NPFC
North Pacific Fisheries Commission

NPFC-2023-SSC PS11-Final Report

North Pacific Fisheries Commission
11th Meeting of the Small Scientific Committee on Pacific Saury

28–31 August 2023
Port Vila, Vanuatu

REPORT

Agenda Item 1. Opening of the Meeting

1. The 11th Meeting of the Small Scientific Committee on Pacific Saury (SSC PS11) was held in a hybrid format, with participants attending in-person in Port Vila, Vanuatu, or online via WebEx. The meeting was attended by Members from Canada, China, the European Union, Japan, the Republic of Korea, the Russian Federation, Chinese Taipei, the United States of America, and the Republic of Vanuatu. The Pew Charitable Trusts (Pew) attended as an observer. Dr. Larry Jacobson participated as an invited expert.

2. The meeting was opened by Dr. Toshihide Kitakado (Japan), the SSC PS Chair. He expressed his gratitude to Vanuatu for hosting the meeting and to the Vanuatu Department of Fisheries, the NPFC Secretariat, and the staff of the Warwick Le Lagon Hotel for making the arrangements for the meeting.

3. Mr. Sompert Gereva, Director of Fisheries, welcomed the participants to Port Vila on behalf of the host Member. He expressed Vanuatu's honor to host a series of important scientific meetings and noted that science forms the backbone of fisheries management. Mr. Gereva acknowledged the importance of Pacific saury to the NPFC and shared Members' concerns about the historically low level of the stock. Furthermore, he stated that Vanuatu, as a Small Island Developing State, recognizes the significance of balancing conservation and management with aspirations for fisheries development. Finally, Mr. Gereva reiterated his welcome to all participants and expressed his hope that their discussion would be productive and that their joint efforts would lead to fruitful outcomes for the conservation of NPFC fisheries resources.

4. The Science Manager, Dr. Aleksandr Zavolokin, outlined the procedures for the meeting.

5. Mr. Alex Meyer was selected as rapporteur.

Agenda Item 2. Adoption of Agenda

6. The agenda was adopted without revision (Annex A). The List of Documents and List of Participants are attached (Annexes B, C).

Agenda Item 3. Overview of the outcomes of previous NPFC meetings

3.1 SSC PS10 and SC07

7. The Chair presented the outcomes and recommendations from the SSC PS10 meeting and the 7th meeting of the Scientific Committee (SC07).

3.2 SWG MSE PS03

8. The Chair presented the outcomes and recommendations from the 3rd meeting of the joint SC-TCC-COM Small Working Group on Management Strategy Evaluation for Pacific saury (SWG MSE PS03).

3.3 COM07

3.3.1 CMM 2023-08 for Pacific Saury

9. The Science Manager presented the outcomes from the 7th Commission meeting, including an overview of Conservation and Management Measure (CMM) 2023-08 for Pacific Saury.

3.3.2 NPFC Performance Review

10. The Science Manager presented an overview of the NPFC Performance Review and outlined some recommendations from the Performance Review report that concern Pacific saury.

11. The Chair informed the SSC PS that he would draft the proposed response to these recommendations while liaising with the SC Chair and the Secretariat by the next SSC PS meeting in December 2023.

3.3.3 Resolution on Climate Change

12. The Science Manager presented an overview of the Resolution on Climate Change.

Agenda Item 4. Review of the Terms of References of the SSC PS and existing protocols

4.1 Terms of References of the SSC PS

13. The SSC PS reviewed and recommended an update to the Terms of References (ToR) of the SSC PS, adding a new item on exploring the impact of climate change on Pacific saury stock assessment and fishery performance (Annex D).

4.2 CPUE Standardization Protocol

14. The SSC PS reviewed the catch-per-unit-effort (CPUE) Standardization Protocol and determined that no revisions are currently necessary.

4.3 Stock Assessment Protocol

15. The SSC PS reviewed and updated the Stock Assessment Protocol, adding a new item on including relevant ecosystem considerations regarding the Pacific saury stock in future assessment documents (Annex E).

Agenda Item 5. Member's fishery status including 2023 fishery

16. The Science Manager presented the compiled data on Pacific saury catches in the northwestern Pacific Ocean from 1950 to 2022 (NPFC-2023-SSC PS11-WP01 (Rev. 1)).

17. The Science Manager presented the cumulative catch of Pacific saury as of mid-August in 2020, 2021, 2022 and 2023. The cumulative catch in 2023 is approximately 36,487 MT compared to 14,342 MT in 2022, 23,701 MT in 2021, and 9,875 MT in 2020.

18. Chinese Taipei presented its fisheries status (NPFC-2023-SSC PS11-IP01). The catch recovered to around 180,000 tons in 2018 and showed a declining trend until 2021. 93 vessels conducted fishing activities in 2021, and in 2022, the number decreased to 81. Standardized effort (catch/standardized CPUE) was 59,404 hauls in 2022. In 2023, the accumulated catch as of the end of July was 13,536 tons, which was more than that of the same period in 2022 (4,198 tons). Through July, the seasonal catch in 2023 was better than the previous year. From May to July 2023, the nominal CPUE has been about 2.22 tons/haul, which is more than that of the same period in 2022. Compared to 2022, fishing grounds were observed to be further north and more broadly distributed in 2023. Regarding the size box composition (s: >29 cm; 1: 27–31 cm; 2: 26–30 cm; 3: 24–29 cm; 4: 22–28 cm; 5: 20–26 cm), the mode size box for Pacific saury caught in June was 3, and the mode for those caught in July was 5.

19. China presented its fisheries status (NPFC-2023-SSC PS11-IP02). Total catch in 2022 was 35,477 MT. As of 15 August, the total catch in 2023 is 19,456 MT and a total of 55 vessels have been operating, a decrease of 8 from 2022. Accumulated catch in 2023 has been at its highest since 2013. As of 15 August, the nominal CPUE has been 10.05 MT/vessel/day, the highest since 2020. Standardized effort was 8,367 vessel days in 2022. The fishing grounds so far in 2023 have been to the northwest of those in 2022. A yearly comparison of body length compositions has been conducted up to 2018, using a size-length key provided by Japan. Biological measurements had been delayed by the COVID-19 pandemic and calculation of the

body length compositions for subsequent years is ongoing.

20. The SSC PS encouraged China to accelerate its efforts to calculate body length compositions for 2019 onwards and present the data ahead of the SSC PS12, or, if that is not possible, to provide any other relevant information, such as subsamples of the body length composition for 2019–2022.

21. Vanuatu presented its fisheries status (NPFC-2023-SSC PS11-IP03). Total annual catch peaked at 8,231 MT in 2018. Total catch in 2022 was 929 MT, the lowest after 2018. Vanuatu's Pacific saury fishery began in 2004. In total, it has authorized 16 vessels. The number of operating vessels was 4 from 2015 to 2021 and was 3 in 2022. Only 1 vessel is currently active in 2023. Annual comparison of accumulated catch shows a trend of abundance increasing from September. Looking at relative accumulated catch, in 2022, fishing operations began later than previous years and catch increased significantly from mid-September. Annual comparison of the relative seasonal catch shows that there are usually two peaks in the fishing season. In 2022, the first peak occurred slightly later than the one in 2021, while the second peak occurred at similar timings in both years. Nominal CPUE in 2022 was 5.7 MT/day. The main fishing grounds began in the east early in the season, before shifting to the west. Fishing grounds did not cross 165ºE longitude in 2021 and 2022. Looking at the monthly size box compositions in 2022 (s: >29 cm; 1: 27–31 cm; 2: 26–30 cm; 3: 24–29 cm; 4: 22–28 cm; 5: 20–26 cm), the percentage of size box 1 catches was very low.

22. Japan presented its fisheries status (NPFC-2023-SSC PS11-IP04 (Rev. 2)). In 2022, the annual catch was 18,064 MT, the lowest since 1950. Most of the Japanese fishing vessels had finished fishing for Pacific saury before the beginning of December. 112 vessels were registered, a decrease of 13 from the previous year. There were 12 small fishing vessels without any Pacific saury catch. The trend of accumulated catch in 2022 was similar to that in 2021. The catch exceeded 17,000 MT (97% of the annual catch) in the middle of November. The increment of relative cumulative catch has declined in recent years. In 2022, the catch exceeded 50% of the total in mid-October. Previously, the peak catch has been in October or September but more recently, it has been in November. In 2022, seasonal catch peaked at the beginning of November (4,632 MT), and then sharply dropped in the middle of the month. The maximum proportion of 10-day catch has increased in recent years, indicating that the duration of the fishing season is getting shorter. In 2022, nominal CPUE was 0.46, the lowest since 2000. Standardized effort was 66,903 hauls. The fishing grounds in August and September were located only in the high seas. The main fishing grounds were in the high seas by the end of November. In recent years, the fishing grounds in August have moved south. The fishing

grounds have moved eastward after 2018. About 70% of Pacific saury caught in 2022 were age-1 fish. The percentage of age-0 fish increased after October. Annual change of body length compositions for the whole fishing season and for the August to November period shows that the percent of age-1 fish has been high in the past two years. In 2023, Japanese Pacific saury fishing started in August. 109 vessels are registered. There has been no catch information so far.

23. Korea presented its fisheries status (NPFC-2023-SSC PS11-IP05). Total catch in 2022 was 3,438 MT, a new historical low following the historical low in 2021. In 2023, the catch until early August has increased by approximately 50% compared to the same period in the previous year. The number of vessels operating has gradually decreased each year from 2015 to 2022, and has decreased from 10 in 2022 to 5 in 2023 so far due to the continued low level of Pacific saury catch, but 1 or 2 of the rest of the vessels are expected to begin operations later in the season. Nominal CPUE was 2.33 MT/vessel/day in 2022, a historical low. Standardized effort was 2,122 days in 2022. So far in 2023, fishing grounds have been between 160°E and 170°E. In 2022, the overall body length range was 19–32 cm, with a mean value of 27.7 cm. The monthly mean body length was lowest in July and highest in October. By size box composition (S: 18–30 cm; M: 23–33 cm; L: 27–34 cm; 2L: 29–34 cm (fork length)), the ratio of S was the highest in May and December and the ratio of L-2L was the highest in November.

24. Russia informed the SSC PS that it has neither fished for nor caught Pacific saury since 2022. It reminded the SSC PS of the 2021 fisheries status information that it previously presented, namely that there continues to be a declining trend in catch, that the total catch in 2021 (610 MT) was the lowest since 1991, and that the CPUE in 2021 (4.2) was the lowest since 2000.

25. Canada presented its Pacific saury catch information (NPFC-2023-SSC PS11-IP06). Canada does not have a commercial fishery targeting Pacific saury, but occasionally takes Pacific saury as bycatch. No bycatch of Pacific saury has been taken by commercial fishing since 2020. It should be noted that historical survey catches focused primarily on Salmonids and at times the bycatch species (including Pacific saury) were not entered in the databases. There is an effort underway to include bycatch species, so it is likely that the historical numbers will be updated in future. The peak of observed Pacific saury lengths was ~28 cm. Pacific saury has been found to be a regular component of the diet of seabirds in British Columbia, such as Rhinoceros Auklets, and has also sometimes been found in the diet of adult salmon.

Agenda Item 6. Fishery-independent abundance indices

6.1 Review of results of abundance estimation including 2023 Japanese biomass survey

26. Japan presented a report of its 2023 biomass survey (NPFC-2023-SSC PS11-IP07). The Japanese biomass survey was conducted with three research vessels, all using the same type of trawl. The survey was conducted at 103 stations from 6 June to 9 July and covered the area from 143°E to 177°W. It was not possible to survey the area east of 173°W this year due to the occurrence of an emergency situation. 30,259 individuals were caught in the survey. Pacific saury occurred between 151°E and 177°W. The age-1 fish were mainly distributed between 163°E and 175°E.

27. Japan presented the Japanese survey biomass index of Pacific saury up to 2023 using the Vector Autoregressive Spatio-temporal (VAST) model (NPFC-2023-SSC PS11-WP11). Japan applied the VAST model to Japanese fishery-independent survey data to predict Pacific saury distribution and estimate biomass index from 2003 to 2023. The estimated biomass index from the selected VAST model with minimum Akaike information criterion (AIC) indicated similar year trends with the index from a design-based approach. In 2020, the estimated biomass index dropped to the lowest level historically since 2003, before recovering but remaining at a low level in 2023. Japan recommended using the estimated biomass index, like the previous year, in the BSSPM stock assessment because the CVs of biomass indices in 2023 were at a comparable level to those of other years, except for the significantly high CV in 2020.

28. The SSC PS agreed to use the Japanese survey biomass index of Pacific saury up to 2023 using the VAST model as an input for the stock assessment.

29. Japan presented an evaluation of vessel effects in the Japanese biomass survey for Pacific saury (NPFC-2023-SSC PS11-WP09). Japan evaluated research vessel effects and fishing gear effects in the application of the VAST model to Japanese fishery-independent survey data from 2003 to 2022. The incorporation of these effects in the VAST model only resulted in a small improvement in AIC, and there seems to be little advantage to doing so. Furthermore, because many of the vessels were assigned to specific periods and sea areas, the estimated catchability for each vessel and gear seemed to contain not only the effects of vessel and/or gear abilities but also the effects of period and sea area assigned for each vessel. These effects could not be separated from the effects of catchability. Therefore, Japan did not support the inclusion of the estimated vessel/gear effects in the estimation of the biomass index.

30. The SSC PS noted that the recent biomass survey and CPUE data show different trends since 2018, with the CPUE data declining steadily during 2018–2022, while the survey data dropped rapidly during one year to the time series low in 2020 and then increasing rapidly over one year to higher values in 2021–2023. The SSC PS suggested that the appearance of the recent survey

decline was driven largely by the anomalously low survey biomass estimate in 2020, which was likely due to the large area that was not surveyed that year, and agreed that the apparent changes in stock biomass implied by the survey data for 2019–2021 were too rapid to be biologically plausible. The SSC PS agreed that the 2020 survey observation is likely to have little effect on this year's BSSPM biomass estimates because the large CV will down-weight the observation in fitting the model, as in the previous assessment, so additional modifications to the assessment model are not required. Some sensitivity analysis will be carried out as well.

31. The invited expert pointed out the importance of improving the approach to extrapolation in the VAST model because such sampling problems occur periodically.

6.2 Review of plans of future biomass surveys

32. Japan stated that it would present its future biomass survey plans at the SSC PS12 meeting.

6.3 Recommendations for future work

33. The SSC PS suggested that Japan confirm the assumption that the distribution pattern of Pacific saury is similar from year to year by conducting retrospective analyses of the VAST model removing the terminal years' data.

34. The SSC PS suggested that Japan conduct simulation analyses to investigate the consequences of different reductions of the survey area on the biomass survey results because portions of the survey area are missed periodically due to unavoidable circumstances.

35. The SSC PS suggested that Japan conduct simulations to test the performance of the VAST model using different sizes of survey area. The SSC PS noted that this might also inform discussions on the conditioning of operating models for testing harvest control rules and/or management procedures to account for periodic unforeseen deviations from the survey plan and management procedures that might deal with them, as well as distribution patterns and migration of Pacific saury.

36. The SSC PS suggested that, in the event that the survey area is reduced again in future, it would be worthwhile checking the robustness of the biomass estimates by examining the residual patterns in space and time.

37. At the request of the SSC PS, Japan presented a preliminary comparison of the biomass estimates for the age-0 fish against the age-1 fish with a one-year delay. The correlation between the age-0 and age-1 fish with a one-year delay was 0.55. The SSC PS considered this

result to be encouraging because it supported the development of age-structured models, demonstrated generally consistent results from the survey, and may be used to improve future assessments.

38. The SSC PS noted that the distribution of Pacific saury appears to be shifting further offshore (eastward) and to the north. The SSC PS discussed whether or not it would be appropriate and possible to adjust the survey design in response to this shift.

39. Japan explained that it is possible to expand the survey northward if the weather allows it and extra ship time becomes available during the survey period and that Japan has tried to do so. However, expansion eastward would be very difficult logistically for reasons including the fuel limitation of research vessels, the limited period during which research vessels are available for the Pacific saury survey, and limited simultaneous availability of vessels and researchers for conducting the survey. Furthermore, keeping a consistent survey area would be important from the viewpoint of monitoring. Japan invited other Members to engage in surveys in more eastern areas.

40. The SSC PS noted that expansion of the survey farther offshore could be beneficial scientifically but would be difficult because of serious logistical problems, disruption of long-term sampling patterns, and additional costs. However, potential benefits should be considered as survey plans evolve, particularly if additional resources become available. Such resources might include sampling by other Members using additional vessels based in eastern ports.

41. Russia reminded the SSC PS that it conducts annual summer surveys for Pacific salmon and chub mackerel in areas mostly north of the Japanese biomass survey and that Pacific saury are sometimes caught in these surveys.

42. The invited expert suggested that logbook data that record locations where saury were caught are readily available and may be useful in improving the Japanese survey area. He cautioned, however, that it would be important, in such an analysis, to use logbook data collected during the survey season.

43. The SSC PS noted that the survey area had been reduced in 2020 and, to a lesser extent, in 2023 due to unforeseen circumstances. The SSC PS noted that this will probably occur again in the future, as is the case with other surveys around the world, and potentially result in reduced precision in biomass estimates and impact the effectiveness of a HCR. The SSC PS agreed that such a scenario should be carefully considered in evaluating the robustness of potential HCRs

and could constitute an "exceptional circumstance."

Agenda Item 7. Fishery-dependent abundance indices

7.1 Review of Members' standardized CPUEs up to 2022

44. Chinese Taipei presented a standardization of CPUE data for Pacific saury from 2001 to 2022 using a generalized additive model (GAM) on the assumption of lognormal distribution of errors (NPFC-2023-SSC PS11-WP02). Chinese Taipei recommended using the standardized CPUE derived from GAM as input for the stock assessment.

45. The SSC PS agreed to use Chinese Taipei's standardized CPUE derived from GAM as an input for the stock assessment.

46. Russia presented a standardization of CPUE data for Pacific saury from 1994 to 2021 using a generalized linear model (GLM) (NPFC-2023-SSC PS11-WP03). Russia recommended using the standardized CPUE derived from GLM as input for the stock assessment.

47. The SSC PS agreed to use Russia's standardized CPUE derived from GLM as an input for the stock assessment.

48. China presented a standardization of CPUE data for Pacific saury from 2013 to 2022 using GLM and GAM on the assumption of lognormal distribution of errors (NPFC-2023-SSC PS11-WP04). China recommended using the standardized CPUE derived from GAM as an input for the stock assessment.

49. The SSC PS agreed to use China's standardized CPUE derived from GAM as an input for the stock assessment.

50. Korea presented a standardization of CPUE data for Pacific saury from 2001 to 2022 using GLM (NPFC-2023-SSC PS11-WP05 (Rev. 1)). Korea recommended using the standardized CPUE derived from GLM as input for the stock assessment.

51. The SSC PS agreed to use Korea's standardized CPUE derived from GLM as an input for the stock assessment.

52. Japan presented a standardization of CPUE data for Pacific saury from 1994 to 2022 using GLM (NPFC-2023-SSC PS11-WP06). Japan recommended using the standardized CPUE derived from GLM as input for the stock assessment.

53. The SSC PS agreed to use Japan's standardized CPUE derived from GLM as an input for the stock assessment.

54. Japan presented a preliminary standardization of CPUE data for Pacific saury from 1994 to 2022 using the VAST model (NPFC-2023-SSC PS11-WP07). Japan explained that incorporating monthly (seasonal) effects in CPUE standardization is particularly important for species like Pacific saury that migrate over a large sea area within the same year and that it therefore conducted a preliminary analysis using two simple approaches to address monthly (seasonal) effects on Pacific saury density (Approach 1: year-season time steps; Approach 2: Density covariate). Japan confirmed that the VAST model can derive a similar year trend of standardized abundance index as the GLM, and that the estimated seasonal sea surface temperature (SST) effects and spatial distribution reflected the characteristics of the collected fishery data. However, there are concerns with these two approaches. First, although there is a seven-month gap between the November and December season and the August season, the degree of autocorrelation between each time step was assumed to be the same in Approach 1. Second, Approach 2 did not account for monthly autocorrelation. Japan expressed its intention to continue to further develop this analysis to address these concerns and derive a more reliable abundance index for Pacific saury using the VAST model.

7.2 Review of joint CPUE

55. Chinese Taipei presented a joint CPUE standardization of Pacific saury in the Northwestern Pacific Ocean from 1994 to 2022 using a VAST model (NPFC-2023-SSC PS11-WP12). Step plots indicated that the spatial and spatio-temporal effects had large influences on the time series of estimated CPUE among all variables compared to the other effects in VAST. The results indicated that the annual standardized CPUE trend had a fluctuating pattern over the studied periods, and the annual standardized CPUE value in 2022 was slightly decreased compared to 2021. The correlation analysis indicated that the joint index could resolve the issue of inconsistency among individual indices.

56. The SSC PS agreed to use the standardized joint CPUE as an input for the stock assessment.

57. The SSC PS noted that the current joint CPUE would reduce the uncertainty for the Pacific saury stock assessment.

58. The SSC PS noted that catchability may be a potential issue for the standardization of the joint CPUE index, such as changes of fishing equipment or fishing vessel sizes.

59. The finalized table of abundance indices is attached to the report as Annex F. A plot of Members' standardized CPUEs is attached to the report as Annex G.

7.3 Recommendations for future work

60. The SSC PS noted that the relationship between Pacific saury distribution and SST differed by area or period between the model used for the Japanese biomass survey index and the model used for the joint CPUE standardization index. The SSC suggested that Japan and Chinese Taipei examine the residual plots for their models and try to identify any hidden mechanism to explain this difference, such as sea surface height, sea surface temperature, time of day (day/night), or other environmental factors.

61. The SSC PS considered that the sharing of finer-resolution catch and effort data among Members could enable the joint CPUE standardization index to be estimated more reliably and agreed to discuss this further at SSC PS12.

Agenda Item 8. Biological information on Pacific saury

8.1 Review of any updates and progress

62. Japan presented an index of Pacific saury fecundity based on the estimated number of eggs spawned per fish per day (NESFD) of age-0 fish by winter field sampling in 2015, 2020, 2021, and 2022 (NPFC-2023-SSC PS11-WP08). Japan compared estimated NESFD of age-0 fish to that of age-1 fish provided by previous studies to understand the difference in fecundity among ages. Estimated NESFD of age-0 fish in winter was lower than that of age-1 fish in winter estimated by the previous study. The estimated NESFD of age-1 fish for other seasons was also higher than age-0 fish in winter. Furthermore, given the age-specific body weight in winter, NESFD per body weight of age-0 fish was also lower than that of age-1 fish, suggesting non-proportional fecundity to spawning stock biomass. These results stem from the lower spawning frequency and smaller amount of batch fecundity of age-0 than age-1 fish. Assuming the general rule that larger or older fish have longer spawning seasons, Japan considered that age-1 fish spawn more eggs per fish per spawning period than age-0 fish. Based on this study, Japan recommended to not assume equal fecundity for age-0 and age-1 fish when conducting stock assessments of Pacific saury using age-structured models.

8.2 Distribution and migration patterns of juvenile Pacific saury

63. No information on distribution and migration patterns of juvenile Pacific saury was provided. The SSC PS encouraged Members to present such information at SSC PS12.

8.3 Recommendations for future work

64. At the request of the SSC PS, Japan presented a plot of batch fecundity against body weight for age-0 and age-1 Pacific saury across different years and seasons, a plot of the proportion of age-0 fish that spawned during the first spawning season (PSFS) by year, and a plot of PSFS against the mean body weight of age-1 fish.

65. The SSC PS encouraged Japan to continue to update these figures as new data become available and present them at future meetings.

66. The SSC PS noted that the estimation of spawning stock biomass is difficult due to the small contribution of age-0 fish to recruitment, as well as rapid rates of growth, maturity and mortality.

67. The SSC PS encouraged Members to continue investigating the relationship between spawning stock biomass and recruitment, recognizing its importance for developing an age-structured assessment model and for setting HCRs.

Agenda Item 9. Stock assessment using "provisional base models" (BSSPM)

68. The Chair reminded the participants of the timeline for data preparation and the procedure for initial investigations among research groups (China, Japan and Chinese Taipei), which were agreed in the intersessional meetings. On behalf of the research groups, the Chair presented the combined preliminary results of their MCMC runs across the two base cases (NPFC-2023-SSC PS11-WP13).

69. The SSC PS noted that it used an accelerated stock assessment process this year to allow time for work on MSE. This was possible because BSSPM procedures are well developed and understood. It may be advisable to use the accelerated schedule in future, if possible, to allow time for work on other important topics, such as age-structured models.

9.1 Review and update of the existing specification

70. The SSC PS reviewed the existing specification of the stock assessment BSSPM and agreed to follow it again for this year's stock assessment.

9.2 Recommendations for future work

71. The SSC PS noted that there continues to be differences in scale among the three Members' preliminary results and agreed to continue to explore the reasons behind it.

72. The SSC PS agreed to test the code of Members' BSSPM models in the intersessional period

prior to SSC PS12 by running all of them with the same priors and input data and comparing the results.

73. The SSC PS agreed to produce time series of the box plots of the process errors for each base model and present them at SSC PS12, and to include the median values of the process errors in the table of biomass estimates.

74. The SSC PS agreed to use the MCMC output median value and the distribution of the MCMC output as starting points for the base case operating models.

75. As a default, the SSC PS agreed to use the estimated error in the stock assessment to produce future simulated total allowable catch (TAC) estimates in the HCR simulations.

Agenda Item 10. New stock assessment models

10.1 Data available

76. Japan presented a comparison of season-, area-, and Member-specific size composition of Pacific saury using catch-at-size (CAS) data (NPFC-2023-SSC PS11-WP10). Japan conducted the study for the purpose of facilitating discussion on how to include the CAS information into stock assessment models. The fish size distributions showed distinct patterns in inshore and offshore areas in some years, seasons, and Members, indicating differences in the fish availability between the two areas. There were only three grids in which all Member's data ware available during 2014–2018 (two grids in October 2016 and one grid in September 2017). The comparison of size distribution among Members also showed that the shapes of the histograms were not similar in some cases, indicating that the size selectivity varied among Members. Japan suggested that incorporating these results into the current and future stock assessment models might improve the performance of the stock assessment and, to that end, further investigation focusing on Members' tendencies in fish availability and selectivity would likely be meaningful.

77. Japan presented its updated age-length key (ALK) with data for 2022. Japan explained that it applied the age determination method set out in NPFC-2020-SSC PS06-WP16.

78. The SSC PS agreed on an interim basis to continue to use the Japanese ALK going forward. At the same time, it recognized that there may potentially be a need to develop an ALK stratified by inshore/offshore or by area and requested Japan to consider this issue and present its recommendation at SSC PS12.

79. Chinese Taipei informed the SSC PS that it has an ALK for offshore Pacific saury and offered to share it with Japan and other Members on the Collaboration site.

80. The SSC PS encouraged other Members to develop and present their own ALKs, if possible.

10.2 Review of any progress on new stock assessment models

81. Chinese Taipei presented its ongoing work to develop a preliminary stock assessment model in Stock Synthesis 3.30 (SS3) for Pacific saury in the Northwestern Pacific Ocean. Chinese Taipei first presented this work at SSC PS09 (NPFC-2022-SSC PS09-WP10).

82. The SSC PS welcomed the work done by Chinese Taipei.

83. Japan presented its previous work to develop a state-space age-structured stock assessment model for Pacific saury. Japan first presented this work at SSC PS07 (NPFC-2021-SSC PS07-WP21).

84. The SSC PS welcomed the work done by Japan.

85. The SSC PS invited other Members to also present any new stock assessment models at future meetings.

10.3 Finalization of specification for new stock assessment models

86. The SSC PS compiled a table with the specifications of the SS3 model and the state-space age-structured model presented by Chinese Taipei and Japan (Annex H).

10.4 Recommendations for future work

87. The SSC PS agreed to establish a Technical Working Group on New Stock Assessment Models (TWG NSAM) to further develop the SS3 model and the state-space age-structured model. The SSC PS agreed that, to enhance collaboration and transparency, the code for the models should be shared among the participants of the SSC PS.

88. The SSC PS agreed that, in addition to the invited expert Dr. Larry Jacobson, the Technical Working Group should also include a technical expert. The SSC PS agreed to seek candidates from among Members to serve as the technical expert or, if that is not possible, to consider seeking funding to hire an external expert. The members of the TWG NSAM are as follows: Toshihide Kitakado (Lead, Japan), Chris Rooper (Canada), Libin Dai (China), Shinichiro Nakayama (Japan), Hyejin Song (Korea), Vladimir Kulik (Russia), Yi-Jay Chang (Chinese

Taipei), Jhen Hsu (Chinese Taipei), Erin Bohaboy (USA), Ada Sokach (Vanuatu), Larry Jacobson (invited expert).

89. The SSC PS agreed that it should eventually decide on a single new model for conducting the Pacific saury stock assessment, rather than taking an ensemble approach.

Agenda Item 11. Progress on development and evaluation of an interim harvest control rule (HCR) as a short-term task

11.1 Review of conditioning of operating models (OMs)

90. The Chair presented the outcomes of previous meetings relating to management objectives, reference points, tuning criteria, conditioning of OMs, and possible/candidate HCRs, and ongoing progress towards the development and evaluation of an interim HCR as a short-term task (NPFC-2023-SSC PS11-WP17). The information in the paper had also been presented at the intersessional SSC PS meetings.

91. The Chair presented a draft paper on the specification of simulation for testing HCRs (NPFC-2023-SSC PS11-WP18) for further refinement by the SSC PS.

92. The invited expert presented an analysis of the statistical properties of potential process errors in *K* (carrying capacity) and *r* (intrinsic rate of increase) based on the 2022 Pacific saury stock assessment (NPFC-2023-SSC PS11-WP19), with the aim informing the design of the simulations for evaluating HCRs for Pacific saury. Annual overall process errors (as used in the current assessment model), process errors in *r*, and process errors in *K* can be calculated to give the same resulting biomass and annual productivity values in the last assessment. Such process errors in *r* and *K* are highly correlated (rho=0.75). The invited expert suggested that there seems to be no need to conduct HCR simulations with all three types of process errors. Rather, the overall process errors are simpler, already used in the assessment model, and perhaps the best option for use in simulations.

93. The SSC PS reviewed and refined the draft specification of simulation for testing HCRs (NPFC-2023-SSC PS11-WP18 (Rev. 1)). The SSC PS requested that the SWG MSE PS continue to discuss and finalize the specification, including the management objectives, so that simulation work can commence as scheduled.

11.2 Review of candidate harvest control rules (HCRs)

94. The SSC PS reaffirmed the value of HCR2 and HCR3 in that they allow for the adjustment of the total allowable catch based on the stock assessment result one year ago during the fishing

season, which is important in light of Pacific saury's short lifespan and interannual fluctuation in recruitment strength. At the same time, the SSC PS also recognized that, compared to HCR0 and HCR1, which are simpler and commonly used, HCR2 and HCR3 include additional components that would necessitate a heavier and more time-consuming computational workload. The SSC PS also formulated an additional HCR based on a flat catch rate (HCR000) and recommended that this should be considered alongside HCR0 and HCR1 if, for example, the MSE process initially focuses on these simpler HCRs. The SSC PS requested SWG MSE PS04 to choose from the proposed HCR options in NPFC-2023-SSC PS11-WP18 (Rev. 1) and specify which options will be evaluated. The SSC PS recommended that this be a manageable number of options for meeting the deadline set by the Commission.

95. The SSC PS noted that its decisions for the HCR analysis were made early in the process and that modifications to the specifications will be required as software is developed and analyses are carried out. Such changes must be clearly described and explained to Members so they can review, agree/disagree and make suggestions. Also, the review and comment process must be fast given time constraints. The SSC PS agreed that the Chair should inform all Members of important changes, discuss them with interested Members by correspondence as necessary, and record any changes that are agreed upon. As it is necessary to complete the draft simulation work by SSC PS12, it will be important to strike the right balance between scientific detail and the development of an interim HCR in the time available.

11.3 Recommendations for future work

96. The SSC PS agreed to continue to progress its work in line with the timeline and tasks agreed to at the SWG MSE PS03 meeting (SWG MSE PS03 Report, Annex E).

Agenda Item 12. Other matters

12.1 Observer Program

97. The Science Manager reminded the SSC PS of information he had previously presented regarding the establishment of a regional NPFC observer program, including background information, the nature of Members' respective observer programs, and work done to identify data gaps and needs that could be filled by a regional observer program.

98. The SSC PS agreed that there are specific data gaps from the Pacific saury fisheries. These include age, size, weight and fecundity information from Members' catch. The implementation of a regional observer program could enable the efficient and standardized collection of data that would improve the Pacific saury stock assessment, especially as the SSC PS moves towards the use of an age-structured model and data requirements become more demanding.

99. The SSC PS agreed that there are also specific gaps in information about fishing trips and individual hauls that hinder stock assessment work (e.g., fishing locations, time, bycatch, number of hauls, SST, gear characteristics, etc.). Such data are often recorded in logbooks or by observers.

100. The SSC PS recommended that the development and implementation of a regional observer program be guided by the data needs that the SSC PS has identified.

12.2 Draft agenda, priority issues and timeline for next meeting

101. The SSC PS drafted the provisional agenda for SSC PS12.

102. The SSC PS agreed on the following priorities for the next meeting:

(a) Finalize technical work for evaluating HCRs.
(b) Review progress on the development of age-structured stock assessment models and finalize a set of models and specification.
(c) Review progress on the BSSPM analyses and provide management advice.
(d) Discuss possible effects of retrospective patterns and scaling issues on Members' assessments.

12.3 Other

103. No other issues were discussed.

Agenda Item 13. Adoption of the Report

104. The SSC PS11 Report was adopted by consensus.

Agenda Item 14. Close of the Meeting

105. The SSC PS thanked the Chair for leading a successful meeting.

106. The Chair thanked the participants for their engagement and cooperation, the invited expert for his guidance, the Secretariat and the Rapporteur for their support, and Vanuatu for hosting the meeting.

107. The meeting closed at 12:40 on 31 August 2023, Port Vila time.

Annexes:

Annex A – Agenda

Annex B – List of Documents

Annex C – List of Participants

Annex D – Terms of Reference for the Small Scientific Committee on Pacific Saury

Annex E – Revised Stock Assessment Protocol for Pacific Saury

Annex F – Updated total catch, CPUE standardizations and biomass estimates for the stock assessment of Pacific saury

Annex G – Time series of Members' standardized CPUE and joint standardized CPUE from 1980-2022 and Japanese survey index from 2003-2023

Annex H – Specifications of the Stock Synthesis 3 model and the state-space age-structured model

Annex A

Agenda

Agenda Item 1. Opening of the Meeting

Agenda Item 2. Adoption of Agenda

Agenda Item 3. Overview of the outcomes of previous NPFC meetings
- 3.1 SSC PS10 and SC07
- 3.2 SWG MSE PS03
- 3.3 COM07
  - 3.3.1 CMM 2023-08 for Pacific Saury
  - 3.3.2 NPFC Performance Review
  - 3.3.3 Resolution on Climate Change

Agenda Item 4. Review of the Terms of References of the SSC PS and existing protocols
- 4.1 Terms of References of the SSC PS
- 4.2 CPUE Standardization Protocol
- 4.3 Stock Assessment Protocol

Agenda Item 5. Member's fishery status including 2023 fishery

Agenda Item 6. Fishery-independent abundance indices
- 6.1 Review of results of abundance estimation including 2023 Japanese biomass survey
- 6.2 Review of plans of future biomass surveys
- 6.3 Recommendations for future work

Agenda Item 7. Fishery-dependent abundance indices
- 7.1 Review of Members' standardized CPUEs up to 2022
- 7.2 Review of joint CPUE
- 7.3 Recommendations for future work

Agenda Item 8. Biological information on Pacific saury
- 8.1 Review of any updates and progress
- 8.2 Distribution and migration patterns of juvenile Pacific saury
- 8.3 Recommendations for future work

Agenda Item 9. Stock assessment using "provisional base models" (BSSPM)
- 9.1 Review and update of the existing specification
- 9.2 Recommendations for future work

Agenda Item 10. New stock assessment models
- 10.1 Data available
- 10.2 Review of any progress on new stock assessment models
- 10.3 Finalization of specification for new stock assessment models

10.4 Recommendations for future work

Agenda Item 11. Progress on development and evaluation of an interim harvest control rule (HCR) as a short-term task

11.1 Review of conditioning of operating models (OMs)
11.2 Review of candidate harvest control rules (HCRs)
11.3 Recommendations for future work

Agenda Item 12. Other matters

12.1 Observer Program
12.2 Draft agenda, priority issues and timeline for next meeting
12.3 Other

Agenda Item 13. Adoption of Report

Agenda Item 14. Close of the Meeting

Annex B

List of Documents

MEETING INFORMATION PAPERS

Symbol	Title
NPFC-2023-SSC PS11-MIP01	Meeting Information
NPFC-2023-SSC PS11-MIP02	Provisional Agenda
NPFC-2023-SSC PS11-MIP03 (Rev. 1)	Annotated Indicative Schedule

WORKING PAPERS

Symbol	Title
NPFC-2023-SSC PS11-WP01 (Rev. 1)	Compiled data on Pacific saury catches in the northwestern Pacific Ocean
NPFC-2023-SSC PS11-WP02	Standardized CPUE of Pacific saury (*Cololabis saira*) caught by the Chinese Taipei stick-held dip net fishery up to 2022
NPFC-2023-SSC PS11-WP03	Standardized CPUE of Pacific saury (*Cololabis saira*) caught by the RUSSIA's stick-held dip net fishery up to 2021
NPFC-2023-SSC PS11-WP04	Standardized CPUE of Pacific saury (*Cololabis saira*) caught by the China's stick-held dip net fishery up to 2022
NPFC-2023-SSC PS11-WP05 (Rev. 1)	Standardized CPUE of Pacific saury (*Cololabis saira*) caught by the Korean's stick-held dip net fishery up to 2022
NPFC-2023-SSC PS11-WP06	Standardized CPUE of Pacific saury (*Cololabis saira*) caught by the Japanese stick-held dip net fishery up to 2022
NPFC-2023-SSC PS11-WP07	Preliminary application of the VAST model in CPUE standardization for the Japanese fishery of Pacific saury
NPFC-2023-SSC PS11-WP08	Age-specific fecundity of Pacific saury
NPFC-2023-SSC PS11-WP09	Evaluation of vessel effects in Japanese biomass survey for Pacific saury
NPFC-2023-SSC PS11-WP10	Comparing season-, area-, and member-specific size composition of Pacific saury using catch-at-size (CAS) data
NPFC-2023-SSC PS11-WP11	Japanese survey biomass index of Pacific saury up to 2023 using VAST model

NPFC-2023-SSC PS11-WP12	Joint CPUE standardization of the Pacific saury in the Northwest Pacific Ocean by using the spatio-temporal modelling approach
NPFC-2023-SSC PS11-WP13	Combine 3 members' MCMC
NPFC-2023-SSC PS11-WP14	2023 updates on Pacific saury stock assessment in the North Pacific Ocean using Bayesian state-space production models
NPFC-2023-SSC PS11-WP15	Preliminary updates of stock assessment for Pacific saury in the North Pacific Ocean up to 2023
NPFC-2023-SSC PS11-WP16	Preliminary updates of stock assessment of Pacific saury (*Cololabis saira*) in the Western North Pacific Ocean through 2022
NPFC-2023-SSC PS11-WP17	Background paper on "Development of HCR for Pacific saury for the short-term objective "
NPFC-2023-SSC PS11-WP18	Draft paper on specification of simulation for testing HCR
NPFC-2023-SSC PS11-WP19	Variability in r and K for Pacific saury based on stock assessment results
NPFC-2022-SSC PS09-WP10	Preliminary stock assessment model in Stock Synthesis 3.30 for the Pacific saury in Northwestern Pacific Ocean
NPFC-2021-SSC PS07-WP21	An example state-space age-structured stock assessment model for Pacific saury

INFORMATION PAPERS

Symbol	Title
NPFC-2023-SSC PS11-IP01	Pacific saury fishery status - Chinese Taipei
NPFC-2023-SSC PS11-IP02 (Rev. 1)	Fishery Status of PS in China including 2023
NPFC-2023-SSC PS11-IP03	Fishery Status for Pacific saury from Vanuatu
NPFC-2023-SSC PS11-IP04 (Rev. 2)	Pacific saury fishing condition in Japan in 2022 and 2023
NPFC-2023-SSC PS11-IP05	Korean Stick-held dip net (SHDN) Fishery Status up to 2023
NPFC-2023-SSC PS11-IP06	Saury Catch in Canada (updated for 2023)
NPFC-2023-SSC PS11-IP07	2023 Japanese biomass survey

REFERENCE DOCUMENTS

Symbol	Stock assessment protocol for Pacific Saury
NPFC-2023-SSC PS11-RP01	1st intersessional SSC PS meeting summary

NPFC-2023-SSC PS11-RP02	2nd intersessional SSC PS meeting summary
NPFC-2023-SSC PS11-RP03	3rd intersessional SSC PS meeting summary
NPFC-2023-SWG MSE PS03-Final Report	SWG MSE PS03 report
CMM 2023-08	CMM 2023-08 for Pacific Saury
	NPFC Performance Review
	Resolution on Climate Change
	Terms of References of the SSC PS
	CPUE Standardization Protocol for Pacific Saury
	Stock Assessment Protocol for Pacific Saury
NPFC-2022-SSC PS10-Final Report	SSC PS10 report
NPFC-2022-SC07-Final Report	SC07 report

Annex C

List of Participants

CHAIR

Toshihide KITAKADO
kitakado@kaiyodai.ac.jp

CANADA

Chris ROOPER
chris.rooper@dfo-mpo.gc.ca

Janelle CURTIS
Janelle.Curtis@dfo-mpo.gc.ca

CHINA

Chuanxiang HUA
cxhua@shou.edu.cn

Libin DAI
644318716@qq.com

Qiuyun MA
qyma@shou.edu.cn

Yong CHEN
yong.chen.2@stonybrook.edu

EUROPEAN UNION

Karolina MOLLA GAZI
karolina.mollagazi@wur.nl

JAPAN

Kazuhiro OSHIMA
oshima_kazuhiro28@fra.go.jp

Shin-Ichiro NAKAYAMA
nakayama_shinichiro16@fra.go.jp

Taiki FUJI
fuji_taiki65@fra.go.jp

Takumi FUKUDA
takumi_fukuda720@maff.go.jp

Midori HASHIMOTO
hashimoto_midori91@fra.go.jp

Hiroshi KUBOTA
kubota_hiroshi89@fra.go.jp

Hiroomi MIYAMOTO
miyamoto_hiroomi47@fra.go.jp

Chiaki MIZUGAKI
chiaki_mizugaki010@maff.go.jp

Shuya NAKATSUKA
nakatsuka_shuya49@fra.go.jp

Miyako NAYA
naya_miyako88@fra.go.jp

Satoshi SUYAMA
suyama_satoshi77@fra.go.jp

Haruo TOMINAGA
haruo_tominaga170@maff.go.jp

Yukiya UCHIDA
yukiya_uchida230@maff.go.jp

Kyutaro YASUMOTO
kyutaro_yasumoto890@maff.go.jp

KOREA

Jae Bong LEE
leejb@korea.kr

Hyejin SONG
hyejinsong@korea.kr

RUSSIA

Vladimir KULIK
vladimir.kulik@tinro.ru

Igor CHERNIENKO
chernienko.igor@gmail.com

CHINESE TAIPEI

Yi-Jay CHANG
yjchang@ntu.edu.tw

Tung-hsieh CHIANG
chiangdon@ofdc.org.tw

Wen-Bin HUANG
bruce@gms.ndhu.edu.tw

Jhen HSU
jhenhsu@ntu.edu.tw

USA

Erin BOHABOY
erin.bohaboy@noaa.gov

VANUATU

Lucy Andrea JOY
ljoy@fisheries.gov.vu

Jeyalda NGWELE
njeyalda@fisheries.gov.vu

Mei-Chin JUAN
meichin.mdfc@gmail.com

Kevin LIN
kevin.mdfc@msa.hinet.net

Sompert GEREVA
sgereva@fisheries.gov.vu

Ada SOKACH
akettner@fisheries.gov.vu

OBSERVERS

THE PEW CHARITABLE TRUSTS

Dave GERSHMAN
dgershman@oceanfdn.org

Shana Miller
smiller@oceanfdn.org

Ashley WILSON
awilson@pewtrusts.org

INVITED EXPERT

Larry JACOBSON
larryjacobson6@gmail.com

RAPPORTEUR

Alex MEYER
meyer@urbanconnections.jp

SECRETARIAT

Robert DAY
rday@npfc.int

Alex ZAVOLOKIN
azavolokin@npfc.int

Sungkuk KANG
skang@npfc.int

Natsuki HOSOKAWA
nhosokawa@npfc.int

Annex D

Terms of Reference for the Small Scientific Committee on Pacific Saury (SSC PS)
(revised in August 2023)

1. To review fishery data
   - Catch series
   - Age/size composition data
   - Others
2. To review fishery-dependent and fishery-independent indices
   - Review/update the existing CPUE Standardization Protocol
   - Review/update the indices
   - Evaluate the quality of the indices
   - Recommendation for future work
3. To review and update biological information/data
   - Stock structure
   - Growth
   - Reproduction and maturity schedule
   - Natural mortality
   - Migration pattern
   - Others
4. To explore the impact of climate change on Pacific saury stock assessment and fishery performance, including distribution, life history characteristics, phenology, biological reference points and relevant parameters
5. To update the stock assessment using “provisional base models” (i.e. Bayesian state-space production models)
   - Review the existing Stock Assessment Protocol
   - Simple update (including projection and evaluation of reference points as well as diagnosis)
   - Consideration of scenarios (for base and sensitivity)
   - Assessment of uncertainties and the implications for management
   - Evaluation/improvement (if necessary) of the models
   - Recommendation of the research for future work
6. To explore stock assessment models other than existing “provisional base models”
   - Data invention/availability (including the identification of potential covariates)
   - Initial (and continued) discussion on age-/size/stage-structure models
   - Identification of lack of information/data gaps and limitations
   - Recommendation of the research for future work
7. To facilitate data- and code- sharing processes

8. To review/improve the presentation of stock assessment results (including stock status summary reports in a format to be determined by the Working Group)
9. To support the technical work related to the Management Strategy Evaluation.

Annex E

Stock Assessment Protocol for Pacific Saury

(revised in August 2023)

(1) Identify the data that will be available to the stock assessment;

(2) Evaluate data quality and quantity and potential error sources (e.g., sampling errors, measurement errors, and associated statistical property (e.g., biased or random errors, statistical distribution) to ensure that the best available information is used in the assessment;

(3) Select population models describing the dynamics of PS stock and observational models linking population variables with the observed variables;

(4) Develop base case scenarios and alternative scenarios for sensitivity analyses;

(5) Compile input data and prior distributions for the model parameterization for the base case and alternative scenarios;

(6) For each scenario, fit the model to the data, diagnostics of model convergence, plot and evaluate residual patterns, compare prior and posterior distributions for key model parameters, and evaluate biological implications of the estimated parameters;

(7) Develop retrospective analysis to verify whether any possible systematic inconsistencies exist among model estimates of biomass and fishing mortality;

(8) Identify final model configuration and model runs for each scenario;

(9) For each scenario, estimate and plot exploitable stock biomass and fishing mortality (and their relevant credibility distributions) over time;

(10) For each scenario, estimate biological reference points (e.g., MSY, Bmsy, Fmsy) and its associated uncertainty;

(11) Identify target and limit reference points for stock biomass and fishing mortality;

(12) Have the Kobe plot for each scenario;

(13) Determine if the stock is “overfished” and “overfishing” occurs for the base and sensitivity scenarios;

(14) Finalize the base-case scenario;

(15) Develop alternative ABCs for the projection (e.g., 5-year projection);

(16) Conduct risk analysis for each level of ABC defined in Step (15) for the base-case scenario;

(17) Develop decision tables with alternative state of nature;

(18) Determine optimal ABCs based on decision tables developed in Step (17);

(19) Provide scientific advice on stock status and appropriate catch level to SC through SSC PS;

(20) Include relevant ecosystem considerations regarding the stock in future assessment documents, including data and results from other scientific studies regarding potential impacts on the stock [assessment] due to climate change, predator-prey dynamics, or impacts of distribution and phenological changes on assessment data.

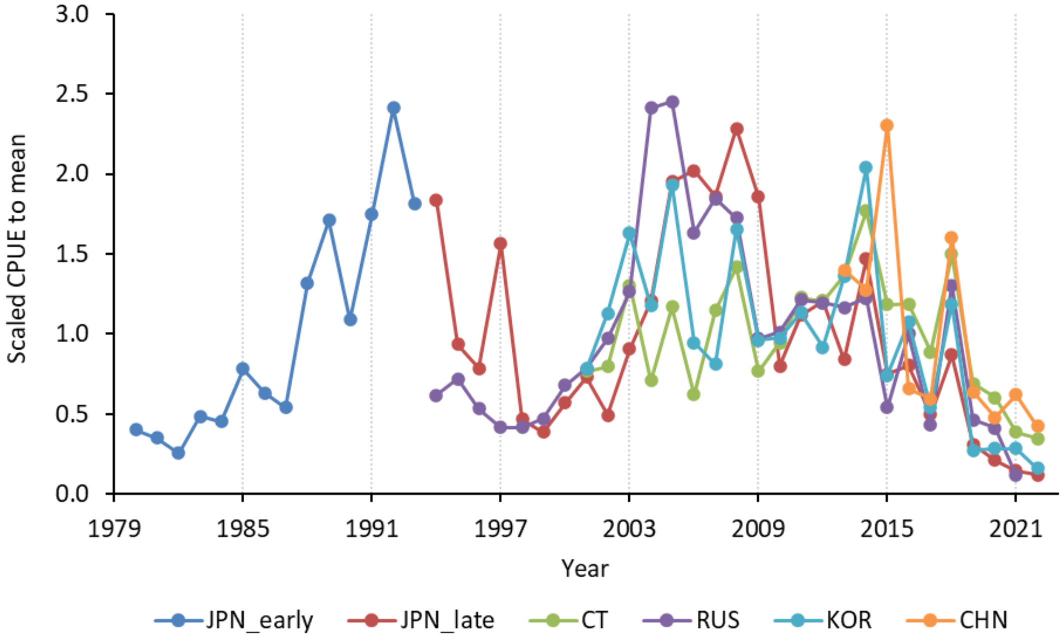
Annex F

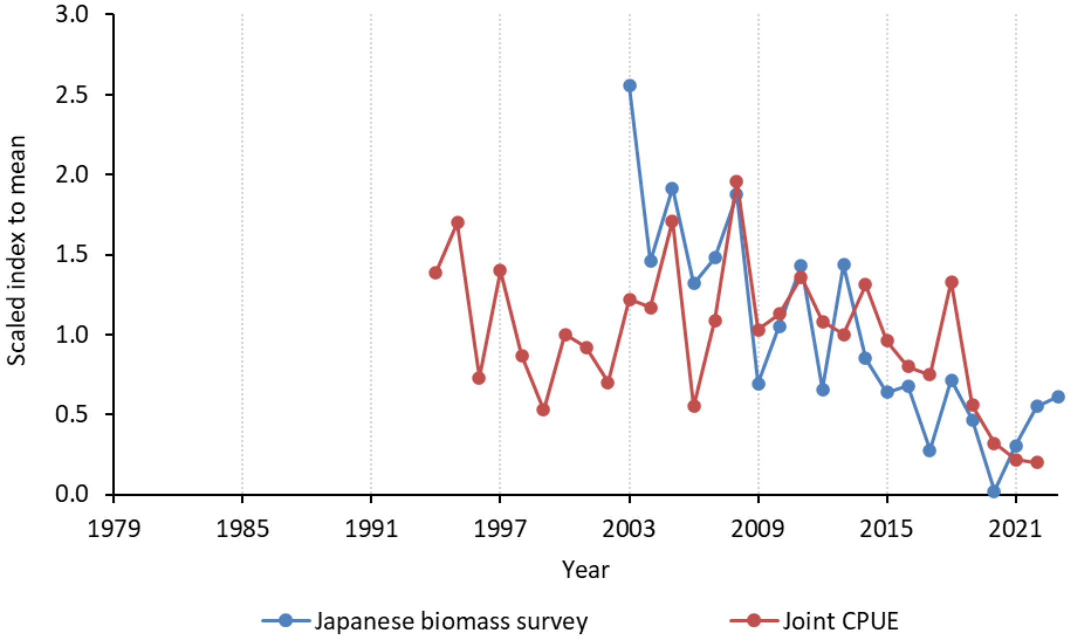
Updated total catch, CPUE standardizations and biomass estimates for the stock assessment of Pacific saury

Year	Total catch (metric tons)	Biomass JPN (VAST, 1000 metric tons)	CV (%)	CPUE CHN (metric tons/ vessel/ day)	CPUE JPN_early (metric tons/ net haul)	CPUE JPN_late (metric tons/ net haul)	CPUE KOR (metric tons/ vessel/ day)	CPUE RUS (metric tons/ vessel/ day)	CPUE CT (metric tons/ net haul)	Joint CPUE (VAST)	CV (%)
1980	238510				0.72						
1981	204263				0.63						
1982	244700				0.46						
1983	257861				0.87						
1984	247044				0.81						
1985	281860				1.4						
1986	260455				1.13						
1987	235510				0.97						
1988	356989				2.36						
1989	330592				3.06						
1990	435869				1.95						
1991	399017				3.13						
1992	383999				4.32						
1993	402185				3.25						
1994	332509					4.13		0.747		1.39	0.29
1995	343743					2.11		0.869		1.70	0.30
1996	266424					1.77		0.646		0.73	0.29
1997	370017					3.52		0.501		1.40	0.30
1998	176364					1.05		0.501		0.87	0.32
1999	176498					0.87		0.568		0.53	0.35
2000	286186					1.28		0.822		1.00	0.32
2001	370823					1.65	7.84	0.947	1.57	0.92	0.19
2002	328362					1.11	11.28	1.172	1.63	0.70	0.18
2003	444642	1348.7	23.9			2.04	16.32	1.526	2.67	1.22	0.18
2004	369400	769.8	20.5			2.72	11.78	2.914	1.45	1.17	0.18
2005	473907	1012.2	30.7			4.40	19.33	2.963	2.39	1.71	0.16
2006	394093	696.6	30.0			4.55	9.45	1.975	1.27	0.55	0.15
2007	520207	782.0	36.9			4.19	8.12	2.231	2.35	1.09	0.17
2008	617509	989.6	26.5			5.15	16.56	2.083	2.90	1.96	0.19
2009	472177	367.4	20.0			4.18	9.60	1.175	1.57	1.03	0.17
2010	429808	554.9	26.4			1.80	9.75	1.224	1.94	1.13	0.17
2011	456263	756.4	35.3			2.52	11.32	1.467	2.51	1.36	0.20
2012	460544	346.4	21.1			2.72	9.19	1.442	2.47	1.08	0.17
2013	423790	758.8	26.6	14.02		1.89	13.61	1.407	2.80	1.00	0.16
2014	629576	448.7	21.7	12.77		3.31	20.42	1.479	3.62	1.31	0.14

2015	358883	337.2	21.4	23.10	1.69	7.41	0.652	2.42	0.96	0.18
2016	361688	358.1	24.4	6.57	1.81	10.76	1.208	2.43	0.80	0.15
2017	262640	145.7	27.3	5.97	1.12	5.40	0.525	1.82	0.75	0.16
2018	435881	378.9	28.7	16.05	1.96	11.89	1.577	3.07	1.33	0.17
2019	195251	247.5	23.4	6.40	0.70	2.75	0.558	1.41	0.56	0.16
2020	139779	12.1	115.7	4.80	0.48	2.85	0.497	1.23	0.32	0.18
2021	92117	161.2	27.0	6.21	0.33	2.83	0.141	0.79	0.22	0.18
2022	100085	290.6	20.4	4.24	0.27	1.62		0.71	0.20	0.16
2023		323.7	26.3							

Time series of Members' standardized CPUE and joint standardized CPUE from 1980-2022 and Japanese survey index from 2003-2023





Annex H

Specifications of the Stock Synthesis 3 model and the state-space age-structured model

Item	SS3 (current, to be modified)	State-space age-structured model (in 2021)
Software	SS3 (NOAA)	Own program coded by TMB
Spatial resolution	Single area (possibly multiple areas from composition perspective?)	Same
Temporal (time-step)	Quarterly	Annual (assuming instantaneous catch in Oct)
Fleet definition	Member-wise + JPN survey	Member-wise + JPN survey
Sex difference	No	No
Catchability	Fleet specific	Fleet specific
Selectivity assumption	Size-based fleet specific	Age-based fleet specific
L-W relationship	Fuji (2019) fixed	Fuji (2019) fixed
Growth (age) / ALK	Refit Suyama et al. (2015) fixed	ALK
Maturity	Size at 50% maturity = 28.7 fixed, Refit Kosaka (2000) and Suyama (2002)	0 for age 0 and 100% for age 1
Fecundity	Fuji et al. (2019) fixed	Not specifically
Natural mortality (by age?)	2.18 (/year) common to ages 0 and 1	Age-specific and several options
S-R relationship	B-H (h=0.86 by referring med r value in BSSPM), sigmaR=0.6	B-H (no assumption for steepness) sigmaR (estimated)
Allocation of Rec over space/time	-No assumption due to single area -Month 7 for age 0	In January instantaneously