Committee, each comprised of three nationals from each country, to oversee investment of the Funds' assets and make decisions about expenditures on projects. Only the earnings from investments can be spent on projects.

Committee Members

Northern Fund Committee

Canada:

Steve Gotch
Tom Protheroe
John McCulloch

United States:

Doug Mecum
Bill Auger
Charlie Swanton

Southern Fund Committee

Canada:

Andrew Thomson
Don Hall
Mike Griswold

United States:

Larry Peck
Peter Dygert
Joe Oatman

Executive Summary

- Total contributed capital (nominal) was U.S. $140,065,000 (the equivalent of CDN $209,796,000 using the exchange rate at the time the last installment was made). Actual fund asset value at December 31st, 2015 was U.S. $193,520,000 or CDN $267,831,000.

- In 2015, the US economy had a year of strong economic growth and labour improvement while most other nations, especially in Europe, Japan, Canada and the emerging markets, struggled with softening growth and declining inflation. The Fund's net return exceeded the benchmark mainly due to the outperformance of the international equity and global infrastructure managers versus their respective benchmarks.

- In 2015 the Southern Fund Committee supported a total of 20 projects for U.S. $1.36 million and in addition provided U.S. $800,000 to the Salish Sea Marine Survival Program.

- In 2015 the Northern Fund Committee supported a total of 64 projects for U.S. $3.75 million.

- Responding to guidance provided by the Commission, U.S. $1.1 million was contributed to support six very high priority chinook projects in 2015. The Northern Fund contributed U.S. $604,000 and the Southern Fund contributed U.S. $511,710.

- Combined project spending by the Northern and Southern Funds slightly exceeded U.S. $7 million in 2015.

- Total Northern and Southern Fund project expenditures to date are U.S. $60.9 million, in support of 883 projects. In addition, the Funds have contributed U.S. $10 million to the Sentinel Stocks Program and U.S. 1.1 million to the very high priority chinook projects. The Southern Fund has contributed U.S. $2.6 million to the Salish Sea Marine Survival Program. Further, the Funds have contributed to infrastructure improvements at the PSC Secretariat including SharePoint installation and deployment and website redevelopment.

- In November 2015, Northern and Southern Fund Committee members met jointly once. In addition in 2015, the Northern Fund Committee met three times in separate session and the Southern Fund Committee met separately on three occasions and made one field trip.

- In the Northern Fund U.S. section Mr. Charlie Swanton replaced Ms. Stefanie Moreland and in the Northern Fund Canadian section Mr. John McCulloch replaced Mr. Mel Kotyk.

- Fund staff provided administrative services for the Yukon River Panel's U.S. $1.2 million Restoration and Enhancement Fund for a fifth year in 2015.

Investment Review

Strong global equity performance in the first quarter was aided by monetary policies that saw reduced interest rates in Canada and the Eurozone. The capacity to cut interest rates was aided by falling oil prices. However, a slowdown in U.S. growth added a new element of uncertainty. The U.S., which investors had relied upon to be the global growth engine, released some disappointing economic data, resulting in lower growth expectations. The total Fund's net returns exceeded the Benchmark return by +0.42% in U.S. dollars. The outperformance of the Infrastructure and International Equity managers versus their benchmark and underweighting bonds were the largest sources of value added.

Equity markets were buoyed early in the second quarter by central bank statements. The Federal Reserve ("Fed") stated that any interest rate rises would be gradual, with the first rate hike expected in late 2015. Also, the European Central Bank announced that quantitative easing would be ramped up before the summer trading lull. However, mounting concerns over Greece at the end of June resulted in a sharp selloff in equity markets when negotiations between Greece and its creditors broke down thus erasing the positive returns of April and May. However, over the quarter, the Total Fund's net return of +1.07% in U.S. dollar terms exceeded the Benchmark return by 70 basis points largely due to the outperformance of our International and Global equity managers.

Global equity markets were weak during the third quarter, with negative returns for equities in August and September prompted by worries over China. Japanese equities declined as their close trade ties with China weighed on the market. European equities were negative despite economic data from the region being relatively strong, but stock specific news from Volkswagen shook the market towards the end of the quarter. Emerging markets equities significantly underperformed affected both by weak Chinese demand for exports and their higher sensitivity to global risk appetites The Canadian dollar weakened sharply during the quarter dragged down by a combination of sliding commodity prices, an interest rate cut by the Bank of Canada and weak economic data. Over the quarter, the Total Fund's net return of -7.08% in U.S. dollar terms trailed the Benchmark return of -6.72%. The underperformance was primarily due to poor performance by the International Equity, Global Equity and Real Estate managers versus their respective benchmarks.

After dismal third quarter, global equities rebounded somewhat in the fourth quarter in an environment where U.S. and European markets were supported by decent economic data and Japanese equities performed strongly helped by the Trans-Pacific Partnership agreement in October. But Chinese growth remained subdued and Emerging Markets lagged once more as weak Chinese trade data took its toll on investor sentiment. By style, growth outperformed value in the fourth quarter and indeed through 2015 as a whole. Fund returns are still preliminary at this time, but it would appear that the Fund slightly outperformed the index for the Quarter.

For the year as a whole, 2015 marked the eighth consecutive year of monetary policy easing and debt expansion among the world's major industrialized economies. Concerns over slowing Chinese economic growth, falling commodity and energy prices, lack of inflation, and competitive currency devaluations highlighted a year in which many equity markets posted their worst year since the 2008 credit crisis. With respect to economic and employment growth, the

U.S. posted strong headline numbers relative to its "Group of Eight" (G8) peers, but still below consensus expectations and softening heading into 2016.

The Pacific Salmon Commission Fund's net return exceeded the benchmark for the year mainly due to the outperformance of the international equity and global infrastructure managers versus their respective benchmarks. On an absolute return basis, U.S. real estate delivered the highest returns while Canadian bonds delivered the lowest returns.

Total contributed capital (nominal) was U.S. $140,065,000 (the equivalent of CDN $209,796,000 using the exchange rate at the time the last installment was made). Actual fund asset value at December 31st, 2015 was U.S. $193,520,000 or CDN $267,831,000.

Contributed capital and asset value of the individual Funds as of December 31st, 2015 stood as follows:

	Contributed Capital	Asset Value
Northern:	U.S. $75,000,000 CDN $112,388,000	U.S. $105,429,000 CDN $145,914,000
Southern:	U.S. $65,000,000 CDN $97,408,000	U.S. $88,090,000 CDN $121,917,000

Note #1:
In 2003 a rescission of 0.65% applied to the FY 2003 appropriations reduced the final contribution to the Northern Fund by U.S.$162,500 and to the Southern Fund by U.S.$97,500. Thus the actual Contributed Capital is:

Northern: U.S. $74,837,500
Southern: U.S. $64,902,500
Note #2:
U.S. Dollar Exchange (noon) rate: per Royal Trust, December 31, 2015   1.3840   0.72254
U.S. Dollar Exchange (noon) rate: per Royal Trust, November 30, 2015   1.3333   0.75002
U.S. Dollar Exchange (noon) rate: per Royal Trust, December 31, 2014   1.1601   0.86199
U.S. Dollar Exchange (noon) rate: per Royal Trust, December 31, 2013   1.0636   0.94020

2015 Project Funding

The Southern Fund Committee funded 14 on-going multi-year projects in 2015 and 6 new projects directly responsive to specific priorities identified by the Pacific Salmon Commission's Fraser River and Southern Panels for $1.36 million US in grant awards. In addition a second year amount of U.S. $800,000 part of a U.S. $5 million, five year commitment, was granted to the Salish Sea Marine Survival Program.

In June 2014 the Northern Fund Committee was able to issue a general Call for Proposals for projects in 2015 that responded to the Fund's full range of goals and objectives. Following the review and selection process, the Committee divided its use of available funding between support for 29 on-going multi-year projects funded by the Northern Fund in the year or years before 2015, and 35 new projects for a total of 64 new and on-going projects totaling U.S. $3.75 million

In the twelve years between 2004 and 2015 the Northern Fund has granted U.S. $32.9 million to 462 projects. Similarly, between 2004 and 2015 the Southern Fund has granted U.S. $28.1 million to 421 projects. Total Fund project expenditures to date are U.S. $61 million in support of 883 projects. In addition to this, the Sentinel Stocks Program has been funded in the amount of U.S. $10 million; a further U.S. $2.6 million was awarded to the Salish Sea Marine Survival Program; and, U.S. $1.1 million invested in very high priority chinook projects.

Joint Funding Initiatives

    (i)   Very high priority Chinook projects

In November 2014, after deliberating over the Chinook Review Committee's (CRC) list of very high priority chinook projects requiring financial support in 2015 and noting the financial obligations and constraints (particularly for the Southern Fund) at the time, the Joint Fund Committee members agreed to fund the top six ranked priority projects on the CRC's list in the amount of U.S. $1.11M. The Northern Fund contributed U.S. $604,000 and the Southern Fund contributed U.S. $511,710.

Grants were awarded in 2015 to the following projects:

	Very high priority chinook projects 2015		Cost	
CRC Rank	Title	Agency	CAD	USD
1	Canadian Mark Recovery program CWT Sampling and Coordination	DFO	$385,000	
2	Terminal Abundance of WCVI Chinook salmon	DFO	$257,000	
3	Increased Chinook salmon stock coded-wire tagging to improve the quality of Chinook indicator stock analyses	DFO	$260,647	
4	Mark Recovery Program Head Lab	DFO	$100,000	
5	Genetic-based abundance estimates for Snohomish River chinook salmon	WDFW		$234,987
6	Abundance estimates for Stillaguamish River chinook salmon using trans-generational genetic mark recapture	WDFW		$67,866

During the latter part of 2015, the process for selecting and recommending future very high priority chinook projects to the Fund Committees for funding in 2016 and beyond was re-examined. At the time of writing a final agreed-upon process is still pending. In the meantime, the 2016 projects proposed by the CRC are under technical review by Fund agency affiliates and funding decisions for the coming year are expected in February 2016.

(ii)   Fund presentation and reception

In January 2015 at the Pacific Salmon Commission's post-season meeting at the Hyatt Regency hotel in Vancouver, BC the Joint Fund Committees sponsored an evening of brief presentations with guest speakers followed by a social event. The intention was to create an Endowment Fund communications opportunity that would draw the attention of the already assembled PSC delegates to 10 years of project investments, $60M awarded in grants, and over 750 projects funded.

The program lasted for about one hour and twenty minutes and consisted of five speakers:- two staff (John Field and Angus Mackay) and three guests (David Peacock, Ed Jones and Don Hall). Seating was available for 120 and the room was filled, with further attendees standing in the back. Feedback to staff during and after the event was positive. Fund Committee communications goals with respect to providing messaging and awareness-raising among the Fund's core user-group were achieved. In the absence of any other opportunity during the week for all the PSC delegates to meet together socially, this event was much appreciated.

Joint Fund Committee Meetings

The Northern and Southern Fund Committees have agreed that given the congruent nature of their agendas, their decision to combine the funds into a single master account for investment management purposes, and the efficiencies involved with respect to interaction with the fund managers, it was appropriate to meet together as a Joint Fund Committee at least once a year for an annual financial review and investment manager interviews. The Joint Fund Committee met in person on November 17th and 18th, 2015

At the Spring meetings of the Northern and Southern Fund Committees (held separately in 2015), Mr. David Geisbrecht of Aon Hewitt presented the 2014 Q4 investment performance report to the Northern Fund and a month later the 2015 Q1 report to the Southern Fund. At both meetings Mr. Geisbrecht discussed Aon Hewitt's downgrading of the Brandes global equity strategy from "Qualified" (formerly "Hold") to "Sell". This change follows a downgrade from "Buy" to "Hold" in July 2012. The rationale for the downgrade was Brandes' disappointing performance since 2008/9, in particular in down markets when their process would be expected to do well. More critically for future results, Aon Hewitt had concerns regarding the high degree of professional turnover, significant asset outflows from the strategy, and, the business direction of the firm. Brandes has been on close watch by the Committee for quite some time and Committee members on both Funds resolved to revisit the issue in November 2015 when they would meet in joint session. Mr. Geisbrecht also presented the results of negotiations with Brandes and with the Fund's EAFE manager LSV concerning a change to their fee structures. A new performance-based fee structure had been negotiated by Aon Hewitt on the Fund's behalf, such that only the achievement of specified performance thresholds would trigger incremental fee increases above a base fee level. The Fund Committees were appreciative of these efforts and instructed Aon to implement the changes immediately. Each Committee also received a presentation on the Fund's audited financial statements and administration costs for 2015 from PSC Secretariat Controller, Ms. Ilinca Manisali. The Committees approved the administration budgets as presented.

The Committees met in joint session for their annual financial meeting, investment manager performance review, and manager interviews on November 17th and 18th, 2015. To open the meeting Ms. Kamila Geisbrecht of Aon Hewitt presented the third Quarter report for 2015 (see investment review above).

The Committee then received the in-person presentations from its managers LSV (international equities manager), RARE (infrastructure manager), Invesco (real estate manager) and Brandes (global equity manager). For the second year running, Aon Hewitt provided the managers ahead of time with specific questions on their performance developed with Committee input. Managers were expected to address these during their presentations. The Committee was generally satisfied with the managers' reports, with the exception of Brandes. Following the interviews and during Ms. Geisbrecht's summarization, Committee members discussed a proposal to fire Brandes and initiate a search for a new manager for this portion of the portfolio. Eventually it was decided to adjourn the meeting and revisit the Brandes issue on the following day.

The Fund Committee reconvened their annual meeting the next day on November 18th. A unanimous motion was passed to instruct Aon Hewitt to terminate Brandes; initiate the liquidation of Northern and Southern Fund assets held by Brandes, arrange the transfer of those funds to a passive global manger (BlackRock) to be held in the interim, and, immediately begin a search for a replacement manager. A manager search sub-committee comprised of two members from each Fund, one Canadian and one US member, was struck. Aon committed to providing the sub-committee with a short-list of potential candidates in February 2016 with a view to arranging interviews with top finalist candidates in the following month or months.

The next agenda item concerned the "very high priority chinook" projects proposed for funding in 2016. PSC Executive Secretary Mr. John Field provided a summary overview of "very high priority chinook" actions to date. The Fund Committee members discussed the program's process issues at great length. The Northern Fund Committee took the position that the group of "very high priority chinook" projects should be subject to the same Northern Fund technical review as all the other detailed proposals and that ultimately they would be considered for funding on their merits in competition with all the others seeking Northern Fund grant support. The Southern Fund expressed their interest in reviewing the results of the Northern Fund's technical analysis. The Committees agreed to meet again jointly in February 2016 to resolve the 2016 "very high priority chinook" project funding issues.

As an information item for the Northern Fund Committee, Mr. John Field described a proposal approved by the Southern Fund Committee to establish a Larry Rutter Memorial Award in Pacific Salmon Conservation - with the inaugural award to be made in February 2016.

Mr. Angus Mackay presented a proposal to the Fund Committees to sponsor a second Endowment Fund communications opportunity that would provide messaging and achieve awareness-raising among the Fund's core user-group. The evening event would once again take the form of one or more brief Fund related presentations followed by a social event at the PSC's annual meeting to be held at the Hyatt Regency hotel in Vancouver in February 2016. The Fund Committees approved the proposal.

Northern Fund Committee Meetings

The Northern Fund Committee met three times during 2015.

February 17th, 2015
- Final selection of projects for funding in 2015. This meeting was held at the Listel Hotel in Vancouver.

April 22nd, 2015
- Investment performance report to end of Q4, 2014.
- Update to Aon's rating of Fund's global equity manager, Brandes.
- Manager performance fee discussion.
- Potential for a Call for Proposals for 2016.
- Fund financial obligations in 2016.
- Consideration of Year 2 very high priority Chapter 3 chinook projects.
- Timetable.

September 30th, 2015
- First round selection of project concepts to be invited to proceed to Stage Two detailed proposals.

Southern Fund Committee Meetings

The Southern Fund Committee met three times during 2015.

February 12th, 2015
- Final selection of projects for funding in 2015. This meeting was held at the Embassy Suites Hotel in Portland.
- Consideration of pressing coho treaty implementation priorities.
- Increase in Southern Fund contribution towards the very high priority chinook projects.

May 20th, 2015
- Investment performance report to end of Q1, 2015.
- Update to Aon's rating of Fund's global equity manager, Brandes.
- Manager performance fee discussion.
- Salish Sea Marine Survival Program annual report.
- Potential for a Call for Proposals for 2016.
- Fund financial obligations in 2016.
- Consideration of Year 2 very high priority Chapter 3 chinook projects.
- Proposal to establish a Larry Rutter Memorial Award in Pacific Salmon Conservation.
- Timetable.

September 23rd, 2015.
- The members of the Southern Fund Committee (absent Andy Thomson) were accompanied on a Fraser River field trip by PSC Executive Secretary John Field, Fund

staff Angus Mackay and Victor Keong, PSC Hydroacoustics manager Fiona Martens and, CRITFC support staff Laura Gephart. The purpose of the field trip was for Committee members to visit both the PSC Mission hydroacoustics station and the Qualark hydroacoustic facility on the Fraser River. Both of these operations have been the recipients of multiple Southern Fund grant awards over the years and continue to be top priority projects recommended to the Committee for funding by the Fraser River Panel. The trip was accomplished via jet boat from the government wharf at Mission. PSC and DFO hydroacoustics staff were on hand at both stops to describe the operation of their facilities and the results achieved with Southern Fund financial support.

September 24th, 2015.

- First round selection of project concepts to be invited to proceed to Stage Two detailed proposals.

2015 Call for Proposals for projects in 2016/17

Both Fund Committees issued Calls for Proposals in mid-2015 for projects starting in 2016.

In April 2015 the Northern Fund Committee forecast that further funding would be available in 2016 to fund new projects that would be in addition to 37 potential on-going projects that if funded would themselves require U.S. $2.36 million and that a general Call for Proposals should be issued. The Committee received a total of 92 proposals for new projects requesting U.S. $5.89 million. At the first round review meeting in September, 58 of the new proposals were selected to move to the second round detailed proposal stage along with the on-going projects. Bilateral technical reviews of the detailed proposals took place in January 2016 and a final decision on 2016 funding will be made at a meeting of the Fund Committee in mid-February 2016.

In May 2015, the Southern Fund Committee anticipated granting up to U.S. $1.96 million to fund seven on-going multi-year project commitments including U.S. $800,000 for year three of a five-year commitment to the Salish Sea Marine Survival Program. After budgeting for these, and taking into account the very limited amount of remaining project funding thought likely to be available in 2016, the Committee focused its Call for Proposals to elicit proposals directly responsive to specific priorities identified by the Pacific Salmon Commission's Fraser River and Southern Panels. The Southern Fund received 40 new project concepts requesting U.S. $2.12 million. During the first round review process in September the Southern Fund Committee short-listed 22 proposals to move to the second stage. The final decisions on 2016 funding will be made at a meeting of the Fund Committee in mid-February 2016.

Committee Appointments

In the Northern Fund U.S. section Mr. Charlie Swanton replaced Ms. Stefanie Moreland and in the Northern Fund Canadian section Mr. John McCulloch replaced Mr. Mel Kotyk.

Yukon River Panel Restoration and Enhancement Fund

In March 2011, PSC Fund staff took over responsibility for the administration of the Yukon River Panel's Restoration and Enhancement Fund (R&E Fund). 2015 was the fifth year in which PSC Secretariat Fund staff administered the R&E Fund.

In 2015, in response to the decline of Yukon River Chinook salmon stocks experienced in recent years, the Yukon River Panel took steps to improve the effectiveness of Fund resources by placing clear emphasis on its Restoration priorities in the R&E Fund Call for Proposals

A total of 30 projects were awarded grants, to a total amount of U.S. $1.27 million. Of these, 22 were on-going multi-year projects and 8 were new.

Process to provide PSC Guidance on Very High Priority Chinook Projects

for 2017 and 2018

Proposal from the Chinook Interface Group (CIG)

Following on Direction from the Commission

February 11, 2016

Introduction:

Following direction from the Commission (attached) on very high priority chinook projects, the CIG is recommending that Option 1 on the process and role of the CTC and the Commission be adopted. The CIG is recommending that this option be further clarified as described below.

Process for providing advice to the Northern and Southern Fund Committees on Very High Chinook Projects in 2016, 2017 and 2018:

December 2016:

Task 1: The CTC meets, together with projects leads if required, to review year-end reports or interim reports on projects undertaken in 2016 provided to them by the Fund Manager.

Task 2: The CTC reviews Detailed Proposals for potential adoption in 2017 in preparation for the annual PSC Post Season Meeting (January 2017 PSC). The CTC advice on Detailed Projects will focus on the technical and operational merits of the projects being considered.

Task 3: CTC will identify key considerations and begin to develop strategic advice related to a preliminary list of very high priority chinook issues for 2018 (key issues and strategic advice) related to potential projects that may be funded in 2018.

January 2017:

Task 1: The CTC provides views to the Commission on the 2016 progress reports.

Task 2: The CTC provides advice to the Commission on the Detailed Proposals reviewed in December 2016. The Commission considers the CTC advice and transmits a prioritized list of projects as funding guidance for the 2017 calendar year to the JFC before January 31st.

Task 3: The CTC recommends a preliminary list of very high priority chinook issues for 2018 calendar year (key issues and strategic advice) to the Commission at the Post-Season Meeting. The Commission considers this advice before the February Annual Meeting.

February 2017:

The JFC considers the prioritized list of detailed proposals from the January Commission meeting and decides which projects to fund in 2017.

1

The Commission confirms for the JFC a list of very high priority chinook issues, project leaders, and cost estimates for the 2018 calendar year to the extent possible.

June 2017: The JFC takes the February Commission advice into consideration when preparing for and soliciting Detailed Proposals in June. The Fund Manager will work with the CTC to ensure the detailed proposal format meets the CTC's minimum information needs for technical review.

November 2017: Very high priority chinook project leaders provide Detailed Proposals (and progress reports as appropriate for the previous funding year) to the Fund Manager.

Implementation:

If the Commission agrees on a process as proposed, the PSC Secretariat will apprise the appropriate groups of the process adopted by the Commission to address very high priority chinook projects.

On an interim basis for 2016, the CTC will provide strategic advice to the Commission in its April 2016 meeting on very high priority chinook issues to help inform the development of requests for proposals for 2017 projects.

The Commission chairs will consider the CTC advice and provide its views to the JFC in advance of 2016 RFPs.

Very High Priority Chinook Projects:

Process to provide Guidance from the Pacific Salmon Commission

Issue:

The Commission is seeking agreement regarding an effective process to provide guidance to the Southern and Northern Endowment Funds for 2017 through 2018. The draft proposal relies on the previous draft documents on this subject.

Background:

- Following the ratification of Chapter 3 for 2009, funds were provided by both Parties to implement agreed work to implement the Chapter.
- In 2014, various funding arrangements expired, requiring continued support for the key programs supporting the chapter.
- In that year, the Chinook Review Committee was formed and provided advice to the Chinook Interface Group and the Commission regarding high priority projects required to implement the treaty, which was then provided the Funds for their consideration, with the ongoing proviso that Funds are mandated to make independent decisions.
- In 2015, the process, which was ad hoc in 2014, did not satisfactorily provide advice resulting in concern from the Funds and the need for an improved understanding of the requirements, process for priority setting and technical review.
- The issue was raised in the January 2016 Commission meeting and it was agreed that the Chair and Vice-chair would work with the National Correspondents and the Secretariat to put options on the table for the February 2016 Commission meeting.
- The initial proposal by the US was that the Chinook Technical Committee, as the primary source of technical advice for the Commission would provide this service. Canada agrees that the CTC is the appropriate body.

Current Status:

- In response to the US proposal to use the CTC as the body to provide advice, a proposal to operationalize that is presented.
- There are two points at which technical involvement is considered in this paper: firstly to provide to the Joint Fund Committee by June 1, a list of the projects at a high level which are required to implement the treaty until the new Chapter is implemented for their consideration in advance of the Funds Request for Proposals process launched in the summer.
- The Parties will have reviewed their projects based on the priorities in advance of the CTC considering agency protocol, context and capacities.

- Secondly, once projects are submitted, a bilateral technical review is proposed in Option 1, including progress from the existing year, and of the technical requirements for ongoing or new projects. The time period for this is approximately December. For the 2016 projects, this review was not completed.

- These elements completed, the Funds are in a position to make final decisions in February with both the general guidance and bilateral technical review from the Commission and the CTC.

Considerations:

- Must reflect the timing of Funds calls for proposals and review process, taking into consideration that the available caps are identified by the Fund in May of the previous year.
- Each party is responsible for review of projects prior to their being submitted to the Funds.
- The Chinook Technical Committee (or subset) is best placed to provide advice to the Commission for priorities for work to implement the Treaty until 2019.
- The Chinook Technical Committee (or subset) is best placed to review projects and progress on projects funded or proposed to be funded by the endowment funds.

Options:

Option 1:

- The CTC provides advice to the Commission in the February Annual meeting.
- The Commission decides on the advice and provides guidance to the Funds (fund manager).
- Fund Manager takes the advice into consideration when soliciting detailed proposals in July and August to be provided by September 30.
- To ensure project proponents have a clear understanding of the requirements for technical review, some alignment of the Fund RFPs and the technical review requirements is necessary.
- Before providing proposals, each Party will review results or status of the proposal to ensure it meets requirements.
- The CTC meets to review detailed proposals provided by the fund manager, in December and transmits a priority list to the Commission by December 31, identifying any unresolved issues.
- Advice from the CTC on the detailed proposals, the previous year's projects and priority ranking is provided to the Commission, for review and transmission to the Fund before January 31.
- The Joint Fund Committee makes final funding decisions for the year.

Option 2:

- The CTC provides advice to Commission in the February Annual meeting.
- The Commission decides on the advice and provides guidance to the Funds (fund manager).
- Fund Manager takes the advice into consideration when soliciting detailed proposals in July and August to be provided by September 30.
- Alignment of the requirements of the RFPs will advise proponents, including practicalities of reporting on ongoing work as new proposals are considered.

- Before providing proposals, each Party will review results or status of the proposal to ensure it meets requirements.
- The Joint Fund Committee makes final funding decisions for the year.

Implementation:

- If the Commission agrees on a process as proposed, an implementation plan to ensure instructions, alignment between the fund manager and CTC, and timelines will be prepared with the involvement of both Parties in consultation with thee fund manager.

Recommendation:

Both Parties support the use of the Chinook Technical Committee in providing guidance on High Priority Projects to implement the Treaty.

The outstanding question for discussion between the Parties is the technical review support for individual proposals under that guidance.

Report of the Standing Committee on Finance and Administration
February 11, 2016

The Standing Committee on Finance and Administration met on several occasions throughout 2015 (on July 28, August 17, September 22, October 8, October 28, December 16), as well as at the 2016 Post-Season and Annual Meeting. The Committee addressed a number of issues and made recommendations for the Commission's consideration as noted below.

Budget proposal for FY 2016/2017 and forecast through FY 2018/2019

The Committee discussed the financial challenges facing the Commission and the Secretariat over the coming years. The Committee has worked with the Secretariat over the last year to examine potential cost reductions for balancing the budget through 2018/2019. As reported in October 2015, the Committee analyzed the impact of these reductions by applying a risk framework using a number of factors including: conservation/biological, stakeholders, external economic, internal, and treaty implementation. While the Committee was unable to agree on any specific reduction, there was agreement that any program reduction would impact the effective delivery of programs by the PSC.

Accordingly, the Committee recommends that the Commission adopt the proposed budget for FY2016/2017 as shown in Attachment 1 (Column C).

Unfunded pension liability

The Parties have worked with the Secretariat to identify supplementary funding over the next three years to mitigate the unfunded pension liability and relieve budgetary pressure on the Commission. Supplementary contributions totaling $660,000 ($330,000 per Party) may be forthcoming over the next three years with the first payment as early as spring, 2016. The United States will endeavor to make these payments in three annual installments, subject to available funding. Canada has been invoiced for a 3-year portion of the liability (i.e., $330,000) and payment is expected prior to March 31, 2016.

For reporting purposes, appropriate adjustments to revenue will be made in the fiscal year that the funds are received.

Capital Asset Replacement Reserve Fund (CARRF)

The Committee recommends that a Capital Asset Replacement Reserve Fund (CARRF) is established to ensure regular availability of funds for lifecycle replacement of capital assets, while giving the Secretariat the flexibility to use these for prescribed needs and to prioritize purchases within a fixed budget.

The CARRF would function similarly to a savings account: a set amount would be credited to the CARRF each year from the General Fund. Capital asset purchases would be charged directly to the CARRF and would not impact the General Fund. The Committee may, from time to time, review the CARRF balance and determine whether additional top-ups are necessary or whether (in the case of an unreasonably high balance) an amount should be returned to the General Fund. The Commission would make the final decisions on such changes to the CARFF, based on recommendations from the F&A Committee.

To establish the CARRF (for FY2017/18 and beyond), the Committee recommends changes to the financial regulations as outlined in Attachment 2.

<u>Test fishing</u>

The PSC separates test fishing program costs and associated revenues from the ordinary Secretariat budget. Nonetheless, the Committee routinely monitors cash flow in PSC test fishing operations and has discussed the results of the 2015 season for Secretariat-administered test fisheries. Due to constraints on PSC catches imposed by low abundance and conservation concerns, the Secretariat incurred a test fishing program deficit of $778,000 during the season ($1.4 million in expenses vs. $622,000 in fish sale revenue). As a result, the PSC Test Fishing Revolving Fund (or TFRF, which receives surplus revenues and pays for operational deficits) has been reduced to approximately $115,000.

Moving forward, there is always uncertainty in Fraser sockeye returns pre-season. This complicates budget forecasting for test fishing operations. Nonetheless, the Committee has worked with the Fraser River Panel and the Secretariat to forecast certain things:

- **2016**: Fraser sockeye returns are not expected to be large in 2016, and thus program deficits are probable in the coming fiscal year. These deficits would range from $170,000 to $890,000 depending on the test fishing program approved by the Fraser River Panel and fish abundance.

- **2017**: Parent year sockeye escapement in 2013 suggest that the 2017 Fraser sockeye return should be much better than 2016, and 2017 also yields pink salmon returns to the Fraser River. Thus potential net revenues in 2017 would range from a potential $475,000 surplus (the 2013 program generated a surplus of approximately $275,000) to a potential deficit exceeding $1,000,000 if returns were very poor and test fishing catches were restricted.

- **2018**: This represents the dominant cycle year for Fraser sockeye, and relatively large returns to the Adams system should provide opportunities for increased national harvest and potentially higher PSC test fishing harvest/revenues.

Prior to 2018, the Secretariat must meet the in-season monitoring needs of the Fraser River Panel while securing adequate funding for program costs. Accordingly, the Secretariat has worked with the Panel and the Committee to a) develop options for reduced test fisheries in 2016; b) solicit supplemental contributions to the TFRF from the Parties; c) begin long-term planning for cost-effective test fisheries; and d) revise the PSC test fishing policy on annual program design and revolving fund access. This PSC test fishing policy must be approved by the Commission, which would ideally happen before June 2016.

The Committee and the Fraser River Panel will work with the Secretariat to reach agreement on a test fishing policy proposal for the Commission in spring 2016. If successful, then intersessional Commissioner approval could happen via email or other appropriate means.

			A	B	C	D
	PACIFIC SALMON COMMISSION					
	PROPOSED BUDGET 2016/2017					
			A	**B**	**C**	**D**
			Forecast Results 2015/2016	**Forecast Budget 2016/2017**	**Draft Budget 2016/2017**	
				as presented	**as presented**	**Difference**
1	INCOME			**February 5, 2015**	**December 16, 2015**	**C-B**
A.	Contribution from Canada		1,879,636	1,879,636	1,879,636	
B.	Contribution from U.S.		1,879,636	1,879,636	1,879,636	
	Sub total		3,759,272	3,759,272	3,759,272	0
D.	Interest		7,700	26,000	8,000	(18,000)
E.	Other income		195,000	177,000	177,000	0
	Carry-over from previous fiscal year		892,586		908,668	908,668
	Top-up from cash reserves (as req'd)			383,215		(383,215)
F.	Total Income		4,854,558	4,345,487	4,852,940	507,453
2	EXPENDITURES					
A.	1. Permanent Salaries and Benefits		2,517,203	2,596,996	2,665,935	68,939
	2. Unfunded pension liability payments		221,412	222,000	221,412	(588)
	3. Temporary Salaries and Benefits		215,960	177,433	183,284	5,851
	4. Total Salaries and Benefits		2,954,575	2,996,429	3,070,631	74,202
B.	Travel		75,984	95,989	98,510	2,521
C.	Rents, Communications, Utilities		107,106	119,726	128,002	8,276
D.	Printing and Publications		6,500	9,000	4,800	(4,200)
E.	Contractual Services		621,408	612,708	629,064	16,356
F.	Supplies and Materials		37,717	50,009	43,091	(6,918)
G.	Equipment		142,600	223,203	264,328	41,125
H.	Total Expenditures		3,945,890	4,107,064	4,238,425	131,361
3	BALANCE (DEFICIT)		908,668	238,423	614,515	376,092

Proposed amendments to Financial Regulations for the creation of the CARRF:

Rule 4 (revised text in bold and brackets)
Budget Categories. The draft budget shall be divided into the following categories:
(a) Salaries, wages and benefits;
(b) Travel and transportation of persons and things;
(c) Rents, communications and utilities;
(d) Printing and reproduction of documents;
(e) Professional services and other contractual services;
(f) Materials and supplies;
[g] [Capital asset replacement reserves as specified in Rule 20bis]
(g) Equipment purchases,
(h) Equipment maintenance and leases.
[With the exception of the capital asset replacement reserves]*, the Executive Secretary may transfer up to $100,000 from one category to another in any fiscal year. Transfers in excess of $100,000 may be made only with authorization of the Chair [**and Vice-Chair**] of the Commission upon recommendation of the Standing Committee on Finance and Administration.*

Rule 16 (revised text in bold and brackets)
<u>*Use of unobligated Funds*</u>*. The Commission may utilize unobligated funds which may accrue in the General Fund, [**Capital Asset Replacement Reserve Fund,**]Working Capital Fund, or Special Funds and Trusts. Such funds shall be applied either as deductions from the next annual budget contribution due or as a source of funding for the subsequent fiscal year(s), as determined by the Commission. If deducted from the next annual contribution due, this shall be in proportion to the original amount contributed by each Party.*

Rule 20bis: <u>*Capital Asset Replacement Reserve Fund*</u>
For the purpose of ensuring regular availability of funds for lifecycle replacement of capital assets, a Capital Asset Replacement Reserve Fund (CARRF) shall be established. On an annual basis, a fixed amount, as determined by the Commission, shall be transferred from the General Fund to the CARRF. The Executive Secretary shall provide an annual report to the Standing Committee on Finance and Administration regarding the use of the CARRF during the most recent fiscal year.

February 10, 2016

Committee for Scientific Cooperation Response to Commission Decision 4, January 2016

At the January 2016 meeting, the Pacific Salmon Commission decided that "By the 2016 Annual Meeting, the CSC shall collaborate with appropriate experts and develop a proposal for annual collation of data on the environment, run size, fish condition, and other metrics that may reveal anomalies in salmon survival." The CSC has developed an outline of possible actions that could be undertaken taken to address this directive.

1. **Documenting 2015 anomalies.**
   Rationale: Reports to date suggest that environmental conditions and the characteristics of salmon returns in 2015 were anomalous. There is no formal mechanism currently in place to collate the observations for 2015. This information would be valuable to inform the assessment and management of impacted stocks into the future.

   Proposal: By consultation with appropriate experts develop a list of environmental and biological anomalies associated with environmental conditions affecting salmon in 2015. We identify two activities which have different levels of resolution and cost to address this issue. The CSC is prepared to move forward with activity a, but would require funding or staff support to also undertake activity b.

   a: Building upon efforts already undertaken (e.g., L. Weitkamp, I. Perry), the CSC surveys experts in the salmon management and research communities to compile a list of unusual or anomalous physical and biological observations in the eastern North Pacific.

   b: Develop an RFP to contract expertise to provide comprehensive, quantitative, and contextual evaluation of 2015 anomalies. This option requires funding support from Commission, Endowment Funds, or other granting entity.

2. *A PSC Strategy for ongoing consideration of environmental variability and its impact on salmon management.*
   Rationale: The Pacific Salmon Treaty is based on the mutual interest of Canada and the United States in the conservation and rational management of Pacific salmon stocks and in the optimum production of such stocks. As a result of changing climate, the business of the Pacific Salmon Commission is increasingly impacted by anomalous environmental conditions. The Commission will need to actively manage processes at all levels to ensure resilience in a rapidly changing environment.

   Proposal:
   i. *Information sharing within the Commission to support future reporting of environmental variation and impacts*. As with 2015 it is important to systematically

collate annual observations.   The CSC will work with the Executive Secretary to develop a web-based repository for the following information.

a. Reporting and documenting anomalous observations and impacts .
b. Links to environmental (physical and biological) data sets.
c. Links to associated salmon data sets.
d. Matrix of stock specific performance data.
e. Capability for on-line discussion on the use of environmental indices in management and forecast models within the PSC science community.

ii.   ***Use of environmental data in forecasting and managing PSC fisheries***.   The PSC and its technical committees generate forecasts and evaluate management scenarios using bi-laterally developed models. The consideration of environmental conditions is variable and limited. Varying environmental conditions at local, regional, and basin scales are affecting all species of Pacific salmon, and thus are of concern to the work of all of the technical committees. To enhance the capacities of the technical committees to consider and incorporate environmental effects, they require the capability to share observations, knowledge and skills between the committees, in order to have access to the most current data and analytical techniques; and learn as an organization. A starting point is assessing the current use of environmental variability. The CSC again identified two activities which have different levels of resolution and cost to address the issue. The CSC is prepared to move forward with <u>activity a</u>, but would require funding or staff support to also undertake <u>activity b</u>.

a: CSC surveys technical committees to identify current use of environmental variation in forecasting and assessment models.

b: A detailed review of the use of environmental conditions in technical committee and agency management and forecast models, and recommendations for their improvement. Recommendations would also address mechanisms for improved collaboration and information exchange between committees and within the PSC science community. Requires funding support from Commission, Endowment Funds, or other granting entity.

iii.   ***Information sharing with other international organizations.*** The PSC is not alone in needing to monitor and understand a rapidly changing environment. In fact understanding will come from observations on stocks at local, North Pacific and on a hemispheric scale. A number of scientific groups are evaluating the impacts of climate change and environmental variation on salmon and other organisms. The activities

identified for this component are explicitly addressed in the CSC Work Plan.

    a.   Develop information exchange mechanisms between PSC-CSC, NPAFC-CSRS, NASCO-Scientific Committee and ICES/PICES, including data sharing and comparisons of stock trends across space and time.

    b.   Participate in the planning for the NPAFC/PICES International Year of the Salmon initiative. This opportunity will allow PSC to influence the body of work undertaken to improve understanding of salmon populations and their responses to a changing environment.

iv.   ***Informing the Commission annually on observations of changing environmental conditions and their relation to salmon production.*** It is important that information on current and future conditions be effectively communicated at the Technical Committee, Panel and Commission level. The CSC identified three activities which represent a range of levels of information that could be provided to the Commission depending on available resources.

    a.   CSC summarizes results from the web-based reporting as part of the CSC annual report. Contingent on direction to proceed on 2.i.

    b.   The CSC manages an annual mini-workshop of 2 hour duration at which invited experts present perspectives on the state of the ocean and the state of salmon from different regions across the North Pacific Rim. The workshop would be scheduled as an evening session at the PSC Annual Meeting. The work shop would require an annual budget for invitational travel for speakers.

    c.   Dedicate (as part of proposed 2018 budget "enhancements") a Commission staff position to compile, evaluate, and synthesize information on the responses of salmon populations to changing environmental conditions. (An alternative is the possibility of a sabbatical-type detail to address more in-depth analyses of the effects of a changing environment on the management and conservation of salmon populations of interest to the PSC.)

Transboundary Panel Annual Meeting – Summary Report to PSC Commissioners
February 11, 2016 – 14:00

Report provided by Steve Gotch (Transboundary Panel Co-Chair Canada) and John H. Clark (Transboundary Panel Co-Chair U.S.)

- The Transboundary Panel met in section meetings on Monday February 8 with the intent to prepare for and review pre-season reporting, technical presentations and prepare for Chapter renewal negotiations.
- The Transboundary Panel met bilaterally starting on Tuesday February 9th. The focus of Tuesday's session was on: 2016 pre-season outlooks and forecasts for Canadian-origin Alsek, Taku and Stikine River salmon stocks; Panel consideration of fishery management performance review rules as they pertain to Base Level Catch; Research and management projects proposed for 2016; and, the Sockeye salmon enhancement program proposed for the Stikine River watershed in 2016.
- The Transboundary Panel met again in bilateral sessions on Wednesday February 10th and Thursday February 11th. Panel discussions were focused on: A harvest share arrangement for Canadian-origin Taku River coho salmon; The Stikine River sockeye salmon enhancement program in 2016; and, Renewal / renegotiation of Chapter 1.
- We anticipate that the Transboundary Panel will continue to meet in bilateral sessions this afternoon (February 11) and on Friday February 12th.
- Although the Parties have respectively strong interests in the specific subjects discussed as a component of the renewal / renegotiation of Chapter 1, progress is being achieved on several subjects.

2016 ANNUAL PSC MEETING
February 8-12, 2016

SOUTHERN PANEL MEETING REPORT

Session Activities:

- *Chum Chapter Renegotiations:*
  - The parties worked within their respective national sections, and also met bilaterally, to review the existing language of Chapter 6 (Chum chapter) as part of initial scoping of the chapter heading into renegotiations. There was general bilateral consensus that the current Chum chapter is working well and is a good template to follow in moving forward.
  - The U.S. section in particular highlighted portions of the chapter in which there were questions on how existing thresholds and targets for management were derived previously. For example, paragraphs 6(a) and 10(a) state that "Inside Southern chum salmon levels of less than 1.0 million as estimated by Canada are defined, for the purposes of this chapter, as critical." The U.S. section asked such questions as: How was this threshold (and others in the Chum Chapter) developed? What is the current status? Are there new data to inform whether or not this threshold is still relevant?
  - Chum Technical Committee and Panel members who had participated in previous negotiations provided much of the needed information regarding the history of the past Chum agreement and how different thresholds and targets for management were derived. The parties agreed that maintaining consistent documentation on these details in the next round of negotiations will be important.
  - The Canadian section had very few suggested edits at the present time to the current Chum Chapter language.
  - The U.S. section relayed intentions of possibly proposing changes to the Chum Chapter language specifically within paragraph 10, pending completion of needed analytical work with the help of U.S. Chum Technical Committee members.   Possible proposed changes would focus on sections (c), (e), and (h) of paragraph 10 – addressing the 130,000 catch ceiling in non-critical years, timing of information exchange on in-season run size estimates, and details on triggers for overages, respectively.
  - The parties developed the following timeline for Chum Chapter renegotiations:

Time Frame	Action	Who
Feb – May 2016	Data Analysis	Chum Technical staff and fishery managers.
June	Development of proposal if appropriate	US section Southern Panel
End of June	Notice to Canada	Laurie, Terry to Andy, Brigid
July	Review of proposal by affected parties	Tribes, State, Federal Rob/Terry, Laurie, Jeromy
August 1-15	U.S. Panel Call	Laurie, Terry/Rob, Jeromy
August 16-31	U.S. provides proposal to Canada	US Panel Andy, Brigid, Laurie, Terry
Sept – Oct	Canadian Review	Canadian Section
October	Update Commissioners	Co-Chairs

Nov – Dec	Discussions - Exchanging Proposals	Bilateral Panel
January 2017	Finalize Chum Chapter	Bilateral Panel

o This timeline shows that the U.S. section will conduct the needed data analysis from February through May 2016, develop a proposal as a section in early summer, and then deliver the proposal to the Canadian section by mid-August. The Canadian section has expressed that they will need two months to review the proposal and provide a response. Therefore, final exchanges of proposals are expected to occur in November-December 2016, and then the parties would plan on reaching final agreement on the Chum Chapter at the PSC post-season meeting in January 2017.

- *Update on 2016 Southern Endowment Fund proposals for Coho*
  o The parties met in sections and bilaterally to make progress on the preparatory work needed for the proposed workshop to explore and report on pros and cons associated with different Southern Coho management regime options (one option will include the current abundance-based management regime). If funded, this workshop would be implemented in Fall 2016.
  o The U.S. Coho Technical Committee Chair, Gary Morishima, gave a presentation to the Panel on concepts and terminology to keep in mind as the parties engage in the workshop process, defining terms such as Goals and Objectives, Characteristics, Criteria, Metrics, Mechanics and Process. This presentation provided Panel members with useful information to support preparatory work for the project.
  o In our status update presentation on this project (a work in progress at each PSC meeting), the parties agreed that the purpose of the project is:
    - To provide information in support of renegotiations;
    - To evaluate options for the international management regime and obligations described in Chapter 5;
    - Not a review of domestic management approaches of the Parties (though domestic approaches and capacities will be a consideration in assessing feasibility of various options);
    - The review is intended to be technical in nature and nothing in the project will be prejudicial to positions taken by the parties during renegotiations;
    - Southern Panel and Coho Working Group will have opportunities to provide input into the project design at various phases of the project.
  o The overall name of the initiative was revised to Southern Coho Management Regime Options
  o The parties are working in sections and bilaterally to to plan preparatory work for the project, including:
    - Confirmation of membership in the project planning team;
    - Confirmation of core objectives to be pursued in development of management regime options;
      - The parties agreed that the current core objectives (at a minimum) of the Chapter 5 would be retained.
    - Identify desired characteristics of any future management regime;
    - Develop a preliminary candidate list of potential management regime options for further consideration (this step will require additional time); and

- Preliminary discussion of criteria and methods for analysis.

- *Update from Chum Technical Committee*
  - Co-chairs from the Chum Technical Committee presented the following list of SEF priorities for the next round. This list is closely tied to the Southern Chum Strategic Plan. Some items on this list may or may not be funded in the 2016 SEF process, therefore the final priorities for the next round will depend on the results of the current 2016 round:
    - Continue model and database development (High, and top priority)
    - Continue commercial and test fishery sampling (High)
      - This is the multi-year joint Canadian-US Chum DNA sampling project
    - Establish sampling program for Strait of Juan de Fuca (High)
      - The U.S. section in particular expressed strong support for a sampling program in the Strait of Juan de Fuca to provide information on the diversion rate of Chum with associated stock identification information.
    - Improve chum salmon escapement estimates (High)
    - Assess biological and environmental variable related to chum (Medium)
    - Develop escapement reference points (Medium)
    - Southern chum workshop (Low)

- *Update from Coho Technical Committee*

  - Coho Technical Committee members presented the initial run of the FRAM model for the 2014 post- season exploitation rate report. The Southern Panel will hold a bilateral session on Thursday afternoon to discuss results of this report.

  - This afternoon Coho Technical Committee will present their list of Southern Endowment Fund priorities for the 2017 cycle.

- *Panel co-chairs began drafting a letter to the Southern Endowment Fund describing the Southern Panel's priority areas of research for the 2017 cycle. The SEF committee will meet next week, after which Panel co-chairs will be able to complete the letter to SEF recommending priority areas for funding in 2017 – at that time we will know more about which SEF priorities will be funded in 2016, possibly affecting the list of priorities for 2017.*

11 February 2016
Pacific Salmon Commission
Annual meeting
Vancouver B.C., Canada

Fraser River Panel Report to the Pacific Salmon Commission

Fraser River Panel; Kirt Hughes, US Section Chair and Jennifer Nener Canadian Section Chair

The Fraser River Panel (the Panel) met this week beginning on Tuesday. In addition to reviewing the 2015 season and receiving preliminary forecasts for the 2016 return year, the Panel has worked to address items identified in our work plan and emerging issues. There are three items of significance the Panel wishes to highlight for the Commission:
- work in support of the hydro-acoustics strategic review committee (FSRC);
- planning for Panel-related test fisheries in 2016; and
- the PSC's Test Fishing Policy Document.

Hydro-acoustic program review
In January the Panel provided its' review of the report provided by Dr. Carl Walters. The Walters report examined and made recommendations on alternative hydroacoustic monitoring configurations for the Mission Bridge and Qualark Creek stations. Dr. Walters also offered his thoughts on others aspects associated with the Panels test-fisheries and management regimes. The Panel's review of the Walters report focused on the hydroacoustic aspects. The Panel also identified work that was incomplete and developed a work plan for items that need to be completed to address the questions raised in the Fraser Strategic Review Committee (FSRC) terms of reference. Progress on this work plan was discussed with the FSRC on Wednesday. The FSRC expressed their appreciation for the effort and accomplishments of the Panels hydroacoustic technical committee and the Panel. The FSRC further commented that they would like to see work products as they are completed by the technical committee and Panel going forward. The FSRC and Panel will next meet in association with the Panels June pre-season meeting.

Test-Fishing Program
In January the Panel anticipated that the 2016 Fraser sockeye return would be relatively low, thereby effecting the ability for test-fishing revenue to sufficiently cover costs of test-fishing activities. Earlier this week the Panel received a presentation that confirmed this to be the case. The 2016 return is projected at the p50 level of forecast, around 2.3 million sockeye, with particularly low expected returns in the Early Stuart and late-time stock groups. In light of the funding and revenue needs the Panel and PSC staff again met with the Finance and Administration Committee (F&A) to discuss funding of test-fisheries and alternative test-fishing programs. A proposal for a reduced test-fishing program for 2016 was presented. The proposal seeks to balance conservation and fiscal needs with the data stream needed to appropriately manager Fraser fisheries. The F&A directed the Panel to manage the 2016 test-fishing program at the reduced level. Further the F&A requested that the Panel provide a post-season report identifying outcomes of the reduced program and management implications resulting from the reduced program.

PSC Test-Fishing Policy

As presented during the Panel report to the Commission at its January 2016 meeting, the Panel and PSC staff are working to complete revisions to the PSC's Test Fishing Policy Document. The revised policy will clarify the balance between conservation and other treaty obligations with program funding and other considerations to guide decisions on salmon retention in Fraser River Panel-Approved Test Fisheries. Yesterday the F&A, Panel, and PSC staff discussed a sub-set of proposed changes to the policy. There is still a substantive amount of discussion needed to inform the policy. Considering this and the direction for the Panel to operate a reduced test-fishing program during 2016, the Panel will continue to work with PSC staff to develop a refined draft for the F&A Committee to consider at a future meeting.

Committee for Scientific Cooperation
Report to the Commission
February 11, 2016

- **Parentage-based Tagging Report**. The CSC presented the results of the PBT report and CSC review of the report to the Commission at the January 2016 meeting. This completed a multi-year initiative and we acknowledge the work of Dr. David Hankin on this issue. The CSC concluded that PBT was not cost effective as a replacement for coded-wire tagging at this point. However, due to the rate of technological developments and decreasing costs in this field, the CSC recommended again reviewing the potential of PBT in 3-5 years. The PBT report and the CSC review have been posted on the PSC website.

- **RFID Review.** The CSC submitted proposals to the Fund Committees' RFP process for reviewing the potential for the use of new generation RFID tags for coastwide salmon tagging programs. The proposal is under consideration for funding by the Northern Fund; the final decision on funding for the project will be next week.

- **Alternative Management Approaches for Chinook and Coho.** This is a logical extension of the review of technologies for PBT and RFID. The Coho Technical Committee and Southern Panel have proposed a workshop on the identification of alternative approaches to the PSC management of Coho fisheries. The CSC will participate in the workshop if the proposal is funded by the Southern Fund.

- **Bayesian Statistics Workshops.**   These workshops were designed to provide the PSC science community with a training opportunity in Bayesian statistics. They were held in Seattle and Nanaimo, and very favorably received**.** We acknowledge the efforts of Commission staff, especially Catherine Michielsens, for making the workshops such a success.

- **Increased Scientific Cooperation among International Commissions.** There are multiple international commissions that have shared interests in the conservation and understanding of factors affecting the productivity of marine resources, including salmon in the North Pacific and elsewhere. The PSC interacts with these Commissions but engagement is ad hoc. Given climate change, rapidly changing environments, and limited resources there is potential benefit in more effective scientific cooperation among these organizations. The CSC met with the PSC Executive Secretary and identified opportunities for communication among Commissions. In addition to participation in workshops and symposia led by these other Commissions, opportunities for communication include 1) the annual meeting for discussion of the shared pension plans and other concerns; 2) meetings between staff from the different Commissions to address specific issues; and 3) the Regional Secretariats Network on the FAO website. The CSC will continue the effort to identify concrete opportunities for scientific cooperation between the Commissions.

- **Consideration of the International Year of the Salmon**. The North Pacific Anadromous Fish Commission (NPAFC) is exploring the development of a broad initiative entitled the International Year of the Salmon (IYS). This is an excellent opportunity to strengthen cooperation among international organizations. The IYS is envisioned as an intensive burst of internationally coordinated, interdisciplinary research focused on salmon across the northern hemisphere and their relation to people. New technologies, observations, and analytical methods will address knowledge gaps and provide tools to understand and manage salmon in a rapidly changing environment. The "Year" is actually a seven year initiative similar in structure to the International Polar Year. The NPAFC conducted one scoping meeting in Vancouver in 2015 and will hold a second scoping meeting in March 2016, again in Vancouver. Key members of the PSC staff and CSC will participate in the March meeting to help refine the scientific objectives and to support the development of a business strategy.

- **Consideration of a PSC Science Plan.** Numerous Commissions and agencies use high level, multi-year, science plans to articulate objectives which, if implemented, would further the goals of their organization. We envision a document that identifies overarching themes that could be addressed to inform the PSC Science Community over the time horizon of the next agreement. This document would not be a list of specific projects, but rather an outline of critical issues that can be used to help direct and support scientific enquiry.

  The initial efforts of the CSC for this task have been to meet with the PSC Executive Secretary, Technical Committees members, Panel co-chairs, the Endowment Fund Manager, and other members of the PSC science community to identify emerging issues and subjects for new or additional research and monitoring, and for presenting scientific information to the Commission. Issues that have been identified include 1) variability in biological responses to a changing environment such as survival, productivity, size at age, migration timing, and distribution; 2) improving forecasting models of abundance affecting PSC management regimes; and 3) application of best available science for informing salmon management actions and policy.

  Subsequently, the CSC received direction from the Commission to address some of the issues identified in the scoping effort, and as noted below has developed a strategy to address them while continuing work on a broader science plan.

- **Direction from the Commission during the January 14 Bilateral Session**.
  At the January 2016 meeting, the Pacific Salmon Commission decided that "By the 2016 Annual Meeting, the CSC shall collaborate with appropriate experts and develop a proposal for annual collation of data on the environment, run size, fish condition, and other metrics that may reveal anomalies in salmon survival." The CSC has developed an outline of possible actions that could be undertaken taken to address this directive and presented them to the Commission at this meeting.

SFEC Report

Pacific Salmon Commission
February 2016
Rob Houtman
Gary S. Morishima

Duties of SFEC

1. Serve as a coastwide clearinghouse for coordination and reporting on MM and MSF programs;

2. Provide advice on potential adverse impacts of MM and MSFs on the CWT program;

3. Assess and monitor the cumulative impacts of MSFs on stocks of concern;

4. Receive and review MM and MSF proposals to identify potential issues and concerns regarding impacts on the CWT program.

SFEC is to establish a technical review process for MM/MSFs that will

- Identify potential impacts on other jurisdictions and the CWT program;

- Review procedures and protocols for marking, sampling, and evaluation;

- Establish standard formats and reporting requirements to provide post-season information and estimates of mortalities on stocks of concern;

- Identify information needs or request modifications of proposals to meet concerns regarding impacts on the CWT program; and

- Periodically assess impacts of MM/MSF programs regarding the integrity of the CWT program.

Overview

- Proposals have been received and review is underway

- MM Proposals

Species	# 2015 Mass Marked	# 2016 Mass Marked
Coho	34.3 million	33.5 million
Chinook	117.3 million	117.1 million

- MSF Proposals

Species	# Proposed for 2015	# Proposed for 2016
Coho	25	18
Chinook	34	34
Coho & Chinook	1	0

MM Proposals

- All MM proposals were received within the requested timeframe, except for one concerning a new hatchery in the Upper Columbia
- MM levels for Chinook remain relatively constant; slight decrease for coho
  - Reduced production of DFO coho related to efforts to increase survival rates
  - Some question regarding ability to meet production goals due to drought, low returns, and small adult body size
- 800k Increase in CWT releases for both Chinook and coho
  - Coordination issues affect reporting of releases from Nez Perce operations
- DIT groups continue to be eliminated
  - Only one coho DIT group remaining in BC
  - ODFW has now dropped all DIT groups
  - Recommended DIT groups not implemented (CR summer and fall Chinook)

- ETD and Visual CWT sampling areas remain unchanged
- MM of Coho & Chinook releases are not all accompanied by CWT releases
  - Difficulty estimating source of MM'd encounters

MM Proposals for 2016 (excluding marked CWT'd fish)

Agency	Coho (million fish)	Chinook (million fish)
ADFG	0	0
CDFO	4.5	0
USFWS	1.3	25.0
WDFW/Tribes	22.2	71.1
ODFW/Tribes	5.5	21.0
IDFG	0	0
TOTAL	**33.5**	**117.1**

MSF Proposals for 2015/2016

Agency	Coho		Chinook	
	2015	2016	2015	2016
ADFG	0	0	1	1
CDFO	6	5	1	1
WDFW	10	11	20	25
ODFW	6	1	6	2
WDFW/ODFW	2	1	4	5
IDFG	0	0	1	0
CDFG	0	0	0	0
TOTAL	24		33	

Chinook MSF Proposals

- PS limited opportunity for spatial expansion. Substantial variation in regulations.
- WA ocean and CR spatial and temporal expansion
  - 3 new proposals in Upper Columbia
- BC sport fishery in Strait of Juan De Fuca – mixture of NSF and MSF
- New for 2016 - SEAK troll fishery
  - 1st MSF proposal for an AABM fishery
  - Retention of clipped legal sized fish during previously non-retention periods (10k limit; areas of high chinook encounters remain closed)

Bag Limits Proposed for 2016
Chinook Recreational Mark-Selective Fisheries

Legend

- 1 clipped adult + 1 unclipped adult
- 2 clipped adults
- 2 clipped adults + 2 clipped jacks
- 2 clipped adults + 4 jacks
- 2 clipped adults + 4 (WA) or 5 (OR) clipped jacks
- 2 clipped adults + 6 clipped jacks
- 3 clipped adults
- 3 clipped adults + 3 jacks
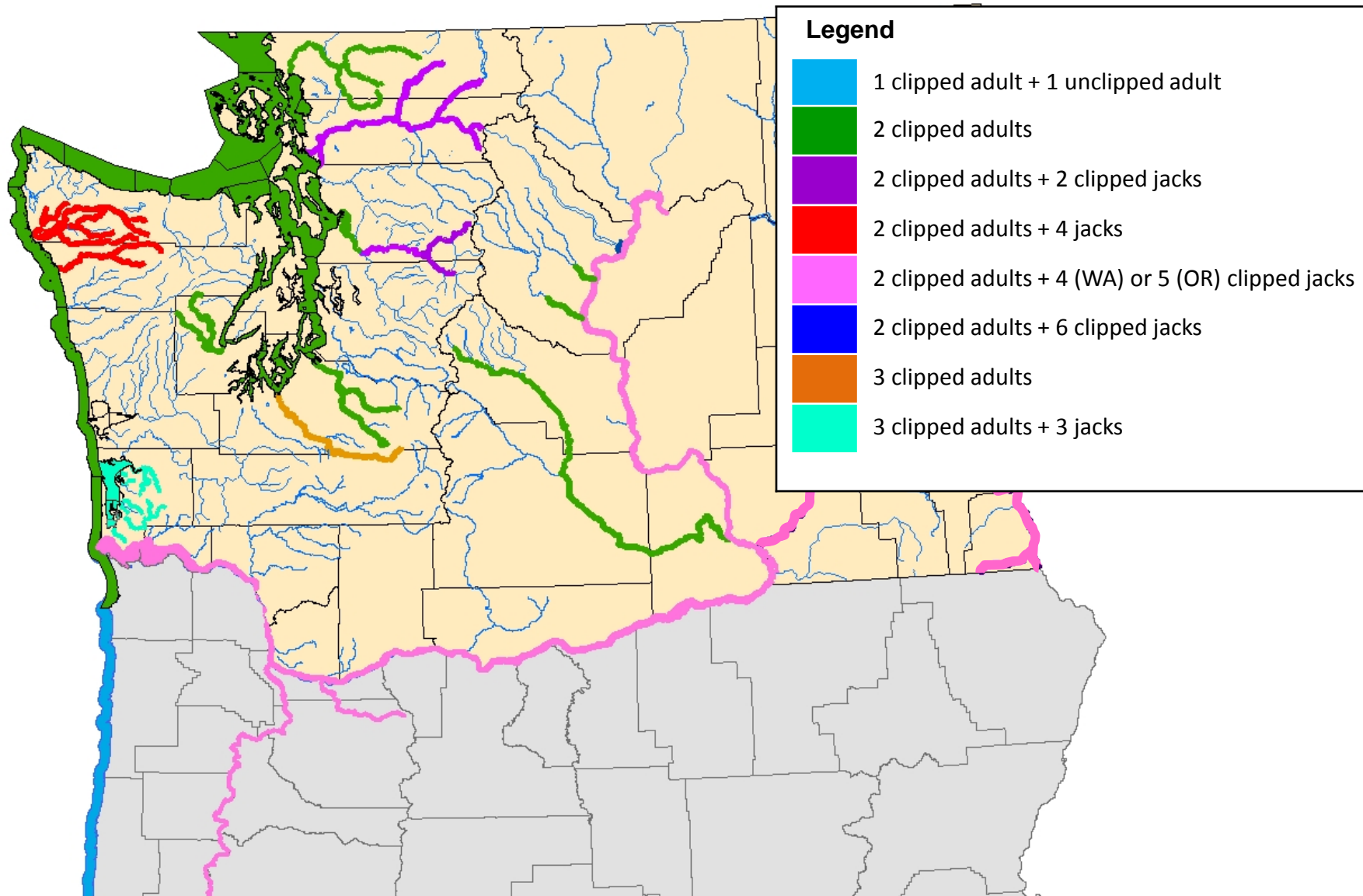
Proposed 2015 Bag Limits for Southern British Columbia Chinook Recreational Fishery by PFMA Sub Area

* Bag limit after June 15, 2/day, HM or wild < 85cm
or HM > 85 cm OR 2/day HM or wild; only 1 > 67cm,
depending on in-season monitoring of chinook returns.

Vancouver Island

N
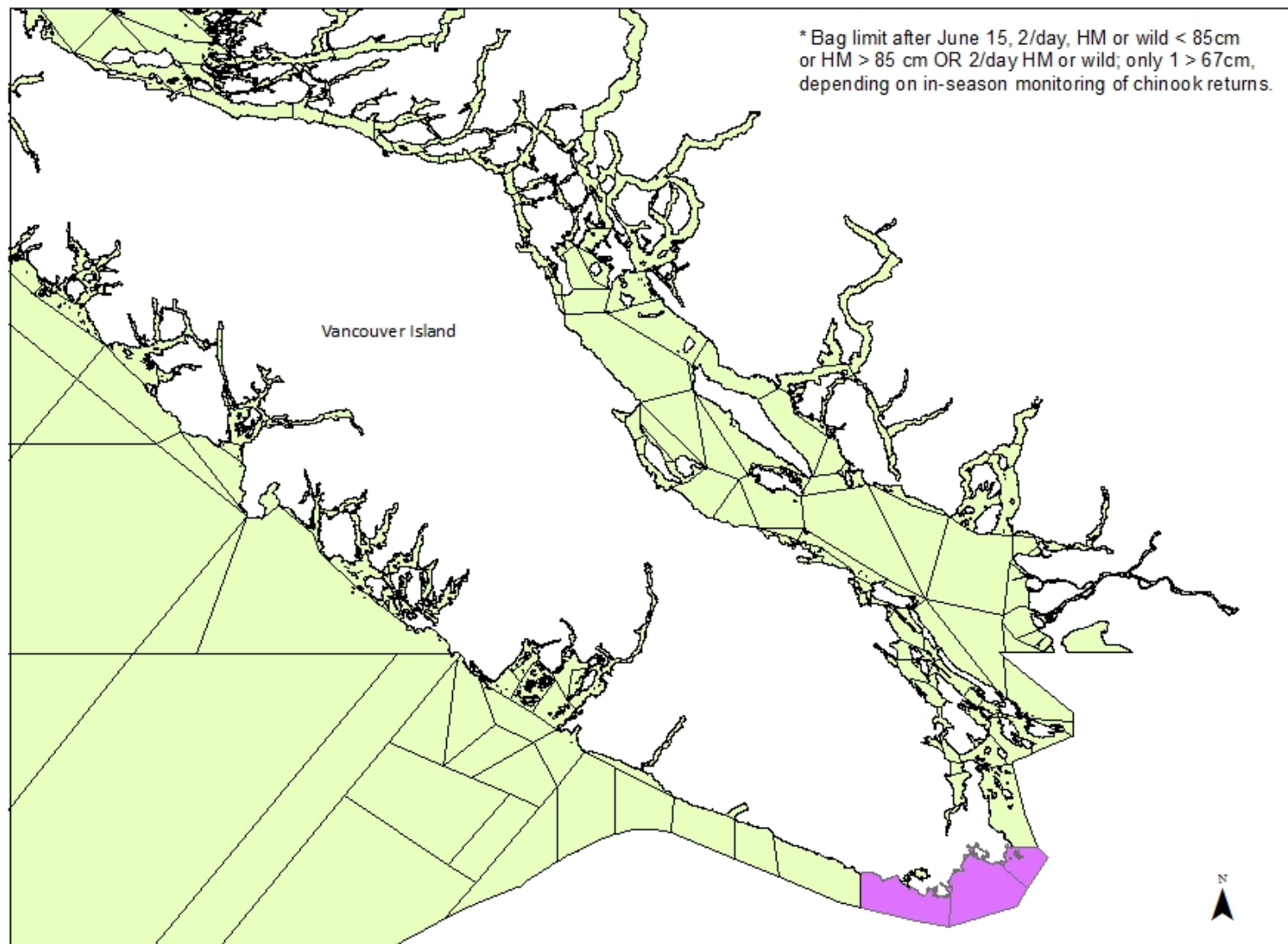
Legend

2 45-67 cm or 1 may be clipped > 67 cm Mar 1 to Jun 15, then 2 where 1 may be clipped > 85 cm Jun 16 to Jul 20

No MSF

SEAK Chinook MSF Proposal For 2016

- First MSF proposed for an AABM fishery
- Retention of marked chinook >28" during periods that previously operated under non-retention restrictions in SEAK
- 10K retention limit, high Chinook encouter areas closed
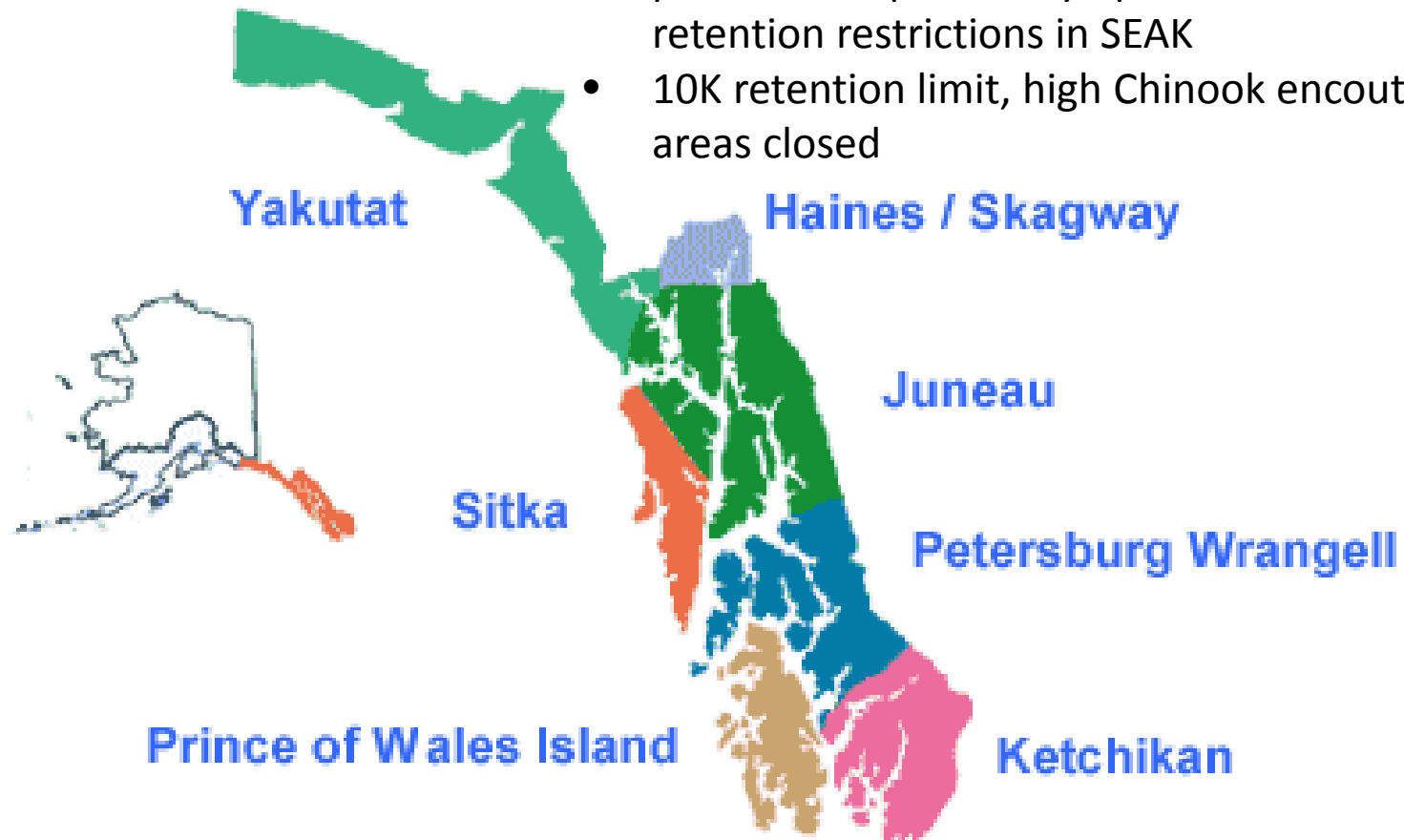
Coho MSF Proposals

- PS, WA ocean, and Columbia River: limited opportunity for spatial expansion
- BC sport fisheries
- Many variations in retention, time-area restrictions.

Bag Limits Proposed for 2016
Coho Recreational Mark-Selective Fisheries

Legend

- **2 clipped**
- **2 clipped + 2 unclipped**
- **2 clipped + 4 jacks**
- **2 clipped + 4 (WA) or 5 (OR) clipped jacks**
- **2 clipped + 2 unclipped + 2-4 jacks**
- **3 clipped + 3 jacks**
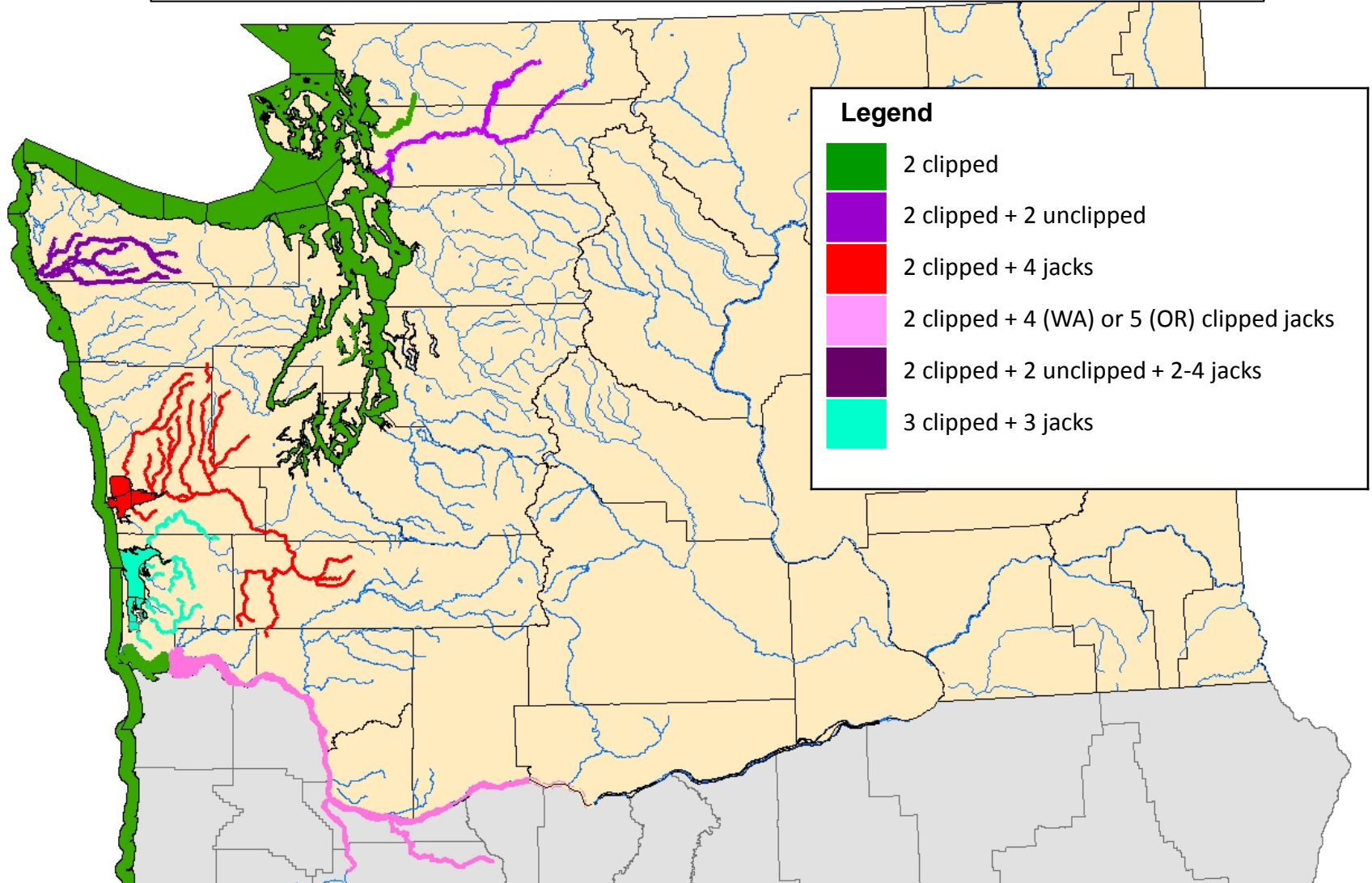
Proposed 2015 Bag Limits for Southern British Columbia Coho Recreational Fishery by PFMA Sub Area

Legend

- 2 (1 may be unclipped)
- 2 clipped
- 2 clipped, 2 (1 may be unclipped) after Oct 1
- 2 clipped, 4 (1 may be unclipped) after Oct 1
- 2 clipped, 4 (2 may be unclipped) after Sep 1
- 2 clipped, 4 (2 may be unclipped) after Sep 4
- 2 clipped, 4 clipped (portion) after Sep 1
- 2 clipped, 4 clipped after Sep 1
- 4 clipped
- No MSF
- No MSF (portion)
- No MSF (portion), 4 (2 may be unclipped) after Sep 1
- No MSF, 4 (2 may be unclipped) after Sep 1

Vancouver Island

* Not included on this map are terminal river regulations for hatchery systems (Chilliwack, Quinsam, Nitinat, Somass and Big Qualicum) after spawning migrations.

MSF Proposals

- R-Y-G tables & issue list
  - Complex regulations (e.g., mixed bag, size limits)
  - Inadequate catch monitoring and CWT sampling programs
    - Voluntary recovery programs in BC sport fisheries
    - Misalignment between MSF and catch sampling programs
    - Insufficient data collection (e.g., mark status, size category, retention)
- Mark rates not being fully considered in decisions regarding use of MSFs and impacts on comingled natural stocks.

At a glance: Green-Yellow-Red Approach being refined

Color	Level of concern to SFEC
	None
#.#.#	Moderate
#.#.#	Major

Red-Yellow-Green - examples

Proposal ID	Location	Fishery Type	Regulations	CWT Sampling Method	CWT Detection Method	CWT Composition Estimation Method	Alignment	Catch Estimation	Indicator Stocks	DIT Stocks	Comments and Concerns	Methods of Estimation
Coho Salmon												
MSF-FOC-03	Lower Fraser River	Terminal, First Nations (Mixed Bag)	1	3	2	4	1	2	1	0,1	This fishery is mixed bag because unmarked Coho that are mortally wounded or dead can be retained. Low CWT submission rates. Numbers of ad-clipped and unclipped Coho are reported in some fisheries.	Total catch estimate using creel survey or census.
MSF-FOC-05	BC Management Areas 23-27, 121-127	Pre-terminal Commercial (MSF)	1	1	1	1	1	1	1	1		Total catch is from fisher reported log books and phone-in catch reports.
Chinook Salmon												
MSF-WDFW-19	Ocean Areas 1-4	Recreational	1	1	1	1	1	1	1	1		Catch estimate from creel survey, based on an effort/CPUE survey with boat exit counts and exit interviews. Stratified by boat type (private or charter boats) and day type (weekend or weekdays). On-water encounter rates (by mark status/size) obtained from charter ride-along trips and VTRs.
MSF-WDFW-09	Puyallup / Carbon River	Recreational	1	3	1	2	1	2	1	1	Lack of direct sampling; only indirect CWT estimates, via electronic sampling at hatchery. These are substantial Chinook freshwater sport fisheries, averaging 1,000 and 400 fish in Puyallup and the Carbon.	Catch estimates from catch record cards. Indirect estimates of CWTs via electronic sampling at hatchery & associated tribal net fisheries.

Proliferation of regulations for implementation of MSFs

- Major types with multiple variations

Category	Description
Simple	Only marked fish can be retained.
marked mixed bag limit	A portion of total bag limit can be unmarked. This can be a daily limit bag or a seasonal bag limit
Mark and size-mixed bag limit	Size-range-specific allowances for retention of unmarked fish .

Implications of MSF Complexity

- Regulations affect complexity and costs for catch monitoring, sampling, and reporting systems

- Difficulty of developing methods to estimate MSF impacts on unmarked fish
  - Planning
  - Post-facto assessment
  - DIT coverage & sampling

Issues

- MSF proposals
  - required before details are known
- Post Season and Detailed reporting of MSFs
  - Pilot project for PS marine Chinook MSFs

Types of Information Needed

1. MSF location, timing, regulations
2. CWT sampling method
3. CWT estimation method
4. Estimates of encounters, retentions, releases for marked and unmarked, legal, and sub/extra legal sized fish

Issues – Budget Pressures

- Concerns for maintaining base sampling programs

- DIT programs (e.g., ODFW discontinued DIT Big Creek fall chinook) and sampling (ODFW has not implemented ETD of Columbia R. fall Chinook).

- Dependency on CWT system – concern for erosion of cornerstone for management, stock & fishery assessments

Examples

- Anadromous Fish Act - imminent loss of ocean fishery sampling in US

- DFO
  - CDFO funding cuts for CWT recovery and dissection affected both commercial and hatchery sampling programs

Data-driven to Assumption-based management

- Uncertainty, risk, and precautionary approaches
    - Compensatory buffers
    - Fishing patterns (decreased reliance on mixed-stock fisheries)
- Additional funding needed to maintain stock and fishery assessment capabilities and the viability of the coastwide CWT system
- **Recommend:** Initiating multi-TC evaluation of impacts of budgetary pressures on the ability to implement PSC regimes (letter from TC Co-Chairs)

Future Plans

- 2016 MM/MSF reviews: target completion date Spring 2016
- MSFs
  - Specific details of proposed MSFs unavailable in November
    - Focus on new proposals and post season reporting
  - Feb '16: Agencies to report on issues relating to post-season reporting of Encounters, releases, etc. (on line or post-season report)
  - Spr '16: Requirements for expanding pilot MSF reporting system under development by NWIFC & WDFW
- Coho DIT update – draft still in progress for PS, WC. Chinook DIT reported by CTC in exploitation rate analysis and calibration reports- differences are becoming apparent.
- Lessons Learned draft has been completed

PACIFIC SALMON COMMISSION

ESTABLISHED BY TREATY BETWEEN CANADA
AND THE UNITED STATES OF AMERICA
MARCH 18, 1985

600 – 1155 ROBSON STREET
VANCOUVER, B.C. V6E 1B5
TELEPHONE: (604) 684-8081
FAX: (604) 666-8707

MEMO

Date: February 10, 2016

To: Joint Technical Committee on Chinook

From: Phil Anderson and Sue Farlinger

CC:

Re: Work Assignment

On behalf of the Commission, we are requesting that an ad hoc group of the Chinook Technical Committee be established to conduct a review of an alternative model for managing the Southeast Alaska Fisheries. We fully recognize and appreciate the added workload this represents and don't make this assignment lightly. However, we believe this is an important task and ask that you make your best effort to provide the commission with the results within the timeline requested.

To assist you in responding to this assignment, we have included a set of questions (see attached) that we are asking you to use in responding to this request. We have also identified a subset of the CTC members that we are asking to take the lead in responding to this assignment.

The members of the CTC that would comprise the ad hoc workgroup are:
1) Bob Clark
2) Tim Dalton
3) Brian Elliott
4) Mike Hawkshaw
5) Robert Kope
6) Gary Morishima
7) Chuck Parken
8) Rishi Sharma
9) Antonio Velez-Espino
10) Ivan Winther

Thank you in advance for responding to this additional work assignment, the Commission very much appreciates your outstanding contribution to the Pacific Salmon Commission process.

CIG Questions Regarding Proposal:
An Alternative to the PSC Chinook Model for Managing Southeast Alaska Fisheries, 2016-2018
February 10, 2016

General Guidance
In addressing these tasks, members of the Chinook Technical Committee (CTC) shall adhere to the bylaws of the Pacific Salmon Commission (PSC).

Process and Time Schedule
The CIG shall identify an Ad-hoc Subcommittee of the Chinook Technical Committee to address the questions regarding the Winter Model. The Ad-hoc Subcommittee will update the full CTC on its deliberations as appropriate, and then provide a verbal or written report on the Winter Model questions to the CIG no later than 3PM on February 11, 2016.

Definitions

1) The winter fishery is defined as the southeast Alaska (SEAK) troll fishery in statistical weeks 42-48 and statistical weeks 7-13 in District 13.

2) Performance of model measured using contemporary statistical methods or analytical tools.

Questions on Winter Model

1) What is the stock composition and age composition (based on available coded-wire-tag recoveries or genetic stock information) in the most recent five years of the winter fishery and the entire summer troll fishery (all districts and days)? How do these estimates compare to those of the CTC Model?

2) What is the performance of the Winter Model if all catch areas, troll gear types and time periods are included?

3) Does the Winter Model produce a preseason abundance index in time to support preseason fishery management planning (i.e., a predicted abundance index available by April 1 of each year)?

4) Can the Winter Model analyses be replicated with the information presented in the [Alaska] proposal?

5) Describe how changes in the distribution of Chinook stocks would affect the performance of the Winter Model and CTC model estimates of the abundance index.

6) What are the performance metrics for the Winter Model and for the preseason predictions of the CTC model?

7) Does the Winter Model have a better performance in predicting the postseason abundance index than using the CTC model preseason prediction for the years 2001 through 2013?

8) What is the unit of effort and what are the pros and cons to using the permit as the measure of effort as opposed to other units?

9) What are the limitations of the Winter Model? Are there any violations of the assumptions? (e.g., systematic bias related to the magnitude of the allowable catch, interpretation of the intercept, predictions outside of the data range, etc.)

10) How much do the known problems of hyperstability of CPUE data affect the performance of this type of model?

11) What are the merits and drawbacks to limiting the data informing the Winter Model to 2001-2013?

12) And questions that may arise that inform or offer insight specific to model performance?

Ad-hoc Subcommittee of the CTC Response to CIG Questions Regarding Proposal: An Alternative to the PSC Chinook Model for Managing Southeast Alaska Fisheries, 2016-2018
Prepared February 11, 2016 – Final Version February 22, 2016

Definitions Provided by the CIG

1) The winter fishery is defined as the southeast Alaska (SEAK) troll fishery in statistical weeks 42-48 and statistical weeks 7-13 in District 13.

2) Performance of model measured using contemporary statistical methods or analytical tools.

Introduction
Responses of the Ad-hoc Subcommittee to a list of questions posed by CIG regarding the Winter Model follow. Upon review of the assignment, members of the Subcommittee found that ambiguity in language resulted in diverse interpretations of the intent of the questions being asked. In these instances, individual members of the Subcommittee restated the questions for clarity and provided responses accordingly. Due to the time frame requested for reporting, the Subcommittee was unable to reconcile divergent views either as to the exact nature of the questions posed or responses thereto. The term "report" as used in these responses refers to the "Proposal: An Alternative to the PSC Chinook Model for Managing Southeast Alaska Fisheries, 20116-2018" dated. February 2, 2016.

A number of preliminary analyses were performed by individual members of the Subcommittee in an attempt to respond to the CIG's questions. The results of these analyses are preliminary; due to the press of time, the Subcommittee as a whole was unable to review the detailed data or methods presented.

Summary Points
The Winter Model shows better overall statistical fit than the current versions of the CTC Chinook model when examining ability to estimate the post season abundance index (AI) during 2001-2013. After making improvements (maturation rates and EVs) to the CTC Model, performance of this model improves to that of the Winter Model.

The Ad-hoc working group have raised several questions about how appropriate it is to use the Winter Model presented here to estimate the first postseason AI (and thus SEAK TAC). These questions are briefly summarized here:
- What is an appropriate way to address the issues with hyper-stability and bias that cause the Winter Model to over-predict the AI at low stock sizes?
- What mechanism is proposed to deal with situations when the Winter PTI values are out of the range used in the regression model and that exceedingly high PTI values would suggest unrealistically high AI values?
- Do the stocks vulnerable to the winter power troll fishery well represent the stock composition of the Abundance Index?
- Are permits an adequate measure of effort in the winter power troll fishery?
- What time series of PTI and AI is appropriate to generating the linear regression?
- How should the PTI be employed relative to Table 1? Table 1 is based on a relationship between fishery harvest rate indices (HRIs), observed catches and AIs produced by calibration 9812. As discussed in responses to several questions, the Power Troll Index

associated by the Winter Model is not equivalent to the AIs produced by the CTC Model.   If the intent is to maintain the relationship between HRIs,, observed catch and the PTI, the allowable catch levels would have to be recomputed for Table 1.

Definitive answers to these questions were not produced in the time available, however information to support discussions of the pros and cons of the Winter Model were collected in our responses to the questions posed by the CIG.

Questions and Responses on the Winter Model

1) **What is the stock composition and age composition (based on available coded-wire-tag recoveries or genetic stock information) in the most recent five years of the winter fishery and the entire summer troll fishery (all districts and days)? How do these estimates compare to those of the CTC Model?**

   Stock compositions in Southeast Alaska troll fisheries were estimated from GSI data in years 2010-2013. We could not include 2009 in this analysis as GSI estimates in that time period were derived with a different baseline, which makes comparisons not possible in the short time frame for this review. In the tables in Appendix A, winter troll fisheries in the early and late period were combined, as were summer troll first and second retention periods. There was no second retention period in 2013 summer troll. Additionally, stock compositions from the SEAK winter and summer troll fisheries can be compared to stock compositions germane to the PSC Chinook Model. The stock group "AK hatchery" is included at the bottom of each table and contains stock groups containing Alaska hatchery production; comparisons with the Chinook Model stock compositions are not possible, however, because Alaska hatchery fish are not included in the Chinook Model.

   Also in response to the question, we provided CWT data in Appendix B. Coded-wire tag (CWT) recoveries are split out in SEAK winter troll and summer troll fisheries and by age; the catch contributions listed below are taken from the Alaska Department of Fish and Game Mark, Tag, and Age lab. Stock groups are also further refined in the CWT analysis and organized first by region and secondly by the specific stock group. CWT contribution data does not represent some Columbia River and Puget Sound stocks that are mass marked because expansion is not possible under this marking regime. CWT info was not weighted by production expansion factor to represent both natural and hatchery origin fish. Alaska hatchery fish are not included in these CWT data.

   Aside from these data, the linear relationship between Winter PTI and PSC Chinook Model postseason AI could reflect the inability of both PSC Chinook Model and PTI to capture temporal changes in the distribution and vulnerability of stocks contributing to fisheries. The PSC Chinook Model is a single-pool model that by design assumes fixed stock distribution. The Winter PTI seems to be equally insensitive to temporal changes in stock distribution. The analysis of CWT conducted and reported annually by the CTC shows changes in the distribution of stocks contributing to fisheries. Changes in abundance indices are mostly influenced by large driver stocks that are vulnerable to the fishery.

   Lastly, the question posed appears to be a roundabout way of asking if there are reasons to expect that the stock composition of the catch taken by power troll vessels during the proposed

2

time/area/gear strata by the SEAK power troll fishery would be expected to differ from that taken by the entire fishery during an entire fishing season. The answer to that question is yes.

The question seems to separate stock composition and age composition when they should be combined into stock-age composition of the landed catch. Considerable effort would be required to generate CWT or genetic based estimates of catch composition and estimates cannot be produced within the target time frame for this response.

There are serious limitations with attempts to generate stock-age compositions from either CWTs or genetic data. CWT data would not be sufficient to generate stock-age compositions for the entire catch because CWT recovery data are only available from CWT release groups recovered during the time of interest. Genetic data could be analyzed to estimate probabilities of percentages of catches comprised of stocks in available genetic baselines. However, these estimates would have to be evaluated in terms of representativeness of strata and adequacy of sample size in sampling programs, details that would require substantial effort and time to compile and analyze. Further, stock-age compositions based on genetic markers would be presented as probabilities of stock groups rather than individual fish and individual stocks of management interest and would be uncertain as to age without additional information on age structure.

Consequently, requested comparisons of either CWT or GSI based estimates with stock-age compositions estimated by the CTC Model would be "apples and oranges" evaluations. The CTC Model stock-age composition estimates represent the stocks in the CTC Model. These estimates would be derived from the multiplication of estimates of abundance of stock aggregates, base period exploitation rates, and age-specific assumptions regarding vulnerability to gear (e.g., fishery regulations such as size limits, season structure). The CTC Model employs an annual time step for regional aggregates of fisheries and the base period exploitation rates employed by the Model reflect CWT recoveries during an entire fishing year instead of just those taken by the PTI sector during a portion of the winter fishery. The CWT groups recovered in the most recent five years differ from those that were represented by recoveries during the 1979-1982 CTC Model base period. For GSI-based estimates, the CTC Model does not include all stocks so composition (expressed as a percentage of the catch) would have inconsistent denominators. Thus, there are stocks that contribute to CPUE data, but not to the model AIs, and the potential for the CPUE data to be sensitive to the abundance of stocks not represented in the model.

Another factor contributing to comparison of stock-age compositions generated by these methods is lack of one-to-one correspondence of names used for analyses on individual stocks.

2) **What is the performance of the Winter Model if all catch areas, troll gear types and time periods are included?**
We interpreted this question to mean: develop a regression model that uses power and hand troll data from all statistical weeks of the winter fishery, all districts, and all troll gears for the 2001-2013 time period and compare it with the Winter Model. Performance of this model relative to the Winter Model is reflected in the table below whereby a negative error implies the PSC Chinook model performs worse than this alternate version of the winter model. This alternate version of the winter model performs worse than the Winter Model. The Chinook Model performs worse than this alternate version of the winter model during 2001-2013 and better than this alternative version of the winter model during 2009-2013.

SEAK winter troll index all gear, all districts, all stat weeks

Time period		MSE	RMSE	MAE	MAPE
2001-2013	model errors	0.0406	0.201	0.161	10.70%
	relative error change*	-10%	-5%	-7%	-4%
2009-2013	model errors	0.0745	0.273	0.230	16.26%
	relative error change*	30%	14%	21%	21%

*relative error change from the PSC Chinook Model [(winter model – PSC Chinook model) / PSC Chinook model]

Winter Model (PTI D13 SW42-48 and SW7-13)

Time period		MSE	RMSE	MAE	MAPE
2001-2013	model errors	0.0338	0.184	0.136	9.16%
	relative error change*	-25%	-14%	-21%	-18%
2009-2013	model errors	0.0267	0.163	0.126	8.53%
	relative error change*	-53%	-32%	-33%	-37%

*relative error change from the PSC Chinook Model

3) **Does the Winter Model produce a preseason abundance index in time to support preseason fishery management planning (i.e., a predicted abundance index available by April 1 of each year)?**
Yes. Catch and effort data from the winter troll fishery in District 13 are available soon after fishing in statistical week 13 (the end of March) has concluded. A Winter Model prediction of the SEAK first postseason AI could be made at that time.

4) **Can the Winter Model analyses be replicated with the information presented in the [Alaska] proposal?**
Yes, however a table of the data of actually used was not made available in the report and is reproduced herein by ADFG. These data and PTI calculations are available from ADFG.

Year	Permits	Catch	PTI	First postseason AI
2001	145	11,728	80.88	1.29
2002	143	16,621	116.23	1.82
2003	149	21,597	144.95	2.17
2004	163	14,216	87.21	2.06
2005	167	19,087	114.29	1.90
2006	158	13,040	82.53	1.73
2007	127	4,216	33.20	1.34
2008	122	2,141	17.55	1.01
2009	88	2,032	23.09	1.20
2010	132	7,332	55.55	1.31
2011	129	8,327	64.55	1.62
2012	156	5,338	34.22	1.24
2013	122	4,421	36.24	1.63
2014	131	8,175	62.40	
2015	187	27,126	145.06	

See also question 12.

5) **Describe how changes in the distribution of Chinook stocks would affect the performance of the Winter Model and CTC model estimates of the abundance index.**
Pre-season and post-season abundance indices derived from the CTC model assume that stocks have the same distribution as they did during the base period. They are essentially weighted averages of the age-specific abundance of all stocks included in the model, with weights that are constant over time.

Catch rates depend on the local density of fish and conduct of the fishery. Local density depends on the abundance of fish and the distribution, so changes in distribution will affect catch rates. Consequently, changes in distribution will affect predictions of the Winter Model, but not pre-season or post-season AI derived from the CTC Chinook model. Specifically, if Chinook distributions change so that fish become more concentrated in SEAK and District 13, catch rates would be expected to be higher and the predictions of the Winter Model would be expected to overestimate AI compared to the Chinook Model. If Chinook distributions change so that fish become less concentrated in SEAK and District 13, catch rates would be expected to be lower and the predictions of the Winter Model would be expected to be biased low. Also fish distribution could shift north or south or inside or outside.

Said in another way, in the CTC Chinook model distribution of the stock aggregates are assumed to be the same as in the base period. As relative abundance changes among the stock aggregates or patterns of exploitation differ from those observed from the time period, their assumed set distribution patterns would affect the abundance of Chinook in SEAK as well as in District 13. That is, when stocks with distribution concentrated in SEAK and District 13 become reduced in abundance among years, abundance will decrease in SEAK and District 13; the opposite will occur when stocks with distribution concentrated in SEAK and District 13 increase in abundance.

6) **What are the performance metrics for the Winter Model and for the preseason predictions of the CTC model?**
Standard metrics of performance (deviations of model predictions from the first postseason AI from the Chinook Model) taken from the report are reproduced in the tables below.

CTC Chinook Model Performance:

Time Period	MSE	RMSE	MAE	MAPE
2001–2013	0.045	0.213	0.173	11.15%
2009–2013	0.057	0.239	0.190	13.43%

Winter Model Performance:

Time period		MSE	RMSE	MAE	MAPE
2001-2013	model errors	0.034	0.184	0.136	9.16%
	relative error change*	-25%	-14%	-21%	-18%
2009-2013	model errors	0.027	0.163	0.126	8.53%
	relative error change*	-53%	-32%	-33%	-37%

*relative error change from the PSC Chinook Model

There are other measures of performance, such as a hindcast of the data or updates to the CTC Model. Alternate performance measures are addressed in question 12.

Metrics for comparison of performance of alternative methods reflect data and information available at a given point in time. It is important to understand that analytical methods and models undergo continual refinement for improvement. While work on development of the Winter Model was underway, the CTC was producing a report on improving the fit between pre and post season AIs using alternative assumptions regarding maturation rates and EVs. The performance metrics above reflect comparisons with AI's produced by various versions of the CTC Model over time. The performance metrics associated with the CTC Model that was recommended as a result of the maturation rate-EV investigation reduced error to a level very close to those produced by the proposed Winter Model. See Question 12. Further, the availability of new information provides further information for the development of alternatives for becomes available, presents an opportunity to improve other models and methods.

7) **Does the Winter Model have a better performance in predicting the postseason abundance index than using the CTC model preseason prediction for the years 2001 through 2013?**
Based on results from the report, the Winter Model has better performance than the CTC Chinook Model based on standard performance metrics. The Winter Model produces an estimate of abundance that differs from the AIs produced by the Chinook Model. This could be due to differences in stock composition that determine CPUEs used in the Winter Model from the stock composition that determines SEAK AIs in the Chinook Model. Question 12 reports the performance metrics associated with the CTC Model that was recommended as a result of the maturation rate-EV investigation, which reduced error to a level very close to those produced by the Winter Model.

8) **What is the unit of effort and what are the pros and cons to using the permit as the measure of effort as opposed to other units?**
Pros:
One advantage to using **permit** as the unit of effort is that **catch per permit** calculations are not affected by trip length or number of trips (number of days fished). You could also use **landing** as the unit of effort as an alternative. When calculating catch per **landing,** note that days fished varies between landings. Using catch/landing/days fished could be useful. The number of permits fished during the winter fishery varies from year to year. Between 2001 and 2013, the number of unique permits fished at some point during the winter ranged from 300-500. Factors influencing number of permits fished include weather (bad weather tends to reduce effort by smaller boats); economics (price per pound vs fuel prices) and what kind of summer season trollers had (economic considerations).

A model that uses catch per landing was attempted using data from 2001-2013 as was done for the Winter Model. Relevant data and model performance is shown below. While this model performed well, it did not perform as well as the Winter Model.

SEAK winter troll Chinook per landing D13 SW 42-48 + SW7-13 2001-2013
(AY is Accounting Year, APE is Absolute Percent Error)

AY	Chinook per landing	Predicted Postseason AI (Landings Model)	Actual Postseason AI (Chinook Model)	APE (Landings Model)
2001	13.16	*1.64*	1.29	*27%*
2002	19.35	*2.00*	1.82	*10%*
2003	20.61	*2.07*	2.17	*5%*
2004	12.30	*1.59*	2.06	*23%*
2005	17.35	*1.88*	1.90	*1%*
2006	13.98	*1.69*	1.73	*2%*
2007	8.33	*1.37*	1.34	*2%*
2008	5.15	*1.19*	1.01	*17%*
2009	6.20	*1.25*	1.20	*4%*
2010	10.88	*1.51*	1.31	*15%*
2011	10.88	*1.51*	1.62	*7%*
2012	7.57	*1.32*	1.24	*7%*
2013	7.22	*1.30*	1.63	*20%*
2014	12.11	*1.58*		
2015	20.00	*2.03*		

SEAK winter troll Chinook per landing D13 SW 42-48 + SW7-13 performance

Time period		MSE	RMSE	MAE	MAPE
2001-2013	model errors	0.0450	0.212	0.163	10.75%
	relative error change*	0%	0%	-6%	-4%
2009-2013	model errors	0.0336	0.183	0.153	10.52%
	relative error change*	-41%	-24%	-19%	-22%

relative error change from the PSC Chinook Model

Cons:
The Winter Troll Model utilizes number of permits for the Power Troll sector as a surrogate for "effort." This has the advantage of providing a readily available statistic that does not require monitoring and analysis. However, this metric does not reflect the degree to which the permits are actively fishing, competition effects, or variations in efficiency of operation. Other expressions of effort employed for fishery analyses involve standardization to effort units. Standardization of effort can require substantial efforts to collate and analyze diverse types of data. For example, number of landings, reported days fished, fishing time (as distinct from travel time), or standardization of fishing power to account for deployment of technological improvements (e.g., GPS, sonar, number of lines or spreads, terminal gear restrictions, or variations in operator behavior (communication and cooperation) have been employed in efforts to standardize effort units.

The use of Permits and then estimating PTI is problematic, as we would get infinite abundance with infinite PTI. CPUE would be better to use as all this relationship says is that if we increase effort, and we would increase catch. This is not from the strict sense related to abundance. In addition the relationship should asymptote out at some value, and not grow till infinity. Based

on this, one could conclude that an infinite number of permits would have an infinite catch, and an infinite abundance, but at some level this relationship should flatten out.

The use of permits implicitly assumes that catchability is proportional to effort, i.e. permits in this case, and that no changes can occur in catchability over time; this assumption is flawed as numerous cases have indicated catchability changes over time; reasons for this maybe **technological change** (which has occurred in improvements in the troller's technology and GPS and communication equipment), **experience** (a lot of these fishermen have been fishing the same areas for over a decade, and with that comes good knowledge to change whatever is needed for the conditions to catch the fish), **environmental changes** (which have occurred over time, e.g., warm waters cause fish to distribute differently, and areas of high abundance may change as a function of that), and changes in **fishing method** (i.e. depth and/or locations are not constant over time and are related to how catchability changes may occur). Finally all four aforementioned factors are occurring and as such it would be difficult to say permits and the PTI are good indicators of effort.

The suggested approach does not distinguish between local availability (distribution and vulnerability) and abundance and is hence not compatible to AI based AABM regimes. The AIs for all three AABM fisheries are driven by the stock-age-cohort sizes and base period exploitation rates for the entire season. It is not possible to determine impacts on AIs coastwide by looking at SEAK Troll AI alone and without determining cohort sizes of all stocks-age groups that contribute the AIs. The evaluation criteria are post-season AI's which are a different creature than in-season estimators of local availability. Again this is primarily a flawed approach and the correct questions are not being asked here.

There is also evidence of hyper-stability (overestimation of abundance as actual abundance decreases; also see comments to questions 9 and 10) in the Winter Model. Hyper-stability is a typical aspect of CPUE-Abundance relationships that can be reduced by robust standardization of CPUE data. The in-season proposal could benefit from the exploration of alternative measures of effort (e.g., catch per boat day) coupled with robust standardization procedures.

9) **What are the limitations of the Winter Model? Are there any violations of the assumptions? (e.g., systematic bias related to the magnitude of the allowable catch, interpretation of the intercept, predictions outside of the data range, etc.)**
   Several aspects of the proposed Winter Model were problematic. Although a strong relationship between Winter PTI and PSC Chinook Model exists when 2001-2013 are included in the analysis (the regressions deteriorates with the inclusion of 1999-2000 data – see response to question 11), there are three major reasons for concern.

   a. The Winter Model exhibits systematic bias characterized by increasing overestimation of actual abundance as actual abundance decreases (see Figure below). This is a typical example of hyperstability that translates into risk of overfishing at low abundances, which is an undesirable situation. The percent error at low abundances can be as large as 38%, which translates into approximately 40,000 fish (see also response to question 10).
   b. The use of an intercept indicates that at 0 PTI, we would still get 156K catch with the Winter Model. This obviously is somewhat meaningless, as with no effort or PTI, the catch is still substantially high, and maybe forcing the data through the intercept would be a better approach to pursue. This will of course change the slope substantially, and then the

relationship may not be very realistic as well. This result demonstrates that the model may have performance problems beyond the range of the data.

c. The in-season proposal did not include any mechanism for cases when the Winter PTI is out of the range of data used in the Winter regression model. A simple decision rule that could be incorporated in a revised proposal is to abide by the PSC Chinook Model "preseason AI" when the Winter PTI value is out of the range used in the linear regression model.
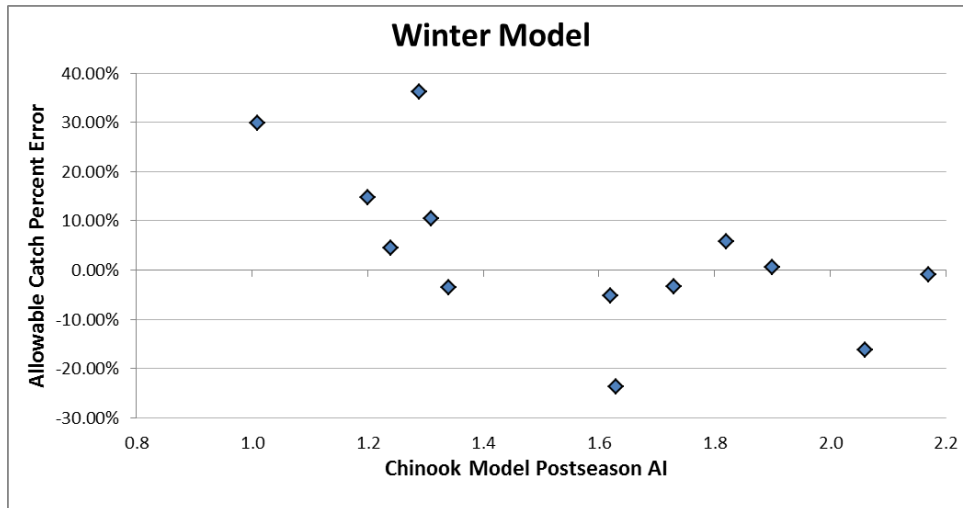
Relationship between PSC Chinook Model postseason AI and the percent error in allowable catch derived from the Winter Model.

Another limitation is the use of an ordinary least squares regression instead of a reduced major axis regression model.

Ordinary least squares (OLS) linear regression models have several assumptions, including that the independent variable (x axis) is measured without error and the dependent variable (y) varies in relation to changes in the independent variable, not vice versa. In the proposed Winter Model there are violations to both of these assumptions. The predictor variable power troll index (PTI) is measured as catch divided by the number of unique permits (catch/permits), a measure of catch per unit effort (CPUE) that apparently has a substantial degree of inaccuracy and uncertainty from year to year. Also, it is very difficult to rationalize that the Winter Model dependent variable (SEAK post-season AI estimated by the CTC Chinook model) is actually dependent on catch/permit CPUE in the Sitka winter fishery, but it is a much more reasonable argument that catch/permit CPUE can be dependent on chinook relative abundance as indicated by post-season AI estimates for SEAK (which index relative abundance starting in October, and also estimated with significant uncertainty).

To determine the relationship, because y is assumed to depend on a very accurate and representative x, OLS regression minimizes squared errors (observed minus expected) along the y-axis, and the upshot of the assumption violations above is that the slope of the relationship will be biased low (underestimated), and the intercept will be overestimated. An alternative regression method termed reduced major axis (RMA) does not assume that x is measured more accurately than y and also does not assume that y is dependent on x, giving equal weight to minimizing errors in x as to errors in y. Relationships estimated by RMA regression therefore

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have greater slope and lower intercept than those estimated by OLS regression, and it is useful to compare such a relationship to the OLS regression Sitka Winter troll model.

As expected the RMA regression relationship had greater slope (0.0089) and lower intercept (0.951) than the OLS regression relationship slope (0.0076) and intercept (1.040). However, both relationships yielded very similar predictions of post AI for 2001-2013 (see table below). Thus the effects and concerns explored elsewhere in this document (e.g., hyper-stability) would be little different if one used an RMA regression model in place of the OLS Winter Model.

Observed post-season AI and predicted AI by OLS and RMA models.

Year	Observed	OLS	RMA
2001	1.29	1.658	1.6692
2002	1.82	1.928	1.9830
2003	2.17	2.147	2.2380
2004	2.06	1.706	1.7525
2005	1.90	1.913	1.9658
2006	1.73	1.670	1.6838
2007	1.34	1.293	1.2575
2008	1.01	1.174	1.1068
2009	1.20	1.216	1.1560
2010	1.31	1.464	1.4419
2011	1.62	1.533	1.5241
2012	1.24	1.301	1.2548
2013	1.63	1.317	1.2728

10) **How much do the known problems of hyperstability of CPUE data affect the performance of this type of model?**
There are many fisheries models that attempts to link commercial CPUE and abundance, but one of the main challenges faced by these models is hyper-stability. Hyper-stability is a well know property of commercial CPUE based models, whereby catch rates remain high even as abundances fall. The Winter Model uses an index of commercial CPUE (PTI)to predict an index of abundance (AI). The Winter Model presented here shows a pattern of over predicting the abundance index when the abundance index is low which is consistent with a hyper-stable index. This means that at lower abundances the Winter Model will tend to over predict the AI and thus predict high TAC even at very low AIs.
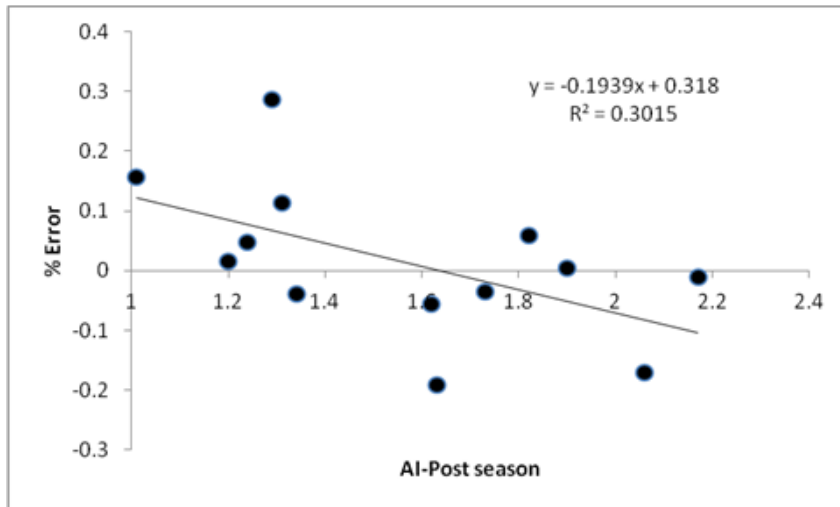
The residuals in the Winter Model (observed AI – modeled AI) show a pattern of over predicting at lower abundances. (The fitted line has an intercept of 0.3 and a slope of -0.2 with a p value of 0.0623, showing the bias in the regression at lower AI)
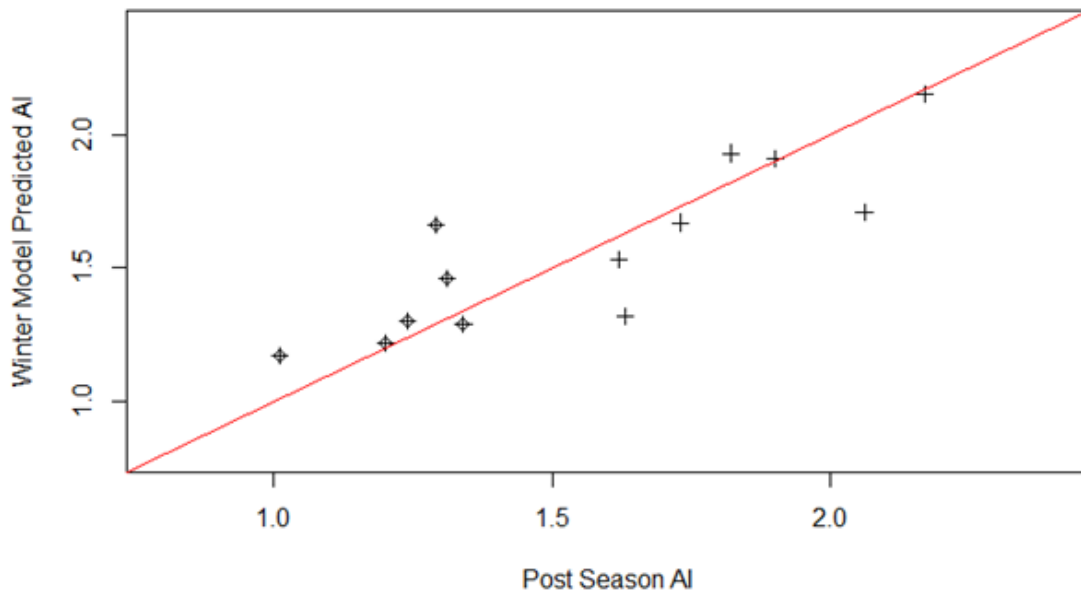
Winter Model predicted AI plotted against post season AI. The diagonal line is a 1:1 line, where points above the diagonal line represent over estimates while points below represent underestimates. Notice that at abundance index values less than 1.5 (circled) the Winter Model over predicts in 5 out of 6 years.

11) **What are the merits and drawbacks to limiting the data informing the Winter Model to 2001-2013?**
Optimally, the 1999-2013 or longer time period should have been used in the Winter Model. However for the reasons stated in the report (i.e., different calibration methods) 1999 and 2000 were excluded. An analysis that uses 1999-2013 was attempted and the standard performance

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metrics are reported below. This model did not outperform the CTC Model for the entire time period (1999-2013), but did for the current Annex time period (2009-2013).

CTC Chinook Model using 1999-2013

Time Period	MSE	RMSE	MAE	MAPE
1999-2013	0.0393	0.198	0.155	10.09%
2009-2013	0.0573	0.239	0.190	13.43%

Winter Model using 1999-2013

Time period		MSE	RMSE	MAE	MAPE
1999-2013	model errors	0.0836	0.289	0.227	16.09%
	relative error change*	112%	46%	46%	60%
2009-2013	model errors	0.0281	0.168	0.138	9.27%
	relative error change*	-51%	-30%	-27%	-31%

relative error changes from the PSC Chinook Model

In regards to years prior to 1999, some domestic regulatory changes in SEAK fisheries implemented during the 1990s affected winter troll catch rates and effort levels, especially in Sitka Sound (District 13):
- o Winter boundary lines were modified during fisheries during 1992-1994, expanding the area open in Sitka Sound, which led to substantial increase in catch rates, effort and harvest.
- o Winter boundary lines were modified again during fisheries in 1995, reducing what they were prior to 1992.
- o In 1992, winter fishery start date was delayed by 10 days to October 11, which eliminated a generally highly productive time period.

The trend towards improved technology led to increased efficiency over time, due to better communication and navigational equipment, better and larger boats, etc.; limiting the time series to recent years reduces influence of those changes. These factors all make use of data prior to 1999 problematic.

Data from 1999 and 2000 were excluded from the winter troll model. The base-period data incorporated into the PSC Chinook Model calibration used to construct Table 1 in the 1999 PST Agreement (Calibration #9812) included the assumption that the stray rate for WCVI hatchery Chinook was 75% across all ages. These same base data were used in the 1999 model calibration (Calibration #9902). However, in 2000 the assumptions regarding the stray rates for WCVI hatchery Chinook were changed to make them age-specific. This change in the base-period data going into the 2000 calibration (Calibration #0021) affected the 1999 postseason AI estimate and the 2000 preseason AI projection. Since this change had a significant effect on the AIs, particularly the SEAK AIs, and departed from fundamental assumptions used to construct Table 1 in the 1999 Agreement, the age-specific stray rates for WCVI were abandoned in the 2001 calibration and reverted back to the 75% stray rate across all ages. This change in the 2000 calibration affected both the 1999 and 2000 AI values. As a result, use of these AI values in developing predictive models is deemed problematic.

By limiting the data to 2001-2013, there is a limited range of AI and PTI data that the model is based on (AI range = 1.01-2.17; PTI: 17.5-144). The post-season calibration for 2014 was not

accepted by the CTC. The CTC model produced a post-season AI for 2014 that would not increase the range of AIs (to 2.13), but this point occurs in the middle of the PTI range (62.4) and would increase the uncertainty and the scatter of the points around the model (Figure 2 in the report).

The thirteen-year data set limits the amount of environmental variability and effects on the spatial distribution and growth rates of chinook stocks that are represented by the winter model. Variation in spatial distribution can directly affect the stock vulnerability to the fishery, and hence the CPUE. Also, variation in stock-specific growth rates can lead to variation in the proportion of the stock that is vulnerable to the fishery (e.g. high growth rate increases the proportion of the cohort that exceeds the minimum size limit, which relates to CPUE). A longer time series would provide more opportunity to fully represent the range of potential conditions.

Limiting the data set to 2013 and not including recent information will limit the model's representation of the unusual recent environmental conditions. The influence of the warm blob since 2014 and 2015/16 *el Nino* on the distribution and growth of chinook stocks is unknown, and when the information is available in the near future it will not be part of the 2001-2013 data. One approach is to update the model with new information, however this was not addressed in the proposal but it was an option described in the oral briefing about the Winter Model.

12) **And questions that may arise that inform or offer insight specific to model performance?**
Q. Are there better measures of performance than the standard metrics used in the report?
Comparisons presented between the Winter Model and the CTC model are between forecast values for the CTC model and fitted regression values for the Winter Model. A more valid comparison would be to compare hindcast values from the Winter Model with forecast values from the CTC model. However, the ability to perform a hindcast exercise is hampered by the limited data set since 2001 (e.g., a forecast of the AI in 2005 would be based on only 4 data points).
Comparison of the hindcast Winter Model with the CTC model pre-season forecasts for the years 2009-2013 is comparable with that of the fitted values from the Winter model. From the table that follows, it has a MAPE of 9% vs 13% for the preseason forecasts from the CTC model.

year	CTC model post-season AI	Winter model pre-season AI	CTC model preseason AI	Winter model APE	CTC model APE
2009	1.20	1.15	1.33	3.8%	10.8%
2010	1.31	1.43	1.35	9.3%	3.1%
2011	1.62	1.49	1.69	7.9%	4.3%
2012	1.24	1.25	1.52	1.2%	22.6%
2013	1.63	1.27	1.20	22.1%	26.4%
2014		1.52	2.57		
Average	1.40	1.32	1.42	8.9%	13.4%

Another approach to outcomes, is that rather than concentrating on statistical measures of model fit an analysis of methods for setting TAC (either pre or in season) could focus on Catch. Model performance should be in judged in terms of effect on harvest. Combining the TAC relationships from Table 1 of Chapter 3 of the Pacific Salmon Treaty with the Winter Model shows high available TAC across all ranges of power troll index values. Another metric would focus on the HRI and the errors with respect to the values used to develop Table 1.
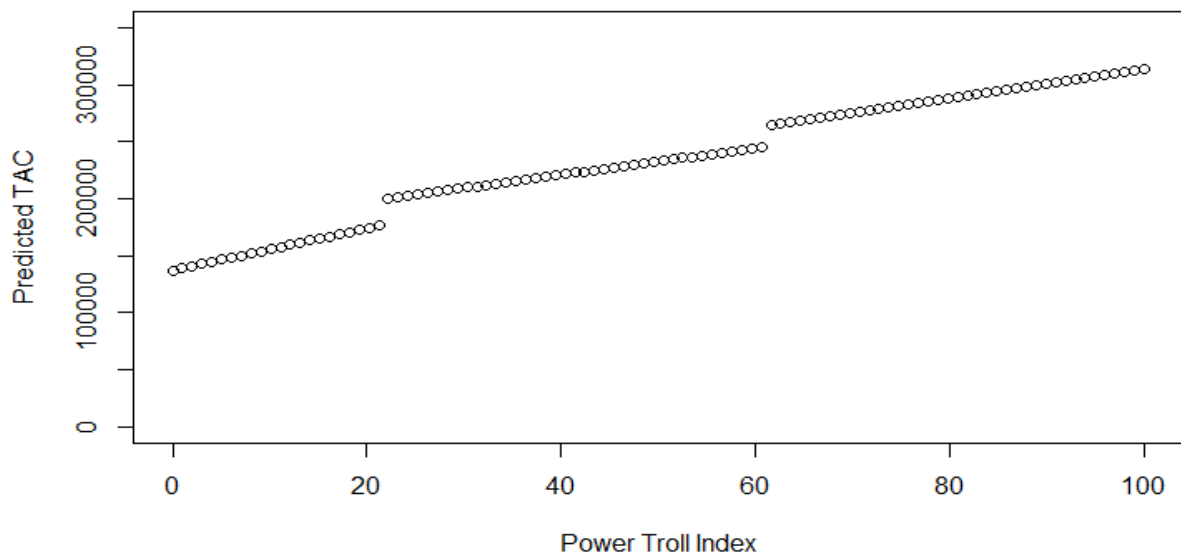
Implied TAC at different Power Troll Index values.

Another measure of performance of the CTC Chinook model can be calculated using the new procedures for representing Maturation Rates (9-year average) and EVs (recent completed cohort) for incomplete cohorts in the CTC Model. The results are from the February 2016 CTC report on the Maturation Rate and EV investigations. Note that the CTC did not report the performance of this technique for 2001-2003 so these results do not align with the statistics reported for the current versions of the CTC Model and the Winter Model. This model has similar performance to the Winter Model for 2009-2013.

Time Period	MSE	RMSE	MAE	MAPE	Mean Error	Mean Percent Error	Error Range	Percent Error Range
2004-2013	0.027	0.164	0.109	7.44%	-0.005	0.77%	-0.42 to +0.24	-24.4% to +18.9%
2009-2013	0.039	0.198	0.127	8.34%	-0.049	-2.00%	-0.42 to +0.12	-24.4% to +9.2%

Q. Would implementation of an in-season abundance estimator for the SEAK troll fishery to drive the SEAK AABM fishery provide a sufficient basis for implementation of the PST Chinook regime and preseason planning for domestic fisheries?

The abundance indices generated by calibration of the CTC Model are derived from projections of stock-age cohort sizes and base period exploitation rates. Once these stock-age cohort sizes

are determined, calculation of abundance indices is a simple matter of arithmetic and catch constraints are automatically determined through Table 1 of Chapter 3 of the PST. The proposed Winter Model troll index relies on catch by power troll vessels during a selected time-area strata without regard to the stocks and ages that comprise the landed catch. No means to distinguish between distributional variability of component stocks and ages from actual stock-age cohort abundance is proposed. Consequently, there is no capacity to estimate abundance indices to establish catch constraints for the NBC and WCVI AABM fishery complexes. Reliable projections of impacts of AABM fisheries are essential to provide a necessary and sufficient basis for planning ISBM fisheries or evaluating fishery proposals against requirements for allocation, avoiding jeopardy determinations of stocks listed under the US Endangered Species Act, or conservation of stocks of concern to Canada.

Canada's domestic management of the NBC troll fishery includes objectives that relate to the forecast of WCVI Chinook return to Canada to address concerns for the stock. The forecast of WCVI Chinook return to Canada is calculated shortly after the model calibration results are presented and includes a forecast of WCVI impacts in SEAK to generate the return to Canada. This process would be confounded and possibly delayed by the move to the Winter Model PTI approach.

Q. Is it appropriate to compare the performance of the Winter Model to the performance of past versions of the CTC model when the CTC has found that new methods, to estimate maturation rates for incomplete cohorts, has reduced the error between the pre and post season AIs?

The CTC has recently found that a new method to estimate maturation rates reduces the error between the pre and the post season AI, based on analyses for 2004-2013 CTC model calibrations. This new method should be applied for future CTC model calibrations. Thus, the amount of error in the past CTC model calibrations (2001-2013), is likely to be slightly higher than the level of error for future CTC model calibrations. This circumstance creates an issue with interpreting the relative performance of the Winter and CTC models in the past, and using that information to make an inference for the future performance of the models.

Q. Is the objective of predicting the 2001-2013 post-season AIs, from the first post-season CTC model calibration, the appropriate target for an in-season model (first post-season vs best post-season)?

The AIs change by small amounts until all the contributing cohorts are completed, and the best series of estimates are typically available from the most recent calibration (considering that there can be revisions to catch, escapement, and CWT recoveries years afterward). The Table 1 relationship for SEAK is based on the AIs, Fishery Indices, and Catch that existed for CTC model Calibration 9812 (the time series of AIs was from 9812). The 2009 Agreement specifies that the compliance of the catch in the AABM fisheries would be based on the first post-season AI.

Q. Are there other ways to replicate the analysis beyond that mentioned in question 4?

As we state in our answer to question 4, if the data employed for the analyses are provided and methods are adequately described, the results can be replicated. There are, however, more seminal issues that are embedded in question 4, which should be explicitly stated, including: (a) have the methods for data collection and reporting been adequately described? The answer is no; (b) has the actual data employed in the analysis been provided? The answer is no; (c) has

the accuracy of the data been verified? The answer is no; (d) have all the data that might be evaluated for use in an in-season abundance estimator been identified and provided to the Small Group? The answer is no; (e) can the data that could be included in a model be selected in other ways? The answer is yes; (f) are there alternative analytical models that could be employed to develop a model? The answer is yes; (g) are there alternative ways to evaluate model performance? The answer is yes. Investigation into selection of data sets and methods of analysis cannot be completed in the time available for response.

GSI Data

GSI-based stock composition estimates which are ≤ 0.05 should be interpreted with caution. Relative uncertainty of the estimates in this range are large (>50%) and may not be distinguishable from 0.0.

SEAK Troll All quadrants	AY2010		
Stock group	Winter	Summer	Chinook Model
AK Wild	0.017	0.018	0.027
NBC/CBC	0.150	0.044	0.147
WCVI	0.165	0.059	0.120
ECVI	0.043	0.007	0.041
Fraser Late	0.006	0.009	0.000
Fraser Early	0.103	0.183	0.083
PugetSd	0.020	0.008	0.004
WA Coast	0.026	0.134	0.054
Low Col. Fall	0.021	0.024	0.011
Willamette Spring	0.072	0.012	0.043
IntColSuFa	0.092	0.196	0.370
OR Coast	0.016	0.171	0.100
AK Hatchery	0.268	0.133	n/a
SEAK Troll All quadrants	AY2011		
Stock group	Winter	Summer	Chinook Model
AK Wild	0.024	0.001	0.017
NBC/CBC	0.219	0.061	0.108
WCVI	0.252	0.076	0.194
ECVI	0.033	0.015	0.036
Fraser Late	0.007	0.007	0.002
Fraser Early	0.026	0.134	0.062
PugetSd	0.018	0.006	0.004
WA Coast	0.024	0.135	0.047
Low Col. Fall	0.027	0.044	0.028
Willamette Spring	0.054	0.009	0.025
IntColSuFa	0.168	0.263	0.388
OR Coast	0.032	0.157	0.089
AK Hatchery	0.117	0.092	n/a

SEAK Troll All quadrants	AY2012		
Stock group	Winter	Summer	Chinook Model
AK Wild	0.055	0.011	0.016
NBC/CBC	0.166	0.077	0.132
WCVI	0.218	0.055	0.170
ECVI	0.066	0.008	0.047
Fraser Late	0.004	0.003	0.001
Fraser Early	0.033	0.068	0.061
PugetSd	0.029	0.007	0.006
WA Coast	0.015	0.158	0.059
Low Col. Fall	0.024	0.048	0.012
Willamette Spring	0.091	0.012	0.024
IntColSuFa	0.092	0.257	0.371
OR Coast	0.014	0.118	0.100
AK Hatchery	0.193	0.179	n/a

SEAK Troll All quadrants	AY2013		
Stock group	Winter	Summer	Chinook Model
AK Wild	0.029	0.003	0.014
NBC/CBC	0.225	0.030	0.097
WCVI	0.222	0.106	0.111
ECVI	0.040	0.003	0.030
Fraser Late	0.005	0.000	0.001
Fraser Early	0.025	0.106	0.049
PugetSd	0.038	0.002	0.004
WA Coast	0.010	0.074	0.039
Low Col. Fall	0.012	0.033	0.012
Willamette Spring	0.037	0.002	0.013
IntColSuFa	0.114	0.399	0.526
OR Coast	0.005	0.140	0.103
AK Hatchery	0.238	0.102	n/a

SEAK Troll All quadrants	2010-2013		
Stock group	Winter	Summer	Chinook Model
AK Wild	0.032	0.008	0.018
NBC/CBC	0.187	0.056	0.118
WCVI	0.216	0.071	0.148
UP + LOW Georgia St.	0.046	0.009	0.038
Fraser Late	0.006	0.005	0.001
Fraser Early	0.047	0.124	0.063
PugetSd	0.025	0.006	0.004
WA Coast	0.020	0.130	0.049
Low Col. Fall	0.022	0.038	0.016
Willamette Spring	0.067	0.009	0.026
IntColSuFa	0.118	0.268	0.421
OR Coast	0.018	0.147	0.098
AK Hatchery	0.196	0.128	n/a

2009 Winter Troll

| Region/Stock Group | Catch | | | | p^ total catch |
	Age-4	Age-5	Age-6	Total	
AK WILD	56	518	1,504	2,077	0.38
BC	1,846	177	55	2,077	0.38
FRASER EARLY	71			71	0.01
LOW GEORGIA S.	219			219	0.04
NBC/CBC	195	47	6	248	0.05
UP GEORGIA S.	372	109	49	529	0.10
WCVI	989	21		1,011	0.19
OR / WA / ID	503	704	37	1,244	0.23
OR COAST	32	18		50	0.01
SNAKE R. FALL	4			4	0.00
WILLAMETTE SPRING	96	48		144	0.03
COL. SUMMER	63	548	34	645	0.12
LOW COL. FALL	3		3	6	0.00
PUGET SOUND	68	5		73	0.01
SNAKE R. FALL	6			6	0.00
URB/MCB	185	38		223	0.04
WA COAST	48	47		94	0.02
Grand Total	2,405	1,399	1,595	5,399	

2010 Winter Troll

Region/Stock Group	Age-3	Age-4	Age-5	Age-6	Total	p^ total catch
AK WILD			1,878	906	2,785	0.37
BC	5	1,321	745	3	2,075	0.27
FRASER EARLY	5	144			149	0.02
FRASER LATE		3			3	0.00
LOW GEORGIA S.		426	4		430	0.06
NBC/CBC		188	373	3	564	0.07
UP GEORGIA S.		75	167		242	0.03
WCVI		486	201		687	0.09
OR / WA / ID	3	1,567	1,115	85	2,770	0.36
OR COAST		106	14		120	0.02
WILLAMETTE SPRINGS		967	348		1,315	0.17
COL. SUMMER		231	491	82	804	0.11
LOW COL. FALL		3	11		14	0.00
PUGET SOUND	3	35	17		55	0.01
SNAKE R. FALL		3	3		6	0.00
URB/MCB		189	157	0	346	0.05
WA COAST		32	74	3	110	0.01
Grand Total	8	2,888	3,738	995	7,629	

2011 Winter Troll

Region/Stock Group	Age-4	Age-5	Age-6	Age-7	Total	p^ total catch
AK WILD		1,018	719		1,736	0.19
BC	3,572	592	4		4,168	0.45
FRASER EARLY	53				53	0.01
LOW GEORGIA S.	288				288	0.03
NBC/CBC	414	190	4		608	0.07
OTHER	42				42	0.00
UP GEORGIA S.	603	32			634	0.07
WCVI	2,171	371			2,542	0.27
OR / WA / ID	1,062	2,278	26	5	3,371	0.36
OR COAST	173	18			191	0.02
SNAKE R. FALL	42				42	0.00
WILLAMETTE SPRING	408	829			1,237	0.13
COL. SUMMER	133	1,352	26	5	1,517	0.16
LOW COL. FALL		8			8	0.00
PUGET SOUND	36	11			48	0.01
SNAKE R. FALL	3	3			6	0.00
URB/MCB	235	10	0	0	246	0.03
WA COAST	30	46			76	0.01
Grand Total	4,633	3,888	749	5	9,275	

2012 Winter Troll

Region/Stock Group	Age-4	Age-5	Age-6	Total	p^ total catch
AK WILD		2,320	2,531	4,851	0.37
BC	1,773	2,944	6	4,723	0.36
FRASER EARLY	65	6		71	0.01
LOW GEORGIA S.	205			205	0.02
NBC/CBC	300	543	6	848	0.06
OTHER		39		39	0.00
UP GEORGIA S.	664	294		958	0.07
WCVI	539	2,064		2,602	0.20
OR / WA / ID	1,573	1,988	110	3,672	0.28
OR COAST	432	40		473	0.04
SNAKE R. FALL	3	10		13	0.00
WILLAMETTE SPRINGS	280	904	37	1,221	0.09
COL. SUMMER	225	467	69	760	0.06
LOW COL. FALL	6	6		12	0.00
PUGET SOUND	60	4		65	0.00
SNAKE R. FALL	6	19		25	0.00
URB/MCB	493	388	5	885	0.07
WA COAST	68	150		218	0.02
Grand Total	3,346	7,252	2,647	13,246	

2013 Winter Troll

Region/Stock Group	Age-3	Age-4	Age-5	Age-6	Age-7		Total	p^ total catch
AK WILD			455	788			1,243	0.26
BC	29	591	984				1,604	0.33
FRASER EARLY	4	9					13	0.00
LOW GEORGIA S.	19	128					147	0.03
NBC/CBC		252	215				467	0.10
OTHER	5	3					9	0.00
UP GEORGIA S.		137	307				444	0.09
WCVI		61	462				523	0.11
CA	15						15	0.00
OTHER	15						15	0.00
OR / WA	77	742	1,137	40		5	2,000	0.41
OR COAST		4	122	5			130	0.03
WILLAMETTE SPRINGS	9	114	306				430	0.09
COL. SUMMER		136	571	21		5	733	0.15
LOW COL. FALL		3					3	0.00
PUGET SOUND	23	30	4				57	0.01
URB/MCB	44	394	105	0		0	543	0.11
WA COAST		61	29	14			103	0.02
Grand Total	120	1,333	2,576	828		5	4,862	

2009 Summer Troll

Region/Stock Group	Age-3	Age-4	Age-5	Age-6	Total	p^ total catch
			Catch			
AK WILD		86	1,065	3	1,155	0.07
BC	310	2,802	106	9	3,227	0.20
FRASER EARLY	115	87			202	0.01
LOW GEORGIA S.	195	116	8		318	0.02
NBC/CBC		454	57	9	520	0.03
UP GEORGIA S.		208	41		249	0.02
WCVI		1,938			1,938	0.12
OR / WA / ID	304	8,850	2,836	53	12,043	0.73
OR COAST	134	623	515		1,272	0.08
SNAKE R. FALL	3	40			43	0.00
OTHER		3	3		6	0.00
WILLAMETTE SPRING	52	622	42		717	0.04
COL. SUMMER	27	510	264	6	807	0.05
LOW COL. FALL	2	412	46	3	462	0.03
LOW COL. SPRING	6	41	3		50	0.00
PUGET SOUND	9	31	6		46	0.00
SNAKE R. FALL		184	8		191	0.01
URB/MCB	39	4,761	1,425	36	6,261	0.38
WA COAST	32	1,624	523	8	2,187	0.13
Grand Total	617	11,778	4,007	65	16,467	

2010 Summer Troll

Region/Stock Group	Catch						p^ total catch
	Age-3	Age-4	Age-5	Age-6	Age-7	Total	
AK WILD		139	556	263		957	0.08
BC	611	1,125	321	5		2,061	0.17
FRASER EARLY	103	112				215	0.02
FRASER LATE	44	24				68	0.01
LOW GEORGIA S.	56	158				214	0.02
NBC/CBC	63	357	74	5		499	0.04
OTHER		7				7	0.00
UP GEORGIA S.		37	71			108	0.01
WCVI	344	430	176			950	0.08
OR / WA / ID	1,221	5,261	2,729	104	4	9,319	0.76
OR COAST	547	1,330	331	17		2,224	0.18
SNAKE R. FALL	57	64	20	0	0	141	0.01
WILLAMETTE SPRING	29	833	14			875	0.07
COL. SUMMER	19	1,236	87	3		1,344	0.11
LOW COL. FALL	9	72	190	4	0	274	0.02
LOW COL. SPRING	14	110	0	0	0	124	0.01
PUGET SOUND	9	11				20	0.00
SNAKE R. FALL	22	40	16			78	0.01
URB/MCB	466	662	996	70	4	2,197	0.18
WA COAST	50	904	1,075	11		2,040	0.17
Grand Total	1,831	6,525	3,606	371	4	12,337	

2011 Summer Troll

Region/Stock Group	Catch					p^ total catch
	Age-3	Age-4	Age-5	Age-6	Total	
AK WILD		155	1,351		1,506	0.08
BC	679	4,562	43	10	5,293	0.29
FRASER EARLY	59	107			166	0.01
FRASER LATE	4	3			8	0.00
LOW GEORGIA S.	436	6			441	0.02
NBC/CBC		414	43	10	467	0.03
OTHER		22			22	0.00
UP GEORGIA S.	124	117			241	0.01
WCVI	55	3,893			3,948	0.21
OR / WA / ID	534	8,837	2,199	103	11,673	0.63
OR COAST	175	1,537	539	7	2,258	0.12
SNAKE R. FALL	17	188	17	0	222	0.01
OTHER		3			3	0.00
WILLAMETTE SPRINGS		574			574	0.03
COL. SUMMER	15	516	371		902	0.05
LOW COL. FALL	8	51	70		129	0.01
LOW COL. SPRING	0	37	7	4	48	0.00
PUGET SOUND	8	86	4		98	0.01
URB/MCB	263	4,635	374	34	5,306	0.29
WA COAST	47	1,209	818	58	2,132	0.12
Grand Total	1,212	13,554	3,592	113	18,472	

2012 Summer Troll

Region/Stock Group	Catch					p^ total catch
	Age-3	Age-4	Age-5	Age-6	Total	
AK WILD			871		871	0.05
BC	221	1,598	770	3	2,592	0.15
FRASER EARLY	41	48			89	0.01
FRASER LATE		4			4	0.00
LOW GEORGIA S.	164	313			477	0.03
NBC/CBC	9	400	100	3	513	0.03
UP GEORGIA S.	7	203	36		247	0.01
WCVI		629	633		1,262	0.07
OR / WA / ID	1,137	9,296	3,084	61	13,577	0.80
OR COAST	195	1,553	563	16	2,328	0.14
SNAKE R. FALL	8	108	34	0	150	0.01
WILLAMETTE SPRING		689	15		704	0.04
COL. SUMMER	37	3,439	230	23	3,729	0.22
LOW COL. FALL	7	35	14	3	59	0.00
LOW COL. SPRING	0	103	10	0	113	0.01
PUGET SOUND	11	39	3		53	0.00
URB/MCB	780	2,316	1,358	4	4,458	0.26
WA COAST	98	1,015	857	14	1,985	0.12
Grand Total	1,358	10,893	4,725	64	17,040	

2013 Summer Troll

Region/Stock Group	Catch					p^ total catch
	Age-3	Age-4	Age-5	Age-6	Total	
AK WILD			25		25	0.00
BC	511	734	369		1,614	0.15
FRASER EARLY	254	122			376	0.04
FRASER LATE	9				9	0.00
LOW GEORGIA S.		22			22	0.00
NBC/CBC	12	272	88		372	0.04
OTHER		2			2	0.00
UP GEORGIA S.		55	66		121	0.01
WCVI	236	259	216		711	0.07
OR / WA / ID	226	7,939	685	48	8,899	0.84
OR COAST	19	736	150	2	908	0.09
SNAKE R. FALL	21	106	17	0	144	0.01
WILLAMETTE SPRINGS		97			97	0.01
COL. SUMMER	3	657	169	10	839	0.08
LOW COL. FALL	3	48	3		53	0.01
LOW COL. SPRING	2	24	20	0	47	0.00
PUGET SOUND	2				2	0.00
URB/MCB	98	5,788	165	0	6,051	0.57
WA COAST	77	484	161	36	758	0.07
Grand Total	737	8,673	1,079	48	10,537	

PACIFIC SALMON COMMISSION
JOINT CHINOOK TECHNICAL COMMITTEE

SPECIAL REPORT
INVESTGATION OF MATURATION-RATE ESTIMATION
MODELS AND THEIR INFLUENCE ON PSC
CHINOOK MODEL ABUNDANCE INDICES

TCCHINOOK (16)-1

February 11, 2016

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List of Acronyms and Abbreviations

AABM	Aggregate Abundance Based Management
AC	Allowable Catch
AKS	Chinook Model stock - SE Alaska stocks
AEQ	Adult Equivalent
AUC	Area-Under-the-Curve
AWG	CTC Analytical Working Group
BON	Chinook Model stock - Bonneville
BTR	Base Terminal Run
BY	Brood Year
BYER	brood year exploitation rate
CAS	cohort analysis database
CI	Confidence Interval
CLB	Calibration
CNR	Chinook Non-retention
CPUE	Catch per unit effort
CR	Columbia River
CTC	Chinook Technical Committee
CV	Coefficient of Variation
CWF	Chinook Model stock - Cowlitz Tule
CWT	Coded Wire Tag
CY	Calendar Year
ESC	Escapement
ETS	Exponential Smoothing Model (Error, Trend, Seasonal)
ERA	Exploitation Rate Analysis
EV	Environmental Variable scalar
FI	Fishery Index
FR	Fraser River
FRL	Chinook Model stock - Fraser Late
GS	Strait of Georgia
GSH	Chinook Model stock – strait of Georgia hatchery
HOR	Hatchery Origin Returns
IM	Incidental Mortality
ISBM	Individual Stock Based Management
LFR	Lower Fraser river
LGS	Lower Strait of Georgia
LRW	Chinook Model stock – Lewis River Wild
MATAEQ	Mature run equivalent, also a Chinook model input file
MR	Maturation Rate
MRE	Mature-Run Equivalent
MSE	Mean squared error
MSF	Mark Selective Fishery

MSH	Maximum Sustainable Harvest
MSY	Maximum Sustainable Yield for a stock, in adult equivalents
NA	Not Available
NC	North Coastal
NBC	Northern British Columbia (Dixon Entrance to Kitimat including Haida Gwaii)
NPS	North Puget Sound
NPS-S/F	North Puget Sound Summer/Fall Chinook stock
NR	Not Representative
ORC	Chinook Model stock – northern Oregon Coast aggregate
PNV	Proportion non-vulnerable
PS	Puget Sound
PSC	Pacific Salmon Commission
PST	Pacific Salmon Treaty
RBH	Chinook Model stock - Robertson Creek Hatchery
RBT	Chinook Model stock - Robertson Creek
RER	Recovery Exploitation Rate
ROM	Ratio of means
SA	Stock Aggregates
SE	Standard Error
SEAK	Southeast Alaska Cape Suckling to Dixon Entrance
SMSY	Escapement producing MSY
SPR	Chinook Model stock – South Puget Sound Recovery
SPS	South Puget Sound
SPFI	Stratified Proportional Index
TAC	Total Allowable Catch
TR	Terminal Run
UFR	Upper Fraser River
UGS	Upper Strait of Georgia
UMT	Upper Management Threshold
UMSY	Exploitation Rate at MSY
URB	Chinook Model stock - Columbia Upriver Bright
WAC	Washington Coast
WCVI	West Coast Vancouver Island excluding Area 20
WSH	Chinook Model stock – Willamette Spring
YA	Year Average

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EXECUTIVE SUMMARY

During the October 2015 Pacific Salmon Commission (PSC) Executive Session held in Suquamish, Washington the following assignment was given to the Chinook Technical Committee (CTC) by the PSC Commissioners:

The PSC Chinook Model performance over the last several years has been highly variable based on the wide swings in estimated abundance as expressed within the model calibration abundance indices. The amount of technical debate that has ensued over the last 8 months has been cause for the CTC and AWG to request of the Commission instruction on several aspects of technical work moving forward (Memo to Commissioners from CTC dated September 4, 2015). There were two elements that were transmitted relative to the US Section meeting on June 10, 2015: one was timeliness of release of the preseason abundance index and the other was stability of the model calibration results. There are also several work products that are of immediate and longer term value for the Commission that we request you complete as best possible within the prescribed timelines as depicted below. We have heard discussion and received reasonable correspondence specific to the timing element; however the model stability element has not been adequately addressed.

The Commission is requesting that the AWG embark on investigating both the maturation rates and environmental variables to update and document the analyses performed in 2012 with the last two years of data. The objective is to provide for improved preseason and postseason abundance indices to be generated for the 2016 season and postseason AI's for both the 2014 and 2015 seasons. We understand it is important to start this work soon to inform the current year calibration, and suggest the work completed by December 15, 2015 and no later than January 1, 2016 so that we can be assured that a preseason AI can be generated, evaluated and released for fishery planning purposes.

The CTC-AWG updated the 2012 maturation rate (MR) and environmental variable (EV) analysis, which used results from the 2004 through 2012 calibrations of the PSC Coast Wide Chinook Model with results from the 2013 and 2014 calibrations (see TCCHINOOK(14)-01 V.1, section 3.1.4 for a description of the original work). The new analyses were based on pairings of MR estimates with the EV of the most recently completed brood. This decision was made because the 2012 analysis showed that the estimates of the age-specific MRs used to represent a stock's incomplete brood years had a much greater influence on AIs compared to the EV. In order to determine if the discrepancy between the preseason and post-season Chinook Model AIs could be reduced from the 5-year average (YA) model chosen in the 2012 analysis, the investigation was expanded to include more MR estimates. In addition to the long-term average (starting in 1979), stock- and age-specific MR averages ranging from 3 to 11 years from recent completed broods were evaluated. An approach to estimating the MRs for incomplete broods based on a time series exponential smoothing model (ETS) was also explored as a potential alternative to the method based on a simple average of a specified number of completed broods.

Model calibration results based on the above MR estimates were evaluated using four statistics (squared error, percent error, median error and absolute scaled error) which quantify the magnitude and direction of the discrepancy between two AIs. The statistics were calculated for the discrepancy observed between (1) the preseason AI for each AABM fishery and the first post-season AI, (2) the preseason AI and an average of the post-season AIs for that same year from calibrations completed three or more years after that preseason, and (3) the first post-season AI and the average AI from calibrations completed three or more years after that preseason calibration. Although the three types of discrepancies above were investigated, the one which carried the most weight in our findings was the discrepancy between the preseason AI and the first postseason AI due to the fact that the measures of compliance in the AABM fisheries are the allowable catches associated with the first postseason AIs.

Means (or median) of the error statistics were then computed to show which of the MR estimation models resulted in the greatest reduction in the discrepancy between AIs obtained from the Chinook Model calibrations. These results are documented in this report as well as other data and results considered relevant. The main findings of the MR-EV investigation are:

- Based on the composite mean squared error statistic (MSE), the 9-year average model (9YA) emerged as the estimation model that most reduced the discrepancy between the preseason and first post-season AI across Chinook Model calibrations and AABM fisheries (Table 1).

- The sensitivity of the above conclusion to the number of contributing calibrations was examined and the 9 YA again emerged as the best overall estimation model based on the composite MSE statistic (Table 2).

- The 9YA, 3-year average model (3YA), and time series model (ETS) most reduced the discrepancy between the preseason and first postseason AI across Chinook Model calibrations for the SEAK, NBC, and WCVI AABM fisheries respectively. However, further work is warranted since the difference in performance of a number of the models was small.

- The model used to estimate the MRs noticeably affected the time series of preseason and first post-season AIs for each AABM fishery, but the overall effect on the magnitude and direction of errors compared to the original calibration results was relatively small.

- An analysis using the North Oregon Coast stock aggregate demonstrated a method to estimate naturally-produced stock aggregate MRs by extrapolation from hatchery CWT indicator stock exploitation analysis, and the hatchery CWT indicator stock MRs differed quite substantially from the naturally-produced stock aggregate MRs.

The CTC recommends the utilization of the 9YA for the MRs and 1 year EV as the basis for estimating the stock- and age-specific MRs for the annual Chinook Model calibration (Table 1), and further recommends that the MR and EV analysis is repeated in subsequent years so that perceived potential improvements can be realized.

Table 1. Mean squared error between the preseason and first postseason AI assuming a 1 year EV. Each MR model depicts how the assumptions around incomplete brood years are modeled, including 3 to 11 year averages (e.g., 3YA), long-term averages (LTA) or via exponential smoothing (ETS). The composite MSE metric is the summation of the MSEs across the 3 fisheries. The scenario that minimized the MSE is highlighted in darker shading and the second best scenario is highlighted lighter shading.

Model	SEAK	NBC	WCVI	Composite
3YA	0.0289	0.0233	0.0161	0.0683
5YA	0.0309	0.0238	0.0157	0.0704
7YA	0.0300	0.0246	0.0132	0.0678
8YA	0.0299	0.0248	0.0134	0.0681
9YA	0.0268	0.0234	0.0125	0.0627
10YA	0.0320	0.0252	0.0125	0.0696
11YA	0.0357	0.0277	0.0131	0.0765
LTA	0.0374	0.0283	0.0180	0.0836
ETS	0.0333	0.0239	0.0122	0.0695

Table 2. The best MR estimation model in response to the number of calibrations included in MSE calculations. The earliest calibration year is 2004 in all cases. The composite is based on the sum of MSE values across fisheries. Abbreviations used in Table 1 are identical to those used in this table as well.

Last Year	# Calibrations	SEAK	NBC	WCVI	Composite
2013	10	9YA	3YA	ETS	9YA
2012	9	9YA	5YA	9YA	9YA
2011	8	9YA	5YA, 9YA	9YA	9YA
2010	7	9YA	9YA	9YA	9YA
2009	6	9YA	9YA	9YA, 10YA	9YA
2008	5	9YA	9YA	9YA	9YA

In summary, this investigation did show that improved performance of the Chinook Model, as measured by a reduction in the across-calibration discrepancy between the preseason and postseason AABM fishery AIs, could be achieved through use of MRs based on a 9YA from completed broods for each stock and age in the MATAEQ file. No analyses were undertaken to determine why any particular MR model performed better or worse than others.

1 INTRODUCTION

During the October 2015 Pacific Salmon Commission (PSC) Executive Session held in Suquamish, Washington the following assignment was given to the Chinook Technical Committee (CTC) by the PSC Commissioners:

The PSC Chinook Model performance over the last several years has been highly variable based on the wide swings in estimated abundance as expressed within the model calibration abundance indices. The amount of technical debate that has ensued over the last 8 months has been cause for the CTC and AWG to request of the Commission instruction on several aspects of technical work moving forward (Memo to Commissioners from CTC dated September 4, 2015). There were two elements that were transmitted relative to the US Section meeting on June 10, 2015: one was timeliness of release of the preseason abundance index and the other was stability of the model calibration results. There are also several work products that are of immediate and longer term value for the Commission that we request you complete as best possible within the prescribed timelines as depicted below. We have heard discussion and received reasonable correspondence specific to the timing element; however the model stability element has not been adequately addressed.

The Commission is requesting that the AWG embark on investigating both the maturation rates and environmental variables to update and document the analyses performed in 2012 with the last two years of data. The objective is to provide for improved preseason and postseason abundance indices to be generated for the 2016 season and postseason AI's for both the 2014 and 2015 seasons. We understand it is important to start this work soon to inform the current year calibration, and suggest the work completed by December 15, 2015 and no later than January 1, 2016 so that we can be assured that a preseason AI can be generated, evaluated and released for fishery planning purposes.

The PSC Chinook Model relies on a number of data inputs and assumptions which impact the preseason Abundance Index (AI). Annual inputs include, but are not limited to, hatchery enhancement, stock specific forecasts of escapements or terminal returns, assumed values of stock- and brood-specific environmental variables (EVs), and assumed values of maturations rates (MRs) by stock and age. The last two inputs are the focus of this investigation. Twelve stocks in the PSC Chinook Model have yearly MRs provided. Historically, only 12 stocks were chosen because reliable MR estimates require Coded-Wire-Tag (CWT) data that are both available and of high enough quality for statistical analysis. More recent analysis to improve the base period representation of stocks in the model will allow for the expansion from these original 12 stocks, but until the new base period work is complete and adopted, our analysis is limited to the present 12 stocks.

In 2012, numerous Chinook Model calibrations were performed using different combinations of MR and EV averages to identify the MR-EV combination that minimizes the discrepancy between the preseason and postseason AIs generated by the PSC Chinook Model. Due to the large number of model calibrations required to investigate the performance of each MR-EV average, an exhaustive set of combinations was not performed, but of the combinations that were investigated, the Analytical Work Group (AWG) of the CTC concluded that a recent 5-year average (5YA) MR and a 1-year (1Y) EV minimized the mean squared error (MSE) between the preseason and postseason AIs across the three Aggregate Abundance-Based Management (AABM) fisheries – SEAK, NBC, and WCVI.

Beginning in 2013, the 5YA MR and 1Y EV combination was used as the default configuration for PSC Chinook Model runs. Prior to 2013, the default configuration consisted of the long-term average MR and 5YA EV. The 2012 MR-EV analysis and the 2013 configuration change is documented in the 2013 CTC Calibration and Exploitation Rate Analysis report TCCHINOOK(14)-1_V1 in section 3.1.4. In this analysis, the AWG updated the 2012 MR and EV analysis with two more years of information (2013 and 2014) and investigated additional MR-EV combinations in order to determine if the discrepancy between preseason and postseason AIs could be reduced further. In addition, this report describes an alternative approach to estimating MRs by comparing a hatchery CWT indicator stocks' MRs to its naturally-produced stock aggregates' MRs estimated by extrapolation from exploitation analysis of the CWT indicator stock, additional material on the program the AWG uses to create the MATAEQ Chinook Model input file, and stock and age-specific graphs of MRs.

2 MATURATION RATE AND ENVIRONMENTAL VARIABLE EVALUATION METHODS

2.1 ENVIRONMENTAL VARIABLE AVERAGE METHOD

The PSC Chinook Model calibration procedure uses stock- and brood-specific EV scalars to adjust the model estimated stock- and brood- specific terminal run size or escapement to the empirical stock- and brood-specific estimates of terminal run size or escapement. More specifically, the EV scalars are used to adjust the stock- and brood-specific age-1 abundances that are calculated with stock-specific spawner-recruit functions. EV scalars can be thought of as survival scalars; however, EV scalars also adjust for biases resulting from errors in the data or assumptions used to estimate the stock-specific spawner-recruit parameters. The EV for incomplete broods uses the average of EVs from the most recently available complete broods. The equation is:

$$AvgEV_s = \frac{1}{n} \sum_{i=BY-n+1}^{BY} EV_{s,i}$$

where $AvgEV_{s,BY}$ is the average EV for a particular stock, $EV_{s,i}$ is the EV for a particular stock, *BY* denotes the brood year, *n* is the number of years to use in the average, and *i* is an indexing variable. The most recent EV that can be used in the analysis depends on the age of the stock. For example, the most recent available incomplete brood year used in the 2015 model calibration is either an EV from 2011 or 2012 depending on whether the maximum age for a stock is age-6 or age-5. EV estimates in subsequent calibrations remain in flux until broods are complete.

2.2 MATURATION RATE AND ADULT EQUIVALENT AVERAGE METHOD

MR and AEQ factors for broods that are incomplete (i.e. when not all ages of a particular brood have returned) are equal to the average of the most recent, valid, complete brood year MR and AEQ values. The MR and AEQ average method is a stock- and age-specific method. MR and AEQ values used in the calculation of the MR and AEQ averages are output from the yearly CTC Exploitation Rate Analysis. The equations are:

$$AvgMatRte_{s,a} = \frac{1}{n - \sum_{i=CY-n+1}^{CY} I(valid_{s,a,CY} = 0)} \sum_{i=CY-n+1}^{CY} I(MatRte_{s,a,i}|valid_{s,a,i} = 1)$$

and

$$AvgAEQ_{s,a} = \frac{1}{n - \sum_{i=CY-n+1}^{CY} I(valid_{s,a,CY} = 0)} \sum_{i=CY-n+1}^{CY} I(AEQ_{s,a,i}|valid_{s,a,i} = 1)$$

where $AvgMatRte_{s,a}$ is the average MR for a particular stock and age, $MatRte_{s,a,i}$ is the MR for a particular stock and age given that the brood is valid (i.e. *valid* = 1 and otherwise $MatRte_{s,a,i} = 0$), $AvgAEQ_{s,a}$ is the average AEQ for a particular stock and age, $AEQ_{s,a,CY}$ is the AEQ factor for a particular stock and age given that the brood is valid (i.e. *valid* = 1 and otherwise $AEQ_{s,a,i} = 0$), *CY* denotes calendar year, *s* is stock, *a* is age class, $valid_{s,a,i}$ is a dummy variable that indicates whether a particular stock and age brood is valid or not (if the brood is valid, $valid_{s,a,i} = 1$ and $valid_{s,a,i} = 0$ otherwise), *n* is the number years to use in the average, *i* is an indexing variable, and $I(\bullet)$ is an indicator function that when evaluated returns a value of 1 or 0. See Observed MR values in Appendix A for details on the stock-specific valid brood years.

2.3 STOCK AND AGE-SPECIFIC PROJECTIONS OF MATURATION RATES

2.3.1 Background

Explorations of time series of MRs have shown that: (1) there are different trends in the trajectories of various stocks; (2) these trends can differ among age-classes for a given stock; and, (3) some stocks exhibit more variability in their MRs than others (see Appendix B). Stock- and age-specific projections of MRs might be more appropriate than the application of a naïve model (e.g., most recent year, 3YA, 5YA, etc.) to all stocks and ages. Stock- and age-specific projections of MRs were produced with exponential smoothing (ETS) models and trend analysis. The former was applied to the last few years in the time series to address the effect of incomplete brood years whereas the later was used to project MRs "one" year in the future. All analyses were based on calendar-year time series of MRs in the 2004-2014 MATAEQ files, which include data for Chinook Model stocks AKS, BON, CWF, GSH, LRW, ORC, RBH, RBT, SPR, URB, WSH, and FRL. Although MRs are originally calculated at the brood year level, the application of statistical models such as the time series and trend analyses conducted herein can directly use calendar-year data in a forecasting fashion.

2.3.2 Addressing the effect of incomplete broods on time series of calendar-year maturation rates in MATAEQ files

The exponential smoothing models (ETS) described herein are a general class of state space models for forecasting univariate time series (Gelper et al. 2010). The acronym ETS denotes the error (E), trend (T), and seasonal components (S) which can be used to describe the time series to be forecasted. The trend component represents the growth or the decline of the time series over an extended period of time. For time series defined at time intervals which are not fractions of a year (e.g., months), the seasonal

component is a pattern of change that repeats itself every number of years (i.e., a cycle). The error component captures irregular, short-term fluctuations present in the series, which cannot be attributed to the trend and seasonal components.

ETS models can be classified according to the nature of the error, trend and seasonal components of the underlying time series. The error (E) component can be either additive (A) or multiplicative (M). The trend (T) component can be additive (A), multiplicative (M) or inexistent (N). The trend (T) component can also be dampened additively (Ad) or multiplicatively (Md). The seasonal (S) component can be either additive (A), multiplicative (M) or inexistent (N).

Each particular combination of options for the error, trend and seasonal components of a time series gives rise to a specific ETS model. Since the possibilities for each component are Error = {A,M}, Trend = {N,A,Ad,M,Md} and Seasonal = {N,A,M}, in total there exist 2 x 5 x 3 = 30 such ETS models. Components designated by the letter N are not present in the time series of interest. Components designated by the letter A are present and are combined with the other components via addition. Components designated by the letter M are present and are combined with the other components via multiplication.

For example, the ETS model ETS(AAN) has E(A), T(A) and S(N) structures, where E(A) stands for additive error, T(A) stands for additive trend and S(N) stands for inexistent seasonality. One can show that ETS(AAN) is Holt's linear model with additive errors according to the classification of methods described in Hyndman et al. (2002) and Hyndman et al. (2008).

The R (R version 3.2.3; R Core Team 2015) package *forecast* (Hyndman 2015) was used to implement exponential smoothing on time series of calendar-year MRs (and AEQs) for all stocks in the 2004-2014 MATAEQ files (see Appendix C). The application of the ETS for a given MATAEQ yearly file was applied to sequential subsets of time series M and starting with the subset not affected by incomplete brood years (usually $M_{s,a,t=i}^{s,a,t=z-4}$, where s is stock, a is age, t is time (i.e., calendar year), i is the start of the time series [1979 in all cases], and z is the "current" calendar year). Given an input time series, the projections were generated by applying the function *forecast()* directly to each of the time series $M_{s,a,t=i}^{s,a,t=z-4}$, $M_{s,a,t=i}^{s,a,t=z-3}$, $M_{s,a,t=i}^{s,a,t=z-2}$, $M_{s,a,t=i}^{s,a,t=z-1}$, and $M_{s,a,t=i}^{s,a,t=z}$ to sequentially populate projected stock- and age-specific data starting from the youngest age through the calendar year z as shown in Figure 2.1. This function selects an ETS model using the AIC, estimates the parameters, and generates forecasts. Although this function returns prediction intervals, only point forecasts were extracted from the forecast distribution. The methodology is fully automatic. The only required argument for *forecast()* is the time series. The ETS model is chosen automatically if not specified.

2.3.3 Projecting calendar-year maturation rates (and adult equivalents) in MATAEQ files using trend analysis

The evaluation of trends in MRs was based on the time series updated to the current calendar year through the aforementioned ETS projections (i.e., $M_{s,a,t=i}^{s,a,t=z}$; see Figure 2.1). The projection of MRs (and AEQs) for year z+1 was based on a state-space exponential growth model (Dennis et al. 2006)

parameterized through state-space restricted maximum likelihood (SSRML, Humbert et al. 2009), which produces rates of change estimates that are generally superior to those produced through maximum likelihood (Staples et al. 2004). This method assumes both observation error and process noise and therefore produces variances and confidence intervals that fully represent the annual variability associated to environmental stochasticity and sampling or observation error (Humber et al. 2009). Analyses were conducted using the R package *MASS* (Ripley 2015) with the selected time period for the characterization of trends starting in 1979 in all cases and ending in the calibration year represented by each of the original MATAEQ files. Although stock- and age-specific projections would be characterized by both long-term mean rate of change (μ) and corresponding 95% confidence intervals, only μ was reported. The value of μ can be positive or negative, indicating the direction and proportional change in MRs expected given the full extent of the time series, with μ = 0.00 indicating equilibrium. Therefore projected MRs for year z+1 were computed as:

$$\hat{M}_{s,a,t=z+1} = M_{s,a,t=z} * \left(1 + \mu_{s,a}\right)$$

2.3.4 Constraints in projected values

Projected values of MRs and AEQs were constrained to the range 0 to 1. The application of the ETS-SSRML model to calendar-year MRs (and AEQs) showed only one case of a slightly negative ETS projected value for the first age for the ORC stock for year 2008, thus highlighting the need to constrain projections to abide by the biological scale in which these rates are expressed. A value of zero is a legitimate possibility in time series of MRs (and AEQs), as shown in the original 2008 ORC time series. In addition, the original time series of MRs for 2013 LRW also showed a value of zero for the first age but projections were positive in this case. Although there were no projected values of 1 or greater than 1 for either MRs or AEQs, a value of 1 is frequently a legitimate value for AEQs in the MATAEQ files. Other possible types of constraints such as constraining values to the observed range for individual time series were not included because the existence of trends in some time series is expected to produce projections that could be out of the range of the time series of observed values. The very essence of the time series and trend analysis methods is to identify patterns and trends, if present, and convey this information into the projected values.

ETS Projection → **ETS Projection** → **ETS Projection** → **ETS Projection** → **ETS/SSRML Projection** → $M_{s,a,t=z}$

Column 1:
$M_{s,a,t=i}$
$M_{s,a,t=i+1}$
$M_{s,a,t=i+2}$
.
.
.
$M_{s,a,t=z-4}$

Applied to: First Age

Column 2:
$M_{s,a,t=i}$
$M_{s,a,t=i+1}$
$M_{s,a,t=i+2}$
.
.
.
$M_{s,a,t=z-3}$

Applied to: First and Second Age

Column 3:
$M_{s,a,t=i}$
$M_{s,a,t=i+1}$
$M_{s,a,t=i+2}$
.
.
.
$M_{s,a,t=z-2}$

Applied to: All Ages

Column 4:
$M_{s,a,t=i}$
$M_{s,a,t=i+1}$
$M_{s,a,t=i+2}$
.
.
.
$M_{s,a,t=z-1}$

Applied to: All Ages

Column 5:
$M_{s,a,t=i}$
$M_{s,a,t=i+1}$
$M_{s,a,t=i+2}$
.
.
.
$M_{s,a,t=z+1}$

Applied to: All Ages

Figure 2.1. Schematic of model used to project stock- and age-specific calendar-year MRs. The methodology uses (1) exponential smoothing (ETS) to complete time series for years affected by incomplete brood years and project MRs for calendar year *z*, and (2) state-space restricted maximum likelihood (SSRML) trend analysis to project MRs for calendar year *z*+1.

Note: The method started with time series $M_{s,a,t=i}^{s,a,t=z-3}$ for the 2013 and 2014 MATAEQ files because there was an extra year of projection-free calendar-year MRs.

For convenience, the combination of ETS and SSRML models above described is simply referred to as ETS in the next sections, including figures and tables.

2.4 DIFFERENCES BETWEEN MATURATION RATES FOR CWT INDICATOR STOCKS AND FOR STOCK AGGREGATES

2.4.1 Background

In producing Abundance Indices (AIs) for pre-terminal marine fishing areas, the PSC Chinook Model fits to inputs of escapement (ESC) or terminal return (TR) of the various stock aggregates (SA) and to inputs of MRs for the CWT indicator stocks representing the SAs. Because of the importance of accurate

estimates and forecasts of TR, in this report the CTC-AWG investigates differences between preseason and postseason AIs over the period of years over which CWT indicator stock MRs are averaged to forecast MRs for incomplete broods. However, almost all CWT indicator stocks are hatchery populations and it is well established that hatchery populations generally exhibit earlier maturation and return by age than nearby natural populations. In contrast, the sum of TR by age for its component river populations best represents the SA and thus should provide for the best estimates of MRs.

2.4.2 Estimation of stock aggregate maturation rates by extrapolation from CWT indicator stock exploitation analysis

A method to estimate MRs for a SA using TRs summed across rivers in combination with CWT indicator stock exploitation analysis is demonstrated here. This demonstration example employs the Salmon River Hatchery (SRH) CWT indicator stock and the North Oregon Coast (NOC) SA, for which five BYs were randomly selected for this analysis. However, the method can be applied to any BY for any SA (or a subset of rivers of an SA) and its CWT indicator stock. Terms used in this demonstration are defined in Table 2.1.

Table 2.1. *Term definitions used in the CWT indicator and stock aggregate analysis.*

Term	Definition
TF	terminal fishing total mortality
ESC	spawning escapement
TR	terminal fishing total mortality plus spawning escapement (TF+ESC)
TRprop	the proportion of total TR of a specific age
PTF	pre-terminal fishery total mortality
CO	cohort size before PTF occurs
PTFR	pre-terminal fishery total mortality rate (PTF/CO)
MR	(TR/(CO-PTF))

For the SA, the TRs consist of the sum across NOC rivers of ESC apportioned by age based on spawner survey peak counts and carcass/scale sampling, plus a TF component reflecting the CWT indicator stock TF/ESC ratio

NOC TF = NOC ESC * (CWT TF/CWT ESC), by age

As done in the CTC's exploitation rate analysis and the PSC Chinook Model, we assume that exploitation of the CWT indicator stock reflects that of the SA

CWT stock PTFR = SA PTFR, by age

Estimates for the SA complimentary to those for the CWT indicator stock were derived using Coshak (the CWT cohort reconstruction program used by the CTC) backwards run reconstruction (exploitation analysis) methods, starting with age 6 since the age 7 cohort is approximately 0.

Finally, ratios for TRprop and MR between the CWT stock and the SA for each brood-year and age simplify comparisons

CWT stock TRprop/SA TRprop

and

CWT stock MR/SA MR

The computations are simple arithmetic, and below are calculations of CO, PTF, and MR for the SA 1992 brood-year (some small rounding error is present, see Results section for figures used). First, one estimates CO for the SA, assuming exploitation of the CWT indicator stock represents that of the SA:

CO age 7 ~ 0

CO age 6 = (CO age 7/0.9+TR age 6)/(1-PTF rate age 6) = (0+19,162)/(1-0.186) = 23,552

CO age 5 = (CO age 6/0.9+TR age 5)/(1-PTF rate age 5) = (23,552/0.9+54,009)/(1-0.275) = 110,514

CO age 4 = (CO age 5/0.9+TR age 4)/(1-PTF rate age 4) = (110,514/0.9+191,224)/(1-0.118) = 355,850

CO age 3 = (CO age 4/0.8+TR age 3)/(1-PTF rate age 3) = (355,850/0.8+37,893)/(1-0.049) = 507,338

CO age 2 = (CO age 3/0.7+TR age 2)/(1-PTF rate age 2) = (507,338/0.7+11,187)/(1-0.055) = 778,665

Next, one estimates PTF for the SA by applying CWT stock PTFR:

PTF age 6 = CO age 6*PTFR age 6 = 23,552*0.186 = 4,390

PTF age 5 = CO age 5*PTFR age 5 = 110,514*0.275 = 30,336

PTF age 4 = CO age 4*PTFR age 4 = 355,850*0.118 = 41,832

PTF age 3 = CO age 3*PTFR age 3 = 507,338*0.049 = 24,632

PTF age 2 = CO age 2*PTFR age 2 = 778,665*0.055 = 42,710

One can then estimate MRs for the SA using the estimates above:

MR age 6 = TR age 6/(CO age 6-PTF age 6) = 19,162/(23,552-4,390) = 1.000

MR age 5 = TR age 5/(CO age 5-PTF age 5) = 54,009/(110,514-30,336) = 0.674

MR age 4 = TR age 4/(CO age 4-PTF age 4) = 191,224/(355,850-341,832) = 0.571

MR age 3 = TR age 3/(CO age 3-PTF age 3) = 37,893/(507,338-24,632) = 0.073

MR age 2 = TR age 2/(CO age 2-PTF age 2) = 11,187/(778,665-42,710) = 0.016

3 RESULTS

3.1 EVALUATION OF RESULTS

3.1.1 Summary of results

We evaluated the performance of each MR on its ability to adequately predict abundance indices (AIs) based on three different metrics each using four different model evaluation criteria. The three metrics were:

1. The discrepancy between a predicted, preseason AI and the average AI 3-10 years postseason for the fishery, when AI values from the model have stabilized. The preseason value is a model predicted AI and the 3-10 year average is considered the observed or true AI.
2. The discrepancy between the first postseason AI estimate and the 3-10 year postseason AI values for the fishery. The first postseason value is a model predicted AI and the average of the 3-10 postseason AIs is considered the observed or true AI.
3. The discrepancy between the preseason and the first postseason AI. The preseason value is the model prediction and the first postseason AI is considered the true value.

The last metric has two more years of data than the other two for each AABM fishery. Each of the three metrics was analyzed by comparing four different criteria across the range of MRs estimated used to calculate AI values. The model evaluation criteria are:

1. The mean squared error (MSE) is an average of the squared differences between predicted and observed (true) AIs. It is a measure of the variability of predicted AIs values. The MSE is always positive and hence does not indicate if a MR estimate tends to under- or overestimate the AI. The best MR estimate is the one that minimizes the MSE.
2. The median error is the median value of the difference between predicted and observed AIs. It is less sensitive to outlier values of differences than a mean and provides information on whether a MR tends to under- or over-estimate AIs. The best MR estimate is the one that produces median values closest to zero.
3. The mean absolute scaled error (MASE; Hyndman and Koehler 2006) is a generally applicable, scale-free measure of forecast accuracy. Ideally, the value of MASE will be significantly less than 1. The MASE is always positive and unlike other metrics that are based on averages, it weighs differences between predicted and observed values evenly, regardless of magnitude. The best MR estimate is the one that minimizes the MASE.
4. The mean percent error (MPE) is the average of the difference between predicted and observed (true) AIs divided by the true AI and multiplied by 100%. Because small AI values can correspond to small MSE values, the MPE is a good metric to accompany an MSE as it scales the average differences between predicted and observed AIs accordingly. The best MR estimate is the one that produces MPE values closest to zero.

More information on each of the evaluation criteria and the equations used in the calculations are provided in Appendix D. Results of the analysis are based on MRs that either minimize an evaluation

criterion or provide values close to one. Hence, we present and evaluate the results graphically, by metric (Figures 3.1-3.3).

3.1.2 Preseason AI to Average 3-10 years postseason AI

Of all the MRs examined in the analysis, model evaluation criteria were most often minimized using the 9YA across all fisheries based on discrepancies between preseason and average 3-10 years postseason AIs (Table 3.1, Figure 3.1). MR estimates that minimize model evaluation criteria most often were the 7YA – 11YA estimates. The notable exception is in the SEAK fishery where the MPE and Median error were minimized using the 3YA MR. However, the difference between the median error resulting from the 3YA and the 9YA was small. The predominance of positive values for the median error and MPE indicate that preseason AIs are overestimated relative to the average 3-10 year postseason AI.

3.1.3 First postseason AI to average 3-10 years postseason AI

Discrepancies between the first postseason AI and the average 3-10 year postseason AI are most often minimized using the 3YA MR estimate (Table 3.2, Figure 3.2). However, the differences are small among the model evaluation criteria for the MRs used in the analysis, indicating that this metric may not be sensitive to the 3YA to 11YA MRs. In SEAK, the 10YA minimized both the MSE and MPE and the MASE in NBC. The largest differences are observed using the ETS and LTA MR estimates.

3.1.4 Preseason AI to first postseason AI

In the SEAK fishery, preseason to postseason AIs discrepancies were most often minimized when the Chinook Model used the 9YA MR estimates (Table 3.3, Figure 3.3). However, preseason AI values are slightly overestimated when compared to the first postseason AI.

In the WCVI fishery, the 9YA MR estimate minimizes 2 of the 4 model evaluation criteria. The 8YA MR minimizes the WCVI Median error; however the value is close to that obtained when using the 9YA. The MSE for the WCVI fishery is lowest when using the ETS MR, but the difference from the MSE using the 9YA is small.

Results from the NBC fishery are not as clear. MRs based on the 3YA minimizes the MSE, but the 11YA and ETS MRs minimize the median error and MPE, respectively. Differences from the 9YA for both of these metrics are small.

Table 3.1. Values of the model evaluation metrics for the preseason AI to the average 3-10 year postseason AI discrepancy. Lowest values indicate the MR estimates that create the best predictions from the Chinook model.

MR Estimate	SEAK				NBC				WCVI			
	MSE	Median Error	Mean Percent Error	MASE	MSE	Median Error	Mean Percent Error	MASE	MSE	Median Error	Mean Percent Error	MASE
3YA	0.049	**0.093**	**0.080**	0.718	0.034	0.072	0.084	0.760	0.020	0.113	0.154	1.153
5YA	0.039	0.097	0.083	0.674	0.024	0.088	0.081	0.603	0.022	0.117	0.154	1.203
7YA	0.041	0.094	0.085	0.664	0.027	0.071	**0.076**	0.641	0.022	0.112	0.137	1.186
8YA	0.037	0.099	0.090	0.657	0.024	0.080	0.078	0.598	0.021	0.106	0.133	1.108
9YA	**0.033**	0.094	0.092	**0.632**	**0.022**	0.078	0.080	**0.561**	0.019	0.103	**0.131**	1.052
10YA	0.038	0.119	0.108	0.716	0.023	**0.068**	0.090	0.599	0.019	**0.101**	0.136	1.055
11YA	0.043	0.141	0.118	0.762	0.027	0.083	0.100	0.647	**0.018**	0.101	0.140	**1.052**
ETS	0.057	0.181	0.149	0.907	0.035	0.112	0.133	0.809	0.019	0.113	0.148	1.090
LTA	0.071	0.214	0.172	1.004	0.047	0.145	0.160	0.916	0.032	0.144	0.215	1.434
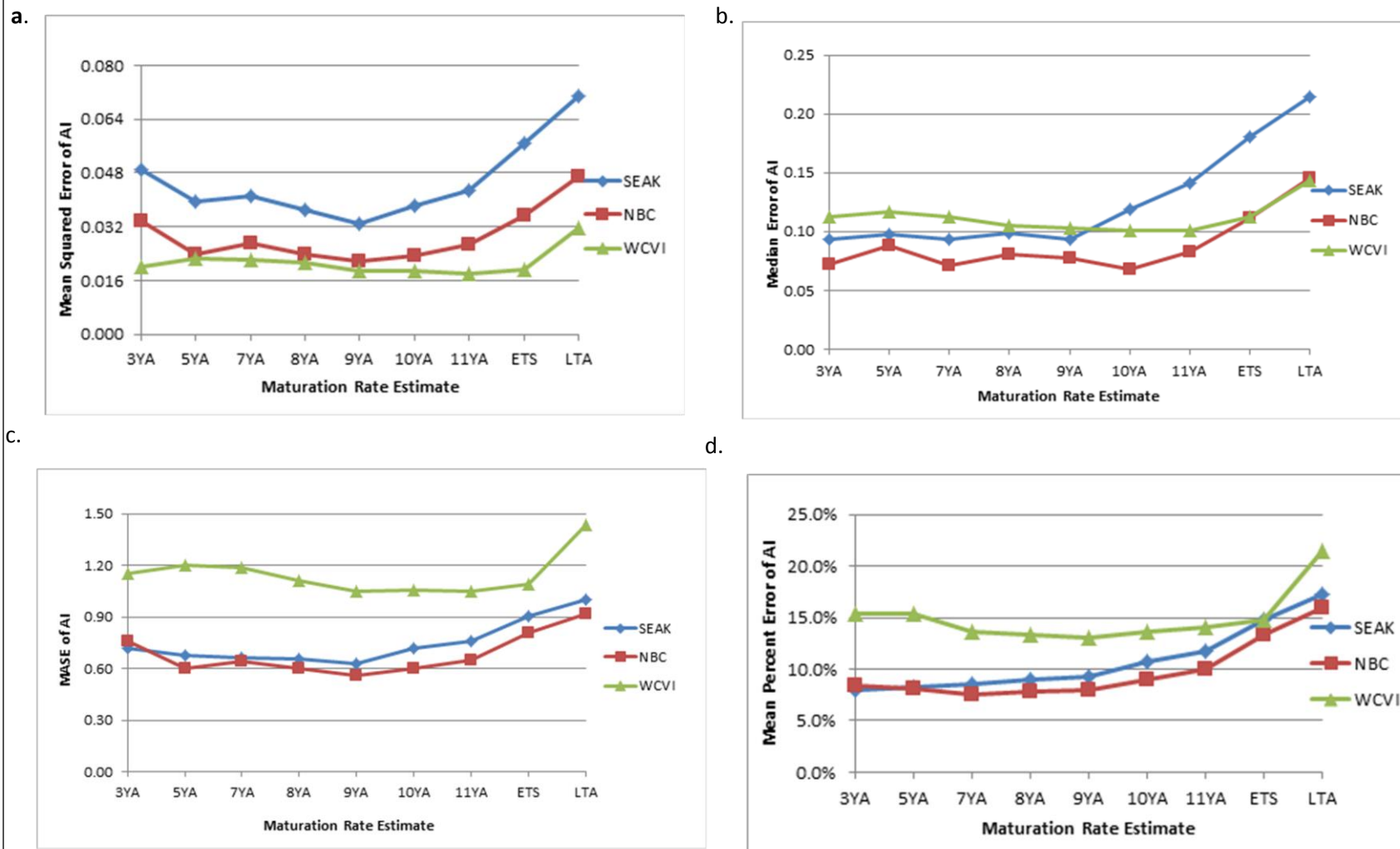
Figure 3.1. Model evaluation metrics of the discrepancy between the preseason AI and the average 3-10 year postseason AI for different MR estimates, a. Mean squared error, b. Median error, c. Mean absolute scaled error, and d. Mean percent error.

Table 3.2. Values of the model evaluation metrics for the first postseason AI to the average 3-10 year postseason AI discrepancy. Lowest values indicate the MR estimates that create the best predictions from the Chinook model.

MR Estimate	SEAK				NBC				WCVI			
	MSE	Median Error	Mean Percent Error	MASE	MSE	Median Error	Mean Percent Error	MASE	MSE	Median Error	Mean Percent Error	MASE
3YA	0.017	**0.061**	**0.051**	0.520	0.015	**0.078**	**0.074**	0.670	**0.003**	**0.034**	**0.053**	0.433
5YA	0.010	0.084	0.055	0.443	**0.011**	0.089	0.074	0.535	0.004	0.039	0.058	0.426
7YA	0.014	0.110	0.059	0.495	0.013	0.080	0.075	0.567	0.005	0.043	0.060	0.521
8YA	0.012	0.105	0.060	0.467	0.012	0.081	0.075	0.536	0.005	0.040	0.057	0.481
9YA	0.012	0.102	0.060	0.454	0.011	0.082	0.075	0.531	0.004	0.039	0.057	0.469
10YA	**0.010**	0.108	0.067	**0.409**	0.011	0.081	0.080	**0.489**	0.004	0.038	0.058	0.437
11YA	0.011	0.112	0.074	0.430	0.012	0.080	0.086	0.504	0.004	0.037	0.061	**0.424**
ETS	0.022	0.154	0.111	0.575	0.021	0.117	0.120	0.669	0.005	0.039	0.074	0.487
LTA	0.025	0.157	0.117	0.601	0.024	0.122	0.129	0.717	0.006	0.053	0.088	0.487
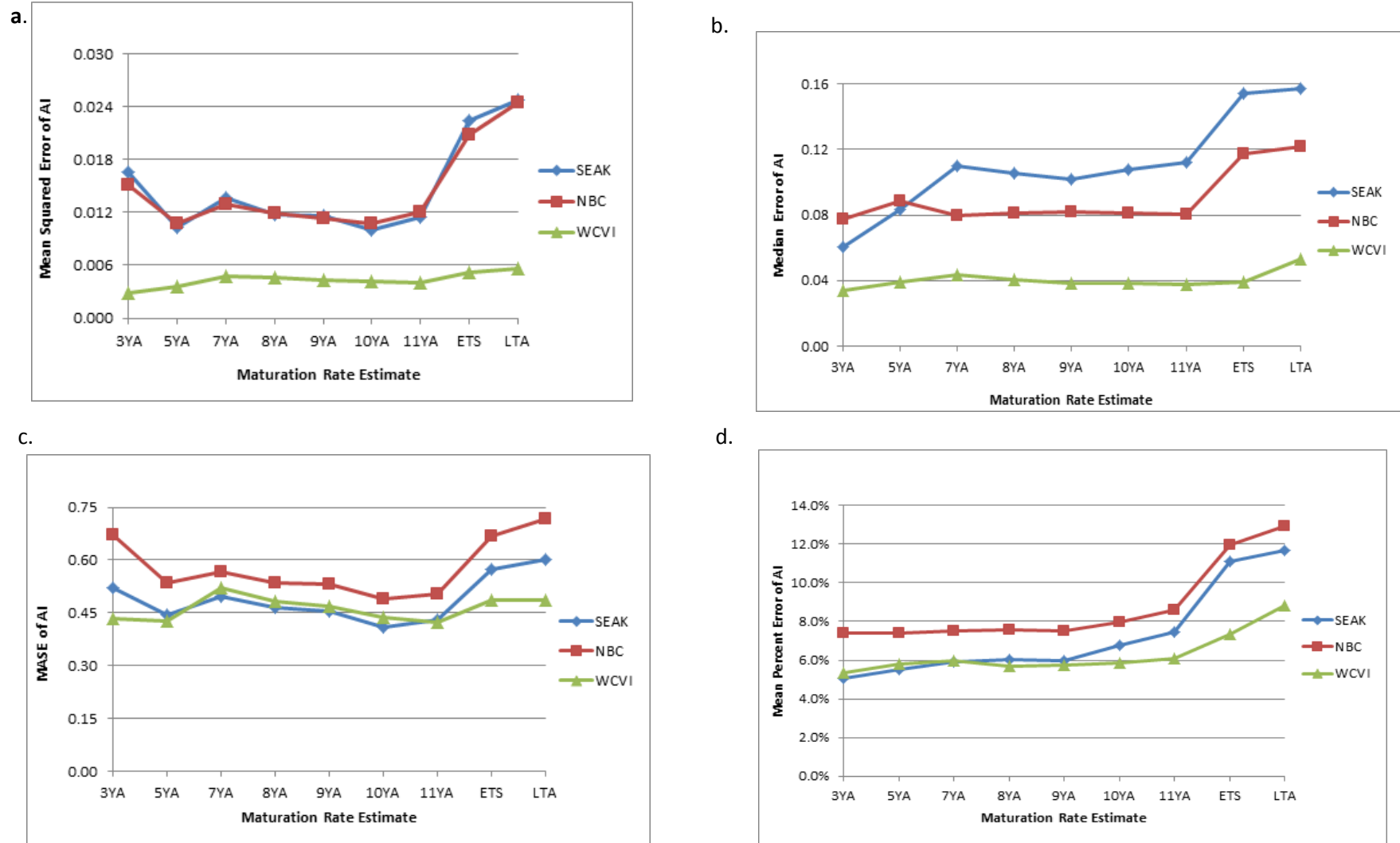
Figure 3.2. Model evaluation metrics of the discrepancy between the first postseason AI and the average 3-10 year postseason AI for different MR estimates, a. Mean squared error, b. Median error, c. Mean absolute scaled error, and d. Mean percent error.

Table 3.3. Values of the model evaluation metrics for the preseason AI to the first postseason AI discrepancy. Lowest values indicate the MR estimates that create the best predictions from the Chinook Model.

MR Estimate	SEAK				NBC				WCVI			
	MSE	Median Error	Mean Percent Error	MASE	MSE	Median Error	Mean Percent Error	MASE	MSE	Median Error	Mean Percent Error	MASE
3YA	0.029	-0.022	-0.002	0.508	**0.023**	-0.023	-0.016	0.546	0.016	0.043	0.050	0.727
5YA	0.031	0.030	**-0.001**	0.489	0.024	-0.008	-0.017	**0.443**	0.016	0.059	0.050	0.694
7YA	0.030	0.023	0.004	0.487	0.025	-0.039	-0.017	0.510	0.013	0.050	0.045	0.642
8YA	0.030	0.030	0.006	0.510	0.025	-0.019	-0.016	0.479	0.013	**0.035**	**0.043**	0.594
9YA	**0.027**	**0.011**	0.008	**0.435**	**0.023**	-0.015	-0.014	0.451	0.013	0.040	**0.043**	**0.582**
10YA	0.032	0.026	0.013	0.479	0.025	-0.013	-0.012	0.459	0.013	0.044	0.045	0.585
11YA	0.036	0.033	0.015	0.501	0.028	**-0.007**	-0.009	0.467	0.013	0.046	0.047	0.593
ETS	0.033	0.026	0.027	0.506	0.024	-0.011	**0.004**	0.459	**0.012**	0.058	0.049	0.598
LTA	0.037	0.054	0.033	0.536	0.028	0.013	0.008	0.483	0.018	0.072	0.086	0.747
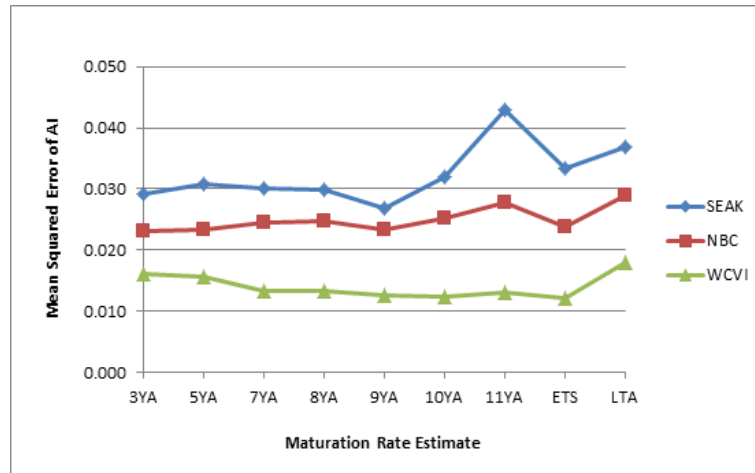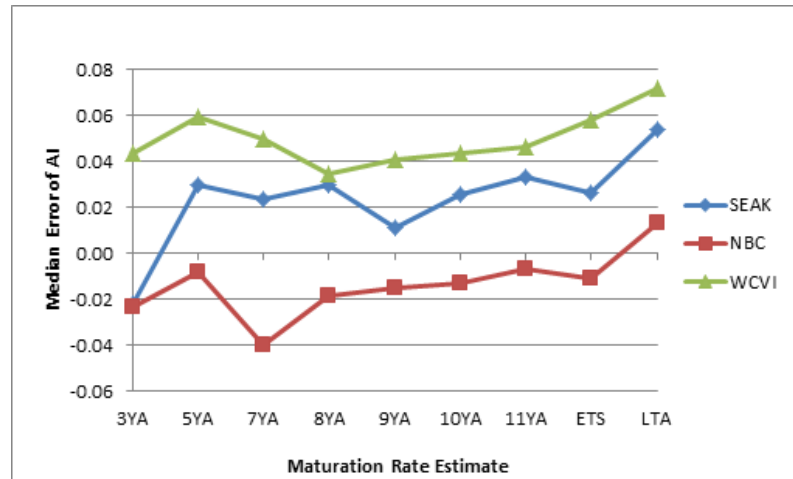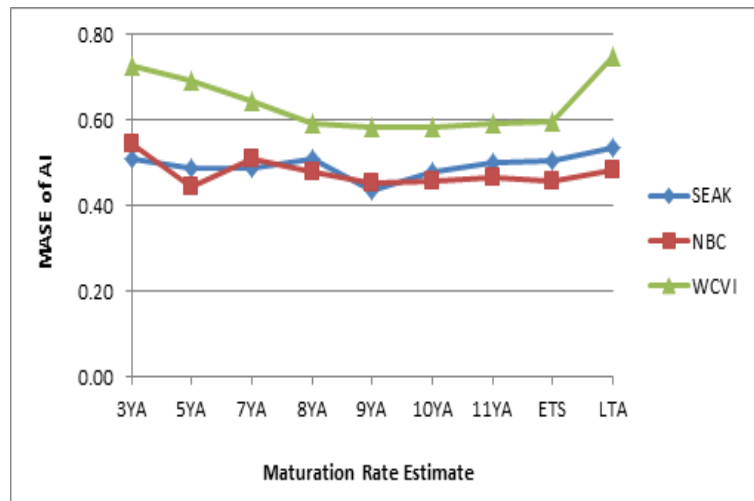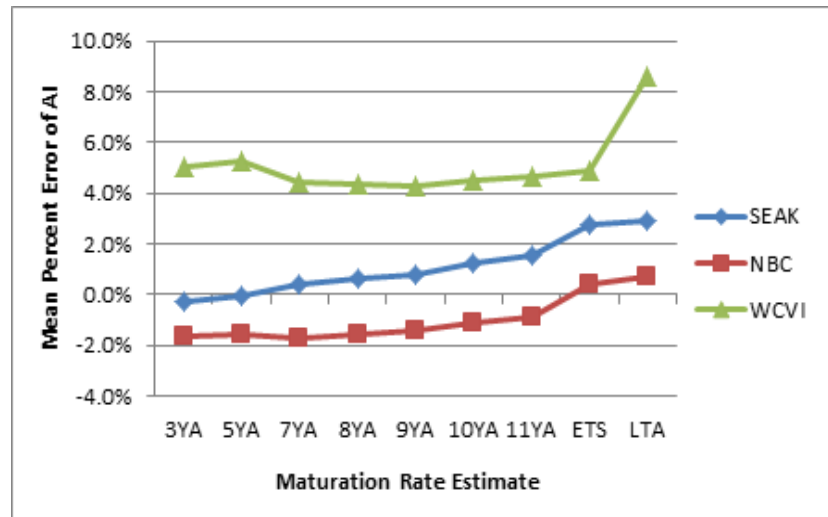
Figure 3.3. Model evaluation metrics of the discrepancy between the preseason and first postseason AI for different MR estimates, a. Mean squared error, b. Median error, c. Mean absolute scaled error, and d. Mean percent error.

3.2 BEST MODEL CHOICE UNDER DIFFERENT DATA AVAILABILITY SCENARIOS

In addition to the evaluation of models for preseason- first postseason discrepancies based on MSE calculations encompassing the 2004-2013 calibration time series, uncertainty in the best projection model was evaluated in response to the extent of time series (i.e., number of calibrations) used for MSE calculations. In some years, more than one model was identified as best because they had identical MSE values but in general the 9YA remained the overall best model (Table 3.4). The first row in this table corresponds to the individual-fishery best model in Table 5.1.

Table 3.4. Best MR projection model for each AABM fishery in response to the number of calibrations included in MSE calculations. The earliest calibration year is 2004 in all cases. The composite is based on the sum of MSE values across fisheries. All models assume a 1Y EV.

Last Year	# Calibrations	SEAK	NBC	WCVI	Composite
2013	10	9YA	3YA	ETS	9YA
2012	9	9YA	5YA	9YA	9YA
2011	8	9YA	5YA, 9YA	9YA	9YA
2010	7	9YA	9YA	9YA	9YA
2009	6	9YA	9YA	9YA, 10YA	9YA
2008	5	9YA	9YA	9YA	9YA

3.3 AI PROJECTIONS OF ALTERNATIVE MODELS

Preseason and first postseason AIs from the original annual calibrations were compared to the AIs generated from calibrations using MR and EV combinations with the lowest MSE for the AABMs as a group (9YA MR, 1Y EV) and for the individual AABM fisheries (Table 3.5). The AIs from the original annual calibrations were developed using a LTA MR and 5YA EV prior to 2013 and changed to a 5YA MR and 1Y EV in 2013 following the CTC 2012 MR and EV analysis. The AIs from the original calibrations are generally higher in both preseason and postseason calibrations than those produced using MR and EV from more recent year data for all three AABMs (Figure 3.4). The exception to this pattern occurred for all three AABM fisheries with the 2013 calibration; this corresponded with a change MR and EV assumptions. The biggest difference between the original calibrations and calibrations performed with the 9YA MRs and 1Y EVs occurred in the preseason AIs (Figure 3.4). The effect on the postseason AI was relatively small. The postseason AIs produced by the original and 9YA MRs and 1Y EVs were almost identical for the WCVI AABM fishery.

The average of the preseason and postseason AIs generated from the 2004-2014 Model calibrations using the best fishery-specific MR and EV for the NBC AABM (3YA MRs and 1 Y EV) were similar to the average of the AIs generated by 9YA MR and 1Y EV. For the WCVI AABM, the best fishery-specific MR and EV combination (ETS MRs and 1Y EV) generated across-calibration averages of the preseason and postseason AIs that were identical to the averages using the 9YA MRs and 1Y EVs. The AIs generated using the best MR and EV combination overall AABMs are the same (SEAK) or very similar to the AIs generated using the best fishery-specific MR and EVs.

Table 3.5. Preseason and first postseason AIs from the annual Chinook Model calibration under three MR-EV models.

AABM	Year	Original Calibration a/		Best MR-EV Overall AABM (9YA MR; 1Y EV)		Best MR-EV SEAK (9YA MR; 1Y EV)	
		Preseason	First Post	Preseason	First Post	Preseason	First Post
SEAK	**2004**	1.88	2.06	1.81	1.90	1.81	1.90
	2005	2.05	1.90	1.87	1.81	1.87	1.81
	2006	1.69	1.73	1.58	1.62	1.58	1.62
	2007	1.60	1.34	1.51	1.27	1.51	1.27
	2008	1.07	1.01	0.99	0.96	0.99	0.96
	2009	1.33	1.20	1.23	1.16	1.23	1.16
	2010	1.35	1.31	1.22	1.23	1.22	1.23
	2011	1.69	1.62	1.53	1.54	1.53	1.54
	2012	1.52	1.24	1.38	1.26	1.38	1.26
	2013	1.20	1.63	1.30	1.72	1.30	1.72
	Average	**1.54**	**1.50**	**1.44**	**1.45**	**1.44**	**1.45**

AABM	Year	Original Calibration a/		Best MR-EV Overall AABM (9YA MR; 1Y EV)		Best MR-EV NBC (3YA MR; 1Y EV)	
		Preseason	First Post	Preseason	First Post	Preseason	First Post
NBC	**2004**	1.67	1.83	1.63	1.70	1.57	1.63
	2005	1.69	1.65	1.54	1.55	1.46	1.59
	2006	1.53	1.50	1.39	1.41	1.45	1.45
	2007	1.35	1.10	1.25	1.04	1.30	1.07
	2008	0.96	0.93	0.88	0.89	0.93	0.90
	2009	1.10	1.07	1.03	1.03	1.04	1.01
	2010	1.17	1.23	1.09	1.17	1.06	1.15
	2011	1.38	1.41	1.29	1.35	1.25	1.30
	2012	1.32	1.15	1.25	1.15	1.18	1.13
	2013	1.10	1.51	1.18	1.59	1.15	1.53
	Average	**1.33**	**1.34**	**1.25**	**1.29**	**1.24**	**1.28**

AABM	Year	Original Calibration a/		Best MR-EV Overall AABM (9YA MR; 1Y EV)		Best MR-EV WCVI (ETS Method)	
		Preseason	First Post	Preseason	First Post	Preseason	First Post
WCVI	**2004**	0.90	0.98	0.87	0.94	0.90	0.96
	2005	0.88	0.84	0.81	0.81	0.82	0.84
	2006	0.75	0.68	0.68	0.66	0.75	0.67
	2007	0.67	0.57	0.61	0.55	0.64	0.55
	2008	0.76	0.64	0.72	0.63	0.67	0.63
	2009	0.72	0.61	0.68	0.61	0.69	0.61
	2010	0.96	0.95	0.93	0.92	0.91	0.94
	2011	1.15	0.90	1.07	0.90	1.09	0.90
	2012	0.89	0.76	0.84	0.74	0.84	0.72
	2013	0.77	1.04	0.84	1.10	0.83	1.05
	Average	**0.85**	**0.80**	**0.81**	**0.79**	**0.81**	**0.79**

a/ Annual calibrations to determine preseason and first postseason AI in 2004-12 were made with a LTA MR and 5YA EV. In 2013, a 5YA MR and a 1Y EV was used in the annual calibration for preseason and first postseason AI.
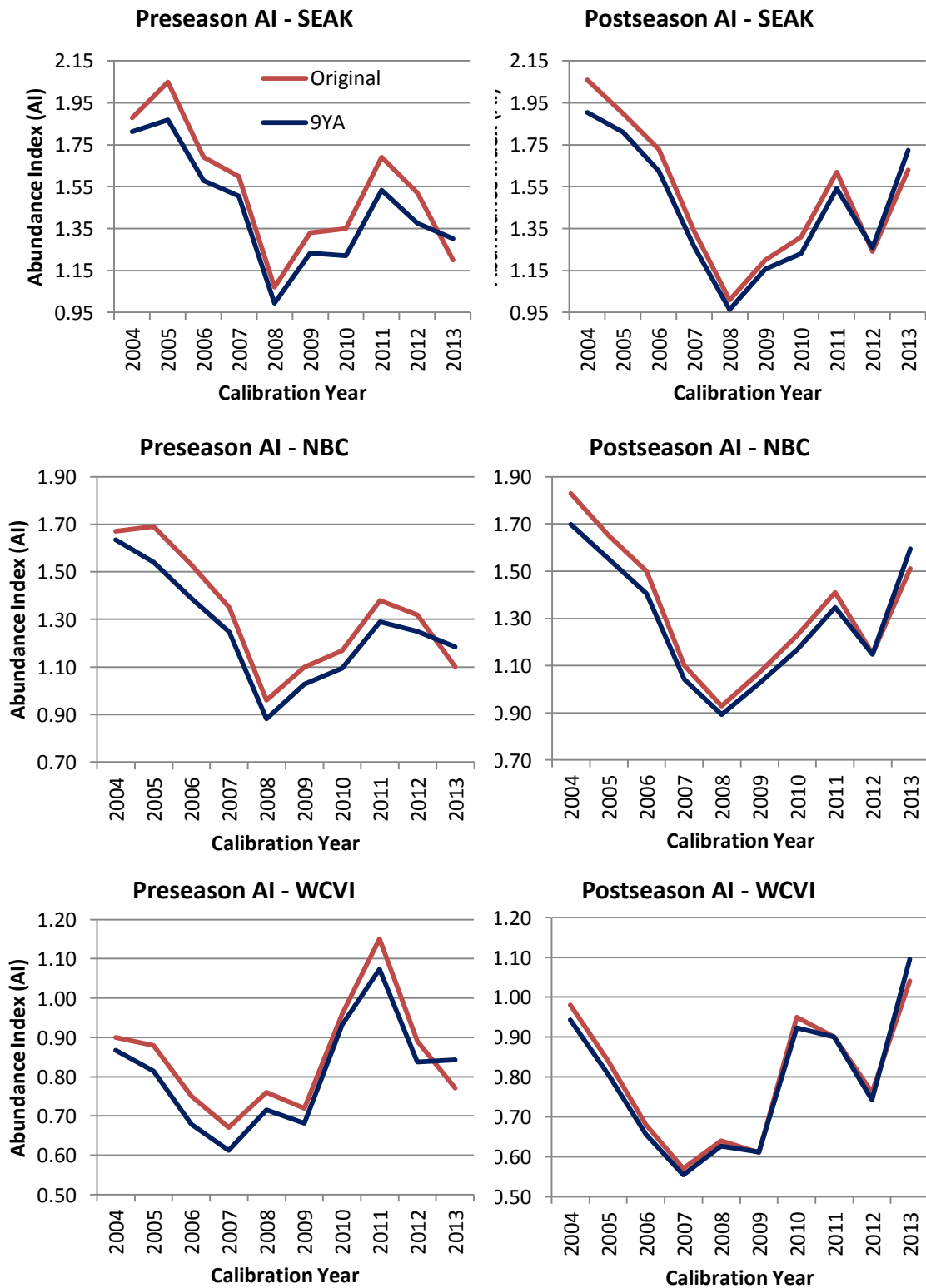
Figure 3.4. Preseason and postseason AIs for the SEAK, NBC and WCVI AABM fisheries from the original 2004-2013 Model calibrations and from calibrations using the 9YA MR and 1Y EV.   Comparisons between preseason AIs are displayed in panels on the left, comparisons of postseason AIs in panels on the right. The original values are indicated by a red line in each panel. Values obtained using the 9YA and 1Y EV are indicated with a blue line in each panel.

3.4 Effect of Maturation Rate Estimates on Pattern of Discrepancies between Preseason and Postseason AIs

Two aspects of the discrepancies between the preseason and first postseason AI for each of the three AABM fisheries have been noted. The first is the magnitude of the discrepancies, with the discrepancy exceeding 20% for two calibrations in each of the three fisheries (see Table 3.6 under the heading Original). The second is that for the annual calibrations from 2005 until 2012, the discrepancies were primarily in one direction for all three AABM fisheries with the preseason AI exceeding the postseason AI (Table 3.6). This pattern was observed despite the occurrence of both decreasing and increasing periods of aggregate Chinook abundance. The most notable exception to the pattern of over-forecasting of the AIs occurred with the calibration in 2013 (see Table 3.5).

Comparison of the magnitude of the percent error between the preseason and first postseason AIs from the original Chinook Model calibrations and from calibrations based on the best fishery-specific estimation model as assessed using the MSE statistic (Table 3.6, compare values under Original and MSE) showed that the mean percentage error (MPE) was reduced for the SEAK and WCVI AABM fisheries but not for the NBC fishery. For the NBC fishery, the MPE was reduced most using ETS MRs and 1Y EVs. The MPE from the original calibrations for the NBC fishery was small and results from calibrations performed with MR-EV estimates from the two other estimation models included in Table 3.6 produced similar results. The estimation model that resulted in lowest fishery-specific MPE differed from the model that resulted in the lowest fishery-specific MSE for each AABM fishery. The difference between the two models was small in each case. The MR-EV estimation model did affect the magnitude of the calibration-specific percent error between the preseason and postseason AIs as well as the MPE. In terms of absolute percentage errors, the employment of the 9YA in SEAK and WCVI reduced the percentage errors by 33% and 30% on average, and the ETS and 3YA both reduced the percentage errors by 11% in the NBC fishery (bottom 2 rows in Table 3.6). The percent error could be reduced in most calibration years through adoption of a different estimation model than had been used in calibrations prior to 2013 and the 9YA MR and 1 Y EV emerged as the best overall choice. The MR-EV estimation model, however, did not substantially change the pattern of percent errors observed across consecutive calibrations in years 2004-2013 for the AABM fisheries (Figure 3.5), meaning other factors or model inputs beyond MR or the EV have had a causative effect. An actual change in sign of the error occurred in only some cases where the percent error was near zero in the original calibration (Table 3.6). There was a slightly greater effect for the WCVI AABM fishery but overall, the influence was relatively minor (Figure 3.5). For the purpose of illustrating that the overall pattern of errors was not really affected by the MR-EV estimation model, results from a limited selection of estimation models was selected for display in Figure 3.5. Results were similar, however, for any of the estimation models that were investigated.

Table 3.6. Percent error (PE) between the preseason and first postseason AI from Chinook Model calibrations 2004-2013 for the SEAK, NBC and WCVI AABM fisheries. For each fishery are shown PE values from 1) the original Chinook Model calibrations (for years 2004-2012, the LTA was used and in 2013 the 5YA/1EV was used); 2) from calibrations based on the fishery-specific estimation model resulting in the lowest MSE; and 3) from calibrations based on the fishery-specific estimation model with the lowest MPE. The bottom three rows contain the overall mean of the percent errors (MPE), the mean of the absolute percentage errors (MAPE) and the percentage reductions in errors compared to the Original column.

Clb Year	SEAK AABM			NBC AABM			WCVI AABM		
	Original	9YA (MSE-based)	5YA (MPE-based)	Original	3YA (MSE-based)	ETS (MPE-based)	Original	ETS (MSE-based)	9YA (MPE-based)
2004	-8.7	-4.7	-10.5	-8.7	-3.7	-6.4	-8.2	-5.9	-8.0
2005	7.9	3.2	3.9	2.4	-8.2	1.8	4.8	-3.0	0.9
2006	-2.3	-2.7	-3.1	2.0	0.0	-1.1	10.3	11.4	3.6
2007	19.4	18.9	16.5	22.7	21.5	21.3	17.5	15.2	10.4
2008	5.9	3.2	4.2	3.2	3.3	-0.5	18.8	7.0	14.3
2009	10.8	6.6	6.0	2.8	3.0	0.6	18.0	11.7	11.5
2010	3.1	-0.9	0.0	-4.9	-7.8	-5.6	1.1	-2.5	1.0
2011	4.3	-0.5	1.3	-2.1	-3.8	-1.7	27.8	20.1	19.3
2012	22.5	9.2	7.4	14.7	4.4	18.6	17.0	16.5	12.6
2013 [1]	-26.3	-24.4	-26.9	-27.1	-24.8	-23.1	-25.9	-21.4	-23.0
MPE	3.7	0.8	-0.1	0.5	-1.6	0.4	8.1	4.9	4.3
MAPE	11.1	7.4	8.0	9.1	8.1	8.1	14.9	11.5	10.5
% Reduction		33.2%	28.2%		11.1%	10.9%		23.2%	30.0%

[1] Note that a 5-yr average for SEAK and BC stocks and 4-yr average for SUS stocks was used in the 2013 CLB
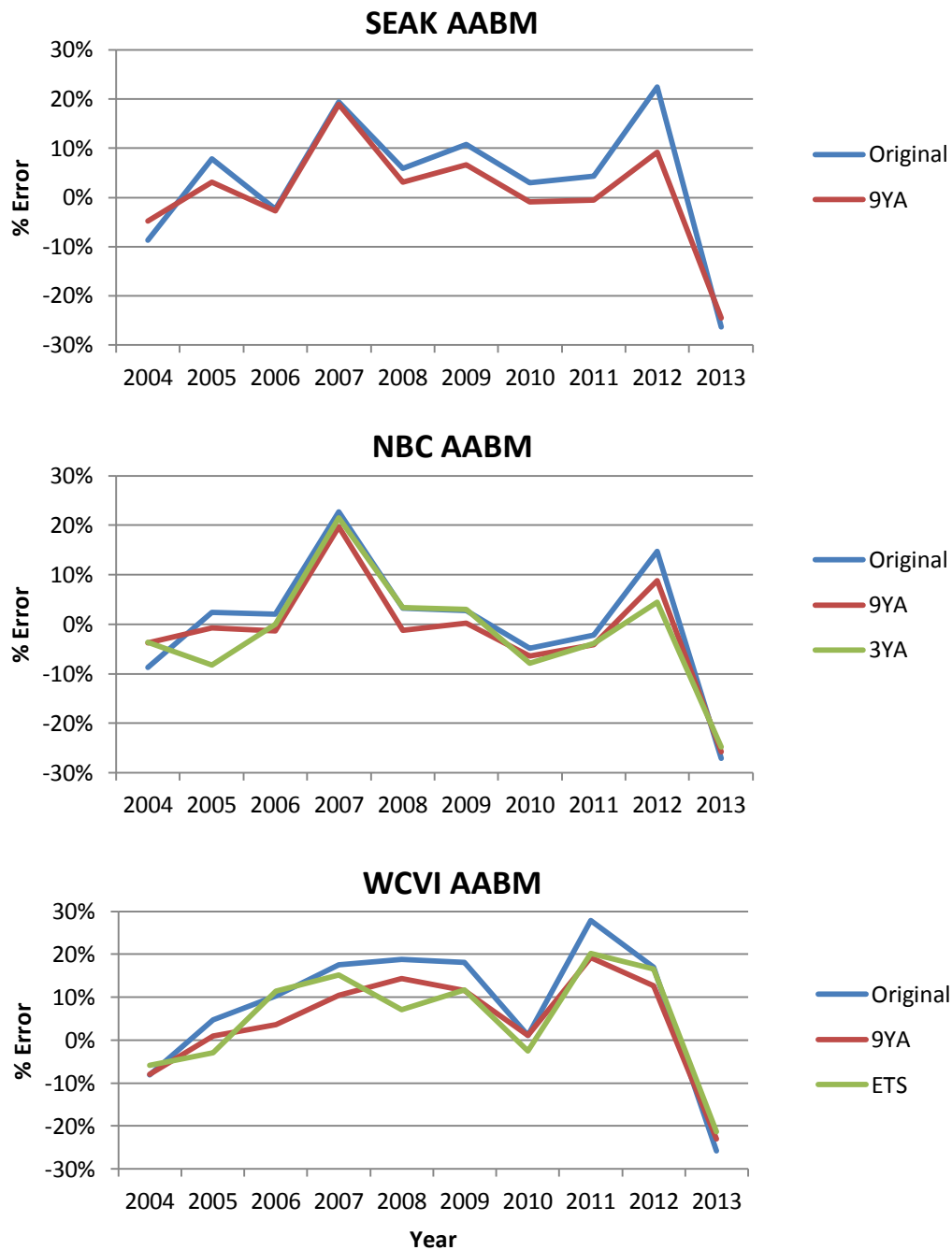
Figure 3.5. Percent error between the preseason and first postseason AI for SEAK, NBC and WCVI AABM fisheries from original 2004-2013 Model calibrations, from the calibrations performed using the 9YA MR-EV model (best overall according to composite MSE), and from best fishery-specific model (SEAK:9YA; NBC:3YA; WCVI:ETS) based on MSE. Blue line is original calibrations, red line is 9YA and green line is best fishery-specific model. Only two lines are shown for SEAK because 9YA was best overall and best fishery-specific.

3.5 Differences between Maturation Rates for CWT Indicator Stocks and for Stock Aggregates

For both the Salmon River Hatchery CWT indicator stock and the NOC SA, estimates by age of Cohort size (CO), pre-terminal fishery total mortality (PTF), pre-terminal fishery total mortality rate (PTFR), terminal return (TR), proportion of terminal return (TRprop), as well as MRs for the 1985, 1988, 1989, 1992, and 1999 brood-years are shown in Tables 3.7-3.11.

The CWT stock/SA ratios for TRprop and MR (Table 3.12) clearly demonstrate that the hatchery CWT stock estimates usually were dissimilar, often quite substantially, to the estimates for the naturally-produced SA, and that CWT stock fish much more often matured and returned at younger ages than did SA fish. The difference between the CWT stock and SA estimates generally decreased (i.e., the ratios became closer to 1.0) as age increased from 2 to 5, but the differences in TRprop for age 6 were similar to those for age 5. For ages 2 and 3, TRprop and MR were higher, usually substantially, for the CWT stock than for the SA, with the exception of age 2 of the 1999 BY and age 3 of the 1985 BY. The means of the ratios for TRprop and MR were 2.03 and 2.41, respectively, for age 2 and were 1.74 and 2.04 for age 3, with highest values of 3.52 for TRprop and 4.59 for MR (1988 BY). The mean of the TRprop ratios for age 4 was very near 1.0 (1.04), but the ratios were higher for 1985 (1.20), and 1988 (1.54) and much lower for 1992 (0.45). Age 4 MR ratios were generally higher with a higher mean (1.32) and were particularly high for 1988 (2.12) but particularly low for 1992 (0.69). For age 5, TRprop was lower for the CWT stock than the SA for all BYs but 1992 (1.30), with relatively substantial difference for 1989 (0.69) and, again particularly, 1988 (0.50), with mean of the ratios of 0.85. Age 5 MR ratios were little different than 1.0 for 1985 and 1988, but somewhat lower for 1989 (0.85) and higher for 1992 (1.34) and 1999 (1.42); the mean was 1.12. Age 6 TRprop was somewhat or much lower for the CWT stock for 1985 (0.80), 1988 (0.67), and particularly 1992 (0.28) and 1999 (0.26), but was substantially higher for 1989 (2.29); the mean of the ratios was 0.86. Because almost all fish mature by age 6, MR for age 6 was very similar for the CWT stock and SA for all brood-years (mean of 0.99).

Table 3.7. Salmon River Hatchery (SRH) CWT stock Coshak outputs by age 2-6, and complimentary North Oregon Coast (NOC) stock aggregate (SA) outputs derived using Coshak methods and estimated NOC Terminal Return (TR, spawning escapement plus terminal fishing mortality), 1985 brood-year. (CO = cohort number of fish, PTF=pre-terminal fishing mortality, PTFR = PTF/CO, TRprop = proportion of total returning fish, MR = maturation rates).

	SRH CWT stock						NOC SA					
Age	CO	PTF	PTFR	TR	Trprop	MR	CO	PTF	PTFR	TR	TRprop	MR
2	646	27	0.04	24	0.12	0.04	535,491	22,375	0.04	14,893	0.10	0.03
3	417	28	0.07	26	0.13	0.07	348,755	23,436	0.07	20,279	0.13	0.06
4	289	32	0.11	57	0.29	0.22	244,033	27,003	0.11	36,730	0.24	0.17
5	180	70	0.39	76	0.39	0.69	162,269	63,238	0.39	66,951	0.44	0.68
6	30	17	0.57	13	0.07	1.00	28,872	16,369	0.57	12,502	0.08	1.00

Table 3.8. Salmon River Hatchery (SRH) CWT stock Coshak outputs by age 2-6, and complimentary North Oregon Coast (NOC) stock aggregate (SA) outputs derived using Coshak methods and estimated NOC Terminal Return (TR, spawning escapement plus terminal fishing mortality), 1988 brood-year. (CO = cohort number of fish, PTF=pre-terminal fishing mortality, PTFR = PTF/CO, TRprop = proportion of total returning fish, MR = maturation rates).

	SRH CWT stock						NOC SA					
Age	CO	PTF	PTFR	TR	Trprop	MR	CO	PTF	PTFR	TR	TRprop	MR
2	2,089	86	0.04	91	0.14	0.05	990,514	40,770	0.04	9,401	0.04	0.01
3	1,339	120	0.09	75	0.12	0.06	658,240	59,000	0.09	26,927	0.11	0.04
4	915	201	0.22	304	0.47	0.43	457,850	100,534	0.22	71,829	0.30	0.20
5	369	177	0.48	164	0.25	0.85	256,938	123,238	0.48	119,373	0.50	0.89
6	24	7	0.29	17	0.03	0.97	12,895	3,693	0.29	9,203	0.04	1.00

Table 3.9. Salmon River Hatchery (SRH) CWT stock Coshak outputs by age 2-6, and complimentary North Oregon Coast (NOC) stock aggregate (SA) outputs derived using Coshak methods and estimated NOC Terminal Return (TR, spawning escapement plus terminal fishing mortality), 1989 brood-year. (CO = cohort number of fish, PTF=pre-terminal fishing mortality, PTFR = PTF/CO, TRprop = proportion of total returning fish, MR = maturation rates).

	SRH CWT stock						NOC SA					
Age	CO	PTF	PTFR	TR	Trprop	MR	CO	PTF	PTFR	TR	TRprop	MR
2	6,054	269	0.04	171	0.09	0.03	453,382	20,145	0.04	8,147	0.06	0.02
3	3,929	318	0.08	371	0.20	0.10	297,563	24,082	0.08	11,989	0.09	0.04
4	2,585	503	0.19	522	0.28	0.25	209,193	40,708	0.19	36,140	0.28	0.21
5	1,402	526	0.38	695	0.37	0.79	119,111	44,693	0.38	69,251	0.53	0.93
6	156	20	0.13	136	0.07	1.00	4,651	595	0.13	4,056	0.03	1.00

Table 3.10. Salmon River Hatchery (SRH) CWT stock Coshak outputs by age 2-6, and complimentary North Oregon Coast (NOC) stock aggregate (SA) outputs derived using Coshak methods and estimated NOC Terminal Return (TR, spawning escapement plus terminal fishing mortality), 1992 brood-year. (CO = cohort number of fish, PTF=pre-terminal fishing mortality, PTFR = PTF/CO, TRprop = proportion of total returning fish, MR = maturation rates).

	SRH CWT Stock						NOC SA					
Age	CO	PTF	PTFR	TR	Trprop	MR	CO	PTF	PTFR	TR	TRprop	MR
2	5,014	275	0.05	265	0.12	0.06	778,665	42,710	0.05	11,187	0.04	0.02
3	3,131	152	0.05	840	0.37	0.28	507,338	24,632	0.05	37,893	0.12	0.08
4	1,710	201	0.12	635	0.28	0.42	355,850	41,832	0.12	191,224	0.61	0.61
5	787	216	0.27	515	0.22	0.90	110,514	30,336	0.27	54,009	0.17	0.67
6	48	9	0.19	39	0.02	0.99	23,552	4,390	0.19	19,162	0.06	1.00

Table 3.11. Salmon River Hatchery (SRH) CWT stock Coshak outputs by age 2-6, and complimentary North Oregon Coast (NOC) stock aggregate (SA) outputs derived using Coshak methods and estimated NOC Terminal Return (TR, spawning escapement plus terminal fishing mortality), 1999 brood-year. (CO = cohort number of fish, PTF=pre-terminal fishing mortality, PTFR = PTF/CO, TRprop = proportion of total returning fish, MR = maturation rates).

	SRH CWT Stock						NOC SA					
Age	CO	PTF	PTFR	TR	Trprop	MR	CO	PTF	PTFR	TR	TRprop	MR
2	12,531	185	0.01	202	0.04	0.02	1,367,408	20,187	0.01	25,698	0.06	0.02
3	8,502	681	0.08	1,481	0.3	0.19	925,066	74,097	0.08	89,052	0.19	0.10
4	5,072	824	0.16	2,063	0.42	0.49	609,534	99,032	0.16	192,313	0.42	0.38
5	1,966	686	0.35	1,059	0.22	0.83	286,370	99,949	0.35	108,913	0.24	0.58
6	197	80	0.41	115	0.02	0.99	69,757	28,366	0.41	41,391	0.09	1.00

Table 3.12. SRH CWT stock/NOC SA ratios, by age, for Proportion of total Terminal Return and MRs, 1985, 1988, 1989, 1992, and 1999 brood years, with means.

	Proportion of Total Terminal Return						MR					
Age	1985	1988	1989	1992	1999	Mean	1985	1988	1989	1992	1999	Mean
2	1.24	3.52	1.44	3.24	0.73	2.03	1.34	4.59	1.57	3.68	0.86	2.41
3	0.99	1.01	2.12	3.03	1.55	1.74	1.07	1.37	2.34	3.59	1.81	2.04
4	1.20	1.54	0.99	0.45	1.00	1.04	1.31	2.12	1.17	0.69	1.29	1.32
5	0.88	0.50	0.69	1.30	0.90	0.85	1.03	0.96	0.85	1.34	1.42	1.12
6	0.80	0.67	2.29	0.28	0.26	0.86	1.00	0.97	1.00	0.99	0.99	0.99

4 DISCUSSION

4.1 RELEVANCE OF THE 9YA MODEL

This investigation showed that amongst the models used to project MRs, including the ETS models, the 9YA performed best across AABM fisheries and for different subsets of calibrations in terms of minimizing composite MSEs and maximizing percentage error reductions. The 2012 analysis identified the 5YA projections of MRs (and most recent EV) as the best, but the 9YA (and most recent EV) model was not examined in 2012. However, the biological or technical basis behind the good performance of the 9YA model at minimizing the discrepancies between preseason and first postseason AIs are unknown. At the core of this analysis is the examination of MR estimation models for incomplete broods. Two types of MR models were considered in the analysis. The average model (Section 2.2) is applied uniformly across all stock and ages, whereas the ETS model (Section 2.3) fits an exponential smoothing model to each stock and age. Both models are able to capture recent trends, but the ETS model also attempts to capture any long term trends that may be present. The ETS model is more complex in terms of the number of parameters to process. No examination of the biological or technical basis for the performance of either of the models was performed.

The analysis conducted herein did not seek to find the biological mechanism behind any of the models because such an exercise would be time intensive, outside the scope of the assignment, and due to the complexity would likely be inconclusive. There are some possible reasons why the best model, the 9YA MR and 1Y EV, outperformed all the rest. One potential biological explanation to the best MR model is that it incorporates the MR from the last two complete broods. And similarly, a technical explanation is that the 9YA MR model, across all stocks and ages, provides the optimal level of smoothing to minimize the preseason and postseason discrepancy.

4.2 AIS AND MATURATION RATES

MRs affect the number of fish estimated to remain available to ocean fisheries during the Chinook Model calibration process. This investigation examined the MR projection assumptions and its impact on the preseason and postseason AIs. From these comparisons, the quantification of preseason error relative to the first postseason AI is germane for PST monitoring of AABM fisheries performance. Ordinarily, the same assumptions have been employed for incomplete broods of all stocks and ages and for the one-year projection necessary for Chinook Model calibrations. These assumptions have been discussed given the detection of trends in MRs for some stocks and the different degree of variability in the time series of MRs display across stocks and ages (Appendix B). The development of models and methods to improve the ability to predict stock- and age-specific MRs is important to avoid confounding of inter-relationships between data involving multiple stock and fisheries across years. The exploration of stock- and age-specific methods (the average and ETS models) included in this report responds to this realization. However, additional investigation is important because robust projection of MRs transcends their influence on discrepancies between preseason and postseason AIs - i.e., the development of robust projections of MRs helping to cope with incomplete broods and future expectations of MR values would have a positive influence on the estimation of other relevant statistics derived from the exploitation rate analysis in addition to its relevance for AIs.

PSC Chinook Model AI forecasting involves a large number of data inputs, algorithms and assumptions, and only a systematic exploration of the interaction between these factors would help to understand and improve the forecasting abilities of the PSC Chinook Model and therefore enable the possibility of reducing even more AI discrepancies. More specifically, perfect information about MRs will not produce perfect AI forecasting or eliminate preseason-postseason discrepancies because many other factors affect the Chinook Model forecasting procedure. This observation points to the need for further investigation into other aspects of the Chinook Model that may influence its performance, including forecasts, estimates of terminal runs, delays in obtaining CWT and some escapement data, as well as base-period data and assumptions.

4.3 DATA QUALITY

One limitation of projecting MRs is gaps in the brood-year time series of MRs of some stocks. These gaps are the consequence of no CWT releases for a given stock and year or invalid broods characterized by extremely poor marine survival and sparse CWT recoveries producing anomalous statistics in cohort analyses. The ETS methodology, as applied in this exercise, is the only one using calendar-year data directly from the MATAEQ files (see Appendix C for more detail), and therefore uses time series of MRs

without gaps. However, the problem of gaps in time series of MRs affects all models used for projections. This situation arises because infilling or inputting assumptions are necessary (averages are currently used) in order to complete the time series of brood-year MRs and create the gap-free time series of calendar-year MRs necessary for the MATAEQ file. For the average models, the impact of invalid broods means less data is used to compute the recent average. Future investigations on the use time series models (including the ETS model) to estimate MRs can include their application at the brood-year level with or without infilling or inputting missing values in the time series. Without infilling, for instance, the time series algorithms used herein would be based on the longer string of subsequent brood-year MR values if the time series has gaps. Different infilling procedures could be explored in the future, including a revaluation of whether or not the data quality of MR time series warrants changes in the list of stocks currently in the MATAEQ file.   Additionally, there are potential improvements to be realized with the incorporation of additional stocks into the MATAEQ file to better represent those stock groups present in contemporary fisheries.

4.4 RETROSPECTIVE COMPARISONS WITH COMPLETE-BROOD MATURATION RATES

The ability to produce robust projections of MRs for incomplete broods and for one-year forecasts is important for other analyses the CTC conducts annually, including statistics derived from exploitation rate analysis and the fitting procedures involved in Chinook Model calibrations. Finding models that take into consideration the unique characteristics of time series of observed MRs exhibited by each stock and age is therefore important. A straightforward way of evaluating the performance of models used to project MRs is to compare the projected values with those obtained by cohort analysis of completed broods. An example of such comparisons is shown in Appendix A and appendices E to H for a subset of models. This kind of retrospective evaluation has the potential of providing insights about the effect assumptions intrinsic in estimation models have on the magnitude of discrepancies with observed (actual) MR values. A thorough evaluation of these discrepancies could increase the reliability of selected models and improve the quality of all statistics affected by incomplete broods.

4.5 DIFFERENCES BETWEEN MATURATION RATES FOR CWT INDICATOR STOCKS AND FOR STOCK AGGREGATES

A complication to the MR analysis above is that the MR estimates used in the PSC Chinook Model assume that a stock aggregate (SA) and its CWT indicator stock share the same maturation and exploitation rates. This demonstration analysis shows that if the age structure of a CWT indicator stock is substantially different from that of the natural populations it is meant to represent then it is unavoidable that MRs of the CWT indicator stock will improperly represent those of its stock aggregate. If such is common for the stock aggregates in the Chinook Model, almost all of which have hatchery CWT indicator stocks, then the Chinook Model's ability to accurately estimate pre-terminal fishery AIs, both preseason and postseason, would be compromised because the Model will fit to the inputted CWT indicator stock MRs.

Estimation of AIs would likely be improved by using stock aggregate MR inputs based on summed estimates of terminal return for the component populations of the stock aggregates. There are some stock aggregates for which data to do this for the various component populations is extremely limited or absent. For such stock aggregates, however, it may still be preferable to use the method shown here to estimate MRs for those natural populations for which data is available and to use those MR estimates as more likely representative of the MRs of the entire natural stock aggregate than the MRs for the CWT indicator stock.

The time-frame for potential implementation of the methodology demonstrated here is uncertain because the method has only very recently been developed and must be considered by the full CTC under PSC Commission guidance. It is unknown how adjustment to using naturally-produced stock aggregate MRs will influence the Chinook Model's forecasting abilities, but this seems likely to result in improvement in AI estimates. In any case, going through the exercise of calculating SA MRs will better inform the Chinook Model and its underlying assumptions as well as increase our understanding of the processes driving changes to AIs.

5 SUMMARY

Recent discrepancies between the preseason and postseason AI prompted the PSC Commissioners to task the CTC-AWG to update the previous MR-EV analysis. The previous MR and EV investigation conducted by the CTC in 2012 on a limited number of MR-EV models found that the MR-EV model that minimized the MSE was a 5YA MR and a 1Y EV (TCChinook 14-1 V1). In updating the analysis, the AWG confirmed that use of various other models resulted in smaller discrepancies between the preseason and postseason AIs generated by the Chinook Model, across calibrations, compared to the LTA and 5YA MRs. According to the composite MSE metric, the MR-EV model that minimized the preseason to postseason AI discrepancy across the three AABM fisheries was the 9YA MR and 1Y EV (Table 5.1; see Appendix I for details). Though a different estimation model produced the smallest discrepancy between the preseason and first post-season AI for each AABM fishery across Model calibrations 2004-2014 based on the fishery-specific MSE.

The CTC recommends that the 9YA MR and 1Y EV is used for the annual Chinook Model calibration. Given this departure from the MR average used in previous Chinook Model calibrations, it may be advisable to periodically reassess whether the 9YA MRs continue to provide the best overall approach to minimizing the discrepancy between the preseason and postseason AIs generated by the Chinook Model across calibrations.

The investigation of the ETS method did demonstrate that it was possible and feasible to employ a time series modelling approach. While the 9YA emerged as the overall recommended approach to estimate age-specific MRs for stocks in the Chinook Model's MATAEQ input file, the ETS method also showed promise. This method, in fact, generated the best overall results in terms of precision (MSE) for WCVI (Table 5.1) and in terms of accuracy (MPE) for NBC (Table 3.3). Future investigation of time series approaches for the projection of MRS can include applications of the ETS model to brood year-based MRs and the exploration of ARIMA models. One challenge that was encountered was the need to infill gaps in the MR time series which can occur due to missing or invalid broods; these are brood years that

were tagged, but had such low survivals that CWT recoveries were either absent or produced nonsensical MRs, and the LTA was used. The infilling can be achieved but the best approach to do so could not be determined in the time frame of this investigation.

Stock aggregate MRs are different than CWT indicator stock MRs. Results using data from the North Oregon Coast show that there is a large discrepancy between naturally-produced stock aggregate MRs and hatchery CWT indicator stock MRs, which could result in errors in both preseason and postseason AIs because the model will fit to the inputted CWT indicator stock MRs. The results also indicate that CWT MRs may be biased high for any age given the earlier maturation of the hatchery stock versus the natural stock. Given that nearly all driver stocks use a hatchery indicator (e.g., Fraser Lates), this approach to adjust the maturation rates for the natural stocks has potential to improve abundance predictions.

As noted above, other factors and inputs undoubtedly contribute to errors in forecasting AIs. These include, but are not limited to, preseason forecasts, delays in obtaining CWT data and some terminal run and catch data, escapement estimation, etc. A future examination of forecasting relative abundance should examine issues like these with the same rigor applied in this investigation.

Table 5.1. Mean squared error between the preseason and first postseason AI assuming a 1-year EV. The scenario that minimized the MSE is highlighted in darker shading and the second best scenario is lighter shading.

Model	SEAK	NBC	WCVI	Composite
3YA	0.0289	0.0233	0.0161	0.0683
5YA	0.0309	0.0238	0.0157	0.0704
7YA	0.0300	0.0246	0.0132	0.0678
8YA	0.0299	0.0248	0.0134	0.0681
9YA	0.0268	0.0234	0.0125	0.0627
10YA	0.0320	0.0252	0.0125	0.0696
11YA	0.0357	0.0277	0.0131	0.0765
LTA	0.0374	0.0283	0.0180	0.0836
ETS	0.0333	0.0239	0.0122	0.0695

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APPENDICES

Appendix A. Estimated and Observed MRs at Three Ages from Completed Broods for Each of the 12 Model Stocks in the MATAEQ Input File for the 2004-2014 Chinook Model Calibrations.

The estimated values were constructed using three models: 1) an average of the three most recently completed and valid broods (3YA); 2) an average of the nine most recently completed and valid broods (9YA), and 3) a projection using a time series exponential smoothing model (ETS). Estimates from the 3YA, 9YA and ETS models were included because each produced the lowest fishery-specific MSE for one of the AABM fisheries. For the average models, invalid broods were not replaced with other values in the computation of averages (see Section 2.2). The first, second and third age is 3, 4 and 5 respectively for the two spring stocks (AKS and WSH). The first, second and third age is 2, 3 and 4 respectively for the other (fall) stocks. All observed values are from the cohort analysis procedure completed by the CTC-AWG in March 2015 for CWT indicator stocks associated to the Chinook Model stocks in the MATAEQ file. The most recent year with CWT recovery data in this analysis was 2014 for Chinook Model stocks AKS, GSH, RBH and RBT and 2013 for all others. An observed MR is given for only those stock-brood-age combinations where the brood was complete in the 2015 cohort analysis results.

Table A.1. The name of the Chinook Model stocks in the MATAEQ file and the associated CWT indicator stock is provided at the end of this appendix.

CLB YR	Stock	Stock #	First Age				Second Age				Third Age			
			3YA	9YA	ETS	Observed	3YA	9YA	ETS	Observed	3YA	9YA	ETS	Observed
2004	AKS	1	0.0187	0.0151	0.0193	0.0078	0.1448	0.0892	0.1049	0.3152	0.6862	0.5747	0.6129	0.7049
	BON	2	0.0236	0.0392	0.0263	0.0215	0.4988	0.5320	0.5972	0.2230	0.9792	0.9833	0.9561	0.8869
	CWF	3	0.0153	0.0359	0.0075	0.0135	0.2705	0.2635	0.2278	0.1414	0.7773	0.7887	0.7560	0.4718
	GSH	4	0.0374	0.0505	0.0420	0.1171	0.2578	0.3473	0.2838	0.2595	0.7305	0.8065	0.7677	0.8000
	LRW	5	0.0472	0.0895	0.0680	0.0412	0.1092	0.1027	0.1115	0.1230	0.6600	0.3505	0.4187	0.6034
	ORC	6	0.0461	0.0414	0.0678	0.0241	0.1516	0.1407	0.1155	0.1243	0.5058	0.4405	0.4443	0.4064
	RBH	7	0.0189	0.0188	0.0192	0.0127	0.1574	0.1619	0.1573	0.3015	0.7028	0.6662	0.6318	0.7170
	RBT	8	0.0189	0.0188	0.0192	0.0127	0.1574	0.1619	0.1573	0.3015	0.7028	0.6662	0.6318	0.7170
	SPR	9	0.0710	0.0586	0.0746	0.1059	0.6282	0.6716	0.6491	0.5962	0.9771	0.9851	0.9686	0.9680
	URB	10	0.0225	0.0270	0.0294	0.0369	0.1731	0.1661	0.1641	0.2160	0.7197	0.5992	0.5926	0.4709
	WSH	11	0.0036	0.0134	0.0114	0.0241	0.3955	0.4454	0.4464	0.6229	0.9763	0.9725	0.9677	0.9730
	FRL	12	0.0792	0.0767	0.0779	0.1100	0.2554	0.2591	0.2106	0.3191	0.8907	0.9056	0.8417	0.7992

2005	AKS	1	0.0162	0.0142	0.0099	0.0107	0.1621	0.0956	0.1056	0.1853	0.7454	0.5992	0.6206	0.7472
	BON	2	0.0148	0.0220	0.0202	0.0306	0.4955	0.5214	0.6034	0.6032	0.9749	0.9832	0.9578	0.9657
	CWF	3	0.0124	0.0336	0.0048	0.0340	0.3078	0.2916	0.3062	0.2377	0.7035	0.7884	0.7414	0.8211
	GSH	4	0.0405	0.0508	0.0418	0.0494	0.3140	0.3501	0.3109	0.3928	0.7858	0.8039	0.8240	0.7110
	LRW	5	0.0180	0.0503	0.0539	0.0544	0.0237	0.0881	0.1066	0.0297	0.4153	0.3699	0.4176	0.2050
	ORC	6	0.0442	0.0397	0.0401	0.0524	0.1521	0.1449	0.1171	0.1459	0.5920	0.4984	0.4873	0.5520
	RBH	7	0.0236	0.0165	0.0120	0.0058	0.2182	0.1825	0.1622	0.1146	0.7148	0.6800	0.6348	0.7402
	RBT	8	0.0236	0.0165	0.0120	0.0058	0.2182	0.1825	0.1622	0.1146	0.7148	0.6800	0.6348	0.7402
	SPR	9	0.0829	0.0619	0.0721	0.0833	0.6572	0.6851	0.6522	0.7911	0.9845	0.9858	0.9697	0.9612
	URB	10	0.0206	0.0235	0.0254	0.0296	0.2013	0.1757	0.1675	0.2050	0.7030	0.6172	0.5900	0.5451
	WSH	11	0.0048	0.0121	0.0112	0.0425	0.4768	0.4309	0.4554	0.4948	0.9828	0.9777	0.9688	0.9684
	FRL	12	0.1088	0.0851	0.0801	0.1583	0.2746	0.2296	0.3627	0.2857	0.8644	0.8858	0.8639	0.9461
2006	AKS	1	0.0140	0.0143	0.0154	0.0212	0.1502	0.1036	0.1084	0.1795	0.7367	0.6279	0.6235	0.7627
	BON	2	0.0164	0.0214	0.0166	0.0427	0.4678	0.4942	0.5052	0.4867	0.9790	0.9843	0.9318	0.7649
	CWF	3	0.0282	0.0360	0.0099	0.1535	0.2174	0.2577	0.2211	0.3674	0.7125	0.7847	0.7386	0.7576
	GSH	4	0.0415	0.0540	0.0430	0.0102	0.2902	0.3488	0.3042	0.3937	0.8056	0.7949	0.7703	0.9606
	LRW	5	0.0104	0.0327	0.0429	0.0132	0.0179	0.0801	0.1016	0.0668	0.2304	0.3257	0.3192	0.4535
	ORC	6	0.0371	0.0392	0.0499	0.0027	0.1437	0.1567	0.1387	0.1481	0.5248	0.5081	0.4696	0.4271
	RBH	7	0.0123	0.0171	0.0091	0.0170	0.1639	0.1748	0.1586	0.2159	0.5287	0.6512	0.6232	0.7640
	RBT	8	0.0123	0.0171	0.0091	0.0170	0.1639	0.1748	0.1586	0.2159	0.5287	0.6512	0.6232	0.7640
	SPR	9	0.0364	0.0585	0.0759	0.0912	0.5338	0.6688	0.6450	0.6985	0.9794	0.9865	0.9697	1.0000
	URB	10	0.0148	0.0241	0.0254	0.0800	0.1496	0.1829	0.1669	0.2723	0.6358	0.6266	0.5900	0.8041
	WSH	11	0.0069	0.0105	0.0111	0.0117	0.5000	0.4634	0.4592	0.6696	0.9881	0.9785	0.9691	0.9436
	FRL	12	0.0652	0.0590	0.0593	0.4047	0.1821	0.2227	0.1433	0.4917	0.8707	0.8837	0.8080	0.9603
2007	AKS	1	0.0161	0.0148	0.0166	0.0282	0.1453	0.1178	0.1159	0.2133	0.7293	0.6446	0.6352	0.7134
	BON	2	0.0143	0.0182	0.0157	0.0533	0.4242	0.4540	0.4495	0.8686	0.9512	0.9624	0.9556	1.0000
	CWF	3	0.0243	0.0181	0.0270	0.0632	0.2519	0.2633	0.2839	0.5152	0.7012	0.7571	0.7486	0.9183
	GSH	4	0.0435	0.0485	0.0428	0.1260	0.3303	0.3362	0.3036	0.5315	0.8016	0.7850	0.7771	0.7950
	LRW	5	0.0138	0.0285	0.0389	0.0000	0.0208	0.0745	0.0609	0.0554	0.3755	0.3754	0.4780	0.2653
	ORC	6	0.0348	0.0375	0.0351	0.0147	0.1568	0.1650	0.1468	0.0548	0.4762	0.5151	0.4628	0.6102
	RBH	7	0.0115	0.0130	0.0096	0.0242	0.1764	0.1819	0.1592	0.1374	0.6404	0.6720	0.6326	0.6653
	RBT	8	0.0115	0.0130	0.0096	0.0242	0.1764	0.1819	0.1592	0.1374	0.6404	0.6720	0.6326	0.6653
	SPR	9	0.0417	0.0585	0.0473	0.1511	0.5937	0.6552	0.6412	0.9712	0.9770	0.9826	0.9692	1.0000

	URB	10	0.0161	0.0225	0.0243	0.0708	0.1605	0.1883	0.1638	0.1921	0.5521	0.6407	0.5869	0.7480
	WSH	11	0.0117	0.0107	0.0114	0.0113	0.5287	0.4740	0.4574	0.5869	0.9819	0.9804	0.9692	0.9712
	FRL	12	0.0804	0.0608	0.0608	0.1355	0.1601	0.2174	0.1976	0.4360	0.8290	0.8691	0.8666	0.9492
2008	AKS	1	0.0177	0.0155	0.0198	0.0118	0.1887	0.1226	0.1574	0.2442	0.6344	0.6600	0.6307	0.8238
	BON	2	0.0094	0.0158	0.0158	0.0303	0.3011	0.4106	0.4001	0.5878	0.9439	0.9636	0.9562	1.0000
	CWF	3	0.0187	0.0174	0.0078	0.0831	0.1836	0.2577	0.2016	0.2840	0.7006	0.7523	0.7503	1.0000
	GSH	4	0.0366	0.0448	0.0416	0.0551	0.2957	0.3290	0.2946	0.3908	0.7543	0.7788	0.7548	0.9497
	LRW	5	0.0101	0.0283	0.0339	0.0217	0.0532	0.0742	0.0803	0.0382	0.3283	0.3669	0.3498	0.6246
	ORC	6	0.0120	0.0268	0.0030	0.0126	0.1402	0.1445	0.1358	0.1665	0.4709	0.5244	0.4715	0.4545
	RBH	7	0.0123	0.0133	0.0093	0.0316	0.1994	0.1981	0.1654	0.3185	0.6382	0.6827	0.6377	0.6602
	RBT	8	0.0123	0.0133	0.0093	0.0316	0.1994	0.1981	0.1654	0.3185	0.6382	0.6827	0.6377	0.6602
	SPR	9	0.0499	0.0573	0.0480	0.0187	0.5219	0.6251	0.6395	0.7372	0.9637	0.9777	0.9688	1.0000
	URB	10	0.0188	0.0208	0.0228	0.1131	0.1517	0.1858	0.1660	0.2882	0.5300	0.6227	0.5855	0.7410
	WSH	11	0.0153	0.0090	0.0125	0.0206	0.5300	0.4681	0.4737	0.6190	0.9740	0.9788	0.9704	1.0000
	FRL	12	0.0654	0.0613	0.0606	0.1021	0.1623	0.2185	0.3627	0.4279	0.8677	0.8748	0.9427	0.8981
2009	AKS	1	0.0163	0.0154	0.0393	0.0441	0.2060	0.1447	0.1669	0.3028	0.7268	0.6730	0.6936	0.8232
	BON	2	0.0089	0.0163	0.0136	0.0192	0.3572	0.4398	0.4654	0.7700	0.8661	0.9336	0.9488	0.9600
	CWF	3	0.0101	0.0168	0.0114	0.0326	0.2280	0.2397	0.2253	0.3676	0.7137	0.7476	0.7516	0.9076
	GSH	4	0.0624	0.0474	0.0622	0.0833	0.3182	0.3134	0.3106	0.3995	0.8320	0.7855	0.8202	0.9322
	LRW	5	0.0224	0.0239	0.0416	0.0000	0.0581	0.0761	0.0696	0.0478	0.4470	0.3517	0.3530	0.3440
	ORC	6	0.0262	0.0268	0.0359	0.0144	0.1141	0.1434	0.1308	0.1060	0.4436	0.5209	0.4491	0.5606
	RBH	7	0.0123	0.0125	0.0114	0.0103	0.2076	0.1773	0.1640	0.1327	0.7488	0.6872	0.6423	0.8615
	RBT	8	0.0123	0.0125	0.0114	0.0103	0.2076	0.1773	0.1640	0.1327	0.7488	0.6872	0.6423	0.8615
	SPR	9	0.0671	0.0633	0.0783	0.2126	0.6339	0.6330	0.6435	0.8142	0.9641	0.9751	0.9669	0.9874
	URB	10	0.0265	0.0222	0.0296	0.0429	0.1884	0.1866	0.1693	0.1485	0.6112	0.6331	0.5926	0.7705
	WSH	11	0.0193	0.0105	0.0140	0.0479	0.5141	0.4772	0.4733	0.6193	0.9615	0.9766	0.9686	0.9938
	FRL	12	0.0684	0.0603	0.0618	0.1390	0.2156	0.2159	0.2313	0.1799	0.9041	0.8852	0.9466	0.8408
2010	AKS	1	0.0119	0.0167	0.0099	0.0100	0.2181	0.1598	0.1698	0.2345	0.7356	0.6885	0.6994	0.8464
	BON	2	0.0176	0.0176	0.0201	0.0787	0.4389	0.4449	0.4659	0.7692	0.9021	0.9406	0.9509	1.0000
	CWF	3	0.0160	0.0189	0.0148	0.0469	0.2505	0.2551	0.2529	0.1576	0.8338	0.7640	0.7563	0.7000
	GSH	4	0.0612	0.0497	0.0636	0.0471	0.3451	0.3170	0.3272	0.4588	0.8288	0.7903	0.7916	0.8820
	LRW	5	0.0342	0.0237	0.0427	0.0191	0.0767	0.0484	0.0717	0.0328	0.3245	0.3396	0.3455	0.4559
	ORC	6	0.0252	0.0257	0.0628	0.0341	0.1215	0.1506	0.1289	0.2841	0.4399	0.5051	0.4306	0.6027

	RBH	7	0.0134	0.0141	0.0110	0.0294	0.2141	0.1873	0.1667	0.1706	0.7322	0.6883	0.6437	0.7480
	RBT	8	0.0134	0.0141	0.0110	0.0294	0.2141	0.1873	0.1667	0.1706	0.7322	0.6883	0.6437	0.7480
	SPR	9	0.0822	0.0650	0.0815	0.0898	0.6955	0.6310	0.6451	0.9138	0.9871	0.9792	0.9693	1.0000
	URB	10	0.0239	0.0212	0.0267	0.0973	0.2356	0.1907	0.1721	0.2741	0.6960	0.6506	0.5993	0.5599
	WSH	11	0.0263	0.0120	0.0152	0.0539	0.6007	0.4921	0.4785	0.7821	0.9606	0.9731	0.9683	0.9844
	FRL	12	0.0980	0.0738	0.0655	0.1097	0.2513	0.2225	0.2820	0.4333	0.9554	0.8905	0.9254	0.9493
2011	AKS	1	0.0130	0.0173	0.0260	0.0210	0.1860	0.1742	0.1563	0.3668	0.7651	0.7195	0.7004	0.9038
	BON	2	0.0314	0.0194	0.0208	--	0.6475	0.4786	0.4749	0.7617	0.9158	0.9406	0.9557	1.0000
	CWF	3	0.0647	0.0188	0.0314	--	0.3746	0.2553	0.3174	0.4520	0.8921	0.7674	0.7675	0.9197
	GSH	4	0.0591	0.0483	0.0439	0.0984	0.4348	0.3506	0.4022	0.4587	0.8999	0.8126	0.8731	1.0000
	LRW	5	0.0309	0.0213	0.0403	--	0.0448	0.0450	0.0756	0.0218	0.4607	0.3218	0.5010	0.3543
	ORC	6	0.0317	0.0257	0.1417	--	0.1083	0.1425	0.1320	0.3564	0.5650	0.5535	0.5021	0.6595
	RBH	7	0.0097	0.0144	0.0275	0.0089	0.1611	0.1892	0.1658	0.1859	0.6940	0.6845	0.6442	0.6453
	RBT	8	0.0097	0.0144	0.0275	0.0089	0.1611	0.1892	0.1658	0.1859	0.6940	0.6845	0.6442	0.6453
	SPR	9	0.0880	0.0711	0.0532	--	0.8199	0.6684	0.6491	0.7927	1.0000	0.9821	0.9694	1.0000
	URB	10	0.0452	0.0282	0.0362	--	0.2261	0.1958	0.1685	0.4015	0.7613	0.6680	0.6009	0.7889
	WSH	11	0.0240	0.0153	0.0143	--	0.5850	0.5231	0.4825	0.6786	0.9715	0.9724	0.9685	0.9949
	FRL	12	0.2257	0.1160	0.1309	0.0974	0.2830	0.2418	0.2037	0.4510	0.9347	0.8908	0.8821	0.9579
2012	AKS	1	0.0194	0.0180	0.0171	--	0.2051	0.1870	0.1821	0.1352	0.7862	0.7418	0.7380	0.8215
	BON	2	0.0447	0.0244	0.0243	--	0.6451	0.4926	0.4892	--	0.9845	0.9420	0.9547	1.0000
	CWF	3	0.0827	0.0426	0.0353	--	0.3910	0.2874	0.3337	--	0.9422	0.8086	0.8446	0.8669
	GSH	4	0.0618	0.0551	0.0704	--	0.4387	0.3506	0.3654	0.3814	0.8938	0.8440	0.8637	0.8542
	LRW	5	0.0227	0.0225	0.0320	--	0.0546	0.0483	0.0628	--	0.4258	0.3746	0.3594	0.3187
	ORC	6	0.0252	0.0203	0.0223	--	0.0933	0.1280	0.1167	--	0.6116	0.5346	0.5123	0.6990
	RBH	7	0.0134	0.0132	0.0116	--	0.2207	0.2031	0.1676	0.1743	0.7280	0.6996	0.6512	0.7453
	RBT	8	0.0134	0.0132	0.0116	--	0.2207	0.2031	0.1676	0.1743	0.7280	0.6996	0.6512	0.7453
	SPR	9	0.1084	0.0717	0.0970	--	0.8017	0.6557	0.6586	--	0.9959	0.9844	0.9709	1.0000
	URB	10	0.0606	0.0340	0.0515	--	0.2496	0.1961	0.1757	--	0.7496	0.6680	0.6094	0.8392
	WSH	11	0.0215	0.0154	0.0146	--	0.6265	0.5255	0.5502	--	0.9904	0.9755	0.9708	0.9821
	FRL	12	0.2343	0.1236	0.1466	--	0.4123	0.2962	0.3362	0.2565	0.8956	0.8880	0.8852	0.9670
2013	AKS	1	0.0195	0.0184	0.0279	--	0.2043	0.1893	0.2284	--	0.7864	0.7517	0.8001	0.8448
	BON	2	0.0429	0.0254	0.0242	--	0.7436	0.5348	0.7130	--	0.9855	0.9498	0.9585	--
	CWF	3	0.0991	0.0472	0.0380	--	0.3890	0.2958	0.3467	--	0.8742	0.7986	0.8495	--

Year	Code	No.												
	GSH	4	0.0889	0.0620	0.0759	--	0.4109	0.3798	0.4322	--	0.9444	0.8632	0.9156	1.0000
	LRW	5	0.0116	0.0199	0.0152	--	0.0471	0.0471	0.0408	--	0.4748	0.3805	0.4356	--
	ORC	6	0.0214	0.0193	0.0127	--	0.1063	0.1191	0.1213	--	0.5255	0.5303	0.5636	--
	RBH	7	0.0217	0.0150	0.0125	--	0.2084	0.1888	0.1681	--	0.7357	0.6885	0.6545	0.7940
	RBT	8	0.0217	0.0150	0.0125	--	0.2084	0.1888	0.1681	--	0.7357	0.6885	0.6545	0.7940
	SPR	9	0.0869	0.0710	0.1131	--	0.8401	0.7078	0.6769	--	0.9959	0.9864	0.9733	--
	URB	10	0.0877	0.0438	0.0671	--	0.2128	0.2018	0.1789	--	0.7126	0.6442	0.6139	--
	WSH	11	0.0215	0.0163	0.0295	--	0.6299	0.5446	0.7575	--	0.9892	0.9795	0.9726	--
	FRL	12	0.1252	0.1360	0.1645	--	0.3478	0.3052	0.3789	--	0.9186	0.9070	0.9232	0.9378
2014	AKS	1	0.0282	0.0220	0.0343	--	0.2620	0.2245	0.2878	--	0.8597	0.7811	0.8345	--
	BON	2	0.0342	0.0253	0.0426	--	0.7087	0.5576	0.7537	--	0.9867	0.9520	0.9628	--
	CWF	3	0.0609	0.0494	0.0387	--	0.2704	0.2760	0.3600	--	0.8490	0.8133	0.8758	--
	GSH	4	0.0618	0.0638	0.0789	--	0.4391	0.3993	0.4563	--	0.9128	0.8775	0.9003	--
	LRW	5	0.0116	0.0198	0.0149	--	0.0471	0.0470	0.0402	--	0.4748	0.3799	0.4173	--
	ORC	6	0.0138	0.0174	0.0198	--	0.1831	0.1450	0.2050	--	0.6064	0.5242	0.5612	--
	RBH	7	0.0214	0.0155	0.0216	--	0.1490	0.1821	0.1546	--	0.6914	0.7078	0.6399	--
	RBT	8	0.0214	0.0155	0.0216	--	0.1490	0.1821	0.1546	--	0.6914	0.7078	0.6399	--
	SPR	9	0.1274	0.0886	0.1199	--	0.8217	0.7190	0.7306	--	0.9958	0.9869	0.9746	--
	URB	10	0.0756	0.0483	0.0776	--	0.2401	0.2099	0.2461	--	0.7251	0.6725	0.6884	--
	WSH	11	0.0147	0.0183	0.0347	--	0.6086	0.5734	0.6650	--	0.9927	0.9787	0.9835	--
	FRL	12	0.1165	0.1430	0.1511	--	0.3542	0.3509	0.4945	--	0.9579	0.9163	0.9274	--

Table A.2 The following table provides the name for each Chinook Model stock in the MATAEQ files and the associated CWT indicator stock:

Sequence in MATAEQ file	Model Stock Acronym	Model Stock Name	CWT Indicator Acronym
1	AKS	Alaska Spring	AKS
2	BON	Lower Bonneville Hatchery	LRH
3	CWF	Cowlitz Fall Hatchery	CWF
4	GSH	Lower Georgia Strait Hatchery	BQR
5	LRW	Lewis River Wild	LRW
6	ORC	Oregon Coastal	SRH
7	RBH	WCVI Hatchery	RBT
8	RBT	WCVI Wild	RBT
9	SPR	Spring Creek Hatchery	SPR
10	URB	Columbia River Upriver Bright	URB
11	WSH	Willamette Spring Hatchery	WSH
12	FRL	Fraser Late	CHI*

* Note: The MRs for the Fraser Late aggregate stock, consisting of the Harrison River natural stock and the Chilliwack River Hatchery stock, are calculated external to the MATAEQ program using a method that relies on the observed MRs for CHI CWT indicator stock.

Appendix B. Graphical Presentation of the Time Series of Brood-Specific MRs at Age, the Stock-Specific Cohort-Based Survival Rate for the Youngest Mature Age and the Mean Age of Maturation for the Suite of Individual and Composite Chinook CWT Indicators.

Data used to generate all figures presented in this appendix originated from or were based on results of the annual CWT-based exploitation rate analysis (ERA) carried out by the CTC-AWG in March 2015.

Two side-by-side panels are presented for each CWT indicator stock. The three-letter acronym used for each CWT indicator appears at the top of each panel. The stock name for each indicator and other information such as geographical location is given in a table which follows after the series of graphs. Each panel displays the following time series by brood:

Left panel: This panel shows the rate of maturation on a scale from 0 to 1 for each age with recovery data. The commonly used acronym for the CWT indicator appears above the panel as well as the oldest age with recovery data used in the cohort analysis procedure for the stock. The range and number of ages of maturing fish varies among stocks but the youngest age included in the cohort analysis procedure is 2 and the oldest is 6. The range of ages is typically 3 – 6 for spring stocks and is either 2 - 5 or 2 - 6 for summer and fall stocks. The same line color indicates the same numerical age for every stock (red = 2, blue = 3, green = 4, purple = 5 and grey = 6). The time series for each stock includes all broods for which the analysis was completed. A gap in the time series at all ages in a brood indicates that no CWTs were released. A gap in the time series for the oldest age only indicates that the no CWTs were observed at the oldest age and thus the brood was complete (MR = 1) at the next-to-oldest age. Age-specific estimates for incomplete broods are shown as colored dots. The estimates for incomplete broods were calculated by assuming a MR equal to the average of the five most recently completed broods for the oldest available age of mature fish. All MR values were extracted from the calendar year ('CYR') version of the brood-specific 'OUT' files which are generated as a standard output by the cohort analysis program.

Right panel: Two time series are displayed in the right panel. One time series is the mean age of maturation (indicated by the line in a lighter blue color) and it is associated with the left-hand Y-axis scale ranging from 2 – 6 years. The second is the cohort-based survival rate for tagged smolts to the first age vulnerable in fisheries (indicated by the line in a darker blue color) and it is associated with the right-hand Y-axis scale. The youngest age is 2 for summer and fall stocks and age 3 for most spring stocks, though 2 in a few cases. This survival rate, expressed as a percentage out of 100, is a statistic automatically produced by the cohort analysis procedure used by the CTC-AWG in the analysis of CWT recoveries and it was extracted from the stock-specific 'SVRC.csv' output file.

The mean age of maturation, equivalent to generation time in semelparous species (Wootton and Smith 2015), is a brood-specific composite value in years which incorporates the rate of maturation across all ages included in the cohort analysis. It can be calculated using the following two approaches:

1) Mean Age of Maturation (with fishing effects) $= \frac{\left(\prod_{a=min}^{a=max}(a * Esc_{BY,a})\right)}{TotEsc_{BY}}$

Where a = age, with possible values ranging from 2 - 6 depending on the stock, $Esc_{BY,a}$ = estimated CWT escapement at age for a brood year, and $TotEsc_{BY}$ = total escapement for the brood. Values will lie between the observed minimum and maximum ages with mature fish for a given stock.

This formulation uses the estimated CWT escapement as determined from the CWT sampling programs and population estimation method employed for each CWT indicator stock. It also reflects size- (and therefore, age-) selective effects of pre-terminal and terminal fisheries which influence the population 'escaping' to spawning locations. These effects are likely to have stock, age and calendar year dependencies due to the particular set of fisheries impacting a stock and the magnitude and regulations characterizing each fishery in a given year. A second formulation of the mean age of maturation metric was developed to remove the potential influence of fishing effects on the mean age of maturation. It was used in the figures presented in this appendix.

2) Mean Age of Maturation (fishing effects removed) $= \frac{\left(\prod_{a=min}^{a=max}(a * EscNF_{BY,a})\right)}{TotEscNF_{BY}}$

Where a = age with possible values from 2 - 6 depending on the stock. The total brood escapement with fishing effect removed, $TotEscNF_{BY}$, is obtained in an analogous fashion to the total of the conventional estimated CWT escapement for a brood:

$$TotEscNF_{BY} = \left(\sum_{a=min}^{a=max} EscNF_{BY,a}\right)$$

The escapement at age with fishing effects removed, starting with the youngest and proceeding to the oldest in sequence, $EscNF_a$, is obtained with the following set of equations:

1) $EscNF_{a1} = (CohANM_{a1} * MR_{a1})$

2) $EscNF_{a2} = \left((CohANM_{a1} * MR_{a1}) * SR_{a2}\right) * MR_{a2}$

3) $EscNF_{a3} = \left(\left(\left((CohANM_{a1} * MR_{a1}) * SR_{a2}\right) - EscNF_{a2}\right) * SR_{a3}\right) * MR_{a3}$

4) $EscNF_{a4} = \left(\left(\left(\left((CohANM_{a1} * MR_{a1}) * SR_{a2}\right) - EscNF_{a2}\right) * SR_{a3}\right) - EscNF_{a3}\right) * SR_4\right) * MR_{a4}$

5) $EscNF_{a5} = \left(\left(\left(\left(\left((CohANM_{a1} * MR_{a1}) * SR_{a2}\right) - EscNF_{a2}\right) * SR_{a3}\right) - EscNF_{a3}\right) * SR_4\right) - EscNF_4\right) * SR_5\right) * MR_{a5}$

Terms in the above equations are brood-specific. Values are obtained from the cohort analysis procedure used by the CTC-AWG to conduct the annual ERA, and they are defined as follows:

$CohANM_{a1}$ = cohort size, after over-wintering natural mortality has occurred, for the youngest age of maturing fish for a stock (and brood)

MR_{a1} to MR_{a5} = MR at age, from the youngest to oldest age, for a stock (and brood)

SR_{a2} to SR_{a5} = survival rate at age, from the second youngest to oldest age

The age subscript (*a*) of 1 - 5 refers to the five (though typically four) possible ages of maturation starting with the youngest (*a1*) to the oldest (*a4* or *a5*, depending on the stock). For fall and summer stocks the span of actual ages is 2 – 5 (*a1* - *a4*), though there are a few cases of 2 – 6 (*a1* - *a5*). For these stocks the second actual age is 3. For spring stocks, the span of actual ages is 3 - 6 and for this adult life history pattern, the second actual age is 4.

The survival rates (*SR*) are age-specific constants employed by the CTC in the cohort analysis procedure and expressed as proportions. They are 0.7, 0.8 and 0.9 for the second through fourth ages of maturation. For stocks with an additional fifth age, 0.9 is also used.

The mean age of MR metric is an integration of the age-specific MRs which can change in opposite direction from one brood to the next. The overall effect of these changes at age within a brood can be difficult to determine and the mean age of maturation metric captures the overall effect in a single value. It's useful for revealing trends in the maturation pattern across successive broods. A pattern of an increase in the MRs at age across broods (i.e., an increaing proportion of fish are maturing at younger ages) will tend to correpond with a declining trend in the mean age of maturation, and vice versa.

Trends exist in the age-specific MRs for a number of the CWT indicator stocks (e.g., QUI, GAD, LYY and SPS), including some of the CWT indicators which contribute MR data for Model stocks in the calibration of the Chinook Model (e.g., AKS, BQR, SPR and WSH). The most common pattern is a trend toward increaing rate of maturation and an overall effect of earlier maturation schedule is supported by a corresponding declining trend in the mean age of maturation. As an indication of a directional tendency, the slope of a line of simple linear regression was obtained from the complete data set for each CWT indicator associated to a Chinook Model stock with the following results:

CWT Indicator	Model Stock	Slope from Linear Regression
BQR	GSH	-0.0099
RBT	RBT, RBH	+0.0006
CHI	FRL	-0.0230
HAR	FRL	-0.0170
AKS	AKS	-0.0080
CWF	CWF	-0.0140
LRW	LRW	+0.0200
LRH	BON	-0.0094
SRH	ORC	-0.0076
SPR	SPR	-0.0089
URB	URB	-0.0047
WSH	WSH	-0.0060

This review across stocks indicates that a pattern of increasing rates at one or more ages and a declining trend in the mean age of maturation has occurred in all regions. The direction of trend in mean age of maturation was downward for all but two of the stocks (RBT and LRW). It has also occurred in stocks considered predominantly natural (e.g., transboundary stocks STI and TAK and the northern BC stock KLM) as well as those considered dominated by releases of hatchery-origin Chinook salmon (e.g., BQR and LRH).

WSH   Oldest Age=6

WSH

- Complete Brood Years
- Incomplete Brood Years

- Age 2
- Age 3
- Age 4
- Age 5
- Age 6
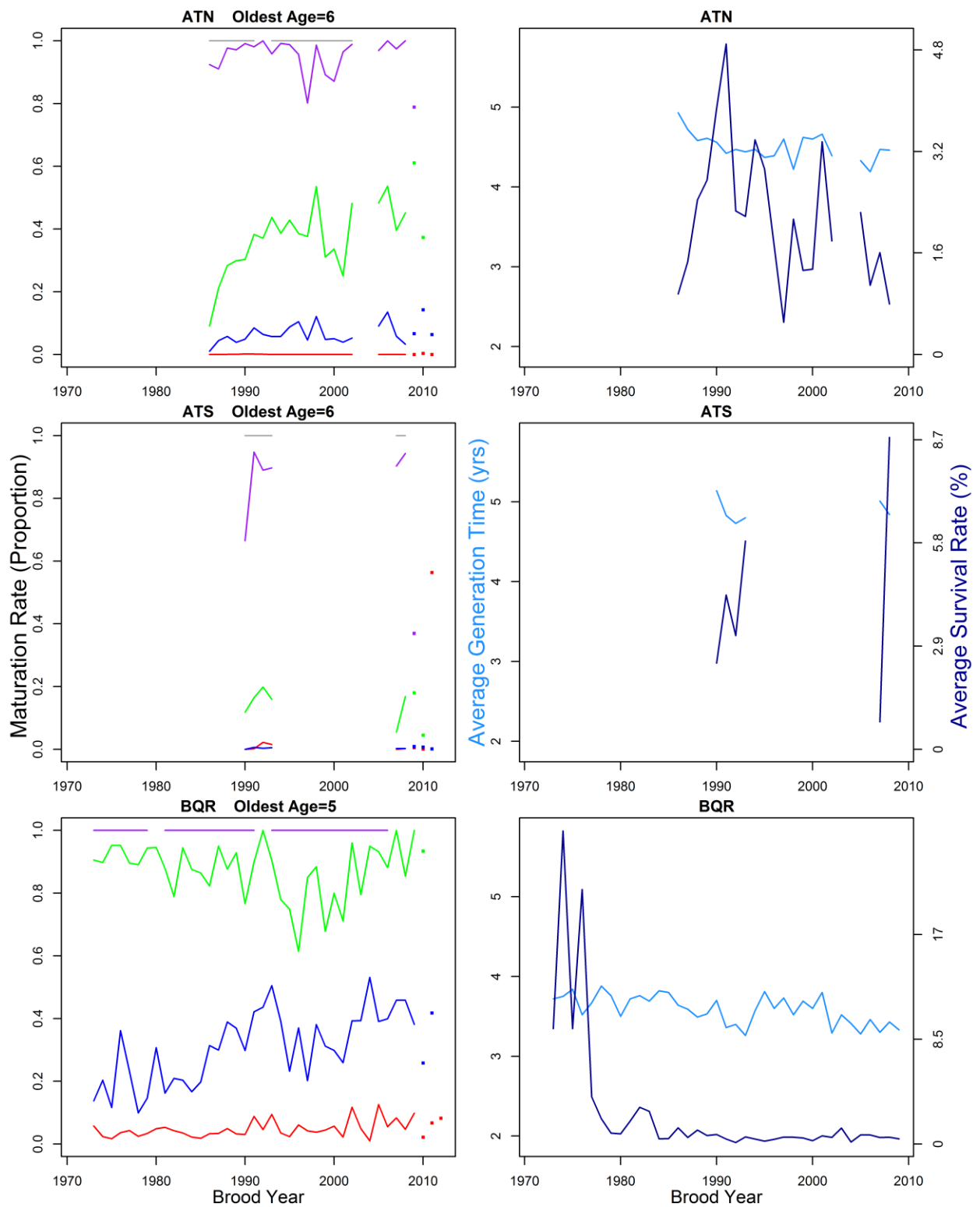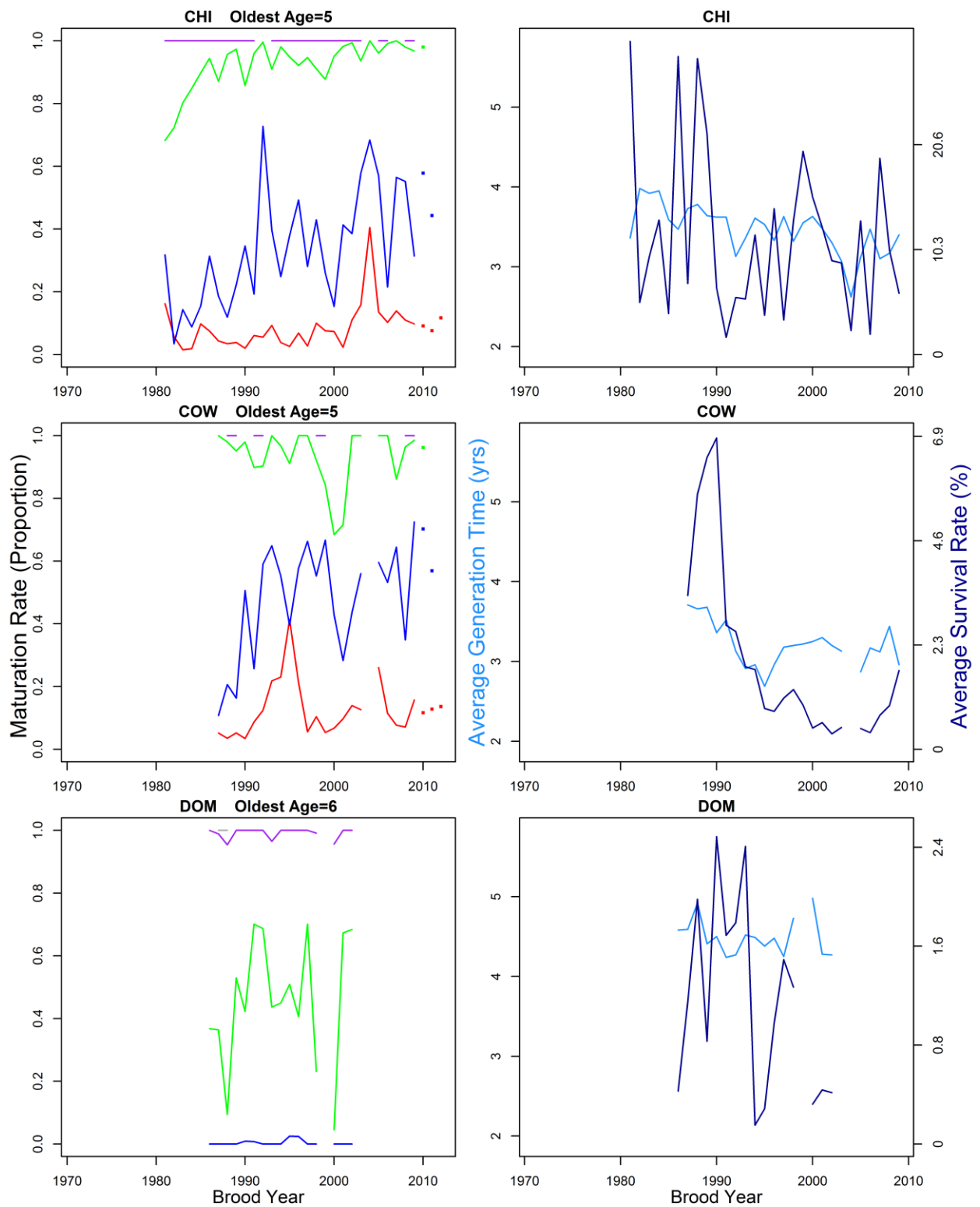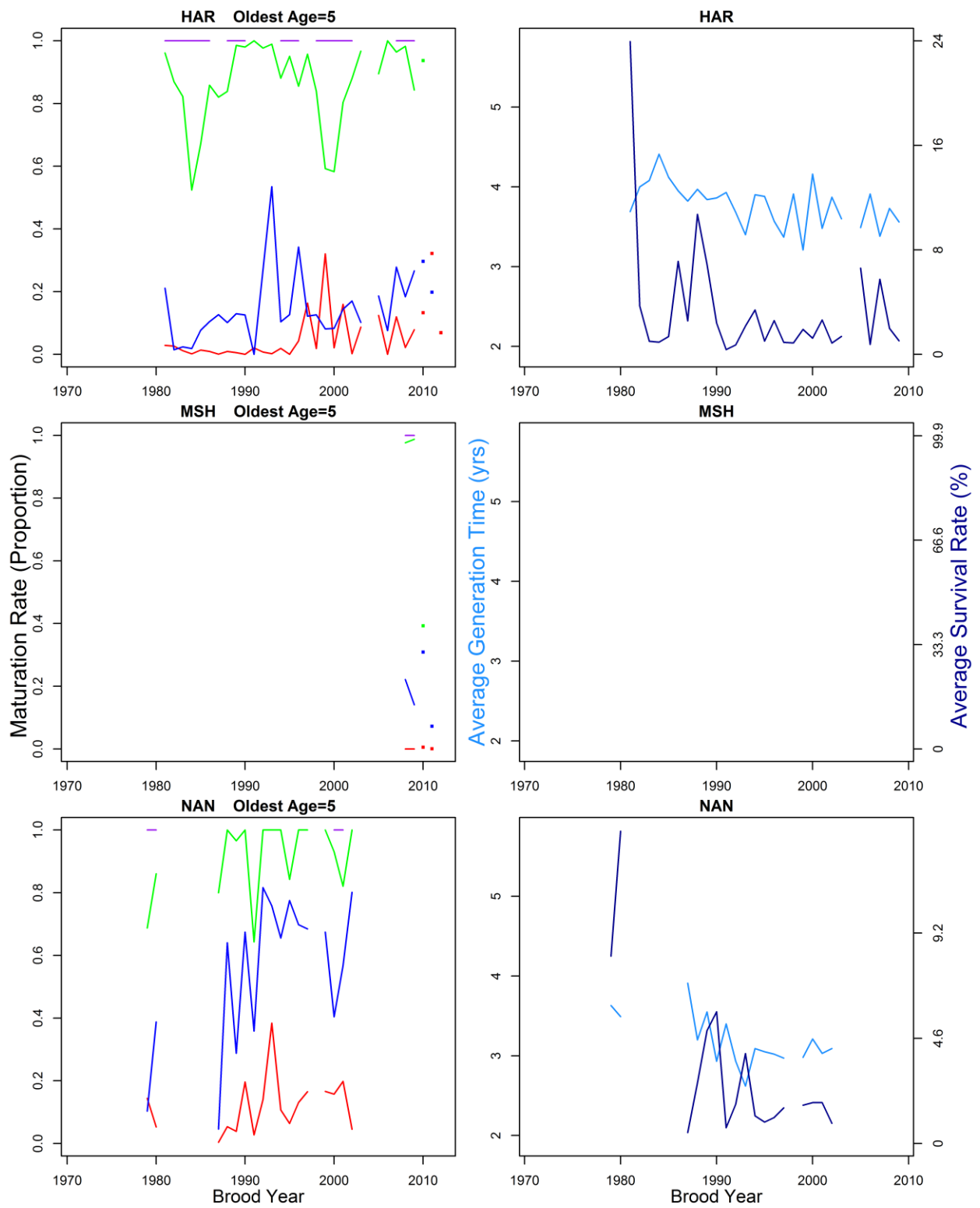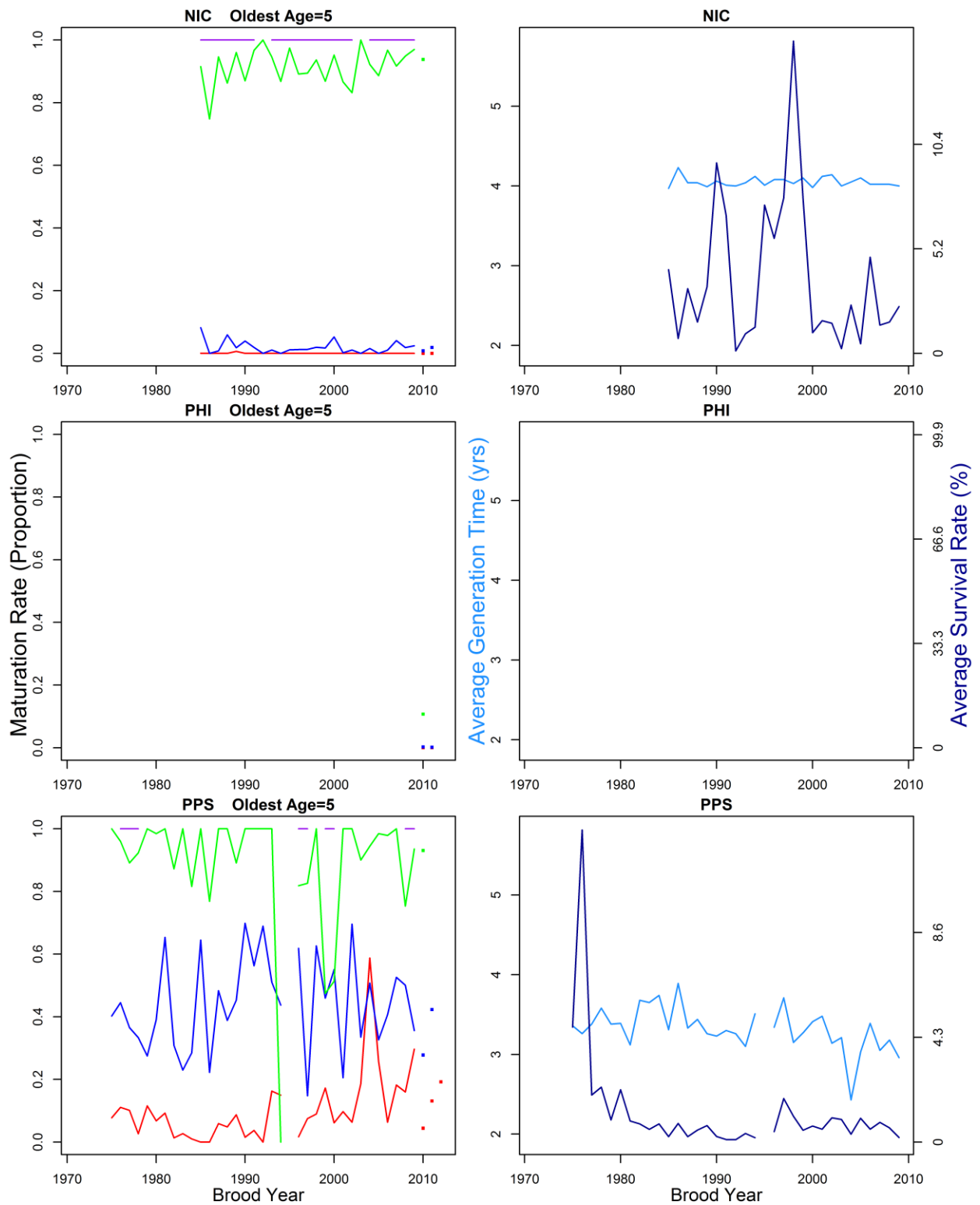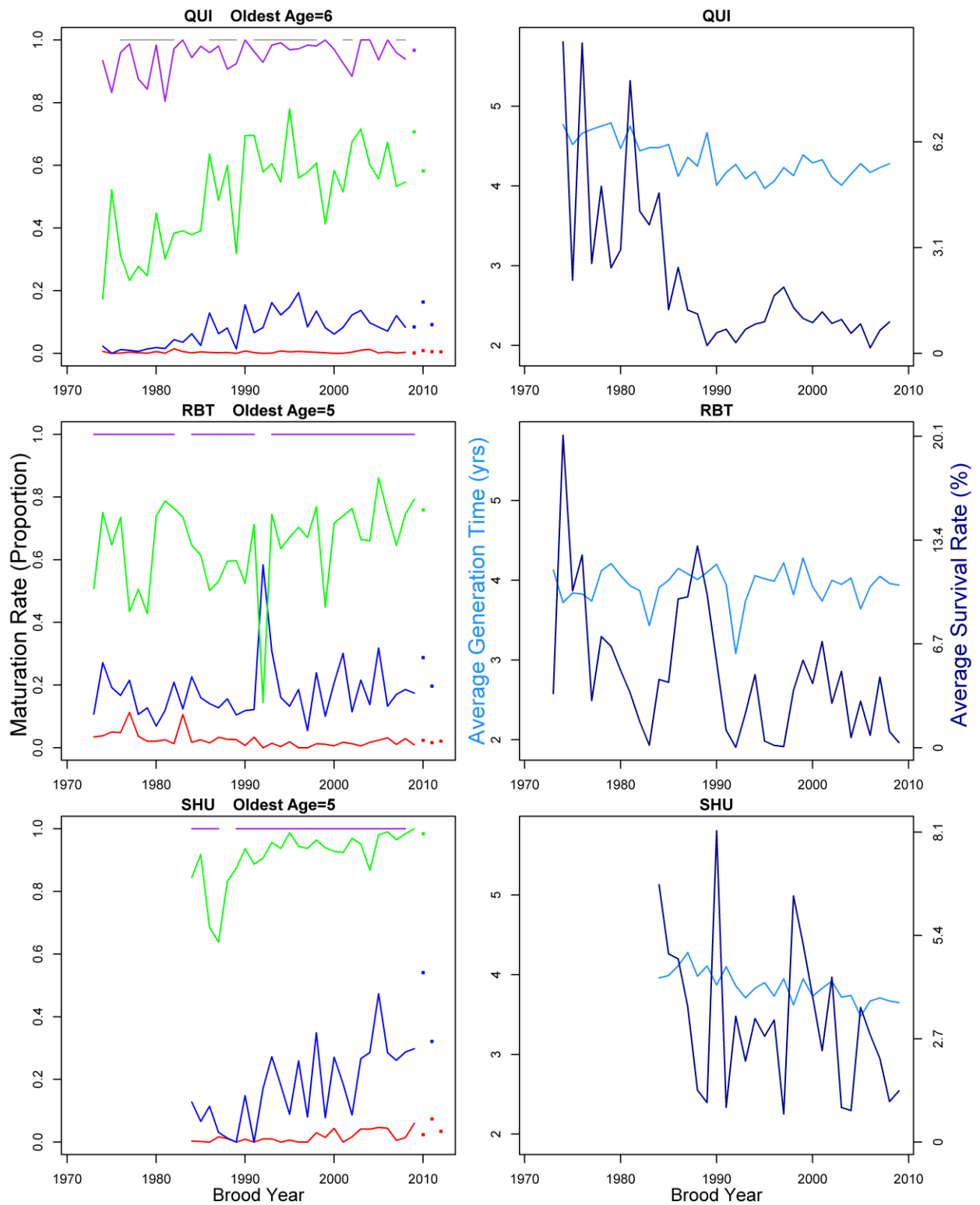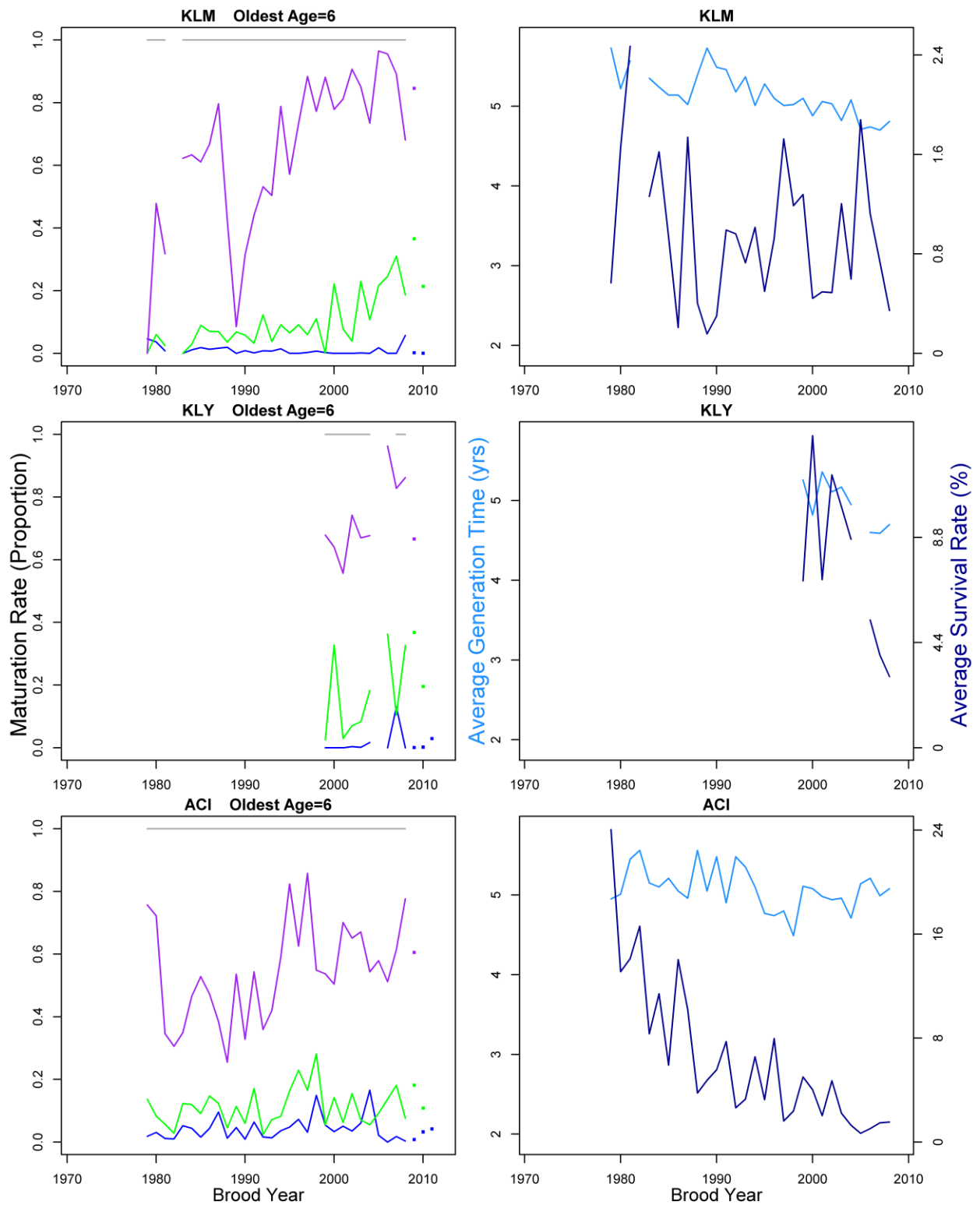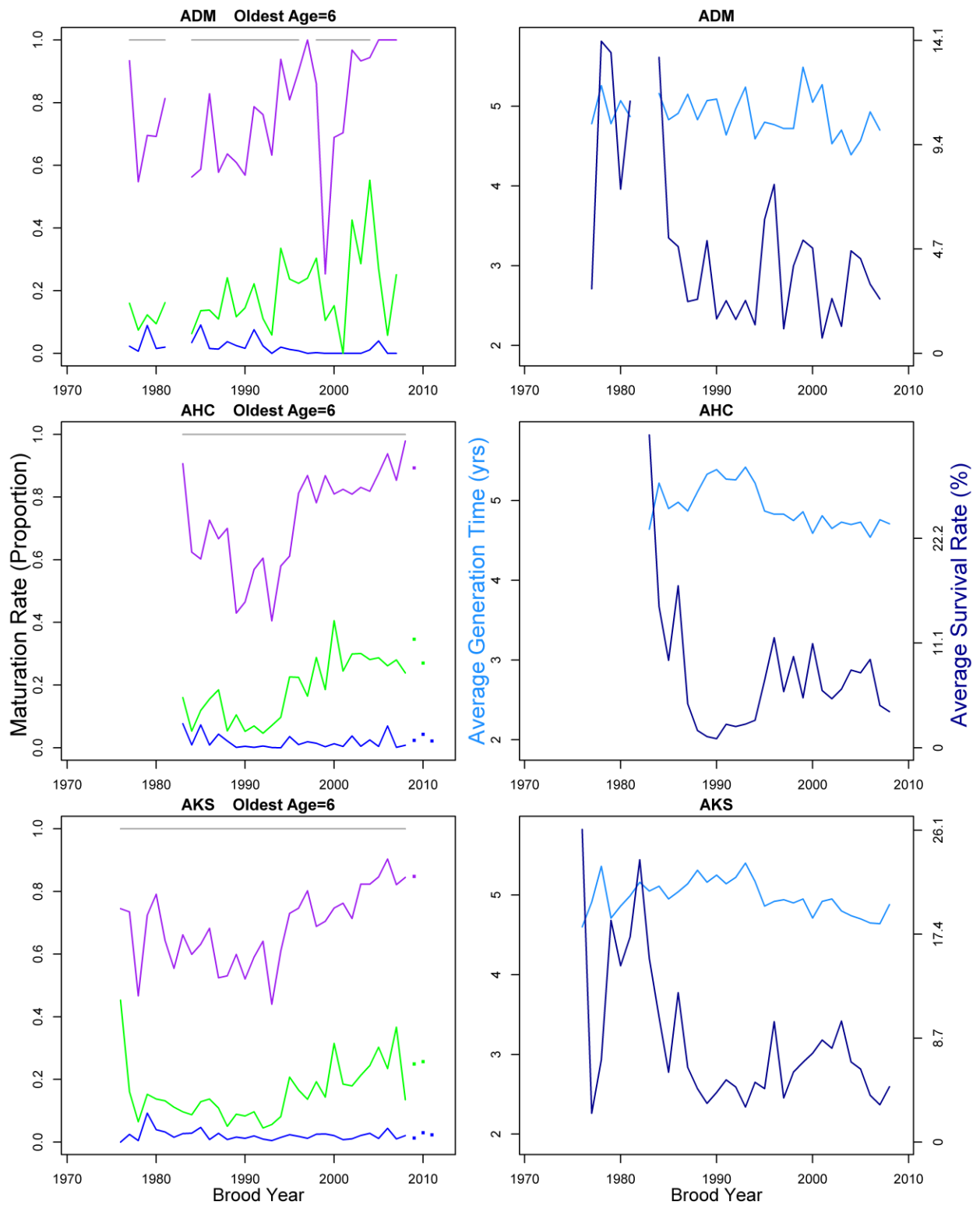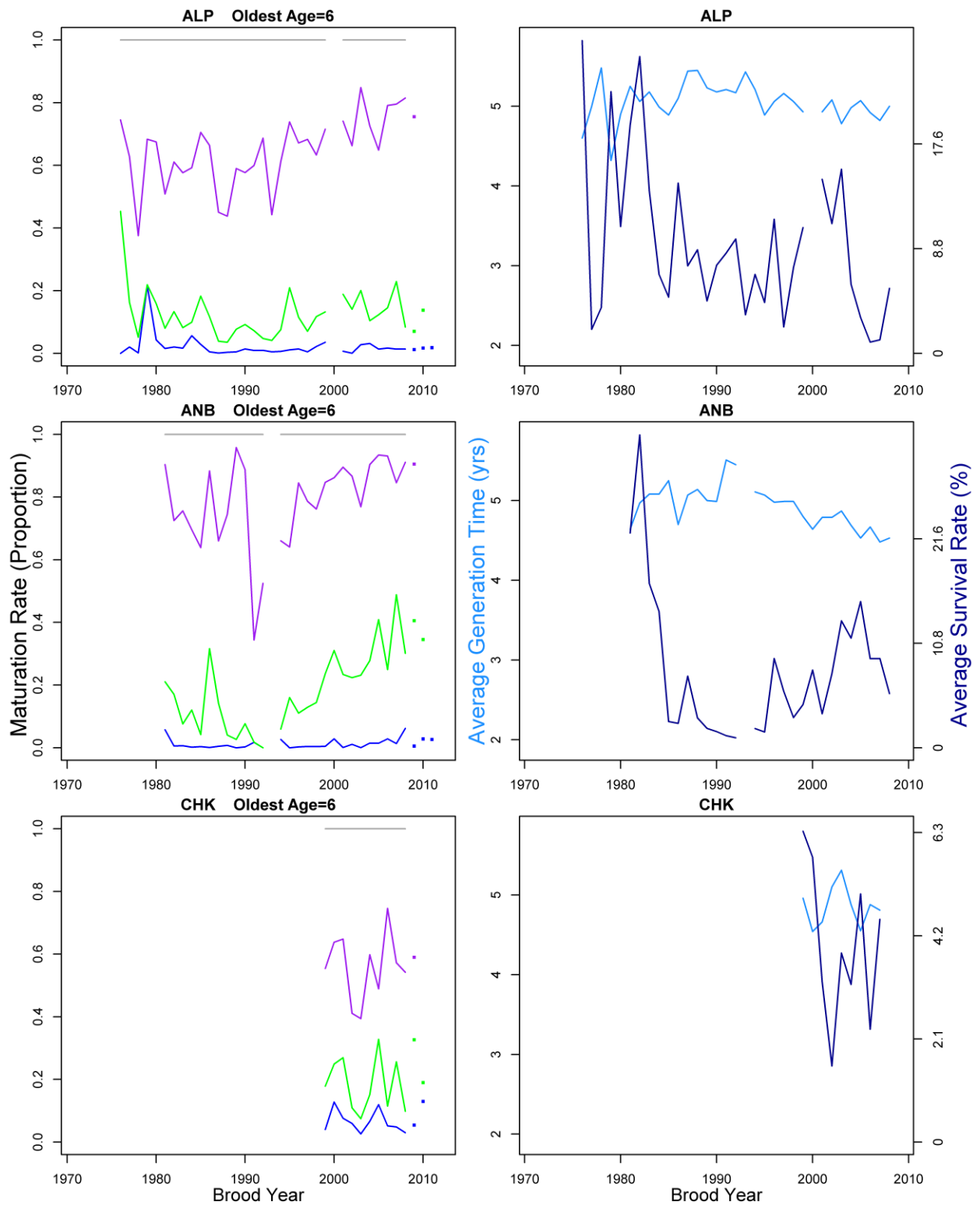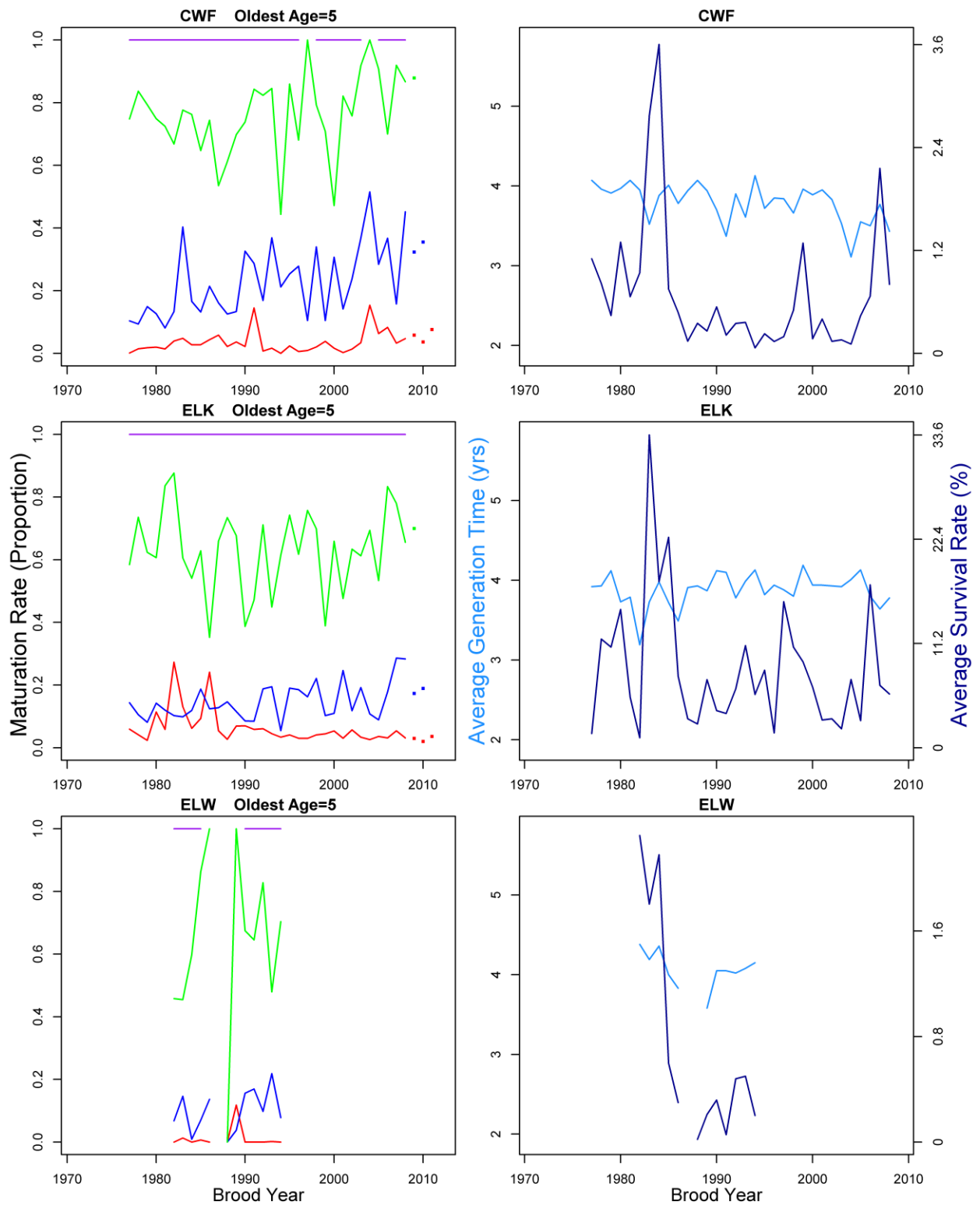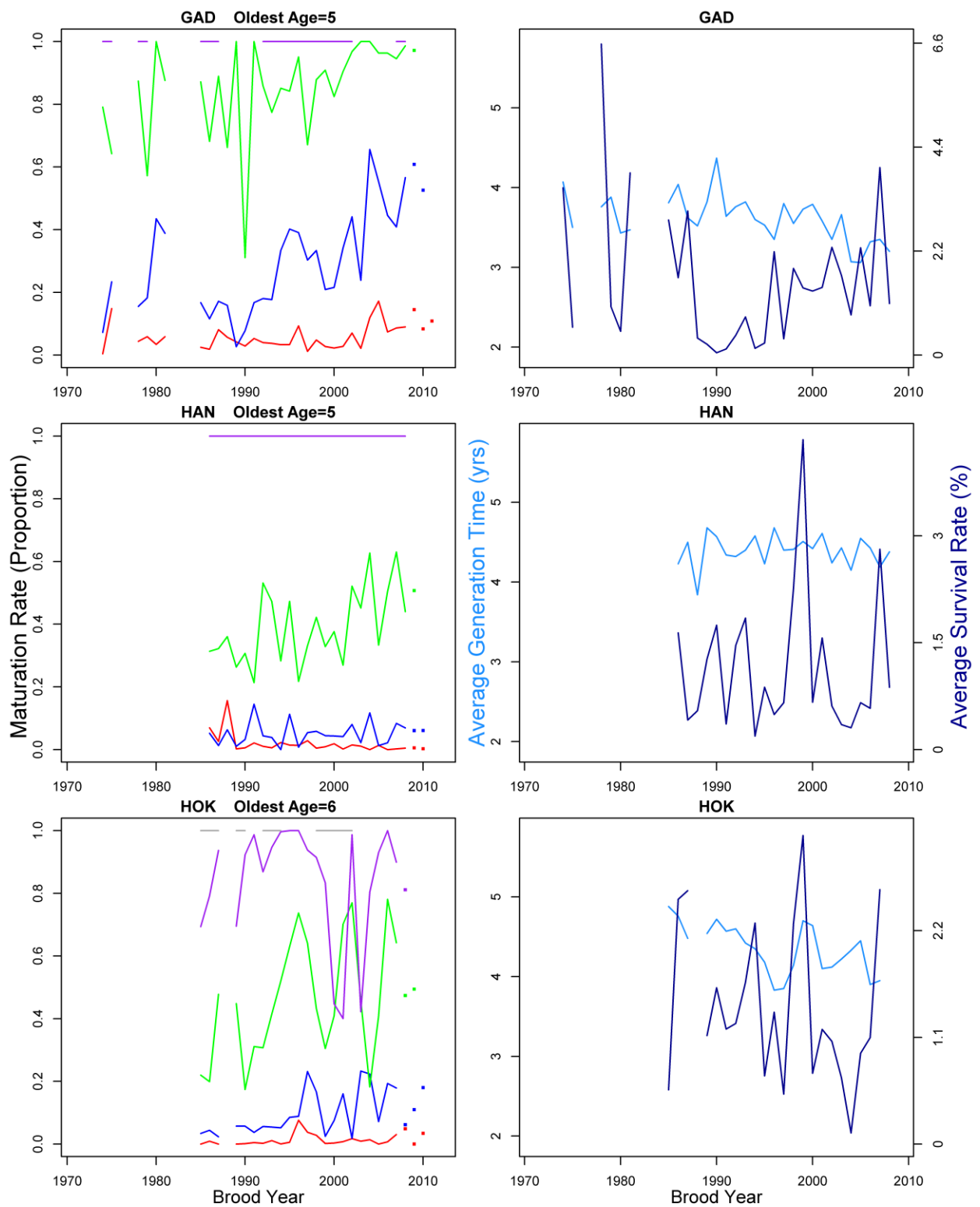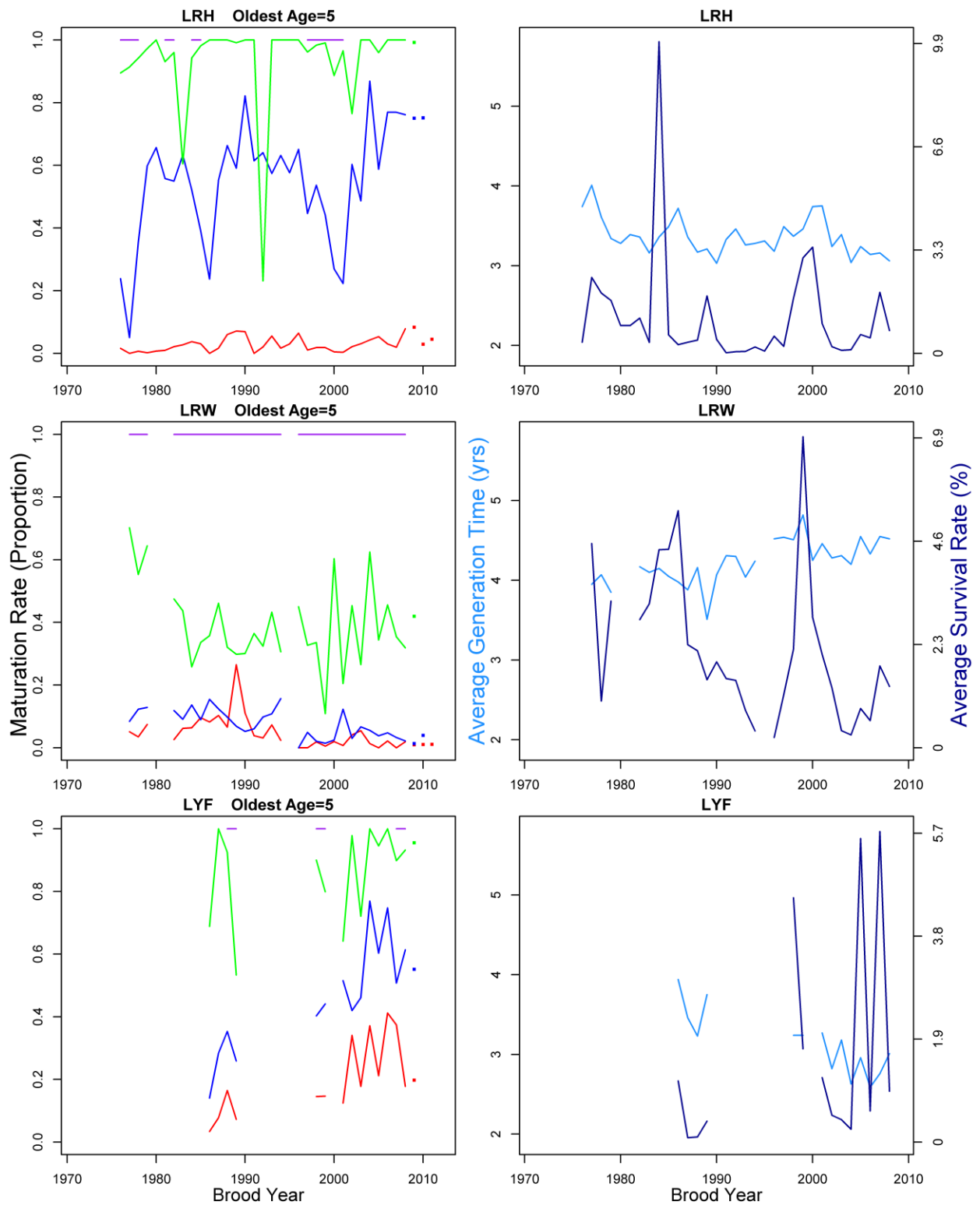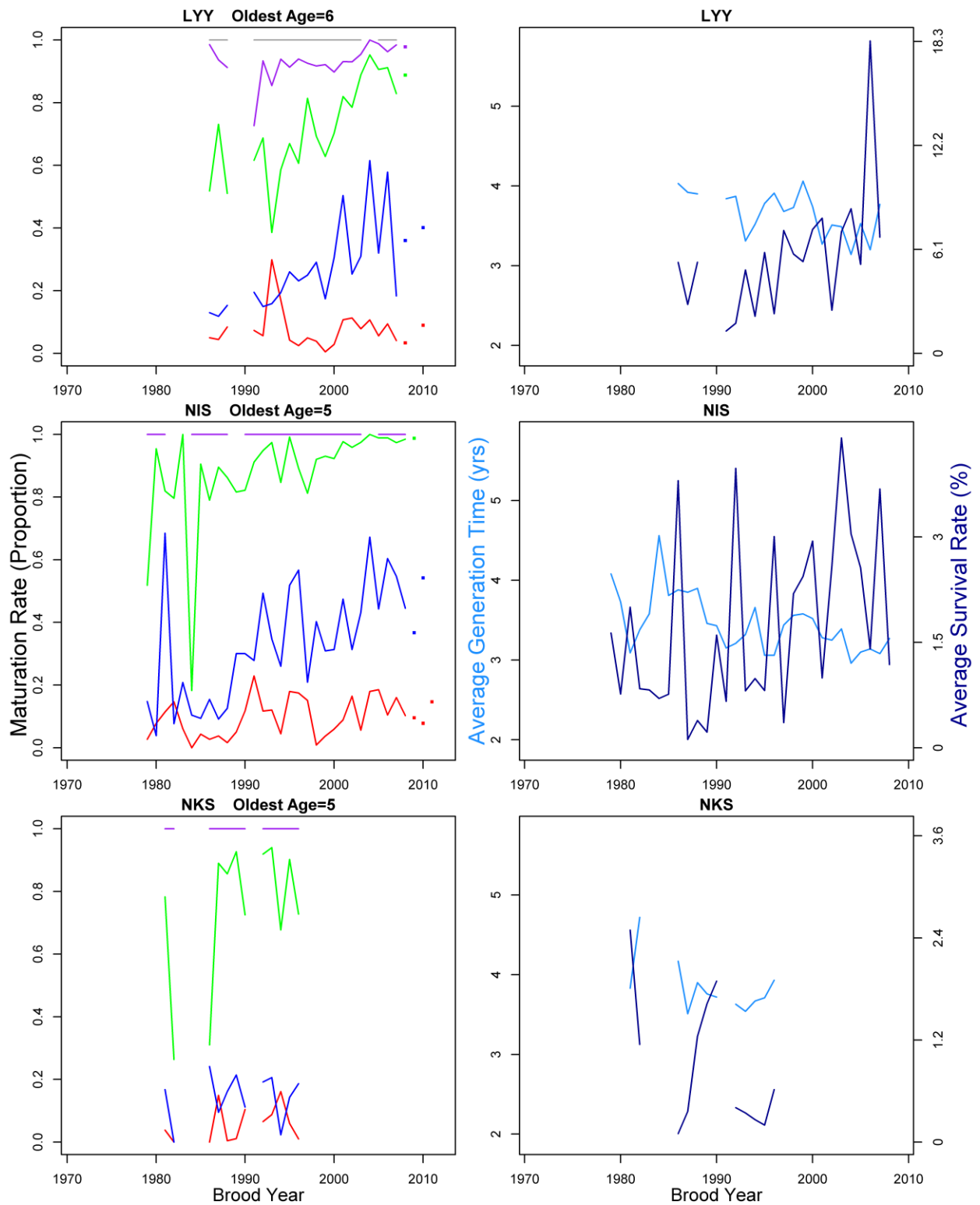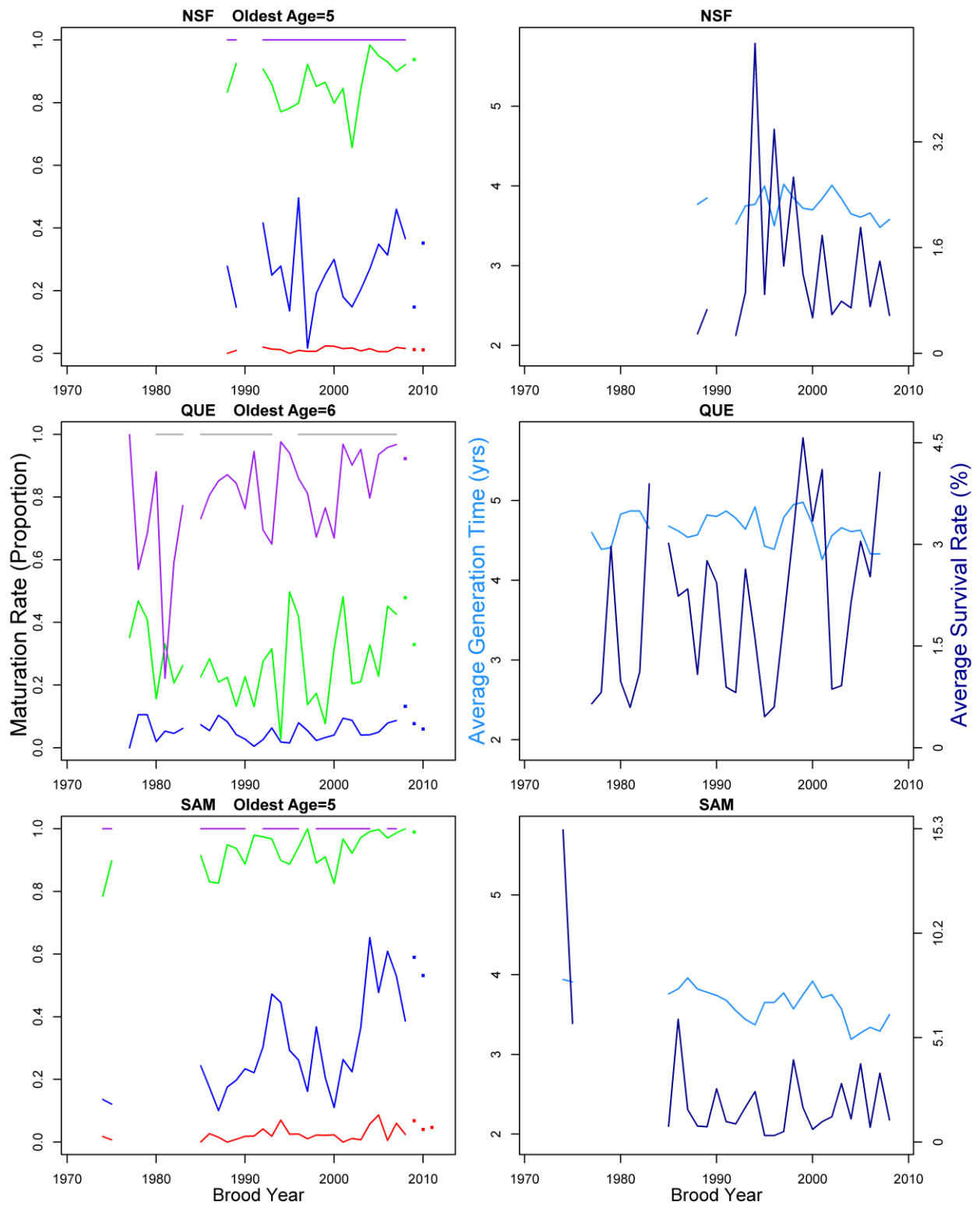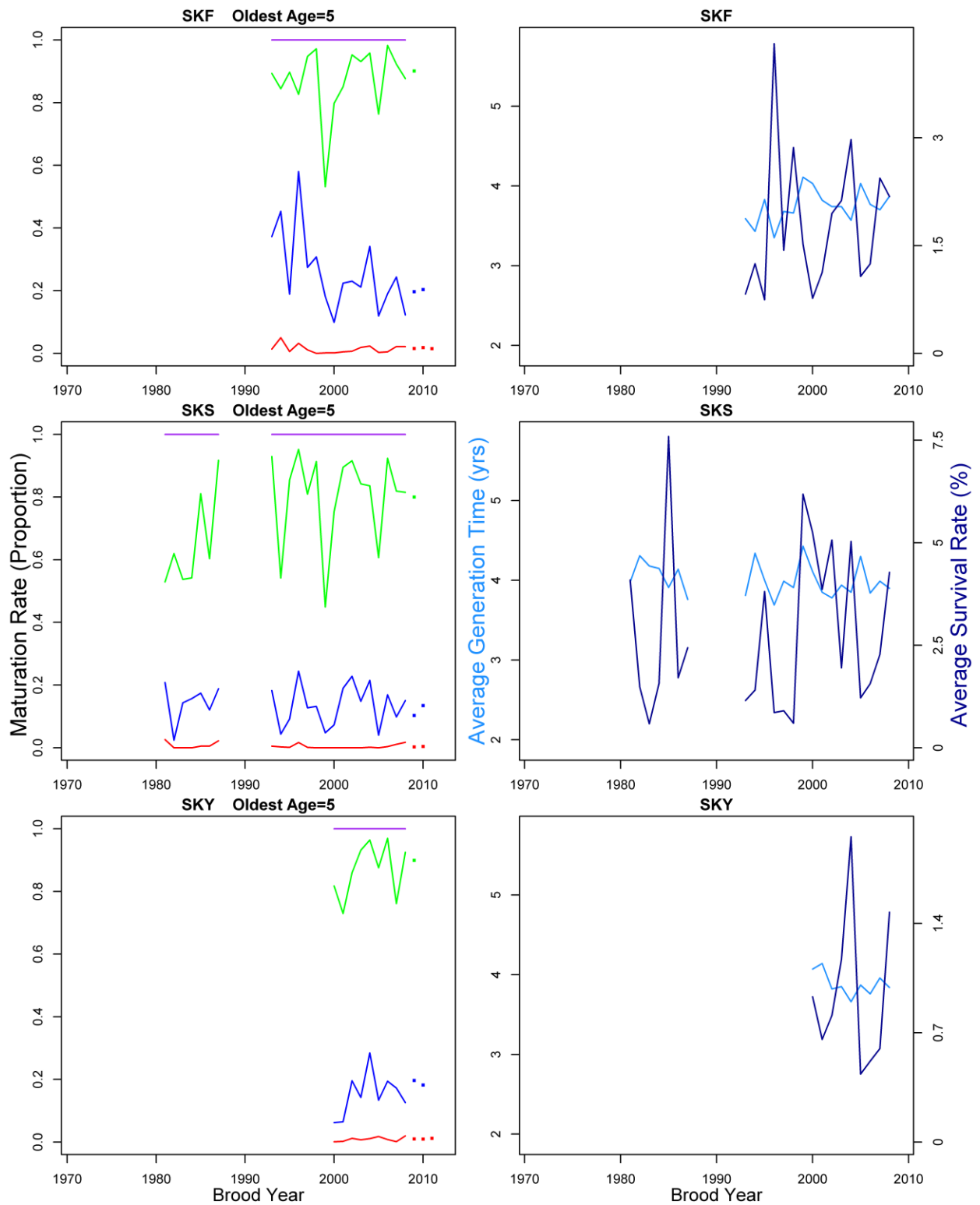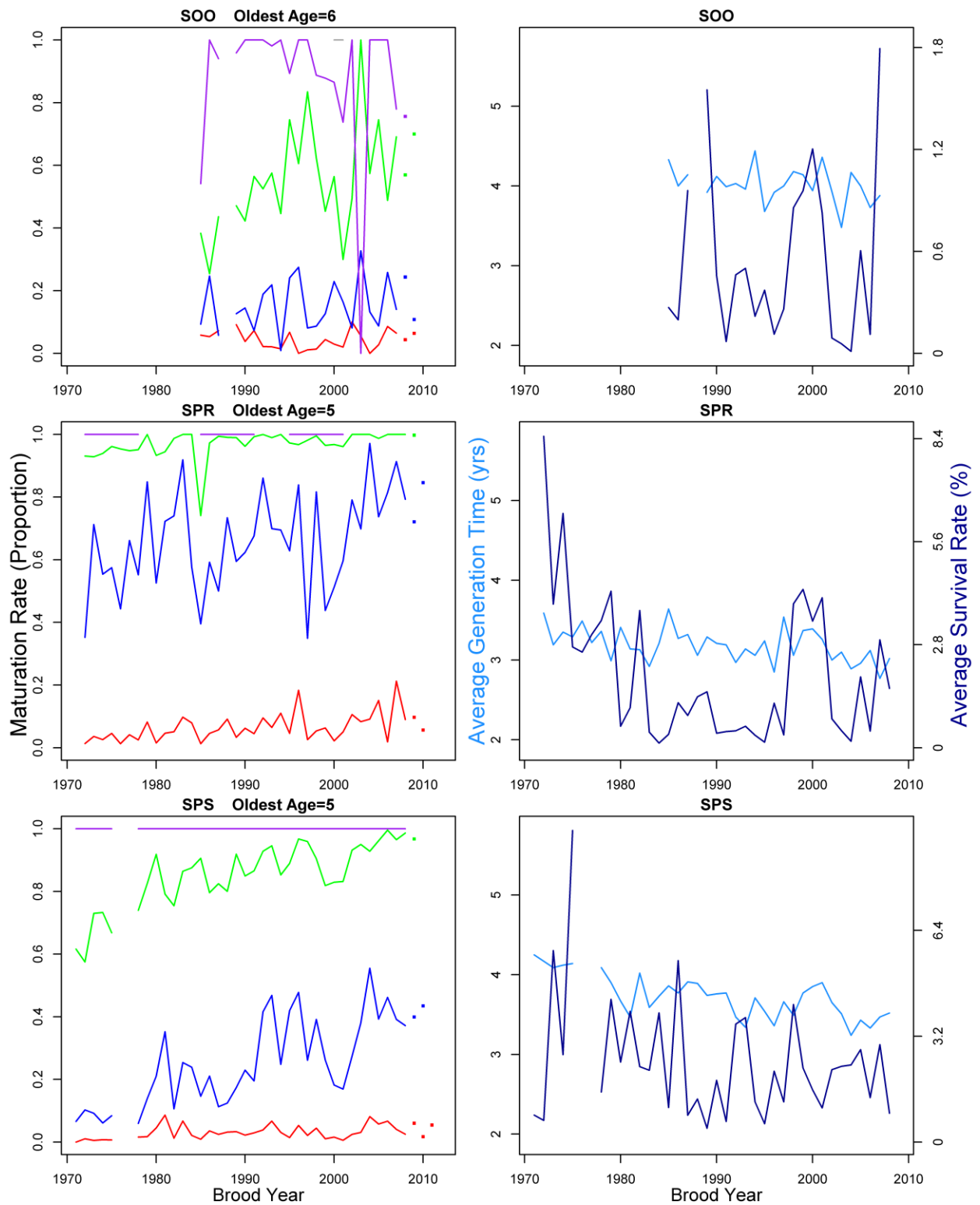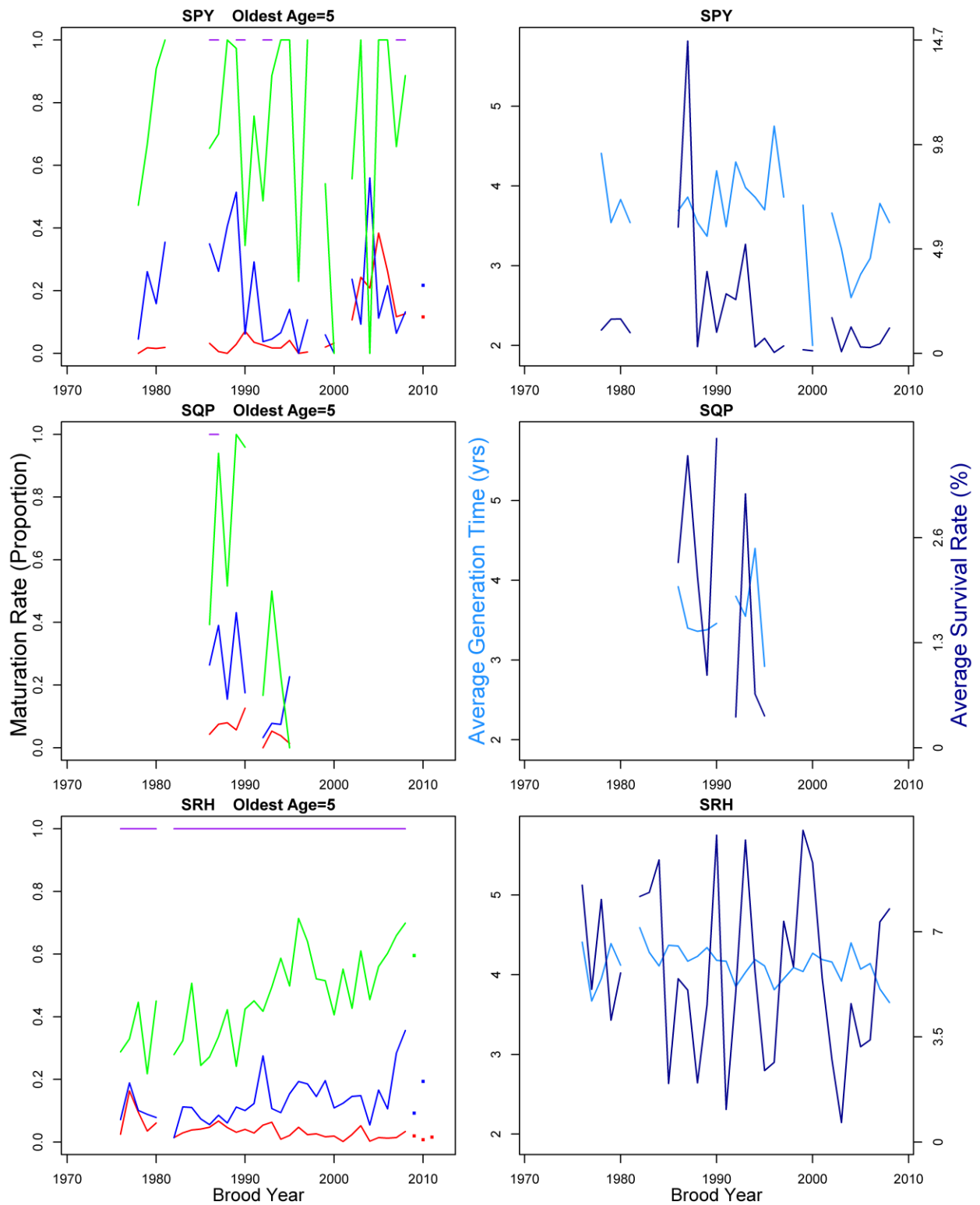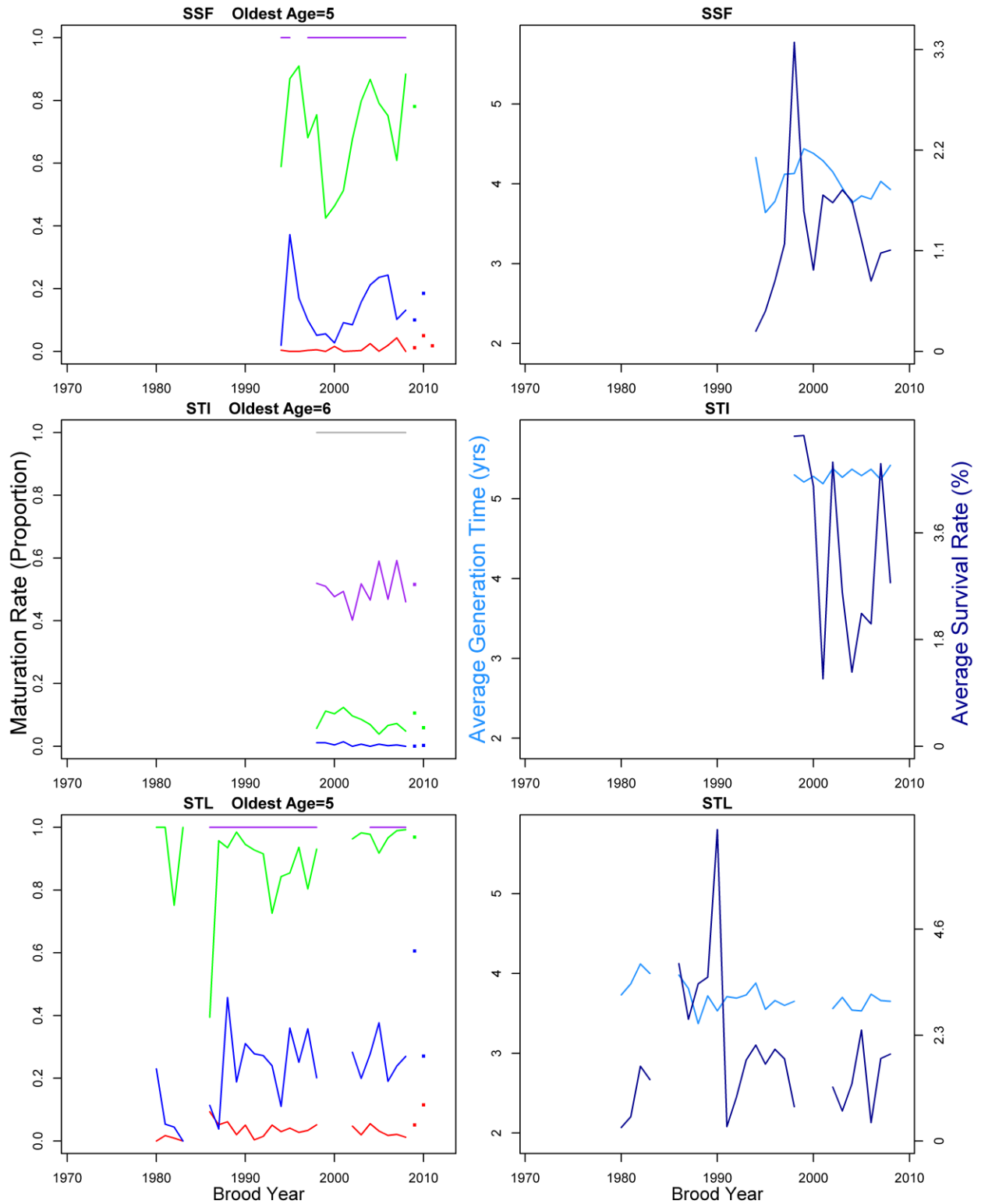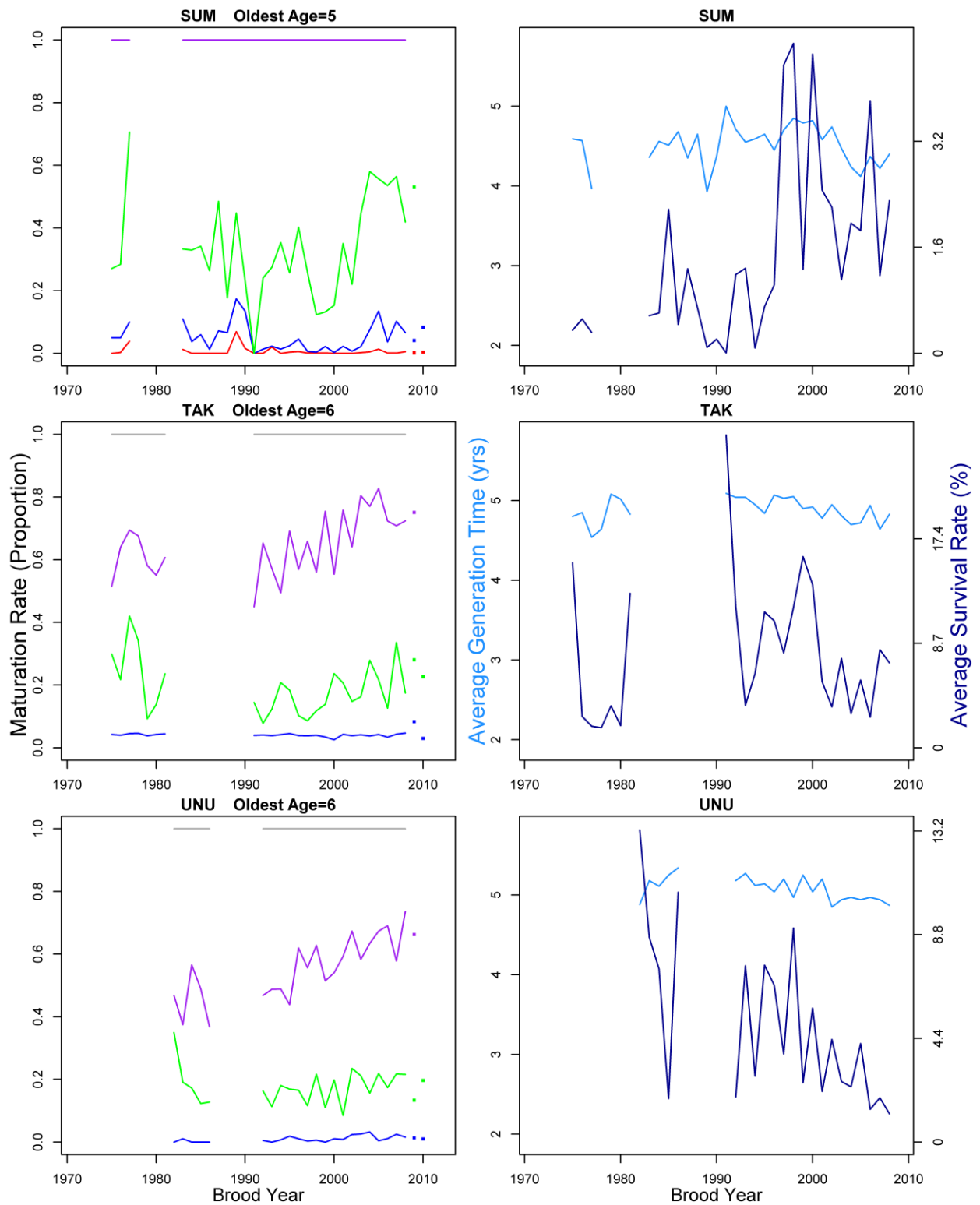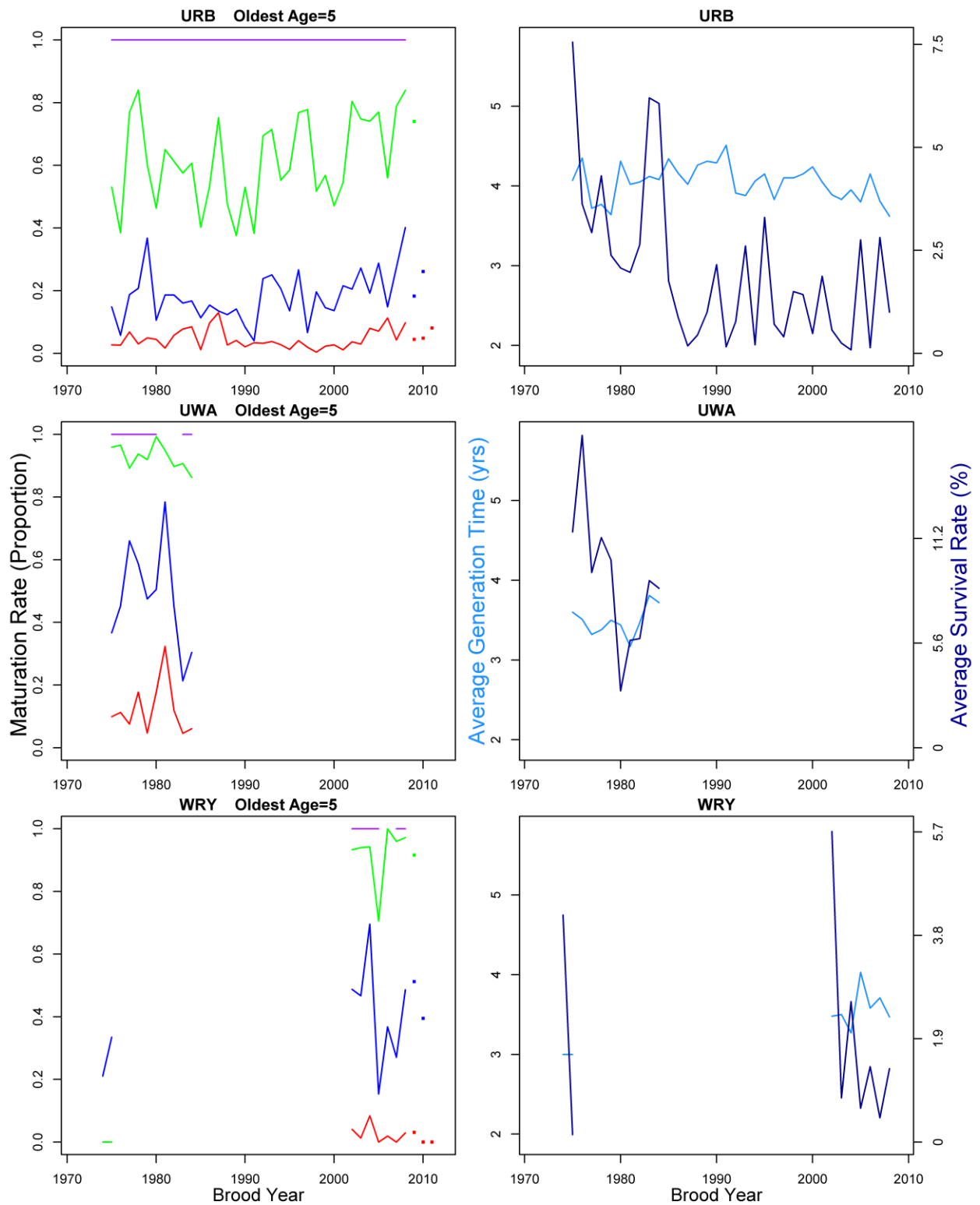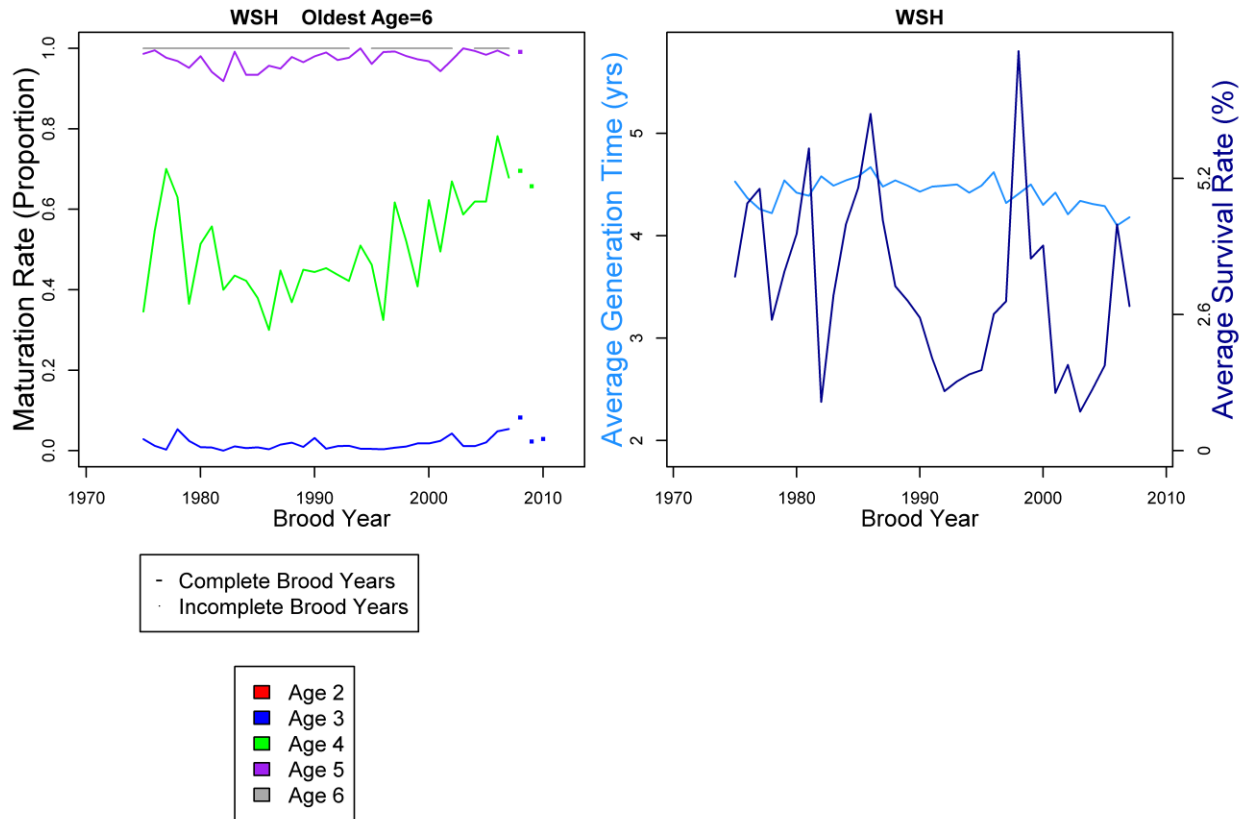
Table B.1. The table below provides a stock name and other information for each CWT indicator stock identified using its three-letter acronym in the graphs above. The stock acronym is highlighted in bold type for those stocks which currently annually provide MR data for Chinook Model stocks included in the MATAEQ file.

CWT Indicator	Stock Name	Jurisdiction	Region	First Age	Final Age
ACI	Alaska Central Inside	AK	SEAK	3	6
ADM	Alaska Deer Mountain	AK	SEAK	3	6
AHC	Alaska Herring Cove	AK	SEAK	3	6
AKS	Alaska Spring	AK	SEAK	3	6
ALP	Little Port Walter	AK	SEAK	3	6
ANB	Alaska Neets Bay	AK	SEAK	3	6
ATN	Atnarko River Summer	BC	CBC	2	6
ATS	Atnarko River Spring	BC	CBC	2	6
BQR	Big Qualicum River Fall	BC	ECVI	2	5
CHI	Chilliwack River Fall	BC	LFR	2	5
CHK	Chilkat Spring	AK	SEAK	3	6
COW	Cowichan River Fall	BC	ECVI	2	5
CWF	Cowlitz Fall Tule	CR	LCOLR	2	5
DOM	Dome Creek Spring	BC	UFR	3	6
ELK	Elk River	OR	ORCST	2	5
ELW	Elwha Fall Fingerling	WA	JFUCA	2	5
GAD	George Adams Fall Fingerling	WA	HOODC	2	5
HAN	Hanford Wild	CR	UCOLR	2	5
HAR	Harrison River Fall	BC	LFR	2	5
HOK	Hoko Fall Fingerling	WA	JFUCA	2	6
KLM	Kitsumkalum River Summer	BC	NBC	3	6
KLY	Kitsumkalum River Yearling	BC	NBC	3	6
LRH	Columbia Lower River Hatchery	CR	LCOLR	2	5
LRW	Lewis River Wild	CR	LCOLR	2	5
LYF	Lyons Ferry	CR	UCOLR	2	5
LYY	Lyons Ferry Yearling	CR	UCOLR	3	6
NAN	Nanaimo River Fall	BC	ECVI	2	5
NIC	Nicola River Spring	BC	MFR	2	5
NIS	Nisqually Fall Fingerling	WA	SPGSD	2	5
NKS	Nooksack Spring Yearling	WA	NPGSD	2	5
NSF	Nooksack Spring Fingerling	WA	NPGSD	2	5
PPS	Puntledge River Summer	BC	ECVI	2	5
QUE	Queets Fall Fingerling	WA	WACST	2	6
QUI	Quinsam River Fall	BC	ECVI	2	6
RBT	Robertson Creek Fall	BC	WCVI	2	5
SAM	Samish Fall Fingerling	WA	NPGSD	2	5
SHU	Lower Shuswap River Summer	BC	MFR	2	5
SKF	Skagit Spring Fingerling	WA	NPGSD	2	5
SKS	Skagit Spring Yearling	WA	NPGSD	2	5
SKY	Skykomish Fall Fingerling	WA	NPGSD	2	5

SOO	Sooes Fall Fingerling	WA	WACST	2	6
SPR	Spring Creek Tule	CR	MCOLR	2	5
SPS	South Puget Sound Fall Fingerling	WA	SPGSD	2	5
SPY	South Puget Sound Fall Yearling	WA	SPGSD	2	5
SQP	Squaxin Pens Fall Yearling	WA	SPGSD	2	5
SRH	Salmon River	OR	ORCST	2	6
SSF	Skagit Summer Fingerling	WA	NPGSD	2	5
STI	Stikine Spring	TBR	TBR	3	6
STL	Stillaguamish Summer Fingerling	WA	NPGSD	2	5
SUM	Columbia Summers	CR	UCOLR	2	5
TAK	Taku Spring	TBR	TBR	3	6
UNU	Unuk Spring	SEAK	SEAK	3	6
URB	Upriver Brights	CR	UCOLR	2	5
UWA	University of Washington Accelerated	WA	SPGSD	2	5
WRY	White River Spring Yearling	WA	SPGSD	2	5
WSH	Willamette Spring	CR	LCOLR	3	6

Appendix C. Description of the MATAEQ Program

In order to produce the MATAEQ file that contains the yearly MR values for the twelve stocks with adequate CWT information and the MR averages computed from these values, a Microsoft VB.NET program (MATAEQVB_xxx.EXE) is used to extract the MR and Adult Equivalent (AEQ) values from the ERA output (OUT) files of the twelve stocks. The VB.NET program also reads the base period MR and AEQ values from the STK file (containing base period stock and age specific cohort sizes, MRs, AEQs, and exploitation rates by fishery) of the Chinook Model. The VB.NET program then calculates the average MR and AEQ values to be used for the years being projected.

Occasionally, MR and AEQ values are missing for certain stocks and broods due to lack of CWT releases and/or recoveries for those broods. In addition, some broods have CWT data but due to inadequate CWT recoveries the MR and AEQ values cannot be reliably estimated. Typically these values are readily detected as outliers relative to MRs calculated by the cohort analysis procedure. In these situations where the CWT recovery data are inadequate, the MR and AEQ values that are read from the OUT files are excluded and treated as though they were missing. The stocks and broods where the MR and AEQ values exist but are set to missing are identified in the table below:

Table C.1. The stocks and broods where the MR and AEQ values exist but are set to missing.

Model Stock	Acronym	ERA Indicator	Excluded Broods[1]
Alaska Spring	AKS	AKS	1976
Lower Bonneville Hatchery	BON	LRH	1977, 1980, 1983, 1986, 1988, 1990-1994, 1996
Cowlitz Fall Hatchery	CWF	CWF	1994, 1997
Lower Georgia Strait Hatchery	GSH	BQR	1992
Lewis River Wild	LRW	LRW	1996, 1997
Oregon Coastal	ORC	SRH	1976
WCVI Hatchery	RBH	RBH	1992, 1997
WCVI Wild	RBT	RBH	1992, 1997
Willamette Spring Hatchery	WSH	WSH	1982, 1994

[1] Excluded broods experienced such poor survival that CWT recoveries were so few that MRs were nonsensical, and the long-term average was used.

In addition, the MR values read from the OUT files for the CHI CWT indicator stock (associated with the Fraser Late Model stock) are replaced with values supplied by Canadian Department of Fisheries and Oceans staff. The replacement values have been adjusted to take into account the differing maturation schedules between the hatchery and wild components of the Fraser Late stock. The resulting AEQ values are then calculated from the user supplied MR values.

The VB.NET program then produces a year, stock and age specific MATAEQ_xxx.DAT file containing the MR and AEQ values that are read into the PSC Chinook Model during the calibration and projection runs. The base period years in the MATAEQ_xxx.DAT file contain the base period MR and AEQ values from the STK file. Years after the base period but prior to the projection years that have valid (non-missing) MR and AEQ values contain data from the ERA OUT files (with the exception of Fraser Late). Years that have missing CWT data (or have been set to missing) contain LTA MR and AEQ values calculated for each stock and age. The projection years contain the average MR and AEQ values calculated for each stock and age based on a specified number of completed broods. For all Chinook Model calibrations prior to 2013, the MRs are based on the average of all available completed broods (except missing or excluded broods). Starting in 2013, the MRs are based on the average of the five most recent complete broods. The average could consist of less than five broods if the five-brood 'window 'also included missing or excluded broods.

Appendix D. Details of Model Evaluation Criteria

D.1 Mean Squared Error (MSE):

MSE provides a measure of the variability of the retrospective forecast errors. It is the average of each of the individual squared errors, i.e., the difference between the model estimated AI and some measure of the true AI, calculated as,

$$MSE = \frac{\sum_{i=1}^{n}(\widehat{AI}_i - AI_i)^2}{n},$$

where $\widehat{AI}_i$ is the estimated AI for year i using a particular MR estimate and AI_i is the "true" value of the abundance index for year i. It is a measure that includes both the variability of errors, and the bias in AI estimates.

Each of the individual square errors, i.e., $\left(\widehat{AI}_i - AI_i\right)^2$, contributes a proportion of the error to the total. Because the errors are squared, large errors can contribute more to the proportion than smaller errors. Hence large errors can unduly influence the overall MSE and will grow as the total error is concentrated within a decreasing number of increasingly large individual errors. The effect of different MRs on the MSE of model estimates of the AI are shown graphically.

D.2 Median Error

The median error is calculated as,

$$Med.\,Error = median\left(\widehat{AI}_i - AI_i\right), \forall\, i.$$

Medians, like means, are a measure of central tendency. However, unlike averages, or means, it is not influenced by large values. Positive values of the median error will result when AIs tend to be overestimated, negative when AIs are underestimated. Thus, it provides a little more information on overall model behavior than the MSE. Median errors for different estimates of the MR based on different metrics of the true AI are shown graphically.

D.3 Mean Absolute Scaled Error (MASE)

MASE was proposed by Hyndman and Koehler (2006) as a generally applicable, scale-free measure of forecast accuracy. This measure never gives infinite or undefined values. MASE is computed as the average of the absolute values of the scaled retrospective estimation errors. The scaling of the errors involves dividing the errors by the Mean Absolute Error (MAE) computed from the retrospective estimation errors associated with the naïve model based on the MRs for the previous year. A value of MASE less than 1 suggests that the retrospective estimation accuracy of MRs is better than the retrospective estimation accuracy of the benchmark naïve model based on the MRs for the previous year. A value of MASE greater than 1 suggests that the retrospective estimation accuracy is worse than the retrospective estimation accuracy of the benchmark naïve model based on MRs for the previous year.

MASE measures the magnitude of the error compared to the magnitude of the error of a naive one-step ahead forecast as a ratio. A naïve estimate assumes that whatever the MR value was last year it will be the same value this current year. Ideally, the value of MASE will be significantly less than 1. For example, a MASE of 0.5 means that the MR estimate is likely to have half as much error as a naïve estimate. Since MASE is a normalized statistic that is defined for all data values and weighs errors evenly, it is an excellent metric for comparing the quality of different estimation methods.

The advantage of MASE over the more common Mean Absolute Percent Error (MAPE) metric is that MASE is defined for time series that contain zero, whereas MAPE is not. Also, MASE weights errors equally, whereas MAPE weights positive and/or extreme errors more heavily.

D.4 Mean Percent Error

The Mean Percent Error (MPE) takes into account values of the AI, and scales the error accordingly. MPE is calculated as,

$$MPE = \frac{\sum_{i=1}^{n} \frac{(\widehat{AI}_i - AI_i)}{AI_i}}{n}.$$

Because the MPE is not calculated from absolute errors, values indicated by what percentage the AI will be over or under estimated.

Appendix E. Percent Error for Three MR Estimates (3YA, 9YA and ETS) Relative to the Observed MR at Age for Model Stocks in the MATAEQ File for the 2004-2010 Chinook Model Calibrations.

All contributing broods were complete through to the 2010 calibration for each of the Chinook Model stocks based on using observed MRs from the CTC-AWG's exploitation rate analysis in March 2015. Positive values indicate that the forecasted MR exceeded the observed MR at age. Negative values indicate the forecasted MR was below the observed MR. Cases where the observed MR was 0 and percent error could not be calculated are indicated with a horizontal bar ('—'). The first, second and third age are stock-dependent and are defined in the caption for Appendix A.

CLB Year	Stock #	Stock	First Age			Second Age			Third Age		
			3YA	9YA	ETS	3YA	9YA	ETS	3YA	9YA	ETS
2004	1	AKS	139.7	93.6	147.4	-54.1	-71.7	-66.7	-2.7	-18.5	-13.1
2005	1		51.4	32.7	-7.5	-12.5	-48.4	-43.0	-0.2	-19.8	-16.9
2006	1		-34.0	-32.5	-27.4	-16.3	-42.3	-39.6	-3.4	-17.7	-18.3
2007	1		-42.9	-47.5	-41.1	-31.9	-44.8	-45.7	2.2	-9.6	-11.0
2008	1		50.0	31.4	67.8	-22.7	-49.8	-35.5	-23.0	-19.9	-23.4
2009	1		-63.0	-65.1	-10.9	-32.0	-52.2	-44.9	-11.7	-18.2	-15.7
2010	1		19.0	67.0	-1.0	-7.0	-31.9	-27.6	-13.1	-18.7	-17.4
2004	2	BON	9.8	82.3	22.3	123.7	138.6	167.8	10.4	10.9	7.8
2005	2		-51.6	-28.1	-34.0	-17.9	-13.6	0.0	1.0	1.8	-0.8
2006	2		-61.6	-49.9	-61.1	-3.9	1.5	3.8	28.0	28.7	21.8
2007	2		-73.2	-65.9	-70.5	-51.2	-47.7	-48.3	-4.9	-3.8	-4.4
2008	2		-69.0	-47.9	-47.9	-48.8	-30.1	-31.9	-5.6	-3.6	-4.4
2009	2		-53.6	-15.1	-29.2	-53.6	-42.9	-39.6	-9.8	-2.8	-1.2
2010	2		-77.6	-77.6	-74.5	-42.9	-42.2	-39.4	-9.8	-5.9	-4.9
2004	3	CWF	13.3	165.9	-44.4	91.3	86.4	61.1	64.8	67.2	60.2
2005	3		-63.5	-1.2	-85.9	29.5	22.7	28.8	-14.3	-4.0	-9.7
2006	3		-81.6	-76.5	-93.6	-40.8	-29.9	-39.8	-6.0	3.6	-2.5
2007	3		-61.6	-71.4	-57.3	-51.1	-48.9	-44.9	-23.6	-17.6	-18.5
2008	3		-77.5	-79.1	-90.6	-35.4	-9.3	-29.0	-29.9	-24.8	-25.0
2009	3		-69.0	-48.5	-65.0	-38.0	-34.8	-38.7	-21.4	-17.6	-17.2
2010	3		-65.9	-59.7	-68.4	58.9	61.9	60.5	19.1	9.1	8.0
2004	4	GSH	-68.1	-56.9	-64.1	-0.7	33.8	9.4	-8.7	0.8	-4.0
2005	4		-18.0	2.8	-15.4	-20.1	-10.9	-20.9	10.5	13.1	15.9
2006	4		306.9	429.4	321.6	-26.3	-11.4	-22.7	-16.1	-17.2	-19.8
2007	4		-65.5	-61.5	-66.0	-37.9	-36.7	-42.9	0.8	-1.3	-2.3
2008	4		-33.6	-18.7	-24.5	-24.3	-15.8	-24.6	-20.6	-18.0	-20.5

2009	4		-25.1	-43.1	-25.3	-20.4	-21.6	-22.3	-10.7	-15.7	-12.0
2010	4		29.9	5.5	35.0	-24.8	-30.9	-28.7	-6.0	-10.4	-10.2
2004	5	LRW	14.6	117.2	65.0	-11.2	-16.5	-9.3	9.4	-41.9	-30.6
2005	5		-66.9	-7.5	-0.9	-20.2	196.6	258.9	102.6	80.4	103.7
2006	5		-21.2	147.7	225.0	-73.2	19.9	52.1	-49.2	-28.2	-29.6
2007	5		--	--	--	-62.5	34.5	9.9	41.5	41.5	80.2
2008	5		-53.5	30.4	56.2	39.3	94.2	110.2	-47.4	-41.3	-44.0
2009	5		--	--	--	21.5	59.2	45.6	29.9	2.2	2.6
2010	5		79.1	24.1	123.6	133.8	47.6	118.6	-28.8	-25.5	-24.2
2004	6	ORC	91.3	71.8	181.3	22.0	13.2	-7.1	24.5	8.4	9.3
2005	6		-15.6	-24.2	-23.5	4.2	-0.7	-19.7	7.2	-9.7	-11.7
2006	6		1274.1	1351.9	1748.1	-3.0	5.8	-6.3	22.9	19.0	10.0
2007	6		136.7	155.1	138.8	186.1	201.1	167.9	-22.0	-15.6	-24.2
2008	6		-4.8	112.7	-76.2	-15.8	-13.2	-18.4	3.6	15.4	3.7
2009	6		81.9	86.1	149.3	7.6	35.3	23.4	-20.9	-7.1	-19.9
2010	6		-26.1	-24.6	84.2	-57.2	-47.0	-54.6	-27.0	-16.2	-28.6
2004	7	RBH	48.8	48.0	51.2	-47.8	-46.3	-47.8	-2.0	-7.1	-11.9
2005	7		306.9	184.5	106.9	90.4	59.2	41.5	-3.4	-8.1	-14.2
2006	7		-27.6	0.6	-46.5	-24.1	-19.0	-26.5	-30.8	-14.8	-18.4
2007	7		-52.5	-46.3	-60.3	28.4	32.4	15.9	-3.7	1.0	-4.9
2008	7		-61.1	-57.9	-70.6	-37.4	-37.8	-48.1	-3.3	3.4	-3.4
2009	7		19.4	21.4	10.7	56.4	33.6	23.6	-13.1	-20.2	-25.4
2010	7		-54.4	-52.0	-62.6	25.5	9.8	-2.3	-2.1	-8.0	-13.9
2004	8	RBT	48.8	48.0	51.2	-47.8	-46.3	-47.8	-2.0	-7.1	-11.9
2005	8		306.9	184.5	106.9	90.4	59.2	41.5	-3.4	-8.1	-14.2
2006	8		-27.6	0.6	-46.5	-24.1	-19.0	-26.5	-30.8	-14.8	-18.4
2007	8		-52.5	-46.3	-60.3	28.4	32.4	15.9	-3.7	1.0	-4.9
2008	8		-61.1	-57.9	-70.6	-37.4	-37.8	-48.1	-3.3	3.4	-3.4
2009	8		19.4	21.4	10.7	56.4	33.6	23.6	-13.1	-20.2	-25.4
2010	8		-54.4	-52.0	-62.6	25.5	9.8	-2.3	-2.1	-8.0	-13.9
2004	9	SPR	-33.0	-44.7	-29.6	5.4	12.6	8.9	0.9	1.8	0.1
2005	9		-0.5	-25.7	-13.4	-16.9	-13.4	-17.6	2.4	2.6	0.9
2006	9		-60.1	-35.9	-16.8	-23.6	-4.3	-7.7	-2.1	-1.4	-3.0
2007	9		-72.4	-61.3	-68.7	-38.9	-32.5	-34.0	-2.3	-1.7	-3.1
2008	9		166.8	206.4	156.7	-29.2	-15.2	-13.3	-3.6	-2.2	-3.1
2009	9		-68.4	-70.2	-63.2	-22.1	-22.3	-21.0	-2.4	-1.2	-2.1
2010	9		-8.5	-27.6	-9.2	-23.9	-30.9	-29.4	-1.3	-2.1	-3.1
2004	10	URB	-39.0	-26.8	-20.3	-19.9	-23.1	-24.0	52.8	27.2	25.8
2005	10		-30.4	-20.6	-14.2	-1.8	-14.3	-18.3	29.0	13.2	8.2
2006	10		-81.5	-69.9	-68.3	-45.1	-32.8	-38.7	-20.9	-22.1	-26.6

Year	Age	Stock								
2007	10		-77.3	-68.2	-65.7	-16.4	-2.0	-14.7	-26.2	-14.3	-21.5
2008	10		-83.4	-81.6	-79.8	-47.4	-35.5	-42.4	-28.5	-16.0	-21.0
2009	10		-38.2	-48.3	-31.0	26.9	25.7	14.0	-20.7	-17.8	-23.1
2010	10		-75.4	-78.2	-72.6	-14.0	-30.4	-37.2	24.3	16.2	7.0
2004	11	WSH	-85.1	-44.4	-52.7	-36.5	-28.5	-28.3	0.3	-0.1	-0.5
2005	11		-88.7	-71.5	-73.6	-3.6	-12.9	-8.0	1.5	1.0	0.0
2006	11		-41.0	-10.3	-5.1	-25.3	-30.8	-31.4	4.7	3.7	2.7
2007	11		3.5	-5.3	0.9	-9.9	-19.2	-22.1	1.1	0.9	-0.2
2008	11		-25.7	-56.3	-39.3	-14.4	-24.4	-23.5	-2.6	-2.1	-3.0
2009	11		-59.7	-78.1	-70.8	-17.0	-22.9	-23.6	-3.3	-1.7	-2.5
2010	11		-51.2	-77.7	-71.8	-23.2	-37.1	-38.8	-2.4	-1.1	-1.6
2004	12	FRL	-28.0	-30.3	-29.2	-20.0	-18.8	-34.0	11.4	13.3	5.3
2005	12		-31.3	-46.2	-49.4	-3.9	-19.6	27.0	-8.6	-6.4	-8.7
2006	12		-83.9	-85.4	-85.3	-63.0	-54.7	-70.9	-9.3	-8.0	-15.9
2007	12		-40.7	-55.1	-55.1	-63.3	-50.1	-54.7	-12.7	-8.4	-8.7
2008	12		-35.9	-40.0	-40.6	-62.1	-48.9	-15.2	-3.4	-2.6	5.0
2009	12		-50.8	-56.6	-55.5	19.8	20.0	28.6	7.5	5.3	12.6
2010	12		-10.7	-32.7	-40.3	-42.0	-48.6	-34.9	0.6	-6.2	-2.5

Note that Percent Error (PE) for a stock, age, calibration year and estimate type is calculated as:

$$PE = \left(\frac{(Estimate - Observed)}{Observed} \right) * 100\%$$

Appendix F. Mean Percent Error (MPE) of Three MR Estimates (3YA, 9YA and ETS) Relative to the Observed MR at Each of Three Ages for Chinook Model Stocks in the MATAEQ File.

Means are based on percent errors calculated by stock and age for calibration years 2004-2010 and are based directly on data in Appendix E. The statistical summary was limited to this set of calibrations because all observed MRs are from completed broods. Observed values were obtained from the results of the CTC-AWG's March 2015 cohort analysis procedure applied to CWT indicator stocks associated to the Chinook Model stocks in the MATAEQ file. Positive values indicate that the MPEs exceeded the actual MR at age. Negative values indicate the MPEs were below the actual MR at age. The first, second and third age are stock-dependent and are defined in the caption for Appendix A.

		First Age			Second Age			Third Age		
Stock #	Stock	3YA	9YA	ETS	3YA	9YA	ETS	3YA	9YA	ETS
1	AKS	17.2	11.4	18.2	-25.2	-48.7	-43.3	-7.4	-17.5	-16.5
2	BON	-53.8	-28.9	-42.1	-13.5	-5.2	1.8	1.3	3.6	2.0
3	CWF	-58.0	-24.3	-72.2	2.1	6.9	-0.3	-1.6	2.3	-0.7
4	GSH	18.1	36.8	23.0	-22.0	-13.4	-21.8	-7.3	-7.0	-7.6
5	LRW	-9.6	62.4	93.8	3.9	62.2	83.7	8.3	-1.8	8.3
6	ORC	219.6	247.0	314.6	20.6	27.8	12.1	-1.7	-0.8	-8.8
7	RBH	25.6	14.0	-10.2	13.1	4.6	-6.2	-8.4	-7.7	-13.2
8	RBT	25.6	14.0	-10.2	13.1	4.6	-6.2	-8.4	-7.7	-13.2
9	SPR	-10.9	-8.4	-6.3	-21.3	-15.1	-16.3	-1.2	-0.6	-1.9
10	URB	-60.7	-56.2	-50.3	-16.8	-16.1	-23.1	1.4	-1.9	-7.3
11	WSH	-49.7	-49.1	-44.6	-18.6	-25.1	-25.1	-0.1	0.1	-0.7
12	FRL	-40.2	-49.5	-50.8	-33.5	-31.6	-22.0	-2.1	-1.9	-1.8
Grand MPE		2.2	12.9	11.6	-8.2	-4.1	-5.6	-2.2	-3.4	-5.1

Note that Mean Percent Error for a stock at age and forecast method is calculated as:

$$MPE = \frac{\sum_{clb=2004}^{clb=2010}\left(\frac{(Estimate-Observed)}{Observed}\right)}{NumCalibrations} * 100\%$$

NumCalibrations in the above formula equals 7 at each age for all stocks except the first age for LRW. The observed value for the first age was zero in two years (2007 and 2009, see Appendix E) and thus MPE could not be calculated.

The sample size and denominator for the Grand MPE = 7 calibrations x 12 stocks = 84.

Appendix G. Squared Error for Three MR Estimates (3YA, 9YA and ETS) Relative to the Observed MR at Age for Model Stocks in the MATAEQ File for the 2004-2010 Chinook Model calibrations.

All contributing broods were complete through to the 2010 Chinook Model calibration for each of the Model stocks based on using observed MRs from the exploitation rate analysis conducted by the CTC-AWG in March 2015. The first, second and third age are stock-dependent and are defined in the caption for Appendix A.

CLB Year	Stock #	Stock	First Age			Second Age			Third Age		
			3YA	9YA	ETS	3YA	9YA	ETS	3YA	9YA	ETS
2004	1	AKS	0.00012	0.00005	0.00013	0.02904	0.05108	0.04423	0.00035	0.01695	0.00846
2005	1		0.00003	0.00001	0.00000	0.00054	0.00805	0.00635	0.00000	0.02190	0.01603
2006	1		0.00005	0.00005	0.00003	0.00086	0.00576	0.00506	0.00068	0.01817	0.01938
2007	1		0.00015	0.00018	0.00013	0.00462	0.00912	0.00949	0.00025	0.00473	0.00612
2008	1		0.00003	0.00001	0.00006	0.00308	0.01479	0.00753	0.03587	0.02683	0.03729
2009	1		0.00077	0.00082	0.00002	0.00937	0.02500	0.01847	0.00929	0.02256	0.01680
2010	1		0.00000	0.00004	0.00000	0.00027	0.00558	0.00419	0.01228	0.02493	0.02161
2004	2	BON	0.00000	0.00031	0.00002	0.07607	0.09548	0.14003	0.00852	0.00929	0.00479
2005	2		0.00025	0.00007	0.00011	0.01160	0.00669	0.00000	0.00008	0.00031	0.00006
2006	2		0.00069	0.00045	0.00068	0.00036	0.00006	0.00034	0.04584	0.04814	0.02786
2007	2		0.00152	0.00123	0.00141	0.19749	0.17189	0.17564	0.00238	0.00141	0.00197
2008	2		0.00044	0.00021	0.00021	0.08220	0.03140	0.03523	0.00315	0.00132	0.00192
2009	2		0.00011	0.00001	0.00003	0.17040	0.10903	0.09278	0.00882	0.00070	0.00013
2010	2		0.00373	0.00373	0.00343	0.10910	0.10517	0.09199	0.00958	0.00353	0.00241
2004	3	CWF	0.00000	0.00050	0.00004	0.01667	0.01491	0.00746	0.09333	0.10043	0.08077
2005	3		0.00047	0.00000	0.00085	0.00491	0.00291	0.00469	0.01383	0.00107	0.00635
2006	3		0.01570	0.01381	0.02062	0.02250	0.01203	0.02140	0.00203	0.00073	0.00036
2007	3		0.00151	0.00203	0.00131	0.06933	0.06345	0.05350	0.04713	0.02599	0.02880
2008	3		0.00415	0.00432	0.00567	0.01008	0.00069	0.00679	0.08964	0.06136	0.06235
2009	3		0.00051	0.00025	0.00045	0.01949	0.01636	0.02025	0.03760	0.02560	0.02434
2010	3		0.00095	0.00078	0.00103	0.00863	0.00951	0.00908	0.01790	0.00410	0.00317
2004	4	GSH	0.00635	0.00444	0.00564	0.00000	0.00771	0.00059	0.00483	0.00004	0.00104
2005	4		0.00008	0.00000	0.00006	0.00621	0.00182	0.00671	0.00560	0.00863	0.01277
2006	4		0.00098	0.00192	0.00108	0.01071	0.00202	0.00801	0.02403	0.02746	0.03621
2007	4		0.00681	0.00601	0.00692	0.04048	0.03814	0.05194	0.00004	0.00010	0.00032
2008	4		0.00034	0.00011	0.00018	0.00904	0.00382	0.00925	0.03818	0.02921	0.03799
2009	4		0.00044	0.00129	0.00045	0.00661	0.00741	0.00790	0.01004	0.02152	0.01254
2010	4		0.00020	0.00001	0.00027	0.01293	0.02011	0.01732	0.00283	0.00841	0.00817

2004	5	LRW	0.00004	0.00233	0.00072	0.00019	0.00041	0.00013	0.00320	0.06396	0.03411
2005	5		0.00132	0.00002	0.00000	0.00004	0.00341	0.00591	0.04423	0.02719	0.04520
2006	5		0.00001	0.00038	0.00088	0.00239	0.00018	0.00121	0.04977	0.01633	0.01804
2007	5		0.00019	0.00081	0.00151	0.00120	0.00036	0.00003	0.01214	0.01212	0.04524
2008	5		0.00013	0.00004	0.00015	0.00023	0.00130	0.00177	0.08779	0.06641	0.07552
2009	5		0.00050	0.00057	0.00173	0.00011	0.00080	0.00048	0.01061	0.00006	0.00008
2010	5		0.00023	0.00002	0.00056	0.00193	0.00024	0.00151	0.01727	0.01353	0.01219
2004	6	ORC	0.00048	0.00030	0.00191	0.00075	0.00027	0.00008	0.00988	0.00116	0.00144
2005	6		0.00007	0.00016	0.00015	0.00004	0.00000	0.00083	0.00160	0.00287	0.00419
2006	6		0.00118	0.00133	0.00223	0.00002	0.00007	0.00009	0.00955	0.00656	0.00181
2007	6		0.00040	0.00052	0.00042	0.01040	0.01214	0.00846	0.01796	0.00904	0.02173
2008	6		0.00000	0.00020	0.00009	0.00069	0.00048	0.00094	0.00027	0.00489	0.00029
2009	6		0.00014	0.00015	0.00046	0.00007	0.00140	0.00062	0.01369	0.00158	0.01243
2010	6		0.00008	0.00007	0.00082	0.02644	0.01782	0.02409	0.02650	0.00953	0.02962
2004	7	RBH	0.00004	0.00004	0.00004	0.02076	0.01949	0.02079	0.00020	0.00258	0.00726
2005	7		0.00032	0.00011	0.00004	0.01073	0.00461	0.00227	0.00065	0.00362	0.01111
2006	7		0.00002	0.00000	0.00006	0.00270	0.00169	0.00328	0.05537	0.01272	0.01982
2007	7		0.00016	0.00013	0.00021	0.00152	0.00198	0.00048	0.00062	0.00004	0.00107
2008	7		0.00037	0.00033	0.00050	0.01418	0.01450	0.02344	0.00048	0.00051	0.00051
2009	7		0.00000	0.00000	0.00000	0.00561	0.00199	0.00098	0.01270	0.03038	0.04805
2010	7		0.00026	0.00023	0.00034	0.00189	0.00028	0.00002	0.00025	0.00356	0.01088
2004	8	RBT	0.00004	0.00004	0.00004	0.02076	0.01949	0.02079	0.00020	0.00258	0.00726
2005	8		0.00032	0.00011	0.00004	0.01073	0.00461	0.00227	0.00065	0.00362	0.01111
2006	8		0.00002	0.00000	0.00006	0.00270	0.00169	0.00328	0.05537	0.01272	0.01982
2007	8		0.00016	0.00013	0.00021	0.00152	0.00198	0.00048	0.00062	0.00004	0.00107
2008	8		0.00037	0.00033	0.00050	0.01418	0.01450	0.02344	0.00048	0.00051	0.00051
2009	8		0.00000	0.00000	0.00000	0.00561	0.00199	0.00098	0.01270	0.03038	0.04805
2010	8		0.00026	0.00023	0.00034	0.00189	0.00028	0.00002	0.00025	0.00356	0.01088
2004	9	SPR	0.00122	0.00224	0.00098	0.00102	0.00569	0.00280	0.00008	0.00029	0.00000
2005	9		0.00000	0.00046	0.00013	0.01793	0.01124	0.01929	0.00054	0.00061	0.00007
2006	9		0.00300	0.00107	0.00023	0.02713	0.00088	0.00286	0.00042	0.00018	0.00092
2007	9		0.01197	0.00857	0.01077	0.14251	0.09986	0.10890	0.00053	0.00030	0.00095
2008	9		0.00097	0.00149	0.00086	0.04635	0.01257	0.00955	0.00132	0.00050	0.00097
2009	9		0.02117	0.02229	0.01804	0.03251	0.03283	0.02914	0.00054	0.00015	0.00042
2010	9		0.00006	0.00062	0.00007	0.04765	0.07998	0.07220	0.00017	0.00043	0.00094
2004	10	URB	0.00021	0.00010	0.00006	0.00184	0.00249	0.00269	0.06190	0.01646	0.01481
2005	10		0.00008	0.00004	0.00002	0.00001	0.00086	0.00141	0.02493	0.00520	0.00202
2006	10		0.00425	0.00312	0.00298	0.01506	0.00799	0.01111	0.02832	0.03151	0.04584
2007	10		0.00299	0.00233	0.00216	0.00100	0.00001	0.00080	0.03838	0.01151	0.02595
2008	10		0.00889	0.00852	0.00815	0.01863	0.01049	0.01493	0.04452	0.01399	0.02418

Year	Age	Stock									
2009	10		0.00027	0.00043	0.00018	0.00159	0.00145	0.00043	0.02538	0.01888	0.03165
2010	10		0.00539	0.00579	0.00498	0.00148	0.00696	0.01040	0.01852	0.00823	0.00155
2004	11	WSH	0.00042	0.00011	0.00016	0.05171	0.03151	0.03115	0.00001	0.00000	0.00003
2005	11		0.00142	0.00092	0.00098	0.00032	0.00408	0.00155	0.00021	0.00009	0.00000
2006	11		0.00002	0.00000	0.00000	0.02876	0.04252	0.04427	0.00198	0.00122	0.00065
2007	11		0.00000	0.00000	0.00000	0.00339	0.01275	0.01677	0.00011	0.00008	0.00000
2008	11		0.00003	0.00013	0.00007	0.00792	0.02277	0.02111	0.00068	0.00045	0.00088
2009	11		0.00082	0.00140	0.00115	0.01107	0.02019	0.02132	0.00104	0.00030	0.00064
2010	11		0.00076	0.00176	0.00150	0.03291	0.08410	0.09217	0.00057	0.00013	0.00026
2004	12	FRL	0.00095	0.00111	0.00103	0.00406	0.00360	0.01177	0.00837	0.01132	0.00181
2005	12		0.00245	0.00536	0.00612	0.00012	0.00315	0.00593	0.00667	0.00364	0.00676
2006	12		0.11526	0.11951	0.11930	0.09585	0.07236	0.12138	0.00803	0.00587	0.02320
2007	12		0.00304	0.00558	0.00558	0.07612	0.04779	0.05683	0.01445	0.00642	0.00682
2008	12		0.00135	0.00166	0.00172	0.07054	0.04385	0.00425	0.00092	0.00054	0.00199
2009	12		0.00498	0.00619	0.00596	0.00127	0.00130	0.00264	0.00401	0.00197	0.01119
2010	12		0.00014	0.00129	0.00195	0.03312	0.04444	0.02289	0.00004	0.00346	0.00057

Note that Squared Error for a stock, age, calibration year and forecast method is calculated as:

$$SqE = (Estimate - Observed)^2$$

Appendix H. Mean Squared Error (MSE) for Three MR Estimates (3YA, 9YA and ETS) Relative to the Observed MR at Three Ages for the Chinook Model Stocks in the MATAEQ File.

Means are based on squared errors calculated for calibration years 2004-2010 and are based directly on data in Appendix G. All contributing broods for each Chinook Model stock were complete for these calibrations based on results from the exploitation rate analysis conducted by the CTC-AWG in March 2015. A smaller value for MSE indicates less error. The first, second and third age are stock-dependent and are defined in the caption for Appendix A.

	Model	First Age			Second Age			Third Age		
Stock #	Stock	3YA	9YA	ETS	3YA	9YA	ETS	3YA	9YA	ETS
1	AKS	0.0002	0.0002	0.0001	0.0068	0.0270	0.0305	0.0084	0.0278	0.0197
2	BON	0.0010	0.0009	0.0008	0.0925	0.0111	0.0108	0.0112	0.0076	0.0057
3	CWF	0.0033	0.0031	0.0043	0.0217	0.0041	0.0060	0.0431	0.0068	0.0130
4	GSH	0.0022	0.0020	0.0021	0.0123	0.0040	0.0062	0.0122	0.0148	0.0132
5	LRW	0.0003	0.0006	0.0008	0.0009	0.0079	0.0094	0.0321	0.0116	0.0153
6	ORC	0.0003	0.0004	0.0009	0.0055	0.0525	0.0601	0.0113	0.0085	0.0182
7	RBH	0.0002	0.0001	0.0002	0.0082	0.0256	0.0274	0.0100	0.0065	0.0105
8	RBT	0.0002	0.0001	0.0002	0.0082	0.0095	0.0144	0.0100	0.0235	0.0256
9	SPR	0.0055	0.0052	0.0044	0.0450	0.0343	0.0259	0.0005	0.0092	0.0099
10	URB	0.0032	0.0029	0.0026	0.0057	0.0068	0.0058	0.0346	0.0147	0.0219
11	WSH	0.0005	0.0006	0.0006	0.0194	0.0232	0.0211	0.0007	0.0081	0.0085
12	FRL	0.0183	0.0201	0.0202	0.0402	0.0334	0.0317	0.0061	0.0041	0.0078
Grand MSE		0.0029	0.0030	0.0031	0.0222	0.0199	0.0208	0.0150	0.0119	0.0141

Note that Mean Squared Error for a stock at age and forecast method is calculated as:

$$MSE = \frac{\sum_{clb=2004}^{clb=2010}(Estimate - Observed)^2}{7}$$

The sample size and denominator for the Grand MSE = 7 calibrations x 12 stocks = 84.

Appendix I. Preseason (Pre) to First Postseason (Post 1) Squared Error (SQE) and Percent Error (PE) Calculated for Each AABM Fishery and Calibration Years 2004-2013 for All MR Estimation models.

3YA MRs

	SEAK				NBC				WCVI			
Year	Pre	Post 1	SQE	PE	Pre	Post 1	SQE	PE	Pre	Post 1	SQE	PE
2004	1.68	1.81	0.0169	-7.2%	1.57	1.63	0.0036	-3.7%	0.87	0.93	0.0036	-6.5%
2005	1.74	1.86	0.0144	-6.5%	1.46	1.59	0.0169	-8.2%	0.80	0.86	0.0036	-7.0%
2006	1.65	1.68	0.0009	-1.8%	1.45	1.45	0.0000	0.0%	0.75	0.68	0.0049	10.2%
2007	1.56	1.30	0.0676	20.0%	1.30	1.07	0.0529	21.5%	0.67	0.58	0.0081	15.5%
2008	1.04	0.95	0.0081	9.5%	0.93	0.90	0.0009	3.3%	0.82	0.63	0.0360	30.1%
2009	1.22	1.12	0.0100	8.9%	1.04	1.01	0.0009	3.0%	0.69	0.59	0.0093	16.4%
2010	1.16	1.19	0.0009	-2.5%	1.06	1.15	0.0081	-7.8%	0.87	0.88	0.0001	-1.1%
2011	1.46	1.47	0.0001	-0.7%	1.25	1.30	0.0025	-3.8%	0.95	0.82	0.0169	15.9%
2012	1.26	1.22	0.0016	3.3%	1.18	1.13	0.0025	4.4%	0.73	0.71	0.0004	2.8%
2013	1.25	1.66	0.1681	-24.7%	1.15	1.53	0.1444	-24.8%	0.78	1.06	0.0784	-26.4%

5YA MRs

	SEAK				NBC				WCVI			
Year	Pre	Post 1	SQE	PE	Pre	Post 1	SQE	PE	Pre	Post 1	SQE	PE
2004	1.70	1.90	0.0400	-10.5%	1.58	1.70	0.0144	-7.1%	0.85	0.94	0.0081	-9.6%
2005	1.87	1.80	0.0049	3.9%	1.54	1.54	0.0000	0.0%	0.81	0.82	0.0001	-1.2%
2006	1.56	1.61	0.0025	-3.1%	1.38	1.40	0.0004	-1.4%	0.70	0.67	0.0009	4.5%
2007	1.48	1.27	0.0441	16.5%	1.24	1.05	0.0361	18.1%	0.63	0.57	0.0036	10.5%
2008	1.00	0.96	0.0016	4.2%	0.90	0.90	0.0000	0.0%	0.77	0.63	0.0196	22.2%
2009	1.23	1.16	0.0049	6.0%	1.03	1.03	0.0000	0.0%	0.69	0.62	0.0044	10.8%
2010	1.23	1.23	0.0000	0.0%	1.11	1.17	0.0036	-5.1%	0.97	0.91	0.0036	6.6%
2011	1.52	1.50	0.0004	1.3%	1.30	1.32	0.0004	-1.5%	1.04	0.84	0.0400	23.8%
2012	1.30	1.21	0.0081	7.4%	1.20	1.12	0.0064	7.1%	0.77	0.71	0.0036	8.5%
2013	1.22	1.67	0.2025	-26.9%	1.13	1.55	0.1764	-27.1%	0.78	1.05	0.0729	-25.7%

7YA MRs

	SEAK				NBC				WCVI			
Year	Pre	Post 1	SQE	PE	Pre	Post 1	SQE	PE	Pre	Post 1	SQE	PE
2004	1.72	1.88	0.0237	-8.2%	1.57	1.67	0.0114	-6.4%	0.84	0.93	0.0076	-9.4%
2005	1.83	1.79	0.0014	2.1%	1.50	1.55	0.0023	-3.1%	0.79	0.81	0.0003	-2.1%
2006	1.56	1.65	0.0083	-5.5%	1.38	1.43	0.0018	-2.9%	0.68	0.67	0.0001	1.7%
2007	1.53	1.27	0.0713	21.1%	1.27	1.04	0.0541	22.4%	0.63	0.56	0.0052	13.0%
2008	0.99	0.95	0.0018	4.5%	0.88	0.88	0.0000	-0.4%	0.73	0.63	0.0106	16.5%
2009	1.21	1.16	0.0031	4.8%	1.02	1.03	0.0002	-1.4%	0.68	0.62	0.0043	10.6%
2010	1.22	1.24	0.0005	-1.8%	1.10	1.18	0.0065	-6.8%	0.96	0.93	0.0012	3.7%
2011	1.55	1.54	0.0001	0.6%	1.31	1.35	0.0014	-2.7%	1.08	0.90	0.0333	20.4%
2012	1.38	1.24	0.0185	10.9%	1.25	1.14	0.0120	9.6%	0.83	0.73	0.0096	13.4%
2013	1.27	1.69	0.1716	-24.5%	1.17	1.57	0.1560	-25.2%	0.82	1.07	0.0602	-23.0%

8YA MRs

	SEAK				NBC				WCVI			
Year	Pre	Post 1	SQE	PE	Pre	Post 1	SQE	PE	Pre	Post 1	SQE	PE
2004	1.77	1.92	0.0218	-7.7%	1.60	1.70	0.0095	-5.7%	0.86	0.94	0.0068	-8.8%
2005	1.89	1.79	0.0104	5.7%	1.53	1.54	0.0000	0.0%	0.81	0.80	0.0000	0.6%
2006	1.55	1.63	0.0073	-5.2%	1.36	1.41	0.0026	-3.6%	0.67	0.66	0.0001	1.7%
2007	1.51	1.28	0.0553	18.4%	1.26	1.05	0.0450	20.2%	0.62	0.56	0.0034	10.4%
2008	1.00	0.96	0.0019	4.6%	0.89	0.89	0.0000	-0.2%	0.73	0.63	0.0107	16.5%
2009	1.23	1.15	0.0062	6.9%	1.03	1.02	0.0000	0.5%	0.68	0.61	0.0052	11.9%
2010	1.20	1.24	0.0014	-3.0%	1.08	1.18	0.0090	-8.1%	0.93	0.93	0.0000	-0.3%
2011	1.55	1.54	0.0003	1.0%	1.31	1.35	0.0013	-2.6%	1.10	0.89	0.0416	22.9%
2012	1.38	1.25	0.0159	10.1%	1.25	1.14	0.0118	9.5%	0.82	0.74	0.0067	11.1%
2013	1.29	1.71	0.1789	-24.7%	1.18	1.59	0.1690	-25.9%	0.84	1.08	0.0592	-22.5%

9YA MRs

	SEAK				NBC				WCVI			
Year	Pre	Post 1	SQE	PE	Pre	Post 1	SQE	PE	Pre	Post 1	SQE	PE
2004	1.81	1.90	0.0081	-4.7%	1.63	1.70	0.0040	-3.7%	0.87	0.94	0.0057	-8.0%
2005	1.87	1.81	0.0033	3.2%	1.54	1.55	0.0001	-0.7%	0.81	0.81	0.0001	0.9%
2006	1.58	1.62	0.0020	-2.7%	1.39	1.41	0.0003	-1.3%	0.68	0.66	0.0006	3.6%
2007	1.51	1.27	0.0572	18.9%	1.25	1.04	0.0421	19.7%	0.61	0.55	0.0033	10.4%
2008	0.99	0.96	0.0009	3.2%	0.88	0.89	0.0001	-1.3%	0.72	0.63	0.0080	14.3%
2009	1.23	1.16	0.0059	6.6%	1.03	1.03	0.0000	0.2%	0.68	0.61	0.0050	11.5%
2010	1.22	1.23	0.0001	-0.9%	1.09	1.17	0.0056	-6.4%	0.93	0.92	0.0001	1.0%
2011	1.53	1.54	0.0001	-0.5%	1.29	1.35	0.0030	-4.1%	1.07	0.90	0.0301	19.3%
2012	1.38	1.26	0.0135	9.2%	1.25	1.15	0.0104	8.9%	0.84	0.74	0.0088	12.6%
2013	1.30	1.72	0.1774	-24.4%	1.18	1.59	0.1680	-25.7%	0.84	1.10	0.0635	-23.0%

10YA MRs

	SEAK				NBC				WCVI			
Year	Pre	Post 1	SQE	PE	Pre	Post 1	SQE	PE	Pre	Post 1	SQE	PE
2004	1.84	1.99	0.0219	-7.5%	1.66	1.75	0.0083	-5.2%	0.88	0.95	0.0058	-8.0%
2005	1.99	1.83	0.0241	8.5%	1.60	1.57	0.0012	2.2%	0.83	0.81	0.0005	2.8%
2006	1.61	1.64	0.0011	-2.1%	1.41	1.42	0.0001	-0.6%	0.69	0.66	0.0007	4.0%
2007	1.53	1.26	0.0715	21.2%	1.26	1.04	0.0512	21.8%	0.62	0.55	0.0042	11.7%
2008	0.99	0.96	0.0011	3.4%	0.87	0.89	0.0001	-1.4%	0.71	0.62	0.0079	14.3%
2009	1.22	1.16	0.0034	5.0%	1.02	1.03	0.0002	-1.3%	0.67	0.61	0.0037	10.0%
2010	1.23	1.24	0.0001	-0.7%	1.10	1.17	0.0053	-6.2%	0.93	0.92	0.0001	0.9%
2011	1.55	1.53	0.0004	1.2%	1.30	1.34	0.0012	-2.6%	1.08	0.89	0.0343	20.7%
2012	1.36	1.26	0.0108	8.3%	1.23	1.14	0.0082	7.9%	0.83	0.75	0.0069	11.1%
2013	1.30	1.73	0.1856	-24.8%	1.18	1.60	0.1759	-26.1%	0.85	1.10	0.0607	-22.4%

11YA MRs

Year	SEAK Pre	Post 1	SQE	PE	NBC Pre	Post 1	SQE	PE	WCVI Pre	Post 1	SQE	PE
2004	1.85	2.00	0.0241	-7.8%	1.67	1.77	0.0086	-5.2%	0.89	0.96	0.0049	-7.3%
2005	2.01	1.86	0.0246	8.4%	1.63	1.59	0.0014	2.4%	0.85	0.82	0.0008	3.5%
2006	1.64	1.67	0.0005	-1.3%	1.44	1.43	0.0000	0.2%	0.69	0.66	0.0010	4.7%
2007	1.56	1.28	0.0786	22.0%	1.28	1.05	0.0551	22.4%	0.62	0.56	0.0044	12.0%
2008	1.00	0.96	0.0022	4.9%	0.88	0.89	0.0000	-0.2%	0.72	0.62	0.0093	15.5%
2009	1.22	1.16	0.0039	5.4%	1.01	1.03	0.0001	-1.1%	0.67	0.61	0.0037	10.0%
2010	1.22	1.25	0.0006	-2.0%	1.09	1.18	0.0074	-7.3%	0.92	0.92	0.0000	-0.5%
2011	1.56	1.54	0.0004	1.3%	1.31	1.34	0.0010	-2.4%	1.08	0.90	0.0333	20.3%
2012	1.38	1.24	0.0171	10.5%	1.24	1.13	0.0123	9.8%	0.83	0.74	0.0078	11.9%
2013	1.29	1.74	0.2048	-26.0%	1.17	1.60	0.1910	-27.2%	0.85	1.11	0.0661	-23.3%

LTA MRs

Year	SEAK Pre	Post 1	SQE	PE	NBC Pre	Post 1	SQE	PE	WCVI Pre	Post 1	SQE	PE
2004	1.89	2.06	0.0289	-8.3%	1.72	1.82	0.0100	-5.5%	0.93	0.99	0.0036	-6.1%
2005	2.08	1.90	0.0324	9.5%	1.70	1.64	0.0036	3.7%	0.90	0.84	0.0036	7.1%
2006	1.70	1.73	0.0009	-1.7%	1.51	1.50	0.0001	0.7%	0.74	0.69	0.0025	7.2%
2007	1.64	1.34	0.0900	22.4%	1.36	1.09	0.0729	24.8%	0.67	0.57	0.0100	17.5%
2008	1.06	1.00	0.0036	6.0%	0.94	0.92	0.0004	2.2%	0.76	0.64	0.0144	18.8%
2009	1.30	1.20	0.0100	8.3%	1.07	1.06	0.0001	0.9%	0.71	0.63	0.0064	12.7%
2010	1.31	1.30	0.0001	0.8%	1.16	1.23	0.0049	-5.7%	1.00	0.95	0.0025	5.3%
2011	1.68	1.62	0.0036	3.7%	1.40	1.41	0.0001	-0.7%	1.15	0.90	0.0625	27.8%
2012	1.51	1.32	0.0361	14.4%	1.35	1.20	0.0225	12.5%	0.90	0.77	0.0169	16.9%
2013	1.41	1.82	0.1681	-22.5%	1.27	1.68	0.1681	-24.4%	0.91	1.15	0.0576	-20.9%

ETS MRs

Year	SEAK				NBC				WCVI			
	Pre	Post 1	SQE	PE	Pre	Post 1	SQE	PE	Pre	Post 1	SQE	PE
2004	1.85	2.05	0.0384	-9.6%	1.69	1.80	0.0133	-6.4%	0.90	0.96	0.0032	-5.9%
2005	2.02	1.89	0.0192	7.3%	1.65	1.62	0.0009	1.8%	0.82	0.84	0.0006	-3.0%
2006	1.66	1.72	0.0038	-3.6%	1.46	1.48	0.0003	-1.1%	0.75	0.67	0.0058	11.4%
2007	1.59	1.33	0.0714	20.1%	1.31	1.08	0.0535	21.3%	0.64	0.55	0.0070	15.2%
2008	1.03	1.00	0.0010	3.2%	0.91	0.92	0.0000	-0.5%	0.67	0.63	0.0020	7.0%
2009	1.28	1.19	0.0069	7.0%	1.06	1.06	0.0000	0.6%	0.69	0.61	0.0052	11.7%
2010	1.29	1.29	0.0000	-0.1%	1.15	1.21	0.0047	-5.6%	0.91	0.94	0.0005	-2.5%
2011	1.62	1.60	0.0004	1.3%	1.36	1.38	0.0006	-1.7%	1.09	0.90	0.0332	20.1%
2012	1.46	1.19	0.0729	22.7%	1.30	1.10	0.0417	18.6%	0.84	0.72	0.0142	16.5%
2013	1.29	1.64	0.1195	-21.1%	1.17	1.52	0.1240	-23.1%	0.83	1.05	0.0506	-21.4%