GROWTH ESTIMATES FOR SKIPJACK TUNA IN THE EASTERN PACIFIC OCEAN

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1st External Review of IATTC staff's stock assessment of skipjack tuna in the eastern Pacific Ocean
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Outline

- Motivation
- Auxiliary analyses
  - Data
  - Analysis
- Results
- Issues
- Summary

Motivation

- Need growth for assessment
  - Fits to length composition data
- Aging is not possible for SKJ
- Length frequency modes are not informative
  - Fast growth
  - Year around recruitment
- Tag growth increment data is available
- Tagging does not provide information on absolute age
- No information for large fish
  - Asymptotic length is uncertain
- Need to include both observation (measurement) error and individual variation in growth

Data

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Analysis

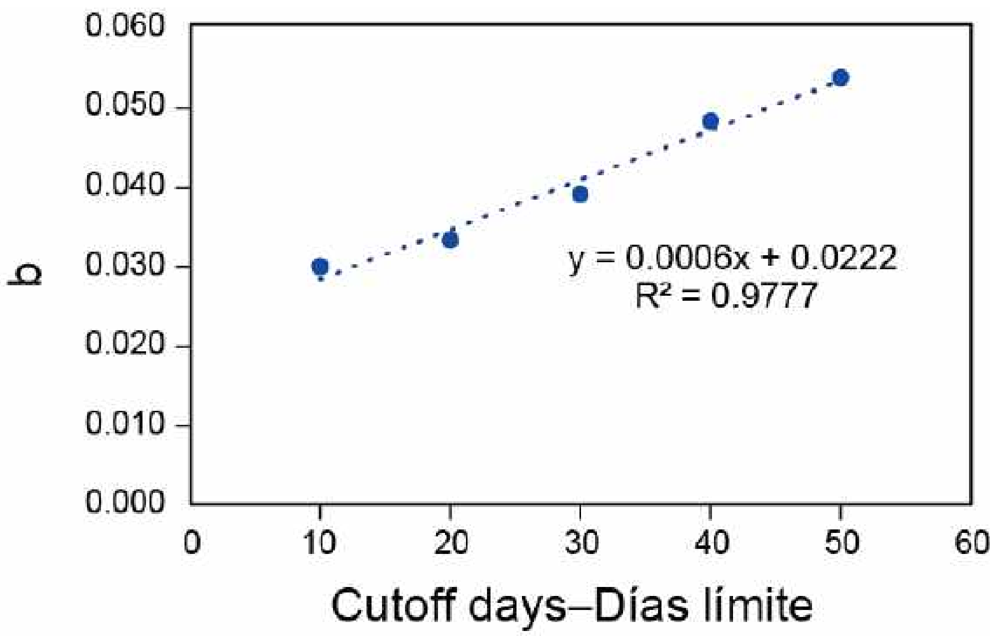
- Observation (measurement) error
- Growth
  - Model that describes length-at-age
  - Model that describes variation of length-at-age
  - Inference
- Fine tuning for assessment

Observation error

- Removed outliers (10 < -0.1 and 4 > 0.2 per day)
- Included in both length-at-release and length-at-recovery
- Normally distributed with no bias
- Estimated parameters
    - Length-at-release
    - Growth rate
    - Standard deviation
- Short term recoveries
    - Assumed no process variation
- Adjusted for shrinkage

Observation error

- < 20 days at liberty had convergence errors
- Used < 50 days at liberty to decide on relationship
- Best AIC model
  - Slope of sd relationship for individual variation
  - Growth rate
- Applied to < 20, < 30, < 40, < 50
- Slope related to days at liberty cutoff
- Extrapolated to 0 days for observation error
- Measurement error sd = 0.0222
- Use in growth analysis



Growth

- Estimate age as a fixed effect
  - Do not know distribution for random effects
- Don't need to know absolute age for SKJ assessment
  - No stock-recruitment relationship
  - Length based processes
  - Assumed 37 cm = 2 quarters (23 cm = 1 quarter Vincent et al. 2019)
- No tags on large SKJ
  - No information on asymptotic length
  - Assume values based on longline data
- No obvious decline in growth rate
  - Growth cessation model
  - Assumed asymptotic length 75 cm, 80 cm, 85 cm.

Growth: Growth cessation model

- Linear initial growth
- logistic function to model decline in growth rate

$$L_a = L_0 + r_{max}\left[\frac{\ln\left(e^{-ka_{50}}+1\right)-\ln\left(e^{k(a-a_{50})}+1\right)}{k}\right.$$

L_0 is the length at age 0
r_{max} is a parameter relating to the maximum growth rate
$k \geq 0$ is the steepness of the logistic function that models the reduction in the growth increment
a_{50} is the age of the logistic function's midpoint.

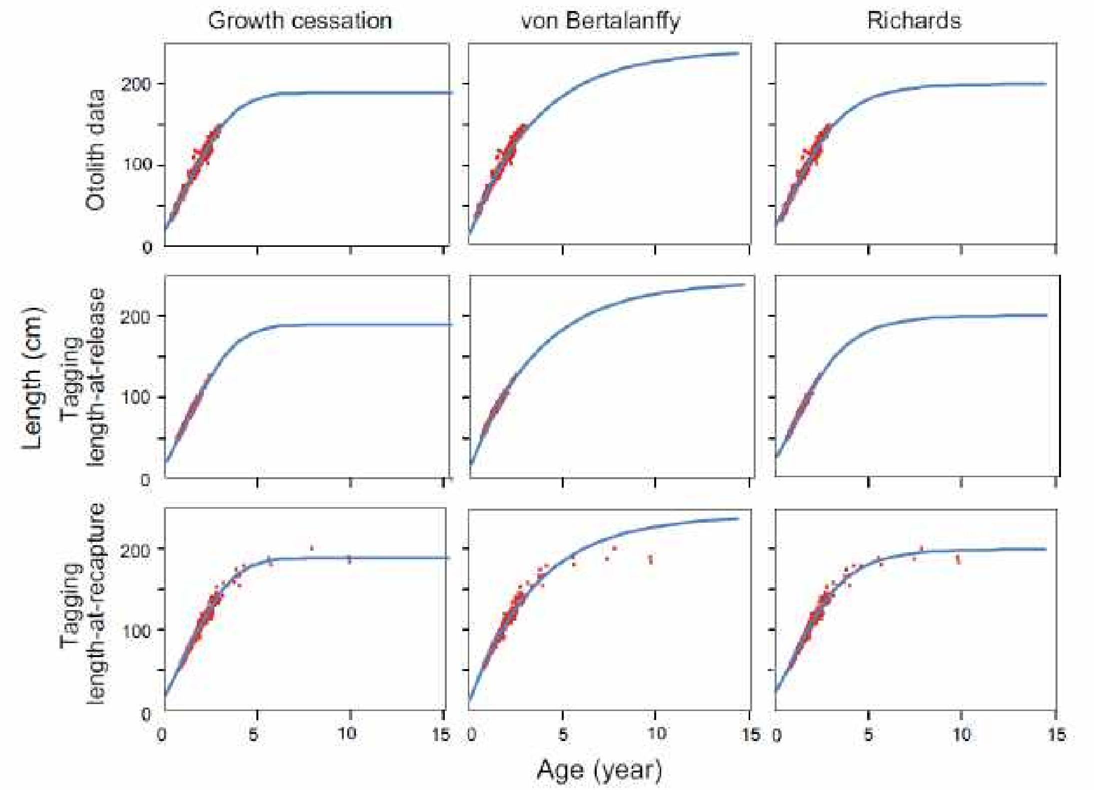


Fig. 1 Fit of the growth-cessation model (left panels) to the otolith age–length data (top), tagging length at release (middle), and tagging length at recapture (bottom) for bigeye tuna in the eastern Pacific Ocean compared to the von Bertalanffy (middle panels) and Richards (right panels) models

Growth: Variation of length-at-age

- Linear relationship between standard deviation and length

$$\sigma_L = \alpha + \beta L$$

Growth: Inference

- Estimate age as a fixed effect

$$L_{obs} = L_{pred} + \varepsilon_L + \varepsilon_m$$

$$\varepsilon_L \sim N[0, \sigma_L^2]$$

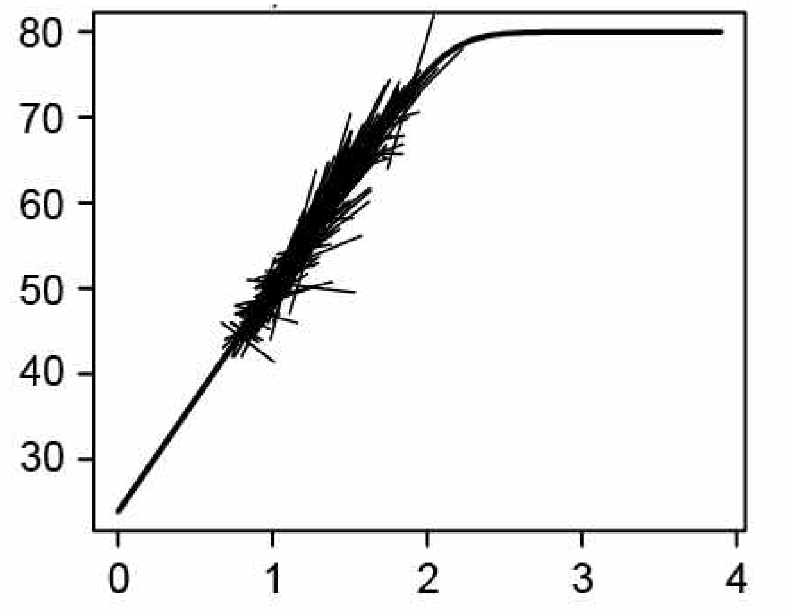
$$\varepsilon_m \sim N[\mu_m, \sigma_m^2]$$

$$\mu_m = 0$$

$$\ell(\boldsymbol{\theta}|\boldsymbol{L}) = \frac{1}{\sqrt{2\pi(\sigma_L^2 + \sigma_m^2)}} exp\left(-\frac{\left(L_{obs} - L_{pred}\right)^2}{2(\sigma_L^2 + \sigma_m^2)}\right)$$

Results

- Convergence issues
- Shape of the curve after the last tagging data point uncertain
- Asymptotic length uncertain
- All models estimate a linear increase in growth within the range of the data
- Average = 26.64 cm per year
- Estimates of individual variation are small



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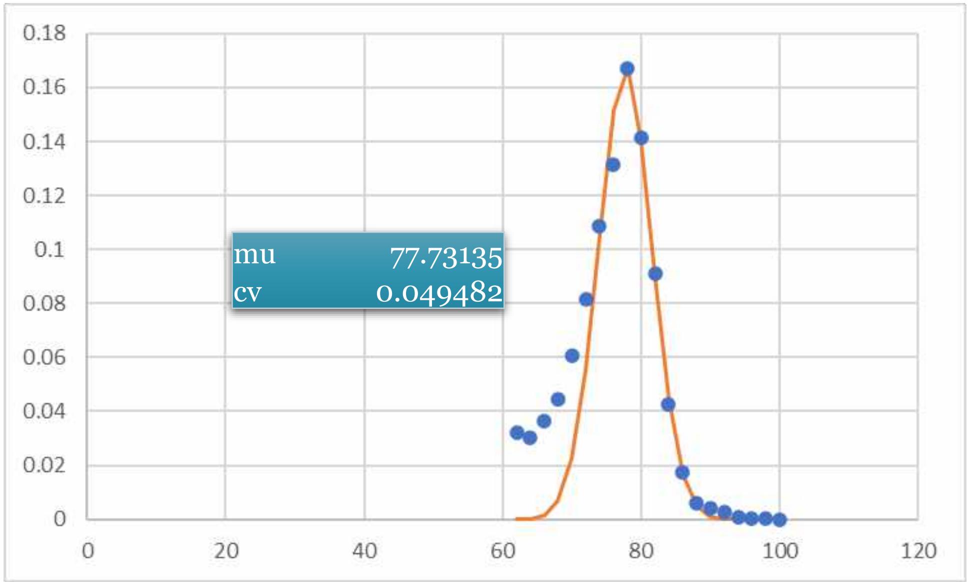
Fine tuning

- For use in assessment
- Fix Linf at 78 cm based on peak of longline length composition
- Variation of length-at-age
  - Estimated using multiple methods
  - Too low
    - Predicts modes in young ages
    - Does not fit longline length composition data
  - CV: 0 = 0.09; 20 = 0.06
  - CV a linear function of length



Summary

- Mean length at age 0 assumed based on 37 cm fish = 2 quarters
- Asymptotic length based on longline length composition data
- Rmax = 26.54 cm taken from average
- K = 5.71 taken as median
- Standard deviations of variation of length-at-age assumed
  - Avoid unobserved modes in length composition data
  - Ability to fit longline length composition data

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Questions