Improved growth estimates from integrated analysis of age-at-length and tag-recapture data for BET and YFT and their impact on stock assessment results

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Indian Ocean Tuna Tagging Symposium

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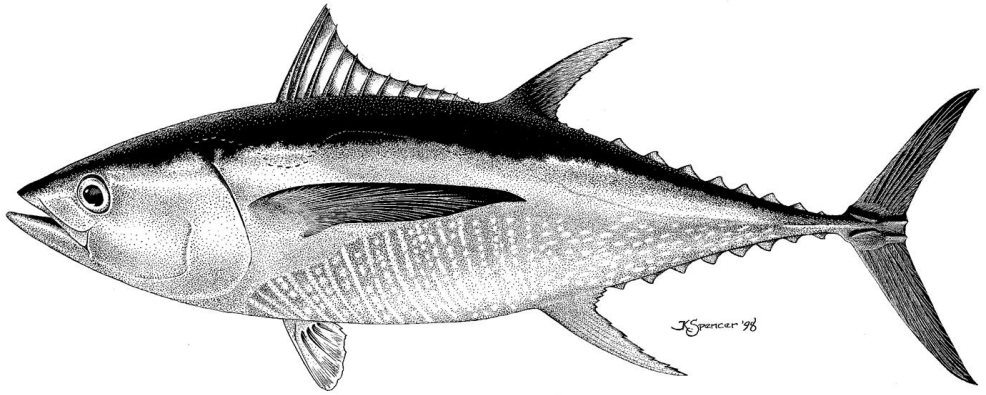

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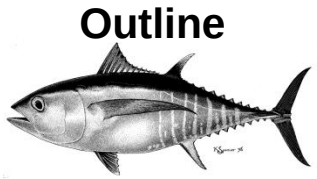
Topics



- Background:
  - Challenges with growth estimation for EPO tropical tuna (BET and YFT)
  - Approaches available to integrate direct age-at-length readings and tag-recapture data
- Results from integrated growth analysis for BET
  - Comparisons among 3 estimation methods (random effects, penalized likelihood and Bayesian approaches)
- Results from integrated growth analysis for YFT
  - One estimation method (penalized likelihood)
  - Impact of new estimates on YFT assessment
- Conclusions and future research

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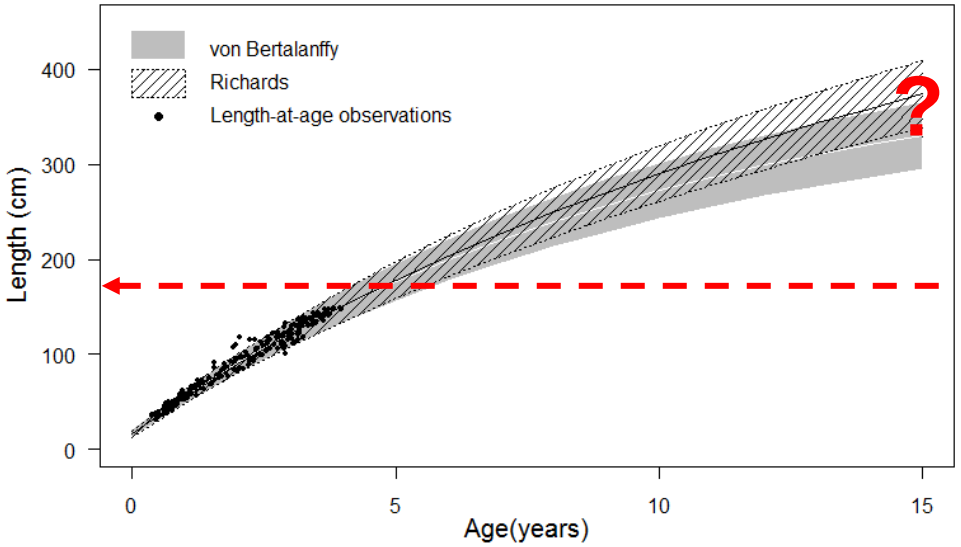
Challenges with EPO tuna growth

BET



Lmax

L max observed (close to virgin population)

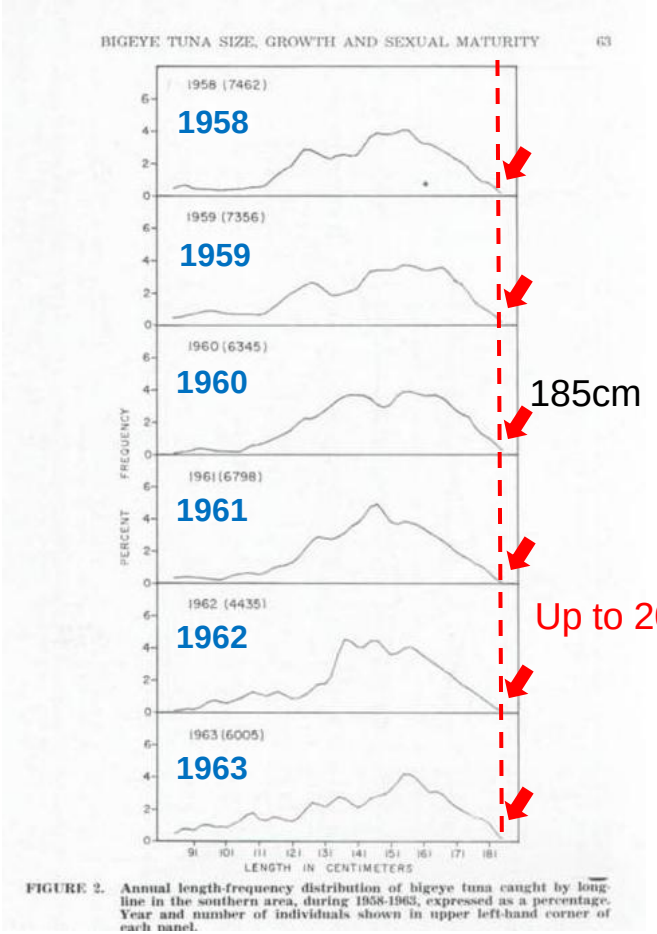
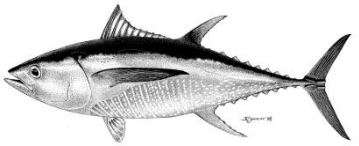


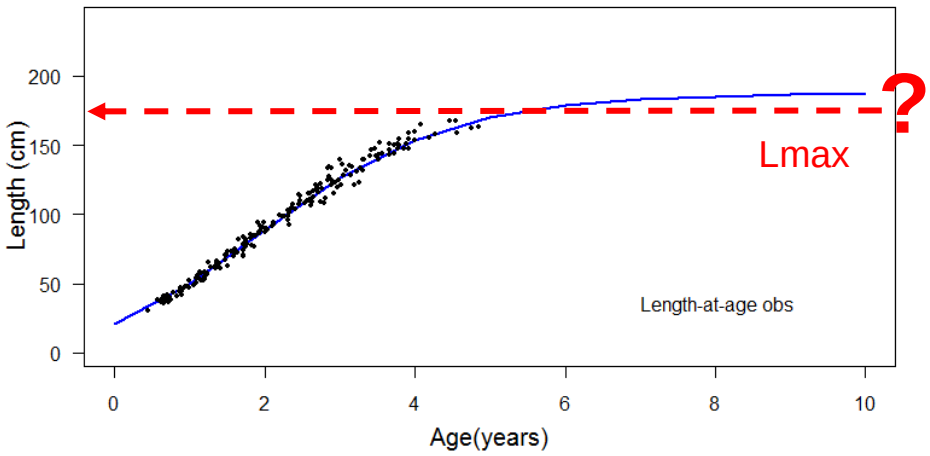
FIGURE 2. Annual length-frequency distribution of bigeye tuna caught by long-line in the southern area, during 1958-1963, expressed as a percentage. Year and number of individuals shown in upper left-hand corner of each panel.

Kume and Joseph (1966)

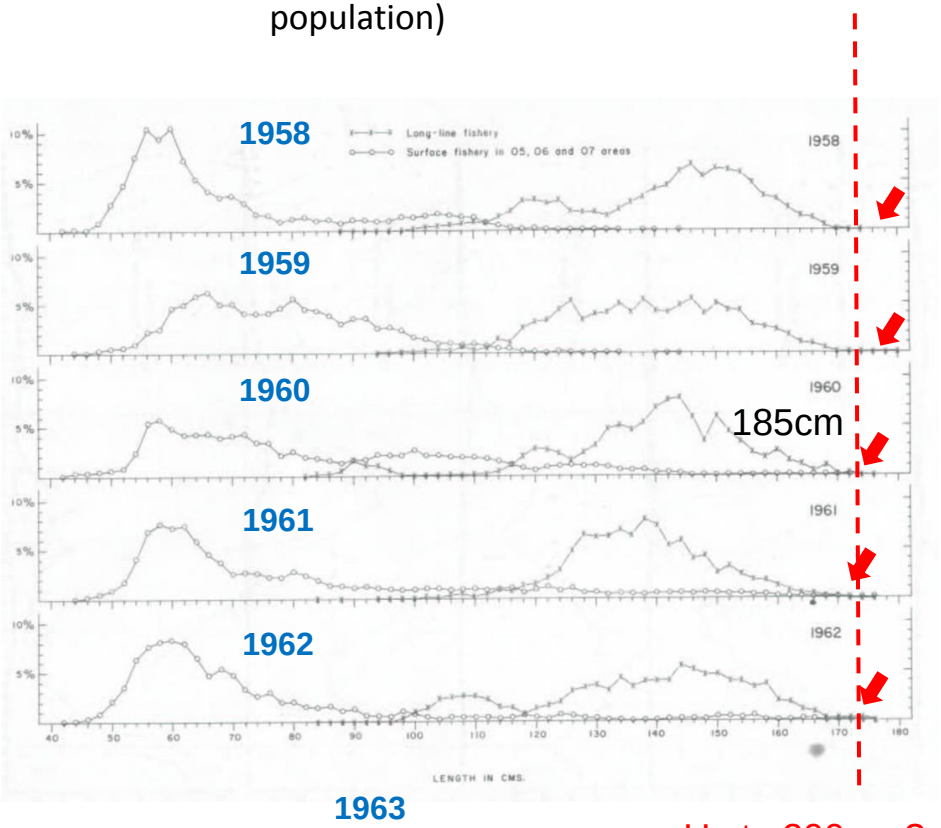
Challenges with EPO tuna growth



YFT



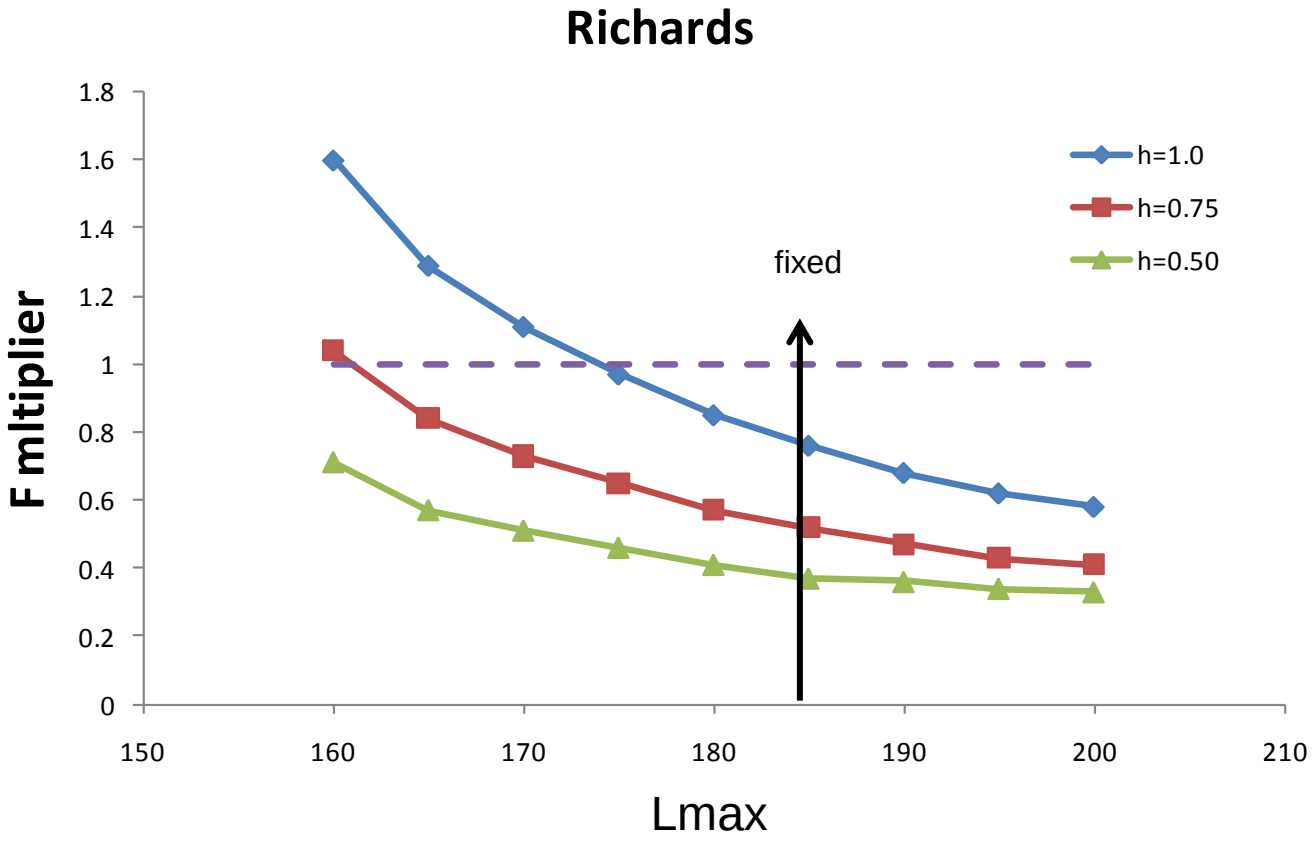
Lmax observed (close to virgin population)



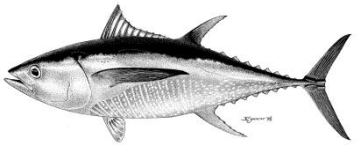
Up to 200 cm?

Suda and Schaefer (1965)

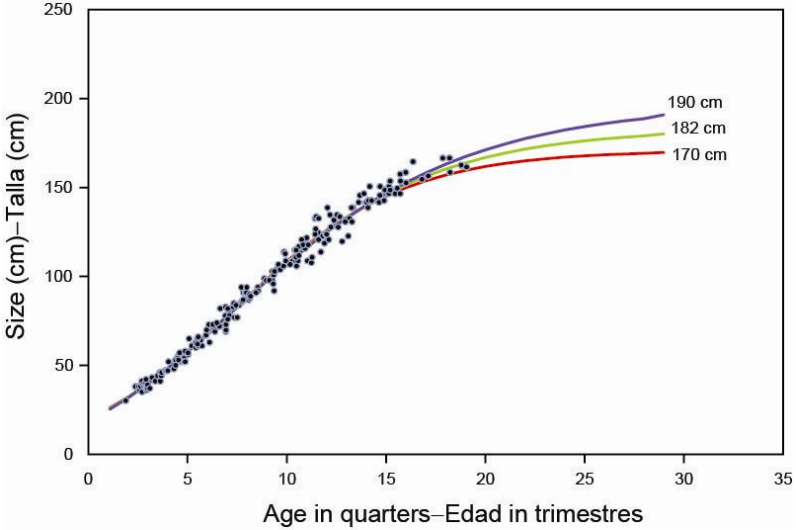
Impact of L_{max} on BET management



Impact of L_{max} on YFT management



SAR 12 (2012)

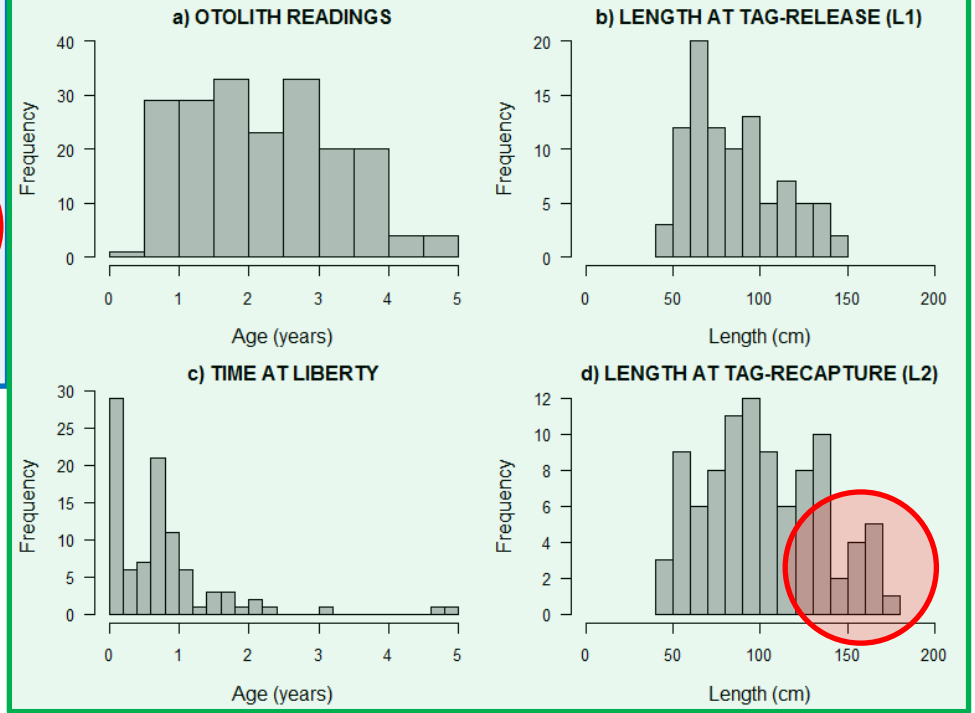


		Lmax	
	Basecase	**170 cm**	**190 cm**
MSY	262,857	275,310	264,704
Bmsy	354,958	370,334	359,144
Smsy	3,305	3,777	3,169
Bmsy/B0	0.31	0.31	0.31
Smsy/S0	0.26	0.24	0.27
Crecent/AMSY	0.88	0.84	0.87
Brecent/Bmsy	0.96	1.20	0.85
Srecent/Smsy	0.71	1.03	0.59
Fmultiplier	1.13	1.65	0.94

Tag-recapture data could help…

BET

YFT



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Growth estimation

- Two most common ways of estimating fish growth
  - Age-at-length data (direct readings of skeletal parts)

$$L = L_{\infty}\left[1 - e^{-K(t-t_0)}\right]$$

  - Length increment data from tag-recapture experiments (Fabens 1965)

$$\Delta L = (L_{\infty} - L)(1 - e^{-K\Delta T})$$

- Growth parameters generated from both methods are not comparable (Sainsbury 1980; Francis 1988)
  - Curves are fitted using different error structures
  - L@A: residuals between observed L@A and expected L@A
  - Tagging: residuals between observed size increments and expected at different time intervals

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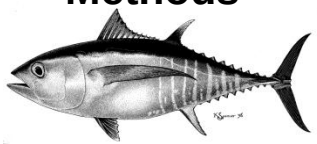

The “Laslett-Eveson-Polacheck” approach

- Maximum likelihood approaches exist that can model the joint density of the release and recapture lengths (Laslett et al. 2002; Eveson et al. 2004)
- Treat unknown ages of tagged fish as parameters to estimate in the model (random effects)
- For example, if we use the VB the assumed growth curve for the fish is:

$$L_t = L_\infty \left[1 - e^{-K(A - t_0)}\right]$$

  - $A = t$, is the age of each fish and treated as a **random variable** with density p(.) and whose parameters will be estimated in the model

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Tag-recapture component

- For a fish *i* tagged at time t_1 with released length L_1 and recaptured at t_2 with L_2

$$L_{1,i} = L_\infty\left[1 - e^{-K(A_i - t_0)}\right]$$

$$L_{2,i} = L_\infty\left[1 - e^{-K(A_i + t_{2,i} - t_{1,i} - t_0)}\right]$$

  - The joint distribution of $L_{1,i}$ and $L_{2,i}$ can be integrated over A:

$$h(L_{1,i}, L_{2,i}) = \int h(L_{1,i}, L_{2,i}|a)p(a)da$$

  - We used AD Model Builder

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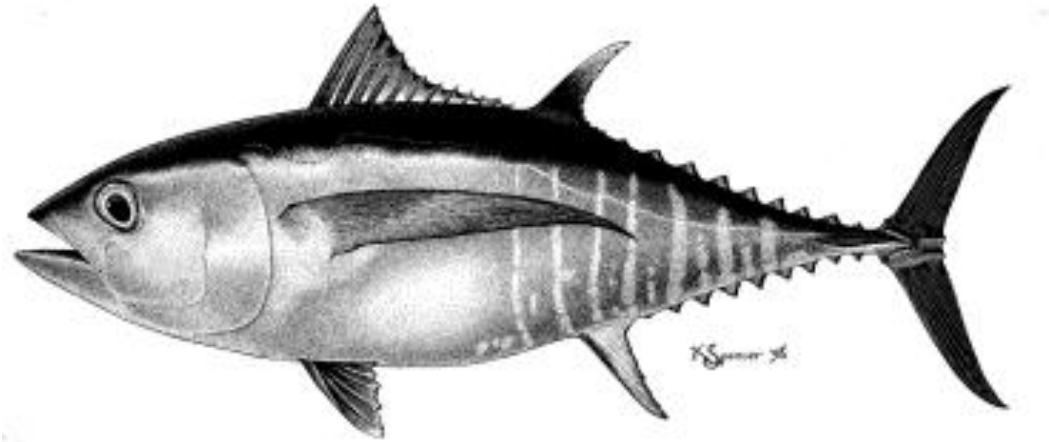
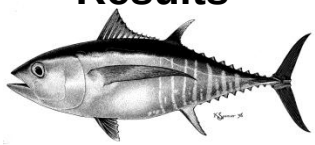


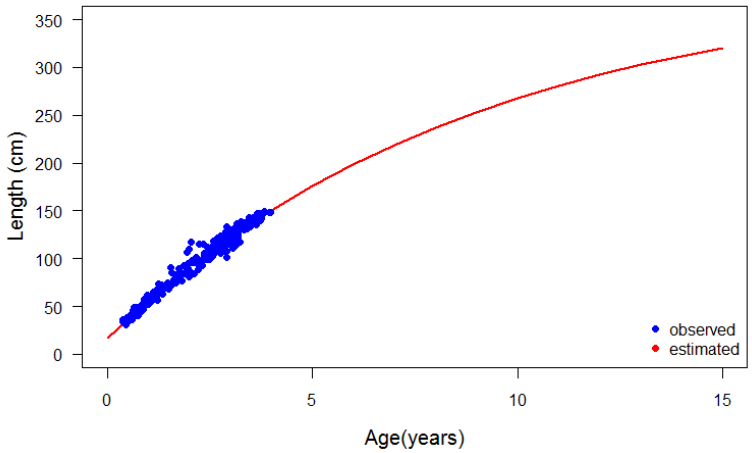
BET analysis

- Three estimation methods
  - Random effects (“Laslett-Eveson-Polacheck” method)
  - Penalized likelihood method
  - Bayesian (MCMC)

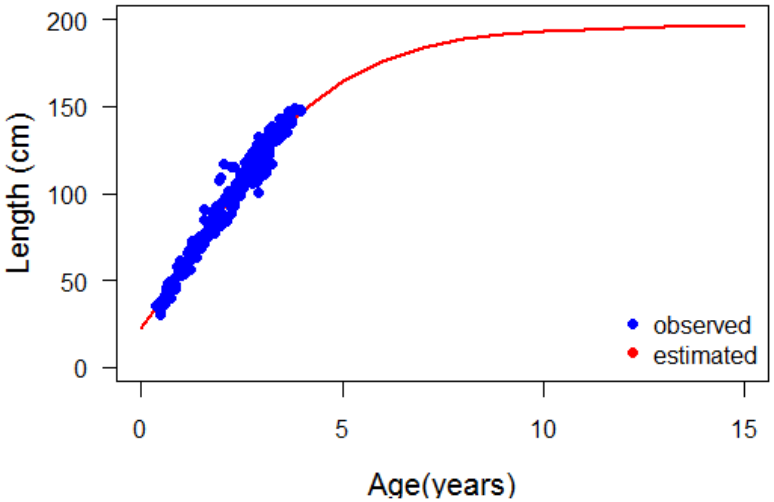
Integrated model (LEP) - BET

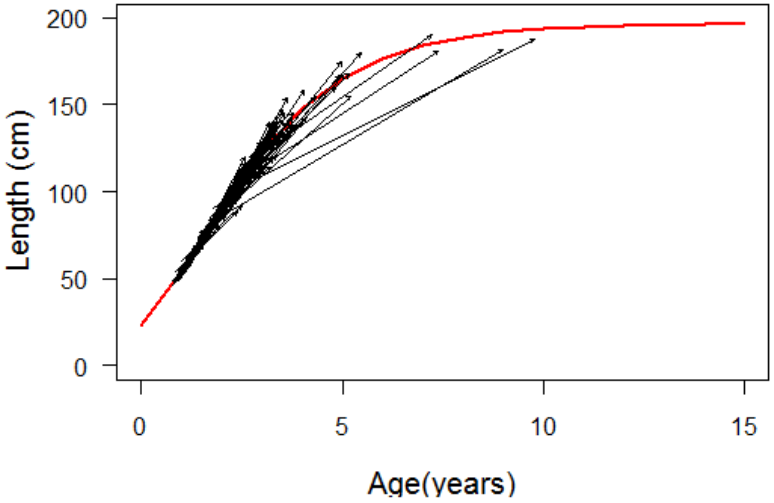


Fit otolith only

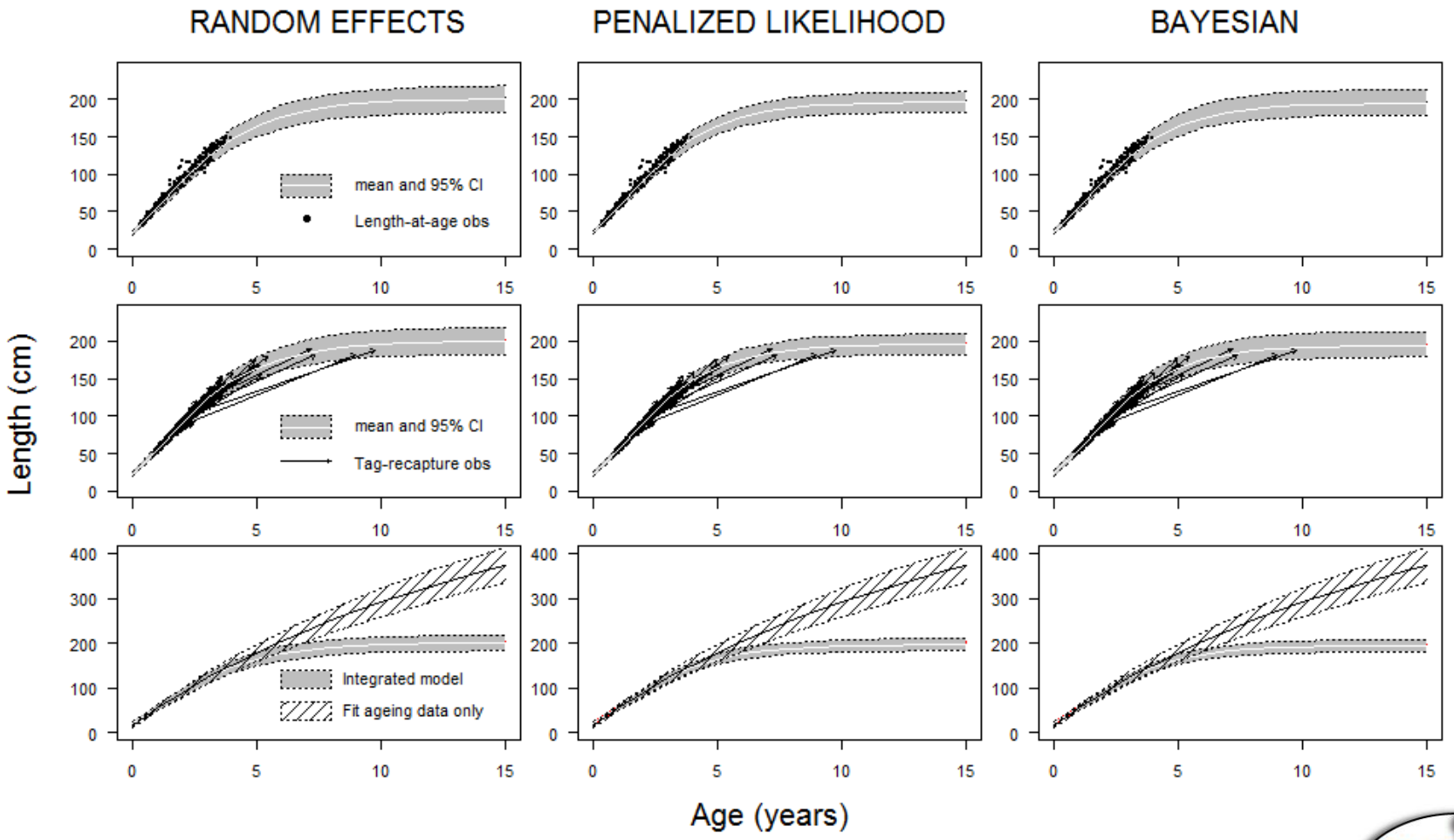


Integrated model





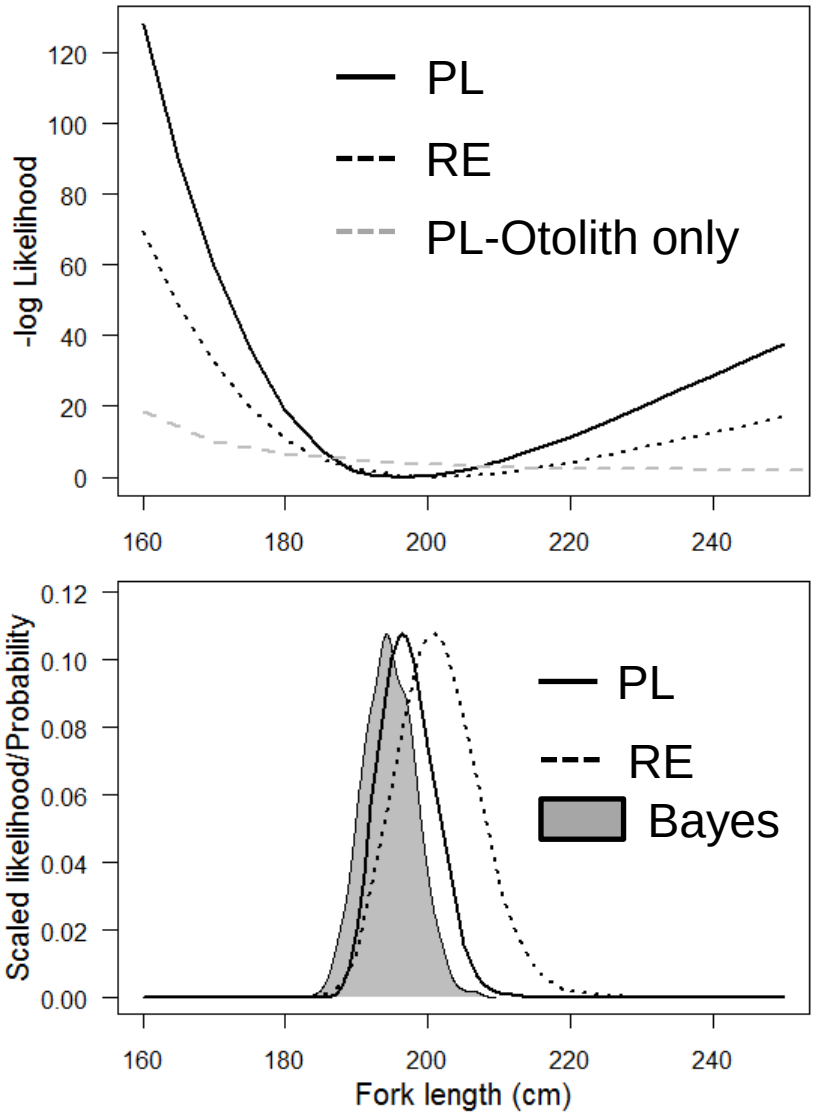
Estimation methods - BET



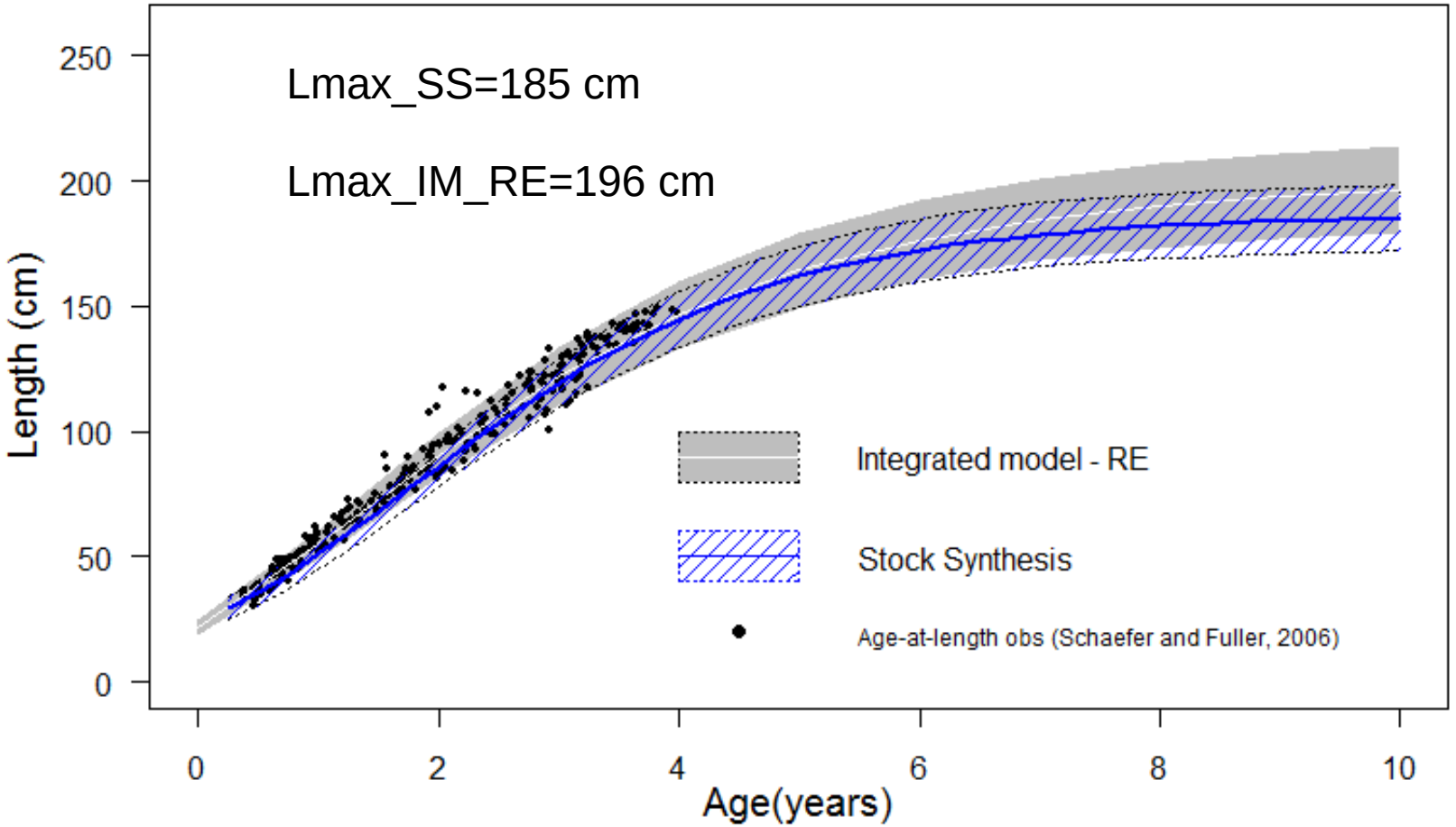
Likelihood profile on L_{max} - BET

RE – Random Effects

PL – Penalized likelihood



IM and SS growth curves - BET



Lessons from BET analysis

- Integrated analysis helped to reduce the uncertainty on growth
  - Average size of the oldest fish (L_{max}) and variability of L@A
- Growth estimates were similar among 3 methods
- Penalized likelihood approach
  - Less computationally intensive, integrate in SS
  - But simulation study is needed to investigate bias
- L_{max} assumption in stock assessment may be low
- Variability of length at age (L_{SD}) similar to Stock Synthesis but around different mean length-at-age
- Evaluate impact in next assessment

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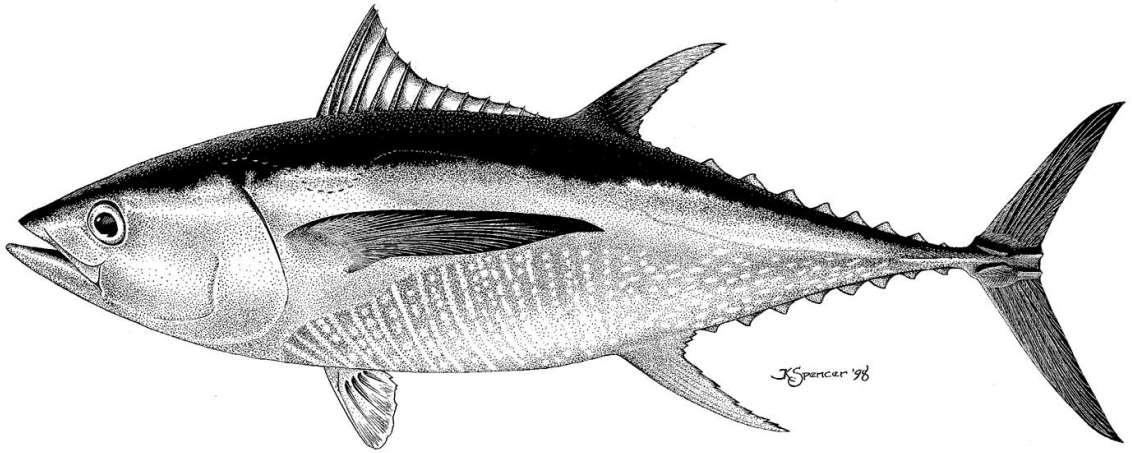
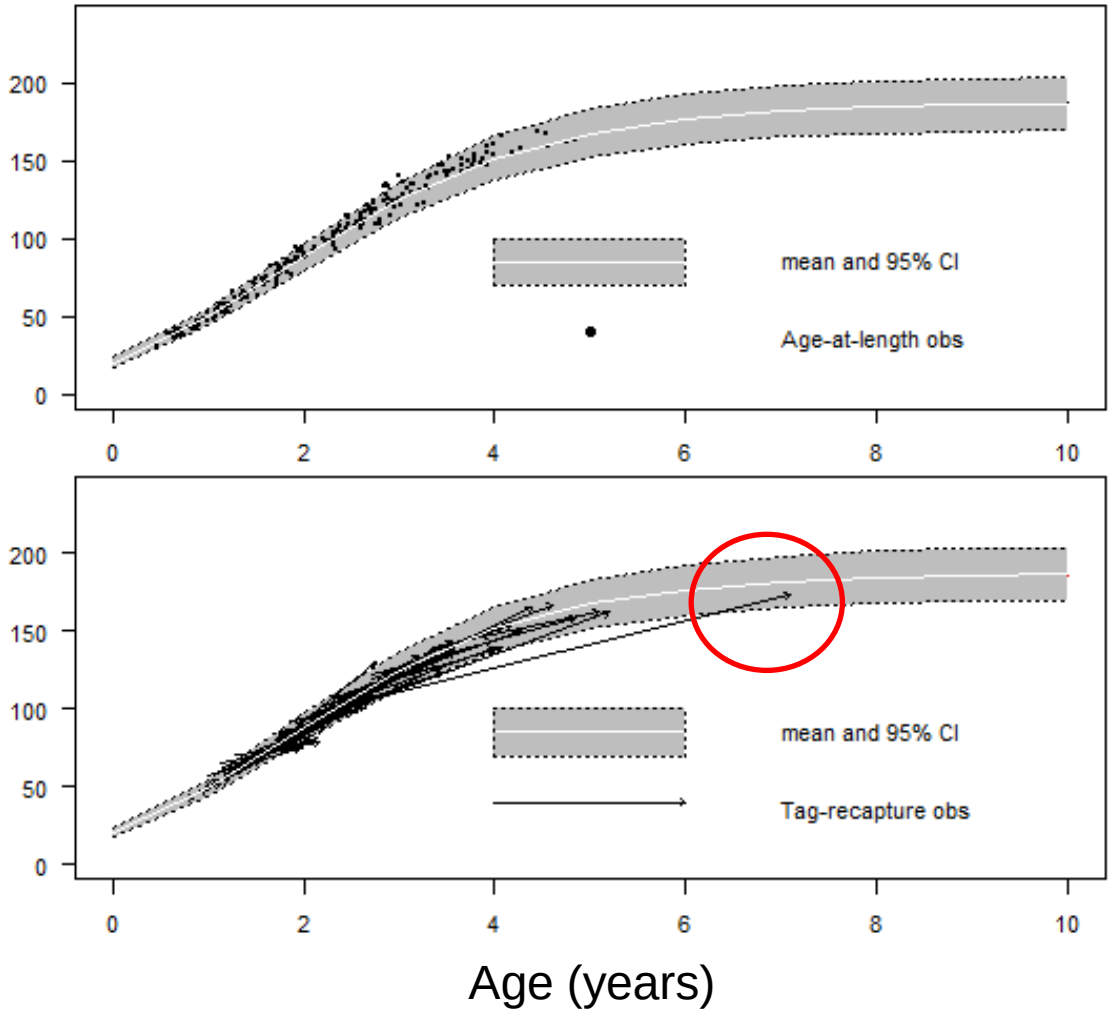


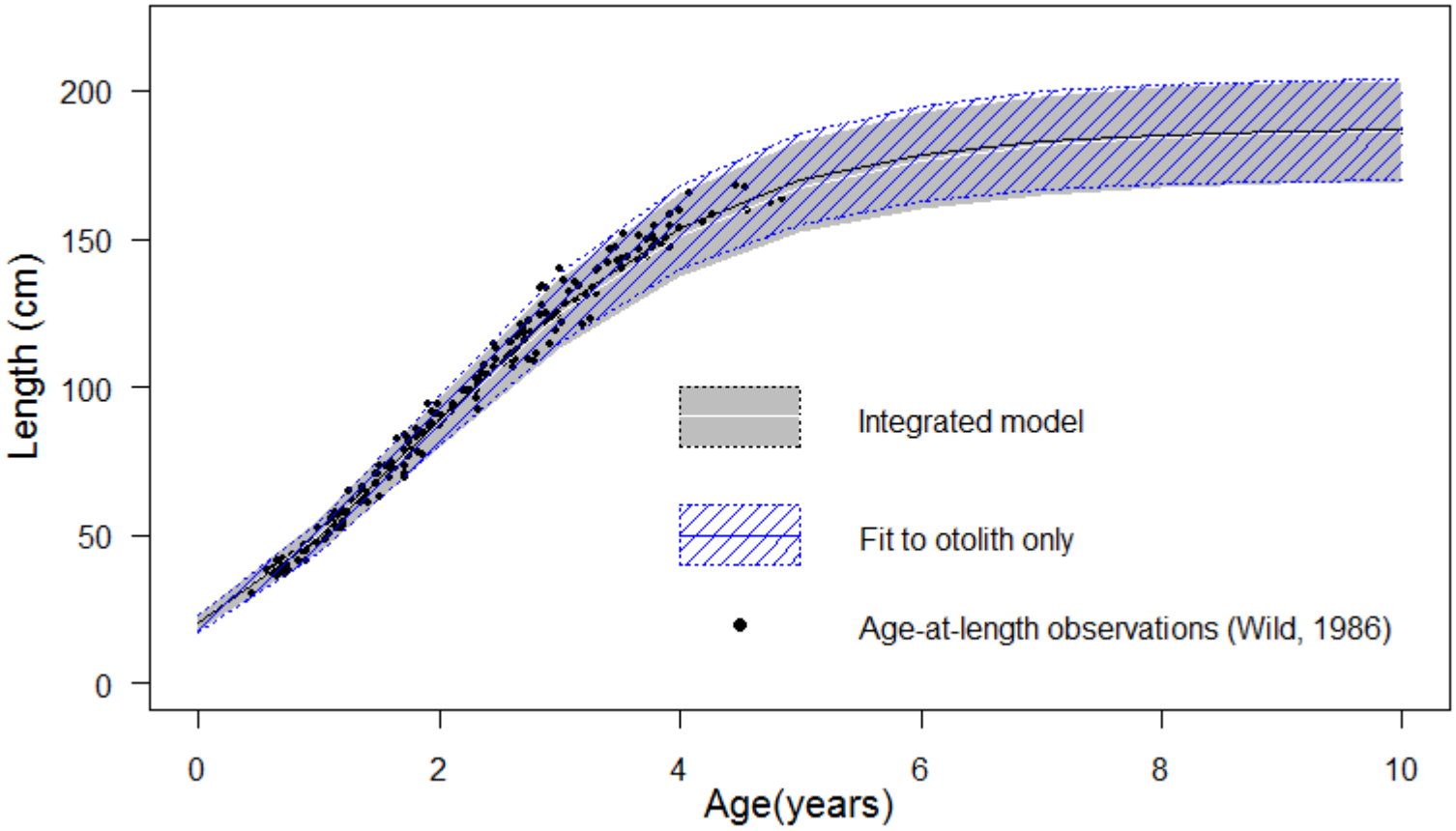
YFT analysis

- Penalized likelihood approach
- Impact of new estimates on stock assessment results and management

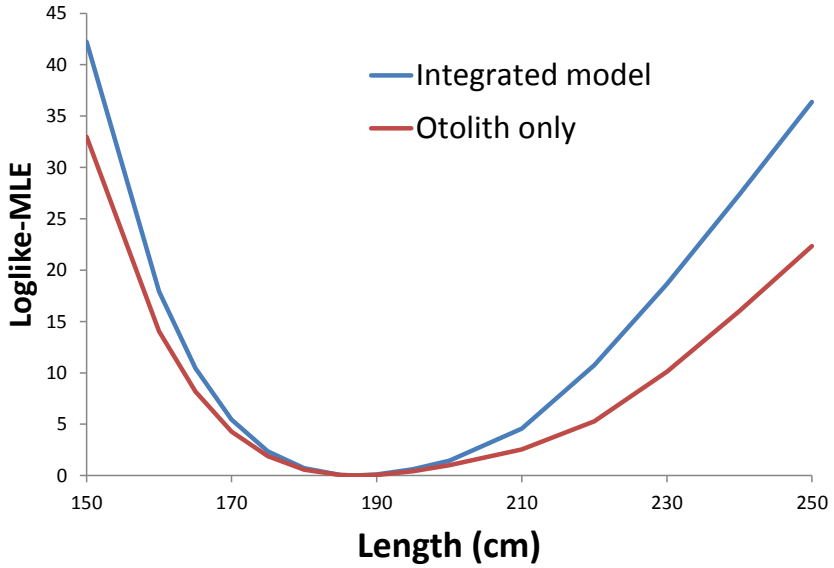
Integrated model - YFT

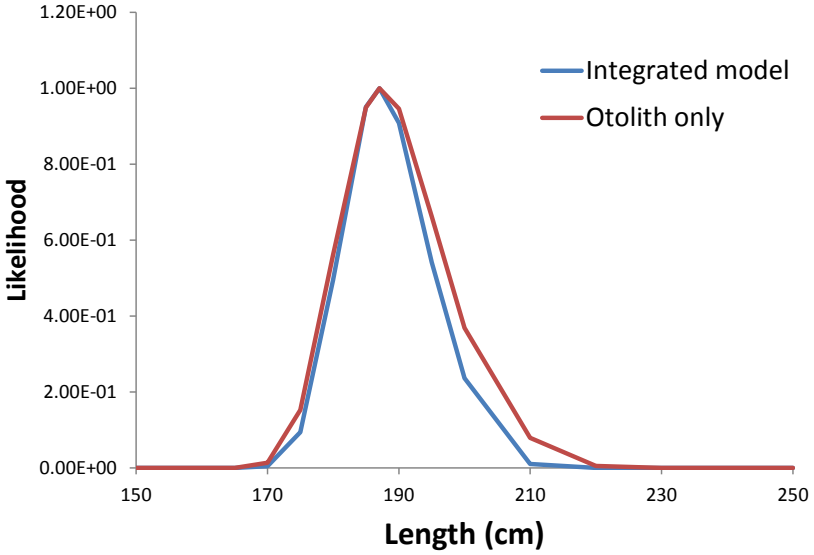


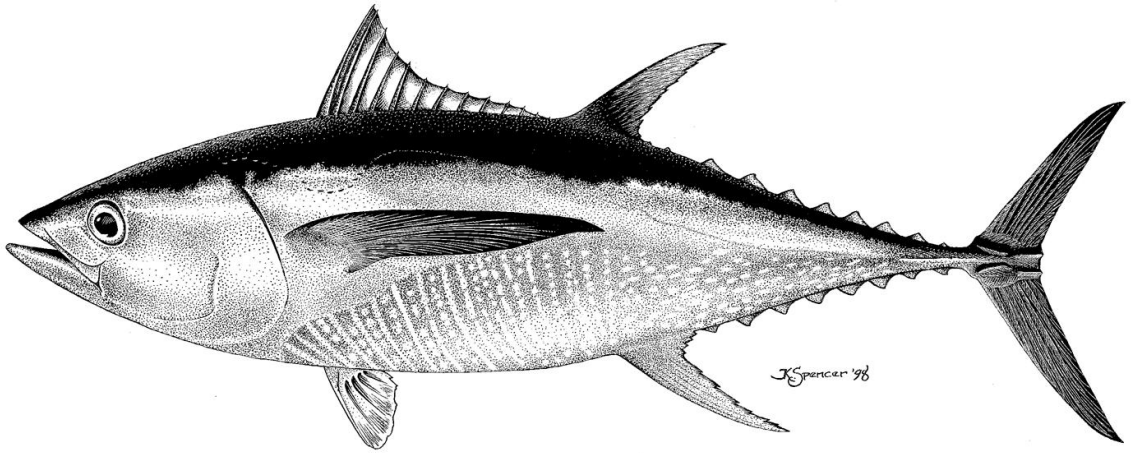
IM and fit to otolith only



Likelihood profile on L_{max} - YFT



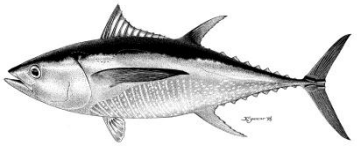




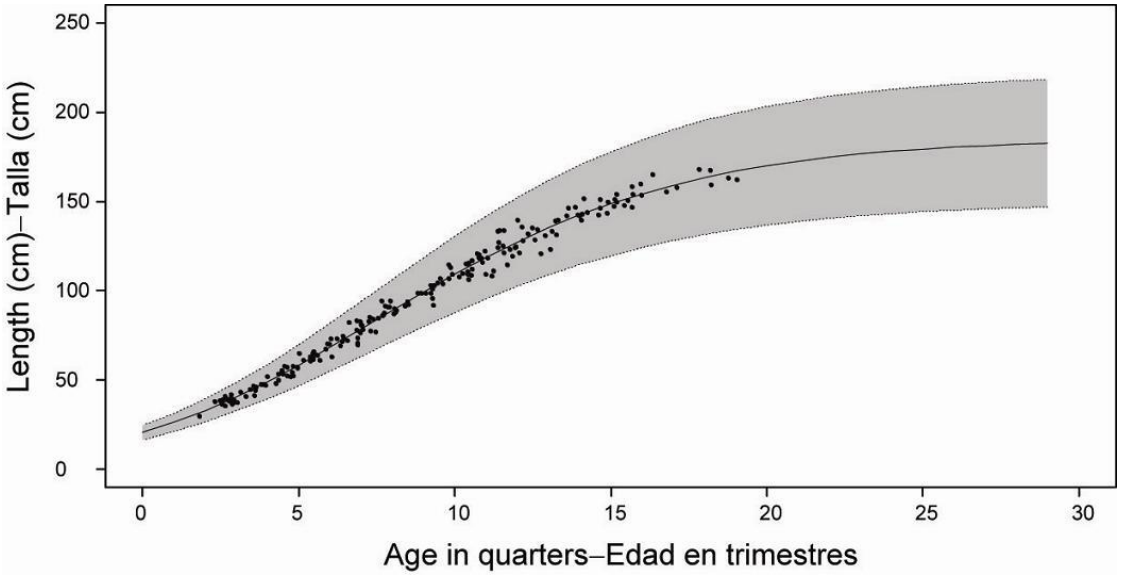
YFT analysis

- Penalized likelihood approach
- Impact of new estimates on stock assessment results and management

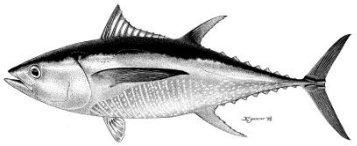
YFT base case – growth assumptions

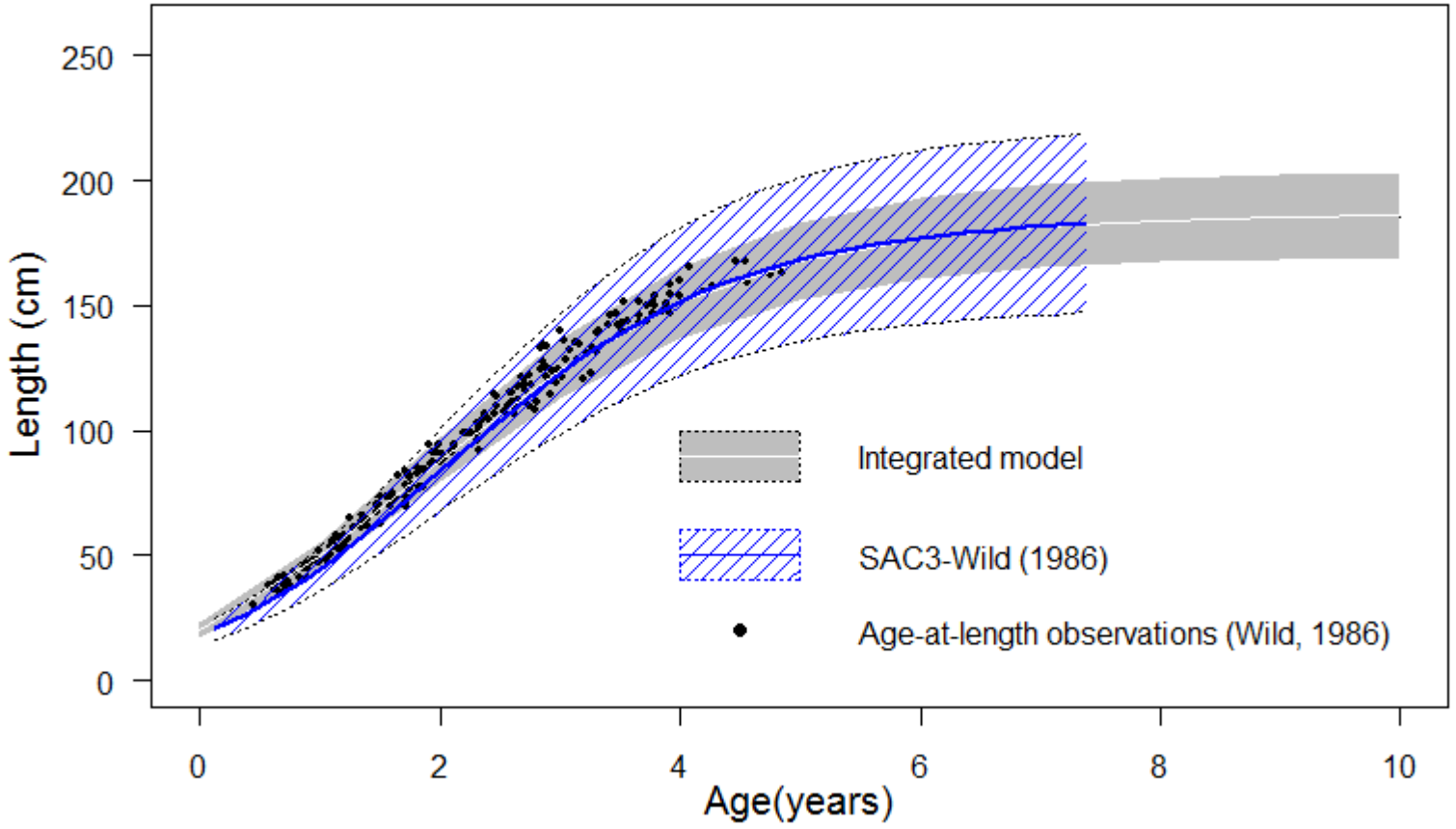


- Richards growth curve
  - Growth parameters fixed to estimates derived internally from early assessment (Maunder and Aires-da-Silva, 2009)
  - L_{max} fixed at 182.3 cm
  - Variability of length-at-age (L_{SD}) fixed
  - L_{SD} linear function of SD(L)

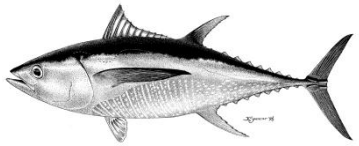


IM and SS growth assumptions - YFT





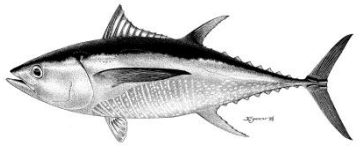
Impact on Stock assessment



- Preliminary work during External Review of IATTC YFT assessment in October
- SS model fit got worse with new growth estimates
  - Conflict with length-composition data needs to be resolved

	Base case	IM	
TOTAL	8289.5	8415.7	+126 units
Survey	-148.9	-155.5	
Length_comp	8443.8	8604.5	+161 units
Recruitment	-5.4	-33.2	

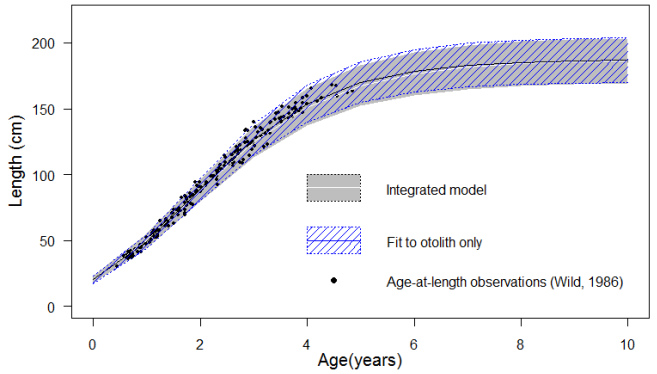
Management quantities



quant	Base case	Growth IM	
msy	262,642	286,750	
Bmsy	356,682	396,187	
Smsy	3,334	3,052	
Bmsy/Bzero	0.31	0.31	
Smsy/Szero	0.26	0.22	↓
Crecent/msy	0.79	0.72	
Brecent/Bmsy	1.0	1.04	
Srecent/Smsy	1.0	1.13	↑
Fmultiplier	1.15	1.46	↑

Lessons from YFT analysis

- Minimal benefits from YFT integrated model
- Growth parameters from IM are very similar to those produced by fitting to otolith data only:
  - Average size of the older fish (L_{max})
  - Variability of the length-at-age (L_{SD})



- Need to increase tag-recapture sample sizes for larger (older) fish

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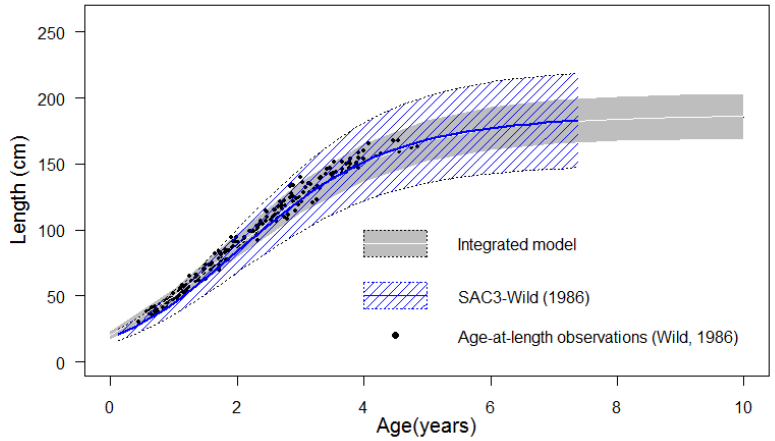
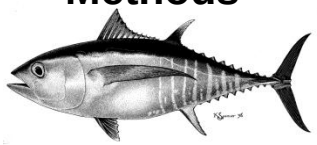
Lessons from YFT analysis (cont.)

- Estimates of variability of L@A by IM are lower than SS assumptions
- Relationships differ:
  - A-SCALA: SD=F(A)
  - Integrated model: SD=F(L)
- SD=F(L) is more appropriate for tropical tuna and should be revised in assessment



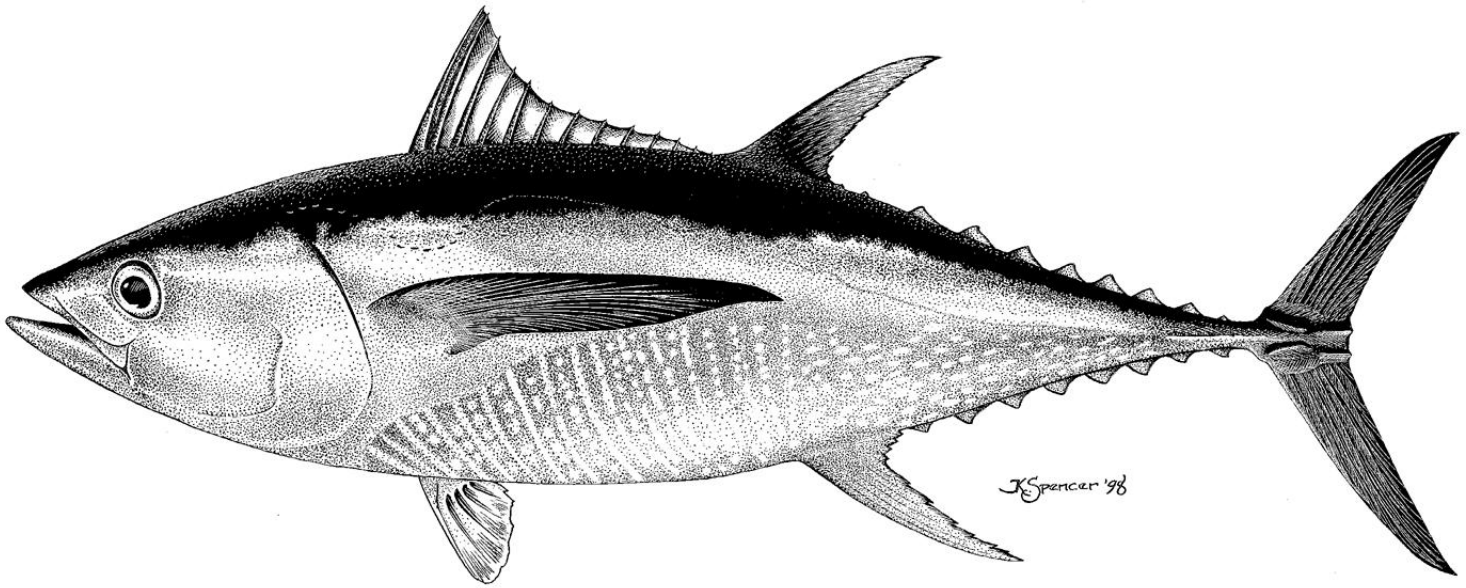
Lessons from YFT analysis (cont.)



- More optimistic assessment results with IM growth estimates:
  - Fmultiplier increases
  - Srecent/Smsy increases

- But other issues will be improved in the assessment (YFT External Review):
  - Appropriate weighting of different datasets (CPUE, size compositions and age at length data)

THANKS!



Longline expansion in EPO

- Length of the largest fish observed (close to virgin population)

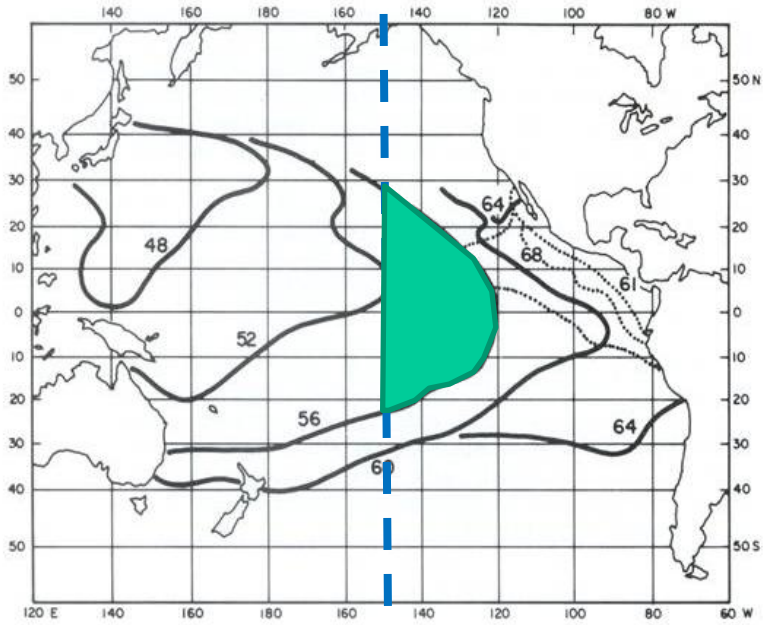


FIGURE 1. Geographical expansion of the Japanese longline fishery (solid curves) and the surface fishery in the eastern Pacific (dotted curves). Numerals denote calendar year.

Suzuki, Tomlinson and Honma (1978)

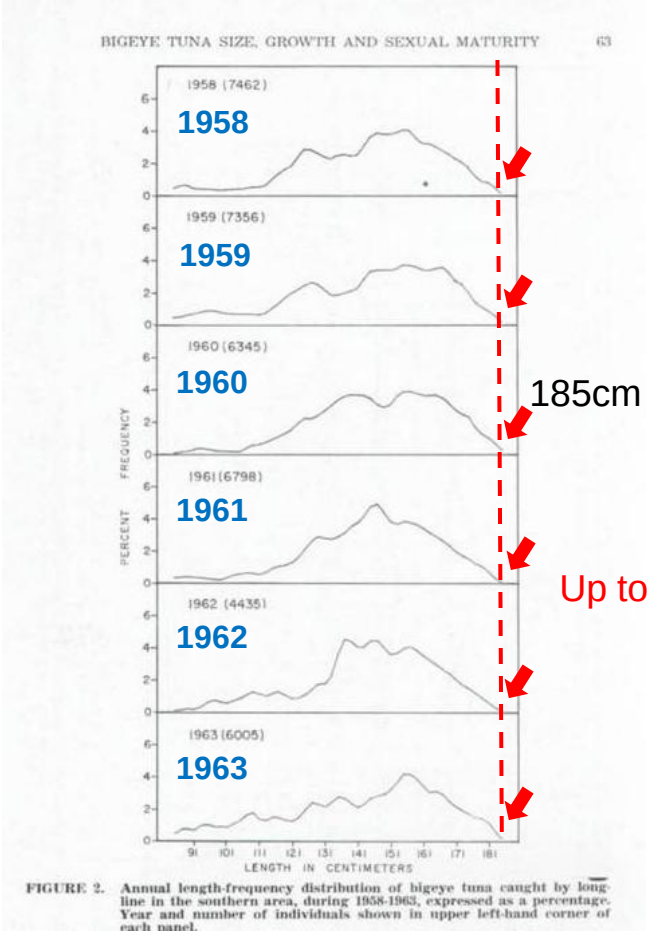
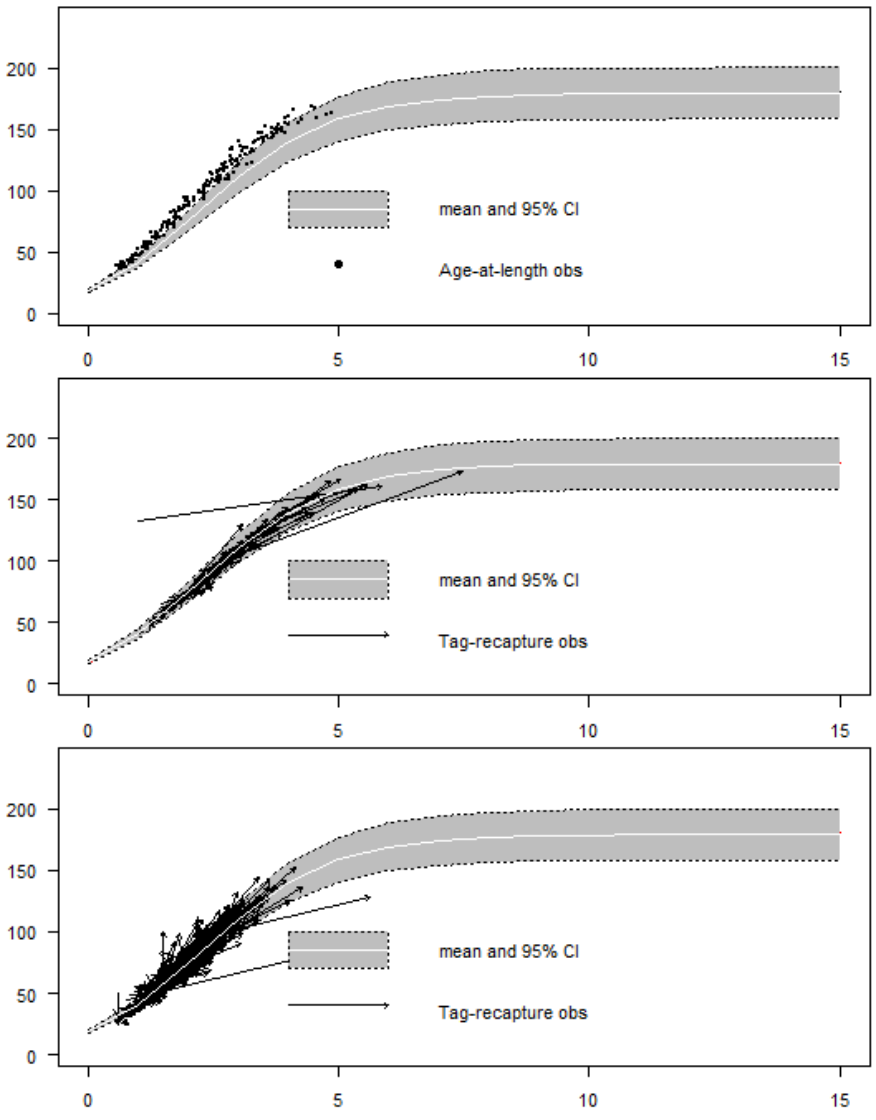


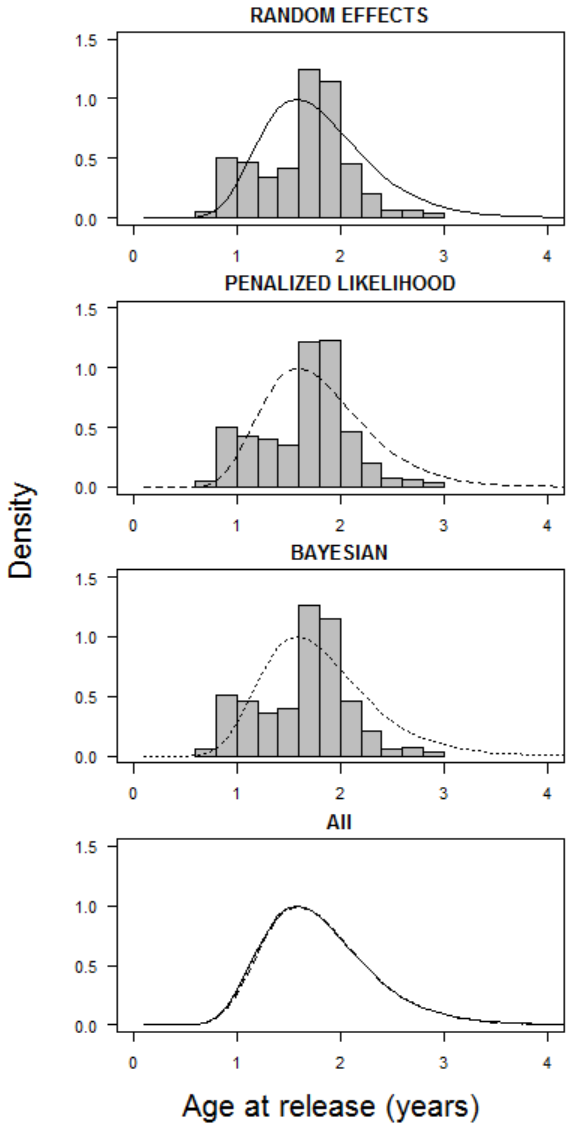
FIGURE 2. Annual length-frequency distribution of bigeye tuna caught by long-line in the southern area, during 1958-1963, expressed as a percentage. Year and number of individuals shown in upper left-hand corner of each panel.

Kume and Joseph (1966)

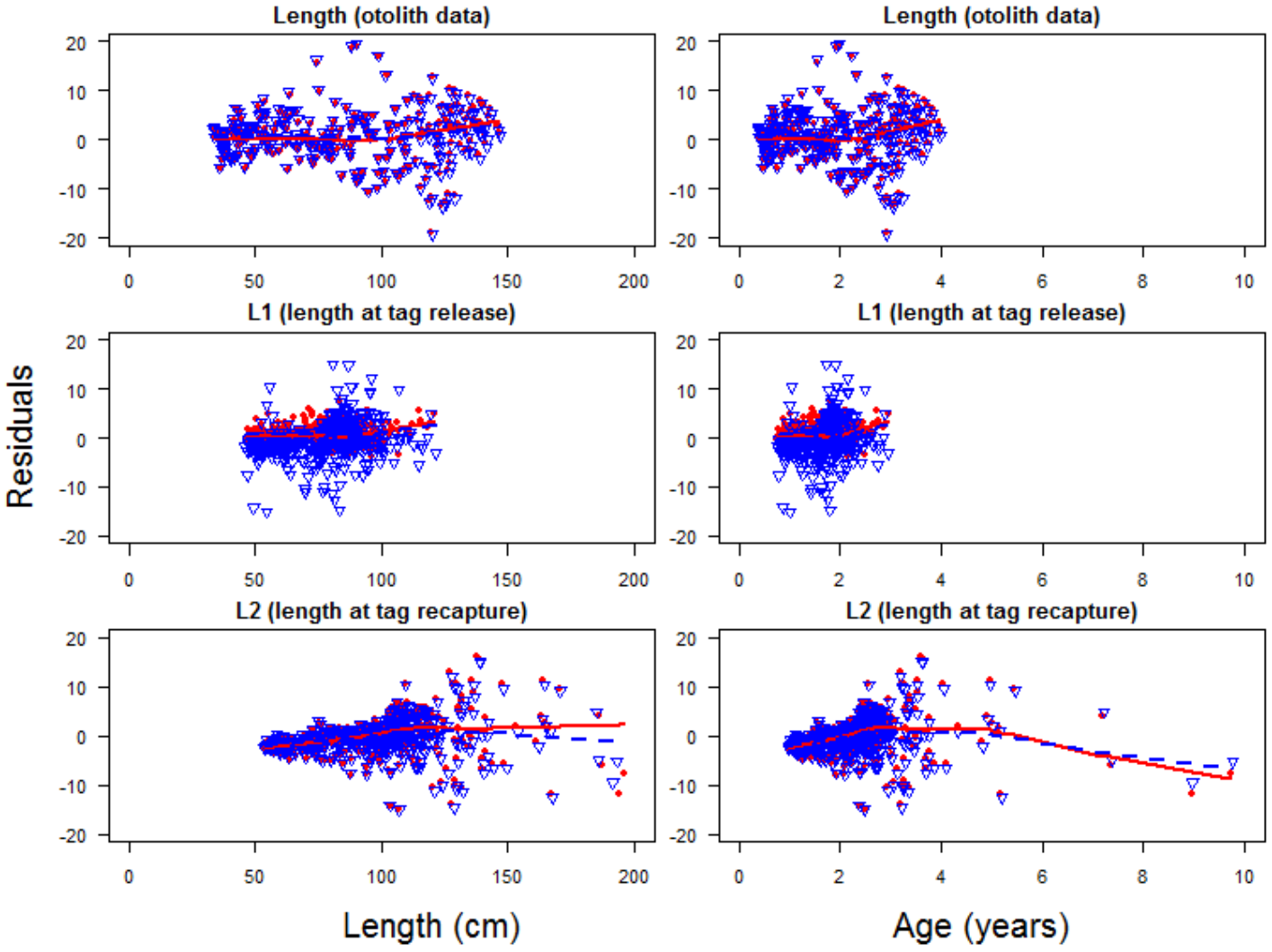

200
150
100
50
0
0
5
10
15
mean and 95% CI
Age-at-length obs
mean and 95% CI
Tag-recapture obs
mean and 95% CI
Tag-recapture obs

Distribution of age at release params.

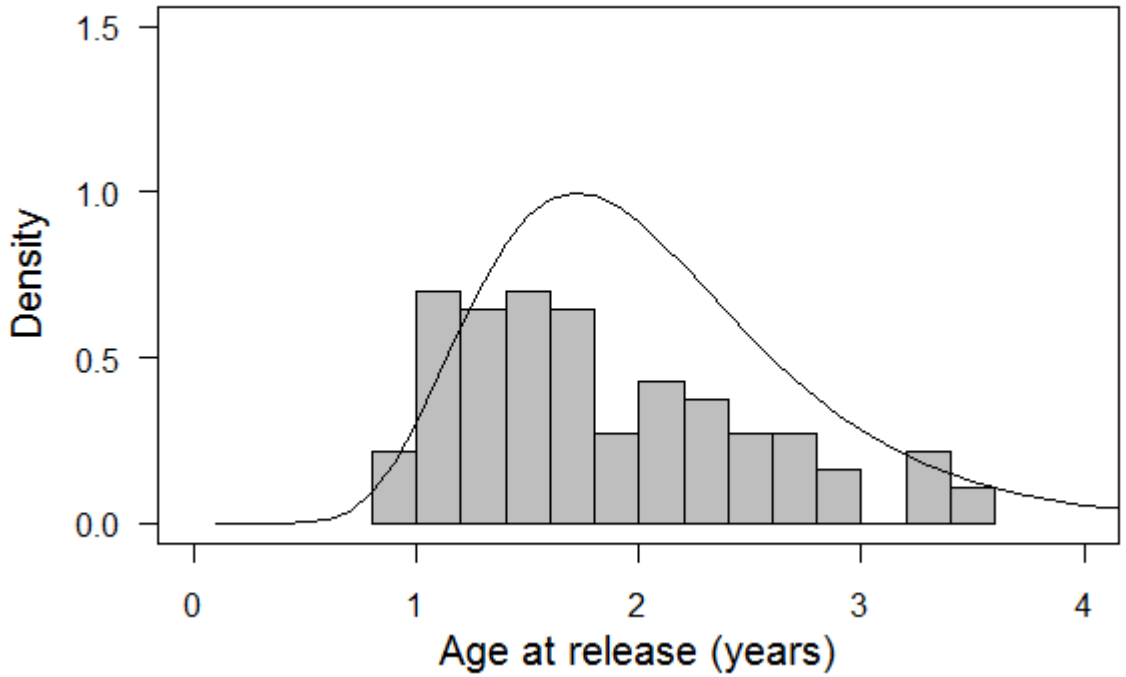
BET



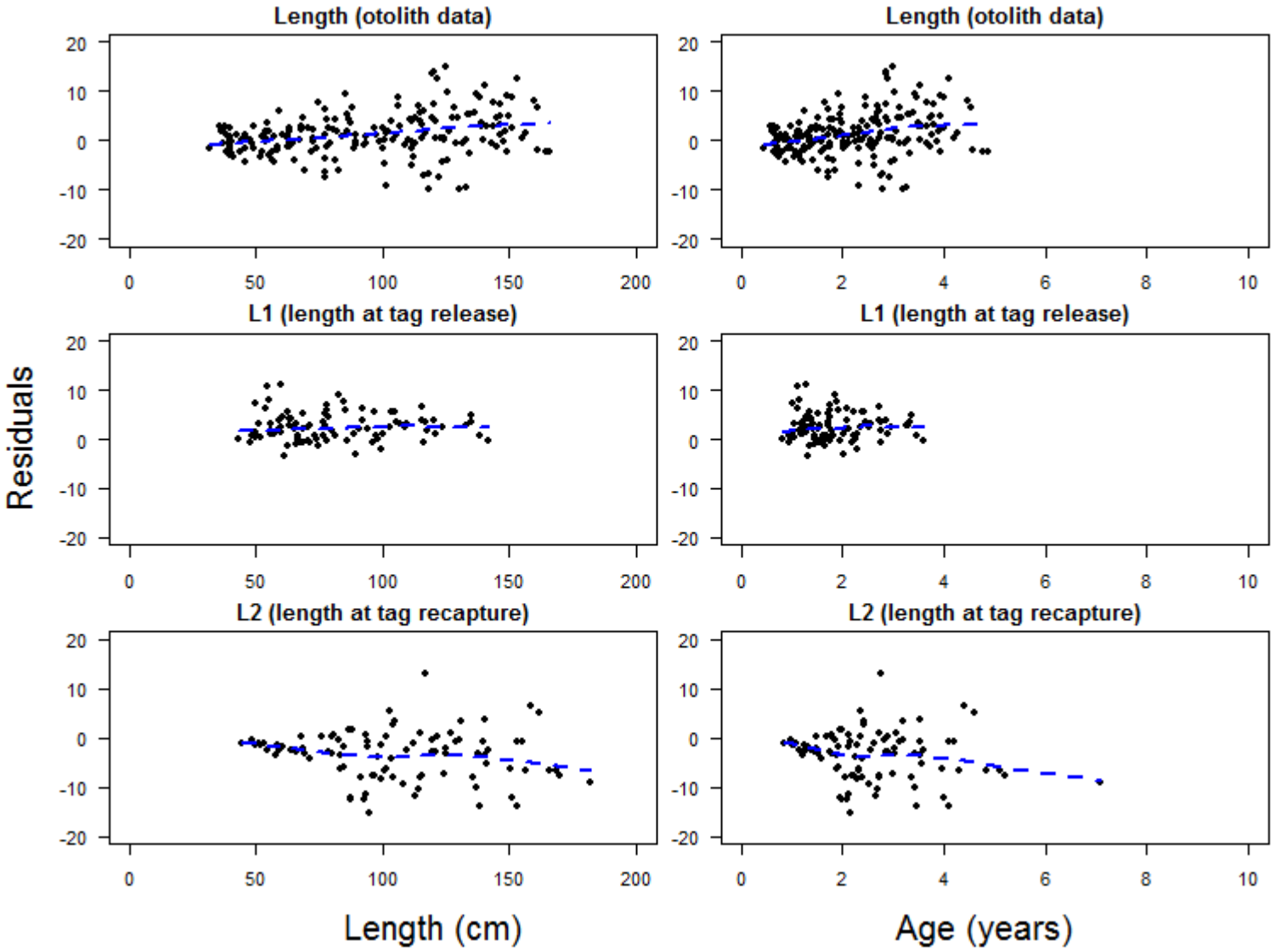
Residual plots - BET



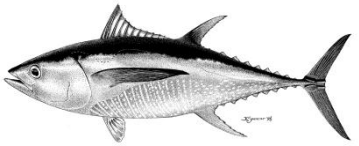
Distribution of age at release params

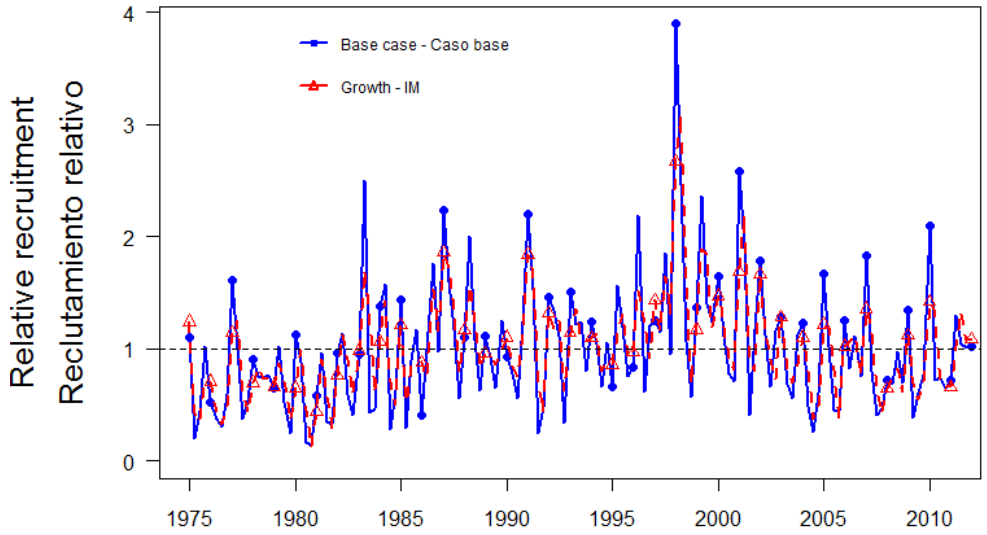


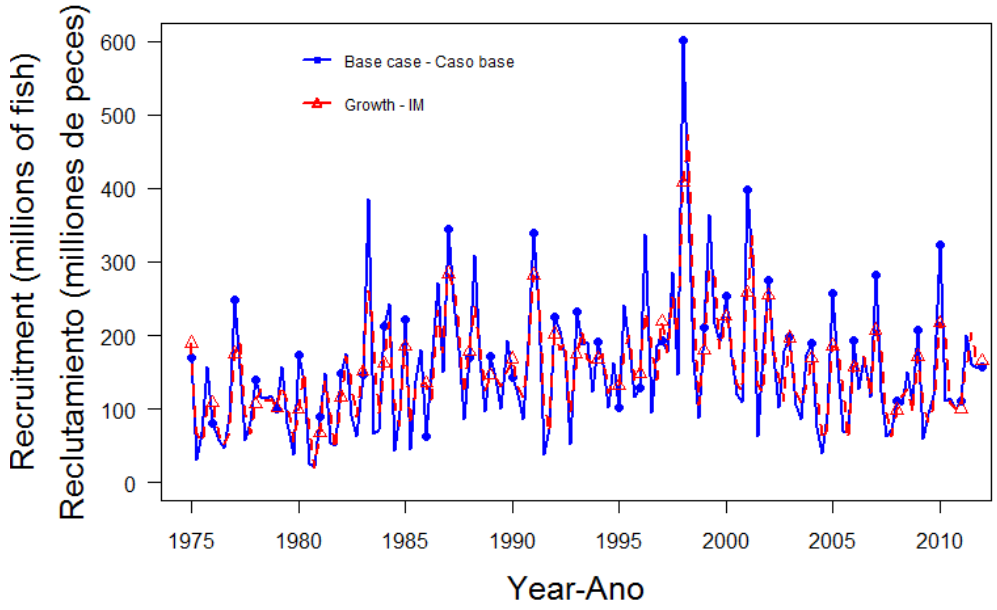
Residual plots - YFT



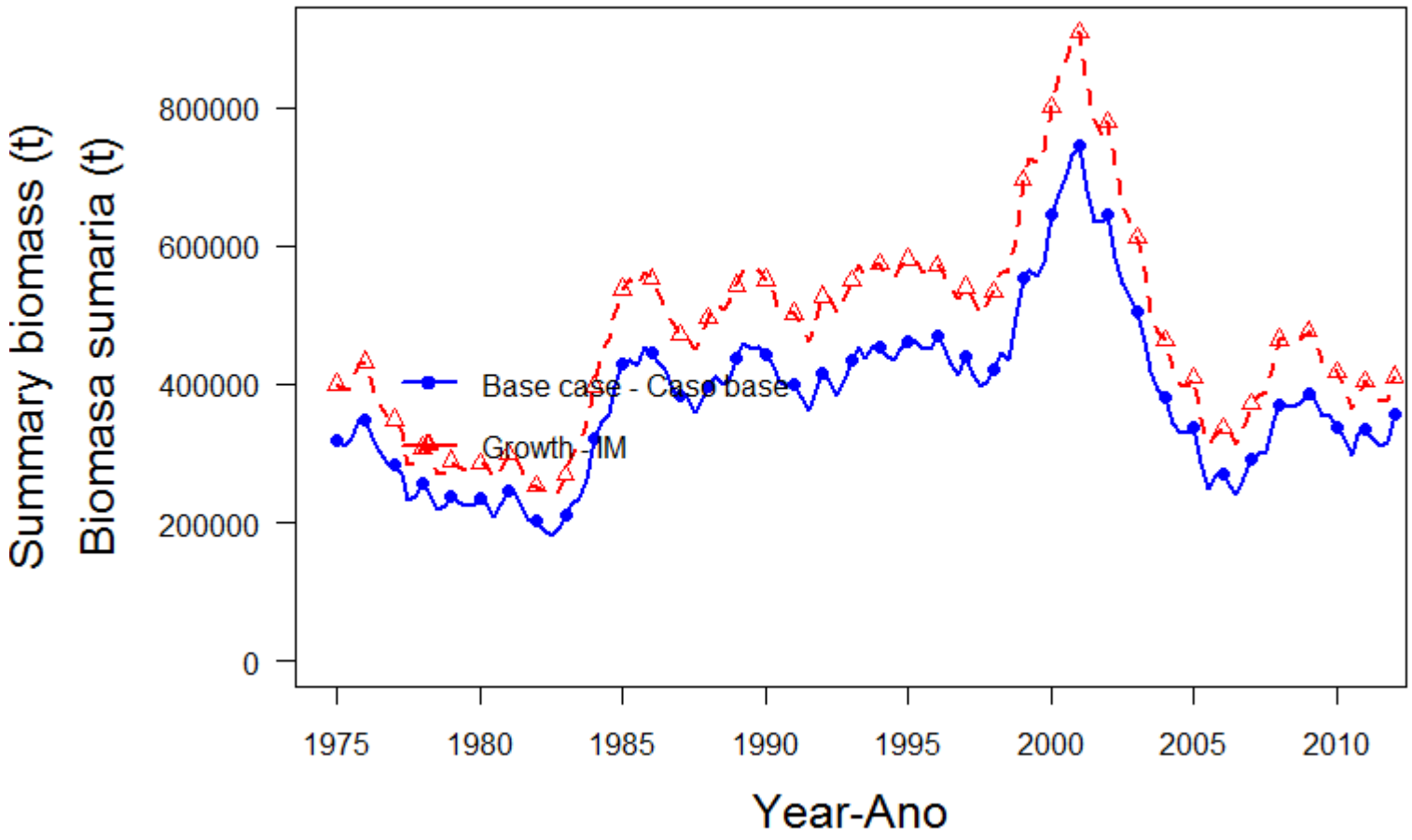
YFT recruitments



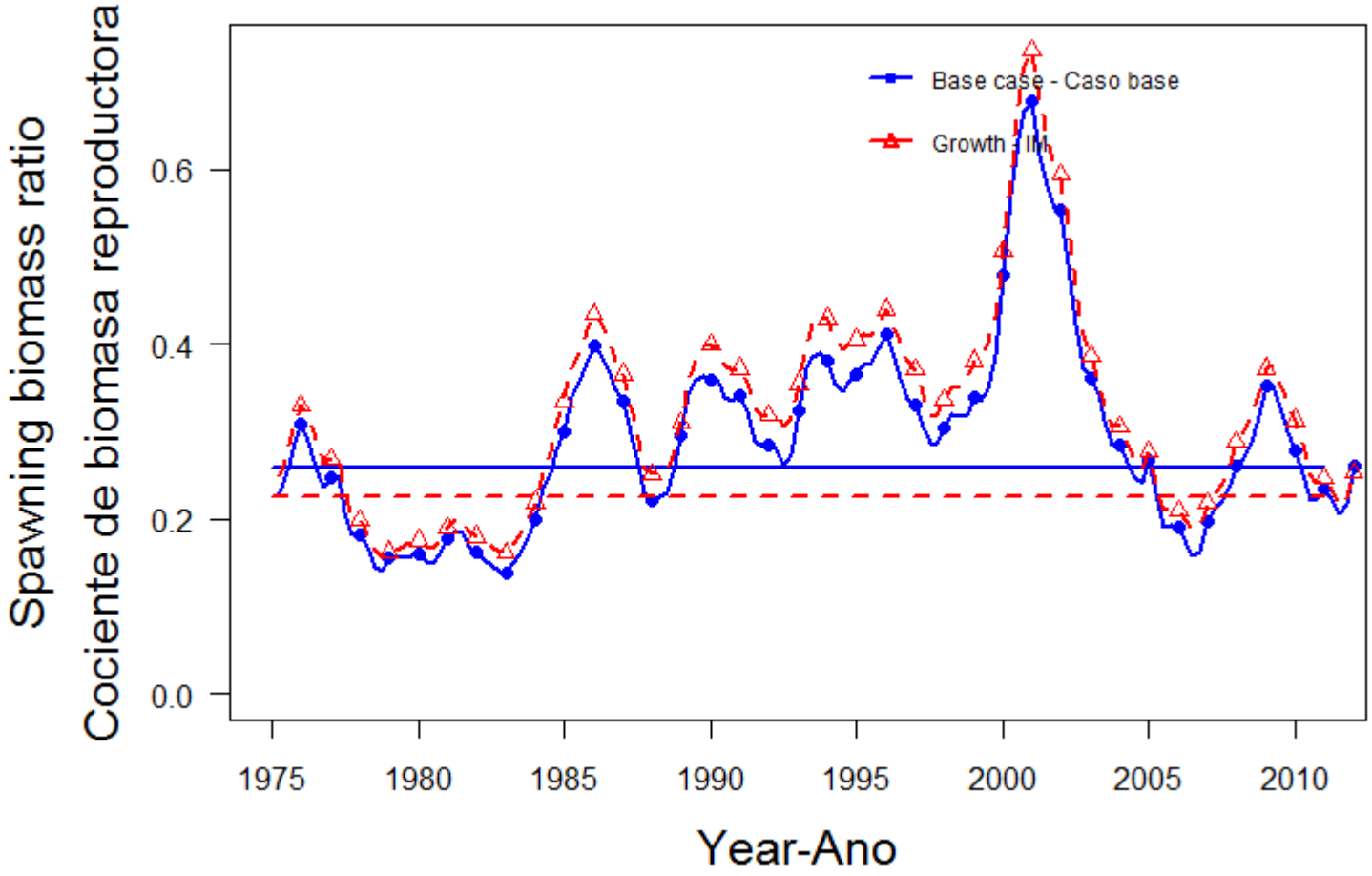




Biomasses


Summary biomass (t)
Biomasa sumaria (t)
800000
600000
400000
200000
0
Base case - Caso base
Growth - IM
1975
1980
1985
1990
1995
2000
2005
2010
Year-Ano

SBR


Spawning biomass ratio
Cociente de biomasa reproductora
0.0
0.2
0.4
0.6
1975
1980
1985
1990
1995
2000
2005
2010
Year-Ano
Base case - Caso base
Growth - Im