Final Considerations of the Use of SS3 ASPM-R as an Estimation Model in PBF MSE *

Norio Takahashi[1], Yohei Tsukahara[1], Desiree Tommasi[2, 3], and Hiromu Fukuda[1]

1: Fisheries Stock Assessment Center
Fisheries Resources Institute
Japan Fisheries Research and Education Agency
2-12-4 Fukuura, Kanazawa, Yokohama, Kanagawa, Japan 236-8648

2: Fisheries Resources Division, NOAA Fisheries, Southwest Fisheries Science Center,
La Jolla, CA, USA

3: Institute of Marine Sciences, University of California Santa Cruz,
Santa Cruz, CA, USA

December 2024

Working document submitted to the ISC Pacific bluefin tuna Working Group, International Scientific Committee for Tuna and Tuna-Like Species in the North Pacific Ocean (ISC), from 10 to 13 December 2024, Webinar.

* Working document submitted to the ISC Pacific bluefin tuna Working Group, International Scientific Committee for Tuna and Tuna-Like Species in the North Pacific Ocean (ISC), from 10 to 13 December 2024, Webinar. **Document not to be cited without author's permission.**

Abstract: This document is a discussion paper that reports comparisons of performance between full Stock Synthesis (SS3) and SS3 ASPM-R (Age-Structured Production Model with Recruitment deviations) when using these models as the estimation model (EM) in PBF management strategy evaluation (MSE). Based on the previous examination (Takahashi et al. 2023b), we further explored to determine what composition data needs to be included and what specifications of ASPM-R need to be improved. An ASPM-R specification with fixed selectivities for all fleets except Japanese F1 and Taiwanese F3 fleets, and with log-likelihood functions of size frequency data included only for F1 and F3 (named 'ASPMR_F1F3') was mainly used in analysis. The use of ASPMR_F1F3 as the EM was able to substantially reduce computation time (approximately -58%) as compared to the full SS3 EM. Among EM options considered, ASPMR_F1F3 appeared to be the best choice with respect to both saving computation time and estimation performance. For the explorative purpose of testing candidate harvest control rules (HCRs), the use of ASPMR_F1F3 as a tentative EM merits computation time reduction without degrading the estimation performance when conducting an enormous number of MSE simulation runs to test candidate HCRs.

1. Introduction

Upon a request from the Commission for the Conservation and Management of Highly Migratory Fish Stocks in the Western and Central Pacific Ocean (WCPFC), the International Scientific Committee for tuna and tuna-like species in the North Pacific Ocean (ISC) Pacific Bluefin Tuna Working Group (PBFWG) is in charge of developing a management strategy evaluation (MSE) to test potential management procedures (MP) for PBF. The ISC-PBFWG has been setting up the management strategy evaluation (MSE) framework since 2022 (Tommasi and Lee 2022, Tommasi et al. 2023). In the PBF MSE, the PBFWG plans to use the Stock Synthesis (SS3) software as the basis for the estimation model (EM). However, the EM based on the SS3 stock assessment requires substantial computation time for MSE simulations even when applying parallel computing. Consequently, this poses a time constraint for conducting a large number of simulation runs to evaluate candidate MPs under a wide array of uncertainty scenarios. As such, the PBFWG decided to consider the use of SS3 ASPM-R (Age-Structured Production Model with Recruitment deviations) as the EM alternative to the full assessment-like SS3 model (ISC-PBFWG 2022).

Based on the previous analysis (Takahashi et al. 2023a), the PBFWG suggested that the ASPM-R fitting to composition data (with fixed selectivities) could be used as a computationally efficient representation of the full SS model to reduce run times (ISC-PBFWG 2023). At the PBFWG meeting in November 2023, we reported comparisons of performance between SS3 ASPM-R (fitting to composition data with fixed selectivities) and full SS3 using these models as the EM in PBF MSE (Takahashi et al. 2023b). This document reports results of further exploration (using the latest PBF MSE platform) to determine what composition data needs to be included and what specifications of ASPM-R need to be considered.

2. Settings of MSE runs for this exploration

R function codes, input/data files, and SS3 (version V3.30.22.1) executable file available in the Github detommas/PBF_MSE repository were used. To use SS3 as ASPM-R for the EM, the

---

* Working document submitted to the ISC Pacific bluefin tuna Working Group, International Scientific Committee for Tuna and Tuna-Like Species in the North Pacific Ocean (ISC), from 10 to 13 December 2024, Webinar. **Document not to be cited without author's permission.**

relevant R function code, 'EM_fun_adj.R', was modified (added the ASPM-R switch). Related to this code modification, control.ss files for ASPM-R modified from 'ctl_PBF_2024_0309_BC.ss' were added to the 'PBF_MSE/Condition/1/SAM' directory. When the ASPM-R switch is on, it prompts the function to read one of the control.ss files for ASPM-R every time the EM function is called depending on choice of the option of ASPM-R specification (e.g., if the option of ASPM-R fitting to composition data from Fleet 1 and 3 is selected, then the function reads data from 'ctl_PBF_2024_0309_BC_qest_ASPMR_F1F3.ss' in which phase values of selectivity and time-varying selectivity for all fleets were set to negative and values of like_comp=6 for all fleets were set to 0 except for Fleet 1 and 3). The ASPM-R EM options considered in this document are described below.

The personal computer used for the MSE runs was Lenovo ThinkStation with a specifications: Intel(R) Core(TM) i9-9900 CPU @ 3.10GHz, 64.0 GB RAM, 64 bits Windows 11 Pro.

The harvest control rule, HCR #1 (referred to the candidate HCRs table in Tommasi et al. 2023), was used as an example MP (Fig. 1). Settings for simulation runs (time horizon, assessment cycle, etc.) were all the same as in ones defined in the codes in the current PBF_MSE repository including the "EM does stock assessment" switch on (sa=1) and observation error switch on/off (obse=2:off and 3:on). We fixed simulation iteration to specific one (specific only 1 iteration) and ran the PBF MSE code using the following three EM options and compared the results:

- full SS3 with no selectivity deviation
- SS3 ASPM-R with fixed selectivities for all fleets except Japanese F1JPN_LL(S4) and Taiwanese F3TWN_LLSouth fleets, and with log-likelihood functions of size frequency data included only for F1 and F3, named 'ASPMR_F1F3'
- In addition to ASPMR_F1F3 above, taken accounted for EPO purse saine F21EPO_COMM(2002-) fleets, named 'ASPMR_F1F3F21'.

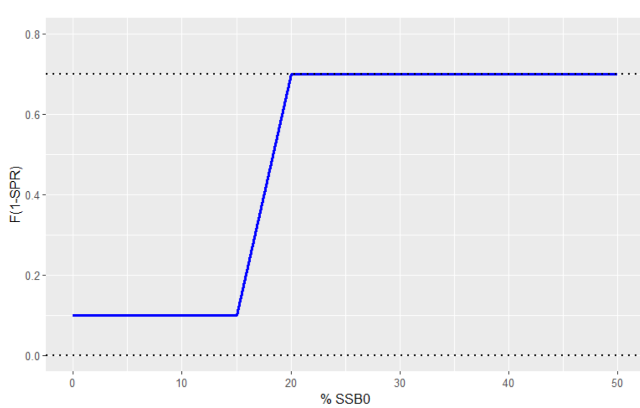


Fig. 1. Illustration of harvest control rule, HCR #1 (HCR1). HCR1 is characterized by: limit reference point = 15%$SSB_{F=0}$, threshold reference point = 20%$SSB_{F=0}$, target reference point = $F_{SPR30\%}$, minimum F = 10%F_{target}.

---

* Working document submitted to the ISC Pacific bluefin tuna Working Group, International Scientific Committee for Tuna and Tuna-Like Species in the North Pacific Ocean (ISC), from 10 to 13 December 2024, Webinar. **Document not to be cited without author's permission.**

3. Results

The results reported below were of the case of iteration #1 (set itr=1). We tried other iteration number cases (itr=5, 8, 14, 17). Results from these other cases also had similar tendencies to the iteration #1 case.

Run times of MSE simulation (for only one iteration) were approximately 10.2 hours for full SS3, 4.3 hours for ASPMR_F1F3, and 6.6 hours for ASPMR_F1F3F21. As expected in advance, the use of ASPM-R specification, especially of ASPMR_F1F3, substantially saved run times (approximately -58% computation time reduction).

As the time step advanced in simulations, computation time in each time step tended to become longer (Fig. 3). This may be because the models need more time for parameter estimation in future time steps (maybe due to increase of data).

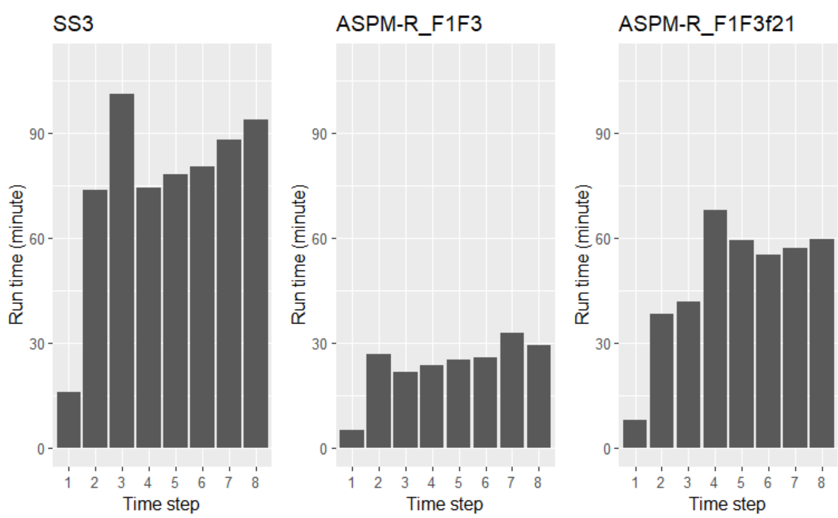


Fig. 3. Approximate computation time taken in each time step in MSE simulation (iteration #1 case, itr=1).

There were some differences in trajectories of future TAC among the three EM options (Fig. 4; note that the results were of no observation error, setting obse=2). Accordingly, the three EM options showed different trajectories of future SSB. Although the trajectories of the TAC and SSB differed among the EM options, when focusing on each EM only, the overall trajectory of TAC determined by HCR1 based on the result from that EM appeared to follow the trend of SSB.

To examine which EM better estimated the "true" SSB generated from the operating model (OM) of PBF MSE, future SSB trajectory generated from OM ("truth") was separately compared with that estimated from each EM (Fig. 5, also see Appendix 1 for other iteration cases). There were some differences between "true" SSB and EM-estimated SSB trajectories. The magnitude and pattern of the difference varies depending upon both EM option and iteration number. Among the three EMs, the difference was larger when using full SS3 as an EM and the SS3 EM tended to overestimate SSB. In the case of introducing observation error in MSE, the difference

* Working document submitted to the ISC Pacific bluefin tuna Working Group, International Scientific Committee for Tuna and Tuna-Like Species in the North Pacific Ocean (ISC), from 10 to 13 December 2024, Webinar. **Document not to be cited without author's permission.**

became blurred due to the presence of the error, but such tendency of the SS3 EM overestimating SSB still remained (Fig. 6, also see Appendix 2 for other iteration cases).

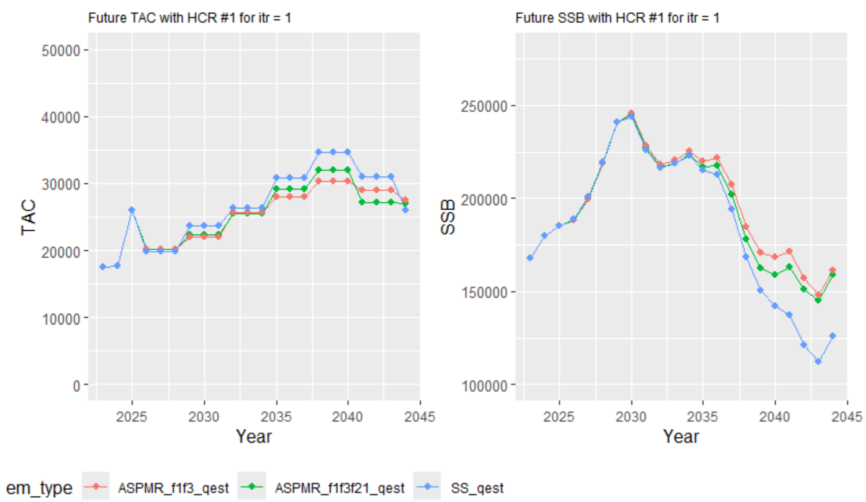


Fig. 4. Comparisons of future TAC and SSB trajectories among three EM options (full SS3, ASPMR_F1F3, and ASPMR_F1F3F21), resulted from MSE simulations (iteration #1 case, itr=1, with no observation error, obse=2) using HCR1.

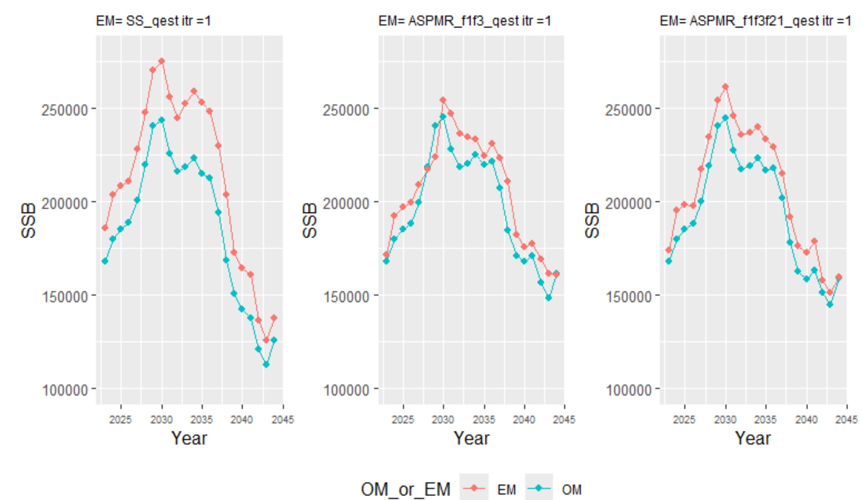


Fig. 5. Comparisons between future SSB trajectories generated from OM ("truth") and estimated from EM for three EM options (full SS3, ASPMR_F1F3, and ASPMR_F1F3F21), resulted from MSE simulations (iteration #1 case, itr=1, with no observation error, obse=2) using HCR1.

* Working document submitted to the ISC Pacific bluefin tuna Working Group, International Scientific Committee for Tuna and Tuna-Like Species in the North Pacific Ocean (ISC), from 10 to 13 December 2024, Webinar. **Document not to be cited without author's permission.**

Fig. 6. Comparisons between future SSB trajectories generated from OM ("truth") and estimated from EM for two EM options (full SS3 and ASPMR_F1F3), resulted from MSE simulations (iteration #1 case, itr=1, with observation error, obse=3) using HCR1.

4. Consideration points and the proposal for future PBF MSE work

Based on the results above, we summarize consideration points and the proposal for future PBF MSE work:

Consideration points

- The use of ASPM-R as an EM can substantially reduce computation time (approximately -58% time-saving when using ASPMR_F1F3), which allows the PBFWG to conduct an enormous number of simulation tests necessary for evaluating candidate HCRs under a variety of uncertainty scenarios in MSE.
- Among the three EM options considered, ASPMR_F1F3 appears to be the best choice with respect to both saving computation time and estimation performance.

Proposal

- During the exploring phase of the MSE process, use ASPMR_F1F3 as the tentative EM for reducing computation time reduction without degrading the estimation performance when conducting a large number of simulation runs to test candidate HCRs. Then, in the final evaluation/selection phase, conduct definitive MSE by switching the tentative EM to the full SS3 EM.
- Alternatively, take the above suggestion further and use ASPMR-F1F3 as the EM to conduct the entire MSE process, including the final evaluation/selection phase. Then, in actual implementation/operation, use the full SS3 as the EM.

---

* Working document submitted to the ISC Pacific bluefin tuna Working Group, International Scientific Committee for Tuna and Tuna-Like Species in the North Pacific Ocean (ISC), from 10 to 13 December 2024, Webinar. **Document not to be cited without author's permission.**

References

ISC (2022) Report of Pacific Bluefin Tuna Working Group Intersessional Workshop. The International Scientific Committee for tuna and tuna-like species in the North Pacific Ocean (ISC), 1–8 November 2022, online.

ISC (2023) Report of Pacific Bluefin Tuna Working Group Intersessional Workshop. The International Scientific Committee for tuna and tuna-like species in the North Pacific Ocean (ISC), 21–24 March 2023, Shinagawa, Tokyo, Japan.

Takahashi N, Tsukahara Y, Fukuda H (2023a) Considerations of the use of SS3 ASPM-R as an estimation model in PBF MSE. ISC/23/PBFWG-1/13 Working document submitted to the ISC Pacific Bluefin Tuna Working Group Workshop, 21–24 March 2023, Shinagawa, Tokyo, Japan.

Takahashi N, Tsukahara Y, Tommasi D, Fukuda H (2023b) Further considerations of the use of SS3 ASPM-R as an estimation model in PBF MSE. ISC/23/PBFWG-2/14 (Rev1) Working document submitted to the ISC Pacific Bluefin Tuna Working Group Workshop, 27 November – 1 December 2023, online.

Tommasi D, Lee H (2022) Overview of the preliminary Pacific bluefin tuna management strategy evaluation framework. ISC/22/PBFWG-2/06 Working document submitted to the ISC Pacific Bluefin Tuna Working Group Workshop, 1–8 November 2022, online.

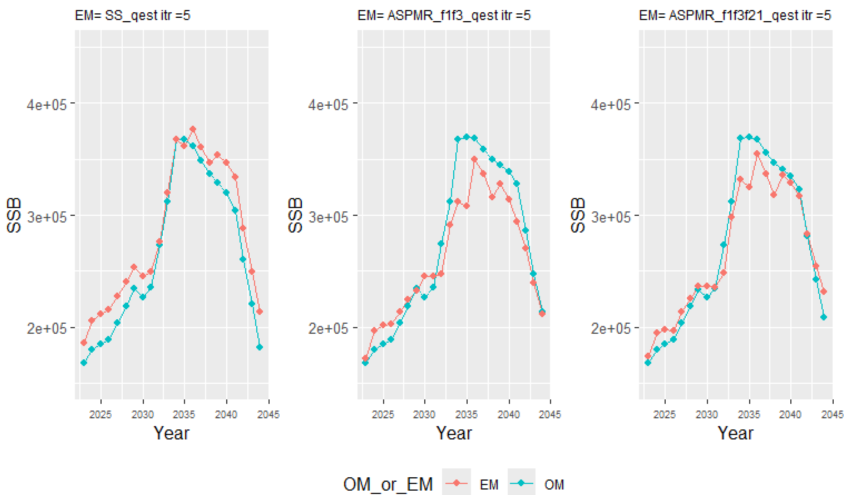
Tommasi D, Lee H, Fukuda H (2023) Implementation of new candidate harvest control rules in the management strategy evaluation for Pacific Bluefin Tuna. ISC/23/PBFWG-2/09 Working document submitted to the ISC Pacific Bluefin Tuna Working Group Workshop, 27 November – 1 December 2023, online.

* Working document submitted to the ISC Pacific bluefin tuna Working Group, International Scientific Committee for Tuna and Tuna-Like Species in the North Pacific Ocean (ISC), from 10 to 13 December 2024, Webinar.

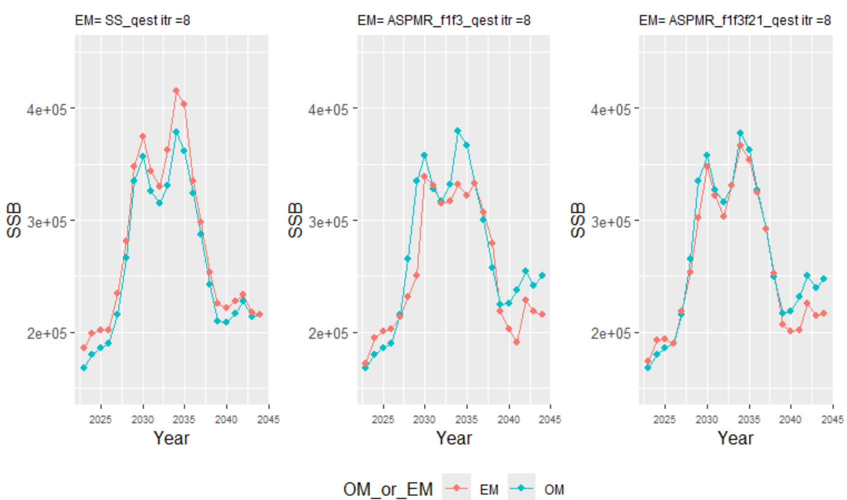
Appendix 1

Fig. A1. Comparisons between future SSB trajectories generated from OM ("truth") and estimated from EM for three EM options (full SS3, ASPMR_F1F3, and ASPMR_F1F3F21), resulted from other iterations (itr=5, 8, 14, and 17, with no observation error, obse=2) of MSE simulations using HCR1.

itr=5



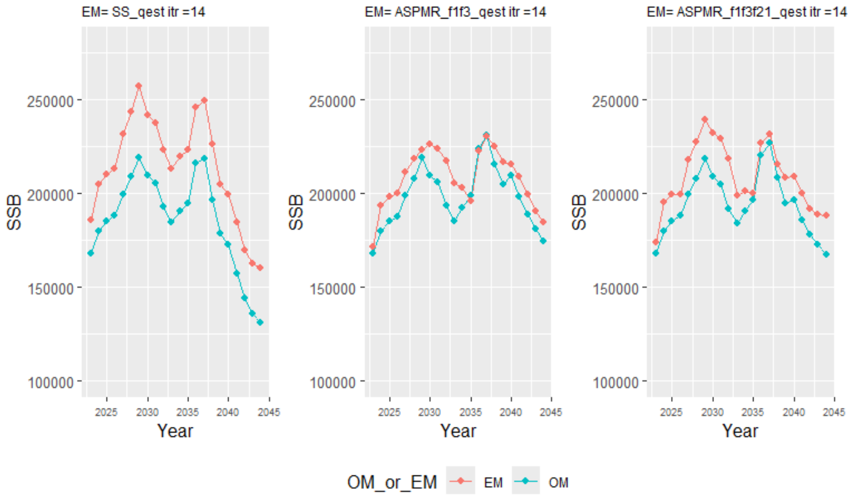
itr = 8



---

* Working document submitted to the ISC Pacific bluefin tuna Working Group, International Scientific Committee for Tuna and Tuna-Like Species in the North Pacific Ocean (ISC), from 10 to 13 December 2024, Webinar. **Document not to be cited without author's permission.**

itr = 14



itr = 17

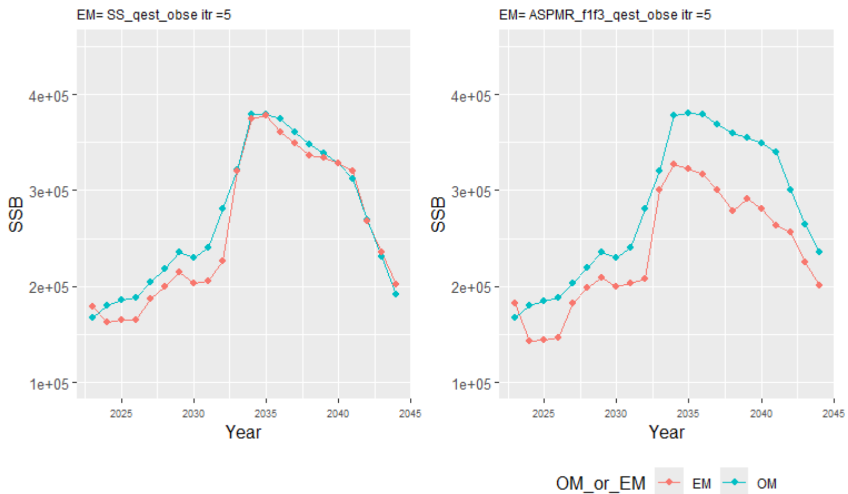
---

* Working document submitted to the ISC Pacific bluefin tuna Working Group, International Scientific Committee for Tuna and Tuna-Like Species in the North Pacific Ocean (ISC), from 10 to 13 December 2024, Webinar. **Document not to be cited without author's permission.**

Appendix 2

Fig. A2. Comparisons between future SSB trajectories generated from OM ("truth") and estimated from EM for three EM options (full SS3 and ASPMR_F1F3), resulted from other iterations (itr=5, 8, 14, and 17, with observation error, obse=3) of MSE simulations using HCR1.

itr=5



itr=8

* Working document submitted to the ISC Pacific bluefin tuna Working Group, International Scientific Committee for Tuna and Tuna-Like Species in the North Pacific Ocean (ISC), from 10 to 13 December 2024, Webinar. **Document not to be cited without author's permission.**

itr=14

itr=17

* Working document submitted to the ISC Pacific bluefin tuna Working Group, International Scientific Committee for Tuna and Tuna-Like Species in the North Pacific Ocean (ISC), from 10 to 13 December 2024, Webinar. **Document not to be cited without author's permission.**