Should we Model or Measure Fish Growth in Stock Assessments?

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Outline

• Growth
• Simulating growth
• Case Study: Pacific Hake
• Extensions
von Bertalanffy Growth

$L(a) = L_{inf} \left( 1 - e^{-k(a-t_0)} \right)$
Three Ways to Handle Growth in Assessments

1. Constant Growth

2. Time-Varying Growth

3. Measure Weight-at-age
Three ways to Handle Growth in Assessments

1. Constant Growth
Time-varying growth

• **External**
  – Environment
  – Competition
  – Food availability

• **Internal**
  – Stress
  – Disease
  – Reproduction
Three ways to Handle Growth in Assessments

2. Time-Varying Growth

Year 1

Year 2

Year 3
Three ways to Handle Growth in Assessments

3. Measure Weight-at-age

| Year | Age | 0.02 | 0.13 | 0.28 | 0.36 | 0.36 | 0.51 | 0.51 | 0.54 | 0.54 | 0.67 | 0.67 | 0.71 | 0.71 | 0.73 | 0.73 | 0.75 | 0.75 | 0.79 | 0.79 | 0.83 | 0.83 | 0.86 | 0.86 | 0.90 | 0.90 | 0.99 | 0.99 | 1.01 | 1.01 | 1.03 | 1.03 | 1.05 | 1.05 |
|------|-----|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|
| 0.01 | 0.02 | 0.03 | 0.04 | 0.05 | 0.06 | 0.06 | 0.07 | 0.07 | 0.08 | 0.08 | 0.09 | 0.09 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 |

Figure 17: Empirical weight-at-age (kg) used in the assessment. Numbers shown in bold were interpolated or extrapolated from adjacent years.
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**Compare Approaches**

- **Biomass**
- **Weight**
- **Length**
- **Age**

**Age + Length**

**Weight-at-age**
Outline

• Growth

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How to generate time-varying growth?

\[ L(a) = L_{\text{inf}} \left( 1 - e^{-k(a-t_0)} \right) \]
\[ L(\alpha) = L_{inf} \left( 1 - e^{-k(\alpha-t_0)} \right) \]
Positive and Negative - $k$

\[ L(a) = L_{inf} \left(1 - e^{-k(a-t_0)} \right) \]
\[ L(\alpha) = L_{inf} \left( 1 - e^{-k(\alpha - t_0)} \right) \]
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Outline

• Growth
• Simulating growth
• Case Study: Pacific Hake
• Extensions
Simulation

- Pacific Hake
- Time-varying growth
  - $L_{\infty}$: Positive and Negative
- Compare
  - age + length
  - weight-at-age
Simulation Approach

1. Simulate The Truth
2. “Collect” Data
3. Estimate
4. Compare to The Truth

Test:
Sampling
Statistical method
b. 

Fishery

Data-rich late-survey
Data-rich
Data-unrealistic

Survey

○ 35
○ 100
☐ 500
Results – Realistic Data

- Time-invariant growth
  - Age + Length better

![Graphs showing relative error (SSB) over years for Age + Length and Weight-at-age, with MARE values of 3 and 7 respectively.](image-url)
Results

• Time-invariant growth
  – Age + Length better

• Time-varying growth
  – Weight-at-age better
Results – Realistic Data

- Time-varying growth
  - Weight-at-age better
Results

• Time-invariant growth
  – Age + Length better

• Time-varying growth
  – Weight-at-age better

• Weight-at-age breaks down with less data
Results – Realistic to Less Realistic

- Breakdown with less data

![Weight-at-age](MARE=7)

![Late Survey](MARE=13)
Does the Simulation Work?

• With Unrealistic Data
  – Weight-at-age
  – Time-varying growth
Future Work

• Different life histories
• Data-limited scenarios
  – Methods of filling missing values

Caveats

• Constant length-weight relationship
• Practical Difficulties
  – Hard to age, weigh
Conclusions

• Time-invariant growth
  – Age + Length better
• Time-varying growth
  – Weight-at-age better
• Weight-at-age breaks down with less data

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• Ian Stewart, Mark Maunder, Andre Punt
• CAPAM
• Alaska Sea Grant
github.com/ss3sim/Empirical
b. Fishery
- Data-rich late-survey
- Data-rich
- Data-unrealistic

Survey
- 35
- 100
- 500
How to sample weights?

For each survey or fishery year, the true age distribution is taken.
Sample True Age

True Age Distribution

Multinomial
– N samples
Convert Age to Length

Multinomial sample – sample size N

Length-at-age

\[ L(a) = L_{\text{inf}} \left(1 - e^{-k(a-t_0)}\right) \]
Convert Length to Weight

Length-at-age

Weight-at-age

\[ W = aL^b \]
Dealing with Missing Years

Year 1

Year 2

Year 3

Year 7
Large Scale of Assessments

1. Constant Growth

- Reproduction
- Maturation
- Mortality