Trends and Status of the Little Colorado River population of Humpback Chub: 1989-2011

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Outline

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- Abundance Recruitment
- Residuals
- Retrospecitve Analysis
- Uncertainty
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Summary

Introduction to ASMR

Mark-recapture information between 1989 and 2011 is used to estimate the abundance and recruitment of Humpback Chub (HBC).

Catch-at-length data are transformed into catch-at-age data using length-age relationship developed from a bioenergetics model.

The unmarked population is reconstructed using Virtual Population Analysis (VPA) with and assumed value of natural mortality rate.

The fate of marked individuals is tracked using an age-structured model, and the capture-recapture probability is assumed to be a Poisson sampling process.

ASMR-3 Analytical details

Age Structure Mark Recapture (ASMR-3)

Data: Marks & Recaptures $m_{t,a}, r_{t,a}$ (1)

Estimate unmarked numbers $\Theta = \hat{U}_{t=2012,a=2:14}$ (2)

Survival rate $S_a = \exp(-M l_\infty / l_a)$ (3)

Unmarked animals $\hat{U}_{t,a} = \frac{\hat{U}_{t+1,a+1}}{S_a} + m_{t,a}$ (4)

Marked animals $\hat{M}_{a+1,t+1} = S_a(\hat{M}_{t,a} + m_{t,a})$ (5)

Predicted new marks $\hat{m}_{t,a} = \hat{p}_{t,a}\hat{U}_{t,a}$ (6)

Predicted recaps $\hat{r}_{t,a} = \hat{p}_{t,a}\hat{M}_{t,a}$ (7)

Capture probability $\hat{p}_{t,a} = \frac{m_{t,a} + r_{t,a}}{\hat{U}_{t,a} + \hat{M}_{t,a}}$ (8)

Negative log likelihood $\ell_{t,a} = (-\hat{m}_{t,a} + m_{t,a}\ln(\hat{m}_{t,a}))$
$+(-\hat{r}_{t,a} + r_{t,a}\ln(\hat{r}_{t,a}))$ (9)

ASMR-3 Analytical details

Age Structure Mark Recapture (ASMR-3)

Assumptions:

- Natural mortality is a function of length.
- Natural mortality is constant over time.
- Marked & unmarked fish have same capture probablility & survival.
- Observation error only.
- Growth is time invariant.
- Age is a function of length (slicing).
- Walters & Martell are never wrong!

Marks released

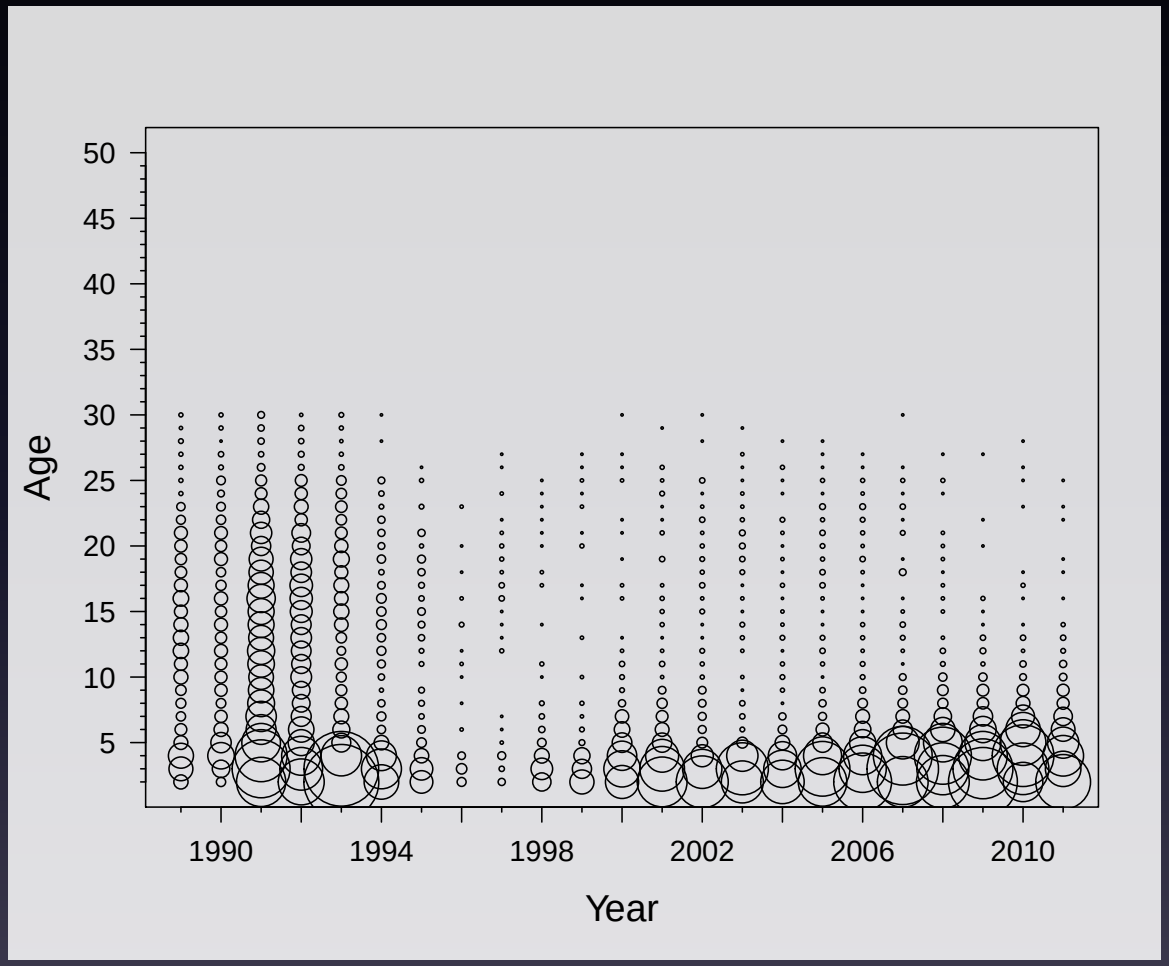

Figure: Number of marks released by age-year. Area of bubble is proportional to the number of marks released.

Marks recaptured

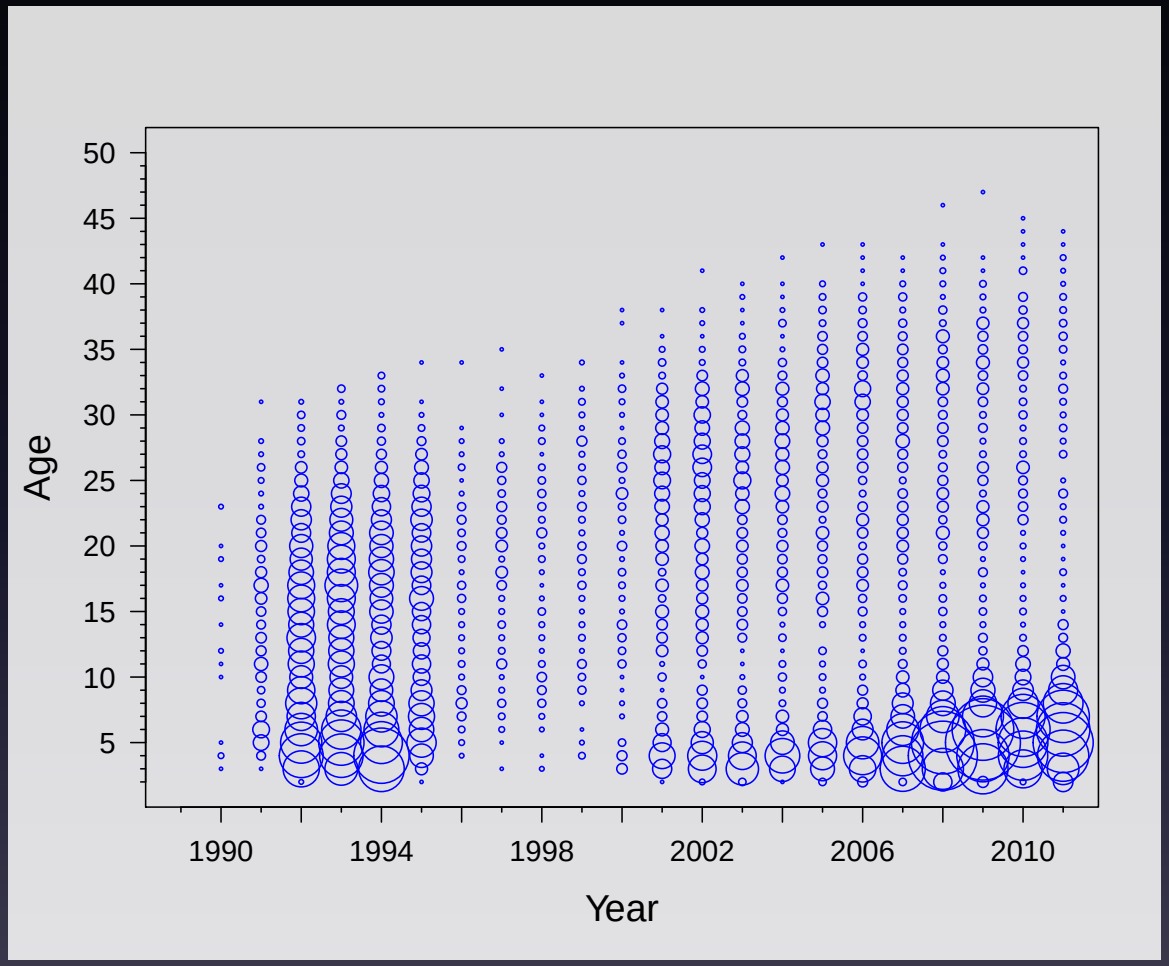

Figure: Number of marks recaptured by age-year. Area of bubble is proportional to the number of marks released.

Marks recaptured

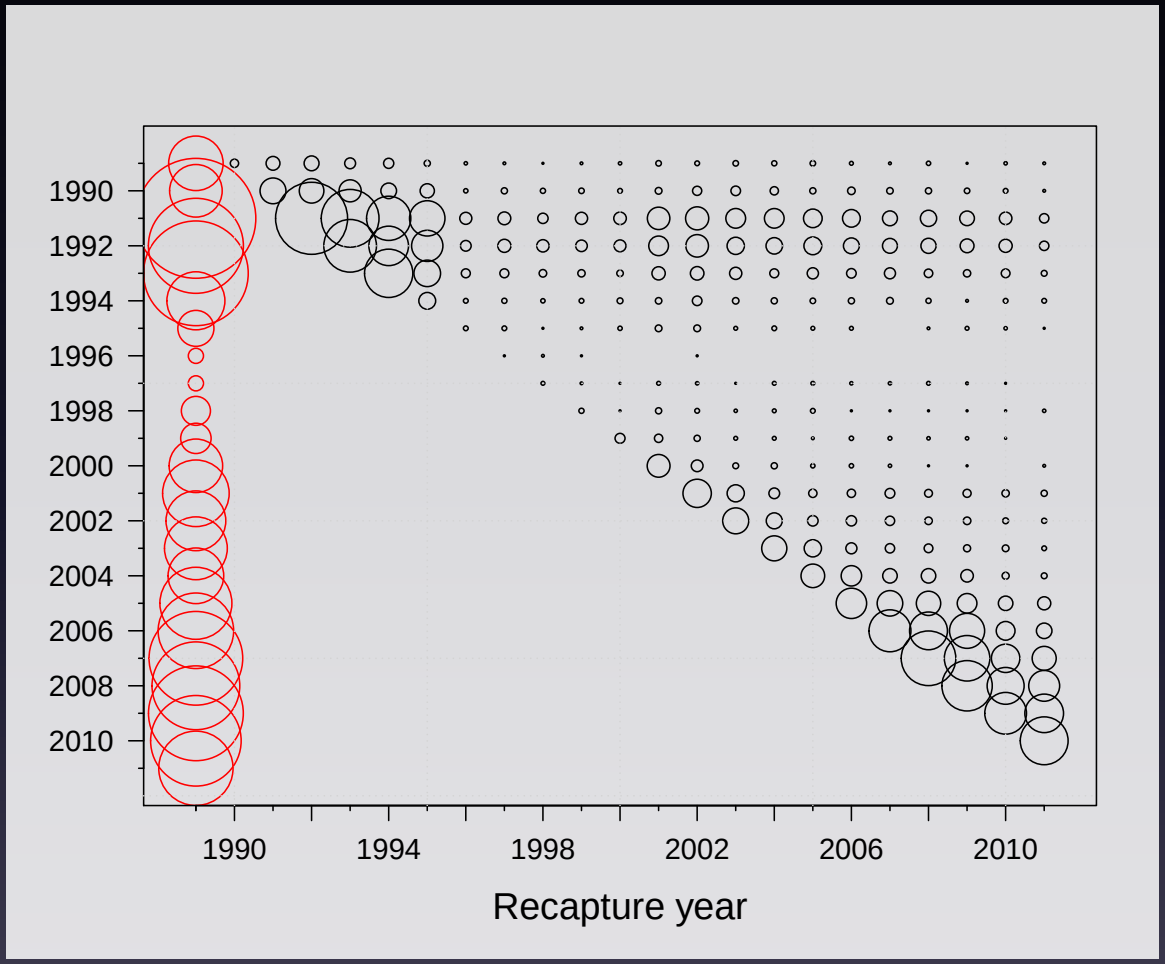

Figure: Tags released each year (red circles) and number recaptured by tag-year (row of black circles).

Age-4+ abundance

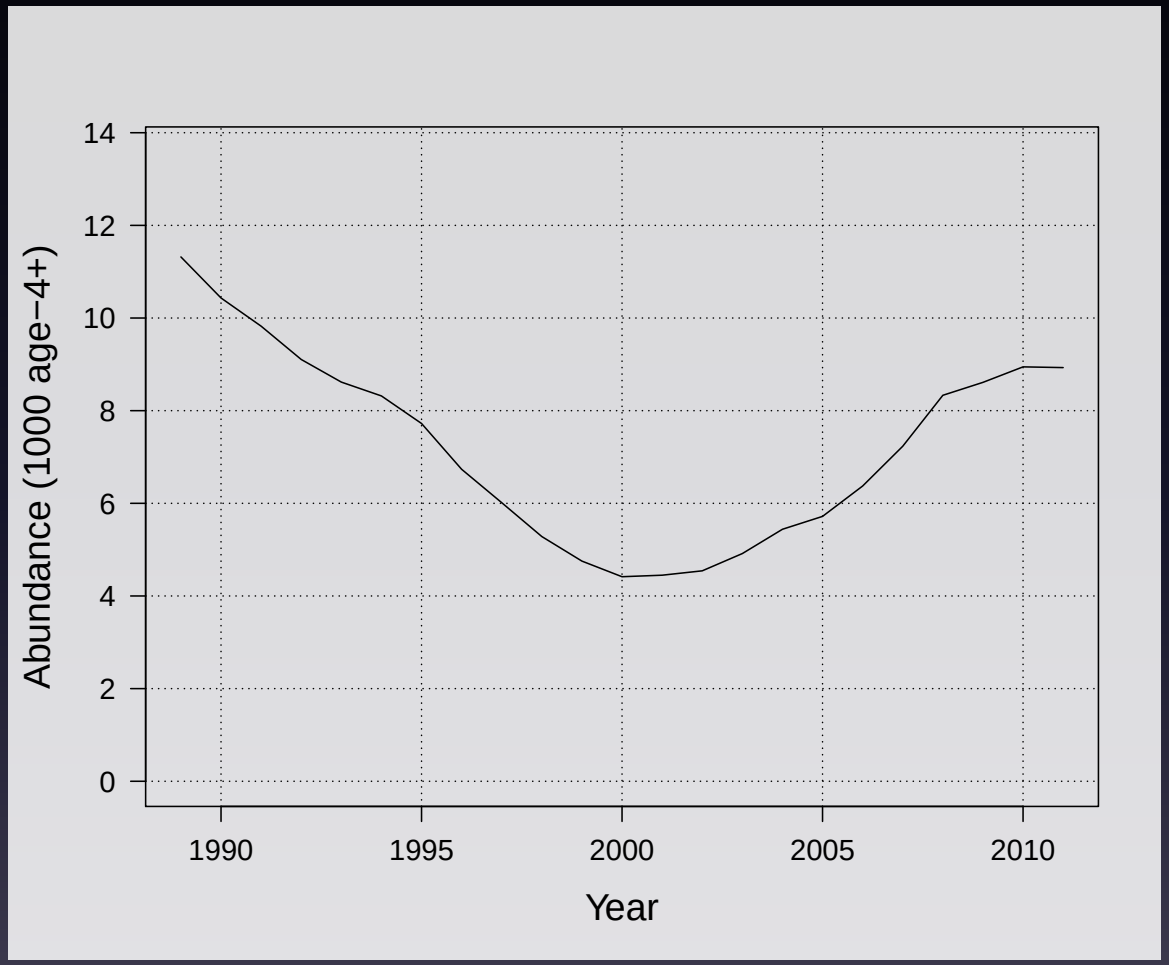

Figure: Maximum likelihood estimates of age-4+ abundance.

Age-2 Recruits

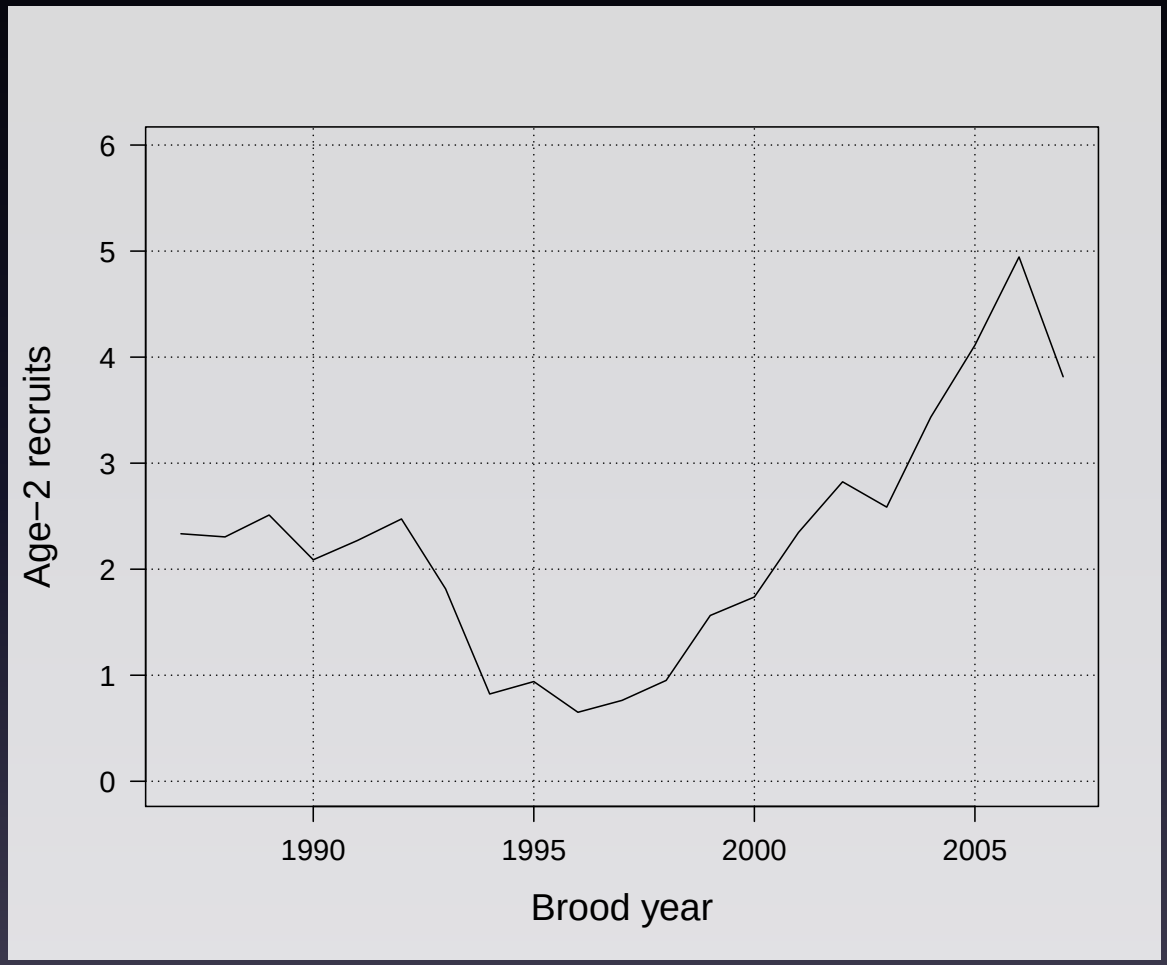

Figure: Maximum likelihood estimates of age-2 recruits.

Capture probability

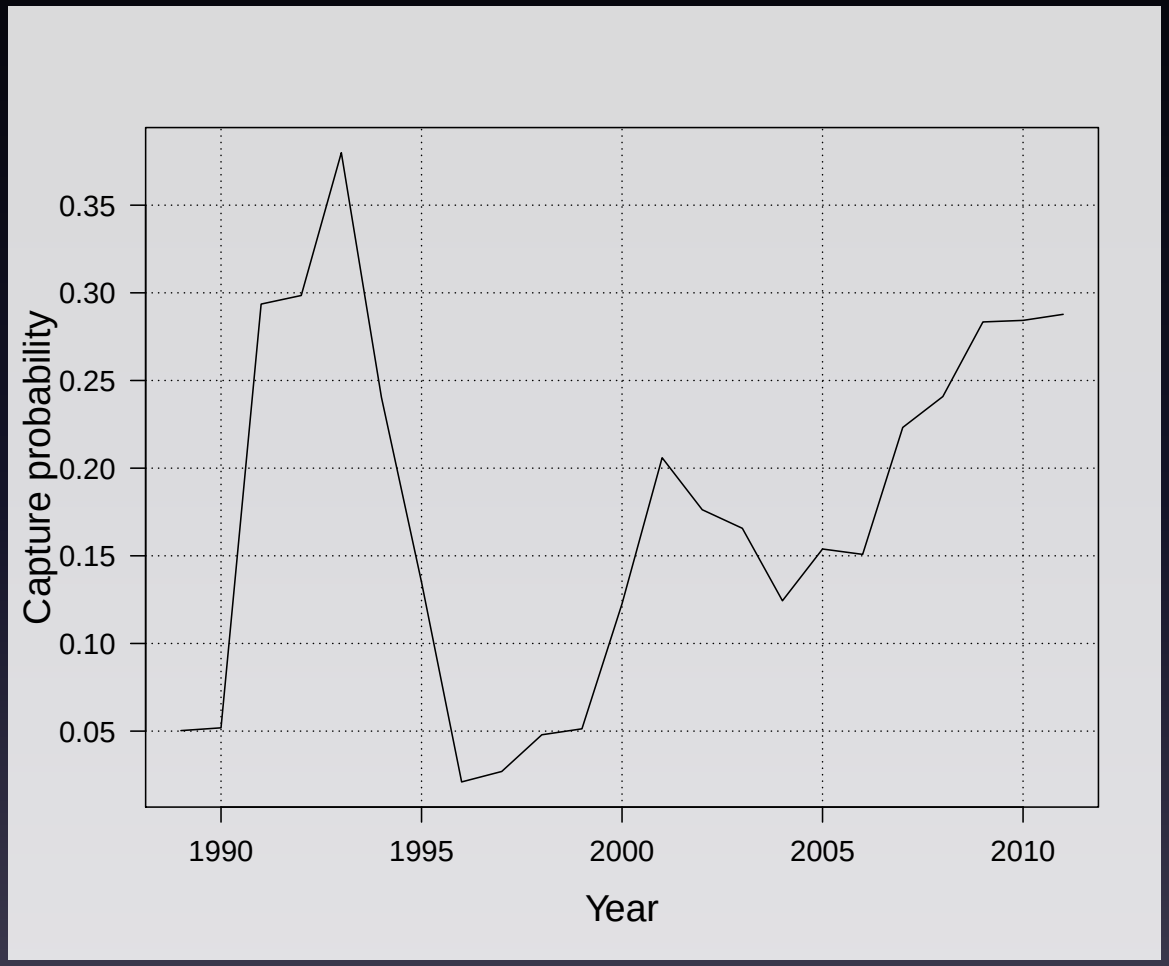

Figure: Maximum likelihood estimates of annual capture probability.

Residuals (released marks)

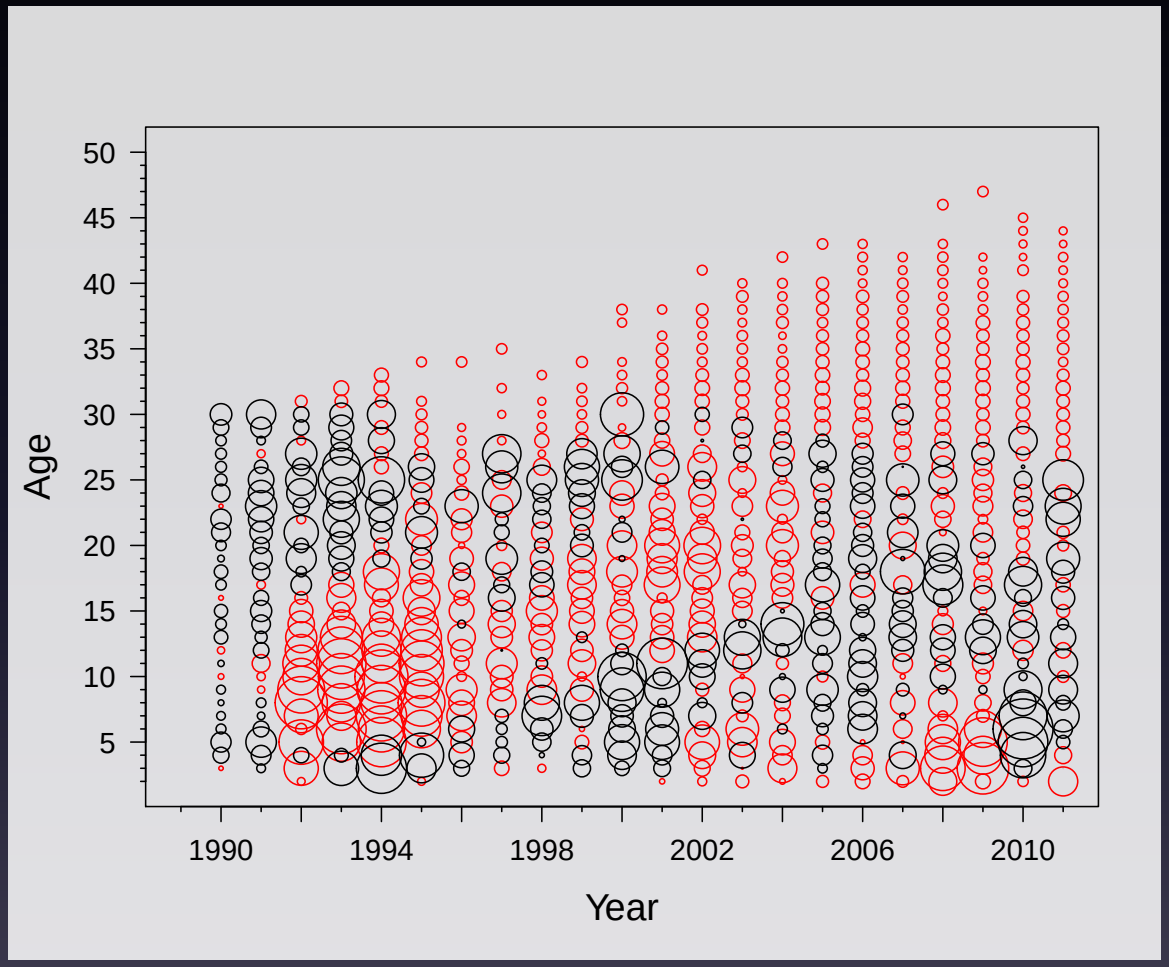

Figure: Pearson residuals (observed - expected) for new marks released (black=positive).

Residuals (recaptured marks)

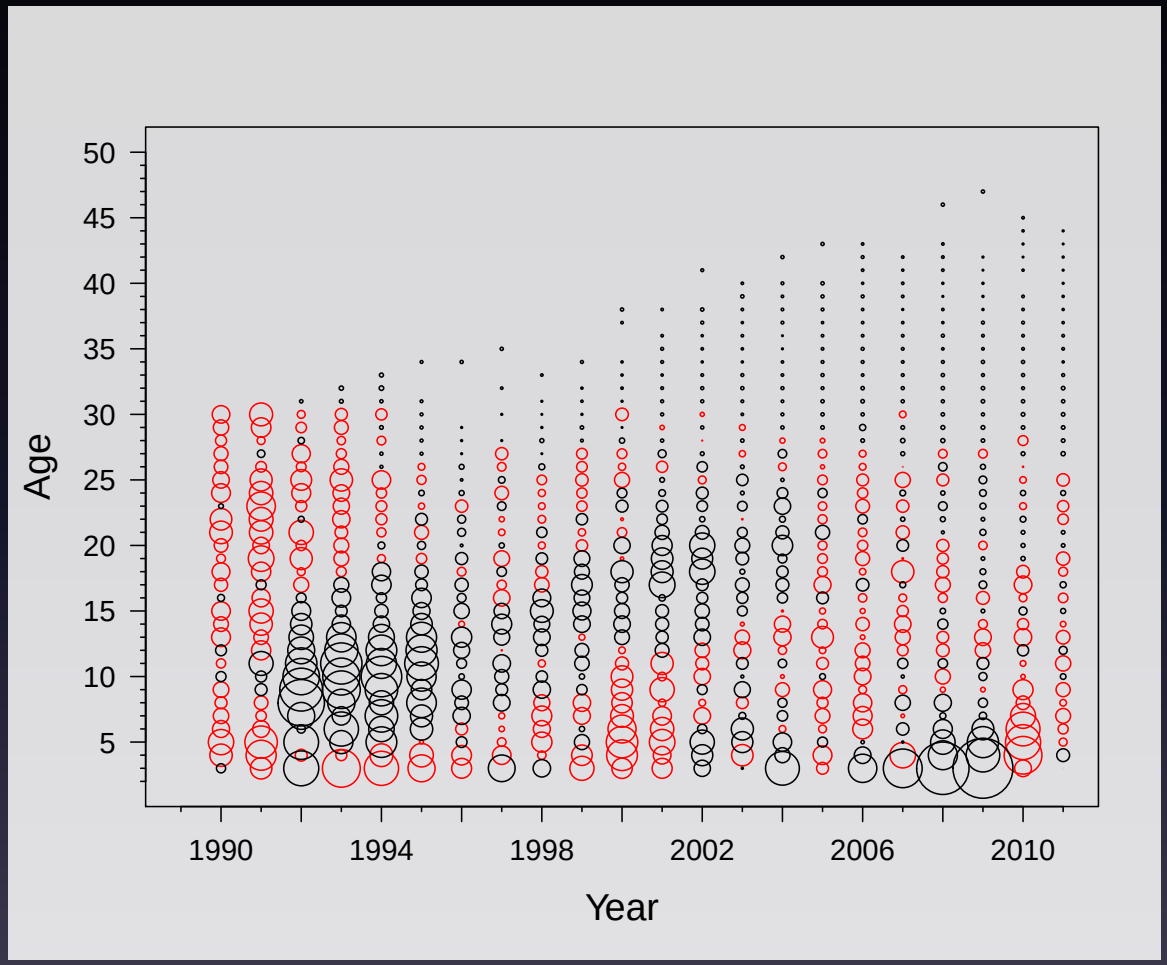

Figure: Pearson residuals (observed - expected) for recaptured marks (black=positive).

Retrospective age-4+ abundance

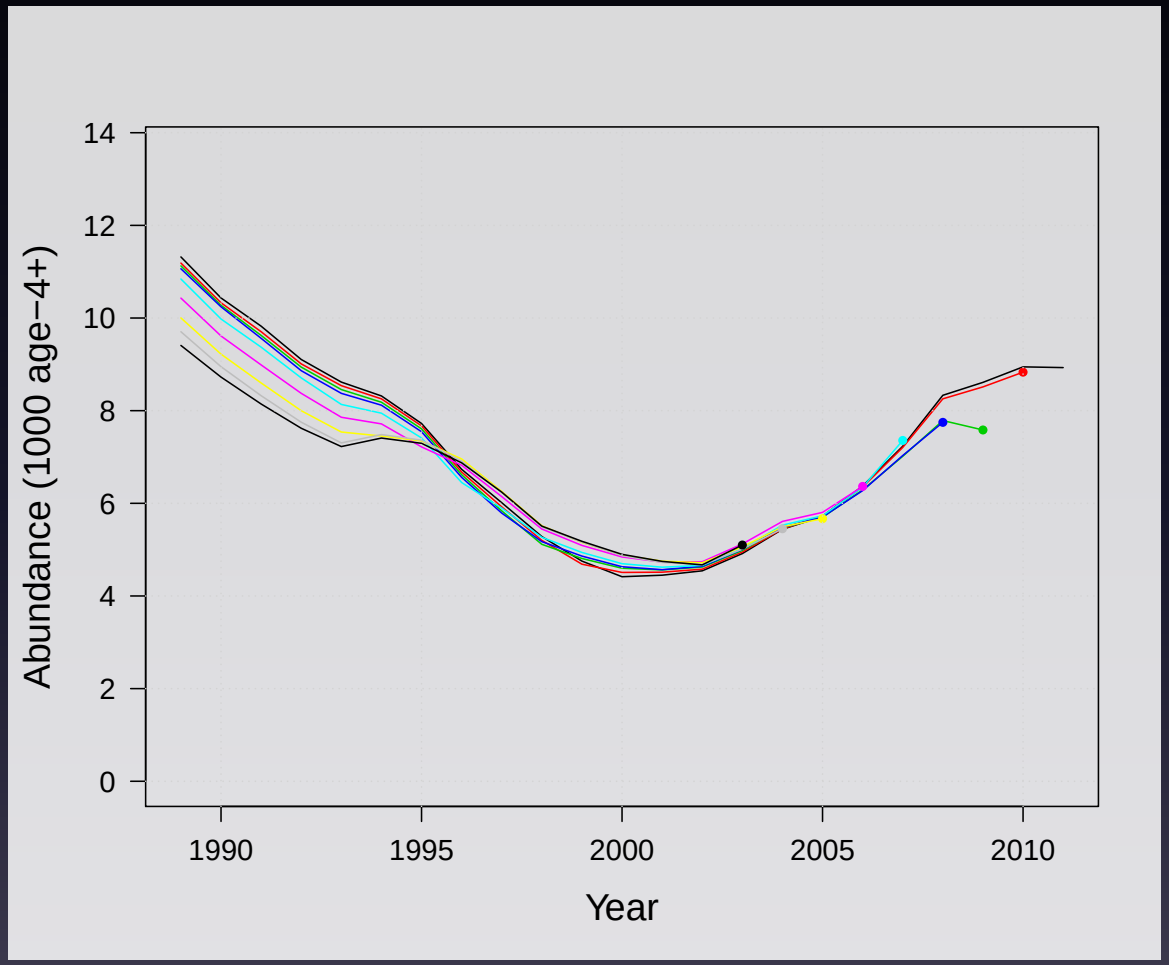

Figure: Retrospective estimates of age-4+ abundance.

Retrospective age-2 recruits

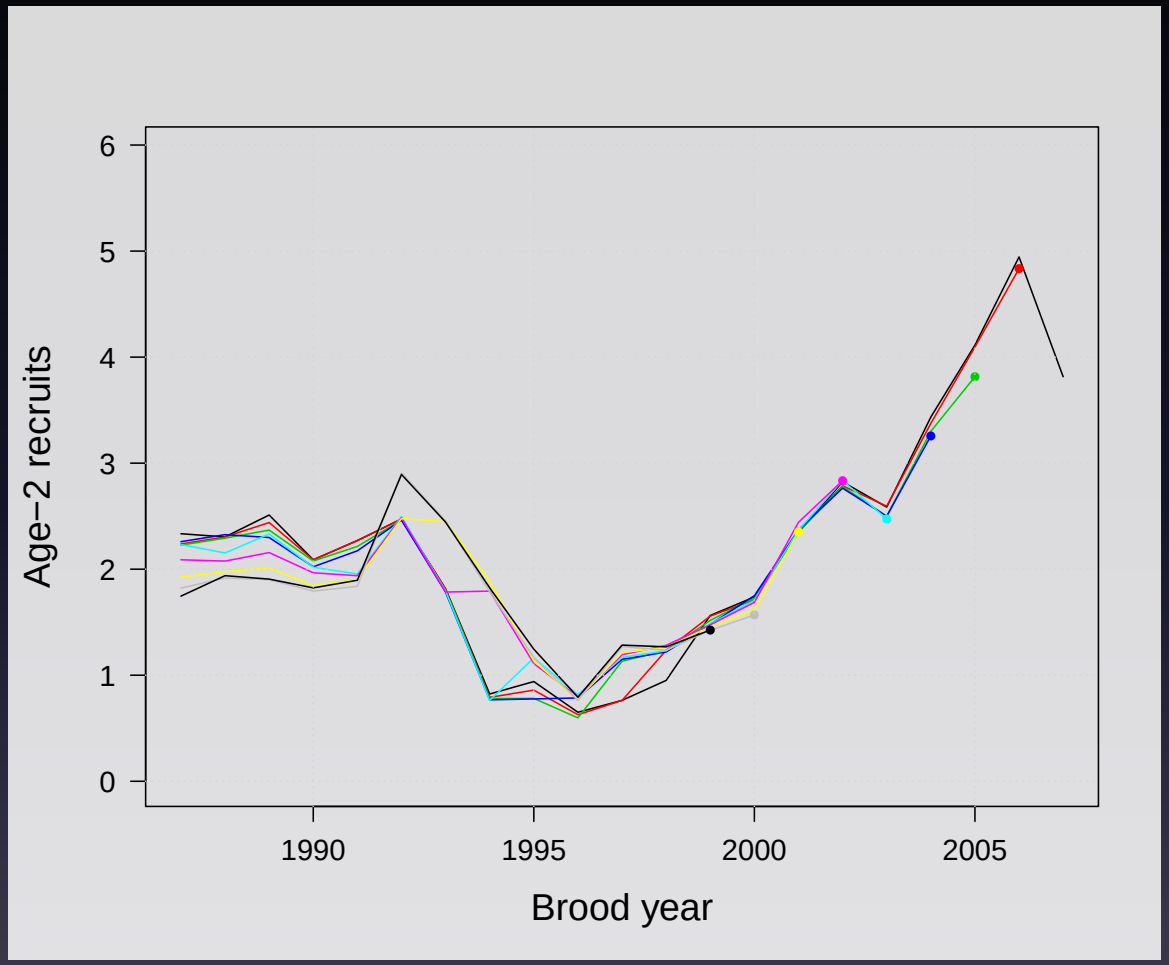

Figure: Retrospective estimates of age-2 recruits.

Uncertainty: Age-4+ & Age-2

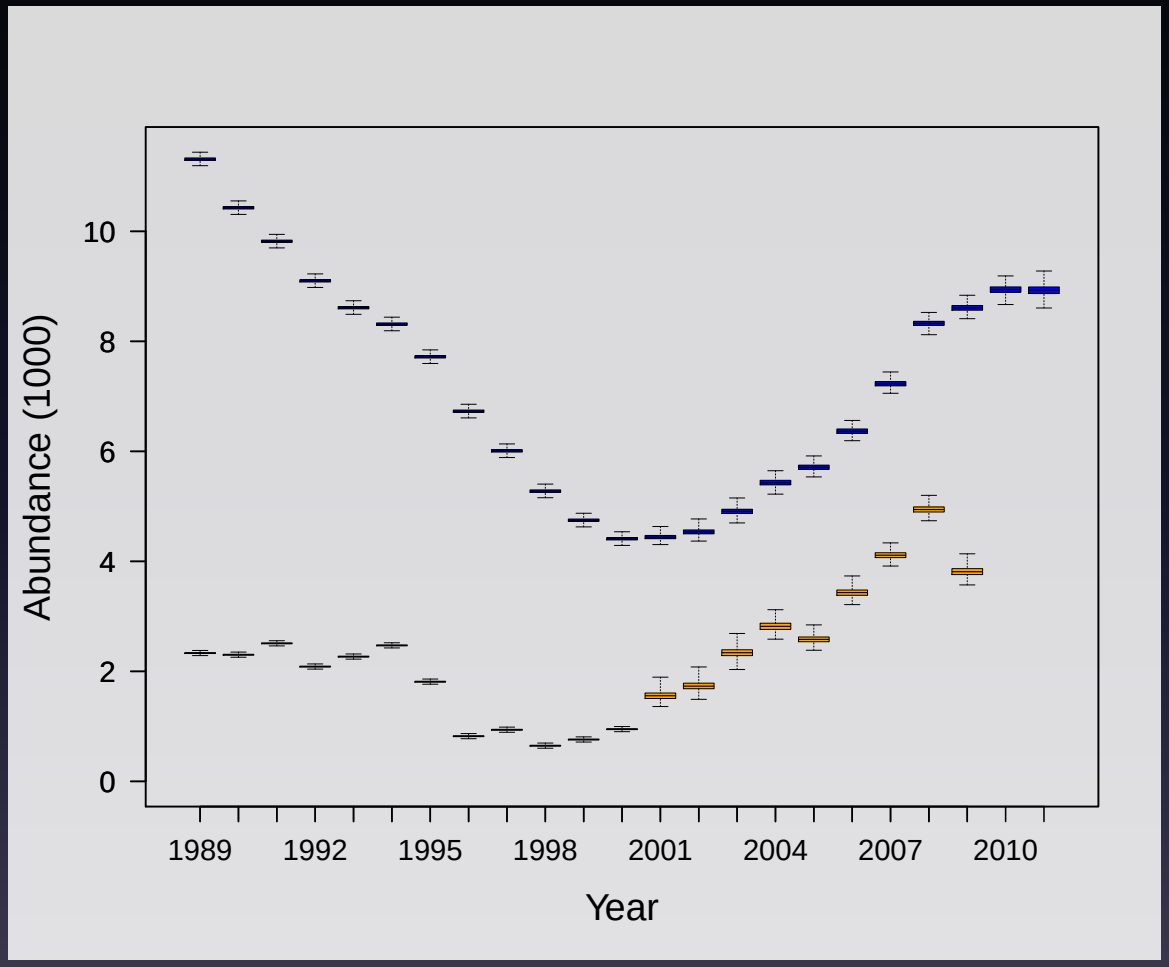

Figure: Marginal distributions for age-4+ (blue) abundance and age-2 recruits (orange).

Age-4+ abundance in 2011

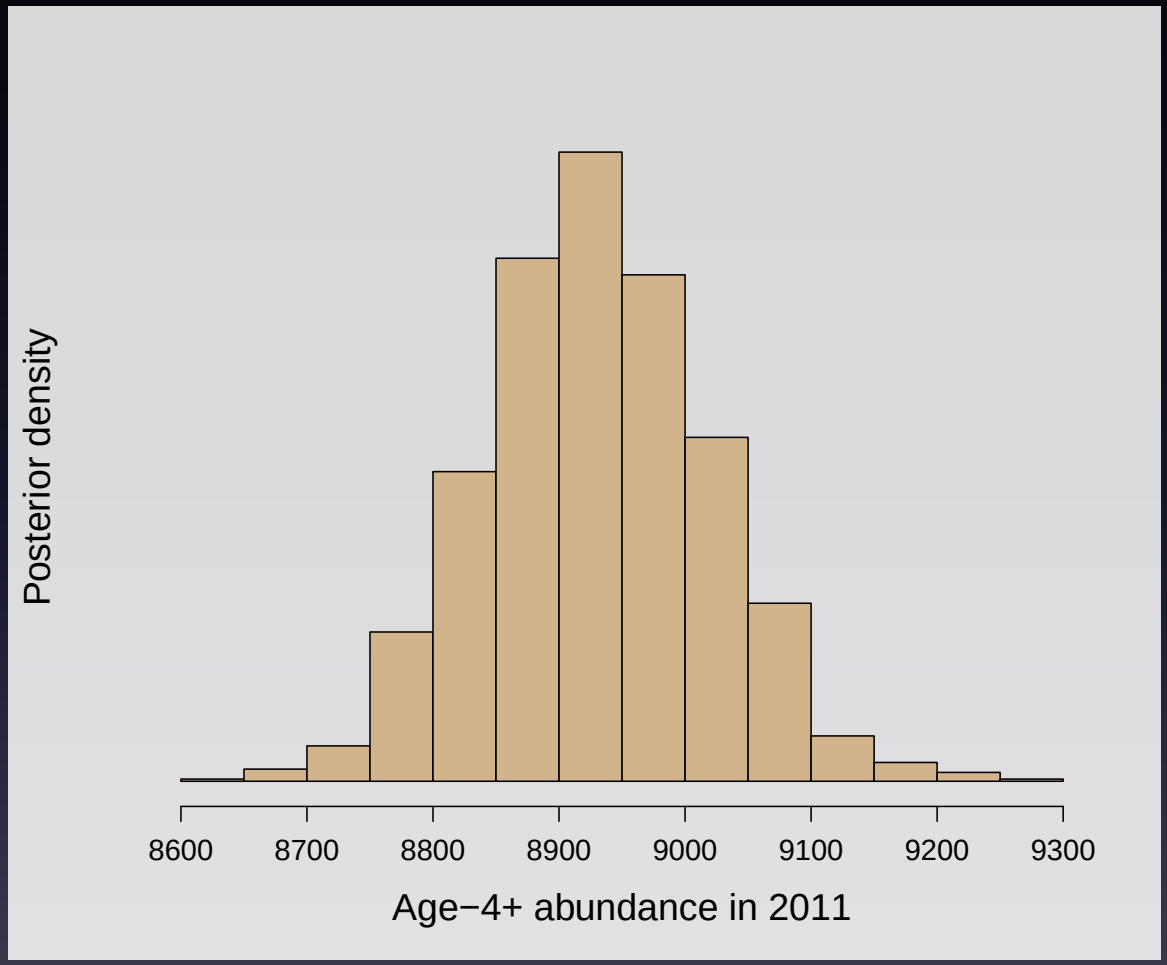

Figure: Marginal posterior density for age-4+ abundance in 2011.

Sensitivity to natural mortality (M)

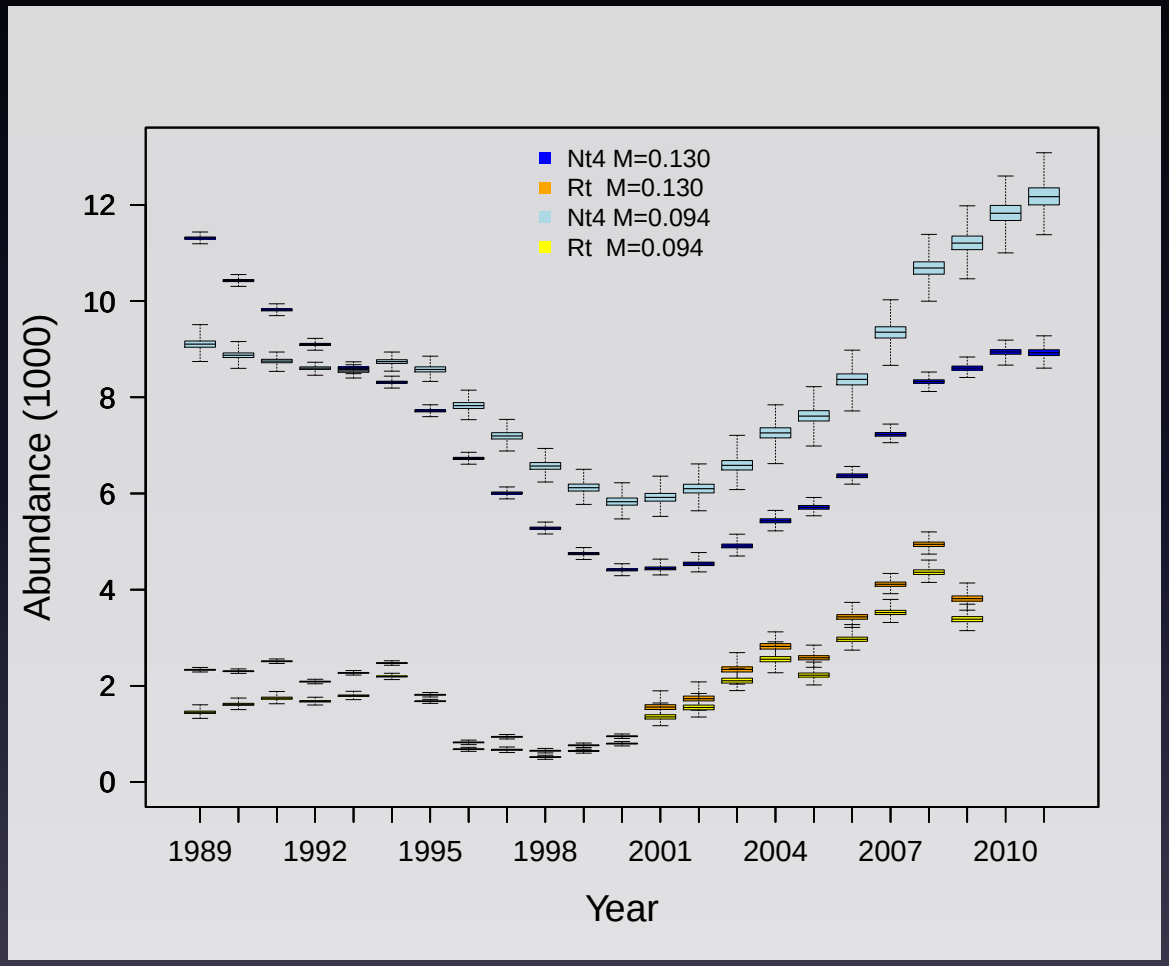

Figure: Freely estimating natural mortality results in increased estimates of age-4 abundance and fewer age-2 recruits.

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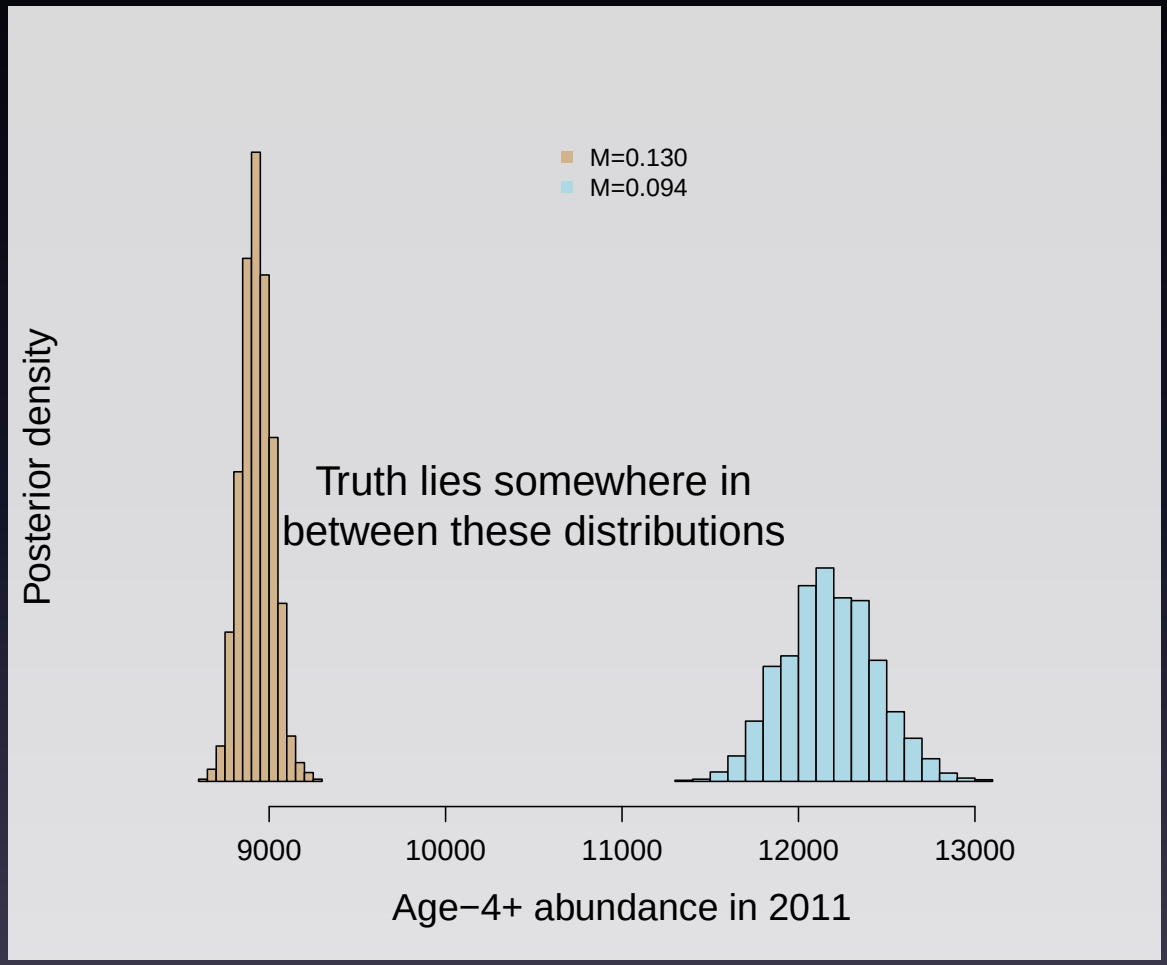

Figure: Marginal posterior density for age-4+ abundance in 2011 with M=0.13 (tan) and M=0.094 (light blue).

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Assuming the asymptotic natural mortality rate of 0.13:

- Median age-4+ in 2011: 8912 (8736, 9095)–95%CI
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Freely estimating natural mortality rate ($M = 0.094$):

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Uncertainty is grossly under-estimated due to observation error only, and assignment of age from length.

Future Work

Developing a length-based version of ASMR where there is no age-assignment from length.

Key Features:

- Mixed-error model (better uncertainty estimates)
- Growth based on length-transition matrix (no aging info)
- Can incorporate information on individuals < 150 mm.

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