

Peer Review of Japanese Flying Squid Stocks in 2022

April 30, 2023

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Background

The Fishery Research and Education Agency (FRA) of Japan organized an independent peer review of selected invertebrate stock assessments in 2022. Invited peer reviewers included two external reviewers from the National Oceanic and Atmospheric Association (NOAA) Fisheries' Southwest Fisheries Science Center (Drs. Steve Teo and E.J. Dick). Reviewers were asked to participate in the assessment review meetings and submit peer review reports (this document). Several documents were made available for consideration prior to the review panel meeting, including:

1. FRA-SA2021-RC05-1e Stock assessment and evaluation for North Pacific stock of snow crab
2. FRA-SA2021-RC06-1e Stock assessment and evaluation for Sea of Japan Area A stock of snow crab
3. FRA-SA2021-RC06-2e Stock assessment and evaluation for Sea of Japan Area B stock of snow crab
4. FRA-SA2021-RC04-1e Stock assessment report on winter-spawning stock of Japanese flying squid
5. FRA-SA2021-RC04-2e Stock assessment report on autumn-spawning stock of Japanese flying squid
6. Supplementary material-Estimating MSY of snow crab
7. Supplementary material-Standardized CPUR for Autumn-spawning stock (flying squid)
8. Supplementary material-Standardized CPUR for winter-spawning stock (flying squid)

Other documents made available to the reviewers included electronic copies of presentations given by analysts during the meeting, an article concerning estimation of MSY for snow crab stocks (Shibata et al. 2020), and two reports detailing standardization of the CPUE. The project manager of the peer review requested that the external reviewers prepare and submit pre-review questions to the assessment teams a month in advance of the meeting, to allow them time to organize their responses. Copies of the pre-review questions from Dr. Dick are included here as Appendix A.

Reviewing system

The peer review was conducted the week of November 7th, 2022, via a hybrid meeting format, i.e., attendees present either online or in-person. Pre-review questions were requested well in

advance and submitted a month prior to the meeting, and translation services were provided during the meeting itself. I appreciated having the opportunity to prepare questions in advance, as it would have been difficult for the stock assessment teams to prepare meaningful responses during the review meeting. A large fraction of the presentations for each stock were devoted to answering the pre-review questions, which was an efficient use of time and provided an opportunity to explore additional questions as they arose.

Stock assessment review report

The review of Japanese Flying Squid stocks began with a presentation titled, “General overview on Japanese flying squid (JFS).” To help the reviewers understand the delineation of stocks, the topics of this overview included the spawning season, distribution, and seasonal migration patterns of each stock, and concluded with points of separation and methods used to allocate catch among stocks.

Spawning, although occurring throughout the year, primarily occurs in autumn or winter. Spring and summer cohorts are combined with winter and autumn spawning stocks, respectively. Stock identification is based on several factors, including timing of spawning seasons, spawning grounds, and northward migration patterns. These patterns have resulted in a set of classification rules. These rules assign catch to stocks based on month, region, and, fishery. Some cells in this classification scheme represent mixtures of the two stocks, but these are a small fraction of the total catch.

It was noted during the review that the classification rules were developed based on a single year (1997). Discussions of revising the rules were held roughly ten years later, but the assessment team recognized the need to update the rules and to consider annual variation in the spatial and temporal distribution of stocks.

1. Japanese Flying Squid, Autumn-Spawning Stock

The autumn-spawning stock of JFS represents the larger of the two stocks, and is distinguished by a dominant mode of spawning from October to December. The autumn stock primarily occupies the Sea of Japan, using it as a nursery area from May-Sep. A northward feeding migration is followed by a southward spawning migration, returning to spawning grounds.

Official catch statistics are published by the Japanese and South Korean governments. Chinese catch is unknown. Recent analysis of satellite data suggests that significant unreported catch is occurring, and is too large to ignore. The current assessment assumes a constant annual catch of 150,000 tons, which represents an intermediate estimate given the range of estimates in the literature. In response to reviewers’ questions about Chinese catch, the stock assessment team noted that future efforts will attempt to scale Chinese catch based on satellite-based estimates of fishing effort (recognizing that these estimates are highly uncertain). The assessors also noted that Chinese fishing effort has decreased since 2020 (likely due to the pandemic), and that a sensitivity assuming Chinese catches of 300,000 tons per year resulted in catch exceeding the estimated recruitment.

The recruitment estimation survey in the Sea of Japan is used to calculate a recruitment index, and this in turn is scaled up to represent actual recruitment ($R_t = q * U_t$). The survey operates from June-July, and uses squid-jigging gear to collect catch and effort data annually since 1979. Dr. Teo noted that the small-jigging index produced similar trends, and was less variable. The assessment team cited lags in logbook data collection as an impediment to using the fishery data. It is possible that advances in electronic data collection and monitoring might reduce this time lag and allow for use of these data in the future.

A large amount of discussion focused on the estimation of q , as this is critical to determination of annual recruitment. Currently, daily decreases in CPUE are used to determine daily total mortality. Given an assumed M , it is possible to adjust q to match an average F of 0.447 based on estimates from 1997-2001.

An encouraging development with this stock is the potential use of the “State-space Assessment Model Used for IKA (SAMUIKA)” to assess stocks of JFS (Nishijima et al. 2021). Their model allows for simultaneous estimation of dynamics for multiple stocks, as well as regime shifts in the stock-recruitment relationship. Application of SAMUIKA to the autumn-spawning stock produced similar recruitment estimates (slightly smaller, preliminary results). This model can provide simultaneous estimation of stock-recruitment parameters and forecasts that incorporate both parameter uncertainty and recruitment variability.

For the current assessment, estimates of recruitment and spawning stock size were fit using a hockey stick model. This model was found to be less sensitive to model misspecification compared to a Beverton-Holt model.

Using this model, reference points were sensitive to the assumed level of Chinese catch. However, it is worth noting that these comparisons (Kobe plots) are all on a relative scale, and implications to potential yield under alternative catch assumptions are not apparent from this analysis (except when Chinese catch was set to zero, an unlikely scenario).

2. Japanese Flying Squid, Winter-Spawning Stock

The winter-spawning stock of JFS represents the smaller of the two stocks, and is distinguished by a dominant mode of spawning from January to March. The winter stock migrates north along the Pacific side of Japan (feeding migration). The southern spawning migration is through the Sea of Japan.

A key difference in methods for the winter stock is the estimation of recruitment based on a fishery-dependent survey (coastal squid-jigging fishery) rather than a recruitment survey. However, a similar approach is taken whereby the index is scaled up to represent total recruitment of squid to the Pacific nursery and fishing grounds. The coastal squid-jigging fishery is the major fishing fleet for the winter-spawning stock, harvesting squid from July to December, with annual effort ranging from 10 to 20 thousand boat days in recent years.

Catch is estimated from sales slips spanning 17 ports (aggregated into 7 regions). CPUE standardization is based on a generalized linear mixed model with the 7 regions representing 'ports', as well as year and month effects, and a year:month interaction (fixed effects). Interactions with port were modeled as random effects. It was noted that standard errors are currently not used in the stock assessment process. However, estimates of uncertainty are easily obtained from the GLMM framework, and could be used in future applications of the current assessment methodology, or incorporated into state-space and/or integrated statistical catch-at-age models.

The stock assessment team was able to clearly answer questions from the reviewers related to calculation of assumed mortality rates, catchability coefficients, and foreign catch estimates. In addition, the team was able to present preliminary results based on the Stock Synthesis model (SS3; Methot and Wetzel, 2013). Estimates of exploitation rates from SS3 were very similar to the conventional estimates, with SS3 estimates 4% larger on average over the time period 1995-2016.

A modified DeLury method (depletion method incorporating M) and the SAMUIKA approach were also able to capture similar dynamics based on data from 1979 to 2021. Estimates of exploitation rates and recruitment from this method were also remarkably consistent with the conventional estimates. The consistency of results across modeling platforms lends support to the findings obtained by the conventional estimation procedure. However, the methods that allow for estimation of uncertainty in reference points have a distinct advantage, as probabilities of exceeding reference points are an integral part of the management process. In addition, closed-loop simulations could help understand the performance of 3-year TAC control rules in the context of short-lives species such as squid.

Overall comments for Japanese Flying Squid assessments

Suggestions to consider Empirical Dynamic Models (Munch et al. 2020) and / or egg production methods (Lasker, 1985) are meant to provide means of validating existing surveys and estimates. However, plans described by the assessment teams to investigate the use of SAM and/or Stock Synthesis in future assessments are likely to be the most productive courses of action.

Overall, the quality of the three assessments for JFS stocks examined during the review, as well as the presentations given by the assessment teams, were excellent. I appreciate and recognize that the assessment teams spent considerable time and effort addressing numerous pre-review questions, and found their answers and results to be informative and reasonable.

References

Lasker, R. (Editor) 1985. An egg production method for estimating spawning biomass of pelagic fish: application to the northern anchovy, *Engraulis mordax*. NOAA Technical Report NMFS 36. 99 p.

- Methot, R. and C. Wetzel. 2013. Stock synthesis: A biological and statistical framework for fish stock assessment and fishery management, *Fisheries Research* 142: 86-99. doi.org/10.1016/j.fishres.2012.10.012.
- Munch, S. B., Brias, A., Sugihara, G., and Rogers, T. L. 2020. Frequently asked questions about nonlinear dynamics and empirical dynamic modelling. *ICES Journal of Marine Science*, 77: 1463–1479. doi:10.1093/icesjms/fsz209
- Nishijima S., Kubota H., Kaga T., Okamoto S., Miyahara H., Okamura H. 2021. State-space modeling clarifies productivity regime shifts of Japanese flying squid. *Popul. Ecol.* 63(1): 27–40. doi.org/10.1002/1438-390X.12062

Appendix A

Pre-review questions for two stock assessments of Japanese flying squid in fiscal year 2021

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Several documents were made available for consideration prior to the panel meeting. These included assessments for the following two stocks of Japanese flying squid in fiscal year 2021:

1. Autumn-spawning
2. Winter-spawning

For each stock, a separate document was also provided describing the method for standardization of CPUE indices used in each assessment. The purpose of this document is to provide questions in advance of the review based on the materials provided, such that the assessment teams can prepare responses for the review panel meeting, currently scheduled for November 2022.

Questions and comments relevant to both Japanese flying squid stock assessments

1. Stocks such as these with annual life spans, and long time series of catch and effort (or CPUE) are prime candidates for application of the Empirical Dynamic Modeling framework (c.f. Munch et al. 2020). I encourage you to explore this approach for Japanese flying squid, and would be happy to introduce you to Dr. Steven Munch at the NMFS SWFSC Fisheries Ecology Division for more information. Dr. Munch has found that the predictive skill of this model improves upon parametric and nonparametric stock recruitment relationships when applied to short-lived species such as squid.
2. Reporting uncertainty in standardized CPUE, q , z^* (daily total mortality), stock-recruitment parameters, and development of a prior for M would allow propagation of uncertainty into management quantities such as spawning biomass.
3. An independent estimate of spawning stock size could be obtained from larval survey data via an egg production method (Lasker 1985). If average fecundity of females is known, then estimation of the parental stock size could be based on observed densities of larvae.

Questions specific to the assessment report on the autumn-spawning stock of Japanese flying squid (fiscal year 2021)

4. Similar to the assessment for winter-spawning squid, it would be useful to calculate and report uncertainty in the standardized CPUE index. This could be used to propagate uncertainty into quantities of interest to management (Fig. 5 in the “CPUE Standardization / Model Diagnostic Results” document).

5. In Appendix 2, you note that the proportionality constant, q , changed by an order of magnitude (from 2.96×10^8 to 3.51×10^9). Is this simply due to an arbitrary scaling change during the CPUE standardization? I'm assuming there was not a 10-fold change in the biomass estimates.
6. To estimate average fishing mortality, is the daily decrease in CPUE obtained by a survey that is operating simultaneously with the fishery, and in the same area, to monitor total mortality? This is what I understood from reading the report, but please correct me if I'm mistaken.
7. If the survey monitors daily changes in relative CPUE, how much variability is there in the rate of decline across years and areas? In other words, if the data are subset by time period or area, how much do the estimates of daily total mortality differ from the estimates derived from the entire time period (1979-2000)?
8. The calculation for relative CPUE was revised to incorporate catchability as a function of average mantle length. Does the assumed exponential relationship reflect how size affects vulnerability of squid to the gear? I am wondering if vulnerability increases with size at first, but may asymptote beyond a certain size.
9. In addition to the ROC and Q-Q plots provided for the standardized index, please show the estimated relationships between predicted CPUE and temperature, area, and mantle length.
10. In the sensitivity test to alternative values of M , can you describe why the 2021 biomass does not change, while the 2021 Spawning Stock Biomass (SSB) changes? Is this change in M applied to all steps in the assessment that rely on M ? Looking at Equation 2, a change in M would affect the estimate of q , which would affect the biomass estimate in Equation 1.
11. How sensitive are the model results to the assumed level of Chinese catch?

Questions specific to the assessment report on the winter-spawning stock of Japanese flying squid (fiscal year 2021)

12. On the title page of the report it is noted that reference points in the report were proposed in July 2020, and were to be finalized in December 2020. Do the reported reference points in the report represent the final values, or did a change occur after publication?
13. In the sensitivity test to alternative values of M (Fig. 4-4), can you describe why the 2021 biomass does not change, while the 2021 Spawning Stock Biomass (SSB) changes? Is this change in M applied to all steps in the assessment that rely on M ? Looking at Equation 2, a change in M would affect the estimate of q , which would affect the biomass estimate in Equation 1.
14. The estimate of q for this stock assumes an average exploitation rate of 0.3 from 1997 to 2000, which is smaller than the average exploitation rate assumed for the autumn-spawning stock (0.447). What is the basis for the difference in average exploitation rates between the two stocks? Also, what is the estimated value of q for this stock? For the 2021 projection, the reported value is 18.32, which is difficult to interpret in this context.
15. Catches by China and Russia are not reported prior to 2012 in Table 3-1. Are catches by these countries likely to be a small fraction of the total catch over this time period? If not, how sensitive is the model to alternative assumptions about foreign catch?

16. What fraction of the potential suitable area for spawning (Appendix Figure 4-7) is sampled by the larval survey each year? If the survey covers a significant fraction of the area, and average estimates of fecundity are available, it could be possible to estimate spawning stock using the above-mentioned egg production methods.

Literature Cited

- Munch, S. B., Brias, A., Sugihara, G., and Rogers, T. L. 2020. Frequently asked questions about nonlinear dynamics and empirical dynamic modelling. *ICES Journal of Marine Science*, 77: 1463–1479. doi:10.1093/icesjms/fsz209
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