Glen Canyon Dam Adaptive Management Work Group
Agenda Item Information
September 9-10, 2008

Agenda Item

Humpback Chub Population Estimate (modeled using data through 2006)

Action Requested

√ Information item only. We will answer questions but no action is requested.

Presenter

Matthew Andersen, Biological Program Manager, Grand Canyon Monitoring and Research Center

Previous Action Taken

√ Other: One of the conservation measures in the Final Biological Opinion (BO) for the Operation of Glen Canyon Dam dated February 27, 2008, established a Humpback chub consultation trigger, as follows:

Humpback Chub Consultation Trigger – Pursuant to 50 CFR § 402.16 (c), reinitiation of formal consultation is required and shall be requested by the Federal agency or by the FWS, where discretionary Federal involvement or control over the action has been retained or is authorized by law and if new information reveals effects of the action that may affect listed species or critical habitat in a manner or to an extent not previously considered. Reclamation and FWS agree to specifically define this reinitiation trigger relative to humpback chub, in part, as being exceeded if the population of adult humpback chub (≥200 mm [7.87 in] TL) in Grand Canyon declines significantly, or, if in any single year, based on the age-structured mark recapture model (ASMR; Coggins 2007), the population drops below 3,500 adult fish within the 95 percent confidence interval. FWS and Reclamation have agreed on this trigger based on the current estimated population size and past population trend, genetic considerations, and the capabilities of the ASMR model to estimate population size. This number was derived as a conservative approach to preventing the population from declining to the minimum viable population size for humpback chub, estimated to be 2,100 adult fish (U.S. Fish and Wildlife Service 2002a), with consideration for a buffer and acknowledging the variance inherent in the ASMR resulting from age estimation based on recent results from this model (Coggins 2007). This trigger provides additional protection against possible adverse affects to humpback chub from the proposed action. If the population of humpback chub declines to this level, Reclamation and FWS will consider appropriate actions through reinitiated section 7 consultation, for example, extending the period of steady releases to include July and August. Conversely, if the population of humpback chub expands significantly, FWS and Reclamation will consider the potential for reinitiation of consultation to determine if steady flows continue to be necessary.

√ TWG: A detailed presentation was made to the TWG's spring 2008 meeting by Lew Coggins on his latest USGS report (OFR 2007-1402), entitled "Abundance Trends and Status of the Little Colorado River Population of Humpback Chub: An Update Considering 1989–2006 Data."

Relevant Science

See below.

Background Information

We will present a brief summary of the USGS open file report 2007-1402, which can be found at http://pubs.er.usgs.gov/usgspubs/ofr/ofr20071402. It updates the Age-Structured Mark-Recapture model of the adult humpback chub population in Grand Canyon using data from 1989-2006. The overall result of the mark-recapture-based open population model assessment is that the adult portion of the Little Colorado River humpback chub population appears to have increased in abundance since 2001. The assessment model best supported by the data is ASMR 3 with aging error. This model produces a 2006 adult abundance estimate of approximately 6,000 fish. This analysis suggests that there has been an increase of approximately 20-25% in adult abundance since 2001. This increase is likely related to an increasing recruitment trend beginning perhaps as early as 1996, but likely no later than 1999. Recruitment of juvenile humpback chub since 2000 appears stable, but the precision of these estimates is low when aging error is included in the assessment.

Abundance Trends and Status of the Little Colorado River Population of Humpback Chub: An Update Considering data 1989-2006

Update for GCDAMP Adaptive Management Workgroup
L.G. Coggins, Jr.
Presented by M.E. Andersen
SBSC/GCMRC
September 9, 2008

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Report Objectives

- Update 2002 HBC stock assessment (Coggins et al. 2006) with most recent information
  - Catch-rate Indices (LCR Inflow and Lower LCR)
  - Summarize Spring LCR Closed Population Estimates
  - Update Age-Structured Mark-Recapture (ASMR) model with data through 2006
    - Utilize various model selection tools to arbitrate among ASMR 1-3
    - Estimate age-length relationship from tagging data
    - Incorporate uncertainty in assignment of age.

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Spring LCR HBC Abundance Estimates

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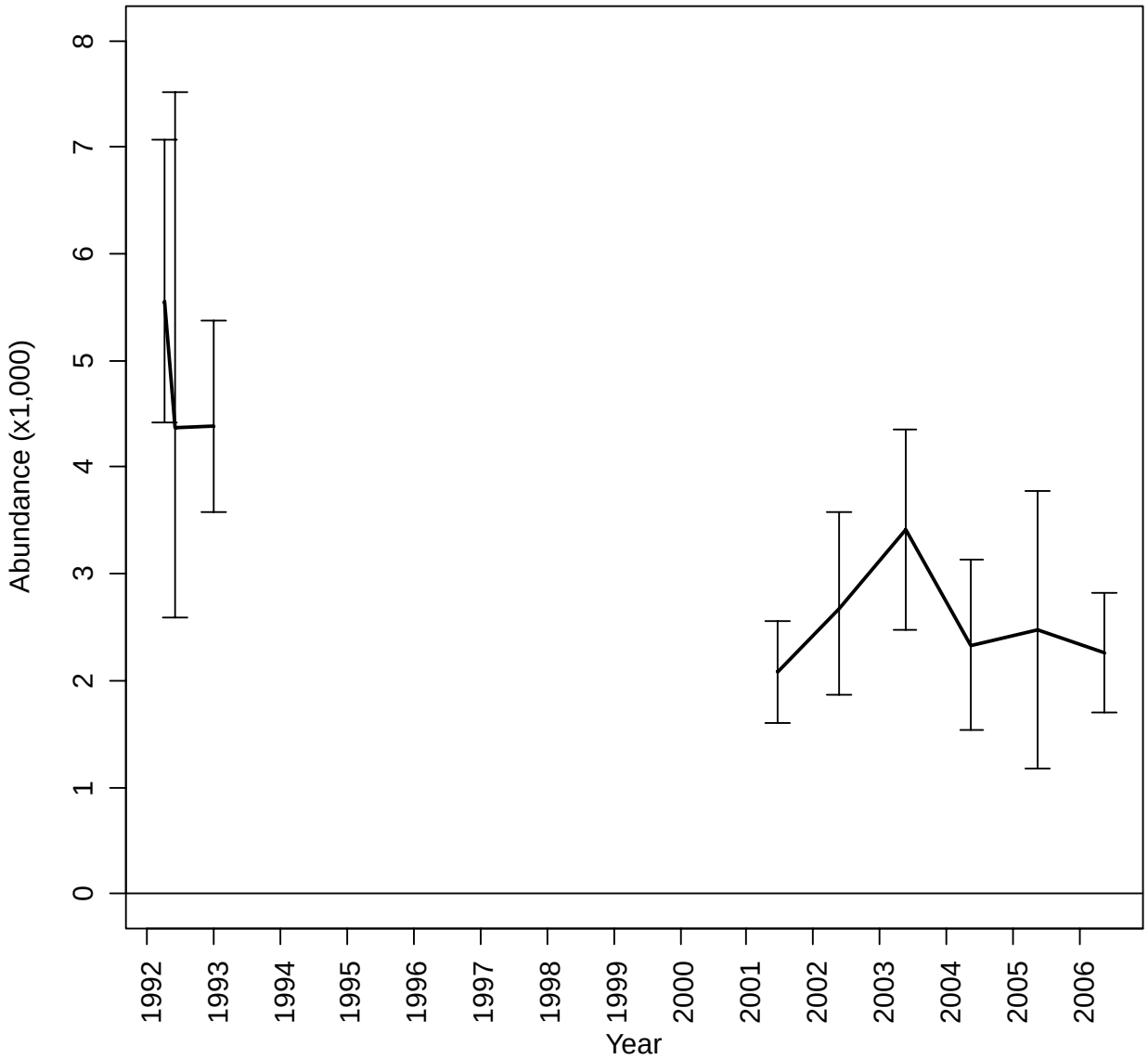
Spring LCR HBC Abundance Estimates

- 2-Event Lincoln-Petersen closed population mark-recapture experiments
- Abundance of HBC >= 150 mm Total Length
- Error Bars are 95% CI



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ASMR Open Population Estimates

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Background – ASMR Model Structure

- Coggins, L.G., Jr., W.E. Pine, III, C.J. Walters, S.J.D. Martell. 2006b. Age-structured mark-recapture analysis: a virtual-population-analysis-based model for analyzing age-structured capture-recapture data. North American Journal of Fisheries Management. 26:201-205.

- ASSUMPTIONS
  - ASMR assumes a length/age dependent mortality schedule.

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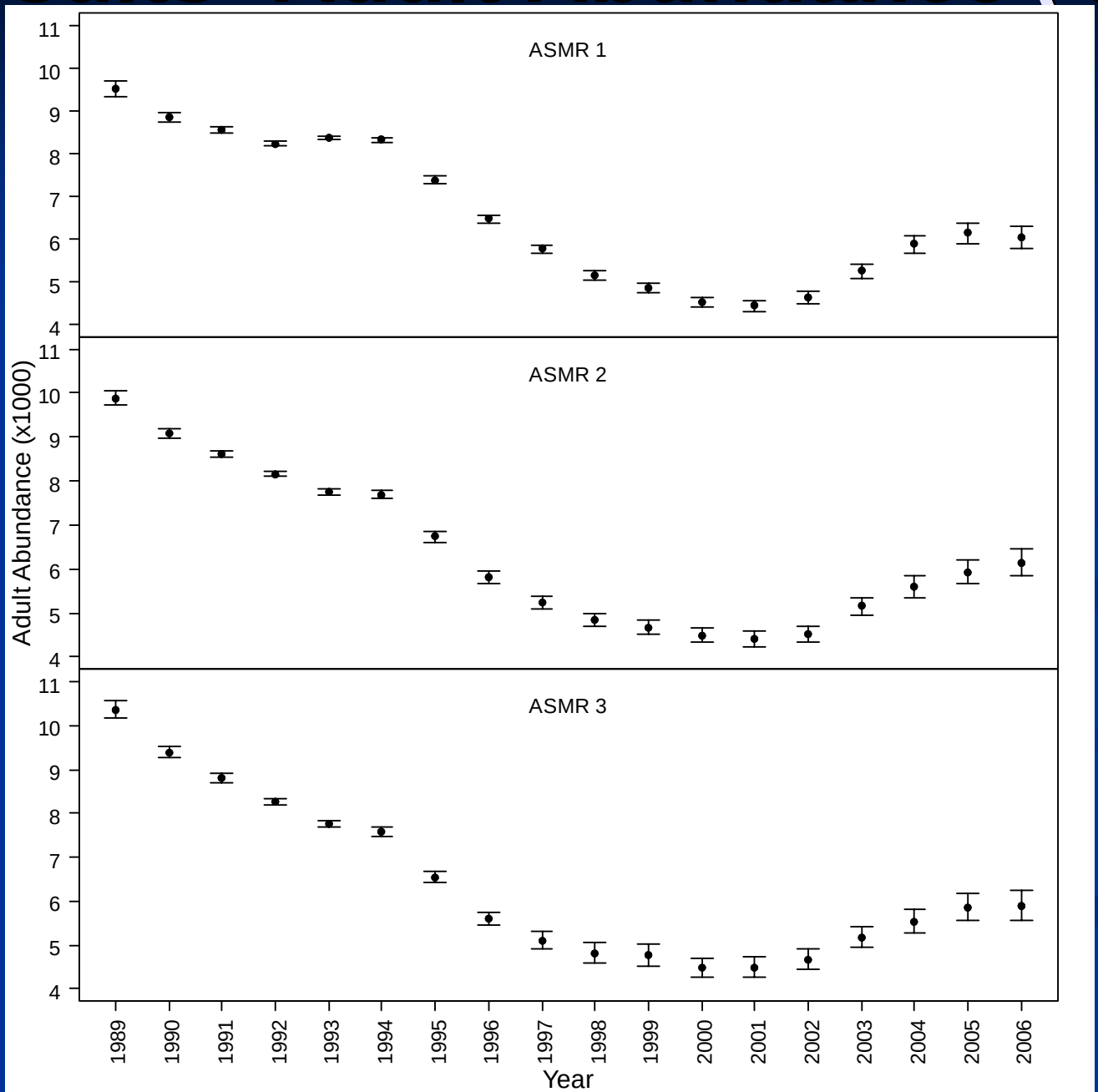
Background – ASMR Model Structure

- ASSUMPTIONS
  - Assumes size (age) dependent mortality rate
  - Three different formulations of ASMR
    - ASMR 1 and ASMR 2 assume that vulnerability to capture is asymptotic with age.
    - ASMR 3 uses conditional maximum likelihood estimators to estimate each time and age specific capture probability

Results- Adult Abundance (4+)



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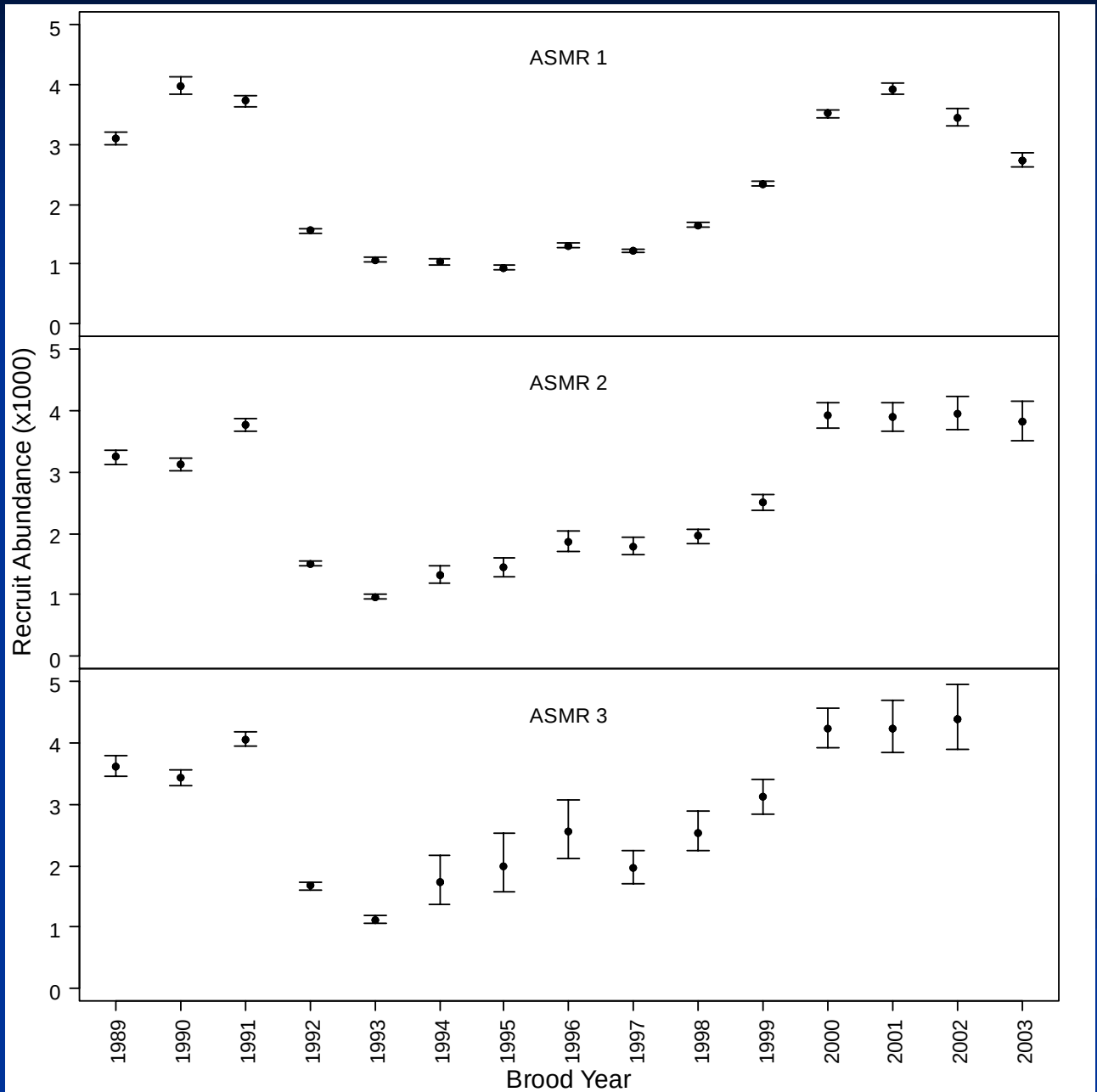
Results- Recruit Abundance



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Results- Which one is “Right”?

- Who Cares… they all say the same thing about adult abundance!
- Maybe we should care… slightly different hypotheses about recruitment.

- How to Arbitrate among models?
  - Pearson Residual Patterns
    - How well does the model fit (predict) the data?
  - AIC scores
    - Kullback-Leibler distance

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Results- Which one is “Right”?

Model	AIC	# Parameters	Rank	ΔAIC
ASMR1	-196278	18	3	2577
ASMR2	-197183	30	2	1672
ASMR3	-198856	895	1	0

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Is there anything wrong with this assessment?

- Estimates are extremely precise… maybe too good.
- HBC review panel (Kitchell et al. 2003) recommended evaluating the effect of ageing error on analysis.

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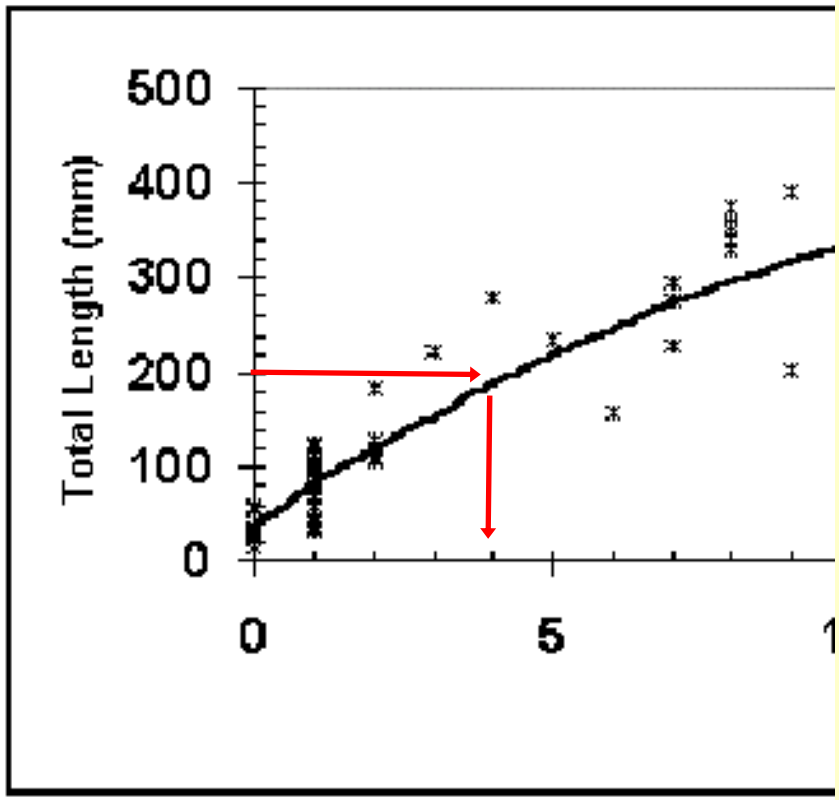
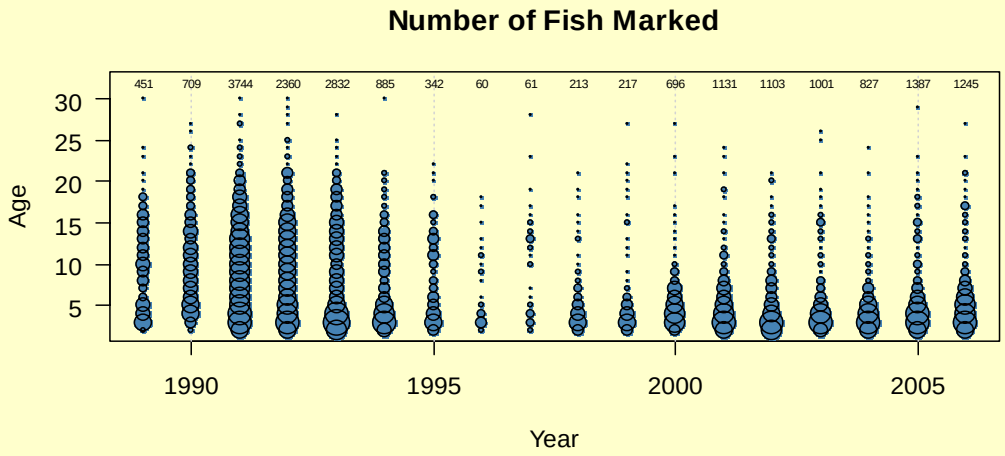
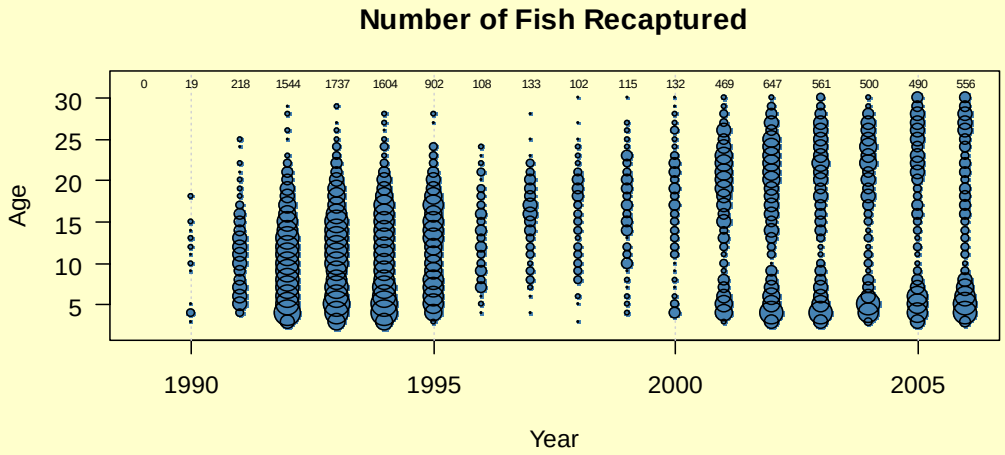
How do you Age chub?

- THE OLD WAY







The Problems

- Better describe humpback chub growth. Why?
  - Based on very limited dataset
  - May not accurately portray growth
    - Particularly growth changes associated with ontogenetic habitat shifts
- Incorporate uncertainty in age assignments into parameter estimates from ASMR. Why?
  - Current assessments may overstate confidence in monitoring results by not honestly incorporating uncertainty from the ageing process.

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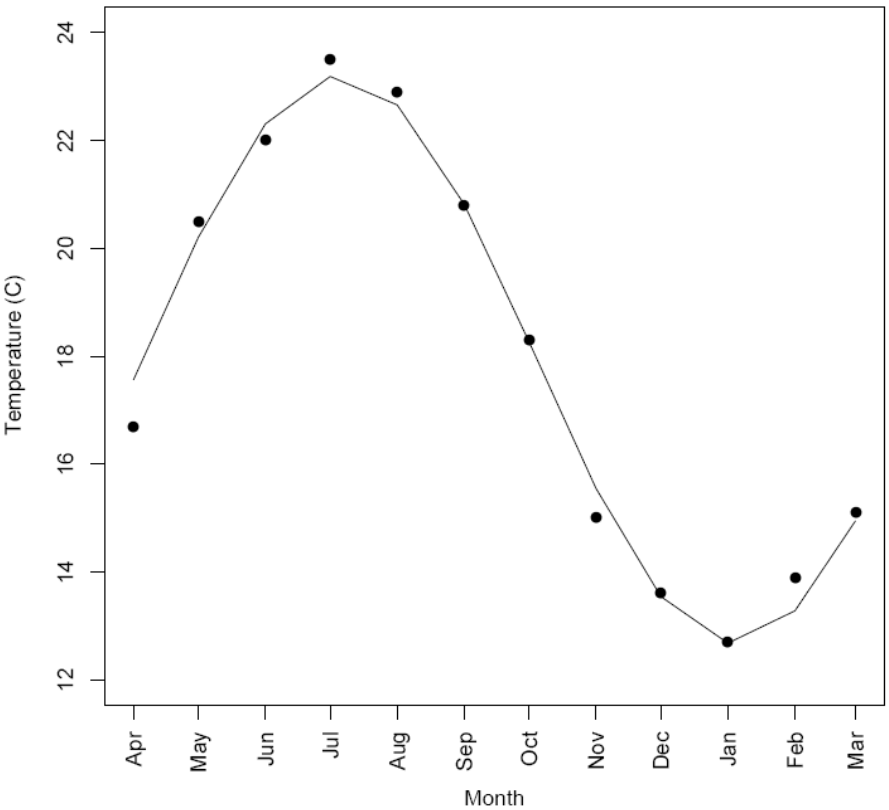
Problem 1 – Better Growth Curve II

- The temperature that a fish experiences depends on whether or not it is in the LCR or the Mainstem and what the temperatures are in each of those habitats.

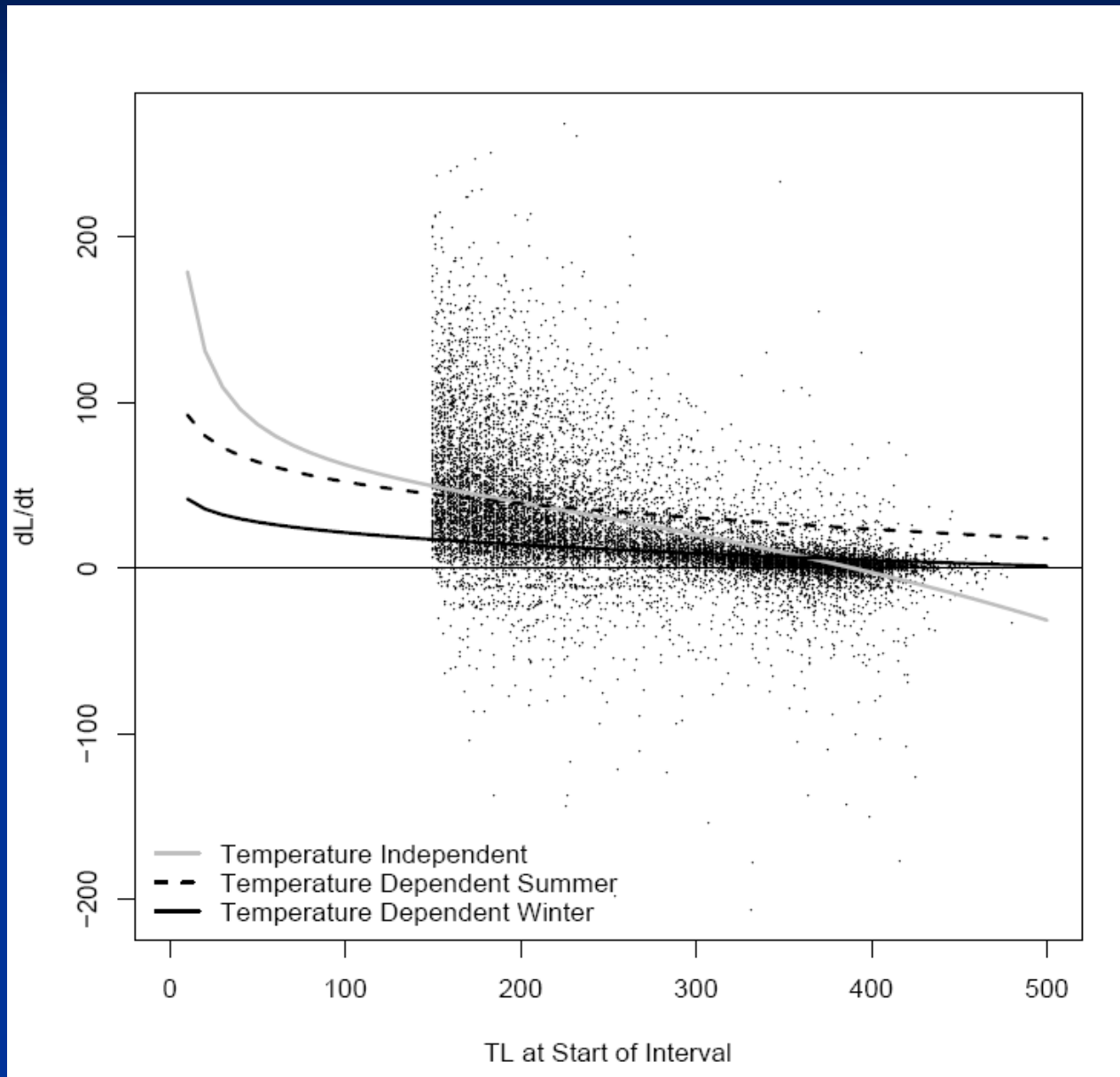


10º C

$$T(t) = (PLCR)T_{LCR}(t) + (1 - PLCR)T_{MS}(t)$$

Growth Curves Fit

- Temperature independent growth curve is a compromise between the winter and summer temperature dependent curves



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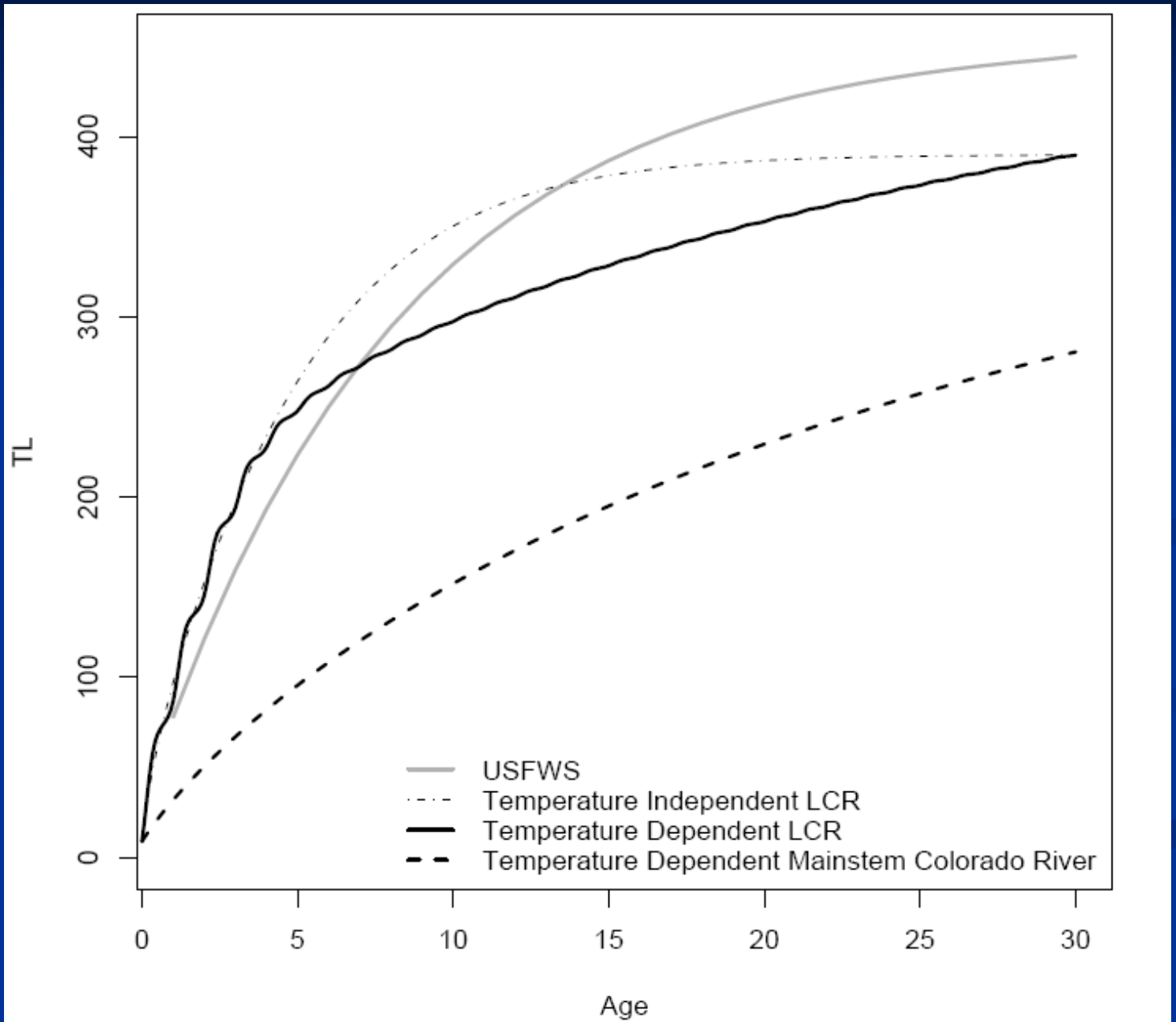
Age-Length Relationship



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Which one is “Right”?

- AIC score clearly indicates that the temperature dependent growth model is superior.

Model	H	d	m	n	L_∞	σ^2_L	Q_c	L_t	Log Likelihood	AIC	# Params.	Rank	?AIC
TIGM	163	0.52	.0007	1.15	391	961	--	--	-66,823	133,658	6	2	38,493
TDGM	21.0	.61	0.46	.89	434	2000	4.59	236	-47,574	95,165	8	1	0

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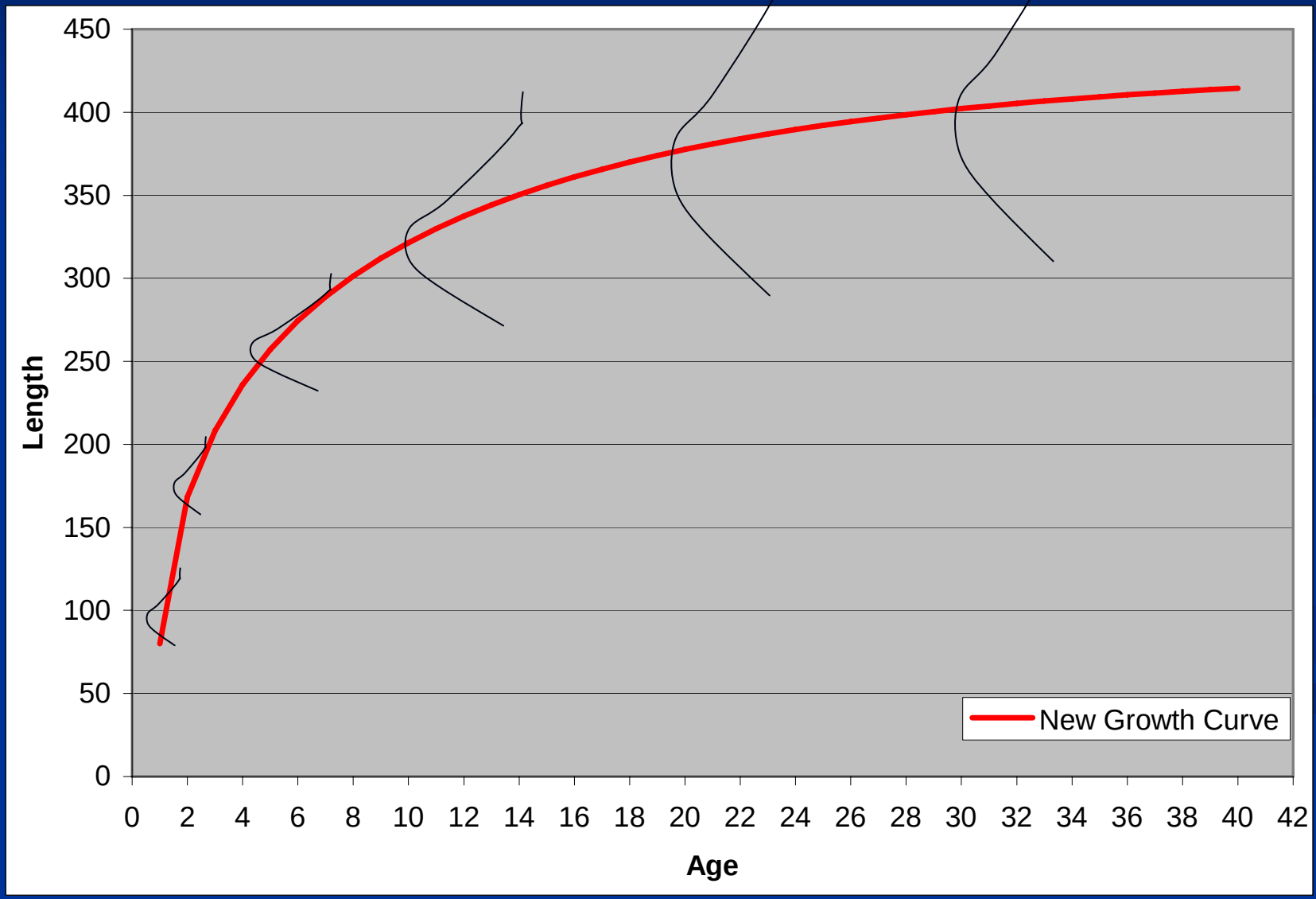
Problem 2-Incorporate Ageing Error



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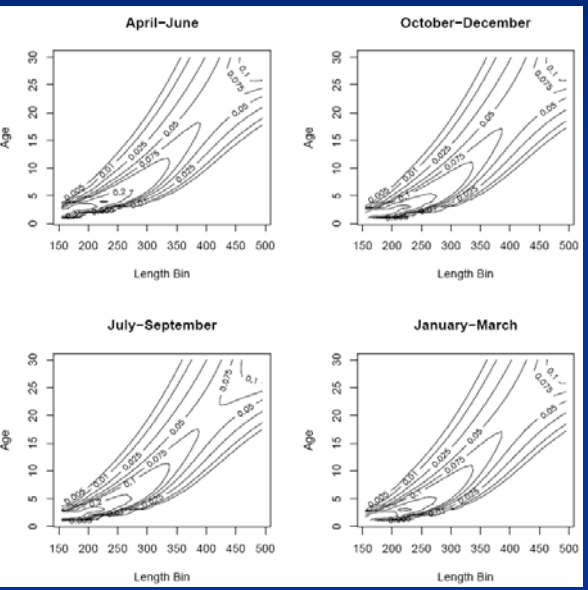
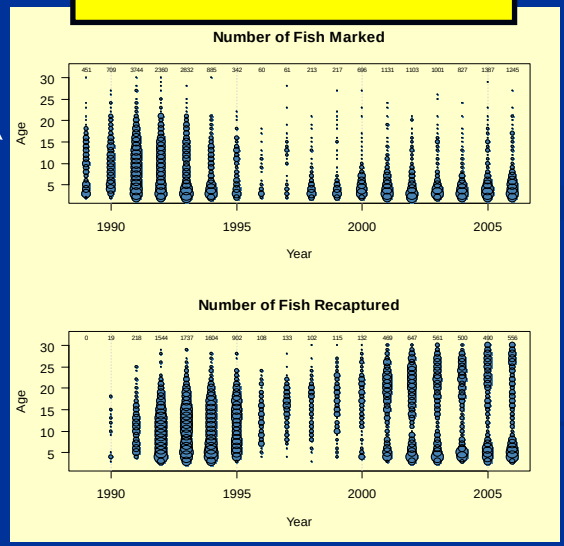
Problem 2-Incorporate Ageing Error

- Flow chart of Monte Carlo simulation…1000 times



- Length of each marked and unmarked fish

AGE-Structured Mark-Recapture Data



ASMR Model

Estimates of: Abundance, Recruitment, Mortality

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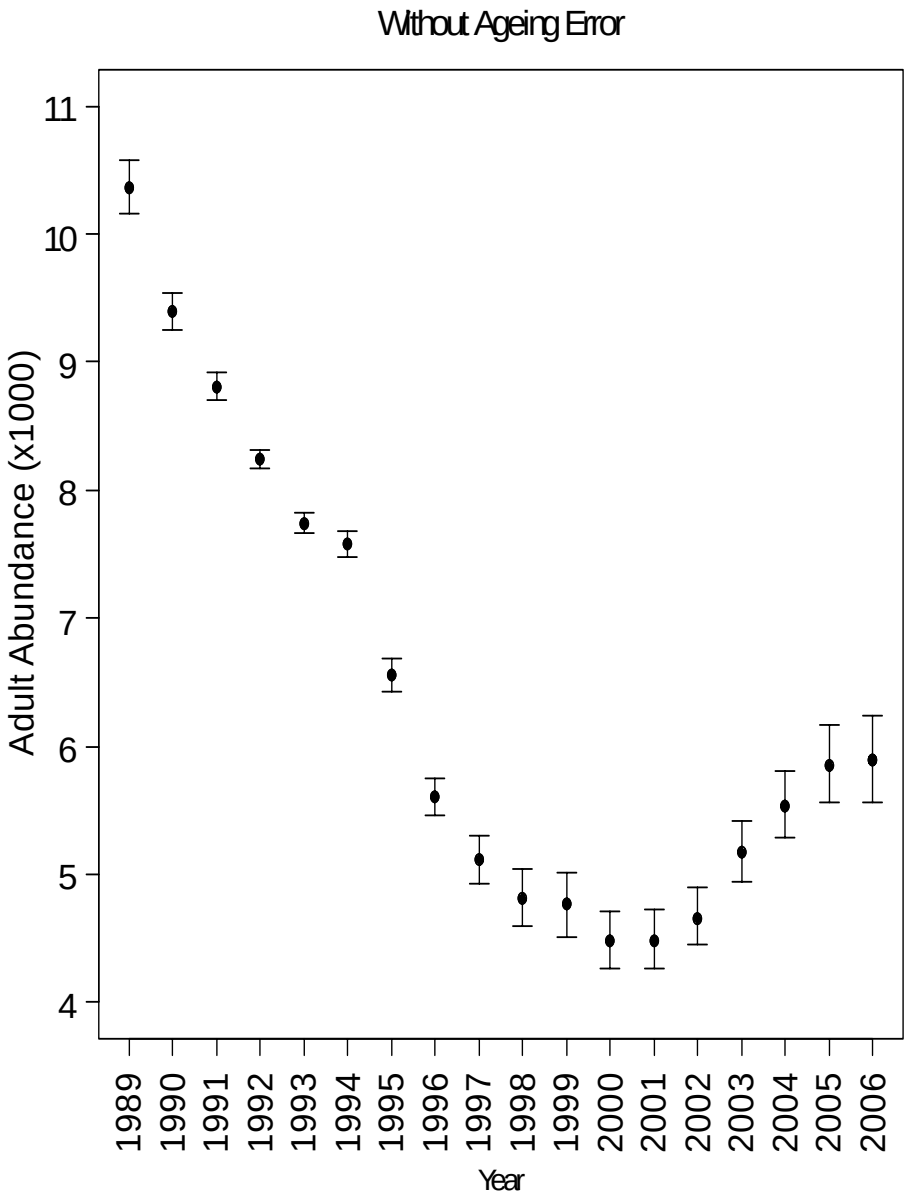
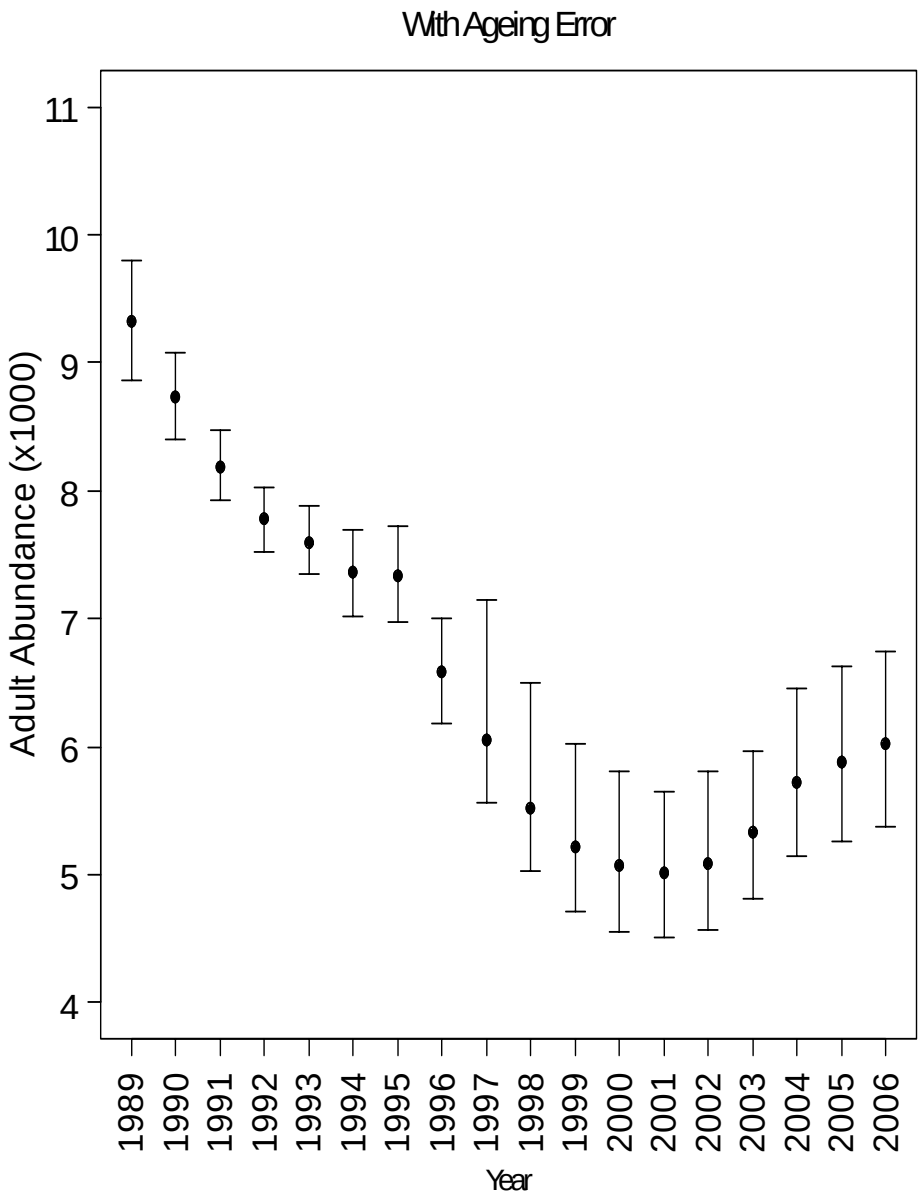
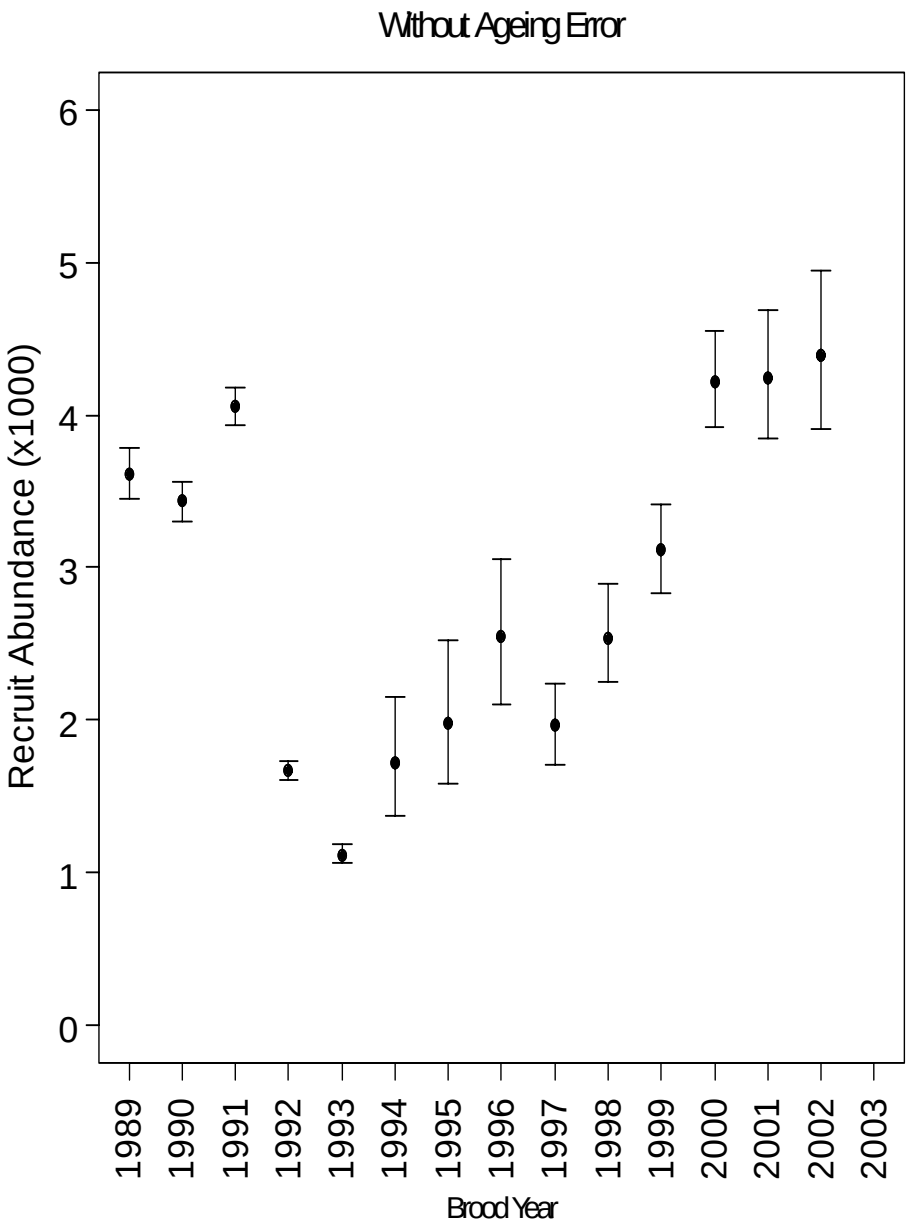
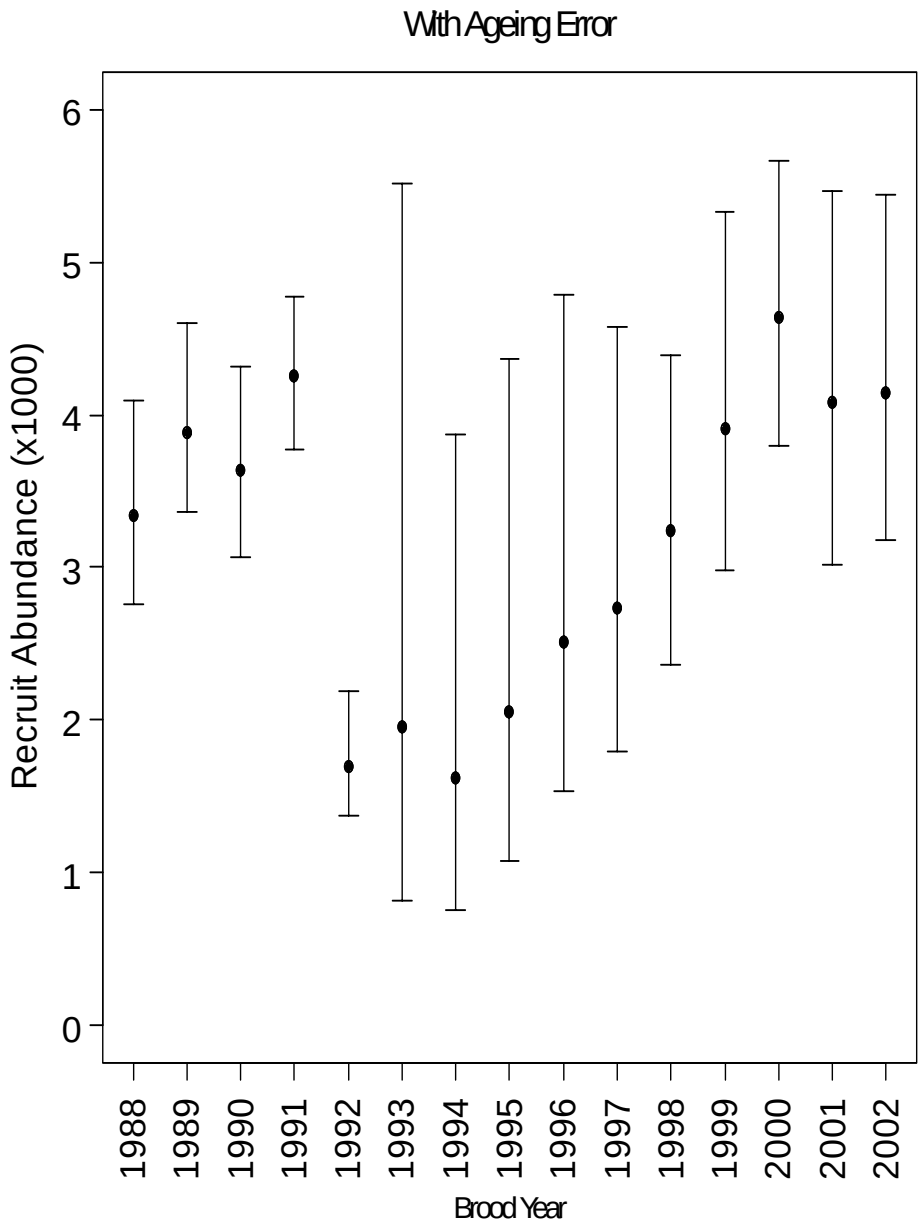
Results- Adult Abundance without/with Ageing Error



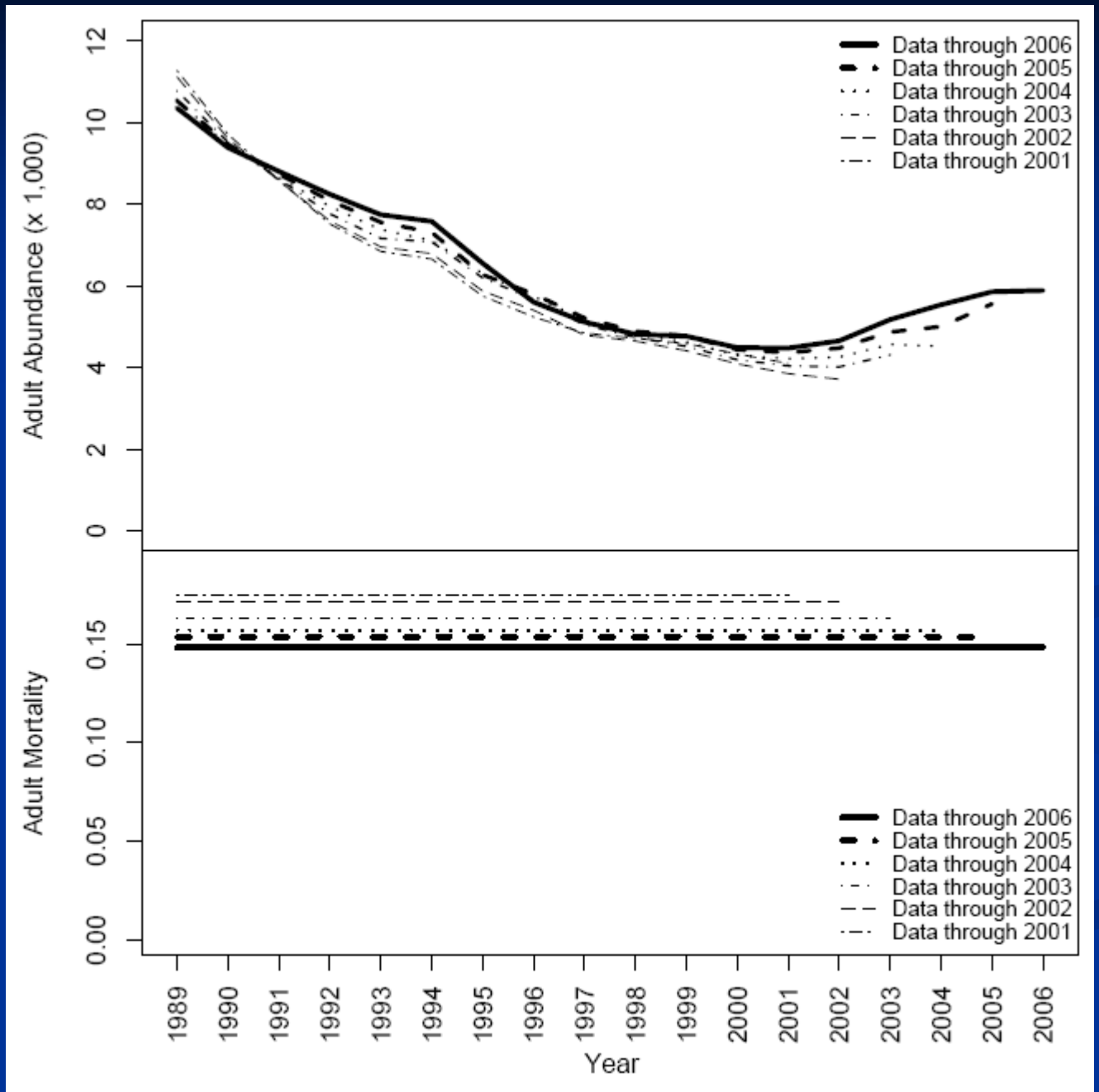


Results- Recruit Abundance without/with Ageing Error





Results- Retrospective Analysis



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Conclusions

- Model selection tools clearly indicate ASMR3 is most consistent with the data.
  - Why big changes in age-specific vulnerability over time?
    - Less trammel-netting in the mainstem?
    - More reliance on small hoop-nets in the LCR?
    - Limited temporal coverage?
- ASMR3 adult (4+) abundance estimates considering ageing error:
  - 2006 - 6,017 (95% CI 5,369–6,747)
  - 1989 - 9,322 (95% CI 8,867–9,799)
  - ~ 20-25% increase in point estimates since 2001
  - Most likely associated with increased recruitment beginning no later than 1999 and possibly as early as 1996

Conclusions

- ASMR Results do not track well with catch-rate indices or Spring LCR mark-recapture
  - For catch-rate data, not too surprising considering reliability of catch-rate metrics.
  - A bit disconcerting for Spring LCR abundance estimates, but not too surprising considering imprecision to detect a 25% increase.
  - Preliminary Spring 2007 LCR abundance estimate looks to be much larger than 2006 ~2x (van Haverbeke, pers. comm.)
    - Provides support for ASMR, but questions reliability of closed population estimates in the LCR.

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Conclusions

- Considering ageing error doesn't seem to add excessive bias, but does decrease precision
  - Need to have big changes in recruitment to detect with ASMR.
  - Argues for experimental treatments that have high probability to impart large changes in recruitment.
- Big changes (decreases in effort) in sampling program are not advised as it is problematic for data interpretation.
  - Witness long lasting effects of decreases in sampling effort ~1996-1999.

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