CHANGES IN LONGLINE SIZE-FREQUENCY DATA
AND THEIR EFFECTS ON THE STOCK ASSESSMENT MODELS FOR
YELLOWFIN AND BIGEYE TUNAS
(Document SAC-07-04a)

C. V. Minte-Vera, A. Aires-da-Silva, K. Satoh, and M. N. Maunder

Comisión Interamericana del Atún Tropical (CIAT)
Inter-American Tropical Tuna Commission (IATTC)

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La Jolla, 09-13 May 2016
Outline

• Background
• Goals
• Database update
• Model runs
• Results
• Conclusion
• Recommendations
Background

- Stock assessments using integrated statistical age-structured stock assessment models (SS3)
- Unified framework, simultaneously fit indices of abundance, size-composition giving assumptions and catches
- For yellowfin and bigeye tuna use longline catches per unit of effort as main index of abundance
- Longlines catches account for about 1/3 of bigeye tuna catches
- Size-frequency data of longline catches is a key piece of information
Background

• Traditionally the size-frequency data for the Japanese fleet to represent the longline fleets in the models.
• Japan provided the size data as length-frequencies
• A pattern was evident in these data, mainly for bigeye but to some extent for yellowfin, which consisted of smaller fish being caught prior to 1990 and larger fish after
Background: prominent residual pattern

Pearson residual plots for the model fit to the length-composition data for the Southern longline fishery assumed in the 2009 base-case assessment for bigeye tuna.

Background

SAC-07-03d


Conclusion:

• Differences in size composition between the periods pre- and post-1990 may be an artifact of the predominant methodology for size sampling and reporting of a combination:
  from commercial longlines:
    ➢ gilled-and-gutted weight converted to fork length
    ➢ fork length
  from training vessels:
    ➢ fork length

Fev 2016: Japan submitted the raw data by vessel category to the IATTC
Goals

• Explore the best way to incorporate the new size-frequency data into the stock assessment models for yellowfin and bigeye in the EPO

• Analyze the effect on the model estimates
Database update

Number of size measurements in the IATTC database before and after the submission of detailed data by Japan.
Details about the data

Yellowfin tuna

LLc: commercial longline vessel
LLt: longline training vessel
Details about the data

Yellowfin tuna

LLc: commercial longline vessel
LLt: longline training vessel
Details about the data

Bigeye tuna

Measurements—Mediciones


0 10,000 20,000 30,000 40,000 50,000 60,000 70,000 80,000 90,000

CIAT IATTC
Details about the data

Bigeye tuna
Details about the data

Type of size measurement by area in the Pacific Ocean

WCPO assessments: mainly use weight-frequency data
EPO: length-frequency data dominates in recent years

Okamoto (2014) SAC-05 INF-D
Methods: data preparation

Gilled-and-gutted processing

Photo credit: Peter Sharples, OFP.
Methods: data preparation

Gilled-and-gutted processing conducted by Japanese distant-water freezer vessels

Methods: conversion factors

Residuals (observed - expected) of the fit between processed (GG) weight and whole weight for yellowfin from three datasets combined.
Methods: conversion factors

Residuals (observed - expected) of the fit between processed (GG) weight and whole weight for bigeye from three datasets combined.
Methods: conversion factors

$w = 1.3264 \times GGw^{0.969}$

Conversion factor for the whole Pacific Ocean
Methods: conversion factors

\[ w = 1.2988 \times GGw^{0.968} \]

Conversion factor for the whole Pacific Ocean
Old length-frequencies bigeye tuna
New size-frequencies bigeye tuna

Fork length training vessels
New size-frequencies bigeye tuna

BET new data—Datos nuevos
- 10° x 20° weight—peso LLC
- 5° x 10° length—talla LLt
- 5° x 10° weight—peso LLc
- 5° x 10° length—talla LLc

Fork length commercial vessels

length comp data, whole catch, F16–LL_S_num_early (max=0.1)

length comp data, whole catch, F17–LL_S_num_late (max=0.1)
New size-frequencies bigeye tuna

BET new data—Datos nuevos

- 10° x 20° weight—peso LLCc
- 5° x 10° length—talla LLt
- 5° x 10° weight—peso LLc
- 5° x 10° length—talla LLc

Gilled-and-gutted weight commercial vessels
## Methods: model runs

<table>
<thead>
<tr>
<th></th>
<th>Description</th>
<th>Additional changes for BET</th>
</tr>
</thead>
<tbody>
<tr>
<td>SAC 6 BC</td>
<td>Base case model for the 2015 stock assessments presented at the 6th Scientific Advisory Committee meeting (SAC 6)</td>
<td></td>
</tr>
<tr>
<td>Run 1</td>
<td>LLc (length + GGw transformed to whole weight) + LLt (length) selectivity shared by all size-frequency data type</td>
<td>time blocks for selectivity and catchability</td>
</tr>
<tr>
<td>Run 2</td>
<td>LLc (length + GGw transformed to length) + LLt (length) selectivity shared by all size-frequency data type</td>
<td>time blocks for selectivity and catchability</td>
</tr>
<tr>
<td>Run 3</td>
<td>As Run 1, each size-frequency data type with its own selectivity</td>
<td>no time blocks</td>
</tr>
<tr>
<td>Run 4</td>
<td>= Run 1</td>
<td>no time blocks for BET</td>
</tr>
<tr>
<td>Run 5</td>
<td>As Run 4 no LLc weight</td>
<td></td>
</tr>
<tr>
<td>Run 6</td>
<td>As Run 5 LLt length with its own selectivity</td>
<td></td>
</tr>
<tr>
<td>Run 7</td>
<td>As Run 6 no LLt length</td>
<td></td>
</tr>
</tbody>
</table>
Results: effect on the models that mimic the base case model

Yellowfin – Aleta amarilla

<table>
<thead>
<tr>
<th>Yellowfin Aleta amarilla</th>
<th>SAC 6 BC</th>
<th>Run 1 (= Run 4)</th>
<th>Run 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>MSY-RMS</td>
<td>275,258</td>
<td>274,909</td>
<td>274,728</td>
</tr>
<tr>
<td>$B_{MSY}/B_{RMS}$</td>
<td>368,336</td>
<td>368,824</td>
<td>368,627</td>
</tr>
<tr>
<td>$S_{MSY}/S_{RMS}$</td>
<td>3,469</td>
<td>3,478</td>
<td>3,492</td>
</tr>
<tr>
<td>$B_{MSY}/B_0 - B_{RMS}/B_0$</td>
<td>0.32</td>
<td>0.32</td>
<td>0.32</td>
</tr>
<tr>
<td>$S_{MSY}/S_0 - S_{RMS}/S_0$</td>
<td>0.27</td>
<td>0.27</td>
<td>0.27</td>
</tr>
<tr>
<td>$C_{recent}/MSY-C_{recent}/RMS$</td>
<td>0.86</td>
<td>0.86</td>
<td>0.86</td>
</tr>
<tr>
<td>$B_{recent}/B_{MSY}-B_{recent}/B_{RMS}$</td>
<td>1.12</td>
<td>1.10</td>
<td>1.10</td>
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<tr>
<td>$S_{recent}/S_{MSY}-S_{recent}/S_{RMS}$</td>
<td>0.99</td>
<td>0.98</td>
<td>0.97</td>
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<tr>
<td>$F$ multiplier - Multiplicador de $F$</td>
<td>1.11</td>
<td>1.10</td>
<td>1.08</td>
</tr>
</tbody>
</table>
Yellowfin – Aleta amarilla

Base-case model
SAC 6

Gilled-and-gutted weight
commercial vessels
Converted to weight
Converted to fork length

Fork length
commercial vessels

Fork length
training vessels

Fits to size-frequency data:
Runs that mimic base case SAC6

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Residual patterns Run 1

Yellowfin – Aleta amarilla

Fork length
commercial
vessels

Gilled-and-
gutted weight
commercial
vessels
converted to
weight

Fork length
training vessels

CIAT
IATTC
Results: runs 3 to 7

<table>
<thead>
<tr>
<th>Run</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Run 3</td>
<td>LLc (length + GGw transformed to whole weight) + LLt (length) each data with its own selectivity</td>
</tr>
<tr>
<td>Run 4</td>
<td>As Run 3 selectivity shared by all size-frequency data type</td>
</tr>
<tr>
<td>Run 5</td>
<td>As Run 4 no LLc weight</td>
</tr>
<tr>
<td>Run 6</td>
<td>As Run 5 LLt length with its own selectivity</td>
</tr>
<tr>
<td>Run 7</td>
<td>As Run 6 no LLt length</td>
</tr>
</tbody>
</table>

Spawning Biomass Ratio (SBR)
Fits to the size-frequency data

Run 3: each data with its own selectivity

Gilled-and-gutted weight commercial vessels
 Converted to weight

Fork length commercial vessels

Fork length training vessels

Yellowfin – Aleta amarilla
## Results: runs 3 to 7

<table>
<thead>
<tr>
<th>Yellowfin Aleta amarilla</th>
<th>SAC 6 BC</th>
<th>Run 1 (≈ Run 4)</th>
<th>Run 2</th>
<th>Run 3</th>
<th>Run 4</th>
<th>Run 5</th>
<th>Run 6</th>
<th>Run 7</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>MSY-RMS</strong></td>
<td>275,258</td>
<td>274,909</td>
<td>274,728</td>
<td>284,147</td>
<td>279,161</td>
<td>282,820</td>
<td>281,444</td>
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<tr>
<td><strong>$B_{MSY}/B_{RMS}$</strong></td>
<td>368,336</td>
<td>368,824</td>
<td>368,627</td>
<td>381,732</td>
<td>374,174</td>
<td>380,219</td>
<td>376,924</td>
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<tr>
<td><strong>$S_{MSY}/S_{RMS}$</strong></td>
<td>3,469</td>
<td>3,478</td>
<td>3,492</td>
<td>3,553</td>
<td>3,495</td>
<td>3,550</td>
<td>3,523</td>
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<tr>
<td><strong>$B_{MSY}/B_0$ $B_{RMS}/B_0$</strong></td>
<td>0.32</td>
<td>0.32</td>
<td>0.32</td>
<td>0.31</td>
<td>0.31</td>
<td>0.31</td>
<td>0.32</td>
<td></td>
</tr>
<tr>
<td><strong>$S_{MSY}/S_0$ $S_{RMS}/S_0$</strong></td>
<td>0.27</td>
<td>0.27</td>
<td>0.27</td>
<td>0.26</td>
<td>0.26</td>
<td>0.26</td>
<td>0.26</td>
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<tr>
<td>$C_{recent}/MSY-$ $C_{recent}/RMS$</td>
<td>0.86</td>
<td>0.86</td>
<td>0.86</td>
<td>0.84</td>
<td>0.85</td>
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<tr>
<td>$B_{recent}/B_{MSY}$ $B_{recent}/B_{RMS}$</td>
<td>1.12</td>
<td>1.10</td>
<td>1.10</td>
<td>1.17</td>
<td>1.14</td>
<td>1.16</td>
<td>1.16</td>
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<tr>
<td>$S_{recent}/S_{MSY}$ $S_{recent}/S_{RMS}$</td>
<td>0.99</td>
<td>0.98</td>
<td>0.97</td>
<td>1.09</td>
<td>1.04</td>
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<tr>
<td>$F$ multiplier-$Multiplicador de F$</td>
<td>1.11</td>
<td>1.10</td>
<td>1.08</td>
<td>1.28</td>
<td>1.20</td>
<td>1.25</td>
<td>1.22</td>
<td></td>
</tr>
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</table>
Results: effect on the models that mimic the base case model

<table>
<thead>
<tr>
<th>Bigeye - Patudo</th>
<th>SAC 6 BC</th>
<th>Run 1</th>
<th>Run 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>MSY-RMS</td>
<td>113,730</td>
<td>115,284</td>
<td>115,274</td>
</tr>
<tr>
<td>$B_{MSY}/B_{RMS}$</td>
<td>433,396</td>
<td>442,264</td>
<td>442,085</td>
</tr>
<tr>
<td>$S_{MSY}/S_{RMS}$</td>
<td>108,502</td>
<td>111,119</td>
<td>111,058</td>
</tr>
<tr>
<td>$B_{MSY}/B_0 - B_{RMS}/B_0$</td>
<td>0.25</td>
<td>0.24</td>
<td>0.24</td>
</tr>
<tr>
<td>$S_{MSY}/S_0 - S_{RMS}/S_0$</td>
<td>0.21</td>
<td>0.2</td>
<td>0.2</td>
</tr>
<tr>
<td>$C_{recent}/MSY$</td>
<td>0.87</td>
<td>0.85</td>
<td>0.85</td>
</tr>
<tr>
<td>$C_{recent}/RMS$</td>
<td>1.03</td>
<td>1.13</td>
<td>1.13</td>
</tr>
<tr>
<td>$B_{recent}/B_{MSY}$</td>
<td>1.06</td>
<td>1.15</td>
<td>1.15</td>
</tr>
<tr>
<td>$S_{recent}/S_{MSY}$</td>
<td>1.14</td>
<td>1.25</td>
<td>1.25</td>
</tr>
</tbody>
</table>
Base-case model
SAC 6

Gilled-and-gutted weight commercial vessels
Converted to weight
Converted to fork length

Fork length commercial vessels

Fork length training vessels

Fits to size-frequency data:
Runs that mimic base case SAC6

Bigeye - Patudo
Residual patterns Run 1

Bigeye - Patudo

Fork length commercial vessels

Gilled-and-gutted weight commercial vessels converted to weight

Fork length training vessels
Results: runs 3 to 7
No time blocks in CPUE catchability and selectivity

<table>
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<th>Run</th>
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<tr>
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<tr>
<td>Run 4</td>
<td>As Run 3 selectivity shared by all size-frequency data type</td>
</tr>
<tr>
<td>Run 5</td>
<td>As Run 4 no LLc weight</td>
</tr>
<tr>
<td>Run 6</td>
<td>As Run 5 LLt length with its own selectivity</td>
</tr>
<tr>
<td>Run 7</td>
<td>As Run 6 no LLt length</td>
</tr>
</tbody>
</table>

**Spawning Biomass Ratio (SBR)**

- SAC 6 BC
- Run 3
- Run 4
- Run 5
- Run 6
- Run 7
Fits to the size-frequency data

Gilled-and-gutted weight commercial vessels
Converted to weight

Fork length commercial vessels

Fork length training vessels

Run 3: each data with its own selectivity

Bigeye - Patudo
Results: runs 3 to 7
No time blocks in CPUE catchability and selectivity

<table>
<thead>
<tr>
<th>Bigeye Patudo</th>
<th>SAC 6 BC</th>
<th>Run 1</th>
<th>Run 2</th>
<th>Run 3</th>
<th>Run 4</th>
<th>Run 5</th>
<th>Run 6</th>
<th>Run 7</th>
</tr>
</thead>
<tbody>
<tr>
<td>MSY-RMS</td>
<td>113,730</td>
<td>115,284</td>
<td>115,274</td>
<td>104,258</td>
<td>99,693</td>
<td>101,064</td>
<td>104,028</td>
<td>103,002</td>
</tr>
<tr>
<td>$B_{MSY}$/$B_{RMS}$</td>
<td>433,396</td>
<td>442,264</td>
<td>442,085</td>
<td>379,012</td>
<td>355,466</td>
<td>364,295</td>
<td>377,664</td>
<td>373,257</td>
</tr>
<tr>
<td>$S_{MSY}$/$S_{RMS}$</td>
<td>108,502</td>
<td>111,119</td>
<td>111,058</td>
<td>92,998</td>
<td>86,599</td>
<td>89,165</td>
<td>92,614</td>
<td>91,462</td>
</tr>
<tr>
<td>$B_{MSY}$/$B_0$/$B_{RMS}$/$B_0$</td>
<td>0.25</td>
<td>0.24</td>
<td>0.24</td>
<td>0.26</td>
<td>0.25</td>
<td>0.25</td>
<td>0.26</td>
<td>0.26</td>
</tr>
<tr>
<td>$S_{MSY}$/$S_0$/$S_{RMS}$/$S_0$</td>
<td>0.21</td>
<td>0.2</td>
<td>0.2</td>
<td>0.21</td>
<td>0.2</td>
<td>0.2</td>
<td>0.21</td>
<td>0.21</td>
</tr>
<tr>
<td>$C_{recent}/MSY$/$C_{recent}/RMS$</td>
<td>0.87</td>
<td>0.85</td>
<td>0.85</td>
<td>0.95</td>
<td>0.99</td>
<td>0.98</td>
<td>0.95</td>
<td>0.96</td>
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<tr>
<td>$B_{recent}/B_{MSY}$/$B_{recent}/B_{RMS}$</td>
<td>1.03</td>
<td>1.13</td>
<td>1.13</td>
<td>0.88</td>
<td>0.85</td>
<td>0.89</td>
<td>0.87</td>
<td>0.86</td>
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<tr>
<td>$S_{recent}/S_{MSY}$/$S_{recent}/S_{RMS}$</td>
<td>1.06</td>
<td>1.15</td>
<td>1.15</td>
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<td>0.85</td>
<td>0.9</td>
<td>0.89</td>
<td>0.88</td>
</tr>
<tr>
<td>F multiplier-Multiplicador de F</td>
<td>1.14</td>
<td>1.25</td>
<td>1.25</td>
<td>0.94</td>
<td>0.91</td>
<td>0.95</td>
<td>0.94</td>
<td>0.92</td>
</tr>
</tbody>
</table>
Conclusions

• The three data types are not compatible with each other

• A conversion factor of gilled-and-gutted weight for the EPO should be developed to be able to use this data

• The training vessels length-composition data is on average smaller than the commercial vessels length-composition data, may contain useful information (e.g. recruitment variability)
Conclusions

Yellowfin tuna:
• The management quantities were more optimistic when the weight-frequency data were excluded or when their effect was minimized by assuming a different selectivity function for them.
• The biomass trajectories are very similar for all runs. The largest difference was observed for the historical period (from 1975 to about 2000) for Runs 3 and 5-7, which either excluded the weight-frequency data or minimized their effects.

Bigeye tuna:
• The largest difference in management quantities was obtained when the assumption of two time periods for each longline series was replaced by assuming one series for the whole time period with the same catchability and selectivity.
• This new assumption is justified by the fact that the residual pattern that motivated the inclusion of the time blocks was likely an artifact of the mixture of incompatible data types used to compose the longline length-frequencies that were used in the stock assessment model.
Recommendations

The size-frequency data for the longline fleets should be entered in the stock assessment models for bigeye and yellowfin as follows:

1. **Base-case model:** length-frequency of the commercial fleet, and length-frequency of the training vessel fleet treated as a survey with its own selectivity function; no time blocks on selectivity or catchability of the standardized CPUE longline series.

2. **Sensitivity model:** as for the base-case model, plus inclusion of the processed weight converted into whole weight using equations 1 or 2. Preferably, a conversion factor specific for the EPO should be developed.

3. **Data weighting:** the weighting for the length- and weight-frequency data should be reevaluated before adopting a model to be used for management advice.
Acknowledgements

Koji Uosaki, National Research Institute of Far Seas Fisheries, and Nick Vogel, IATTC Data Collection and Database Program, for database handling and management; and Sam McKechnie and John Hampton for clarifications regarding the use of Japanese size-frequency data in the stock assessment of bigeye tuna in the Western and Central Pacific Ocean. We are specially grateful to Christine Patnode for her assistance with the figures.
Thank you