AN EXPLORATION INTO JAPANESE SIZE DATA OF TROPICAL TUNA SPECIES BECAUSE OF A PROMINENT SIZE-FREQUENCY RESIDUAL PATTERN IN THE STOCK ASSESSMENT MODEL

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Collaborative work between NRIFSF and IATTC

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A prominent residual pattern in the size frequencies of LL (Japanese LL).

Japanese LL fishery seems to have suddenly begun to catch larger fish after 1990.

The size-composition are very influential on parameter estimates and any resulting management advice.
Introduction

New spatial definitions

From figure 2.1 of document SARM 10-06b (2010)

From figure 2.1 of document SAC-01-08a (2011)

Time-varying selectivity

From figure 2.6f of document SAC-01-08a (2010)

- New spatial definitions (Lennert-Cody 2010, 2013)
- Time-varying selectivity (Aires-da-Silva et al. 2010)
- Implementing these attempts, prominent residual pattern was partially improved, but was not eliminated.
Aires-da-Silva et al. (2010) hypothesized that the residual shift resulted from a change in operational practices (NHBF; the number of hooks between float) around 1990.

NHBF is often considered as a proxy for target species.

An increase in NHBF was observed around 1989-1990, but it was not abrupt.

Thus, the change in fishing operations detected through NHBF is not considered the reason for the shift in residual in 1990.
In a preliminary investigation, similar differences in size composition were also detected for yellowfin.

A clear explanation of the shift in size composition would improve the modelling.

Collaborative work between the IATTC and Japan is needed to address the problem.

Length frequency of LL for two periods (early; 1975-1989 (blue line), later; 1990-2013 (red line)) of bigeye (upper panel) and yellowfin (lower panel) by area in the eastern Pacific Ocean. The area definition and fishery number is same those of the stock assessments in 2015.
Preliminarily comparison

✓ Preliminarily comparison between the IATTC and NRIFSF size data bases was conducted.
✓ If some discrepancies existed around 1990 between the two size data bases, it might be a reason for the residual shift.
✓ The detail results of the comparison are summarized in Appendix.
Preliminarily comparison

- Basically the two data-base showed good consistency except for 1999-2010.
- There are no large discrepancy around 1990 between the two databases.
- Around 2002 when the submitted spatial resolution has changed there could be some try and error for the compiling method of size data and then it leads to the lack of size data. (It had been already corrected)

Comparison of the number of Japanese longline size data for bigeye (upper panel) and yellowfin (lower panel) between the IATTC (dashed line) and NRIFSF (solid line) databases.
Three hypotheses to explain the size composition shift are developed

① Change in Japanese LL fishing strategies, such as selection of fishing ground and/or fishing season between the two periods (pre- and post 1990),

② Development of new fishing gear that affected the sizes of tuna caught around 1990, and

③ Change in the size data collecting and reporting system around 1990.
Summary

① Change in Japanese LL fishing strategies, such as selection of fishing ground and/or fishing season between the two periods (pre- and post 1990) → No

② Development of new fishing gear that affected the sizes of tuna caught around 1990 → No

③ Change in the size data collecting and reporting system around 1990

1. Commercial vs. training → No (but it is important to specify the vessel type for submitted size data for better estimation of selectivity)

2. Unit of fish size (weight vs. length) → Yes!
Hypotheses

Three hypotheses to explain the size composition shift are developed:

① Change in Japanese LL fishing strategies, such as selection of fishing ground and/or fishing season between the two periods (pre- and post 1990),

② Development of new fishing gear that affected the sizes of tuna caught around 1990, and

③ Change in the size data collecting and reporting system around 1990.
Rational explanation for the hypothesis

- The number of Japanese longline hooks deployed in the EPO reached its highest historical level in 1991, since when it decreased, with some fluctuations, and fell to 26% of its highest value in 2013.

- During this decreasing phase, changing the fishing strategy of selecting for the fishing ground spatially and temporally could affect the shift in size composition.
HYPOTHESIS 1: Change in Japanese LL fishing strategies, such as selection of fishing ground and/or fishing season

The difference in seasonal proportion of effort between the two periods was less than 1%, which indicates that the fishing schedule by quarter did not change between the two period.

Figures from Table 1
Proportion of Japanese long line effort by season
Blue line (earlier period; 1975 to 1989) and red line (later period; 1990-2013)
HYPOTHESIS 1: Change in Japanese LL fishing strategies, such as selection of fishing ground and/or fishing season

The fishing effort slightly focused on the specific area (LL S for bigeye) in the later period.

Figures from Table 1
Proportion of Japanese long line effort by fishing ground
blue line (earlier period; 1975 to 1989) and red line (later period; 1990-2013)
HYPOTHESIS 1: Change in Japanese LL fishing strategies, such as selection of fishing ground and/or fishing season

- The shift in size composition occurred in all areas.
- Thus, the change in spatial distribution of effort is not considered responsible for the size shift.

**FIGURE 1.** Length frequencies by area of bigeye (upper four panels) and yellowfin (lower two panels) during two periods (1975-1989 (blue line); 1990-2013 (red line)). The area definitions and fishery numbers coincide with those of the stock assessments in 2015.
Three hypotheses to explain the size composition shift are developed:

① Change in Japanese LL fishing strategies, such as selection of fishing ground and/or fishing season between the two periods (pre- and post 1990),

② Development of new fishing gear that affected the sizes of tuna caught around 1990, and

③ Change in the size data collecting and reporting system around 1990.
HYPOTHESIS 2: Development of new fishing gear around 1990 that affected the size of tuna caught

Rational explanation for the hypothesis

- NRIIFSF and a predecessor of NRIIFSF interviewed fishing masters at several Japanese landing ports and published the results routinely.
- According to one of the reports (left panel) described that mainlines made of nylon had been introduced and rapidly spread in commercial fishing operations near Japan (east of 140°E) instead of the traditional main line around 1990.
HYPOTHESIS 2: Development of **new fishing gear** around 1990 that affected the size of tuna caught

Unfortunately, the report did not directly mention the situation of the new gear in the EPO, but certain descriptions in the report suggest that it was not very popular with the larger vessels in 1990.

At that time the Japanese longline vessels in the EPO were almost all larger vessels (Uosaki and Bayliff 1999).

From Table 1 of Uosaki and Bayliff (1999)
We can find very high proportion (around 90%) of large size vessel (200-500 GRT) operated from 1988 to 1992 in the EPO.
HYPOTHESIS 2: Development of new fishing gear around 1990 that affected the size of tuna caught

- Because the material of the main line was added to the items of mandatory logbook in 1994, subsequent historical changes in the application of the nylon gear can be traced.

- The proportion of nylon gear was around 50%, and increased gradually to around 90% in 2007.

- Thus the new gear was apparently not popular for larger longline vessels in the EPO in 1990.

**FIGURE 3.** Proportion of hooks by main line material, 1994-2007
HYPOTHESIS 2: Development of new fishing gear around 1990 that affected the size of tuna caught

- In addition, there were no clear differences in the annual length frequencies by main line material.

- Thus, the main line material did not much affect the size of fish caught.

**FIGURE 4.1.** Length frequencies of bigeye caught by year and material of main line (blue; nylon, orange; others (including traditional kuronawa)), 1994-1998. Excludes length data converted from weight.
Hypotheses

Three hypotheses to explain the size composition shift are developed

① Change in Japanese LL fishing strategies, such as selection of fishing ground and/or fishing season between the two periods (pre- and post 1990),

② Development of new fishing gear that affected the sizes of tuna caught around 1990, and

③ Change in the size data collecting and reporting system around 1990.
HYPOTHESIS 3: Change in the size data collecting and reporting system around 1990

Rational explanation for the hypothesis

✓ In preliminary comparison between two data-bases of IATTC and NRIFSF, the two things were recognized.
✓ The vessel type (commercial or training) was not specified in the size data submitted, and also
✓ Until 2010, the raw weight data were converted to lengths before being submitted.
✓ There were two components to be investigated, the vessel type (commercial or training) and the unit of fish size (weight or length).

* training vessel; Vessels belonging to the Japanese local governments that are used for teaching fisheries and training vessel crews
HYPOTHESIS 3: Change in the size data collecting and reporting system around 1990

Commercial vs. training vessels

- A comparison of length frequencies of bigeye by vessel type showed a lower proportion of 80-100 cm fish, and a higher proportion of fish over 140 cm, for the commercial vessels.

- Yellowfin from commercial vessels showed higher proportions of fish over 120 cm compared to those from training vessels.

**FIGURE 5.3.** Comparison of length-frequencies of bigeye (top panel) and yellowfin (bottom panel) between commercial vessels (blue line) and training vessels (red line), 1975-2013.
HYPOTHESIS 3: Change in the size data collecting and reporting system around 1990

Commercial vs. training vessels

1975-1989

1990-2013

The length frequencies of both species broken down by period, vessel type and area, suggested that the differences between vessel types were clear for both periods and both species in many cases.
HYPOTHESIS 3: Change in the size data collecting and reporting system around 1990

Commercial vs. training vessels

✓ Since the proportions of samples by vessel type were similar around 1990, the difference in size composition by vessel type did not directly affect the shift in the residual in 1990

Proportion of number of sample size by vessel type (commercial and training). top; bigeye, bottom; yellowfin.
HYPOTHESIS 3: Change in the size data collecting and reporting system around 1990

Unit of fish size (weight vs. length)

Comparisons of length frequencies by unit of measurement (weight (kg) and length (cm)) indicated that, for both species, the measured lengths were greater than the lengths derived from converting weight data.

FIGURE 6.1. Comparison between length data (green line) and length data converted from weight data (black) for length-frequency of bigeye (top) and yellowfin (bottom). Using only commercial vessel data
HYPOTHESIS 3: Change in the size data collecting and reporting system around 1990

Unit of fish size (weight vs. length)

The differences between measured length and converted length were found in many cases when the size data were broken down into area and period for both species.

FIGURE 6.2. Comparison of length frequencies of length data (green line) and length data converted from weight data (black line), from commercial vessels only, by area and period (pre- and post-1990).
HYPOTHESIS 3: Change in the size data collecting and reporting system around 1990

Unit of fish size (weight vs. length)

Using only the weight data from commercial vessels, the average body weight of fish by area did not show any considerable change around 1990.

FIGURE 6.3. Historical changes in average weight (kg) by area, based on weight data from commercial vessel only.
HYPOTHESIS 3: Change in the size data collecting and reporting system around 1990

- In response to a resolution by the Commission for the Conservation of Southern Bluefin Tuna (CCSBT), since 1988 Japanese longline vessels that catch southern bluefin tuna are required to measure the fish in length on board.
- This also affected Japanese longline vessels that caught tropical tuna species.
- The proportion of length data increased after 1990 for both species, equaled that of the weight data in 1991, and since then length data has dominated.

**FIGURE 5.5.** Number of Japanese longline size data by vessel type (commercial or training) and unit of fish size (weight (kg) and length (cm)).
Summary

1. Change in Japanese LL fishing strategies, such as selection of fishing ground and/or fishing season between the two periods (pre- and post 1990) → No

2. Development of new fishing gear that affected the sizes of tuna caught around 1990 → No

3. Change in the size data collecting and reporting system around 1990
   1. Commercial vs. training → No (but it is important to specify the vessel type for better estimation of selectivity)
   2. Unit of fish size (weight vs. length) → Yes!
The evidences we present indicate that the shift in size composition in 1990 for both species is unlikely to be due to a real change in the size of fish caught. The combined effects of a change in the data collecting system and the underestimation of fish size from the weight-length conversion probably leads to an artificial shift in size composition. It is important to update Japanese size data with the information about the unit of fish size. The informative size data should be used to improve the previously-developed stock assessment models. Although it is not directly influenced the residual shift, it is also important to specify the vessel type for better modeling of selectivity.

The informative size data with vessel type and unit of fish size after 1975 had been already submitted to IATTC from Japan on February 2016.
Thank you