Growth models utilized in recent bigeye tuna assessments in the WCPO, and future considerations

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IATTC Workshop on Age and Growth Bigeye and Yellowfin Tunas in the Pacific Ocean

Outline

- Growth parameterisation in MULTIFAN-CL assessments
- Data informing growth estimates
- Recent assessments and impact of growth assumptions
- Future developments
  - Internal growth estimation including conditional age-at-length data
  - Capturing possible spatial variation in growth within the assessment

Growth parameterisation in MULTIFAN-CL

- Von Bertalanffy growth

$$\mu_a = L_1 + (L_A - L_1)\left\{\frac{1-\rho^{a-1}}{1-\rho^{A-1}}\right\}$$

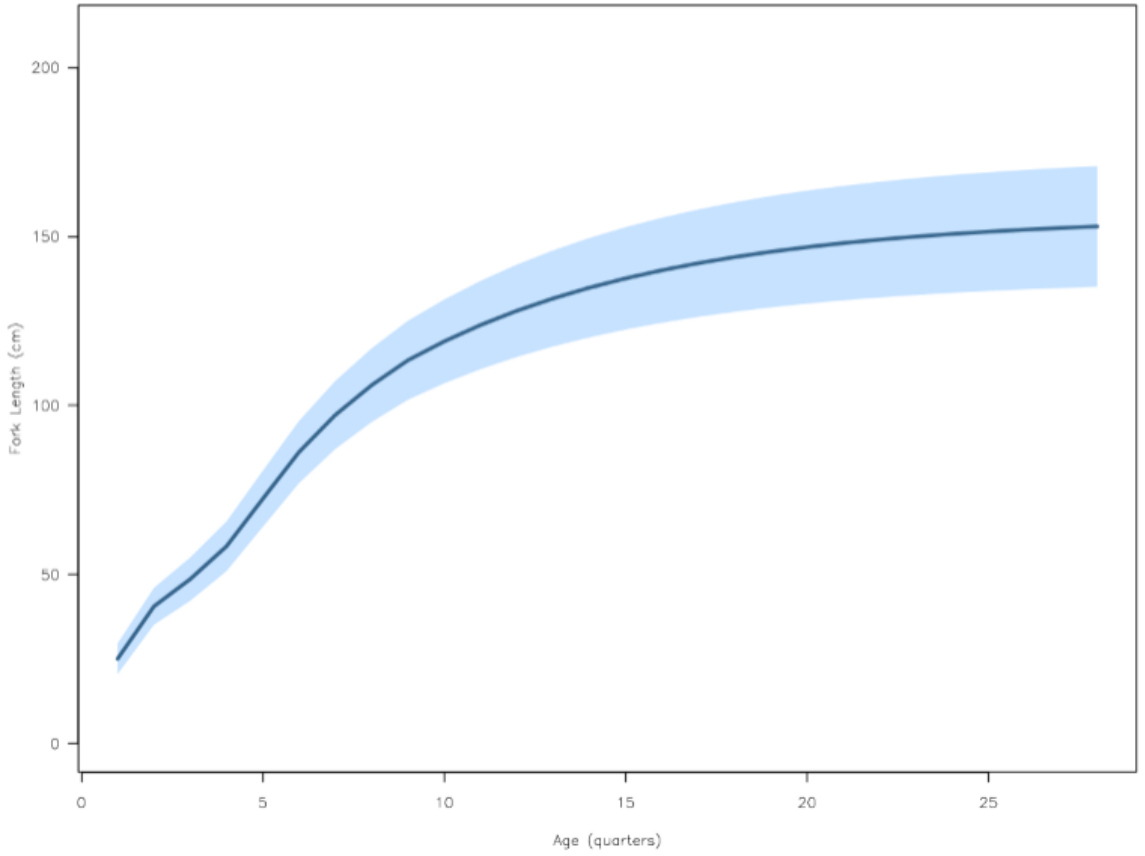
L_1 is the mean length of the first age-class,
L_A is the mean length of the last age-class, and
ρ is the Brody growth coefficient

- Standard deviation of length-at-age

$$\sigma_a = \lambda_1 \exp\left\{\lambda_2\left[-1+2\left(\frac{1-\rho^{a-1}}{1-\rho^{A-1}}\right)\right]\right\}.$$

λ_1 determines the magnitude of the standard deviations and λ_2 determines the length-dependent trend.

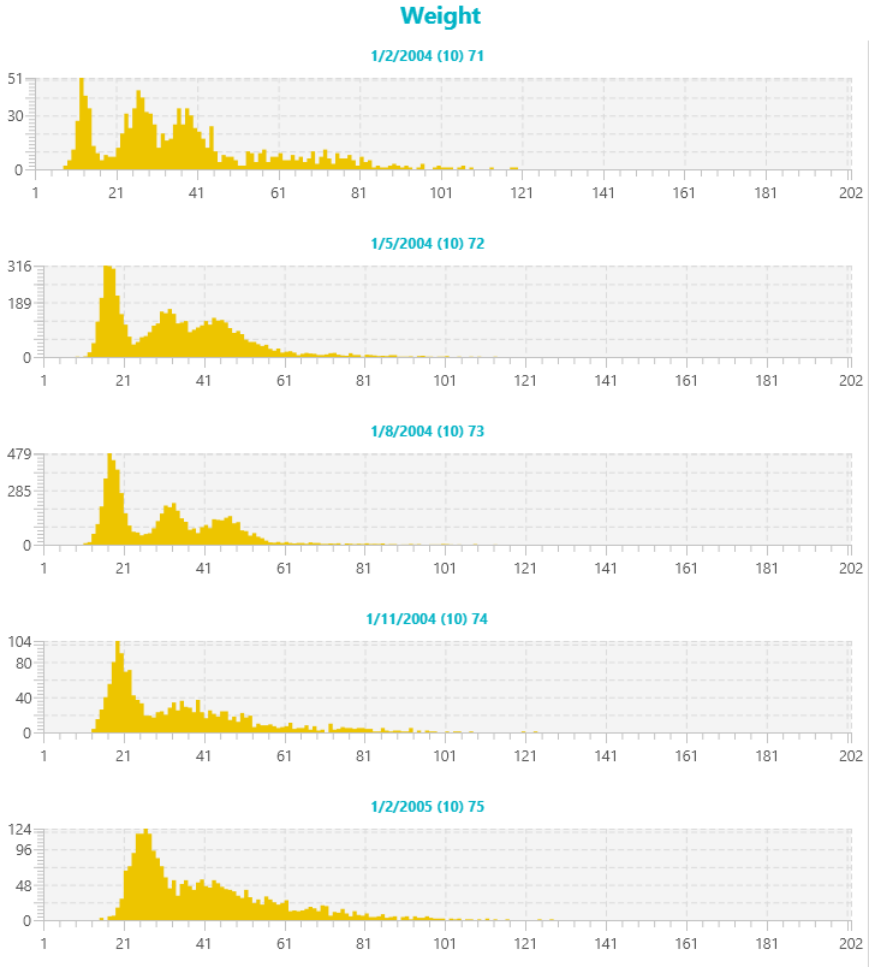
Growth parameterisation in MULTIFAN-CL

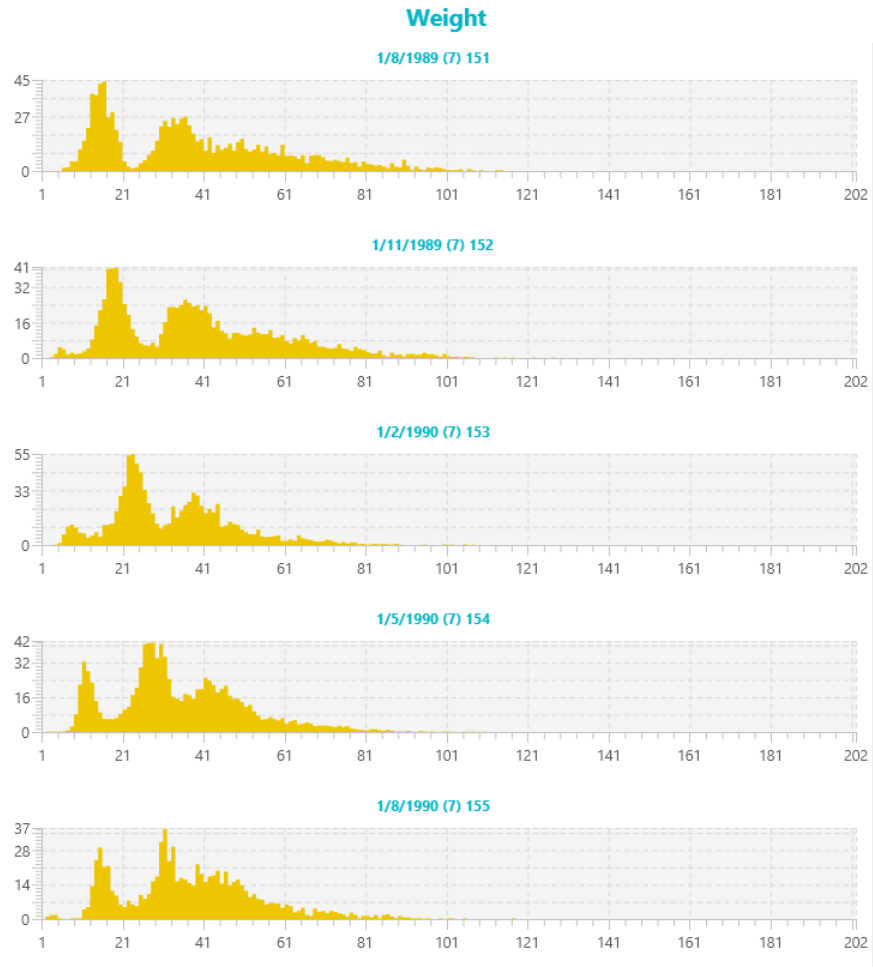


- Note there is flexibility to estimate “offsets” if warranted
- Also a Richards parameterisation

Data informing growth

1. Length and weight frequency data

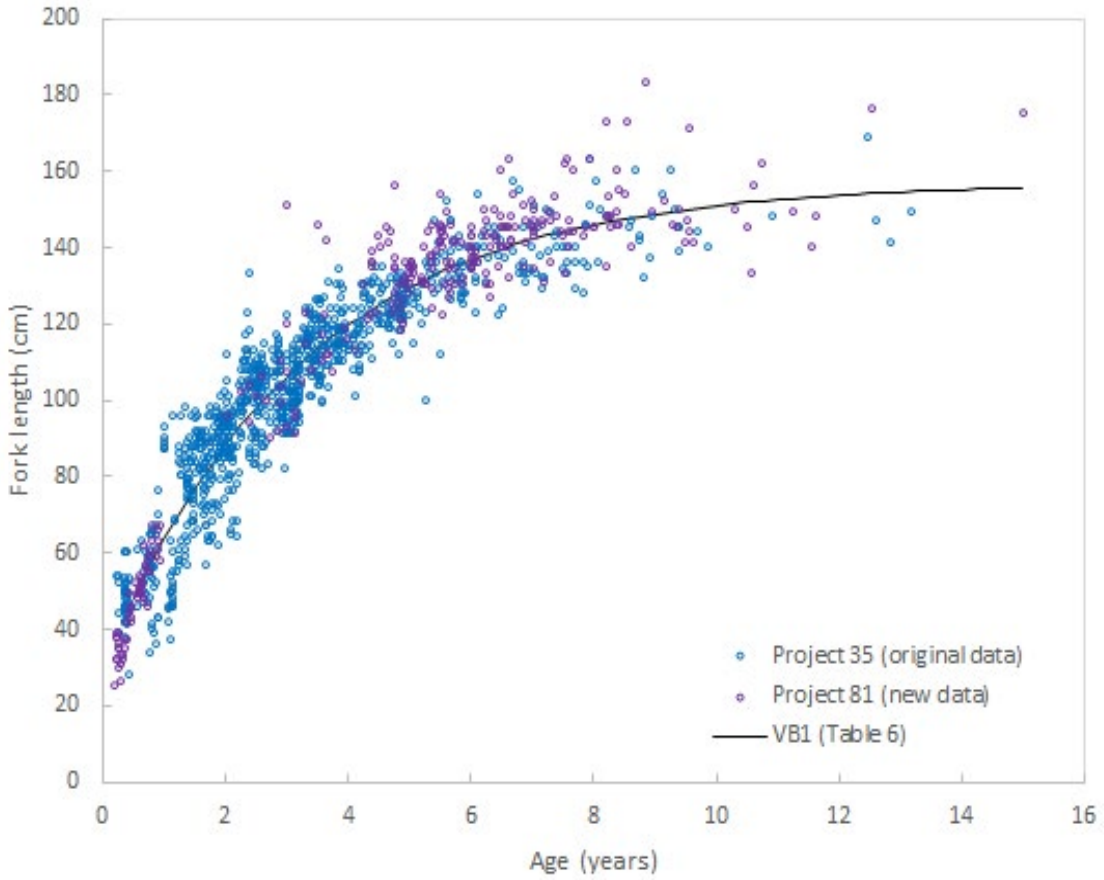




Data informing growth

2. Age-at-length data

Plotted and fitted in length-at-age form



Data informing growth

2. Conditional age-at-length data

Data formulation for inclusion in MULTIFAN-CL

- Observations of age-at-length assumed to be multinomial distribution
- Clearly a problem caused by birth date assumption in age data!

#		Year	Month	Fishery	Species												
		2014	5	4	1												
# Age-class→ Length ↓	1	2	3	4	5	6	7	8	9	10	11	12	13	…	38	39	40
10	0	0	0	0	0	0	0	0	0	0	0	0	0	…	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0	0	0	…	0	0	0
14	0	0	0	0	0	0	0	0	0	0	0	0	0	…	0	0	0
…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…
62	0	0	0	0	0	0	0	0	0	0	0	0	0	…	0	0	0
64	0	0	0	1	0	0	0	0	0	0	0	0	0	…	0	0	0
66	0	0	0	1	0	0	0	0	0	0	0	0	0	…	0	0	0
68	0	0	0	0	0	0	0	0	0	0	0	0	0	…	0	0	0
70	0	0	0	0	0	0	0	1	0	0	0	0	0	…	0	0	0
72	0	0	0	0	0	0	0	2	0	0	0	0	0	…	0	0	0
74	0	0	0	0	0	0	0	1	0	0	0	0	0	…	0	0	0
76	0	0	0	1	0	0	0	0	0	0	0	0	0	…	0	0	0
78	0	0	0	0	0	0	0	1	0	0	0	0	0	…	0	0	0
80	0	0	0	0	0	0	0	0	0	0	0	0	0	…	0	0	0
82	0	0	0	0	0	0	0	1	0	0	0	1	0	…	0	0	0
84	0	0	0	0	0	0	0	4	0	0	0	0	0	…	0	0	0
86	0	0	0	0	0	0	0	2	0	0	0	0	0	…	0	0	0
88	0	0	0	0	0	0	0	5	0	0	0	0	0	…	0	0	0
90	0	0	0	0	0	0	0	3	0	0	0	1	0	…	0	0	0
92	0	0	0	0	0	0	0	6	0	0	0	2	0	…	0	0	0
94	0	0	0	0	0	0	0	6	0	0	0	6	0	…	0	0	0
96	0	0	0	0	0	0	0	4	0	0	0	2	0	…	0	0	0
98	0	0	0	0	0	0	0	3	0	0	0	5	0	…	0	0	0
100	0	0	0	0	0	0	0	1	0	0	0	2	0	…	0	0	0
102	0	0	0	0	0	0	0	0	0	0	0	3	0	…	0	0	0
104	0	0	0	0	0	0	0	0	0	0	0	2	0	…	0	0	0
106	0	0	0	0	0	0	0	0	0	0	0	5	0	…	0	0	0
108	0	0	0	0	0	0	0	0	0	0	0	0	0	…	0	0	0
110	0	0	0	0	0	0	0	0	0	0	0	2	0	…	0	0	0
112	0	0	0	0	0	0	0	0	0	0	0	5	0	…	0	0	0
114	0	0	0	0	0	0	0	0	0	0	0	2	0	…	0	0	0
…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…
194	0	0	0	0	0	0	0	0	0	0	0	0	0	…	0	0	0
196	0	0	0	0	0	0	0	0	0	0	0	0	0	…	0	0	0
198	0	0	0	0	0	0	0	0	0	0	0	0	0	…	0	0	0

Data informing growth

2. Conditional age-at-length data

Data formulation for inclusion in MULTIFAN-CL

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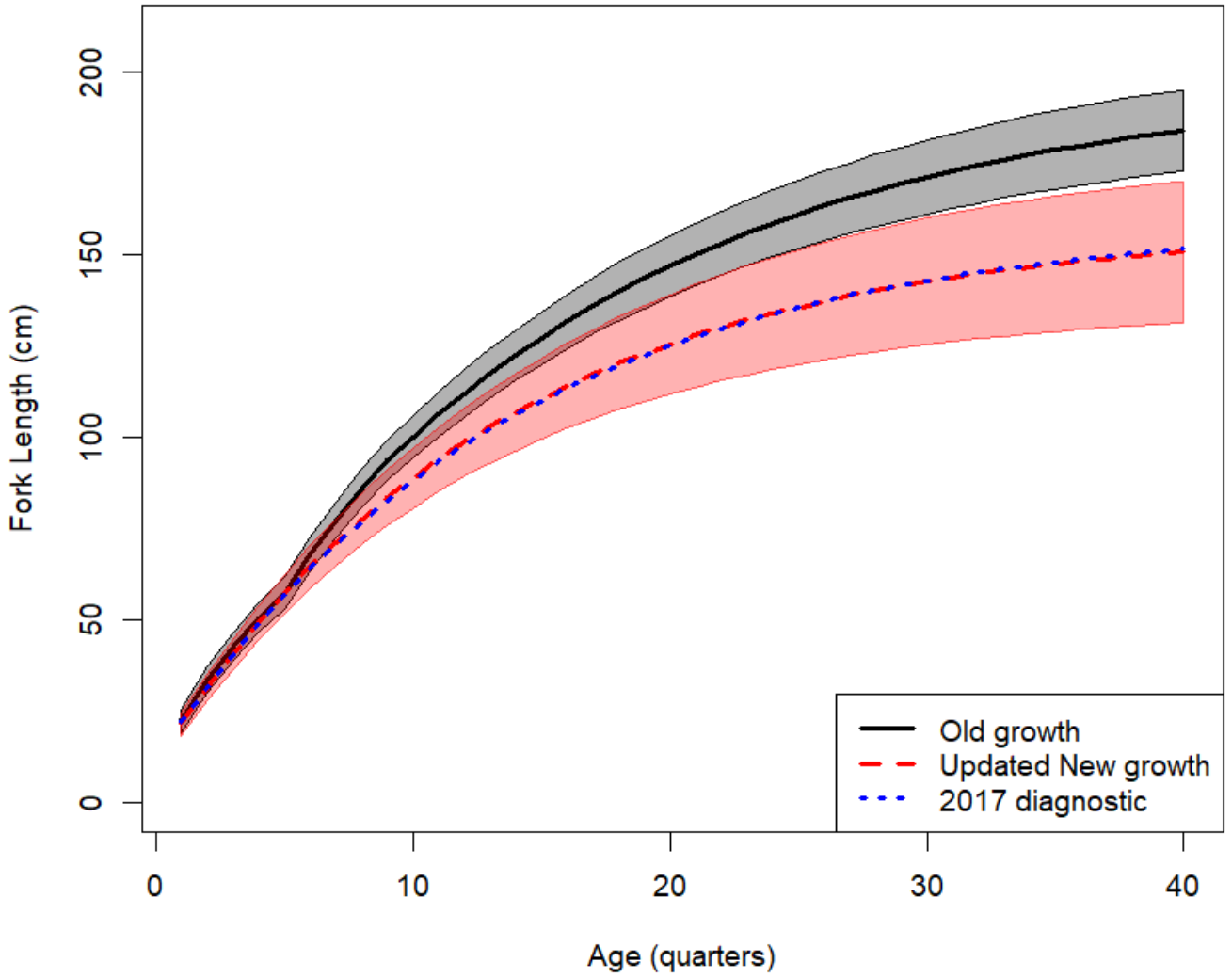
# Age-class→ Length ↓	1	2	3	4	5	6	7	8	9	10	11	12	13	…	38	39	40
90	0	0	0	0	0	0	0	3	0	0	0	1	0	…	0	0	0
92	0	0	0	0	0	0	0	6	0	0	0	2	0	…	0	0	0
94	0	0	0	0	0	0	0	6	0	0	0	6	0	…	0	0	0
96	0	0	0	0	0	0	0	4	0	0	0	2	0	…	0	0	0

Recent assessments

- 2011 and earlier – all growth parameters estimated internally
- 2014 – fixed value of L2, with sensitivity analysis
- 2017/18 – L2 and K based on external analysis of otolith data, L1 estimated

Parameter	2010	2011	2014	2018
L1	21.9	21.7	21.7	21.4
L40	180.7	179.1	184.0	150.7
K	0.066	0.070	0.061	0.076
	All estimated	All estimated	L40 fixed	L40, K fixed

“New” and “Old” growth



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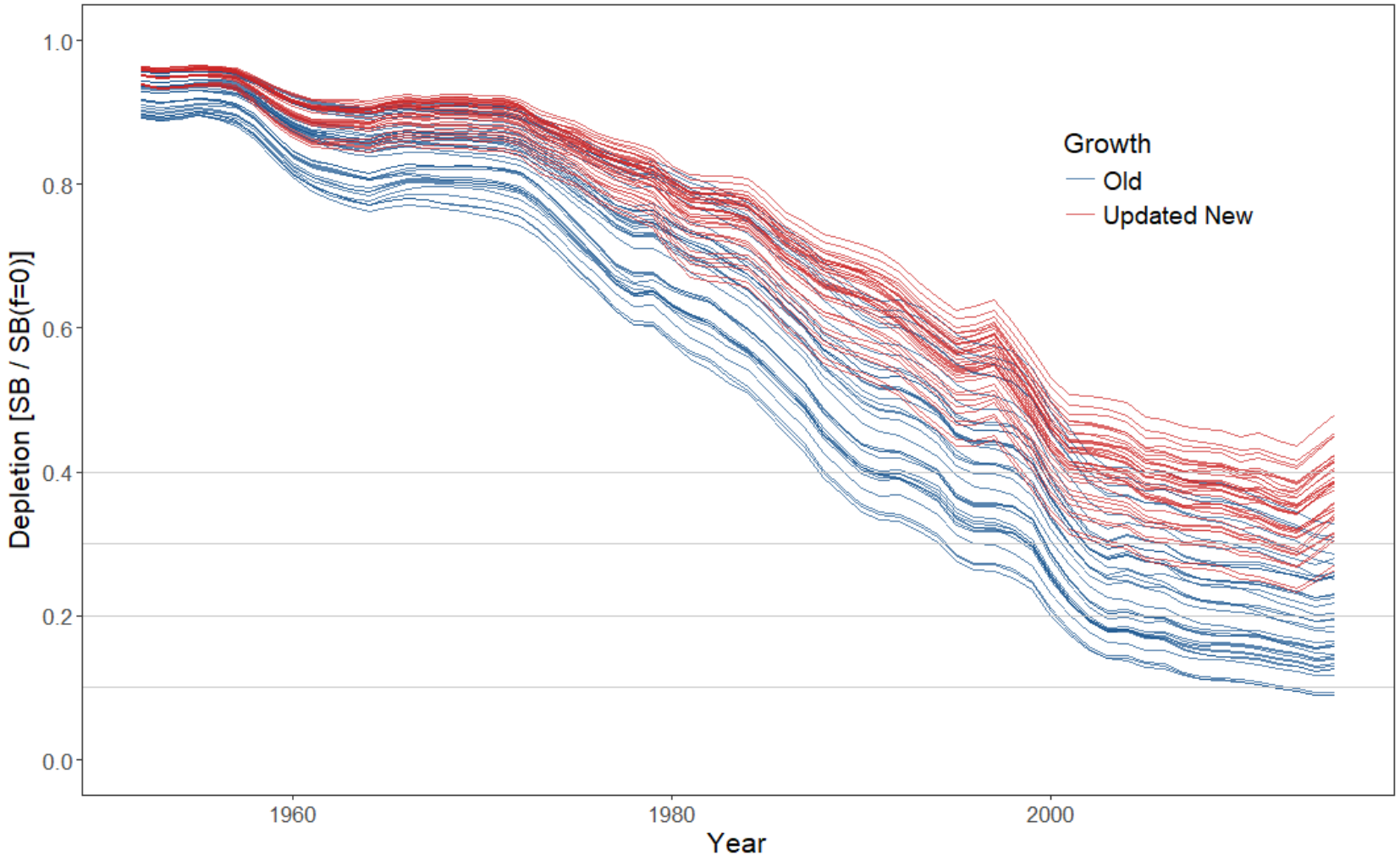
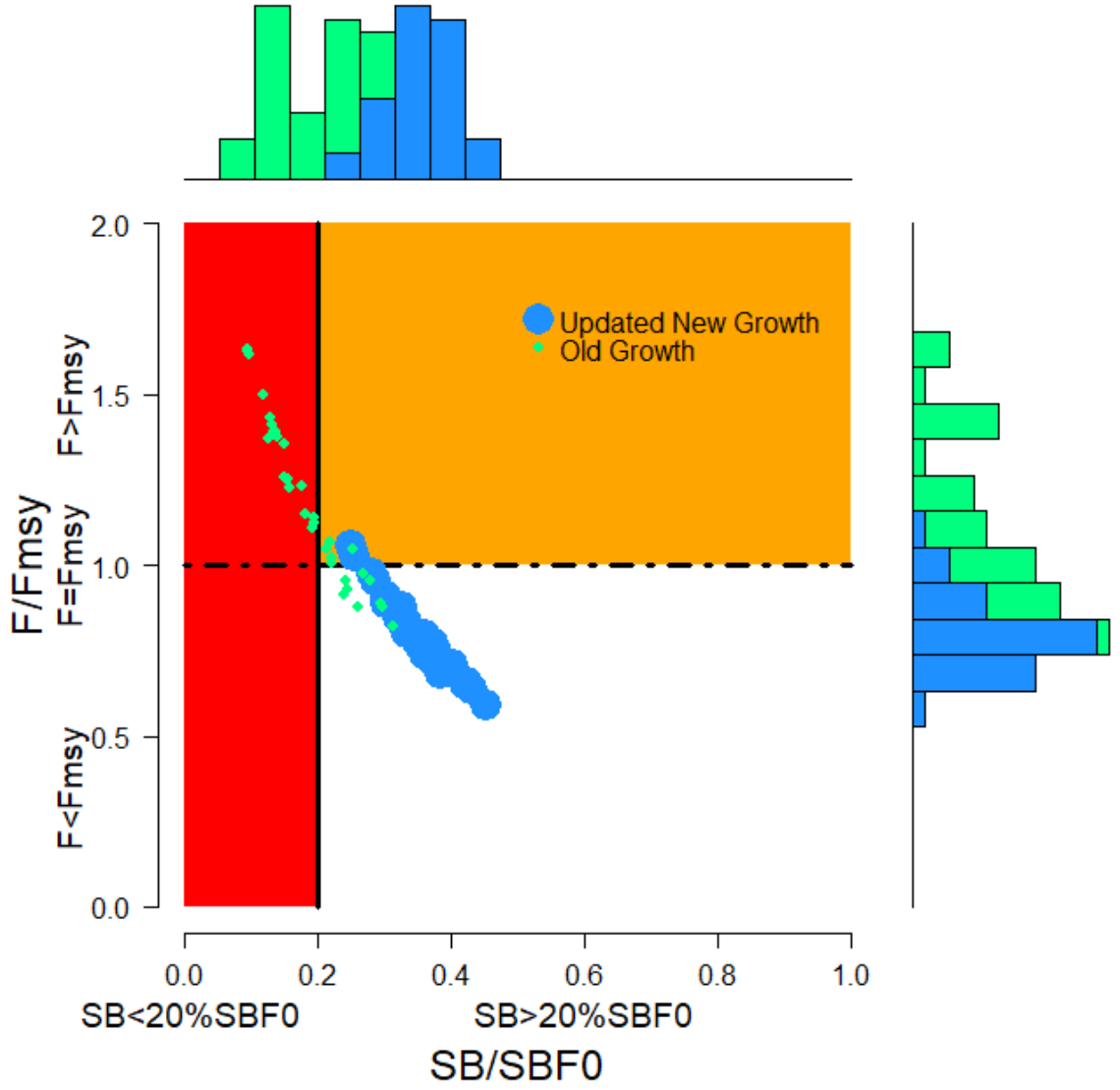


“New” and “Old” growth



Future developments for growth

- Include conditional age-at-length data in assessment models
  - Use data in annual form, rather than quarterly, ESS to acknowledge error
- Include tag length-increment data in assessment models
- Model spatial variability in growth – two hypotheses
  - Growth determined by area of origin, i.e. genetic effect
    - Model using “growth morphs” approach, morphs take their growth with them when they move
    - Predicted distribution of length-at-age in a region is a function of morph composition, movement
  - Growth determined by local environment
    - Requires a length-structured model
    - Region-specific growth-transition matrices, fish change growth when they move
    - Estimation of GT matrices informed by tagging length-increment data