NPFC-2024-SSC PS14-WP08

**Working Group on New Stock Assessment Models for Pacific Saury**

**– Progress Summary for 2024**

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# **Abstract**

In 2024, three scientific meetings were held by the Working Group on New Stock Assessment Models (WG NSAM) to advance the development of age-structured stock assessment models for Pacific saury (*Cololabis saira*). 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. This report summarizes both the progress made and the challenges encountered, with an outlook on the next steps in the development process.

**1. Introduction**

The sustainable management of Pacific saury, a key pelagic species in the North Pacific, requires biologically plausible stock assessment models. In 2024, the Working Group on New Stock Assessment Models (WG NSAM) convened three meetings aimed at developing age-structured stock assessment models for this species, particularly focusing on the Stock Synthesis (SS) model. Significant progress was made in data integration, parameter adjustments, and model configuration, but challenges such as poor fit to size composition data and retrospective bias persist. This report highlights both the progress made and the remaining challenges, and outlines future directions for model improvement.

# **2. WG NSAM01: 27-29 June 2024 (Shanghai)**

2.1 Overview

The first meeting was held in Shanghai, where the WG NSAM reviewed two alternative age-structured models for Pacific saury: SS and the State-Space Age-structured Model (SAM). Both models have been applied to Pacific saury using preliminary data with some success (NPFC-2023-SSC PS12-IP08; NPFC-2023-SSC PS12-WP07 (Rev. 1)). After careful evaluation, The WG NSAM agreed to proceed with SS due to its flexibility, extensive documentation, and global application in fisheries stock assessments.

* 1. Initial Progress on SS

The WG NSAM agreed to use preliminary data and input files for the SS model from a working paper initially presented at the 2023 meeting in Nanaimo, BC (NPFC-2023-SSC PS12-IP08). This SS model incorporated data from seven fleets, including catch and CPUE from 1980 to 2022. However, only length composition data from Japan and Chinese Taipei were utilized. Several sensitivity runs were developed and conducted during the meeting (see Annex B in the WG NSAM01 meeting summary). In most cases, only one aspect of the Nanaimo model configuration was altered. Decisions to modify any part of the model configuration were based on the participants' understanding and knowledge of the data, model, fisheries, and biology.

2.3 Challenges Identified

Despite the initial progress, the SS model exhibited several configuration and diagnostic issues:

* The model struggled to accurately fit size composition data, particularly for larger fish, suggesting the need for further refinement in growth, selectivity, and natural mortality parameters.
* The selectivity pattern for the Japanese survey was assumed to be the same as that of the Japanese fishery.
* Estimated dome-shaped selectivity curves tended to peak and decline abruptly over the largest size bins in the model, indicating potential misspecification.
* Preliminary runs showed sensitivity to the inclusion of early Japanese CPUE data, historical catches, and the starting year.
* A strong retrospective bias was observed, where stock estimates changed significantly when additional years of data were included. This instability underscored the need to revisit how early data were being handled.
* The type of length measurements varied among different fishing fleets. The difference between knob length and fork length may have blurred and reduced the accuracy of the length data.
* Preliminary SS models included ages 0, 1, and 2+, even though few Pacific saury live to age two.

2.4 Key Decisions

* SS was selected as the primary model moving forward, with a focus on enhancing the integration of biological and fishery data from all members.
* The WG NSAM prioritized addressing diagnostic issues related to data fitting and retrospective patterns in future meetings.
* It was decided to ignore the difference between fork and knob lengths in the model, as the average difference for size groups in the fishery is only about 3 mm.
* The WG NSAM agreed that natural mortality and steepness for Pacific saury would not be estimable within SS, and that an external estimate would be required.
* Members were encouraged to conduct a thorough analysis of their own fishery data and provide recommendations on if, how, and when selectivity and catchability patterns may have changed in their fishery or survey.
* Models using only ages 0 and 1+ were run, with results to be discussed at a future meeting.
* The WG NSAM agreed on the need to assume time-varying catchability for early Japanese CPUE.
* It was decided to approximate the Gompertz growth curve in SS by fixing parameters to external estimates.
* The WG NSAM agreed on the use of age-specific survey indices in SS.

**3. WG NSAM02: 2 August 2024 (Online)**

3.1 Overview

In the second meeting, the WG NSAM focused on sensitivity analyses and refining key parameters within the SS model. Progress was made in testing the impact of different parameter assumptions, particularly steepness and selectivity assumptions, on model estimates​.

3.2 Sensitivity Analysis and Model Refinements

* The WG NSAM conducted sensitivity analyses using different steepness values (ranging from 0.59 to 0.93). The results indicated that the steepness parameter had a significant impact on the estimated spawning stock biomass, recruitment and fishing mortality.
* The WG NSAM attempted to address temporal residual patterns in Chinese Taipei’s CPUE index by splitting the dataset into multiple surveys or applying time-varying catchability. Splitting the dataset into two periods (2011-2011 and 2012-2022) within the SS made little improvement and did not resolve the residual pattern. However, using time-varying catchability (random walk) dramatically improved the residual patterns but also altered the scale of recruitment, spawning stock biomass, and fishing mortality.
* The WG NSAM found that model runs using only two age groups (0 and 1+) with asymptotic fishery selectivity did not significantly improve the model fit.
* The WG NSAM experimented with asymptotic selectivity curves to improve the fit to size data. Although the fit improved by estimating growth, selectivity, and natural mortality parameters within the model, this approach was inconsistent with some decisions made at the WG NSAM01 meeting.

3.3 Improvements and Challenges

* Through the sensitivity tests, the WG NSAM gained a deeper understanding of the model's behavior and how key parameters, such as steepness and selectivity, influenced stock estimates.
* Despite these refinements, the SS model continued to display biologically unrealistic growth curves and strong retrospective bias, indicating that further work is needed to improve the model's biological realism.
* Inconsistencies were observed in the size composition data, potentially due to changes in fishing locations or other factors.
* The current model configuration struggles to capture certain aspects, such as the three spawning cohorts of Pacific saury, the relatively short fishing season in the second half of the year, and the varying locations of fishing grounds for members' fleets.

3.4 Key Decisions

* The WG NSAM decided to retain the default steepness value of 0.82 but will continue to test its impact on model outputs.
* The WG NSAM agreed to maintain the current approach of constant catchability for Chinese Taipei’s CPUE index while continuing to explore other options.
* Additional sensitivity analyses and further testing of selectivity, growth curves, and natural mortality will be conducted to address the retrospective bias and improve data fitting.

**4. WG NSAM03: 17 October 2024 (Online)**

4.1 Overview

The third meeting focused on integrating new data into the SS model, with particular emphasis on incorporating size composition data from members beyond Japan and Chinese Taipei, as well as conditional age-at-length data from the Japanese survey. The meeting also highlighted disagreements between the model assumptions, data, and biology of Pacific saury, indicating that these assumptions require further consideration. Additionally, the meeting reviewed responses to questions posed by the WG NSAM to biologists, and made notes based on the preliminary feedback provided by the biologists.

4.2 Progress in Model Update

* The update included several potential modifications, such as incorporating monthly length data, applying random walk time-varying catchability for pre-2012 Chinese Taipei CPUE, and splitting the post-2011 Chinese Taipei CPUE based on updated CPUE standardization. The data file was updated through 2023 (survey for 2024) and now includes size composition data from Korea and China, in addition to Japan and Chinese Taipei. Other features in the updated control files, such as the estimation of all growth and selectivity parameters, remained unchanged from the previous version.

4.3 Issues Identified

* The rationale for applying time-varying catchability to the early Chinese Taipei CPUE was unclear, and this addition may not be beneficial. The random walk in estimated catchability for Chinese Taipei did not show a clear increasing trend, unlike the results for the Japanese fishery. The WG NSAM suggested it might be more effective to apply a single catchability with a random walk to the entire Chinese Taipei CPUE time series (both early and late periods).
* The invited expert suggested that the appropriate growth curve used in SS modeling for saury in SS is related to the biological growth curve for a cohort, but may be substantially different because of the protracted spawning season. The best growth curve for modeling may be one that simply best fits the seasonal patterns in size composition and possibly different from published examples.

4.4 Key decisions

* The WG NSAM decided to assume asymptotic selectivity instead of dome-selectivity patterns, as this approach better reflects the fishery and biological characteristics of Pacific saury.
* The WG NSAM confirmed the decision to reduce the number of age groups from three to two (0 and 1+), recognizing that the absence of age two fish is likely due to spawning mortality rather than fishery selectivity patterns that protect larger, older fish.
* The WG NSAM suggested continuing to prioritize the Japanese fishery-independent biomass index over fishery-dependent CPUE indices when estimating Pacific saury biomass.
* The WG NSAM noted that the currently estimated growth curve in the SS model, which assumes ages 0-2+, differs significantly from published growth patterns. Participants suggested that a published growth curve (NPFC-2019-SSC PS05-WP18) could be used in the SS model instead.

**5. Conclusion**

Throughout 2024, the WG NSAM made significant progress in developing the SS model for Pacific saury, particularly in refining selectivity parameters, adjusting the age structure, and integrating additional data. However, challenges remain, especially regarding diagnostic performance, including poor fits to size composition data, persistent retrospective bias, and limited predictive skill. Moving forward, the WG NSAM will focus on addressing these issues by refining time-varying parameters, enhancing data integration, and collaborating more closely with biologists to ensure the model accurately reflects the biological dynamics of Pacific saury. Additionally, the WG NSAM will consider the impacts of climate change on Pacific saury populations and their habitats, recognizing that these factors may significantly influence stock and fleet dynamics. Next steps will include further sensitivity testing, adjustments to key parameters such as selectivity and growth, and additional data collection and sharing to improve the model's reliability for future stock assessments.

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