North Pacific Fisheries Commission

NPFC-2020-TWG CMSA03-WP03

Review and update on fishery-independent and fishery-dependent indices of the chub mackerel of Japan

Akihiro Manabe[1], Shota Nishijima[1], Ryuji Yukami[1]

1: Fisheries Resources Institute, Japan Fisheries Research and Education Agency (FRA)
2-12-4 Fukuura, Kanazawa, Yokohama, Kanagawa, 236-8468, Japan
(corresponding author: Akihiro Manabe, amanabe@affrc.go.jp)

Summary

Japan had four potential abundance indices of the chub mackerel in the Northwestern Pacific. Two are the recruitment indices that are derived from midwater trawl surveys in summer and autumn, one is the index of spawning stock biomass (SSB) from egg surveys off the Pacific coast of Japan, and the remaining one is a fishery-dependent SSB index. In this paper, we show a brief description of the abundance indices including updated results. All indices are standardized and have time series longer than or equal to 15 years. The indices provide useful information on the stock assessment of the Pacific chub mackerel.

Introduction

The domestic stock assessment of chub mackerel (*Scomber japonicus*) in Japan has long been conducted using a tuned virtual population analysis (VPA) with multiple abundance indices. We already presented the detailed descriptions of the Japanese abundance indices in the previous CMSA TWG (Nishijima et al. 2017; Kanamori et al. 2018) and published the results of index standardization as scientific papers (Hashimoto et al. 2019; Kanamori et al. 2019). Here we briefly describe the methodology and updated results of Japanese four abundance indices originated from three fishery-independent and one fishery-dependent data.

Material and methods

Trawl survey indices for recruitment

Japan conducts midwater trawl surveys in summer and autumn, whose catch rates (numbers per hour per tow) of young-of-the year (YOY) are used as the abundance indices for the number of recruits (Yukami et al. 2020). Although the midwater trawl survey in summer has been conducted since 2001, we used the data from 2002 because the survey covered a limited area in 2001 (N = 1814). This survey uses multiple research vessels to sample small pelagic fishes including chub mackerel in migration to the northern waters. The survey is conducted in May to July in water between Kuroshio-Oyashio transitional area to Oyashio current region (between Pacific coast of Japan to 165W), where is the feeding grounds for chub mackerel.

The midwater trawl survey in autumn (September-October) has been conducted on Eastern Hokkaido, Sanriku, and Joban region of Japan since 2001. The survey area has been expanded to the eastern water of Kuril Islands since 2005 and, therefore, we used the data from this year (N = 586).

The catch rates of YOY were both standardized using the delta-GLM (Lo et al. 1992), a mixture model of positive catch probability and rate, because the data include a high proportion of zero catch (81.8% for summer and 57.3% for autumn). To determine area boundaries, we used "GLM-tree" (Ichinokawa and Brodziak 2010), which conducts automatic area stratification so that an information criterion, such as AIC or BIC, becomes minimized. We named this model as "delta-GLM-tree" because we integrated the GLM-tree approach to the delta-GLM (Hashimoto et al. 2019). Explanatory variables used were year (categorical), area stratified by the delta-GLM-tree (categorical), the interaction between year and area, sea surface temperature (SST) at sampling (continuous), its square, water temperature at 50m depth (continuous), its square, and the interaction between SST and water temperature at 50m depth for the summer survey. Explanatory variables for the autumn surveys were year (categorical), area stratified by the delta-GLM-tree (categorical), the interaction between year and area, sea surface temperature (SST) at sampling (continuous), its square, water temperature at 30m depth (continuous), its square, and the interaction between SST and water temperature at 30m depth. We used a binomial distribution with logit link for the probability of positive catch and a gamma distribution with log link for the rate of positive catch. We selected the best model having the lowest BIC from all potential candidates.

Egg survey index for SSB

Egg surveys are conducted by Japan Fisheries Research and Education Agency (FRA) and its joint venture institutions from 18 prefectures located on the pacific coast. The distribution of eggs of pelagic fishes are sampled and observed using modified NORPAC plankton net (335 micrometer mesh). Of the mackerel eggs, chub and spotted mackerels are segregated since 2005 as species of eggs became identifiable and therefore we analyzed the data from 2005 (N = 12,110). The number of eggs in the water column for each tow was standardized by flowmeter revolution (filtering rate), towing distance, and tow cable angle. Egg density in the water column was then calculated for each 30° latitude × 30° longitude horizontal square resolution. The details of sampling and analysis are shown in Takasuka et al. 2008 and Takasuka et al. 2017.

We standardized the egg density by the Vector-Autoregressive Spatio-Temporal (VAST) model (Thorson 2019), which accounts for spatio-temporal changes in survey design and observation rates and can accurately estimate relative local densities at high resolution. The model is a delta-type model having two components, (i) the encounter probability and (ii) the expected egg density when spawning eggs are sampled. Spatial and spatio-temporal variations in the encounter probability and positive density are approximately estimated using Gaussian random fields (a multidimensional generalization of Gaussian process). More detailed information about the VAST model was provided by Thorson (2019). We used a binomial distribution with logit link for the encounter probability and a lognormal distribution with log link for the positive density. We adopted the lognormal distribution because of a smaller AIC than a gamma distribution (Kanamori et al. 2018). We used 100 knots but confirmed that results are not sensitive to the number of knots (Kanamori et al. 2018; Kanamori et al. 2019).

Fishery-dependent index for SSB

Japan has used a standardized catch-per-unit-effort (CPUE) of dip-net fishery as the index of spawning stock biomass (SSB) in the tuned VPA (Yukami et al. 2020). The dip-net is a type of traditional fishery that uses strong lights at night to aggregate fish and catch fish using dip nets held and controlled by each person on board. The dip-net fishery is operated by Kanagawa and Shizuoka prefectures and the prefectural fisheries laboratories from the two prefectures collect data since 2003 and 2014, respectively. The dip-net fishery primary catches chub mackerels and operates in Izu Islands waters, where is a major spawning ground of chub mackerel (Watanabe and Yatsu 2006), and therefore its CPUE is appropriate as an index of SSB. The CPUE is calculated from the fishing record of vessels as catch per person per hour.

We standardized the CPUE of dip-net fishery using delta-GLM (Lo et al. 1992), because the dip-net CPUE data (kg/hour/person) are continuous numerical values including zeros (the proportion of zero is 20.0%). Similar to the standardization of summer and autumn survey CPUEs described above, bimodal distribution (logit link) and gamma distribution (log link) are used as error distribution. Of the available data (2003-2019), data collected during the spawning season (January-June) are used (N = 1741). Potential explanatory variables are year (categorical), area (categorical), SST during the catch (continuous) and its square, month (categorical), vessel (categorical), and prefecture (categorical). The best model is selected as a model with minimal BIC for each bimodal distribution model and gamma distribution model.

Results

Trawl survey indices for recruitment

For the summer survey, year, area, SST, its square, and water temperature at 50m depth were selected as explanatory variables in the binomial model, whilst year and area were selected in the gamma model. For the autumn survey, year, area, water temperature at 30m depth, and its square were selected in the binomial model, while year and area were selected in the gamma model. The both indices observed high catch rates in 2013 and 2016, and extremely high values in 2018, showing strong year classes of these three years (Fig. 1). However, the both indices showed a significant drop in 2019.

Egg survey index for SSB

The obtained index had an increasing trend of egg abundance (Fig. 1). Although the nominal and standardized trends were generally similar, the standardized index show a slight decrease from 2018 to 2019 in contrast to the nominal index.

Dip-net fishery index for SSB

Year, area, month, SST were selected as explanatory variables in the binomial model, while year, area, and month were selected in the gamma model. The standardized CPUE shows an increasing trend, although a slight decrease in 2019 was found (Fig. 1).

Discussion

Japan had the four abundance indices, which were submitted to shared data for the development of operating models in chub mackerel stock assessment (Nishijima 2020). All the indices are standardized and have relatively long time series. Furthermore, the recruitment and SSB, respectively, showed a similar trend: the recruitment indices revealed the strong recruitment of 2013, 2016, and 2018 year classes, while SSB has gradually increased as shown in the indices of egg survey and dip-net fishery. These abundance indices provide useful information on the stock assessment of chub mackerel in the Northwestern Pacific.

References

Hashimoto, M., Nishijima, S. Yukami, R., Watanabe, C., Kamimura, Y., Furuichi, S., Ichinokawa, M., and Okamura, H. (2019). Spatiotemporal dynamics of the Pacific chub mackerel revealed by standardized abundance indices. *Fish. Res.* 219, 105315.

Lo, N. C. H., Jacobson, L. D. and J. L. Squire, J. L. (1992). Indices of relative abundance from fish spotter data based on delta-lognormal models. *Can. J. Fish. Aquat. Sci.*, 49, 2515-2526.

Ichinokawa, M. and Brodziak, J. (2010). Using adaptive area stratification to standardize catch rates with application to North Pacific swordfish (*Xiphias gladius*). *Fish. Res.*, 106, 249-260.

Kanamori, Y., Takasuka, A. Nishijima, S. and Okamura, H. (2019) Climate change shifts the spawning ground northward and extends the spawning period of chub mackerel in the western North Pacific. *Mar. Ecol. Prog Ser.* 624, 155–166.

Kanamori, Y., Takasuka, A., Nishijima, S., Ichinokawa, M., and Okamura, H. (2018) Standardizing abundance index for spawning stock biomass of chub mackerel in the Northwestern Pacific. NPFC-2018-TWG CMSA02-WP03.

Nishijima, S., Hashimoto, M., Yukami, R., Ichinokawa, M., Okamura, H., Kamimura, Y., Furuichi, S., and Watanabe, C. (2017) Standardizing abundance indices for recruitment and spawning stock biomass of the chub mackerel in the Northwest Pacific. NPFC-2017-TWG CMSA01-WP05.

Nishijima S. (2020) Compilation and summary of shared data for operating models of the chub mackerel in the Northwest Pacific. NPFC-2020-TWG CMSA03-WP04.

Takasuka A, Tadokoro K, Okazaki Y, Ichikawa T, Sugisaki H, Kuroda H, Oozeki Y (2017) *In situ* filtering rate variability in egg and larval surveys off the Pacific coast of Japan: Do plankton nets clog or over-filter in the sea? *Deep-sea. Res.* 120, 132-137.

Takasuka A, Oozeki Y, Kubota H (2008) Multi-species regime shifts reflected in spawningtemperature optima of small pelagic fish in the western North Pacific. *Mar. Ecol. Prog. Ser.* 360, 211-217

Thorson JT (2019) Guidance for decisions using the Vector Autoregressive Spatio-Temporal (VAST) package in stock, ecosystem, habitat and climate assessments. *Fish. Res.* 210, 143-

161.

Yukami, R., S. Nishijima, S. Isu, Y. Kamimura, S. Furuichi, and R. Watanabe. 2020. Stock assessment and evaluation for the Pacific stock of chub mackerel (fiscal year 2019). (available at http://abchan.fra.go.jp/digests2019/details/201905.pdf) (in Japanese)

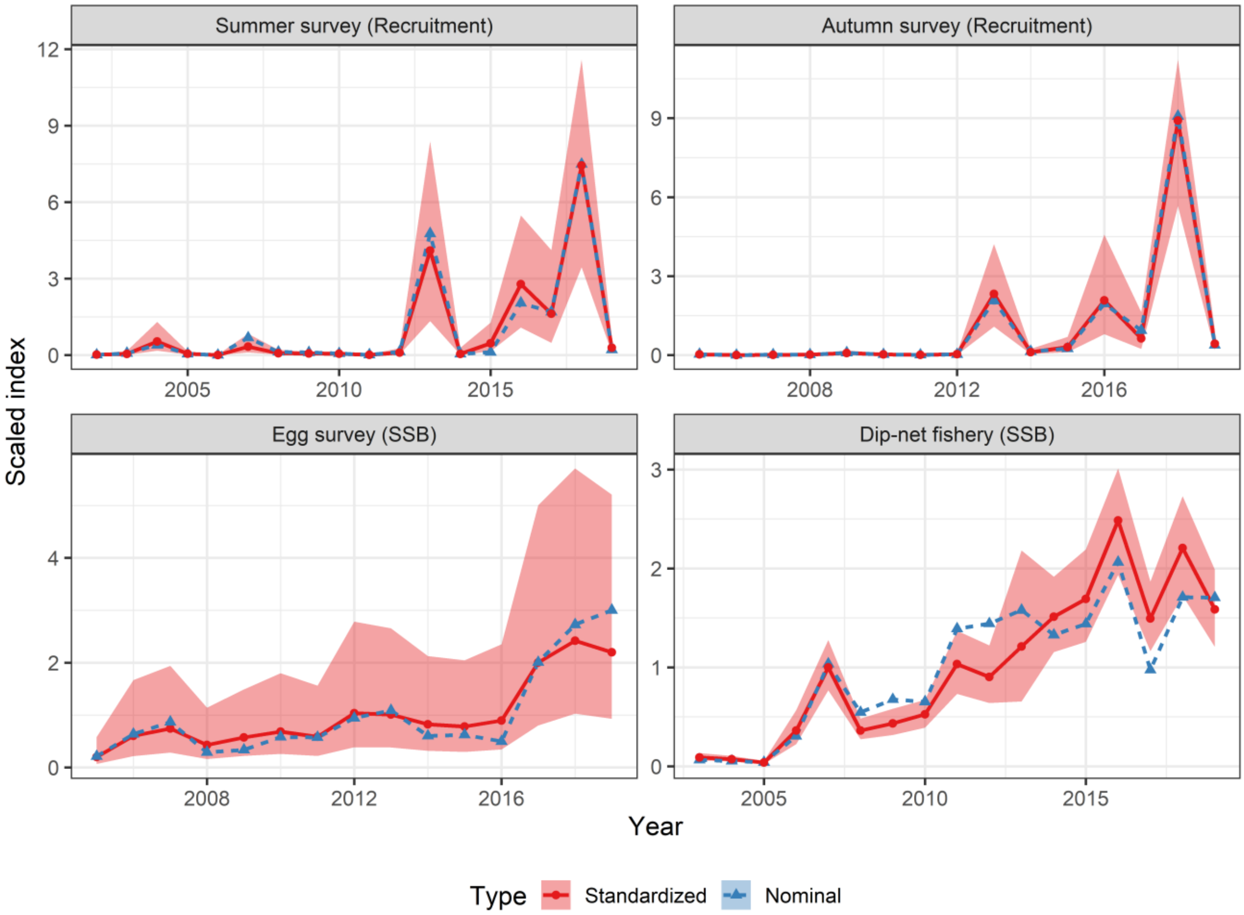

Figure 1. Time series of standardized and nominal (arithmetic mean) abundance indices with 95% confidence intervals for the standardized ones. The vertical axes are scaled by the mean values.