Simulating Growth and Measurement Error for Tag-Recapture Data

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Introduction

- The American Lobster Stock Assessment uses a probabilistic growth transition model to estimate size- and sex-class specific growth.
- The growth transition matrix relies on two estimated parameters for each class: growth increment and molt interval.
- To collect growth information for data poor lobster demographies i.e. large reproductive females, Atlantic Offshore Lobstermen's Association organized tagging of 17,705 lobsters yielding 1800+ recaptures with 771 size observations.
- This project directly addresses the 2015 Stock Assessment Research Priority to "Update information on growth and maturity" in the rapidly changing ocean environment.

Methods

Estimating Measurement Error

Collect Recapture Length Observations

Caculate Length Change, and Filter Growth to Minimum Molt Increment, E[G] = 0

Generate a Normal Vector with Mean = 0, Standard Deviation p

Round Randomized Error Vector to Match Obs. Error Structure

Compare error vectors with KS test, bootstrap to prevent staircase effect.

Minimize the D-statistic in KS by optimizing standard dev. p

Simulating Growth

Generate Lobsters (Size X Sex) and Time at Large (Gamma dist.)

Generate random binomial describing whether mature females molt or reproduce in first simulation year

Calculate growth increment as constant relative growth or constant increment + natural variation

Add growth increment to size, considering whether mature females molt or reproduce

Iterate time-steps, removing lobsters as model time surpasses time at large

Add measurement error based on estimation to first and last obs. for each

- The dataset is audited for unrealistically large growth measurements that may exist due to a separate error structure.
- Measurement error is estimated using 443 observations from the tagging dataset.
- Growth transition parameters are returned for simulated growth data to design a model capable of estimating growth on real data.

Estimating Measurement Error

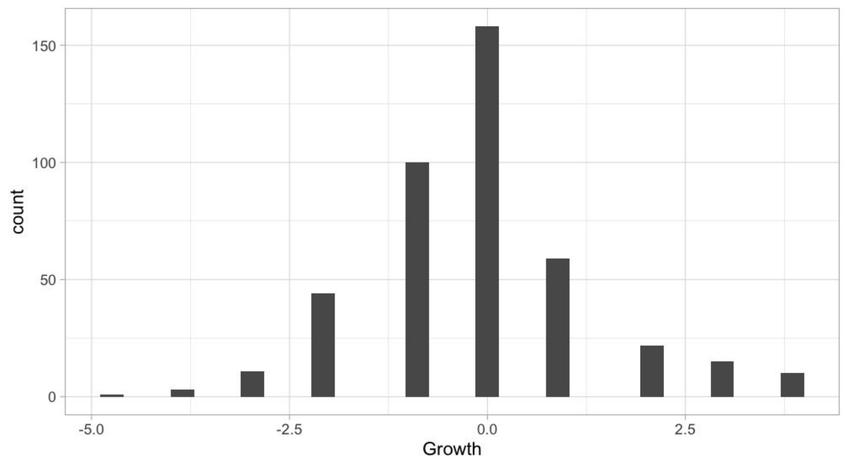

Figure 1: Distribution of low growth measurements i.e. observations with E[G] = 0.

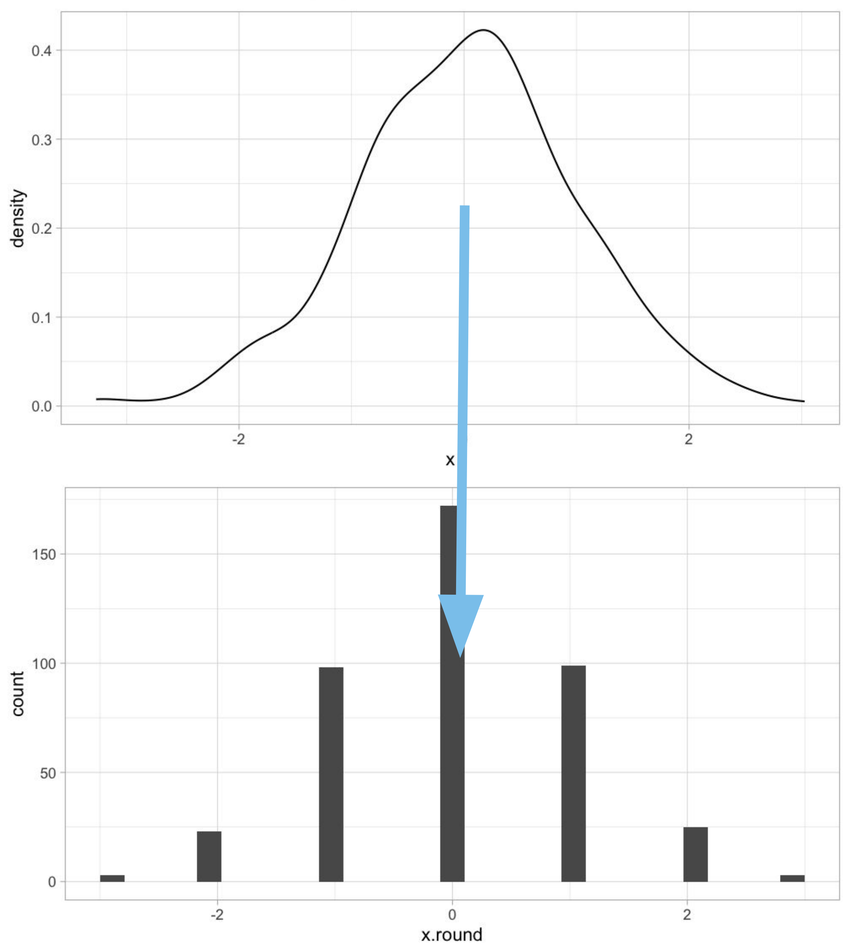

Figure 2 and 3: Random normal generated and discretized to match structuring of observer data.

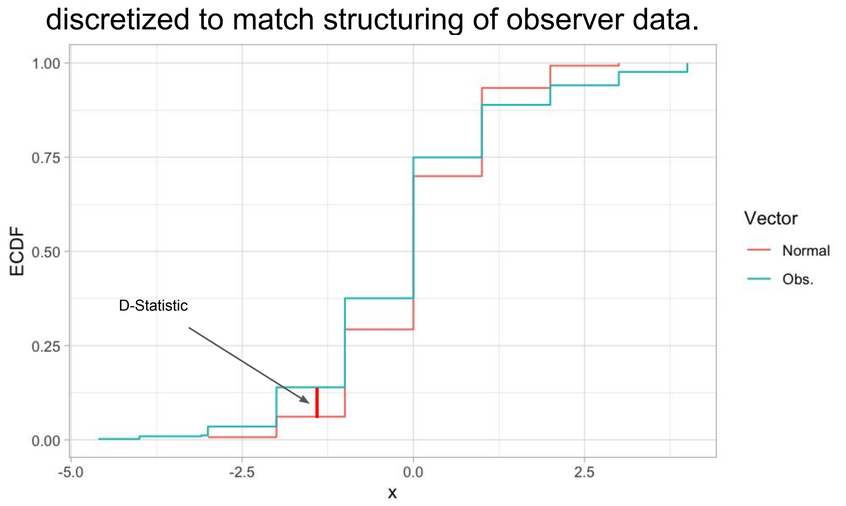

Figure 4: ECDFs of generated data and observed low growth measurements with KS test D-statistic highlighted.

Growth Simulation

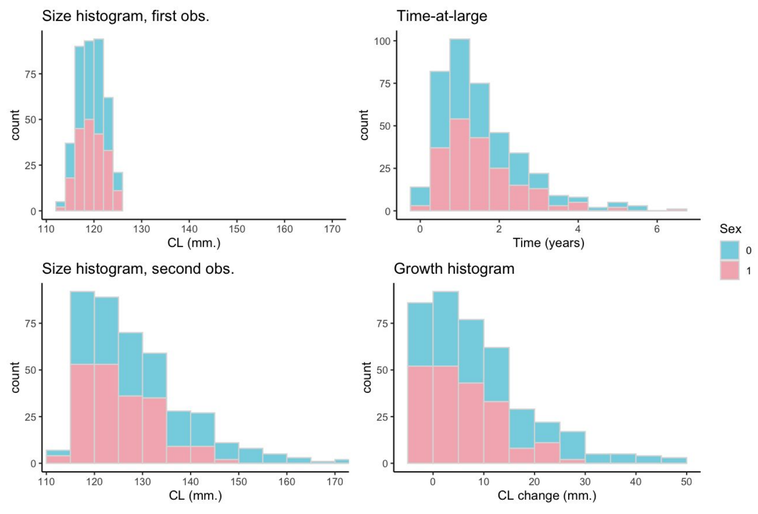

Figure 5: Growth simulation with observation error added at measurements and growth according to time-at-large.

- Growth simulations can be used to then investigate the effect of measurement error on interpretation or model sensitivity.

Results and Significance

- After making measurement error estimation we can generate and include error estimates in growth transition simulations and subsequent models.
- Optimization of D-statistic between observed and generated distributions yields a measurement error vector *N(0, 1.2)*.
- For the 771 AOLA growth records applying measurement error vectors changes the current size bin and therefore, may impact the assumed growth increment and interval parameters 19 % of the time.

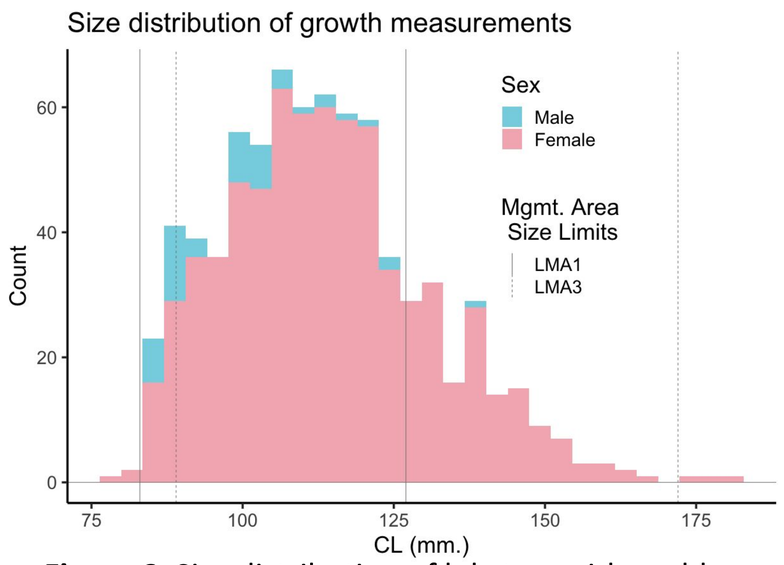

Figure 6: Size distribution of lobsters with usable growth data from the AOLA tagging dataset.

- Providing updated estimates of growth parameters for reproductive females will allow us to more accurately model SSB, TEP and Recruitment.
- Data poor population segments provided additional growth estimates and can be used in the 2025 Stock Assessment.

Acknowledgements

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