North Pacific Fisheries Commission

NPFC-2024-SSC PS14-Final Report

14th Meeting of the Small Scientific Committee on Pacific Saury REPORT

11–13 & 16 December 2024

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North Pacific Fisheries Commission
14th Meeting of the Small Scientific Committee on Pacific Saury

11–13 & 16 December 2024
Tokyo, Japan (Hybrid)

REPORT

Agenda Item 1. Opening of the Meeting

1. The 14th Meeting of the Small Scientific Committee on Pacific Saury (SSC PS14) was held in a hybrid format, with participants attending in-person in Tokyo, Japan, or online via WebEx, on 11–13 & 16 December, and was attended by Members from Canada, China, Japan, the Republic of Korea, the Russian Federation, Chinese Taipei, the United States of America, and the Republic of Vanuatu. The Deep Sea Conservation Coalition (DSCC), the Ocean Foundation, the North Pacific Marine Science Organization (PICES), and the Pew Charitable Trusts (Pew) attended as observers. Dr. Larry Jacobson participated as an invited expert.

2. The meeting was opened by the SSC PS Chair, Dr. Toshihide Kitakado (Japan). Part of the meeting was chaired by the SSC PS vice-Chair, Dr. Libin Dai (China).

3. Japan welcomed the participants to the meeting. Japan expressed appreciation to the participants for their dedicated efforts to advance the Pacific saury stock assessment and hope that they would enjoy their time in Tokyo.

4. The Science Manager, Dr. Aleksandr Zavolokin, and the Data Coordinator, Mr. Sungkuk Kang, outlined the meeting procedures and logistics.

5. Mr. Alex Meyer was selected as rapporteur.

Agenda Item 2. Adoption of Agenda

6. The agenda was adopted (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 PS13

7. The Chair presented the outcomes and recommendations from the SSC PS13 meeting.

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

8. The SSC PS reviewed the Terms of References (ToR) of the SSC PS and determined that no revisions are currently necessary.

9. China reiterated the importance of incorporating the effects of climate change and ecosystem considerations on Pacific saury stock assessment and fishery management.

4.2 CPUE Standardization Protocol

10. 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

11. The SSC PS reviewed the Stock Assessment Protocol and determined that no revisions are currently necessary, notwithstanding suggested changes elsewhere in the report.

Agenda Item 5. Member's fishery status including 2024 fishery

5.1 Report from Members including bycatch

12. Japan presented its fisheries status (NPFC-2024-SSC PS14-IP07). The fishing season in 2024 started on 10 August. Total landing until the end of November is 38,681 MT, compared to 24,046 MT in 2023. 97 fishing vessels were registered in 2024, 12 fewer than in 2023. The peak of the seasonal catch was at the end of October. Nominal CPUE until the end of November was 1.34, the highest in the most recent 5 years, but still low compared to the 2000s. In August and September, fishing grounds were in the high seas. After October, they were also formed in Japan's Exclusive Economic Zone (EEZ). In 2024, Japan has completed age determination work for August only. In August, over 95% of the fish were age-1 fish. From the partial age determination results, the proportion of age-1 fish is likely to remain high until November.

13. Japan presented bycatch information from the Japanese fisheries up to 2023 (NPFC-2024-SSC PS14-WP04). Pacific saury has been historically caught primarily by the stick-held dip nets in Japan and the catch is quite small in other fisheries. In the Japanese stick-held dip net fisheries targeting Pacific saury, several kinds of pelagic fish have been bycaught, including mackerels, Japanese sardine, Japanese anchovy, and Japanese flying squid, but records of their bycatch are very rare.

14. China presented its fisheries status (NPFC-2024-SSC PS14-IP04). The annual catch decreased continuously after 2018, bottoming out in 2021. Total catch in 2023 was 39,252 MT. In 2024,

total catch up to 12 September has been 40,503 MT and a total of 59 vessels have been operating, an increase of 2 from 2023. As of 12 September, nominal CPUE has been 10.25 MT/vessel/day in 2024, which is the highest in the most recent 5 years. Standardized effort was 4,189 vessel days in 2023. The fishing grounds in 2024 have moved to the north and the west in June and July compared to 2023. A yearly comparison of body length compositions has been conducted from 2014 to 2022.

15. China presented Pacific saury bycatch information from its fisheries in the Northwestern Pacific Ocean (NPFC-2024-SSC PS14-WP14). Pacific saury is primarily harvested by the Chinese stick-held dip nets fisheries operating in the high seas of Northwestern Pacific Ocean, with few catches reported from other fishing operations. While the Chinese stick-held dip nets fisheries primarily target Pacific saury, they also incidentally capture squids, but in minimal quantities that are not officially documented in logbooks. Mackerel fisheries, employing purse seines and trawlers, are the primary fishing activities that historically have caught Pacific saury unintentionally. The proportion of Pacific saury caught by these fisheries is exceedingly small and considered insignificant compared to the targeted species such as chub mackerel and Japanese sardine.

16. Vanuatu presented its fisheries status (NPFC-2024-SSC PS14-IP05). Total annual catch peaked at 8,231 MT in 2018, before dropping to a historical low in 2022. Total catch in 2024 was 2,407 MT. The 2024 fishing season began in mid-August. The number of operating vessels was 4 from 2015 to 2021 and was 3 in 2022. Only 2 vessels were active in 2023. So far in 2024, only two vessels are active. An annual comparison of accumulated catch shows a trend of abundance increasing from September. The level of catch in 2024 started exceeding the level in 2023 from September onwards. The main part of the fishing season is from mid-September to the end of October. An annual comparison of the relative seasonal catch shows that there are usually two peaks in the fishing season. In 2024, the peaks have been around late September and late October. Nominal CPUE in 2024 has been 17.6 MT/day. The main fishing grounds began in the east early in the season, before shifting to the west. Looking at the monthly size box compositions in 2023 (S: less than 6 pcs/kg; 1: 6–9 pcs/kg; 2: 10–12 pcs/kg; 3: 13–15 pcs/kg; 4: 15–18 pcs/kg; 5: more than 19 pcs/kg), there were no size box S catches and the percentage of size box 1 catches was very low.

17. Vanuatu also presented information on its bycatch in the Pacific Saury fishery. The proportion of bycatch, comprising sardines and mackerel, in the Pacific saury fishery is very low compared to Pacific saury catch.

18. Korea presented its fisheries status (NPFC-2024-SSC PS14-IP06). In 2023, total catch was

3,107 MT, with 6 vessels, a historical low, and annual catch had continued to decrease since 2018. In 2024, the total catch was 5,866 MT, some increase compared to 2023. The number of vessels operating has gradually decreased each year from 2022 to 2024 due to the continued low level of Pacific saury catch. In 2024, fishing operations with 5 vessels were from May to November and the highest catch was in September. The nominal CPUE was 4.9 MT/vessel/day in 2024, a slight increase from the previous year. Standardized effort was 2,232 days in 2024, a significant increase from 2023. In 2024, fishing operations took place between 145°E and 170°E longitude. The fishing operations in 2023 and 2024 shifted northward compared to 2022. In 2024, the fork-length range was 25–33 cm, with a mean value of 28.4 cm. It was lowest in June (27.7) and highest in September (28.7). Although there were no significant seasonal differences in size compositions, it appears that larger individuals were caught overall compared to the previous year. By size box composition (S: 18–30cm; M: 23–33cm; L: 27–34cm; 2L: 29–34cm (fork length)) the M ratio was dominant during fishing seasons, except in June.

19. Analysis of bycatch data collected by scientific observers on each vessel in 2021 and 2022 indicated that there were 5 and 6 bycatch species from the Korean stick-held dip net fishery in 2021 and 2022, respectively, resulting in a total of 7 species (Pacific chub mackerel, Japanese sardine, butterfish, neon flying squid, Japanese flying squid, Chinook (king) salmon, boreal clubhook squid) observed over the two years. The bycatch rate of total catch weight was less than 10%.

20. Chinese Taipei presented its fisheries status (NPFC-2024-SSC PS14-IP08). The historical catch reached its highest in 2014. The catch is gradually recovering, starting in 2021. In 2024, fishing vessels began operations in fishing grounds in June, and the catch distribution was noted to be slightly further north than 2023. Although the accumulated catch, 67,279 MT, by the end of the fishing season (12 October) in 2024 is higher than that of the same period of 2023, it is noted that the nominal CPUE is 2.11 MT/haul of 2024, which is higher than the 1.56 MT/haul of 2023. Regarding the size box composition (S: less than 6 pcs/kg; 1: 7–9 pcs/kg; 2: 10–12 pcs/kg; 3: 13–15 pcs/kg; 4: 16–18 pcs/kg; 5: more than 19 pcs/kg), the mode size boxes for Pacific saury caught in each month from June to October were 4, 4, 3, 3, and 3, respectively.

21. In the Chinese Taipei fishery, the bycatch rate accounts for only 0.027% of the total catch and was comprised of mostly mackerel.

22. Russia presented its fisheries status (NPFC-2024-SSC PS14-IP09). Catch increased from 51 MT (from 1 fishing vessel) in 2023 to 814 MT (from 2 fishing vessels) in 2024, 286 MT of

which was taken in the Convention Area. Russian vessels did not fish for Pacific saury in 2022. The highest level of catch was in 2007 and 2014, and the decline in Russian Pacific saury catch is mainly due to reduced fishing effort, with the number of vessels declining to 1 in 2023 and 2 in 2024. Accumulated catch and relative accumulated catch were very low. Seasonal trends were not identified due to the low catch level. Relative seasonal catch typically shows two peaks. In 2024, nominal CPUE increased in 2023 and 2024, both in national waters and in the Convention Area. Russia did not calculate standardized CPUE in 2023 and 2024 due to the low number of vessels. Vessels tried to catch Pacific saury in areas close to the Bering Sea but did not find any commercial fishing grounds with high concentrations of Pacific saury, despite several individuals being found during research surveys. Fishing grounds shifted to the south and the west compared to 2023. No bycatch was recorded in the Pacific saury fishery.

23. The SSC PS requested all Members to report Pacific saury catch separately by gear-type in their annual reporting.

24. The SSC PS noted the value of sharing biological and other data for supporting the work of the SSC PS to assess the Pacific saury stock and provide appropriate management advice, and requested that Members continue to do so.

25. The SSC PS noted that the Japanese biomass survey indicated an increasing trend, and that Members' nominal CPUE and catch also showed an increasing trend, although they remain below historical levels. The SSC PS also noted an increase in age-1 fish in Japan's Pacific saury catch. In addition, the SSC PS noted that fishing activities have generally shifted northward.

26. The Science Manager presented the cumulative catch of Pacific saury in 2020, 2021, 2022, 2023, and 2024. The cumulative catch in 2024 as of 29 November is approximately 145,000 MT compared to 102,000 MT in 2023, 95,000 MT in 2022, 89,000 MT in 2021, and 123,000 MT in 2020.

5.2 Others

27. No other information was presented.

Agenda Item 6. Fishery-independent abundance indices

6.1 Survey plans in 2025

28. Japan informed the SSC PS that it plans to conduct its biomass survey with the usual method in 2025.

29. The SSC PS expressed its appreciation to Japan for conducting the biomass survey in 2024, as well as for planning to do so again in 2025.

6.2 Recommendations for future work

30. The SSC PS encouraged other Members to conduct research surveys or share data from existing research surveys that could complement the Japanese biomass survey and provide useful information for better understanding the Pacific saury stock.

31. The SSC PS encouraged Japan to conduct further analyses to test the robustness of its Vector Autoregressive Spatio-Temporal Model (VAST) model against spatial changes in the surveyed area, as was suggested at the previous SSC PS13.

Agenda Item 7. Fishery-dependent abundance indices

7.1 Any information

32. Chinese Taipei presented an evaluation of the impacts of environmental variables on spatial density distributions of Pacific saury using spatio-temporal modelling (NPFC-2024-SSC PS14-WP12). Chinese Taipei investigated the influence of environmental factors on Pacific saury distribution in the Northwestern Pacific Ocean using the spatiotemporal modeling framework sdmTMB. Chinese Taipei analyzed Members' combined CPUE data and examined the variation of CPUE in relation to multiple environmental variables through different functional relationships during 2001–2023 using species distribution models. The quadratic function model provided the best fit, explaining 36.1% of variance. Results suggested positive associations with net primary production and a dome-shaped response to sea surface salinity (SSS), peaking around 33 practical salinity unit (PSU). Spatial random effects showed distinct seasonal migration patterns. This preliminary analysis provided insights on how environmental factors and seasonal patterns influence Pacific saury habitats, with potential for model improvement through the exploration of additional environmental variables.

7.2 Recommendations for future work

33. The SSC PS encouraged Chinese Taipei to conduct further analyses of the impacts of environmental factors on spatial density distributions of Pacific saury using spatio-temporal modelling.

Agenda Item 8. Stock assessment using "provisional base models" (BSSPM)

8.1 Review of results

34. China, Japan, and Chinese Taipei updated their stock assessments for the Pacific saury stock in the Northwestern Pacific Ocean using BSSPM and submitted the results to the SSC PS. The

details of their updated stock assessments are available in NPFC-2024-SSC PS14-WP10, NPFC-2024-SSC PS14-WP11, and NPFC-2024-SSC PS14-WP09, respectively.

35. On behalf of the three Members, the Chair presented a comparison of their BSSPM stock assessment results (NPFC-2024-SSC PS14-IP12).

36. The SSC PS reviewed the stock assessments conducted by Members and aggregated the results, recognizing the agreement in trends among them (Annex D).

37. The SSC PS agreed that this year's stock assessment is of a comparable quality to its previous Pacific saury stock assessments and that it represents the best available understanding of the Pacific saury biomass and population dynamics. The SSC PS recognized that there remain sources of uncertainty that should be further investigated, including the prior assumptions, scaling issues, and retrospective patterns. The SSC PS also noted the need to investigate further refinements to the stock assessment model or the input data to improve predictive performance.

38. The SSC PS developed a stock status summary for Pacific saury (NPFC-2024-SSC PS14-IP13) and recommended that the SC Chair present the information in the summary to the Commission.

8.2 Finalization of input values for the adopted HCR

39. The SSC PS agreed to finalize the input values for the adopted HCR based on the aggregated stock assessment results.

8.3 Recommendations for future work

40. The SSC PS should develop approaches to reducing retrospective patterns which affect TAC calculations. The problem does not occur in some cases so modeling approaches with reduced patterns might be used generally. Retrospective corrections used in other fishery management organizations could be applied with some study. This comment applies to any new age structured models as well.

41. The SSC PS noted that it may be difficult to eliminate retrospective patterns completely. Therefore, the SSC PS should ensure that harvest controls used by the Commission are robust to retrospective patterns in assessment results. Retrospective patterns should be considered in MSE analyses.

Agenda Item 9. Biological information on Pacific saury

42. Chinese Taipei presented estimations of the length-length and length-weight relationships of Pacific Saury in the Northwestern Pacific Ocean (NPFC-2024-SSC PS14-IP02). Neither age nor sex has a significant effect on the length-length and length-weight relationships. The length-length relationships were: fork length = 0.292 + 0.998 knob length (R^2 = 0.999) and standard length = – 0.464 + 0.970 knob length (R^2 = 0.986). The length-weight relationship was: body weight = 3.020×10^{-4} knob length$^{3.788}$ (R^2 = 0.894). The length-weight relationship comparison results indicate that Pacific saury has become thinner from 2004 to 2021.

Agenda Item 10. New stock assessment models

10.1 Review of progress in WG NSAM

43. The Working Group on New Stock Assessment Models for Pacific Saury (WG NSAM) Lead, Dr. Libin Dai, presented a progress report of the three WG NSAM meetings in 2024 (NPFC-2024-SSC PS14-WP08). The focus of these meetings was to explore the potential of applying existing stock assessment packages, primarily Stock Synthesis (SS), and to refine input data and model configurations for enhanced stock management. The WG NSAM made significant progress in refining the SS model by integrating new data, applying time-varying parameters, adjusting age structure and selectivity assumptions, and improving its biological realism. However, several challenges remain, including inconsistencies among the model structure, data, and biology, difficulties in fitting size composition data, strong retrospective patterns, and limited predictive capability. Despite these challenges, the WG NSAM made important strides in model development, which will serve as the foundation for further improvements in future meetings.

44. A summary of the idea exchange between the WG NSAM modelers and biologists in the SSC PS was presented (NPFC-2024-SSC PS14-WP05). The two-way exchange covered Pacific saury biology, including natural mortality and longevity, growth, spawning, data availability, environmental impact (climate change), and sex ratio; the need for better organization of available information on Pacific saury biology and ecology by biologists and better understanding of this information by modelers; and new stock assessment model development.

10.2 Finalization of specification for new stock assessment models

45. The invited expert provided a summary of his progress, ideas, and plans regarding the development of a Stock Synthesis (SS3) model (NPFC-2024-SSC PS14-IP10 (Rev. 1)). The model is close to becoming usable, as biological assumptions are refined. The SS model is a set of almost independent depletion experiments, with one experiment for each annual cohort complicated by high/variable M and growth. There is tension between model complexity and simplicity, both of which seem important. It is important to ensure the assumptions of early life history age and size are realistic. Fit to length composition data is probably crucial but

depends on realistic assumptions about seasonal growth, natural mortality and recruitment/spawning chronology. Information about scale (prior for steepness, recruit variance or Q) is needed. There is also a need for an environmental variable or different steepness to explain recent recruitments. Furthermore, it is necessary to understand/adjust for differences in aging criteria. There is also a need to consider shorter time steps to better estimate growth and catch data / fishing mortality.

46. The SSC PS reviewed the work done by the invited expert, and provided further input and advice on the biological assumptions and model settings. The SSC PS requested the invited expert to continue to develop, in coordination with SSC PS members, the SS model based on the table of model settings and future work described in Annex E.

47. The invited expert presented a request for permission for the WG NSAM to share Pacific saury data with SS3 developer team, consisting of members of the United States National Oceanic and Atmospheric Administration (NOAA), for testing and support (NPFC-2024-SSC PS14-IP11). He emphasized that this would enable more efficient development of the SS model, and that the SS3 developer team has ample experience working with confidential data and ensuring their confidentiality.

48. The SSC PS considered the request and noted the valuable assistance that the SS3 developer team could provide, while also reaffirming the importance of ensuring compliance with the NPFC Data Sharing and Data Security Protocol. The SSC PS noted that one option that would enable both the sharing of data with the SS3 developer team and compliance with the Protocol would be if the United States could name a member(s) of the SS3 developer team to its delegation to the SSC PS, and the SSC PS requested that the United States consider this option. The SSC PS noted that another option would be to share screened or dummy versions of data if those data are confidential, while data that are already publicly available, for example abundance indices in the stock assessment report, could be shared as they are.

49. Chinese Taipei presented an exploratory analysis of spatio-temporal patterns in Pacific saury size composition data (NPFC-2024-SSC PS14-WP13). Chinese Taipei analyzed Pacific saury size composition data from Japan and Chinese Taipei using multivariate regression tree analysis to identify spatial patterns and propose candidate fleet definitions for stock assessment models. Length frequency and commercial category analyses revealed distinct spatial boundaries at 155.5°E for Japanese fleets and 160.3°E for Chinese Taipei fleets. Japanese data showed a mixed length distribution west of 155.5°E and unimodal patterns to the east, while Chinese Taipei data exhibited uniform length frequency patterns across space but heterogeneous commercial size distributions. Both fleets demonstrated consistent seasonal

patterns, with smaller fish distributed in southwestern areas in the fourth season (October–December), and between 163.3°E-170°E. Chinese Taipei recommended using primary boundaries (155.5°E and 160.3°E for Japanese and Chinese Taipei fleets, respectively) to maintain analytical simplicity while effectively capturing size composition heterogeneity for both fleets. These findings suggested the candidate spatially distinct fleet definitions may better account for heterogeneity in catch-at-size data in stock assessment modeling.

50. Japan presented a series of counterfactual simulations to identify which factor, the environment change or fishing, caused the recent and past decrease/increase of Pacific saury population, following up on its previous work that found a temporally-lagged North Pacific Gyre Oscillation (NPGO) index improved the hindcasting skill of Pacific saury recruitment (NPFC-2024-SSC PS14-WP03). Japan simulated how the population dynamics would change without environment factors and/or overfishing by including the identified environment indices into the state-space stock assessment model (SAM) for Pacific saury. The past boom-and-bust cycle disappeared under a constant environment, indicating that the past population dynamics was due to the environmental change. On the other hand, the recent decrease of Pacific saury occurred even under the absence of environment change. This result indicates that, in contrast to the past dynamics, the recent decrease of Pacific saury was caused by both environment change and overfishing.

51. The SSC PS encouraged Japan to conduct further analyses.

10.3 Recommendations for future work

52. The SSC PS tasked the WG NSAM to continue its model development work, including seeking technical support from resources such as the SS3 developer team and continuing to enhance collaboration between modelers and biologists.

53. The SSC PS noted the importance of continuing to build and maintain capacity for model development and analytical work among Members, particularly as the SSC PS transitions to using more complex models for Pacific saury stock assessment.

54. The SSC PS noted that the BSSPM model and any new model should both be run for one or more years as the new model is phased in. It may be advisable to run both models in the future as a matter of policy.

55. The SSC PS encouraged Members to conduct further analyses of spatio-temporal patterns in Pacific saury size composition data.

56. The SSC PS noted that criteria for assigning ages to Pacific saury in the Japanese laboratory and the criteria assumed in stock assessment models are different. It would be better if the criteria used to split the survey data followed the criteria used in the modeling. This applies also to age-length keys and conditional catch-at-length data from Japan and Chinese Taipei.

Agenda Item 11. Progress on development and evaluation of a management procedure as a mid-term task

11.1 Conditioning of operating models (OMs)

57. The Chair summarized the work done to date to complete the development of an interim HCR and previous discussions by the SC-TCC-COM Small Working Group on Management Strategy Evaluation for Pacific Saury (SWG MSE PS) on the mid-term goal of developing a full management procedure (MP).

58. The SSC PS noted the importance of the development of an age-structured model, such as SS3, for facilitating the development of a full MP, and agreed to endeavor to continue to make good progress on the development of such a model within 2025, but this may be delayed due to remaining challenges. The SSC PS recommended that the SWG MSE PS explore options for beginning the MSE process prior to the completion of the age-structured model.

59. The Chair suggested that further into the future, the SSC PS could consider developing more complicated models to account for migration patterns and differences in space and time in Members' fishing operations.

60. The SSC PS noted that it would be valuable to build the capacity of the SSC PS members in using OpenMSE or other software for MSE analyses.

11.2 Types of management procedures (MPs)

61. Pew presented a review of recent literature on harvest strategies and climate change (NPFC-2024-SSC PS14-OP01). In particular, Pew highlighted the following points. First, harvest strategies are an effective adaptation tool for managing stocks under changing climate conditions. Opportunities and limitations exist to incorporate explicit climate-related environmental factors into management procedures (MPs) and management strategy evaluation (MSE). "Climate-informed" MPs can be designed to include extreme events as "Exceptional Circumstances." "Climate-informed" MPs can account for shifts in geographic distribution across management regimes. There are management options available for data-rich and data-poor fisheries.

11.3 Suggestion to SWG MSE PS06 on timeline

62. No concrete timeline was discussed. The SSC PS noted that after further development of the age-structured model, which will contribute to the construction of the OM, some simple application of the MP will be started.

Agenda Item 12. Development of recommendations to improve conservation and management of Pacific saury stock

12.1 Application of the adopted HCR to set a TAC in 2025

63. The SSC PS used the interim harvest control rule (HCR) for Pacific saury adopted by NPFC in April 2024 under CMM 2024-08 For Pacific Saury to calculate TAC in the 2025 fishing year. Based on inputs from the assessment, $TAC_{2025} = (B_{2024}*F_{MSY}*(B_{2024}/B_{MSY}) = 75{,}741$ mt. Based on the adopted HCR, the TAC will be constrained to change by no more than 10% from one year to the next. The constrained 2025 TAC would be 0.9 x 225,000 = 202,500 mt.

64. The SSC PS noted that the unconstrained TACs calculated from the adopted HCR for 2023 (73,490 metric tons) and 2024 (75,741 metric tons) are quite similar. This issue could persist in future years and complicate stakeholders' expectations about stock rebuilding and status. Improvements to the modeling and HCR approaches, as described elsewhere in this report, are important because they would help avoid such problems.

12.2 Others

65. No other matters were discussed.

Agenda Item 13. Review of the Work Plan of the SSC PS

13.1 Climate related issues

66. China presented a preliminary projection of distribution shift for Pacific saury in the Northwestern Pacific Ocean under climate change (NPFC-2024-SSC PS14-WP07). Pacific saury has been showing signs of shifting northeastward over the last decade. sdmTMB was employed to assess the potential shift under the future climate scenarios of the Intergovernmental Panel on Climate Change's (IPCC's) Shared Socio-economic Pathway (SSP)245 and SSP585. The sdmTMB model was developed based on the CPUE data from China's stick-held dip net fisheries in 2013–2022 and environmental variables including sea surface temperature (SST) and mixed layer depth (MLD), as well as spatial and spatio-temporal random field components. The center of gravity movements manifested conspicuous annual fluctuations during 2013–2022 but the trend is unclear and hard to summarize. The projection results are highly dependent on the assumptions of response curves between environmental variables and CPUE. The influence of environmental variables on CPUE might need to consider time- and/or space-varying nature and extend spatial and temporal coverage to improve its biological realism. Future stock assessment and fishery management for Pacific

saury should consider the spatial dynamics under changing environments.

67. The SSC PS encouraged China to continue to conduct further analyses.

68. Chinese Taipei presented an assessment of the potential impact of climate changes on the habitat of the Pacific saury in the Northwestern Pacific Ocean under various scenarios derived from the IPCC Sixth Assessment Report (AR6) (NPFC-2024-SSC PS14-WP02). SST, SSS, sea surface height, dissolved oxygen, MLD, and net primary productivity were used to estimate the habitat suitability index using the yield density approach. Three periods, namely historical (2001-2014), current (2015-2021), and future (2030, 2050, and 2100) were applied to evaluate the climate change impacts on Pacific saury. The grid number of the saury suitable habitat area (SHA) showed a gradually decreasing trend in the historical period and continuously decreased in the current period. In all future projections, the grid number also exhibited a decreasing trend, reaching its lowest in 2100. The SHA shifted northward from the historical period to the current period and was then distributed around 45–46°N in most future projections except for SSP scenarios 1–1.9 (the lowest emission scenarios). The SHA shifted eastward from the historical to the current period, then moved eastward for SSP scenarios 2–4.5, 3–7.5 and 5–8.5, or westward for the SSP scenarios 1–1.9 and 1–2.6 in the future projections. The climate change pathway for Pacific saury came close to SSP 1–2.6 and SSP 2–4.5.

69. The SSC PS encouraged Chinese Taipei to continue to conduct further analyses.

13.2 Work Plan of the SSC PS

70. The SSC PS reviewed, revised and endorsed the 2024-2028 SSC PS 5-Year Rolling Work Plan (NPFC-2024-SSC PS14-WP01 (Rev. 1)).

13.3 NPFC Performance Review recommendations

71. The SSC PS reviewed the NPFC Performance Review recommendations that concern Pacific saury and the updated status of responses drafted by the SC Chair and the Secretariat (NPFC-2024-SC09-WP01(Rev. 6)).

Agenda Item 14. Other matters

14.1 Observer Program

72. The SSC PS held observer-program-related discussions at SSC PS13. No further discussions were held at this meeting.

14.2 Pacific saury species summary update

73. The SSC PS reviewed the updated species summary of Pacific saury (NPFC-2024-SSC PS14-WP06 (Rev. 1)).

74. The SSC PS recommended that the SC adopt the updated species summary (Annex F).

14.3 Draft agenda, priority issues and timeline for next meeting

75. The SSC PS agreed to hold a 5-day data preparatory meeting in a virtual format in the first week of September 2025 and a stock assessment meeting in December 2025, coinciding with the holding of the SC meeting. In addition, the SSC PS will hold regular virtual intersessional meetings. The WG NSAM will hold quarterly intersessional virtual meetings, in addition to an in-person meeting in early July.

76. The SSC PS agreed on the following priorities for the next meetings in 2025:
  (a) Review standardized CPUE up to 2024.
  (b) Review the Japanese fishery-independent survey results up to 2025.
  (c) Update BSSPM analyses.
  (d) Review progress on development and evaluation of management procedure as a medium-term task.
  (e) Review progress made by the WG NSAM on the development of the SS3 model.
  (f) Review Pacific saury bycatch information from Members.

14.4 Invited expert

77. The SSC PS expressed its appreciation for the continued valuable contributions of the invited expert, Dr. Larry Jacobson. The SSC PS recommended that Dr. Jacobson be invited to the next SSC PS and WG NSAM meetings.

14.5 Other

78. The consultant, Dr. Jihwan Kim, presented the updated results of a study on the spatio-temporal variability of density distribution of Pacific saury and its relationship to basin-scale ocean environmental variability in the North Pacific (NPFC-2024-SSC PS14-IP03 (Rev. 1)). The study built on work that was previously presented at SSC PS13 (NPFC-2024-SSC PS13-IP08 (Rev. 2)) by additionally including catch and effort data from the Vanuatu fisheries, and by analyzing variability in standardized CPUE, rather than nominal CPUE, of Pacific saury. The conclusions of the study remained the same, namely, the distribution of CPUE may be related to the NPGO. Specifically, during the positive NPGO, CPUE is higher near the coast of Japan, while during the negative NPGO phase, it is higher inside the Convention Area.

Agenda Item 15. Consolidated recommendations to the Scientific Committee

79. The SSC PS recommended that the SC:
   (a) Endorse the stock assessment report (Annex D).
   (b) Consider the stock status summary for Pacific saury developed for the presentation purpose for the Commission (NPFC-2024-SSC PS14-IP13).
   (c) Endorse the SSC PS Work Plan (NPFC-2024-SSC PS14-WP01 (Rev. 1)).
   (d) Consider the SSC PS's comments on the NPFC Performance Review recommendations that concern Pacific saury (NPFC-2024-SC09-WP01 (Rev. 6)).
   (e) Allocate funds for the participation and technical support (e.g., development of a new stock assessment model) of an invited expert in the next SSC PS and WG NSAM meetings.
   (f) Adopt the updated species summaries of Pacific saury (Annex F).
   (g) Recommend that the SWG MSE PS explore options for beginning the MSE process prior to the completion of the age-structured model.

Agenda Item 16. Adoption of Report

80. The SSC PS14 Report was adopted by consensus.

Agenda Item 17. Close of the Meeting

81. The Chair thanked the participants for their contributions, the invited expert for his dedicated efforts, Japan for providing the meeting venue, and the Secretariat and the Rapporteur for their support.

82. The SSC PS thanked the Chair for his hard work and leadership.

83. The meeting closed at 16:35 on 16 December 2024, Tokyo time.

Annexes:

Annex A – Agenda
Annex B – List of Documents
Annex C – List of Participants
Annex D – Stock Assessment Report for Pacific Saury
Annex E – Specifications of the Stock Synthesis 3 model
Annex F – Species summary for Pacific saury

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 PS13

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 2024 fishery
- 5.1 Report from Members including bycatch
- 5.2 Others

Agenda Item 6. Fishery-independent abundance indices
- 6.1 Survey plans in 2025
- 6.2 Recommendations for future work

Agenda Item 7. Fishery-dependent abundance indices
- 7.1 Any information
- 7.2 Recommendations for future work

Agenda Item 8. Stock assessment using "provisional base models" (BSSPM)
- 8.1 Review of results
- 8.2 Finalization of input values for the adopted HCR
- 8.3 Recommendations for future work

Agenda Item 9. Biological information on Pacific saury

Agenda Item 10. New stock assessment models
- 10.1 Review of progress in WG NSAM
- 10.2 Finalization of specification for new stock assessment models
- 10.3 Recommendations for future work

Agenda Item 11. Progress on development and evaluation of a management procedure as a mid-term task
- 11.1 Conditioning of operating models (OMs)
- 11.2 Types of management procedures (MPs)
- 11.3 Suggestion to SWG MSE PS06 on timeline

Agenda Item 12. Development of recommendations to improve conservation and management of Pacific saury stock

12.1 Application of the adopted HCR to set a TAC in 2025
12.2 Others

Agenda Item 13. Review of the Work Plan of the SSC PS
13.1 Climate related issues
13.2 Work Plan of the SSC PS
13.3 NPFC Performance Review recommendations

Agenda Item 14. Other matters
14.1 Observer Program
14.2 Pacific saury species summary update
14.3 Draft agenda, priority issues and timeline for next meeting
14.4 Invited expert
14.5 Other

Agenda Item 15. Consolidated recommendations to the Scientific Committee

Agenda Item 16. Adoption of Report

Agenda Item 17. Close of the Meeting

Annex B

List of Documents

MEETING INFORMATION PAPERS

Number	Title
NPFC-2024-SC09-MIP01 (Rev. 5)	Meeting Information
NPFC-2024-SSC PS14-MIP02	Provisional Agenda
NPFC-2024-SSC PS14-MIP03 (Rev. 1)	Annotated Indicative Schedule

WORKING PAPERS

Number	Title
NPFC-2024-SSC PS14-WP01 (Rev. 1)	Five-year Work Plan of SSC PS
NPFC-2024-SSC PS14-WP02	Potential impact of climate change on habitat suitability of Pacific saury in the Northwestern Pacific Ocean
NPFC-2024-SSC PS14-WP03	The drivers of the recent and past dynamics of Pacific saury population
NPFC-2024-SSC PS14-WP04	Bycatch information from the Japanese fisheries
NPFC-2024-SSC PS14-WP05	Summary of the idea exchange between the WGNSAM modelers and biologists in SSCPS
NPFC-2024-SSC PS14-WP06 (Rev. 1)	Species summary for Pacific saury
NPFC-2024-SSC PS14-WP07	Preliminary projection of distribution shift for Pacific saury in the Northwestern Pacific Ocean under climate change
NPFC-2024-SSC PS14-WP08	Working Group on New Stock Assessment Models for Pacific Saury – Progress Summary for 2024
NPFC-2024-SSC PS14-WP09	Updates of stock assessment of Pacific saury (*Cololabis saira*) in the Western North Pacific Ocean through 2023
NPFC-2024-SSC PS14-WP10	Updates of stock assessment for Pacific saury in the North Pacific Ocean up to 2024
NPFC-2024-SSC PS14-WP11	2024 update on Pacific saury stock assessment in the North Pacific Ocean using Bayesian state-space production models
NPFC-2024-SSC PS14-WP12	Evaluating the impacts of environmental variables on spatial density distributions of Pacific saury by using spatio-temporal modelling
NPFC-2024-SSC PS14-WP13	Exploratory analysis of spatio-temporal patterns in Pacific saury size composition data

NPFC-2024-SSC PS14-WP14	Bycatch information of Pacific saury from Chinese fisheries in the Northwestern Pacific Ocean
NPFC-2024-SC09-WP01(Rev. 4)	Performance Review Recommendations update

INFORMATION PAPERS

Number	Title
NPFC-2024-SSC PS14-IP01	Saury Catch in Canada (updated for 2024)
NPFC-2024-SSC PS14-IP02	Length−Length and Length−Weight Relationships of Pacific Saury, *Cololabis saira* (Scomberesocidae), in the Northwestern Pacific Ocean
NPFC-2024-SSC PS14-IP03 (Rev. 1)	Spatio-temporal variability of density distribution of Pacific saury (*Cololabis saira*) and its relationship to basin-scale Ocean environmental variability in the North Pacific
NPFC-2024-SSC PS14-IP04	Fishery Status of PS in China Including 2024
NPFC-2024-SSC PS14-IP05 (Rev. 2)	Fishery Status for Pacific saury, including bycatch - Vanuatu
NPFC-2024-SSC PS14-IP06	Korean Stick-held dip net (SHDN) Fishery Status up to 2024
NPFC-2024-SSC PS14-IP07	Pacific saury fishing condition in Japan in 2024 (up to the end of November)
NPFC-2024-SSC PS14-IP08 (Rev. 1)	Fishery status for Pacific saury - Report of Chinese Taipei
NPFC-2024-SSC PS14-IP09	Fishery for Pacific saury by Russian vessels in 2024
NPFC-2024-SSC PS14-IP10 (Rev. 1)	SS3 Progress, Ideas and Plans
NPFC-2024-SSC PS14-IP11 (Rev. 1)	SS data confidentiality and access to NOAA technical help
NPFC-2024-SSC PS14-IP12	Review of BSSPM results
NPFC-2024-SSC PS14-IP13	Draft Pacific saury stock status slide

OBSERVER PAPERS

Number	Title
NPFC-2024-SSC PS14-OP01	Harvest Strategies and Climate Change - A Review of the Literature

REFERENCE DOCUMENTS

Number	Title
	CPUE Standardization Protocol for Pacific Saury
	Stock Assessment Protocol for Pacific Saury
	Terms of References of the SSC PS
NPFC-2024-SSC PS13-Final Report	SSC PS13 report

Annex C

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Stock Assessment Report for Pacific Saury

EXECUTIVE SUMMARY

Data used in the assessment modeling

Data are included from the NPFC Convention Area and Members' Exclusive Economic Zones (EEZs). Pacific saury (*Cololabis saira*) is widely distributed from the subarctic to the subtropical regions of the North Pacific Ocean. The fishing grounds are west of 180º E but differ among Members (China, Japan, Korea, Russia, Chinese Taipei, and Vanuatu). Figure 1 shows the historical catches of Pacific saury by Member. Figure 2 shows CPUE and Japanese survey biomass indices used in the stock assessment. Appendix 1 shows data used for the updated stock assessment.

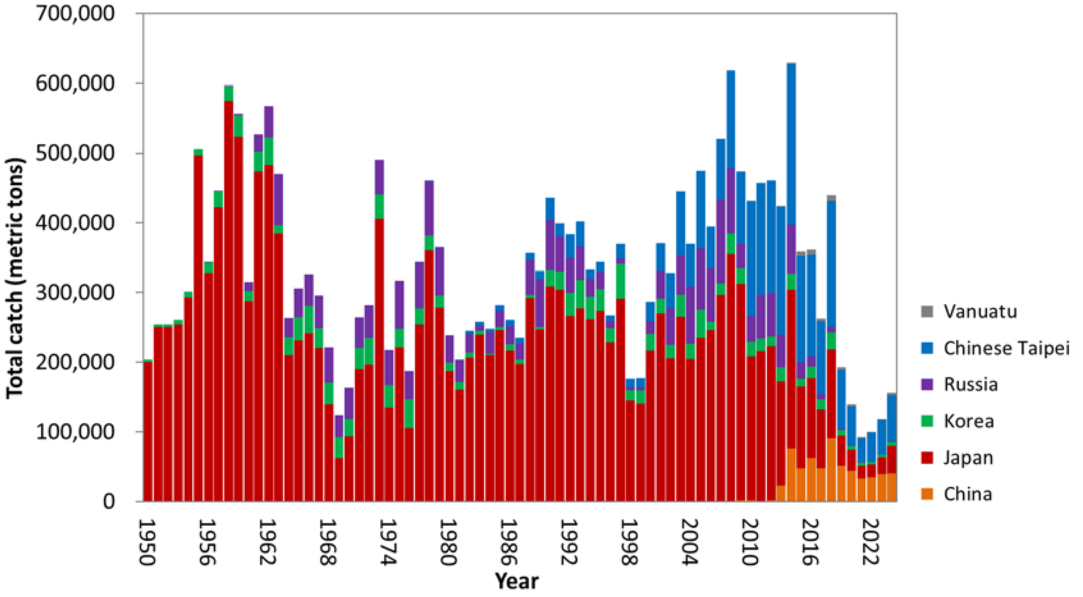

Figure 1. Time series of catch by Member during 1950-2024. The catch data for 1950-1979 are shown but not used in stock assessment modeling. Catch data in 2024 are preliminary (as of 29 November 2024) and not used in the assessment.

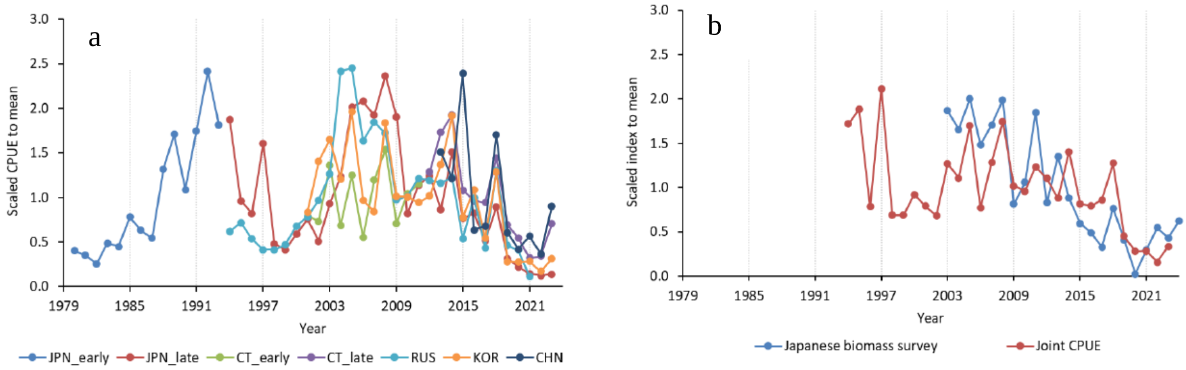

Figure 2. Time series of (a) Japanese survey biomass index and joint CPUE and (b) Member's standardized CPUE indices used in the assessment modeling.

Brief description of specification of analysis and models

A Bayesian state-space production model (BSSPM) used in previous stock assessments was employed as an agreed provisional stock assessment model for Pacific saury during 1980-2024. Scientists from three Members (China, Japan and Chinese Taipei) each conducted analyses following the agreed specification which called for two base case scenarios and two sensitivity scenarios (see Annex F, SSC PS13 report for more details). The two base case scenarios differ in using each Member's standardized CPUEs (base case B1) or standardized joint CPUEs (base case B2). For the two sensitivity cases with Japanese early CPUE (1980-1994), time-varying catchability was assumed to account for potential increases in catchability. A higher weight was given to the Japanese biomass survey estimates than to Members' CPUEs in B1 while comparable weights were given to the Japanese biomass survey estimates and the joint CPUEs in B2. The CPUE data were modeled as nonlinear indices of biomass. Members used similar approaches with some differences in the assumption of the time-varying catchability and prior distributions for the free parameters in the model.

Summary of stock assessment results

The SSC PS considered the BSSPM results and noted the agreement in trends among Members' results for each base case model. However, there was a marked difference in the biomass level between B1 and B2 due to the different CPUE trends used. The SSC PS discussed and recognized that the results covered a wide range of uncertainties in data, model and estimation, and it therefore concluded the outcomes of MCMC runs could be aggregated over the 6 models (2 base case models x 3 Members) as in the previous assessments. The aggregated results for assessing the overall median values and their associated 80% credible intervals are shown in Table 1a (The aggregated results for 2023 are shown in Table 1b). The graphical presentations for times series of a) biomass (B), b) B-ratio (=B/B_{MSY}), c) harvest rate (F), d) F-ratio (F/F_{MSY}) and e) B/K are shown in Figure 3. The Kobe plot with time trajectory using aggregated model outcomes is shown in Figure 4. Time series of median estimated values for biomass, harvest rate, B-ratio, F-ratio and depletion level relative to K are shown in Table 2.

Table 1. Summary of estimates of reference quantities. Medians and credible intervals for the aggregated results are presented. In addition, median values of Member's combined results (over B1 and B2) are shown.

a. 2024 assessment

	Median	Lower10%	Upper10%	Median_CHN	Median_JPN	Median_CT
C_2023 (10000 t)	11.836	11.836	11.836	11.836	11.836	11.836
AveC_2021_2023	10.352	10.352	10.352	10.352	10.352	10.352
AveF_2021_2023	0.328	0.158	0.528	0.352	0.339	0.302
F_2023	0.297	0.155	0.469	0.313	0.307	0.277
FMSY	0.330	0.139	0.543	0.357	0.336	0.310
MSY (10000 t)	39.440	32.021	47.010	40.155	39.284	39.010
F_2023/FMSY	0.920	0.656	1.411	0.915	0.942	0.903
AveF_2021_2023/FMSY	1.008	0.755	1.435	1.013	1.026	0.988
K (10000 t)	248.067	151.766	565.726	234.100	253.396	254.500
B_2023 (10000 t)	39.875	25.214	76.394	37.830	38.599	42.720
B_2024 (10000 t)	52.763	35.130	91.631	50.920	52.120	55.155
AveB_2022_2024	41.563	27.387	77.406	39.705	40.555	44.165
BMSY (10000 t)	120.100	78.060	253.481	113.800	119.008	125.100
BMSY/K	0.485	0.392	0.604	0.480	0.471	0.505
B_2023/K	0.161	0.101	0.228	0.158	0.154	0.169
B_2024/K	0.212	0.122	0.315	0.212	0.206	0.219
AveB_2022_2024/K	0.169	0.106	0.236	0.168	0.163	0.175
B_2023/BMSY	0.328	0.225	0.452	0.323	0.322	0.339
B_2024/BMSY	0.435	0.270	0.628	0.433	0.431	0.440
AveB_2022_2024/BMSY	0.345	0.235	0.470	0.341	0.341	0.352

b. 2023 assessment

	Median	Lower10%	Upper10%	Median_CHN	Median_JPN	Median_CT
C_2022 (10000 t)	10.009	10.009	10.009	10.009	10.009	10.009
AveC_2020_2022	11.066	11.066	11.066	11.066	11.066	11.066
AveF_2020_2022	0.337	0.141	0.621	0.328	0.376	0.316
F_2022	0.245	0.113	0.426	0.231	0.270	0.237
FMSY	0.314	0.108	0.576	0.305	0.350	0.297
MSY (10000 t)	39.657	30.473	48.874	40.434	39.856	38.940
F_2022/FMSY	0.806	0.519	1.436	0.810	0.799	0.809
AveF_2020_2022/FMSY	1.111	0.770	1.748	1.159	1.106	1.079
K (10000 t)	264.054	147.520	702.181	285.000	251.768	260.100
B_2022 (10000 t)	40.820	23.503	88.382	43.290	37.073	42.300
B_2023 (10000 t)	54.940	33.227	108.300	57.340	52.284	55.320
AveB_2021_2023	42.410	25.270	90.015	44.623	39.042	43.883
BMSY (10000 t)	128.100	74.289	317.407	136.900	118.580	130.150
BMSY/K	0.481	0.389	0.604	0.469	0.469	0.506
B_2022/K	0.155	0.089	0.233	0.150	0.151	0.163
B_2023/K	0.209	0.105	0.341	0.200	0.210	0.214
AveB_2021_2023/K	0.163	0.092	0.244	0.156	0.160	0.170
B_2022/BMSY	0.316	0.195	0.474	0.306	0.316	0.323
B_2023/BMSY	0.426	0.227	0.698	0.412	0.441	0.424
AveB_2021_2023/BMSY	0.331	0.201	0.496	0.320	0.336	0.337

Table 2. Time series of median estimated values for biomass, harvest rate, B-ratio, F-ratio and depletion level relative to K. The unit of biomass is 10,000 tons.

Year	Biomass	HarvestRate	Bratio	Fratio	Depletion
1980	136.290	0.175	1.123	0.554	0.549
1981	143.000	0.143	1.217	0.438	0.594
1982	154.500	0.158	1.321	0.482	0.646
1983	159.818	0.161	1.364	0.490	0.671
1984	163.400	0.151	1.391	0.459	0.685
1985	167.300	0.168	1.422	0.511	0.701
1986	167.100	0.156	1.413	0.475	0.697
1987	170.216	0.138	1.434	0.424	0.706
1988	174.700	0.204	1.461	0.630	0.719
1989	164.800	0.201	1.372	0.621	0.677
1990	160.800	0.271	1.346	0.838	0.661
1991	146.700	0.272	1.225	0.849	0.601
1992	138.900	0.276	1.166	0.867	0.567
1993	132.866	0.303	1.115	0.962	0.539
1994	124.225	0.268	1.040	0.860	0.498
1995	121.400	0.283	0.993	0.944	0.473
1996	113.402	0.235	0.911	0.798	0.434
1997	118.500	0.312	0.913	1.110	0.435
1998	103.500	0.170	0.802	0.600	0.383
1999	114.500	0.154	0.873	0.549	0.419
2000	127.800	0.224	1.002	0.769	0.481
2001	131.800	0.281	1.071	0.920	0.518
2002	135.296	0.243	1.120	0.768	0.545
2003	155.200	0.286	1.292	0.890	0.631
2004	153.300	0.241	1.269	0.744	0.625
2005	166.208	0.285	1.350	0.892	0.668
2006	148.600	0.265	1.213	0.826	0.599
2007	155.978	0.334	1.268	1.040	0.629
2008	149.101	0.414	1.198	1.305	0.595
2009	111.116	0.425	0.917	1.315	0.451
2010	109.500	0.393	0.897	1.220	0.442
2011	114.800	0.397	0.924	1.250	0.458
2012	101.700	0.453	0.834	1.402	0.411
2013	100.373	0.422	0.814	1.314	0.404
2014	93.029	0.677	0.768	2.068	0.380
2015	63.708	0.563	0.525	1.736	0.259
2016	56.762	0.637	0.471	1.950	0.232
2017	48.322	0.543	0.402	1.670	0.197
2018	51.780	0.842	0.427	2.545	0.212
2019	30.715	0.636	0.255	1.944	0.126
2020	25.040	0.558	0.209	1.709	0.103
2021	25.250	0.365	0.209	1.127	0.103
2022	31.970	0.313	0.264	0.969	0.130
2023	39.875	0.297	0.328	0.920	0.161
2024	52.763		0.435		0.212

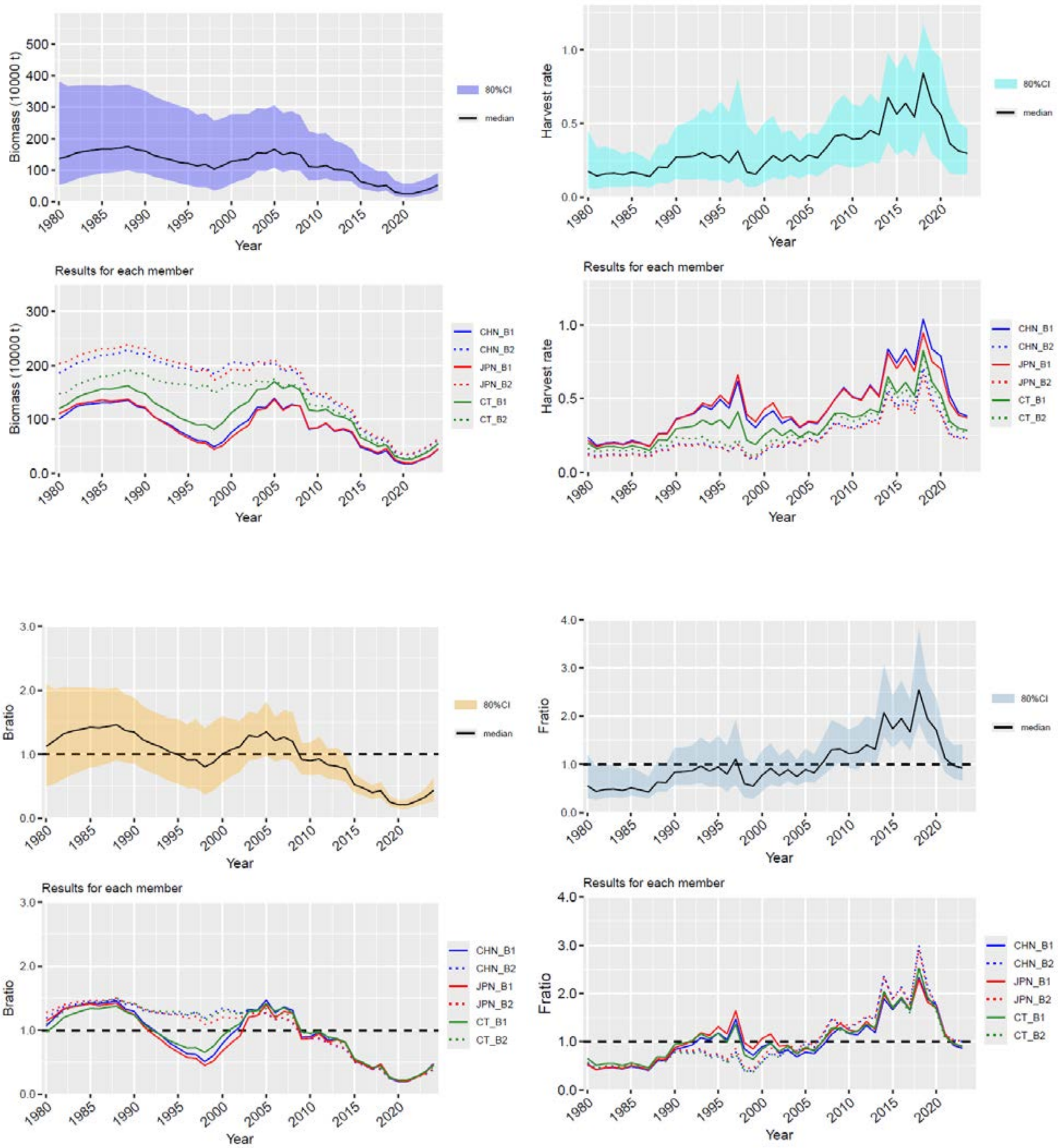

Figure 3. Time series of median estimated values of six runs for biomass, harvest rate, B-ratio, F-ratio and depletion level relative to K. The solid and shaded lines correspond to B1 and B2, respectively.

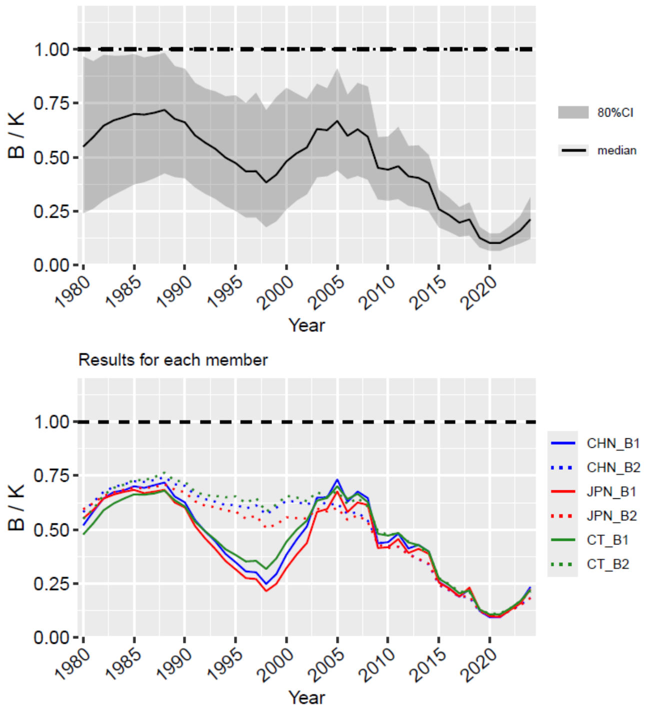

Figure 3 (Continued).

2024 assessment

2023 assessment

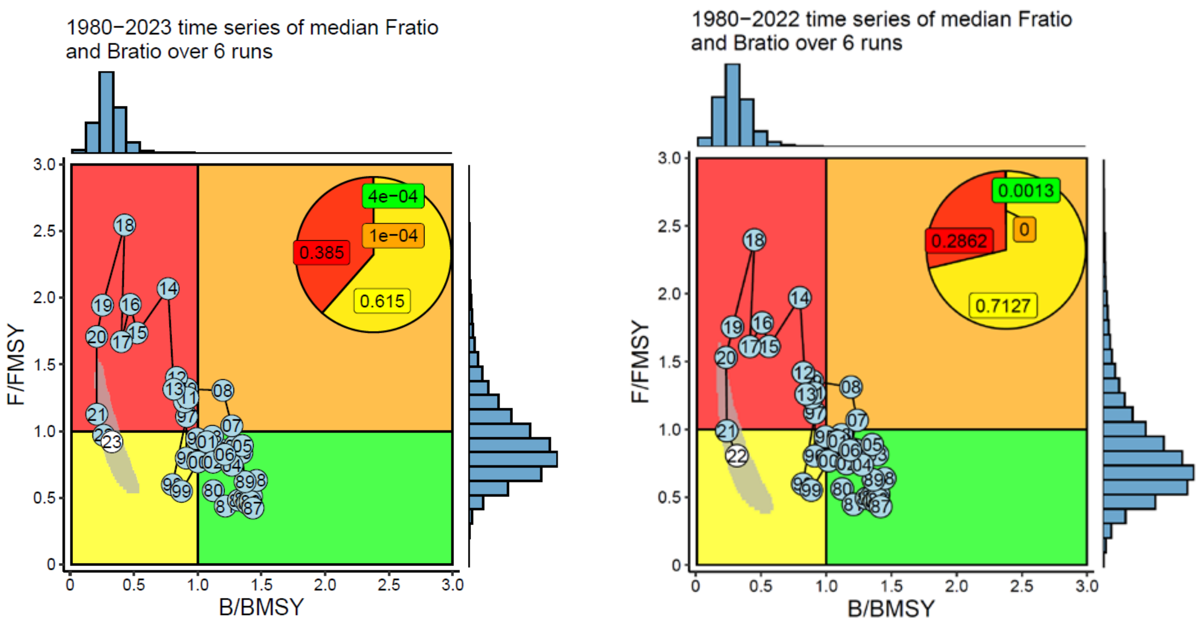

Figure 4. Kobe plot with time trajectory in 2024 (left) and 2023 (right) assessments. The data are aggregated across 6 model results (2 base-case models by 3 Members).

Current stock condition and management advice

Summary of stock status

Results of all Members' and combined model estimates indicate the stock declined with high interannual variability from a high biomass level in the mid-2000's after a period of high productivity to the current low biomass levels. Combined results show that average B was below B_{MSY} during 2022–2024 (median average B/B_{MSY} during 2022–2024 = 0.345, 80%CI = 0.235–0.470) and average F was above F_{MSY} (average F/F_{MSY} during 2021–2023 = 1.008, 80%CI = 0.755–1.435). Thus, stock biomass remained at low levels in recent years. Biomass may have increased modestly during 2022–2024 based on the abundance indices and higher recruitment that may be evident in the Japanese fishery size composition. Based on CPUE, survey data, and model results, the condition of the Pacific saury stock and fishery improved in recent years although biomass remains below B_{MSY}. Harvest rates decreased while biomass and catch increased during 2020–2024. The improvement could be due at least in part to reductions in catch since 2020 and potentially due to unidentified environmental variability.

Uncertainty in assessment

Uncertainty in estimated biomass for the terminal year for Pacific saury translates into uncertainty about unconstrained TAC recommendations for the next fishing season. The estimated biomass for Pacific saury during 2023 in the 2023 assessment (549,400 mt) was substantially higher than the updated estimate (398,750 mt) for 2023 in 2024 assessment. As a result, the recommended 2024 TAC without restriction was 73,490 mt based on the 2023 assessment results, but would have been 75,741 mt based on the 2024 assessment results. Such changes occur because new data bring additional information about recent conditions. Ideally, positive and negative changes are equally likely, and the changes are small. Retrospective patterns in some runs for Pacific saury may have affected the HCR calculations. This is an important topic for work in the next assessment (see "Research Recommendations").

The average ensemble 2024 biomass estimate from all three Members and both base case runs was similar (527,630 mt) to estimates from the Member with no retrospective patterns (Chinese Taipei's average of two base case runs 551.450 mt). The agreement suggests that the ensemble average is precise enough for use in 2025 management.

Management advice

An interim harvest control rule (HCR) for Pacific saury was adopted under CMM 2024-08 For Pacific Saury by the NPFC in April 2024 (Figure 5). The HCR states that the unconstrained Total Annual Catch (TAC) in the following year ($year_{t+1}$) is a function of the biomass, fishing mortality, and B_{MSY} calculated in the current year (t): $TAC_{t+1} = B_t * F_{MSY,} * (B_t/B_{MSY})$. In addition, the HCR constrains changes in TAC to no more than 10% from one year to the next. The unconstrained 2025 TAC based on the results of the 2024 stock assessment is $B_{2024} * F_{MSY} * (B_{2024}/B_{MSY})$ = 75,741 tons, which is smaller than the 90% of the 2024 TAC of 225,000 mt. Following the application of the maximum 10% change aspect of the HCR, the final TAC for 2025 is 202,500 tons.

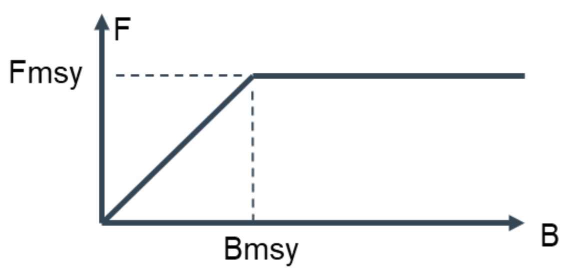

Figure 5. Shapes of the function used in the harvest control rule adopted in 2024 Commission meeting.

Special comments regarding the procedures and stock assessment results

The SSC PS worked collaboratively to produce this consensus stock assessment, which includes significant technical improvements. This section highlights several important aspects of the stock assessment procedure and results.

1) Standardized CPUE data were assumed to be hyperstable and thus less likely to react to changes in biomass. Thus, standardized CPUE were down-weighted relative to the Japanese survey in the first base case (B1), which used CPUE from individual Members. In B1, a single non-linear parameter was used for the CPUEs for each Member. Model results support this decision.

2) Estimated trends in relative stock size measures and reference points from Chinese Taipei (CT), Japan (JPN), China (CHN) and combined models were similar to one another. CPUE, survey trends and model results suggest that stock size is still low but increased since 2020. The F_{MSY} * B * Bratio for 2024 based on the combined models in this assessment is similar to the F_{MSY} * B *Bratio calculated for 2023 in the last assessment despite the recent increasing trend in biomass. The two F_{MSY} * B *Bratio values are similar because recent biomass estimates are lower in the 2024 assessment.

3) Biomass estimates from the 2023 and 2024 assessments are similar in spite of suggestion from the data that stock size increased. This is because the estimated scale of recent biomass is lower in this assessment than in the last assessment. Such uncertainties and shifts in scale can occur because results for most recent years are relatively uncertain and because of retrospective patterns. Retrospective patterns (estimated biomass declined with additional years of data) were noted in results for two Members. Changes were also made in the handling of some CPUE time series in the current model that improved model fit. These changes and the retrospective patterns may have contributed to lower estimated biomass in this assessment for Pacific saury in 2023.

4) Oceanographic or biological factors responsible for changes in Pacific saury productivity have not yet been determined. Development of modeling procedures to incorporate environmental change is an important area for future research. The work should include refinements to stock assessment models to better reflect and estimate environmental effects on recruitment and biology. This work should be coordinated among Members and folded into the development of age-structured and improved BSSPM models.

5) Experience with the HCR rule this year suggests that the use of more current data might improve management advice. Currently, the HCR for 2025 is based on CPUE and catch data through 2023 and survey data through 2024. However, catch data are nearly complete for the most recent year when the assessment for that year is completed and reasonably precise CPUE standardization could probably be completed early as well. It would be advisable for the SSC PS to consider approaches to using the most recent data in the assessment. One approach to demonstrating potential benefits would be to do a retrospective analysis of HCR calculations based on the actual terminal year and the year before.

STOCK ASSESSMENT REPORT FOR PACIFIC SAURY

1. INTRODUCTION

1.1 Distribution

Pacific saury (*Cololabis saira* Brevoort, 1856) has a wide distribution extending in the subarctic and subtropical North Pacific Ocean from inshore waters of Japan and the Kuril Islands to eastward to the Gulf of Alaska and southward to Mexico. Pacific saury is a commercially important fish in the western North Pacific Ocean (Parin 1968; Hubbs and Wisner 1980).

1.2 Migration

Pacific saury migrates extensively between the northern feeding grounds in the Oyashio waters around Hokkaido and the Kuril Islands in summer and the spawning areas in the Kuroshio waters off southern Japan in winter (Fukushima 1979; Kosaka 2000). Pacific saury in offshore regions (east of 160°E) also migrate westward toward the coast of Japan after October every year (Suyama et al. 2012).

1.3 Population structure

Genetic evidence suggests there are no distinct stocks in the Pacific saury population based on 141 individuals collected from five distant locales (East China Sea, Sea of Okhotsk, northwest Pacific, central North Pacific, and northeast Pacific) (Chow et al. 2009).

1.4 Spawning season and grounds

The spawning season of Pacific saury is relatively long, beginning in September and ending in June of the following year (Watanabe and Lo 1989). Pacific saury spawns over a vast area from the Japanese coastal waters to eastern offshore waters (Baitaliuk et al. 2013). The main spawning grounds are considered to be located in the Kuroshio-Oyashio transition region in fall and spring and in the Kuroshio waters and the Kuroshio Extension waters in winter (Watanabe and Lo 1989).

1.5 Food and feeding

The Pacific saury larvae prey on the nauplii of copepods and other small-sized zooplankton. As they grow, they begin to prey on larger zooplankton such as krill (Odate 1977). The Pacific saury is preyed on by large fish ranked higher in the food chain, such as *Thunnus alalunga* (Nihira 1988) and coho salmon, *Oncorhynchus kisutsh* (Sato and Hirakawa 1976) as well as by animals such as minke whales *Balaenoptera acutorostrata* (Konishi et al. 2009) and sea birds (Ogi 1984).

1.6 Age and growth

Based on analysis of daily otolith increments, Pacific saury reaches approximately 20 cm in knob length (distance from the tip of lower jaw to the posterior end of the muscular knob at the base of a caudal peduncle; hereafter as body length) in 6 or 7 months after hatching (Watanabe et al. 1988; Suyama et al. 1992). There is some variation in growth rate depending on the hatching month during this long spawning season (Kurita et al. 2004) and geographical differences (Suyama et al. 2012b). The maximum lifespan is 2 years (Suyama et al. 2006). The age 1 fish grow to over 27 cm in body length in June and July when Japanese research surveys are conducted and reach over 29 cm in the fishing season between August and December (Suyama et al. 2006).

1.7 Reproduction

The minimum size of maturity of Pacific saury has been estimated at about 25 cm in the field (Hatanaka 1956) or rearing experiments (Nakaya et al. 2010). In rare cases, saury have been found to mature at 22 cm (Sugama 1957; Hotta 1960). Under rearing experiments, Pacific saury begins spawning 8 months after hatching, and spawning activity continues for about 3 months (Suyama et al. 2016). Batch fecundity is about 1,000 to 3,000 eggs per saury (Kosaka 2000).

2. FISHERY

2.1 Overview of fisheries

Western North Pacific

In Japan, the stick-held dip net fishery for Pacific saury was developed in the 1940s. Since then, the stick-held dip net gears have become the dominant fishing technique to catch Pacific saury in the northwest Pacific Ocean. Since 1995, more than 97% of Japan's total catch is caught by the stick-held dip net. The annual catch of Pacific saury for stick-held dip net fishery has fluctuated. Maximum and minimum catches of 355 thousand tons and 18 thousand tons were recorded in 2008 and 2022, respectively.

Pacific saury fisheries in Korea have been operated with gillnet since the late 1950s in Tsushima Warm Current region. Korean stick-held dip net fishery started from 1985 in the Northwest Pacific Ocean. The largest catch of 50 thousand tons was recorded in 1997 (Gong and Suh 2013).

Russian fishery for Pacific saury has been conducted using stick-held dip nets in the northwest Pacific Ocean in the area that includes national waters (mainly within the Russian EEZ) and adjacent NPFC Convention Areas. Russian catch statistics for saury fishery exists, beginning from 1956, and standardized CPUE indices from that fishery were calculated since 1994. Saury fishery traditionally occurred from August to November; however, in recent years, the onset of fishing for saury shifted to the early summer period. Peak catch of saury of over 100 thousand tons was in 2007.

China commenced its exploratory saury fishing using stick-held dip nets in the high seas in 2003, but only started to develop this fishery in 2012. The fishing seasons mainly cover the period from June-November.

Chinese Taipei's Pacific saury fishery can date back to 1975 and had its first commercial catch in 1977. Over the past decade, the number of active Pacific saury fishing vessels has been increasing from 68 to 91 and the catch has fluctuated between 39,750 tons and 229,937 tons since 2001. Aside from Pacific saury fishery, most of the Pacific saury fishing vessels also conduct flying squid jigging operations in the Northwest Pacific Ocean.

Vanuatu commenced its development of Pacific saury fishery by using stick-held dip net in the high seas in 2004. Currently there are four vessels operating in the Northwest Pacific targeting saury, but the total accumulative number of its authorized Pacific saury fishing vessels from 2004 to 2020 is 16. The fishing season mainly covers the period from July to November each year.

Eastern North Pacific

Although Pacific saury occur in the Canada EEZ, there is no targeted fishery for the species. There is no historical record of Canadian participation in international fisheries for saury. Domestic fisheries sometimes capture saury as bycatch in pelagic and bottom trawls and there are a handful of records from other gear types including commercial longlines. The most recently compiled estimates indicate around 300 kg of saury were captured by Canadian commercial fisheries over 17 years from 1997-2013 (Wade and Curtis 2015; NPFC-2022-SSC PS09-IP01). There are also records of saury catches from research trawls (surface, pelagic and bottom trawls) in Canadian waters, but the catches have been minimal.

Management plans developed by the United States' National Marine Fisheries Service currently prohibit targeted fishing on marine forage species including the Pacific saury. In the 1950's to mid-1970's there were sporadic attempts to commercially fish for Pacific saury off of California with limited success using purse seines and light attraction (Kato 1992). Catches from 1969-1972 averaged 450 tons. Currently landings are only "occasionally" reported as bycatch in fisheries on the US west coast. Landings of Pacific saury as bycatch on the US west coast averaged 5.5 kg per year from 2011-2015 (NOAA Fisheries National Bycatch Report Database System, https://www.st.nmfs.noaa.gov/, accessed March 8, 2019)

Historically, Japanese and Russian vessels operated mainly within their own EEZs, but they have shifted into the Convention Area in recent years. Chinese, Korean and Chinese Taipei vessels operate mainly in the high seas of the North Pacific (Figure 1).

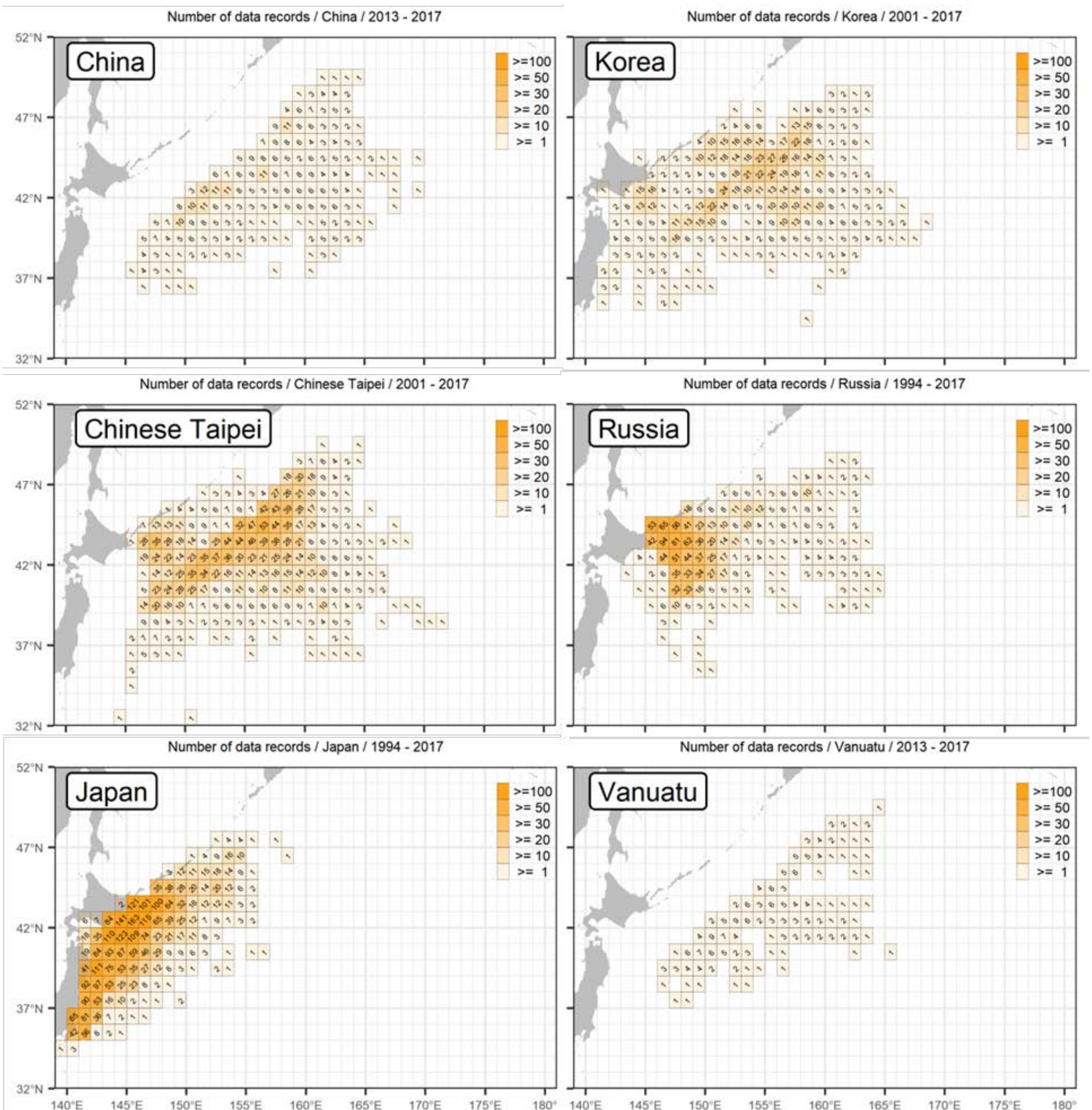

Figure 1 (a). Main fishing grounds for Pacific saury by fishing members in the western North Pacific Ocean during 1994-2017. The legend shows the number of data records. This figure is based on the data shared by the Members for the development of a joint CPUE index

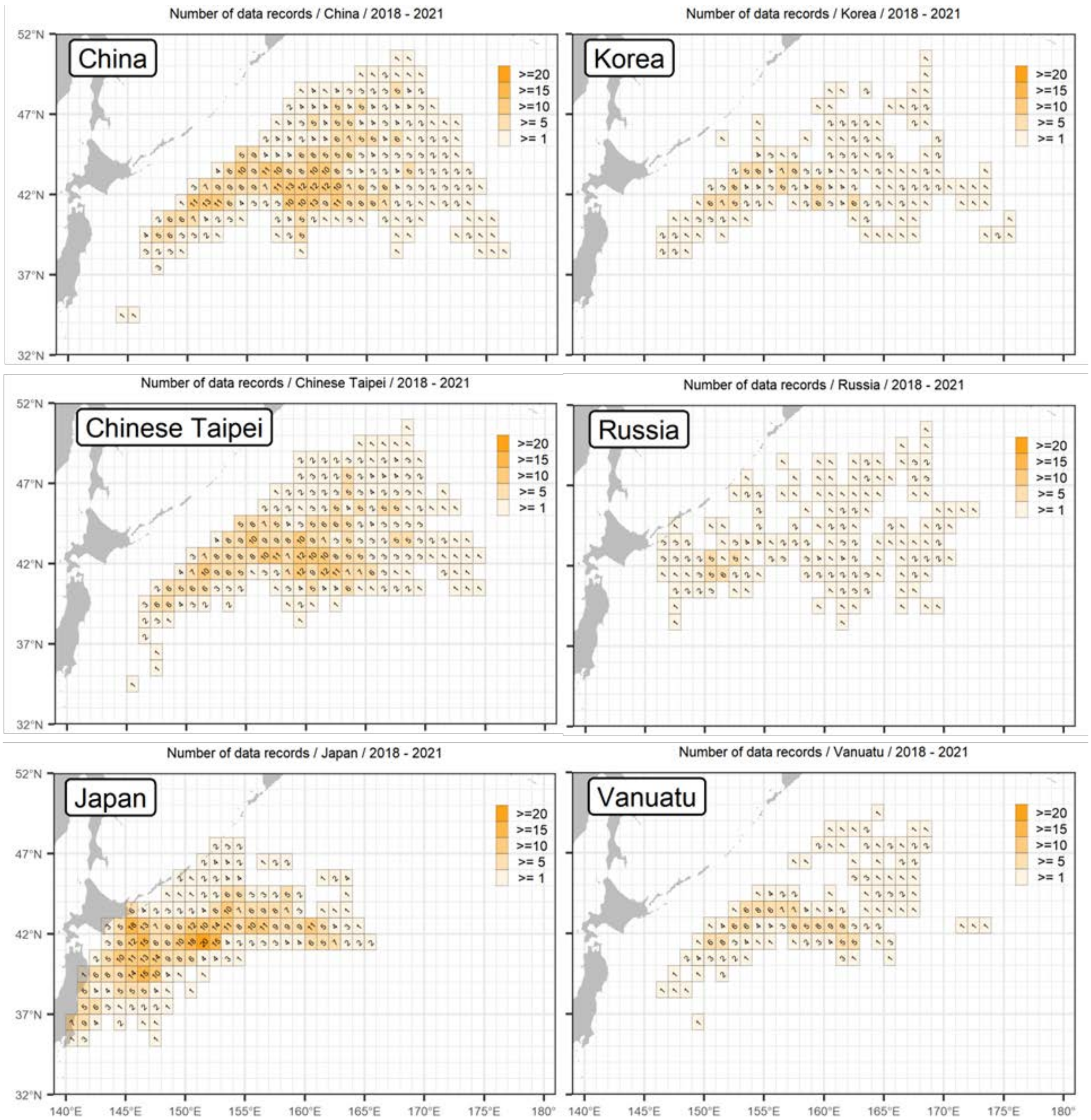

Figure 1 (b). Main fishing grounds for Pacific saury by fishing members in the western North Pacific Ocean during 2018-2021. The legend shows the number of data records. This figure is based on the data shared by the Members for the development of a joint CPUE index

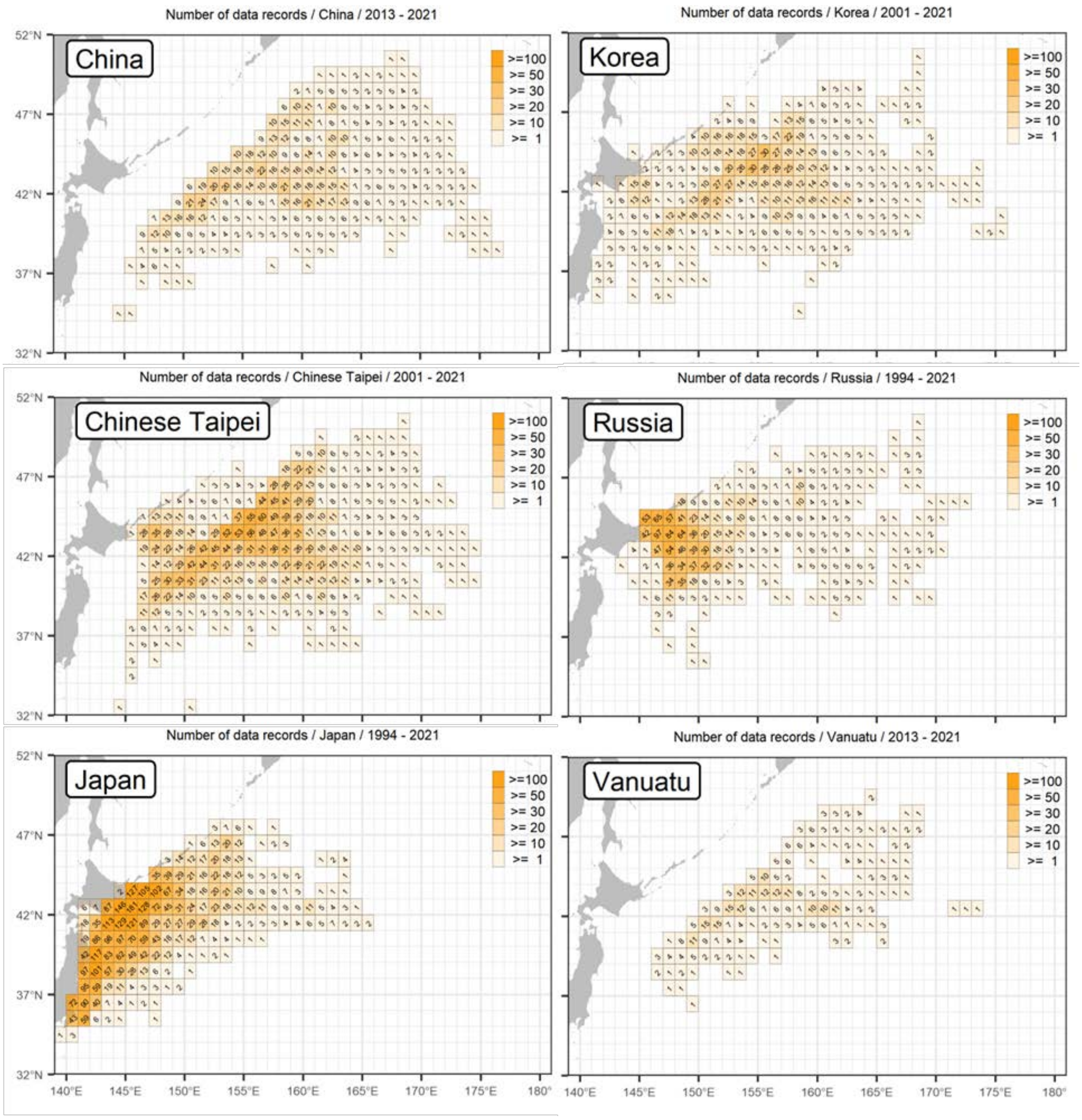

Figure 1 (c). Main fishing grounds for Pacific saury by fishing members in the western North Pacific Ocean during 1994-2021. The legend shows the number of data records. This figure is based on the data shared by the Members for the development of a joint CPUE index

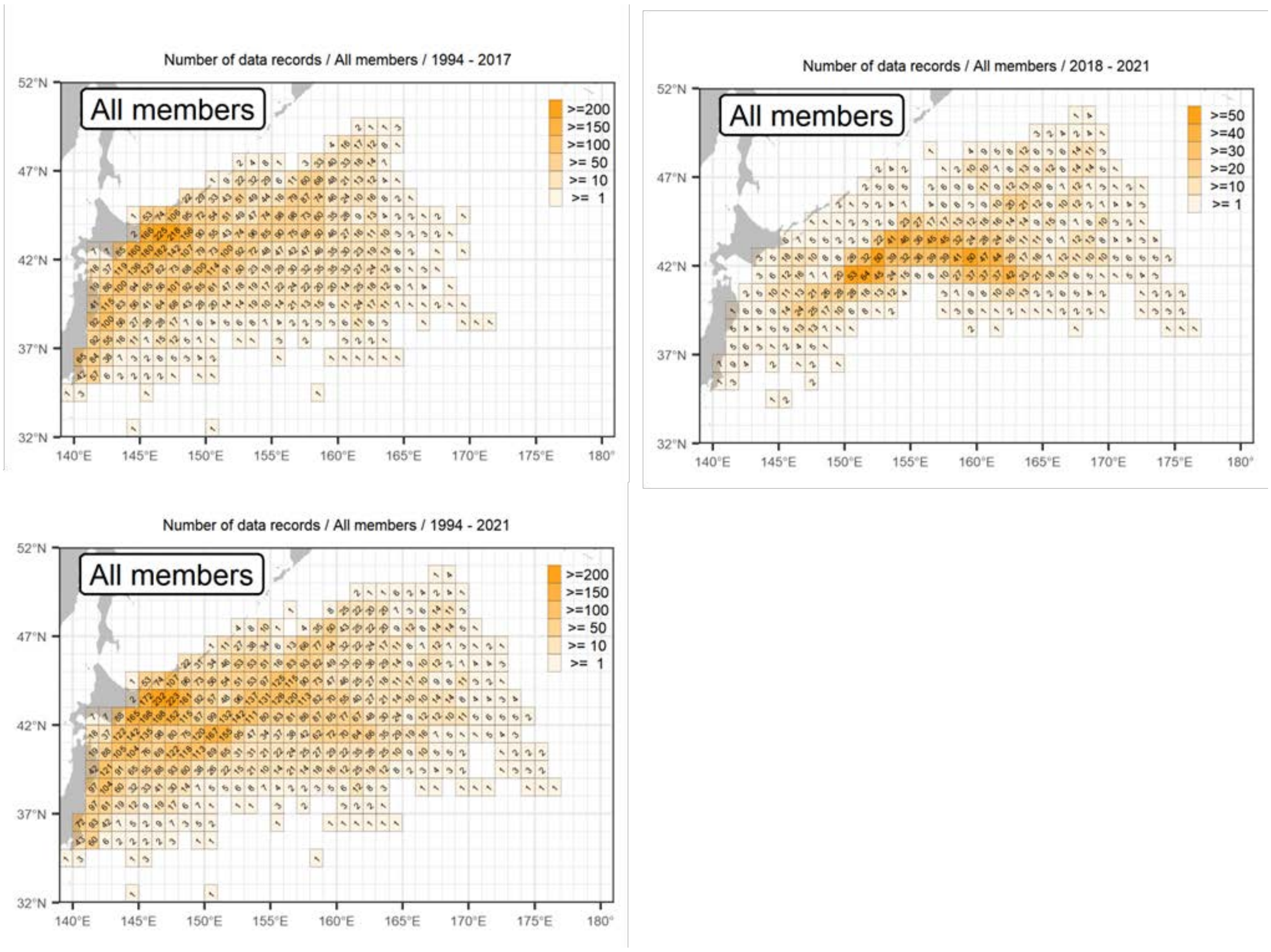

Figure 1 (d). Main fishing grounds for Pacific saury in the western North Pacific Ocean. The legend shows the number of data records. This figure is based on the data shared by the Members for the development of a joint CPUE index

2.2 Catch records

Figure 2 shows the historical catches of Pacific saury in the northwest Pacific Ocean by Member.

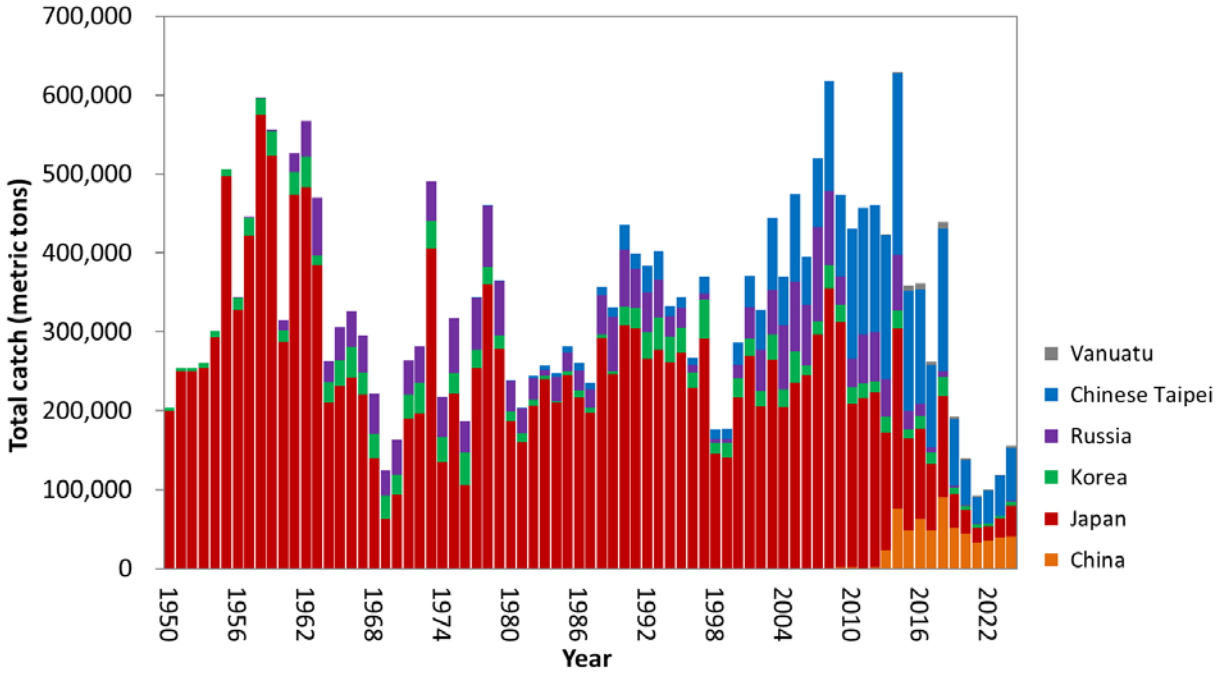

Figure 2. Time series of catch by Member during 1950-2024. The catch data for 1950-1979 are shown but not used in stock assessment modeling. Catch data in 2024 are preliminary (as of 29 November 2024) and not used in the assessment.

3. SPECIFICATION OF STOCK ASSESSMENT

A Bayesian state-space production model (BSSPM) used in previous stock assessments was employed as an agreed provisional stock assessment model for Pacific saury during 1980-2024. Scientists from three Members (China, Japan and Chinese Taipei) each conducted analyses following the agreed specification which called for two base case scenarios and two sensitivity scenarios (see Annex G, SSC PS13 report for more details). The two base case scenarios differ in using each Member's standardized CPUEs (base case B1) or standardized joint CPUEs (base case B2). For the two sensitivity cases with Japanese early CPUE (1980-1994), time-varying catchability was assumed to account for potential increases in catchability. A higher weight was given to the Japanese biomass survey estimates than to Members' CPUEs in B1 while comparable weights were given to the Japanese biomass survey estimates and the joint CPUEs in B2. The CPUE data were modeled as nonlinear indices of biomass. Members used similar approaches with some differences in the assumption of the time-varying catchability and prior distributions for the free parameters in the model.

3.1 Bayesian state-space production model

The population dynamics is modelled by the following equations:

$$B_t = \left\{B_{t-1} + B_{t-1} f(B_{t-1}) - C_{t-1}\right\} e^{u_t}, \quad u_t \sim N(0, \tau^2)$$

$$f(B_t) = r\left[1 - \left(\frac{B_t}{K}\right)^z\right]$$

where

B_t : the biomass at the beginning of year *t*

C_t : the total catch of year *t*

u_t : the process error in year *t*

$f(B)$: the production function (Pella-Tomlinson)
r : the intrinsic rate of natural increase
K : the carrying capacity
z: the degree of compensation (shape parameter; different symbols were used by the 3 members)

The multiple biomass indices are modelled as follows:

Survey biomass estimate

$$I_{t,biomass} = q_{biomass} B_t \, exp(\, v_{t,biomass}), \qquad \text{where} \quad v_{t,biomass} \sim N\left(0, \sigma^2_{biomass}\right)$$

where

$q_{biomass}$: the relative bias in biomass estimate
$v_{t,biomass}$: the observation error term in year *t* for survey biomass estimate
$\sigma^2_{biomass}$: the observation error variance for survey biomass estimate

CPUE series

$$I_{t,f} = q_f B_t^b \, exp(\, v_{t,f}), \qquad \text{where} \quad v_{t,f} \sim N\left(0, \sigma_f^2\right)$$

where

$I_{t,f}$: the biomass index in year *t* for biomass index *f*

q_f : the catchability coefficient for biomass index *f*

b: the hyper-stability/depletion parameter
$v_{t,f}$: the observation error term in year *t* for biomass index *f*
σ_f^2: the observation error in year *t* for biomass index *f*

For the estimation of parameters, Bayesian methods were used with Member-specific differences in preferred assumptions for the prior distributions for the free parameters. MCMC methods were employed for simulating the posterior distributions. For the assumptions of uniform priors used in China and Japan, see documents NPFC-2024-SSC PS14-WP10 and NPFC-2024-SSC PS14-WP11; for the non-uniform priors used in Chinese Taipei, see document NPFC-2024-SSC PS14-WP09.

3.2 Agreed scenarios

Table 1. Definition of scenarios

	Base case (NB1)	**Base case (NB2)**	**Sensitivity case (NS1)**	**Sensitivity case (NS2)**
Initial year	1980	1980	1980	1980
Biomass survey	$I_{t,bio} = q_{bio}\, B_t e^{v_{t,bio}}$ $v_{t,bio} \sim N(0, cv_{t,bio}^2 + \sigma^2)$ $q_{bio} \sim$ U(0,1) (2003-2024)	Same as left	Same as left	Same as left
CPUE	CHN(2013-2023) JPN_late(1994-2023) KOR(2001-2023) RUS(1994-2023) CT(2001-2011, 2012-2023) $I_{t,f} = q_f B_t^b e^{v_{t,f}}$ $v_{t,f} \sim N(0, \sigma_f^2)$ $\sigma_f^2 = c \cdot (ave(cv_{t,bio}^2) + \sigma^2)$, where $ave(cv_{t,bio}^2)$ is computed except for 2020 survey (c = 5)	Joint CPUE (1994-2023) $I_{t,joint} = q_{joint} B_t^b e^{v_{t,joint}}$ $v_{t,joint} \sim N(0, cv_{t,joint}^2 + \sigma^2)$	CHN(2013-2023) JPN_early(1980-1993, time-varying q) JPN_late(1994-2023) KOR(2001-2023) RUS(1994-2023) CT(2001-2011, 2012-2023) $I_{t,f} = q_f B_t^b e^{v_{t,f}}$ $v_{t,f} \sim N(0, \sigma_f^2)$ $\sigma_f^2 = c \cdot (ave(cv_{t,bio}^2) + \sigma^2)$, where $ave(cv_{t,bio}^2)$ is computed except for 2020 survey (c = 6)	JPN_early(1980-1993, time-varying q) $I_{t,JE} = q_{t,JE} B_t^b e^{v_{t,JE}}$ $v_{t,JE} \sim N(0, \sigma_{JE}^2)$ $\sigma_{JE}^2 = c\ ave(cv_{t,joint}^2 + \sigma^2)$ Joint CPUE (1994-2023) $I_{t,joint} = q_{joint} B_t^b e^{v_{t,joint}}$ $v_{t,joint} \sim N(0, cv_{t,joint}^2 + \sigma^2)$
Hyper-depletion / stability	A common parameter for all fisheries with a prior distribution, $b \sim U(0, 1)$	$b \sim U$ (0, 1)	A common parameter for all fisheries but JPN_early, with a prior distribution, $b \sim U(0, 1)$ [b for JPN_early is fixed at 1]	$b \sim U$ (0, 1) for joint CPUE. [b for JPN_early is fixed at 1]
Prior for other than q_{bio}	Own preferred options	Own preferred options	Own preferred options	Own preferred options

Table 2. Description of symbols used in the stock assessment

Symbol	Description
C_{2023}	Catch in 2023
$AveC_{2021\text{-}2023}$	Average catch for a recent period (2021–2023)
$AveF_{2021\text{-}2023}$	Average harvest rate for a recent period (2021–2023)
F_{2023}	Harvest rate in 2023
F_{MSY}	Annual harvest rate producing the maximum sustainable yield (MSY)
MSY	Equilibrium yield at F_{MSY}
F_{2023}/F_{MSY}	Average harvest rate in 2023 relative to F_{MSY}
$AveF_{2021\text{-}2023}/F_{MSY}$	Average harvest rate for a recent period (2021–2023) relative to F_{MSY}
K	Equilibrium unexploited biomass (carrying capacity)
B_{2023}	Stock biomass in 2023 estimated in the model
B_{2024}	Stock biomass in 2024 estimated in the model
$AveB_{2022\text{-}2024}$	Stock biomass for a recent period (2022–2024) estimated in the model
B_{MSY}	Stock biomass that will produce the maximum sustainable yield (MSY)
B_{MSY}/K	Stock biomass that produces the maximum sustainable yield (MSY) relative to the equilibrium unexploited biomass[a]
B_{2023}/K	Stock biomass in 2023 relative to K[a]
B_{2024}/K	Stock biomass in 2024 relative to K[a]
$B_{2022\text{-}2024}/K$	Stock biomass in the latest time period (2022-2024) relative to the equilibrium unexploited stock biomass[a]
B_{2023}/B_{MSY}	Stock biomass in 2023 relative to B_{MSY}[a]
B_{2024}/B_{MSY}	Stock biomass in 2024 relative to B_{MSY}[a]
$B_{2022\text{-}2024}/B_{MSY}$	Stock biomass for a recent period (2022–2024) relative to the stock biomass that produces maximum sustainable yield (MSY) [a]

[a]calculated as the average of the ratios.

4 SOME AGGREGATED RESULTS FOR VISUALIZATION PURPOSE

4.1 Visual presentation of results

The graphical presentations for times series of biomass (B), B-ratio (B/B_{MSY}), exploitation rate (F), F-ratio (F/F_{MSY}) and B/K are shown in Figure 3.

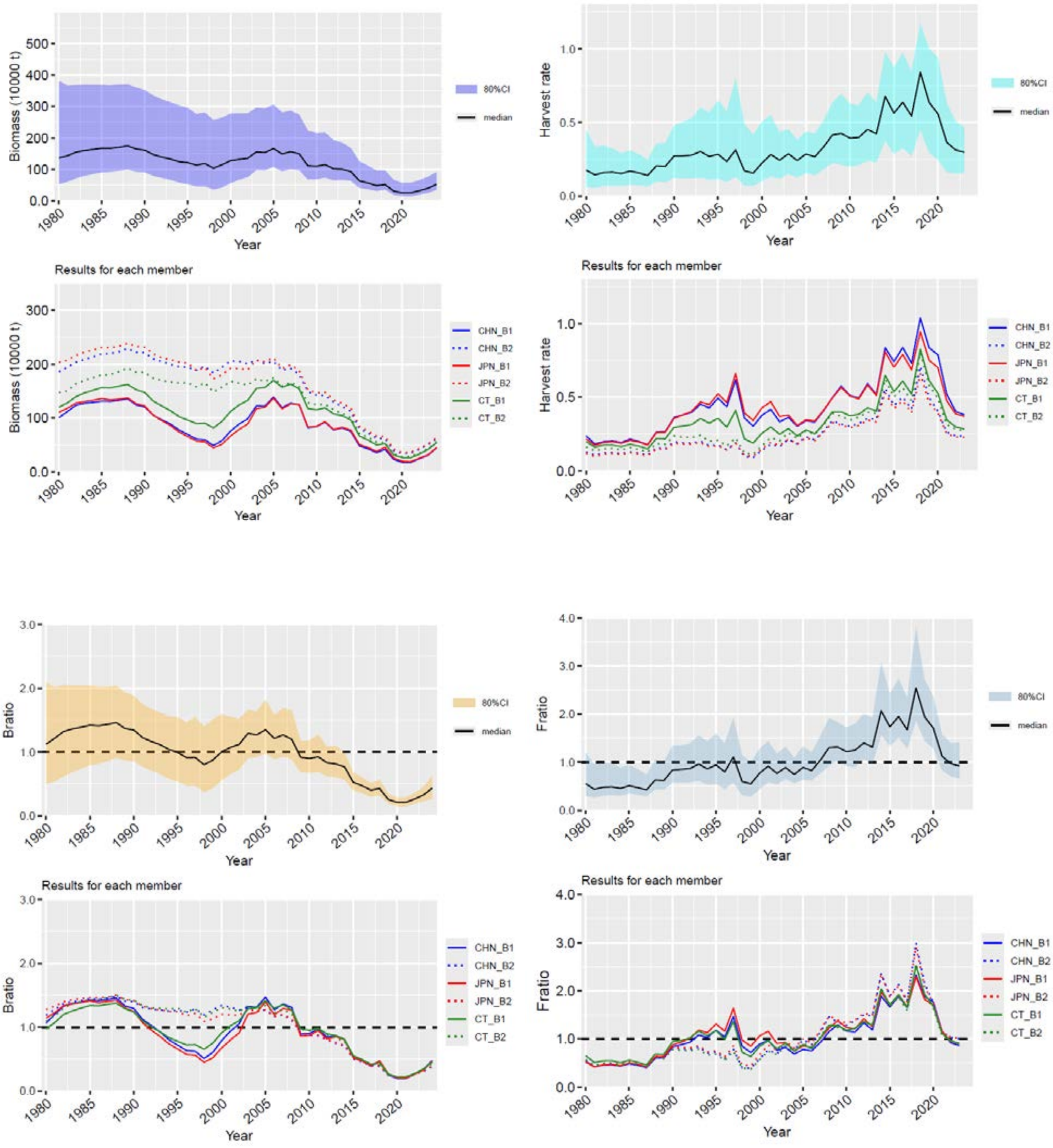

Figure 3. Time series of median estimated values of six runs for biomass, harvest rate, B-ratio, F-ratio and depletion level relative to K. The solid and shaded lines correspond to B1 and B2, respectively.

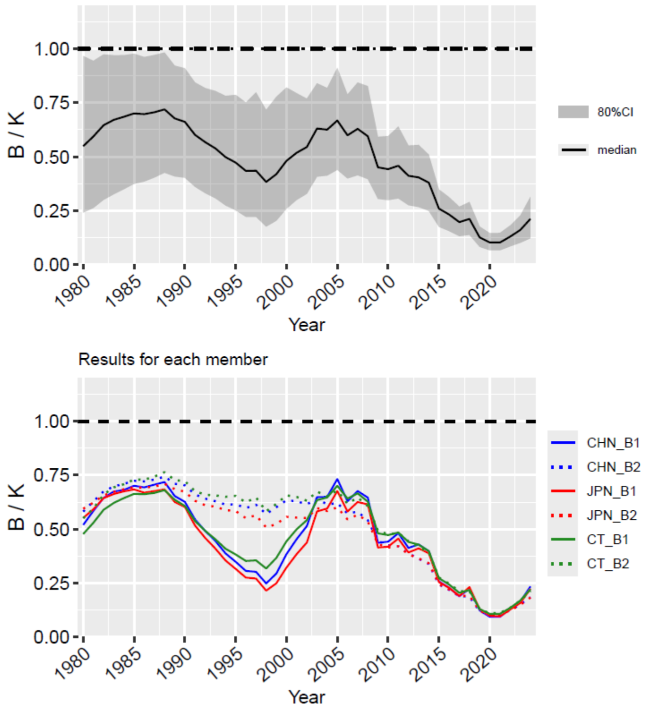

Figure 3 (Continued).

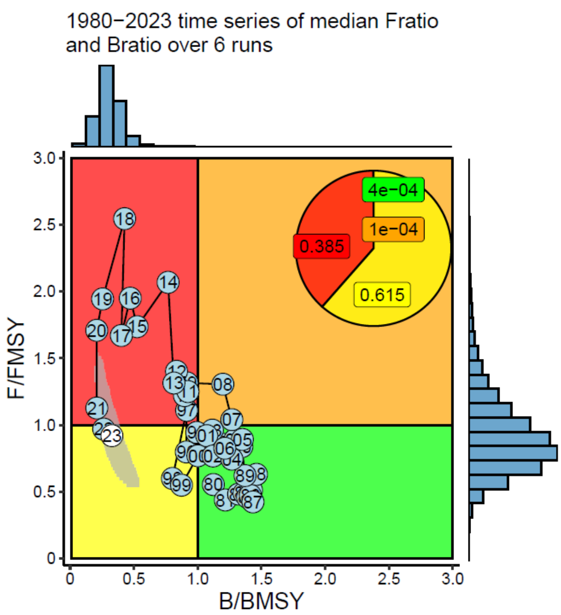

Figure 4. Kobe plot with time trajectory. The data are aggregated across 6 model results (2 base-case models by 3 Members).

4.2 Summary table

Table 3. Summary of estimates of reference quantities. Median and credible interval for the aggregated results are presented. In addition, median values of Member's combined results (over B1 and B2) are shown.

	Median	Lower10%	Upper10%	Median_CHN	Median_JPN	Median_CT
C_2023 (10000 t)	11.836	11.836	11.836	11.836	11.836	11.836
AveC_2021_2023	10.352	10.352	10.352	10.352	10.352	10.352
AveF_2021_2023	0.328	0.158	0.528	0.352	0.339	0.302
F_2023	0.297	0.155	0.469	0.313	0.307	0.277
FMSY	0.330	0.139	0.543	0.357	0.336	0.310
MSY (10000 t)	39.440	32.021	47.010	40.155	39.284	39.010
F_2023/FMSY	0.920	0.656	1.411	0.915	0.942	0.903
AveF_2021_2023/FMSY	1.008	0.755	1.435	1.013	1.026	0.988
K (10000 t)	248.067	151.766	565.726	234.100	253.396	254.500
B_2023 (10000 t)	39.875	25.214	76.394	37.830	38.599	42.720
B_2024 (10000 t)	52.763	35.130	91.631	50.920	52.120	55.155
AveB_2022_2024	41.563	27.387	77.406	39.705	40.555	44.165
BMSY (10000 t)	120.100	78.060	253.481	113.800	119.008	125.100
BMSY/K	0.485	0.392	0.604	0.480	0.471	0.505
B_2023/K	0.161	0.101	0.228	0.158	0.154	0.169
B_2024/K	0.212	0.122	0.315	0.212	0.206	0.219
AveB_2022_2024/K	0.169	0.106	0.236	0.168	0.163	0.175
B_2023/BMSY	0.328	0.225	0.452	0.323	0.322	0.339
B_2024/BMSY	0.435	0.270	0.628	0.433	0.431	0.440
AveB_2022_2024/BMSY	0.345	0.235	0.470	0.341	0.341	0.352

5 CONCLUDING REMARKS

See the Executive Summary.

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Appendix 1

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_early (metric tons/ net haul)	CPUE CT_late (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					4.08		0.747			1.720	0.37
1995	343743					2.10		0.869			1.882	0.37
1996	266424					1.79		0.646			0.786	0.37
1997	370017					3.49		0.501			2.112	0.37
1998	176364					1.05		0.501			0.688	0.41
1999	176498					0.90		0.568			0.688	0.39
2000	286186					1.28		0.822			0.921	0.36
2001	370823					1.65	8.51	0.947	1.44		0.792	0.31
2002	328362					1.11	14.28	1.172	1.33		0.679	0.30
2003	444642	990.8	25.7			2.03	16.80	1.526	2.47		1.272	0.29
2004	369400	879.4	21.3			2.69	12.23	2.914	1.24		1.109	0.29
2005	473907	1064.5	30.4			4.39	19.94	2.963	2.27		1.700	0.27
2006	394093	786.1	30.1			4.53	9.86	1.975	1.00		0.768	0.25
2007	520207	906.3	32.4			4.19	8.54	2.231	2.17		1.285	0.27
2008	617509	1055.6	29.1			5.15	18.70	2.083	2.79		1.742	0.26
2009	472177	433.2	20.7			4.15	10.27	1.175	1.29		1.019	0.28
2010	429808	561.7	28.3			1.78	10.24	1.224	1.89		0.958	0.27
2011	456263	979.3	32.9			2.48	9.61	1.467	2.09		1.235	0.29
2012	460544	439.6	19.7			2.71	10.36	1.442		2.61	1.103	0.30
2013	423790	716.7	27.8	15.63		1.89	13.90	1.407		3.50	0.883	0.27
2014	629576	466.9	22.6	12.60		3.28	19.50	1.479		3.90	1.405	0.25
2015	358883	316.9	20.6	24.81		1.67	7.90	0.652		2.19	0.817	0.28

2016	361688	261.4	26.4	6.60	1.80	11.08	1.208	1.95	0.791	0.27
2017	262640	173.4	27.6	7.06	1.12	5.54	0.525	1.91	0.862	0.27
2018	435881	406.9	28.2	17.70	1.95	13.06	1.577	2.92	1.276	0.28
2019	195251	217.0	21.3	6.29	0.69	2.86	0.558	1.40	0.451	0.22
2020	139779	11.9	99.2	4.37	0.48	2.81	0.497	1.11	0.279	0.27
2021	92117	158.7	31.1	5.85	0.32	2.89	0.141	0.65	0.283	0.29
2022	100085	290.7	22.4	3.82	0.27	1.77		0.69	0.159	0.28
2023	118355	230.0	29.4	9.37	0.30	3.18		1.43	0.335	0.33
2024		331.8	17.2							

Annex E

Specifications of the Stock Synthesis 3 model

Model specification	**Current**	**Suggested changes**	**Priority**	**Comments**
Data and Fleets				
Data	RUS and VAN length comps not included	Add VAN length comps	high	Note that Russia length comps were initially omitted due to sampling concerns
Data	Length comps only	Investigate conditional age at length or include ALKs / aging error directly to .dat	medium	Allows incorporation of time variable growth
Spatial considerations		Possibly use fleets as areas, but very data intense	medium	divide CT or JPN fleets by season (easiest) see NPFC-2024-SSC PS14-WP13
Fleet structure	JPN-early and JPN-late separate	Combine and allow q-walk	low	
Biology				
Natural mortality / post-spawning mortality	annual mortality	if using a monthly timestep, could input vector of monthly M and account for post-spawning mortality	high	
Selectivity	confounded with mortality. As is, using logistic by length comps not fitting	Schooling/fishing behavior and spatial structure suggest dome-shaped selex could happen	high	
Growth	segmented (incorrect	shift to Gompertz	high	

Model specification	Current	Suggested changes	Priority	Comments
	parameters?) von Bert			
Growth variability		will address using better recruitment/settlement timing	high	small CV for larger fish
Maturity	Length logistic inflection ~ 26 cm		high	update with suggestions by Japan (Dr. Fuji)
Fecundity (SSB units)	mature female biomass	some other measure of reproductive output (e.g. number of eggs, etc.)	high	
Recruitment timing	annual with recruitment happening Jan1	More realistically represent the long spawning season with variable survival/growth within the season	medium (see growth)	See NSAM Q&A. Biologists suggested that addressing variability through growth may be more realistic
Model Specifications				
Catchability	non-linear q	Pay attention	medium	
Model timestep	annual with recruitment happening Jan1	explore finer (perhaps monthly) timesteps	low	See old shrimp assessments (Dr. Bohaboy will get) CHALLENGING DATA REQUIREMENTS: would need monthly length, catch, CPUE
Variance weighting	CPUE downweighted	remove variance weighting (or upweight CPUE).	low	
Variance weighting	Effective sample size on length comps max 50	investigate more empirical-driven sample size for length comps, or tuning	low	
Environment				

Model specification	Current	Suggested changes	Priority	Comments
Environment	none	add environmental index into [recruitment?]	low	See NPFC-2024-SSC PS14-WP03: NPGO2?

Annex F

Species summary for Pacific saury

Pacific saury (*Cololabis saira*)

Common names:

秋刀鱼, Qiū dāoyú (China)
サンマ, 秋刀魚, Sanma (Japan)
꽁치, kkongchi (Korea)
сайра, Saira (Russia)
秋刀魚, Chiu-dao-yu or 山瑪魚, San-ma-hi (Chinese Taipei)

Figure 1. Pacific Saury (Cololabis saira).

Management

Active NPFC Management Measures

The following NPFC conservation and management measure (CMM) pertains to this species:

- CMM 2024-08 For Pacific Saury

Available from https://www.npfc.int/active-conservation-and-management-measures

Management Summary

The current management measure for Pacific Saury specifies both catch and effort limits. Catch limits are guided by science advice based on the calculated annual catch level in the entire area of Pacific saury in accordance with the interim HCR. For 2024, Members of the Commission agree that the annual catches of Pacific saury in the Convention Area and the areas under their jurisdiction adjacent to the Convention Area should not exceed 225,000 metric tons. In this year, the annual total allowable catch (TAC) of Pacific saury in the Convention Area shall be limited to 135,000 metric tons. Each Member of the Commission shall reduce the annual total catch of Pacific saury by the fishing vessels entitled to fly its flag in 2024 by 55% from its reported catch in 2018.

In the event that the total reported catch of all Members reaches 90% of the TAC for the Convention Area, the Executive Secretary shall notify all Members without delay. Those Members with more than 10,000 mt of catch limits shall close the fishery within 72 hours from the receipt of the notification. Those Members with less than 10,000 mt of catch limits may continue operations, but their total catch shall not exceed 90% of their catch limits.

The current management measure also states that each Member of the Commission participating in Pacific saury fisheries shall implement either of the following measures:

(a) to reduce the number of fishing vessels flying its flag and fishing for Pacific saury in the Convention Area by 10% from the number of its fishing vessels that fished for Pacific saury in the Convention Area in 2018; or

(b) to prohibit fishing vessels flying its flag from engaging in fishing for Pacific saury in the Convention Area outside its designated fishing period of no longer than 180 consecutive days each year.

In order to protect juvenile fish, Members of the Commission shall take measures for fishing vessels flying their flags to refrain from fishing for Pacific saury in the areas east of 170°E from June to July.

Table 1. Current status of NPFC management measures

Convention or Management Principle	Status	Comment or Consideration
Biological reference point(s)	Established	Updated annually in stock assessment
Stock status	Established	Updated annually in stock assessment
Catch limit	Established	Recommended catch limits updated routinely by Commission
Harvest control rule	Established	Interim HCR (in place until a management procedure is established by the Commission)
Other	Not accomplished	Management strategy evaluation in progress, age structured model development in progress

Assessment

A stock assessment for Pacific Saury is conducted annually by the NPFC's Small Scientific Committee on Pacific Saury (SSC PS) available at: https://www.npfc.int/stock-assessment-reports. The assessment has been a collaborative effort among Members of SSC PS based on a Bayesian state-space production model (BSSPM) since 2019 (Figure 2).

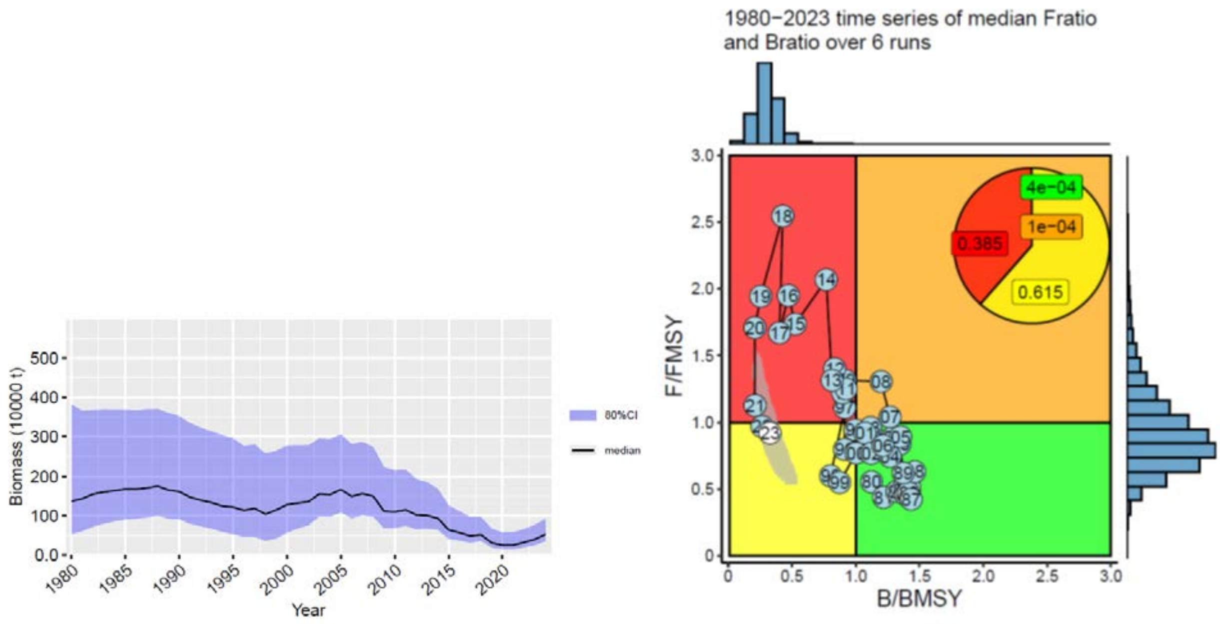

Figure 2. Time series of biomass (left panel) and Kobe plot (right panel) for Pacific Saury stock assessment.

The total catch of Pacific saury has been in decline since approximately 2010 (Figure 3). Similarly, the biomass estimated by the BSSPM stock assessment has also generally declined from its peak during the past two decades.

Data

Surveys

Since 2003, Japan has been conducting a biomass survey covering a wide area of the NPFC Convention area with several research vessels before its main fishing season (Hashimoto et al., 2020). The main purpose of the surveys is to understand the distribution and abundance of Pacific saury and to develop abundance indices for use in stock assessments. Fish sampling also contributes to the understanding of length composition and its inter-annual change.

Fishery

The fishing grounds are west of 180^o E but differ among Members who fish for Pacific saury: China, Japan, Korea, Russia, Chinese Taipei, and Vanuatu. The stick-held dip net gear has become the dominant fishing technique to catch Pacific saury in the northwest Pacific Ocean. Near the coast Japan also catches Pacific Saury with setnet gear. The fishing is mainly carried out from June-November with peaks typically in the late summer or fall. Other NPFC Members (Canada and USA) do not target Pacific saury.

Standardized catch per unit effort (CPUE) is calculated by all Members participating in the Pacific saury fishery and a joint standardized CPUE is calculated across all Member each year and utilized in the assessment (Hsu et al. 2023).

Updated data on Pacific saury catches in the northwestern Pacific Ocean from 1995 are available on the NPFC website: https://www.npfc.int/pacific-saury-catches. Prior years fishery catch data was downloaded from FAO data collections at https://www.openfisheries.org using rfisheries package (Karthik Ram, Carl Boettiger, and Dyck 2013).

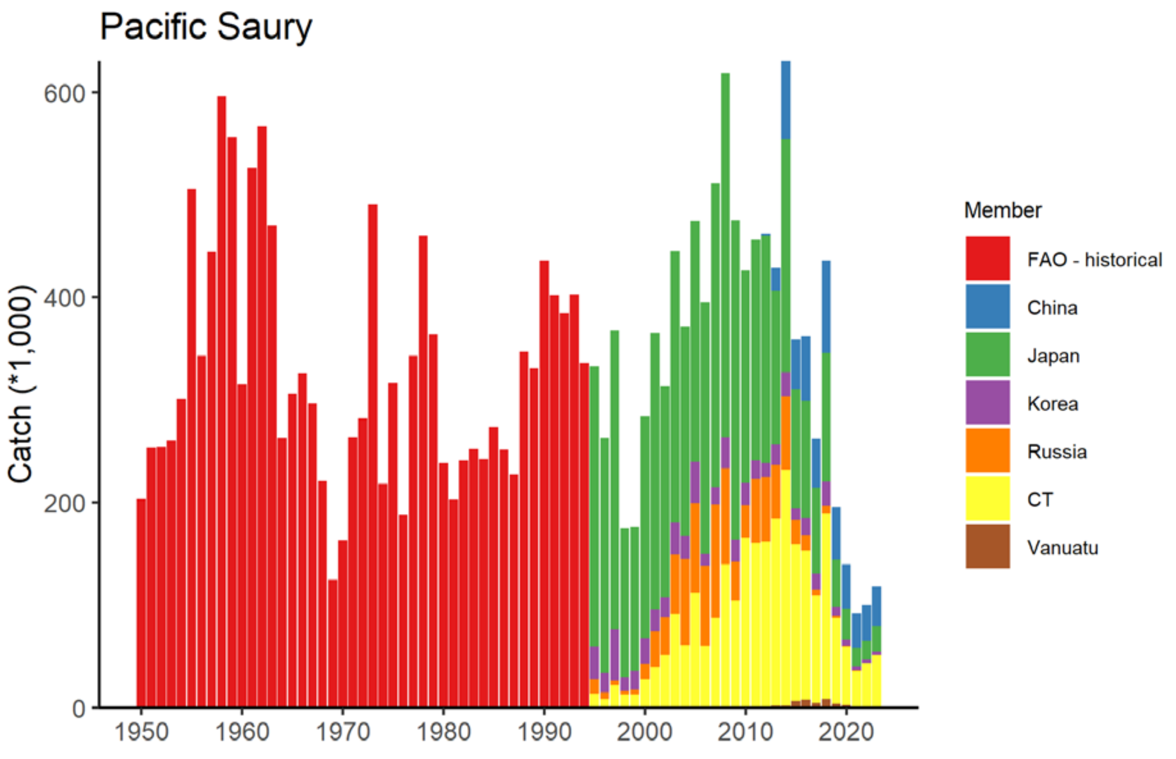

Figure 3. Historical catch of Pacific Saury.

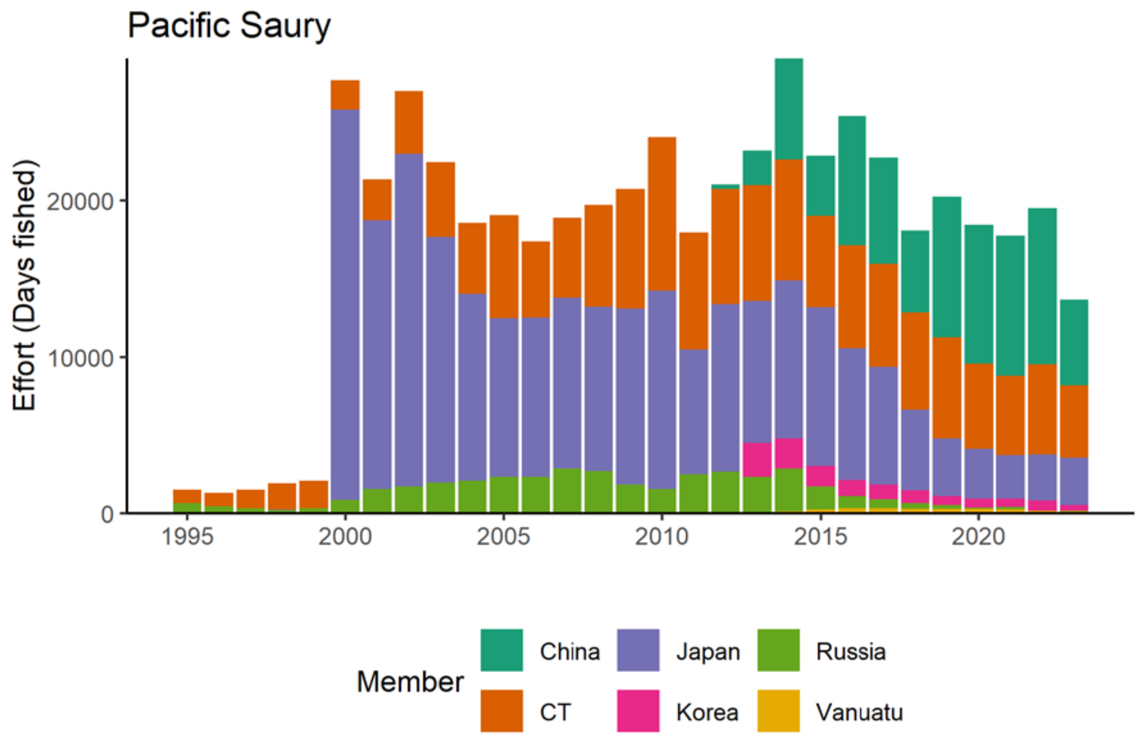

Figure 4. Historical fishing effort for Pacific saury.

Biological collections

All Members collect some size data from fishery catches of Pacific saury. These collections included length data as well as maturity and age structures from some Members.

Japan also collects length, weight, maturity and age data from the survey to support the stock assessment.

Data availability from Members regarding Pacific Saury

Data	**Source**	**Years**	**Comment**
Catch	China	2013-present	Catches from convention area
	Japan	1950-present	Japan<92>s time series of catch data are broken into Early (1980-1993) and Late (1994-2021) CPUE because of time-varying q in the early part of the time series
	Korea	2001-present	
	Russia	1994-present	
	Chinese Taipei	2001-present	

Data	Source	Years	Comment
	Vanuatu	2011-present	
CPUE			CPUE calculated individually by China, Japan, Korea, Russian, Chinese Taipei, and Vanuatu and as a joint CPUE
Survey	Japan		Fishery-independent biomass survey
Length data	All Members		Fishery-independent biomass survey (Japan), fishery data
	Japan		Commercial catch
Maturity/fecundity	Japan		Fishery-independent biomass survey
Age	Japan		Fishery-independent biomass survey

Special Comments

None

Biological Information

Distribution

Pacific saury (*Cololabis saira* Brevoort, 1856) has a wide distribution extending in the subarctic and subtropical North Pacific Ocean from inshore waters of Japan and the Kuril Islands to eastward to the Gulf of Alaska and southward to Mexico. Pacific saury is a commercially important fish in the western North Pacific Ocean (Parin 1968; Hubbs and Wisner 1980). In recent years, the age-0 fish have mainly been distributed in the eastern region east of 170°E in June and July.

Life history

Pacific saury are short-lived and fast growing. Based on analysis of daily otolith increments, Pacific saury reaches approximately 20 cm in knob length (distance from the tip of lower jaw to the posterior end of the muscular knob at the base of a caudal peduncle; hereafter called body length) in 6 or 7 months after hatching (Watanabe et al. 1988; Suyama et al. 1992). There is some variation in growth rate depending on the hatching month during this long spawning season (Kurita et al. 2004) and geographical differences (Suyama et al. 2012b). The maximum lifespan is 2 years (Suyama et al. 2006). The age 1 fish grow to over 27 cm in body length in June and July when Japanese research surveys are conducted and reach over 29 cm in the fishing season between August and December (Suyama et al. 2006). The spawning season of Pacific saury is relatively long, beginning in September and ending in June of the following year (Watanabe and Lo 1989). Pacific saury spawns over a vast area from the Japanese coastal waters to eastern offshore waters (Baitaliuk et al. 2013). The main spawning grounds are considered to be located in the Kuroshio-Oyashio transition region in fall and spring and in the Kuroshio waters and the Kuroshio Extension waters in winter (Watanabe and Lo 1989). The minimum size of maturity of Pacific saury has been estimated at about 25 cm in the field (Hatanaka 1956) or rearing experiments (Nakaya et al. 2010). In rare cases, saury have been found to mature at 22 cm (Sugama 1957; Hotta 1960). Under rearing experiments, Pacific saury begins spawning 8 months after hatching, and spawning activity continues for about 3 months (Suyama et al. 2016). Batch fecundity is about 1,000 to 3,000 eggs (Kosaka 2000). Pacific saury is a highly migratory species that migrates extensively between the northern feeding grounds in the Oyashio waters around Hokkaido and the Kuril Islands in summer and the spawning areas in the Kuroshio waters off southern Japan in winter (Fukushima 1979; Kosaka 2000). Pacific saury in offshore regions (east of 160°E) also migrate westward toward the coast of Japan after October every year (Suyama et al. 2012a). Genetic evidence suggests there are no distinct stocks in the Pacific saury population based on 141 individuals collected from five distant locales (East China Sea, Sea of Okhotsk, northwest Pacific Ocean, central North Pacific Ocean, and northeast Pacific Ocean) (Chow et al. 2009). The Pacific saury larvae prey on the nauplii of copepods and other small-sized zooplankton. As they grow, they begin to prey on larger zooplankton such as krill (Odate 1977). The Pacific saury is preyed on by large fish ranked higher in the food chain, such as *Thunnus alalunga* (Nihira 1988) and coho salmon, *Oncorhynchus kisutsh* (Sato and Hirakawa 1976) as well as by animals such as minke whales *Balaenoptera acutorostrata* (Konishi et al. 2009) and sea birds (Ogi 1984).

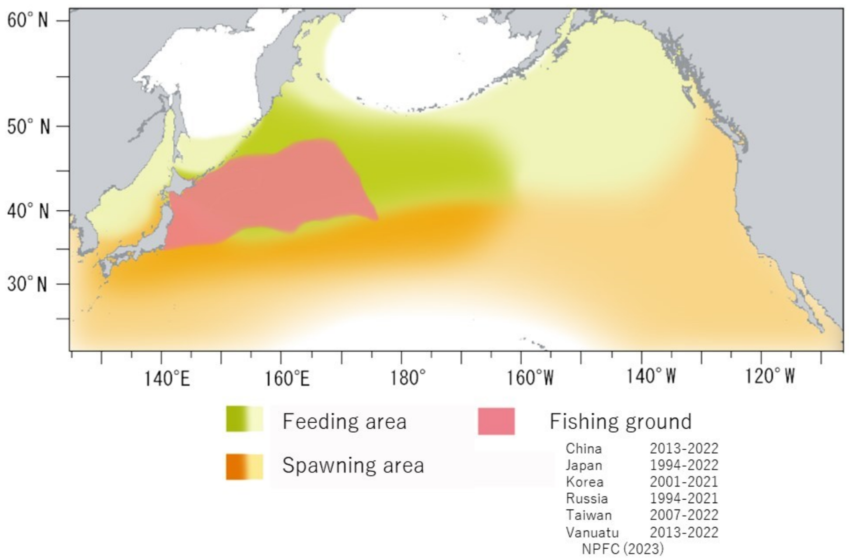

Figure 5. Map of distribution of Pacific saury in the North Pacific.

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