


Comisión Interamericana del Atún Tropical
Inter-American Tropical Tuna Commission

CIAT
IATTC

Comparisons of length-based growth rates from models fit separately to high confidence tagging data and length-at-age data based on daily increment counts from bigeye otoliths from the EPO

Haikun Xu, Kurt Schaefer, Dan Fuller, and Mark Maunder

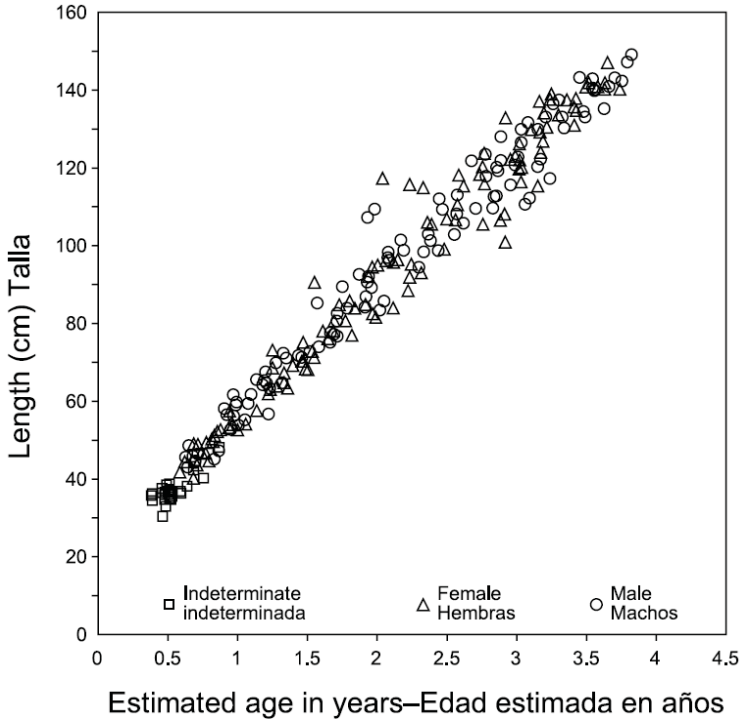
Workshop on age and growth of bigeye and yellowfin tunas in the Pacific Ocean, La Jolla, CA, Jan 23-25, 2019

Outline

- Otolith-based length-at-age data
- Estimated growth rate based on length-at-age data
- Tagging data
- Estimated growth rate based on tagging data
- Comparison of the two estimated growth rates

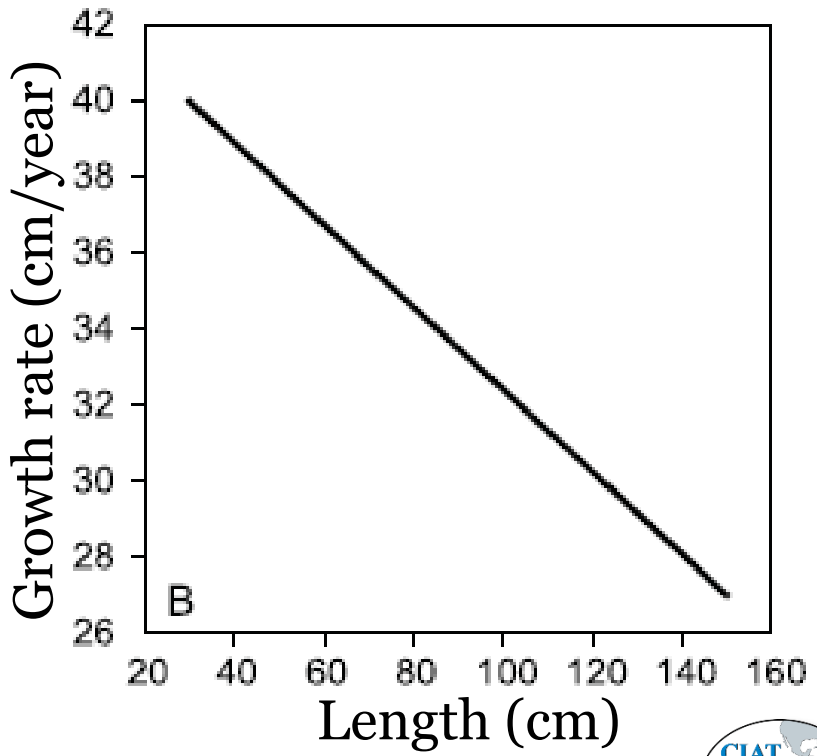
Estimated growth rate based on otolith data

Schaefer and Fuller (2006): $L_\infty = 400.3$, $K = 0.108$, $t_0 = -0.398$



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

$$K(L_\infty - L)$$



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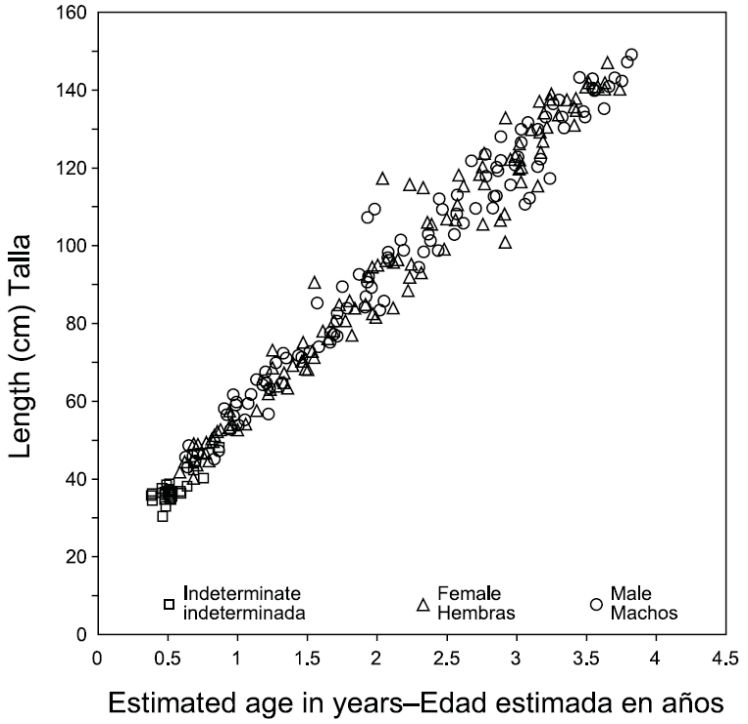
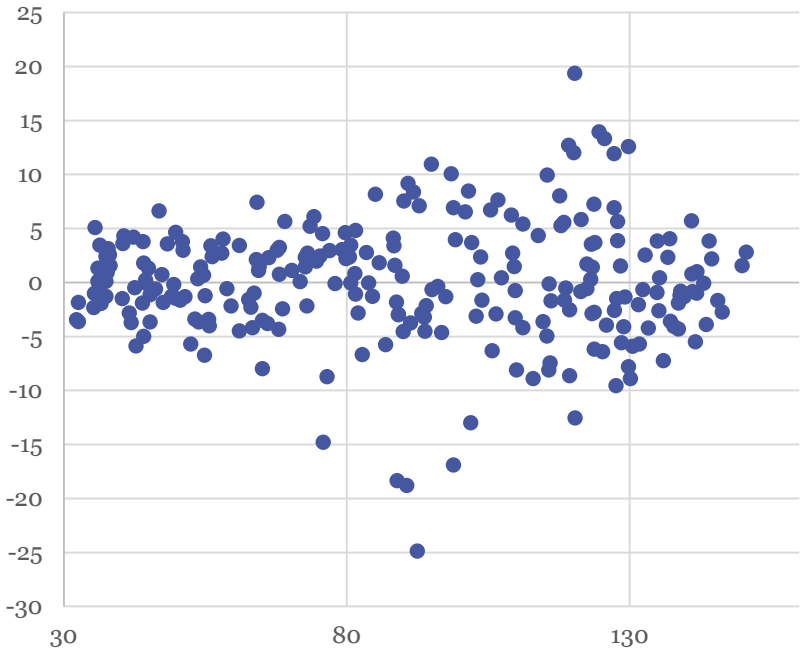


$$L_t = L_\infty\left(1 - e^{-K(t-t_0)}\right)$$

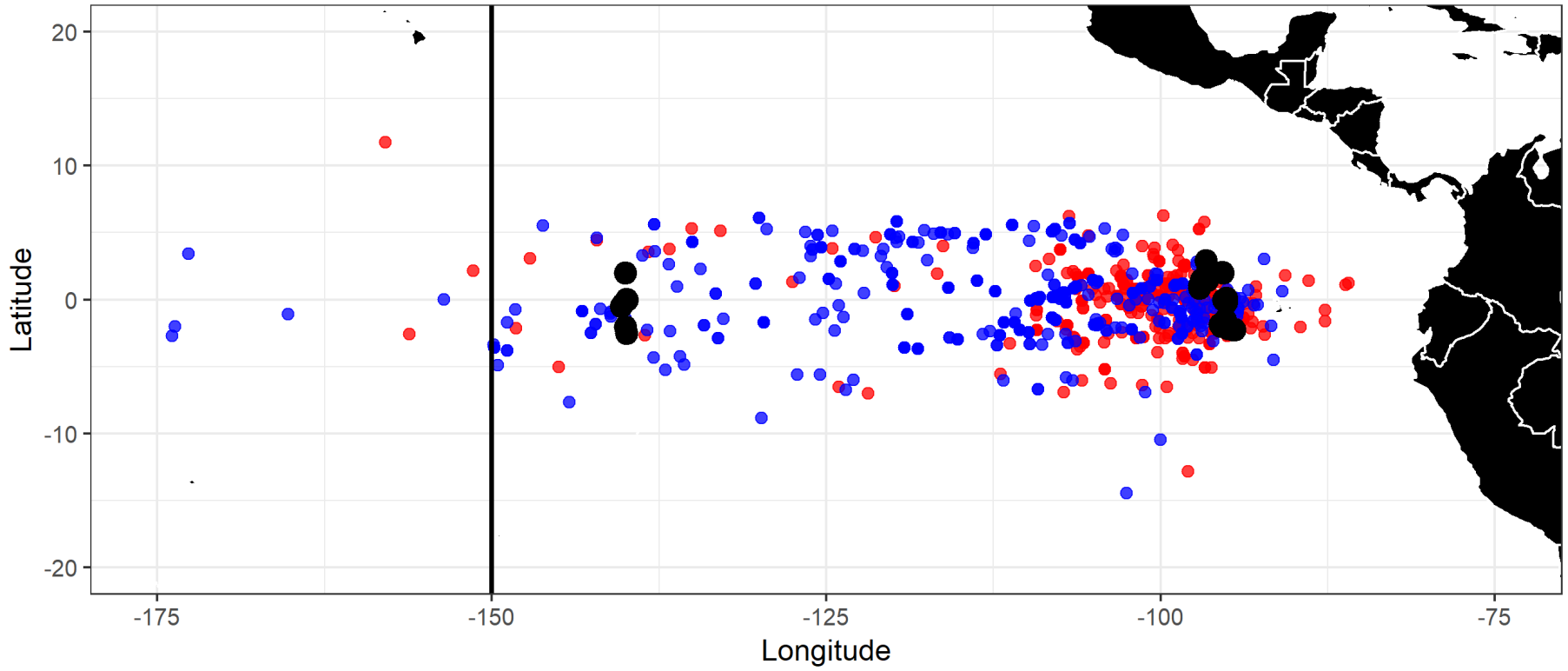
residuals (cm) vs. length (cm)



Tagging data for EPO bigeye: release and recapture

463 recaptured bigeye were released at ~95W

586 recaptured bigeye were released at ~140W



Tagging data for EPO bigeye

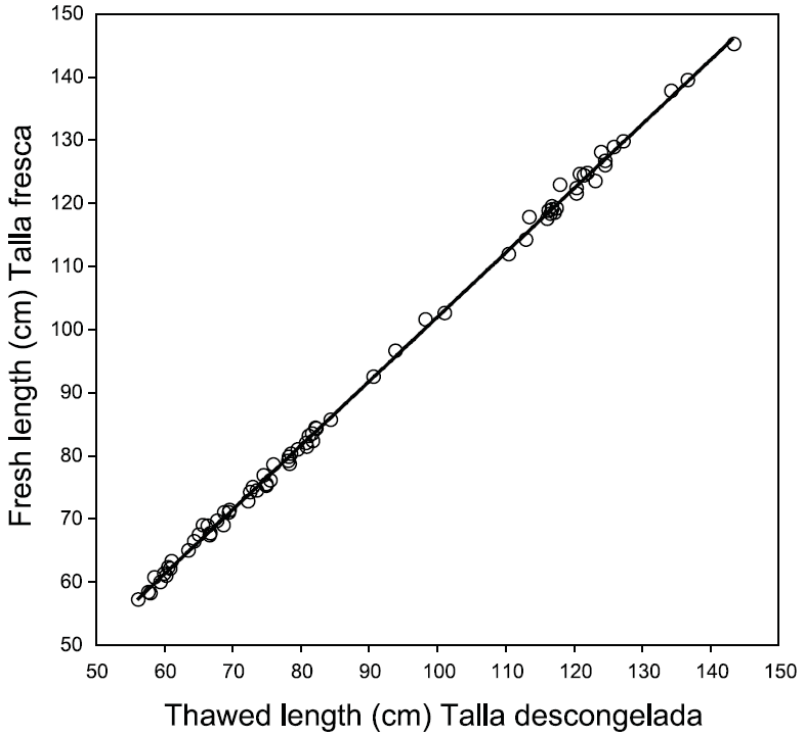
The von Bertalanffy growth curve: $L_{rec} = L_{rel} + (L_\infty - L_{rel})\left(1 - e^{-K(t_{rep} - t_{rel})}\right)$

n=1049

Fish Number	Release Date	Release Length	Recapture Date	Recapture Length
363	5/6/2000	112	8/4/2000	120
425	5/7/2000	106	7/11/2000	107
455	5/8/2000	106	9/13/2000	115
917	5/12/2000	114	7/13/2001	137
1412	4/15/2000	102	7/1/2001	135

The fresh length-thawed length relationship was expressed as:

$$L_f = 1.01814 L_t + 0.1481$$



Schaefer and Fuller (2006)

Tagging data for EPO bigeye

The von Bertalanffy growth curve: $L_{rec} = L_{rel} + (L_\infty - L_{rel})\left(1 - e^{-K(t_{rep} - t_{rel})}\right)$

we used the adjusted length

n=1049

Fish Number	Release Date	Release Length	Recapture Date	Recapture Length	Adjusted Recapture Length
363	5/6/2000	112	8/4/2000	120	122.32
425	5/7/2000	106	7/11/2000	107	109.09
455	5/8/2000	106	9/13/2000	115	117.23
917	5/12/2000	114	7/13/2001	137	139.63
1412	4/15/2000	102	7/1/2001	135	137.60

The fresh length-thawed length relationship was expressed as:

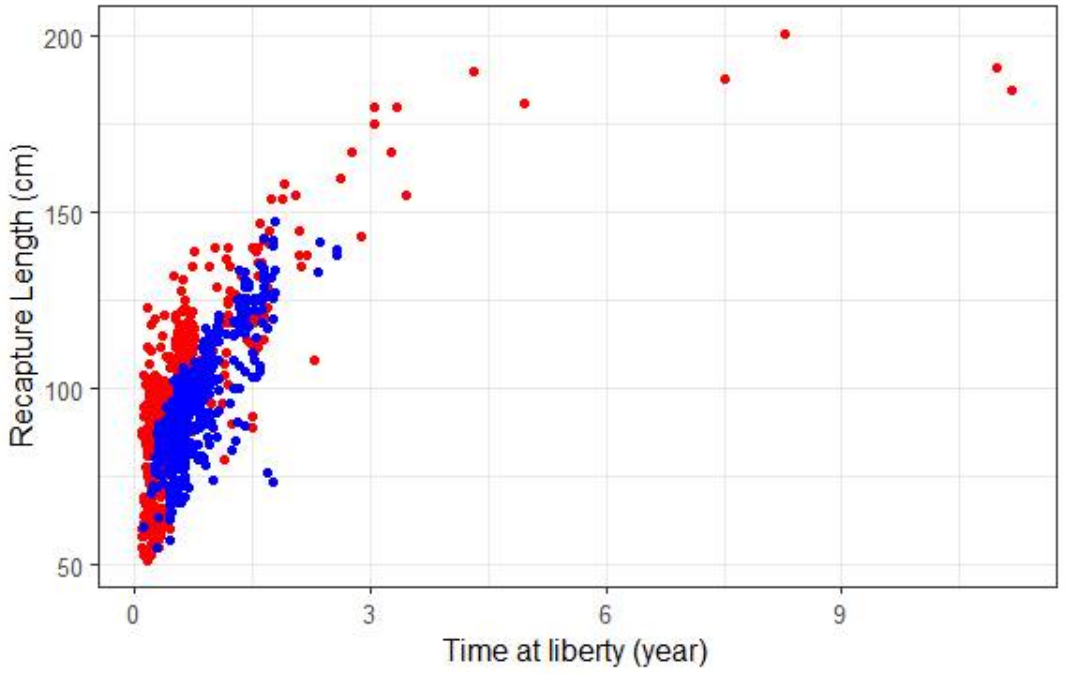
$$L_f = 1.01814 L_t + 0.1481$$

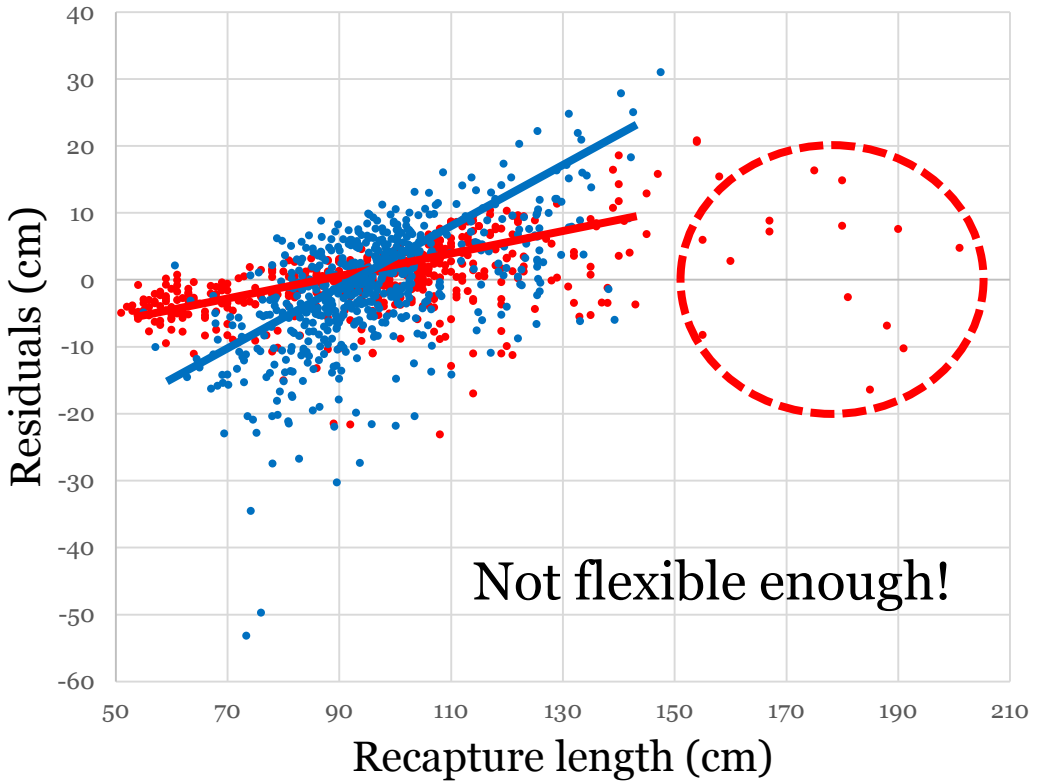
Growth rate based on tagging data at 95W AND 140W

The von Bertalanffy growth curve: $L_{rec} = L_{rel} + (L_\infty - L_{rel})\left(1 - e^{-K(t_{rep} - t_{rel})}\right)$

where $L_\infty = 208.8$ and $K = 0.313$

Bigeye were tagged at 95W and 140W





Growth rate based on tagging data at 95W AND 140W

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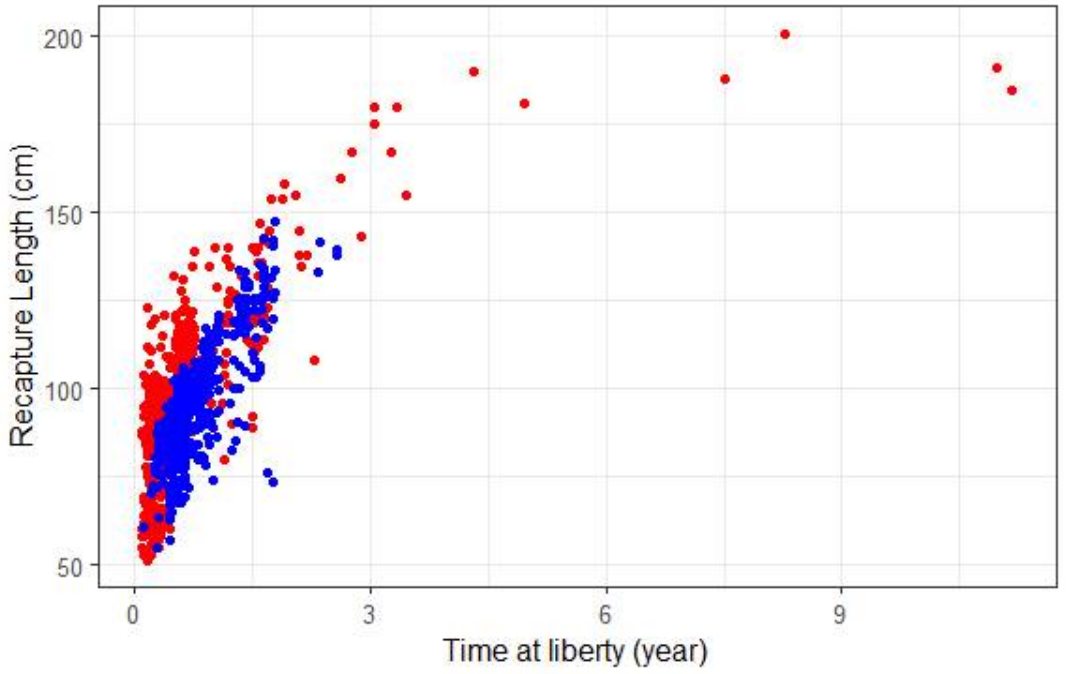
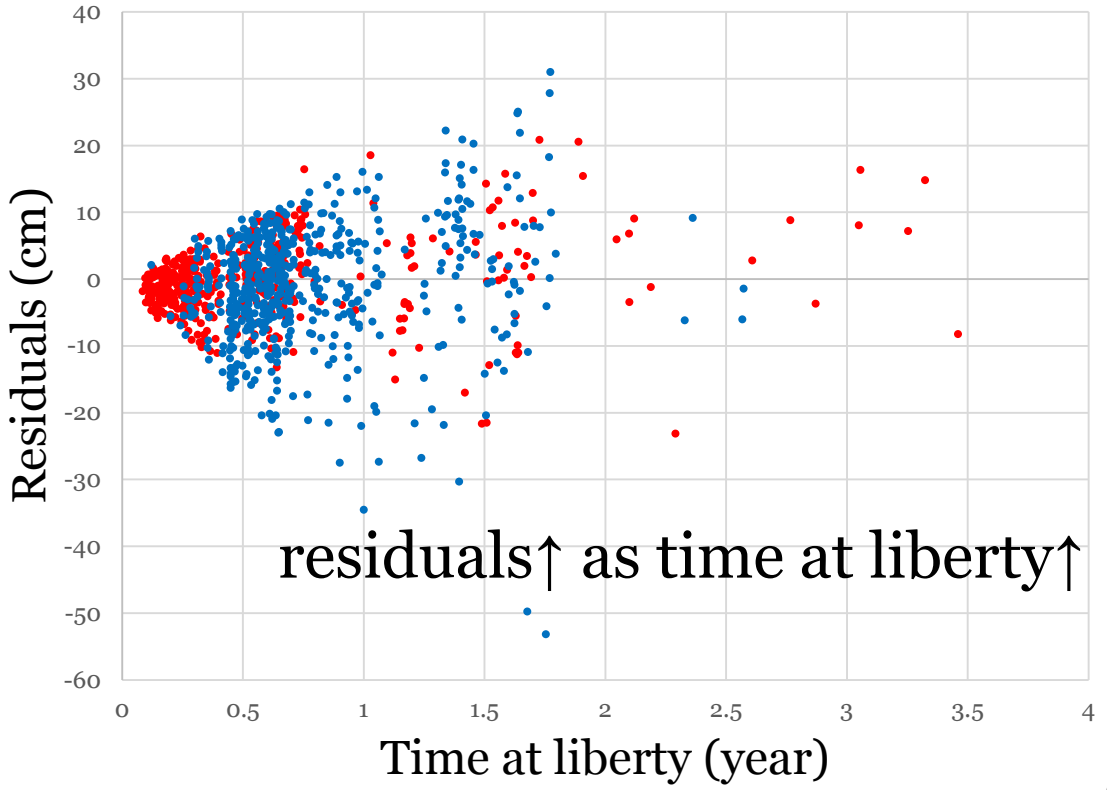
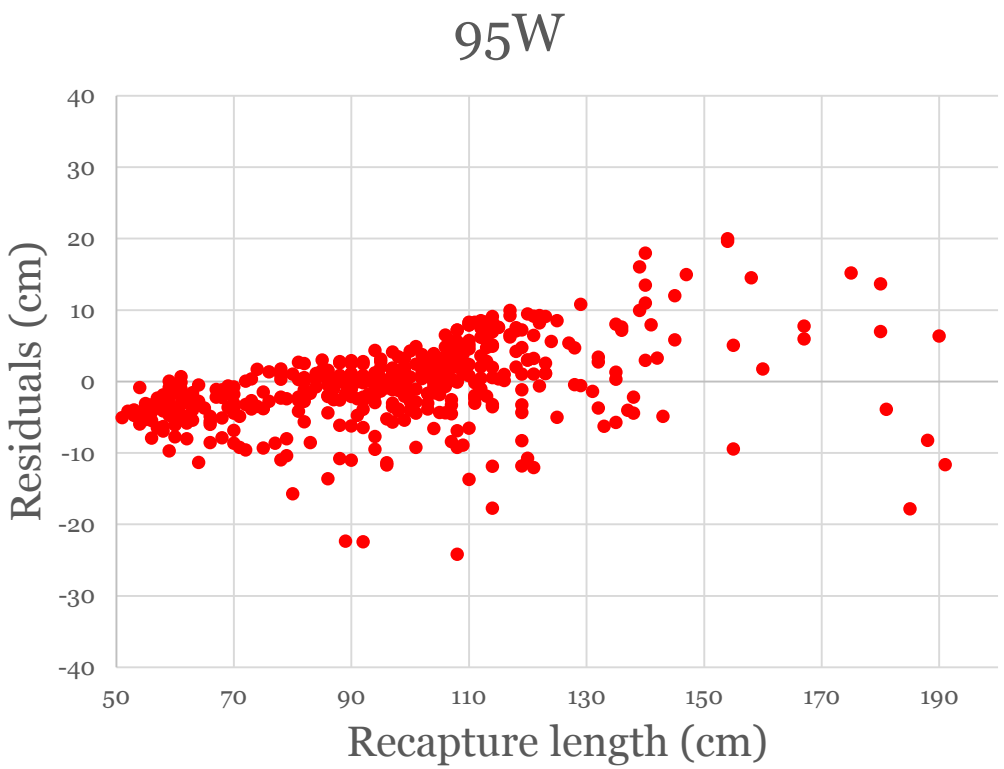


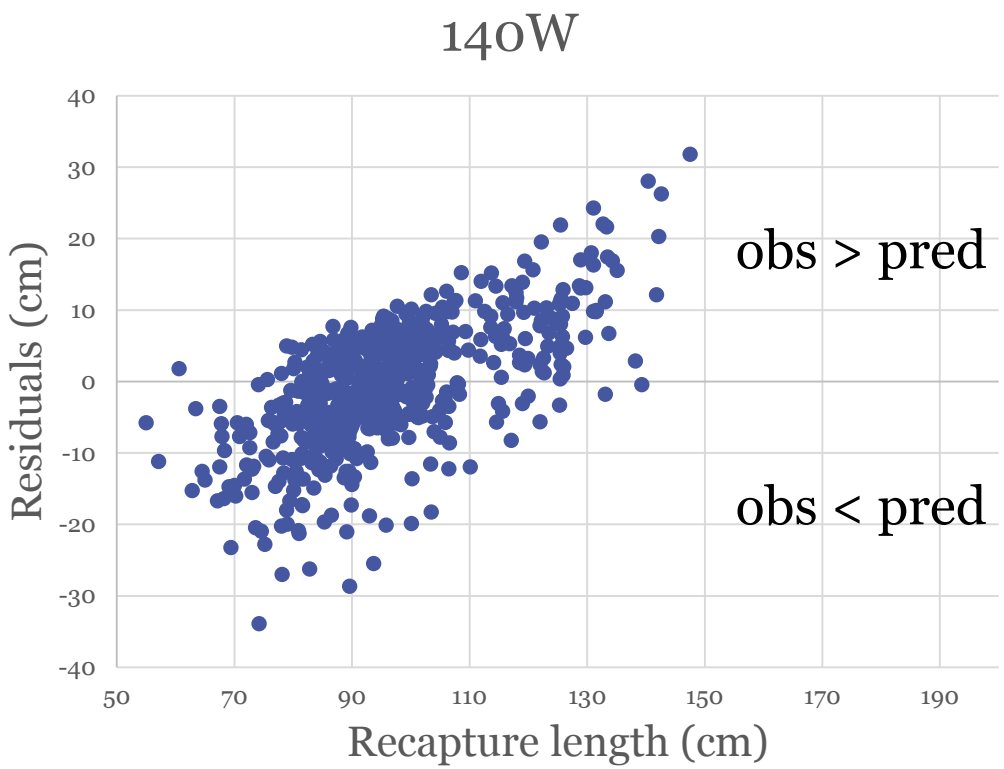


Growth rate based on tagging data at 95W OR 140W

The von Bertalanffy growth curve: $L_{rec} = L_{rel} + (L_\infty - L_{rel})\left(1 - e^{-K(t_{rep} - t_{rel})}\right)$

95W: $L_\infty = 210.1$ and $K = 0.315$; 140W: $L_\infty = 179.3$ and $K = 0.413$



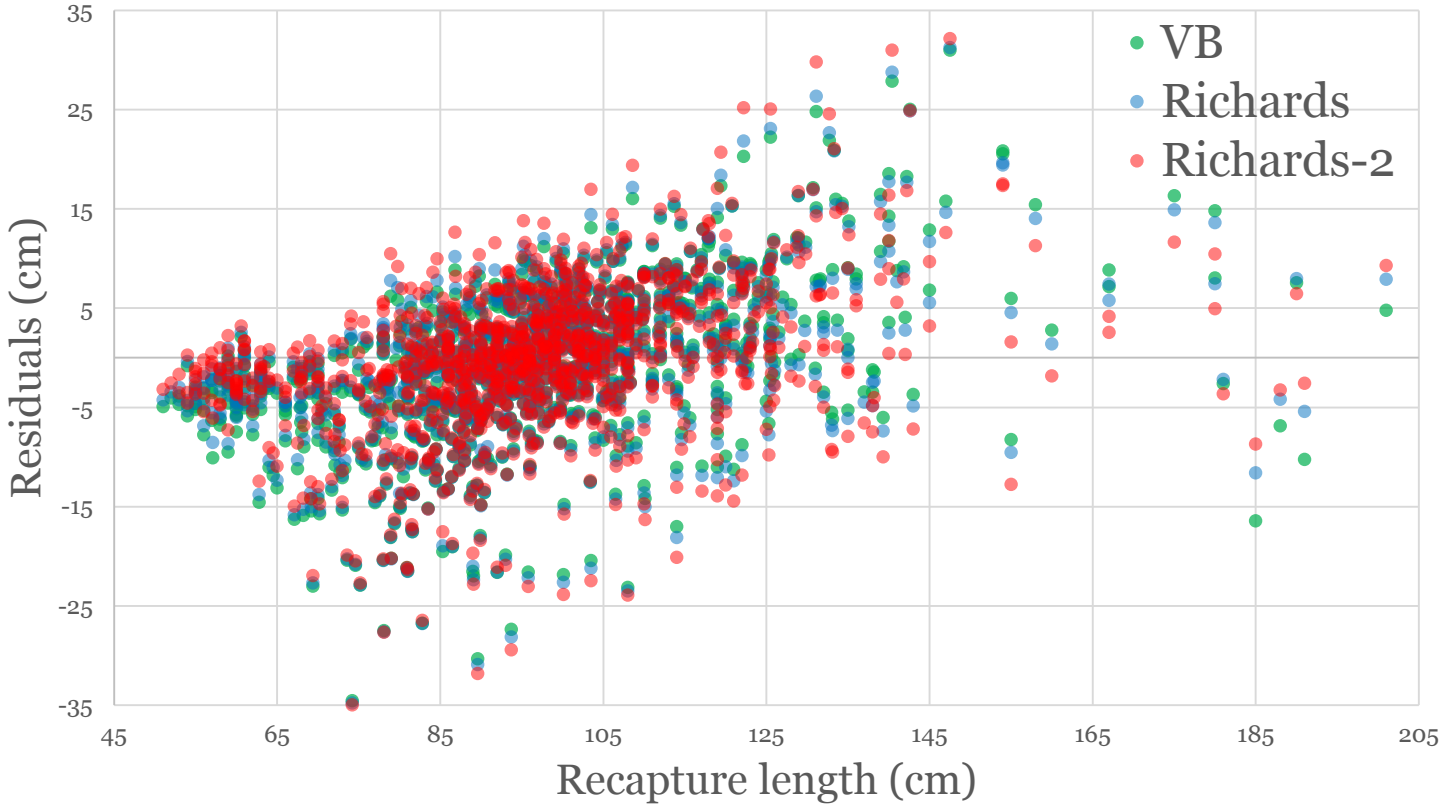


Growth rate based on tagging data at 95W AND 140W

von Bertalanffy: $L_t = L_\infty\left(1 - e^{-K(t-t_0)}\right)$, where $L_\infty = 208.8$ and $K = 0.313$

Richards: $L_t = L_\infty\left(1 - e^{-K(t-t_0)}/p\right)^p$, where $L_\infty = 201.9$, $K = 0.387$, and $p = 1.49$

Richards-2 (up-weight >150cm fish by 25X): $L_\infty = 197.8$, $K = 0.498$, and $p = 7.04$



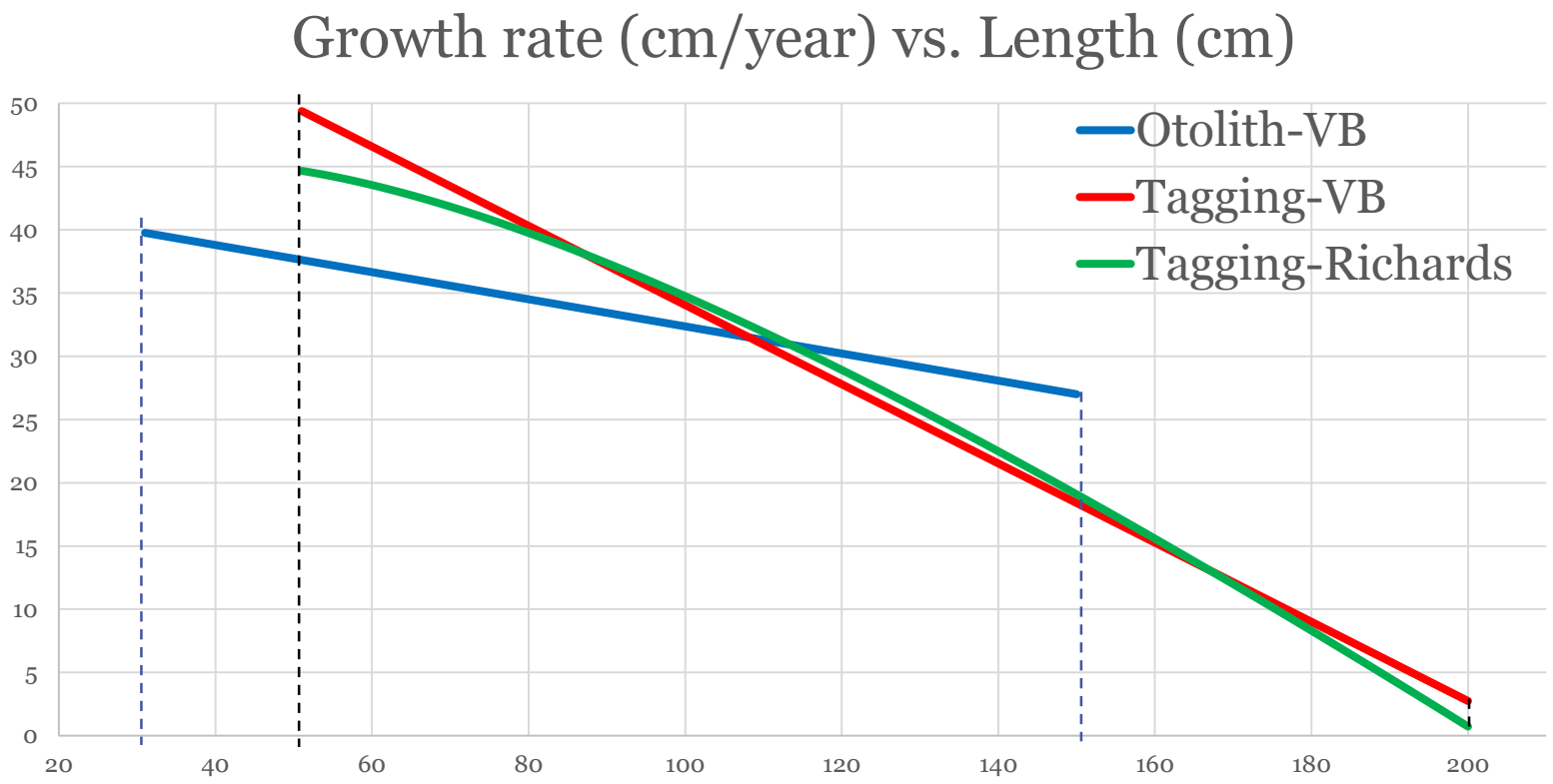
No obvious reduction in the residual pattern

Comparison of estimated growth rate

Otolith-VB: $L_t = L_\infty\left(1 - e^{-K(t-t_0)}\right)$; $L_\infty = 400.3$ and $K = 0.108$

Tagging-VB: $L_t = L_\infty\left(1 - e^{-K(t-t_0)}\right)$; $L_\infty = 208.8$ and $K = 0.313$

Tagging-Richards: $L_t = L_\infty\left(1 - e^{-K(t-t_0)}/p\right)^p$; $L_\infty = 201.9$, $K = 0.387$, and $p = 1.49$

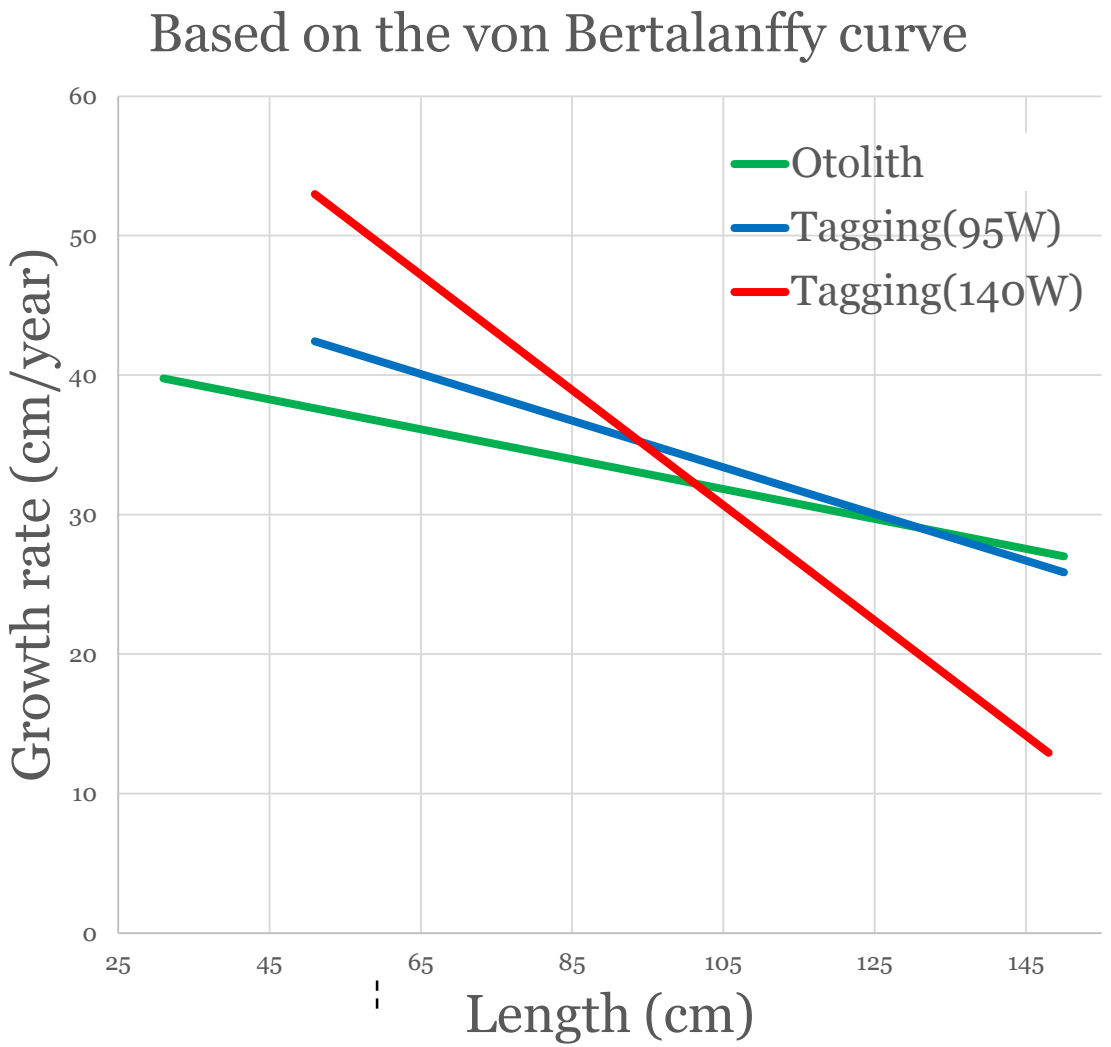


The same growth model (VB) fitted to tagging or otolith data suggests different growth rates

Only fit to bigeye samples with length < 150 cm

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

- Otolith:
  $L_\infty = 400.3$ and $K = 0.108$
- Tagging (95W):
  $L_\infty = 304.5$ and $K = 0.167$
- Tagging (140W):
  $L_\infty = 179.3$ and $K = 0.413$



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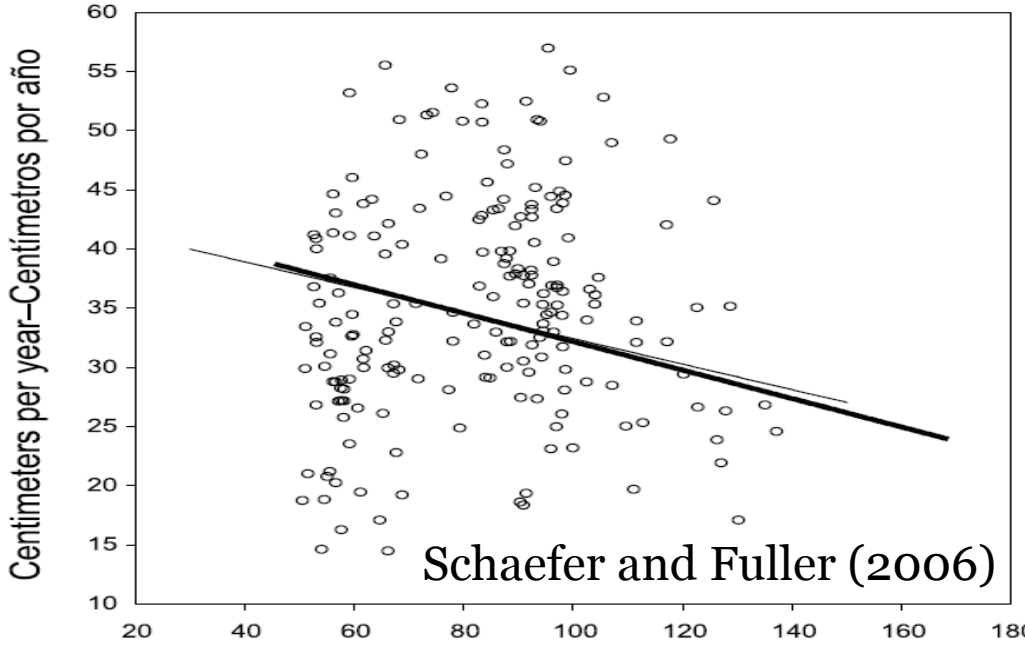
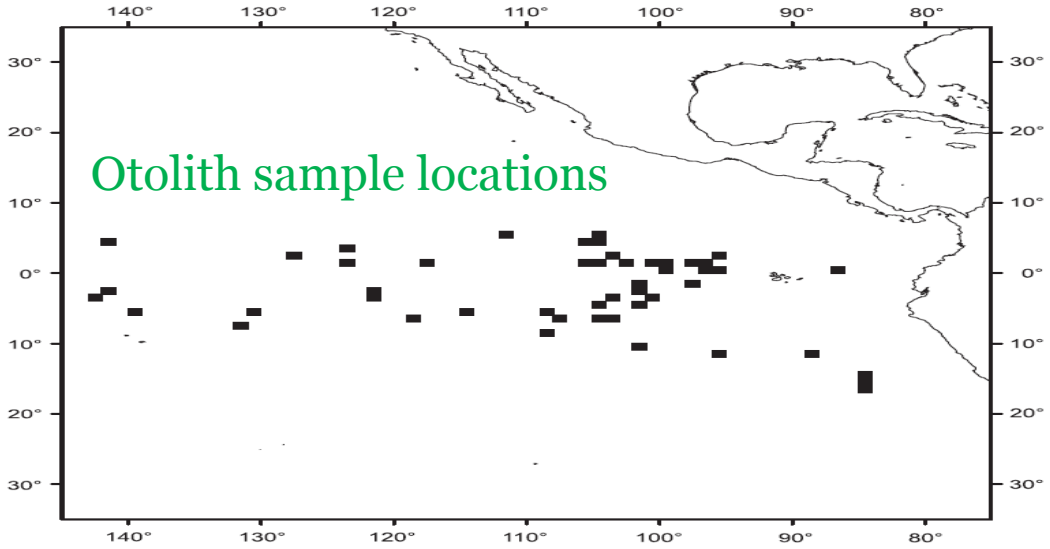
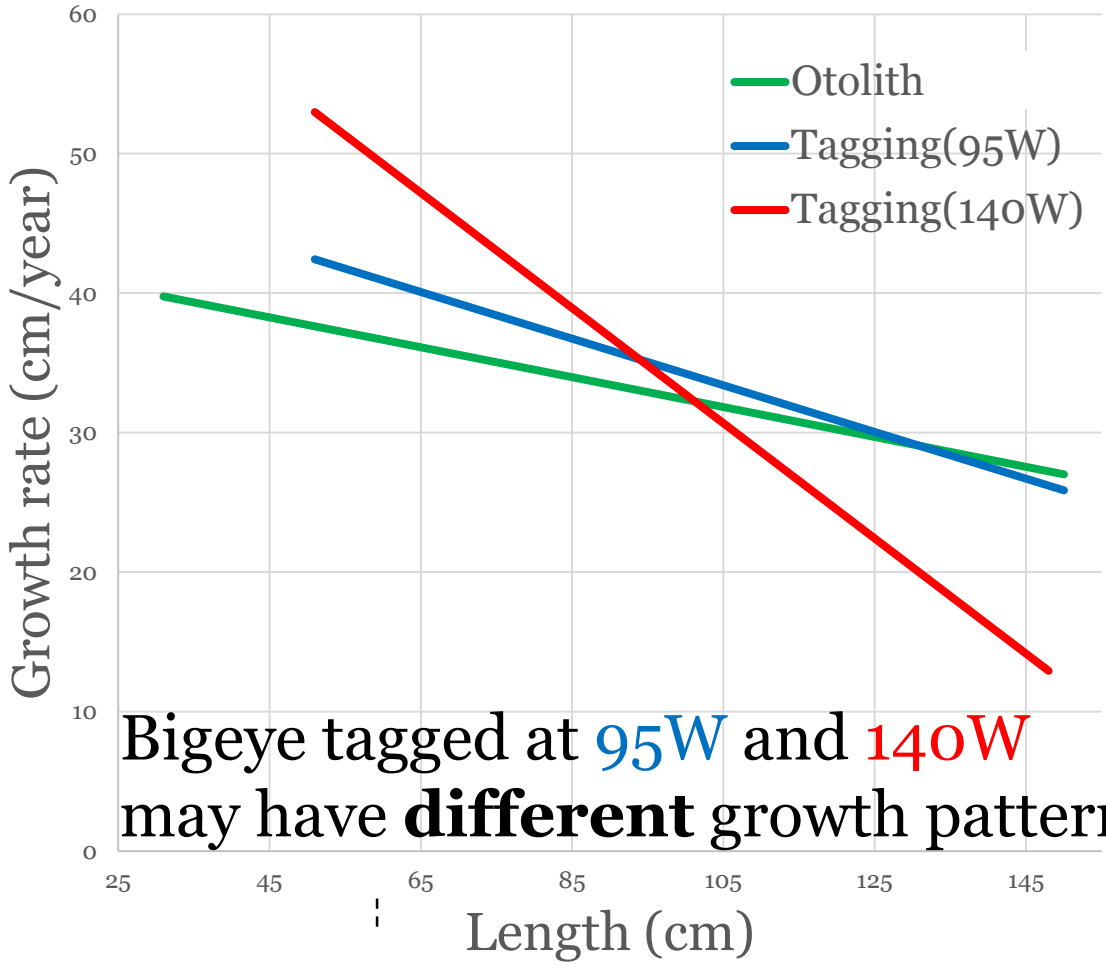


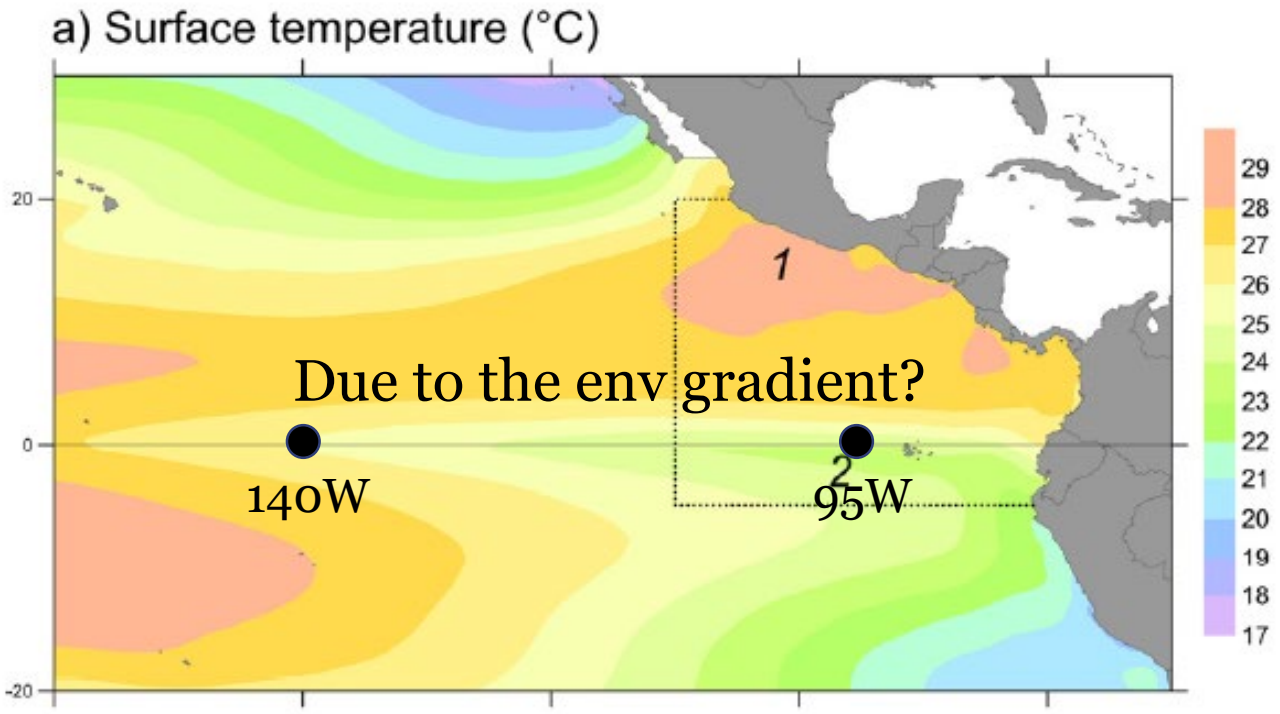


Based on the von Bertalanffy curve



Bigeye tagged at 95W and 140W may have **different** growth patterns

Only fit to bigeye samples with length < 150 cm



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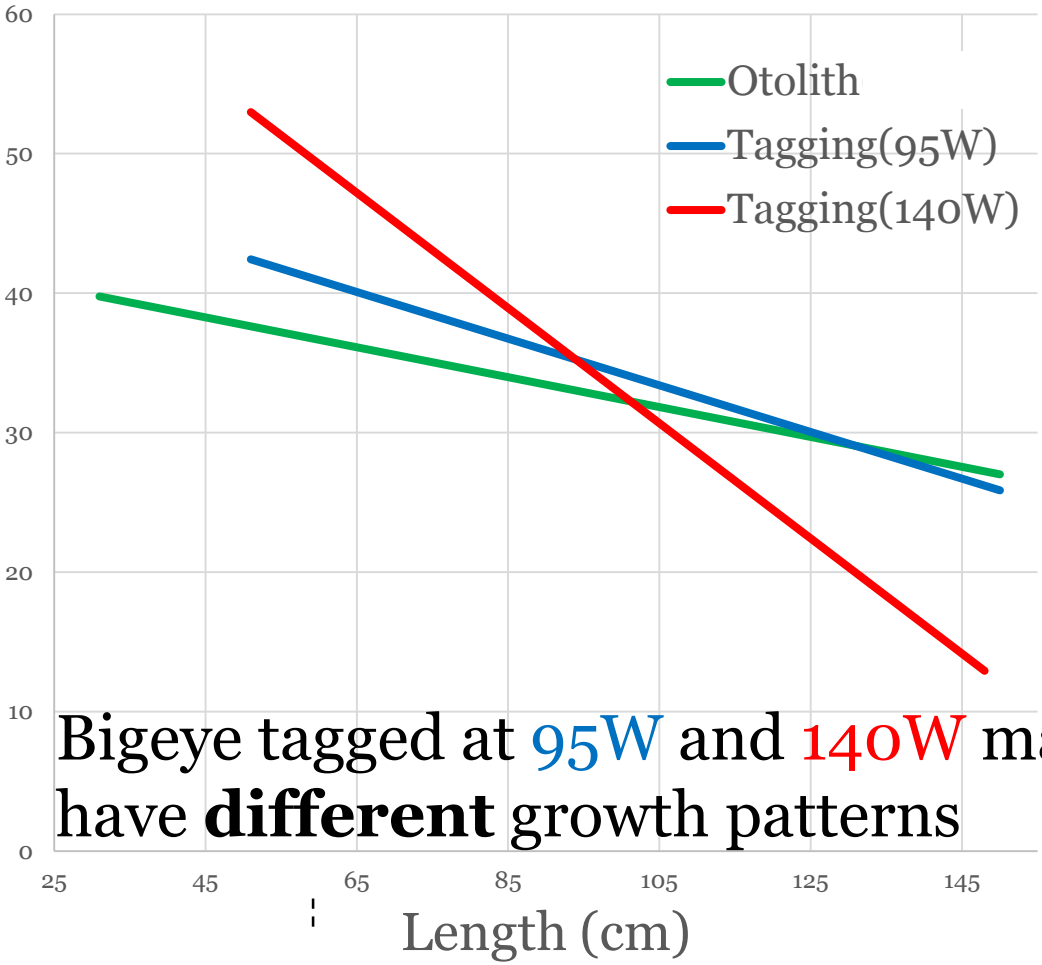
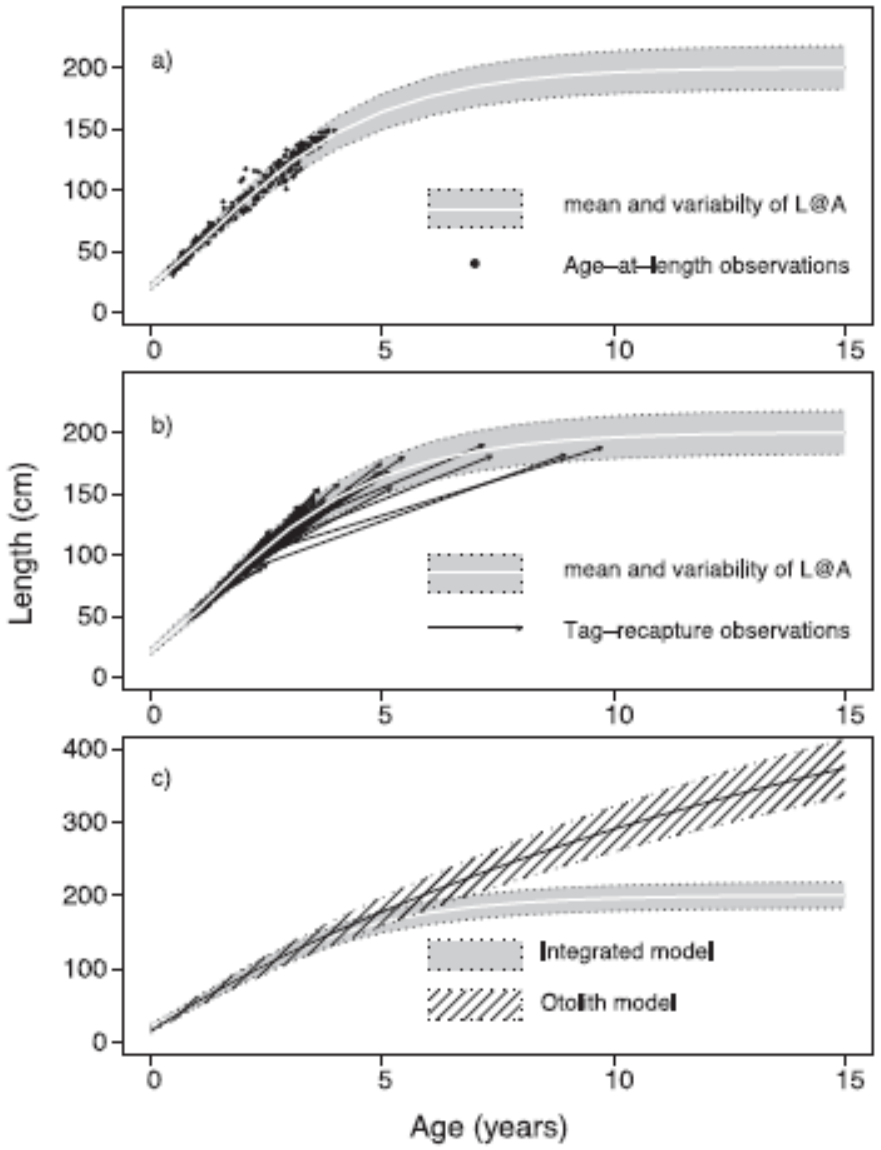
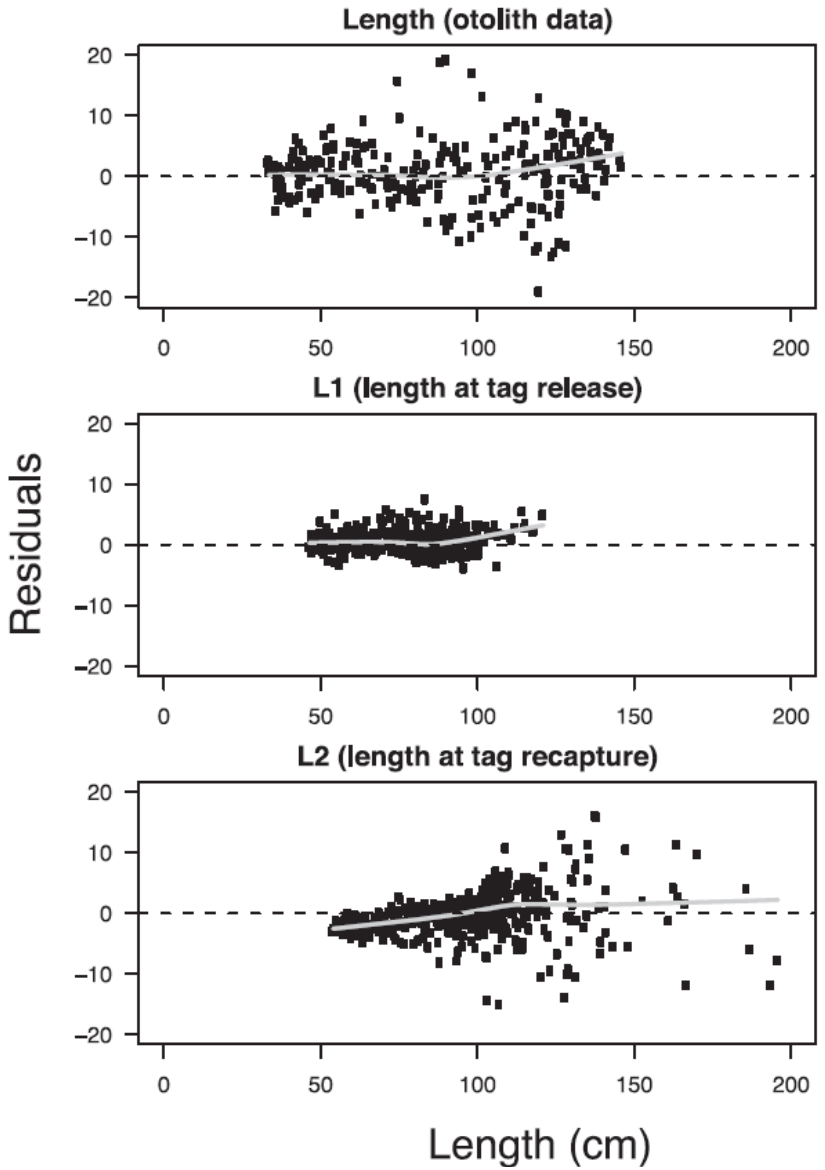


Bigeye tagged at 95W and 140W may have **different** growth patterns

Silva et al. (2015): integrating the two data sources

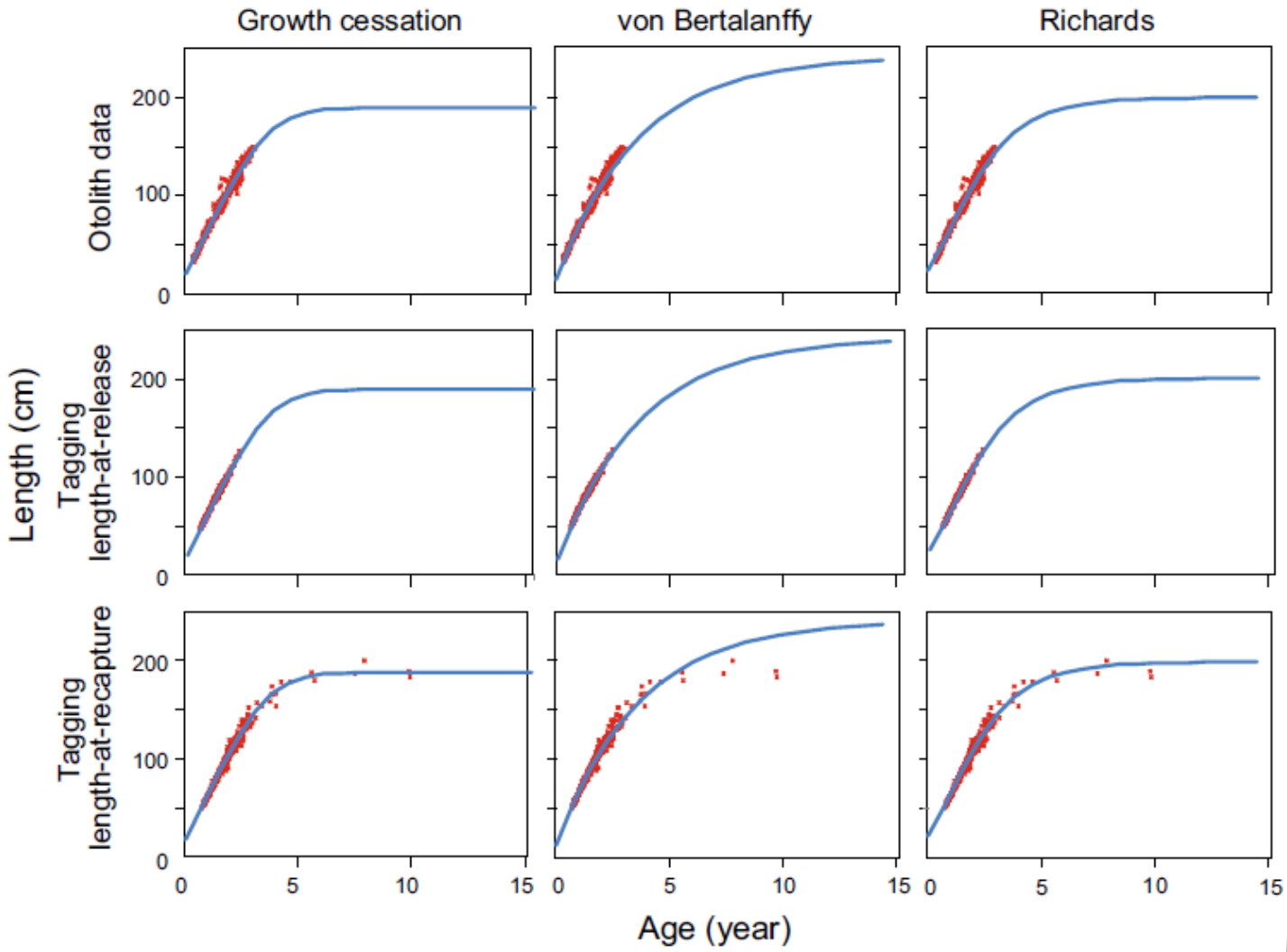




An improved growth model for EPO bigeye

- The growth cessation model (Maunder et al. 2018): "*A linear relationship between length and age followed by a near cessation in growth, typically after the onset of sexual maturity.*"

- The growth cessation model fits data **best.**



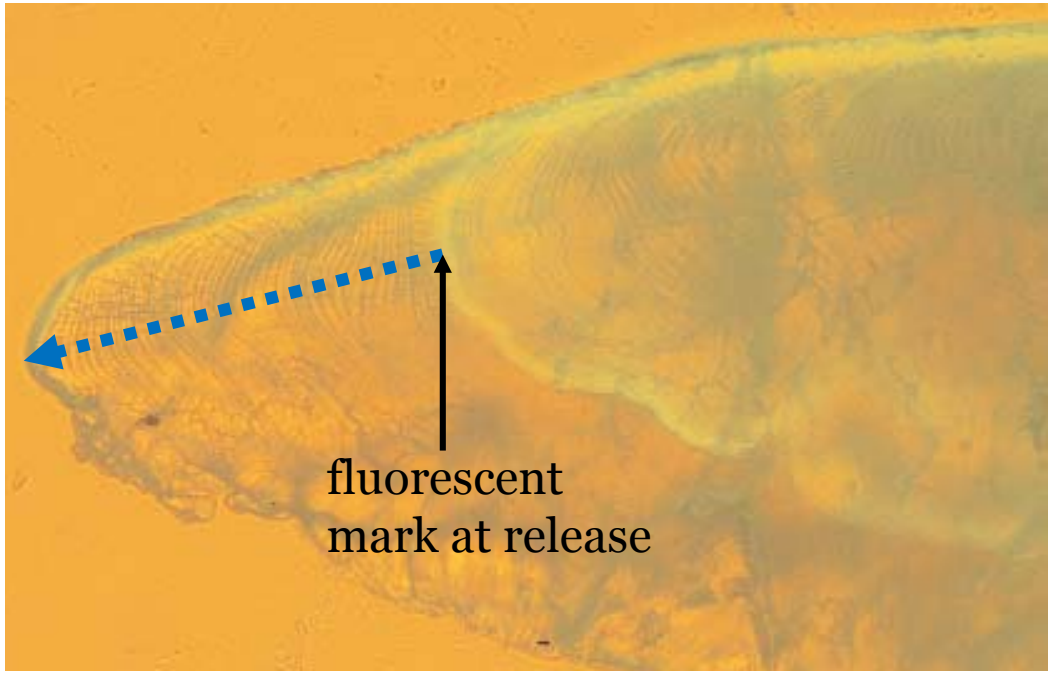
Summary

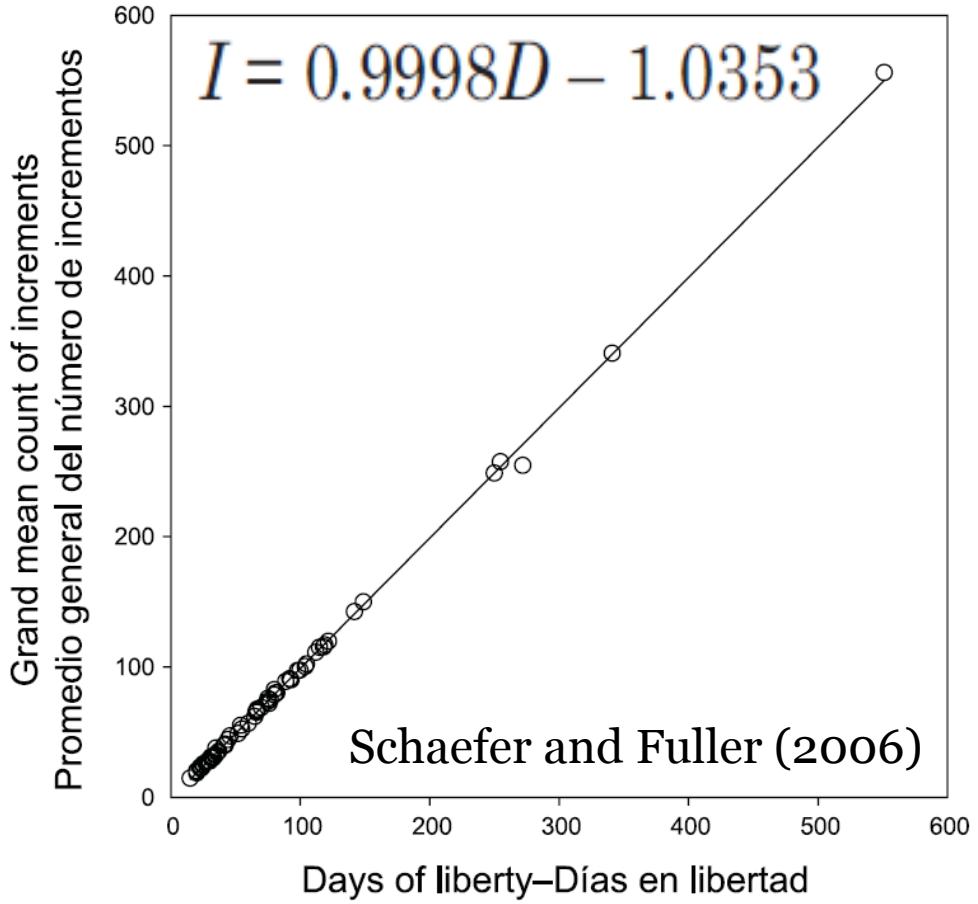
- Minor residual pattern in fit to the otolith-based length-at-age data
- Notable residual pattern in fit to the tagging data
- Length-at-age data and tagging data suggest similar growth rates for 95W-released bigeye (consistent with Schaefer and Fuller 2006)
- Tagging data suggest a spatial pattern in growth: larger K and **probably** smaller L_∞ at 140W in comparison to 95W
- L_∞ is informed by samples released only at 95W

Thank you!

Daily increment counts from EPO bigeye otolith

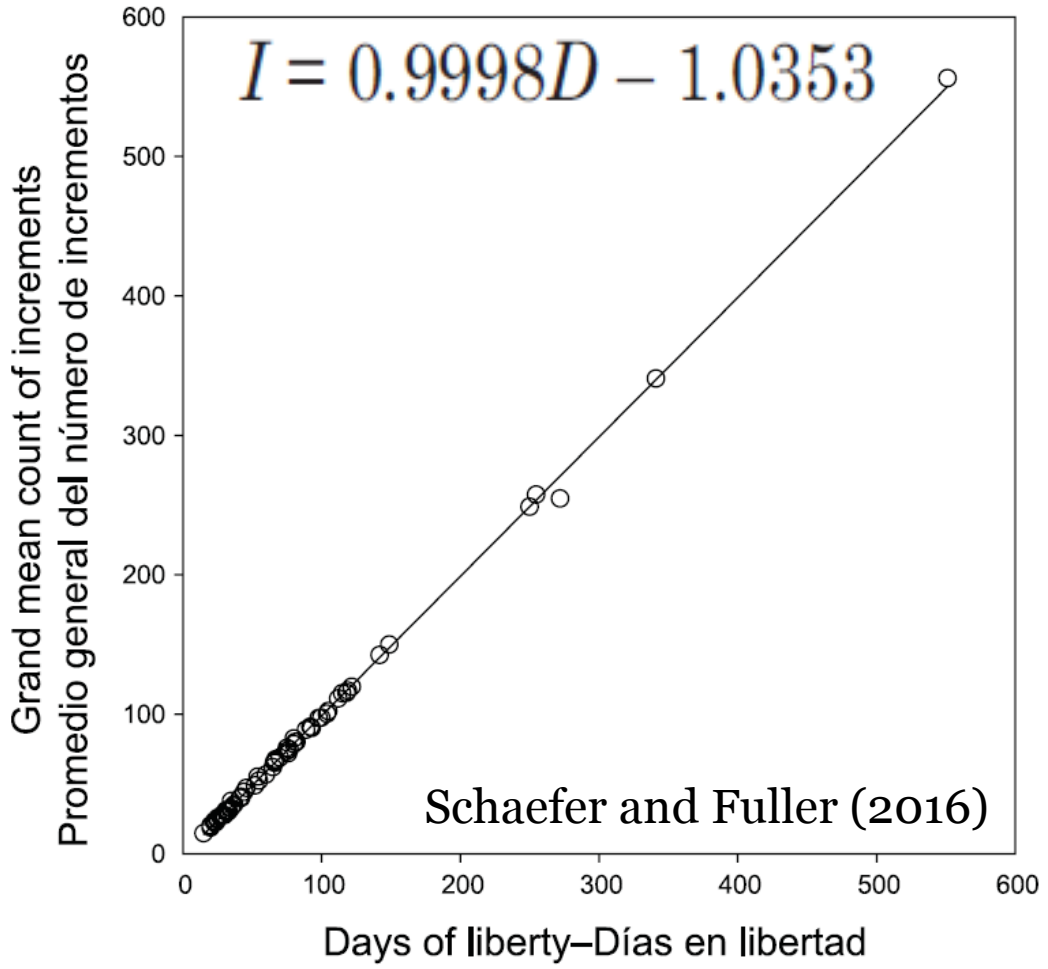
Otolith daily increments (see Schaefer and Fuller (2016))





Daily increment counts from EPO bigeye otolith

- Bigeye (38cm-135cm) produce one otolith increment per day.
- If the deposition rate holds for other lengths, the increment count is a observation of absolute age (in days)
- Counting increment is difficult after age 4 yrs (150cm)

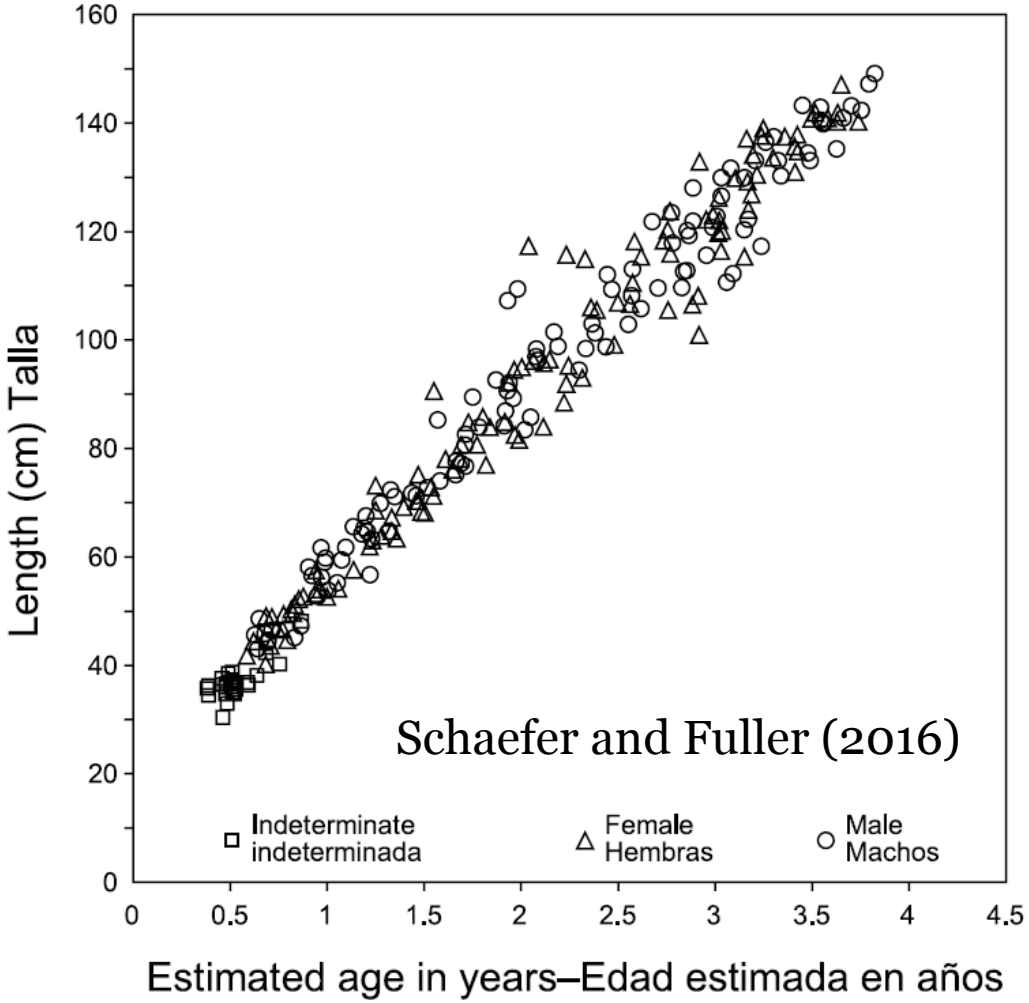


Length-at-age data for EPO bigeye

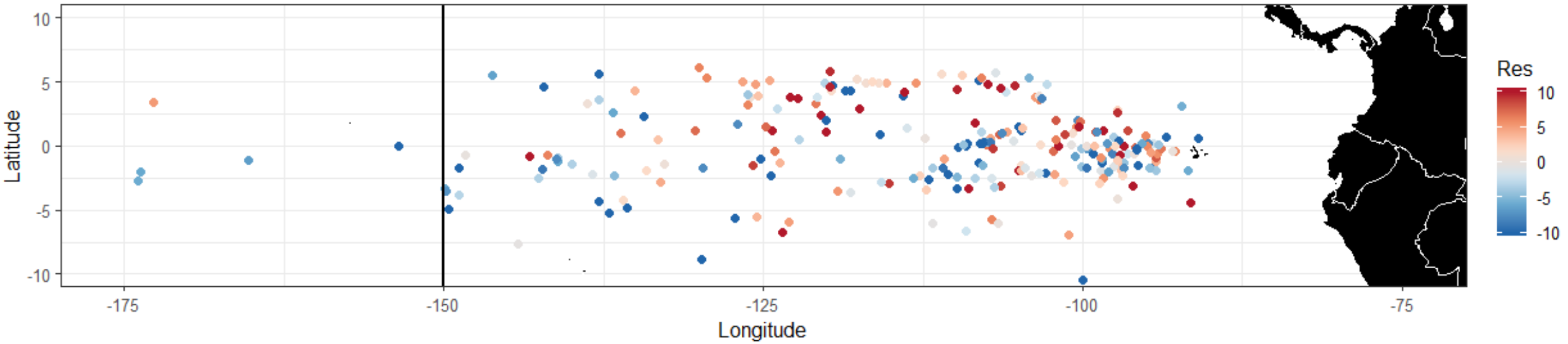
- Length-at-age data based on daily increment counts
- The von Bertalanffy growth curve fits **best** to this data

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

- Growth rates of the two sexes are not significantly different



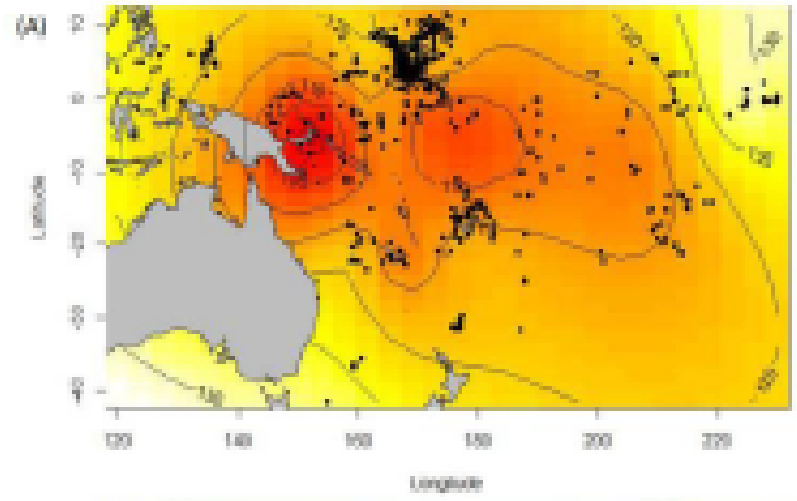
Residuals for 140W tagging data



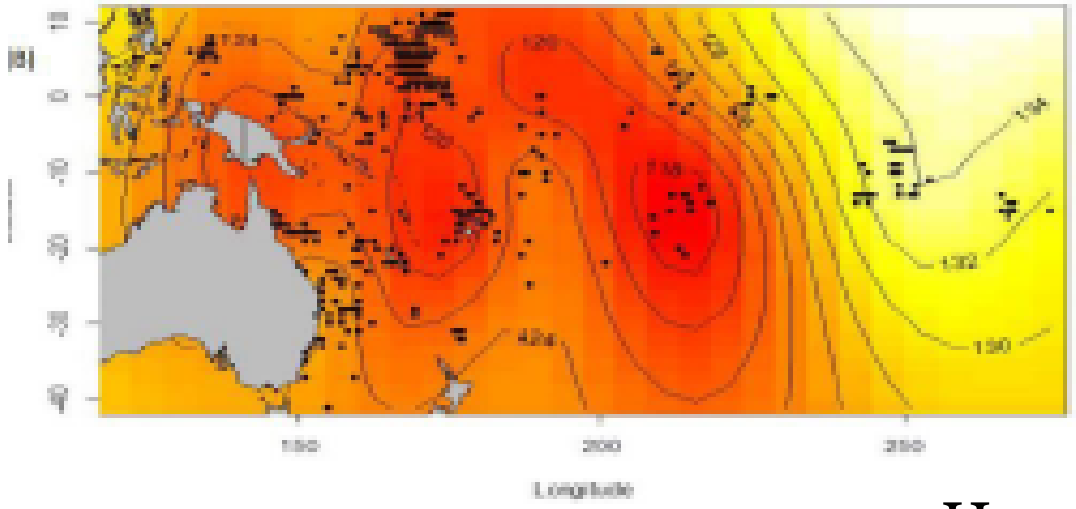
Spatial variation in growth (bigeye tuna)

Pacific Community
Communauté du Pacifique

Jess Farley and Paige Eveson, CSIRO

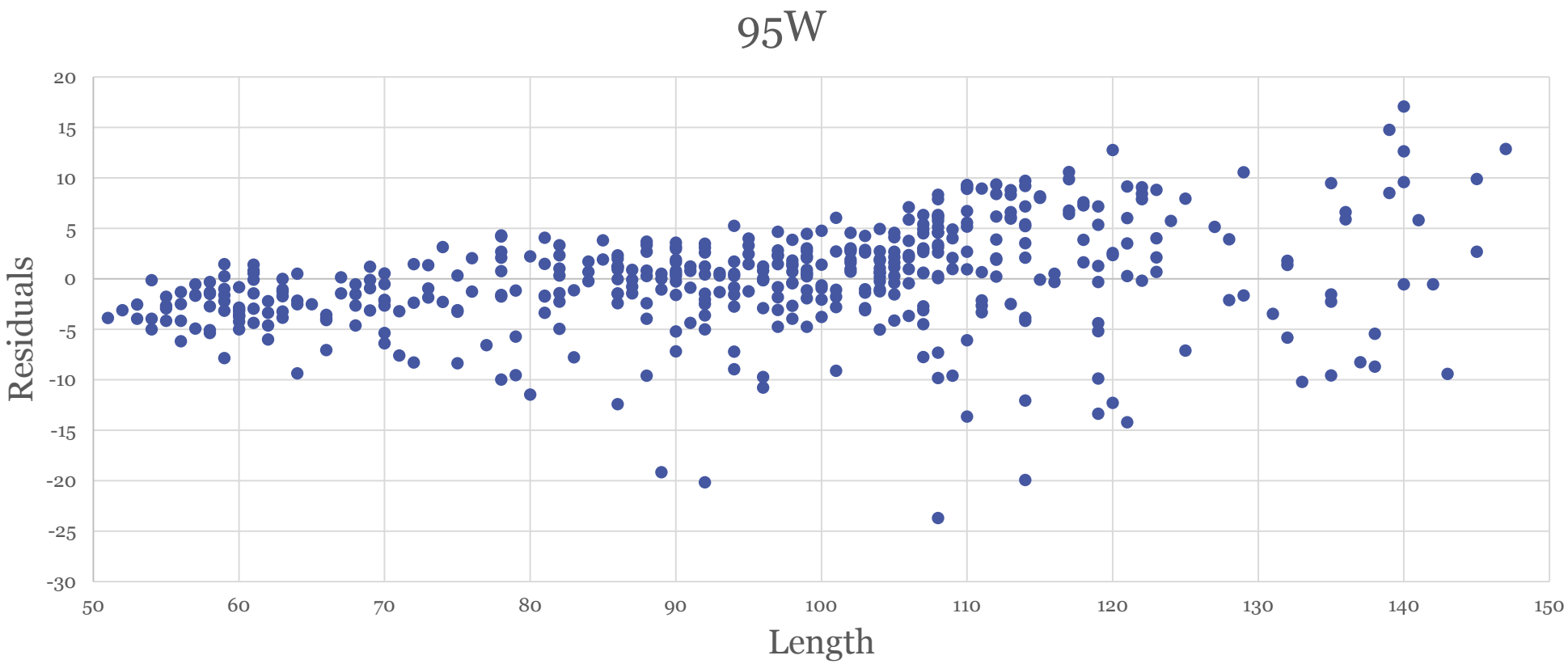


GAM predictions of bigeye mean length at age 3.3 yr



GAM predictions of bigeye mean length at mean otolith weight of 0.06 g

Hampton et al. 2018 (CAPAM spatial workshop)


95W
Residuals
20
15
10
5
0
-5
-10
-15
-20
-25
-30
50
60
70
80
90
100
110
120
130
140
150
Length