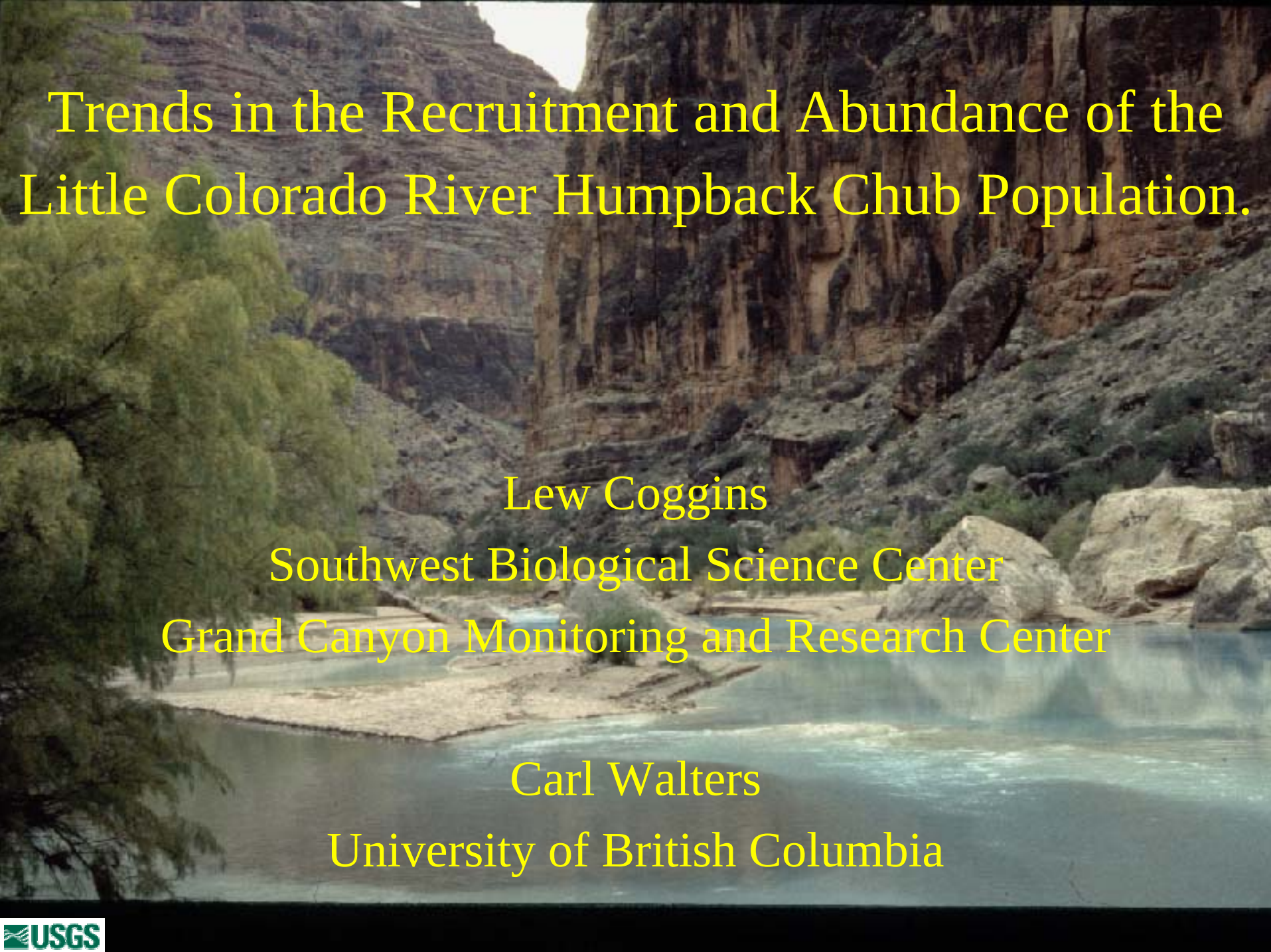

Trends in the Recruitment and Abundance of the Little Colorado River Humpback Chub Population.

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Southwest Biological Science Center

Grand Canyon Monitoring and Research Center

Carl Walters

University of British Columbia

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History of Monitoring Studies

- Scattered mark-recapture estimates prior to early 1990s
- Intensive marking and sampling in LCR and mainstem during early 1990s
- Low intensity sampling from 1996 to 1999
- Moderately intensive sampling from 2000 to present

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Current Stock Assessment Approaches

- Since 2000 we have been developing open population assessment models to infer long-term trends in the recruitment and abundance of the LCR population of humpback chub utilizing mark-recapture data.
  - Supertag
  - Age Structured Mark Recapture (ASMR)
- Since 2000 we have been conducting Spring and Fall closed population abundance estimates within the LCR utilizing mark-recapture data.

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Estimating Abundance via Mark-Recapture

- Open population models
  - Estimate abundance, mortality, or recruitment
  - Jolly-Seber, Cormack-Jolly-Seber, ASMR
  - Long Term Data (Multiple years)
- Closed population models
  - Estimate abundance but not mortality or recruitment.
  - Chapman-Peterson, Schnabel, Program Capture
  - Short Term Data (within a year)

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Recap of Recent Open Population Assessment Models

- Supertag
  - Assumed initial stable age distribution
  - Specified age/size dependent vulnerability
    - Did not account for complex patterns of age/time dependent capture probabilities resulting from changes in sampling programs, fish movement patterns.
  - Resulted in gross overestimate of mortality.
  - Resulted in downward bias in estimates of abundance.
  - Provided an unbiased trend assessment.
- Age Specific Mark-Recapture (ASMR) model
  - Attempts to deal with above issues

Model Structure - ASMR

- ASMR comprised of two sub-models:
  - State Dynamics Model : specified by age-structured population model
  - Observation Model : Predicts number of marked and unmarked fish captured by age and year
- Observations (or data) consist of numbers of unmarked and marked fish sampled over ages and years.

Model Structure - ASMR

- Estimate Unmarked Fish by cohort each year
  - Backward Virtual Population Analysis (VPA) type calculation
- Estimate Marked fish by cohort each year
  - Forward mortality type calculation
- Allows size (age) dependent mortality rate
- Estimates time and age specific capture probability (p^)

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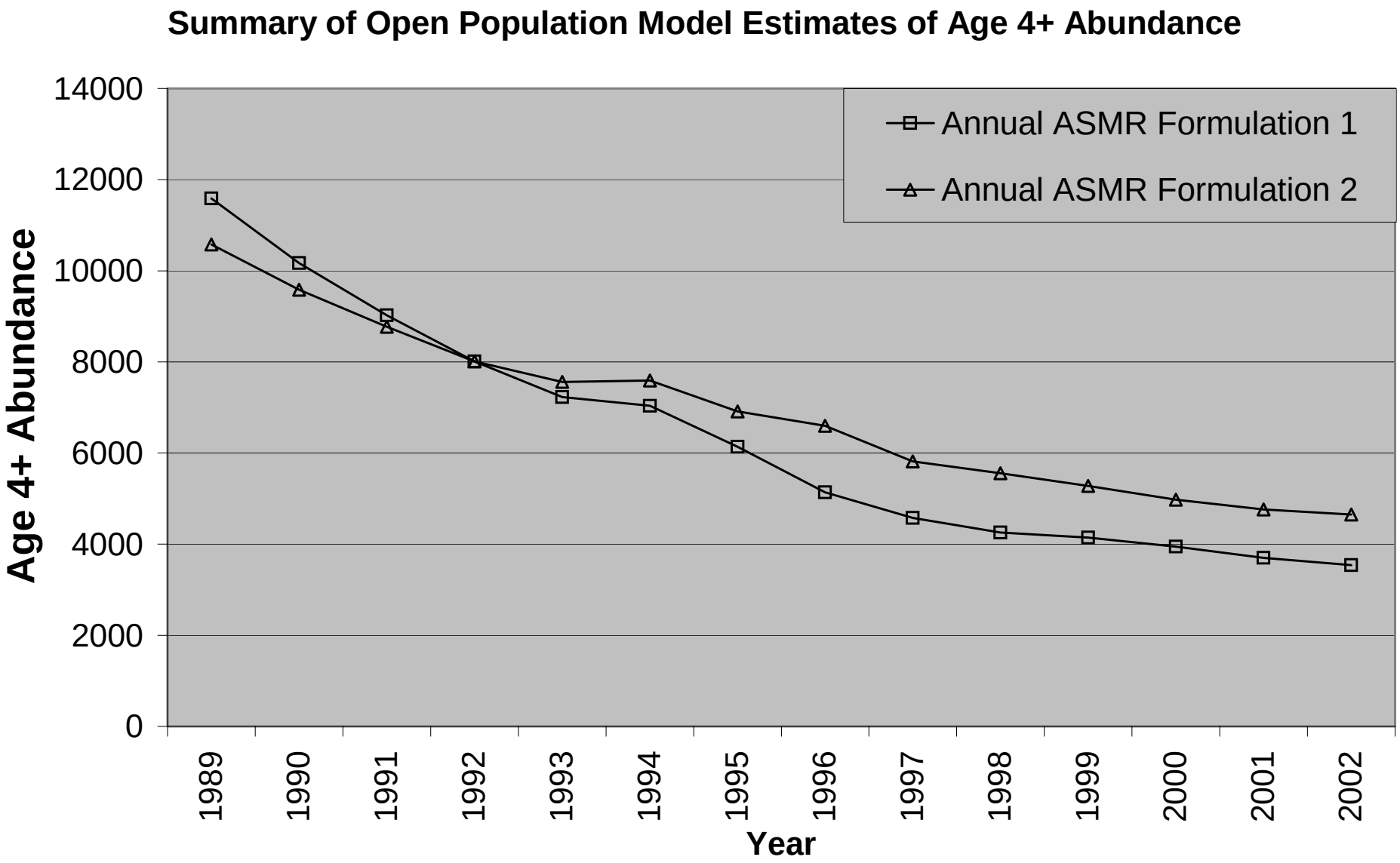
Model Structure - ASMR

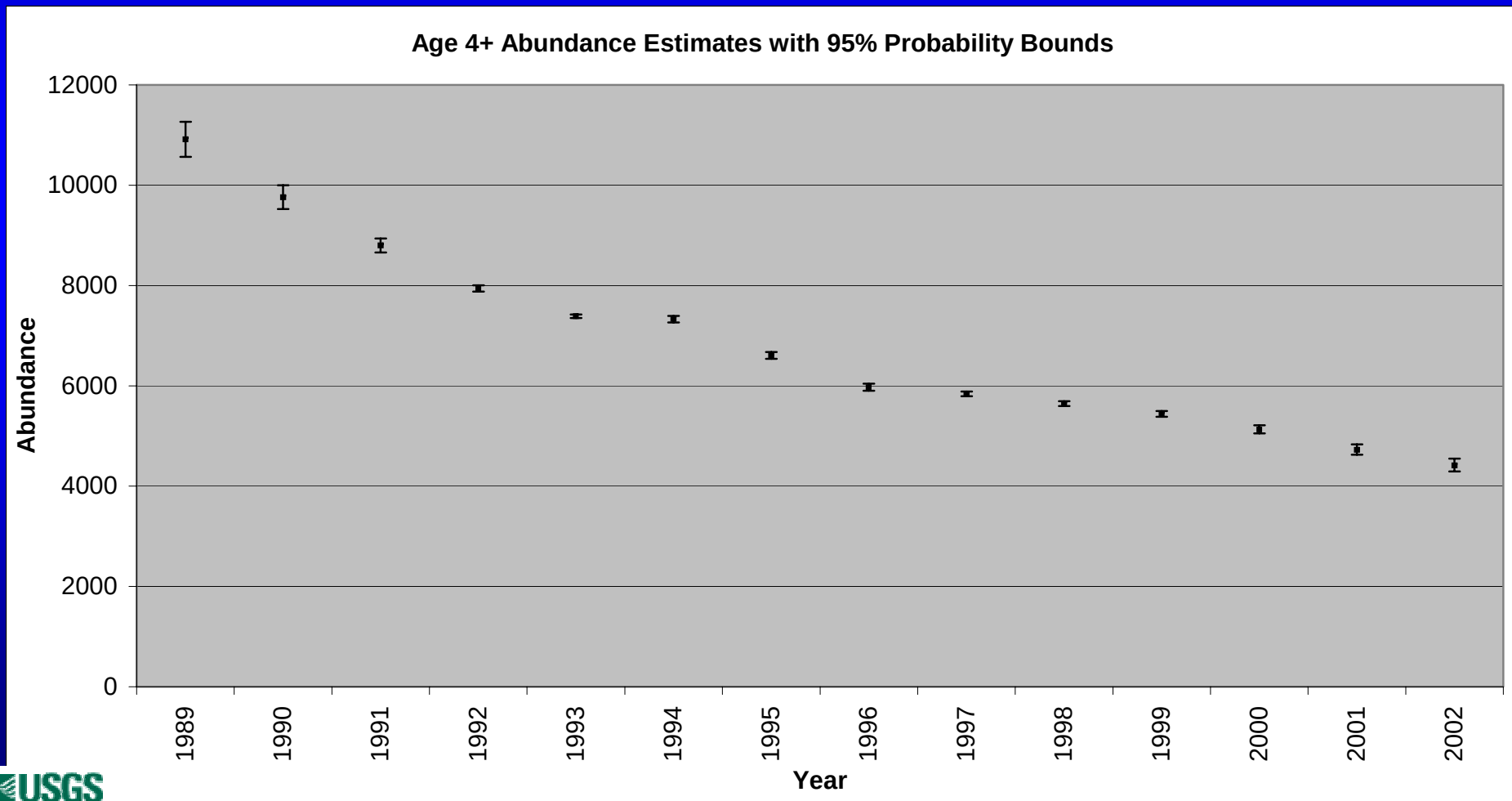
- Two basic incarnations of Annual ASMR
  - Formulation 1: Adult Mortality, Age/Time Specific Vulnerability, Terminal Abundances
    - Assumes age specific vulnerability is constant over blocks of time
  - Formulation 2: Adult Mortality, Terminal Abundances, age and time specific capture probability
    - Assumes age specific vulnerability not constant

Results – ASMR Adult Abundance



Results – ASMR Adult Abundance

- Can estimate confidence (credible) intervals from posterior probability distribution using markov-chain monte carlo (mcmc) procedure.



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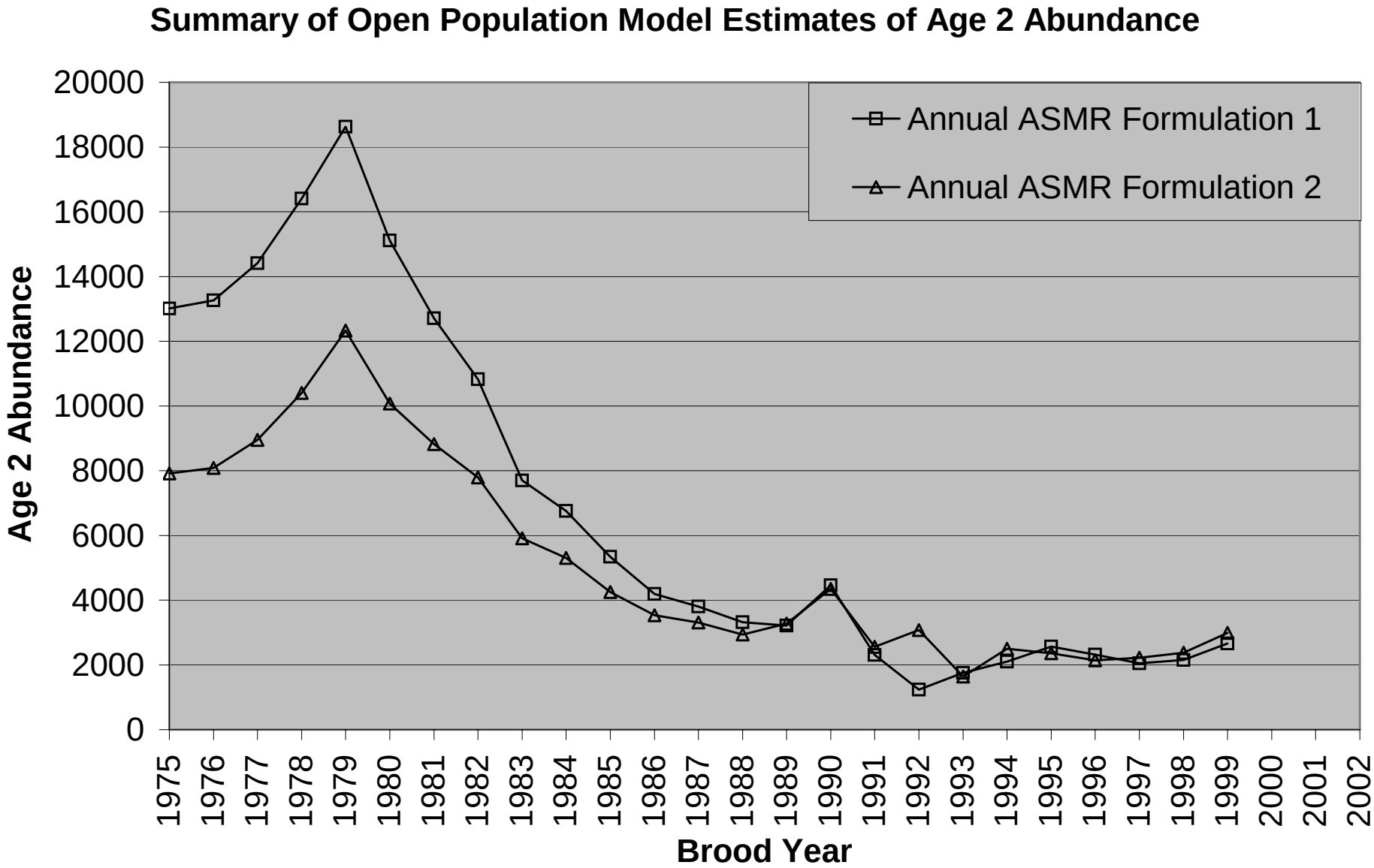
Results – ASMR Recruitment



Results - ASMR

- Differences in model estimates due to:
  - Lower mortality estimate in Version 2
    - Trade off between variability in capture probabilities and mortality
- Both models suggest that adult abundance has been in decline for over a decade.

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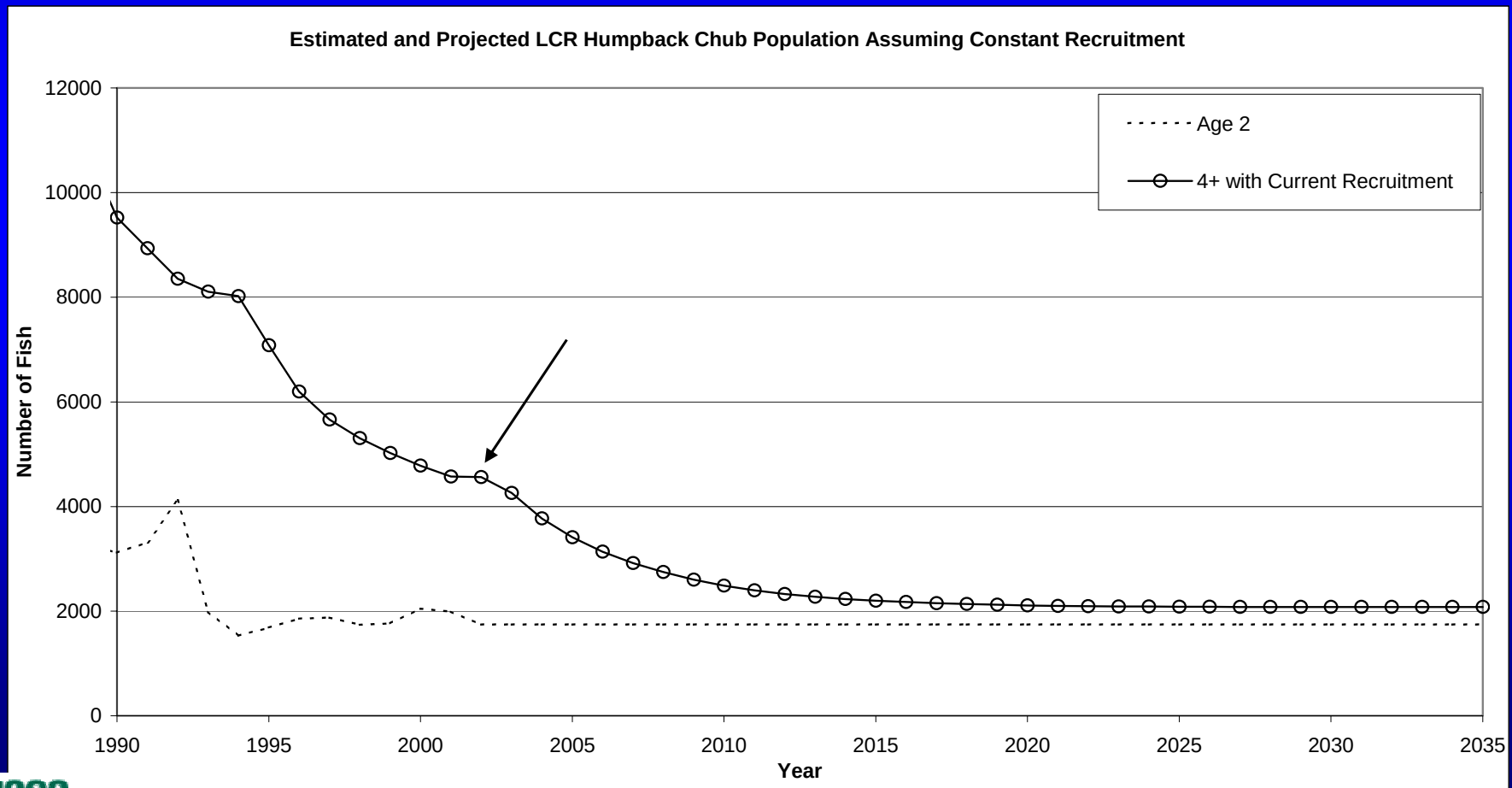
Results - ASMR

- Both models suggest that recruitment is leveling off at about 2000 age-2 fish.
- If this recruitment trend persists,adult abundance will level out at approximately ½ of current level.



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Model Performance

- Three factors greatly complicate the open population mark-recapture analysis, and cause methods to disagree about precise numbers
  - Size-dependent seasonal movement between the LCR and the mainstem (spawning runs, juveniles joining adult runs)
  - Size/age dependent survival rates
  - Assignment of age based on size

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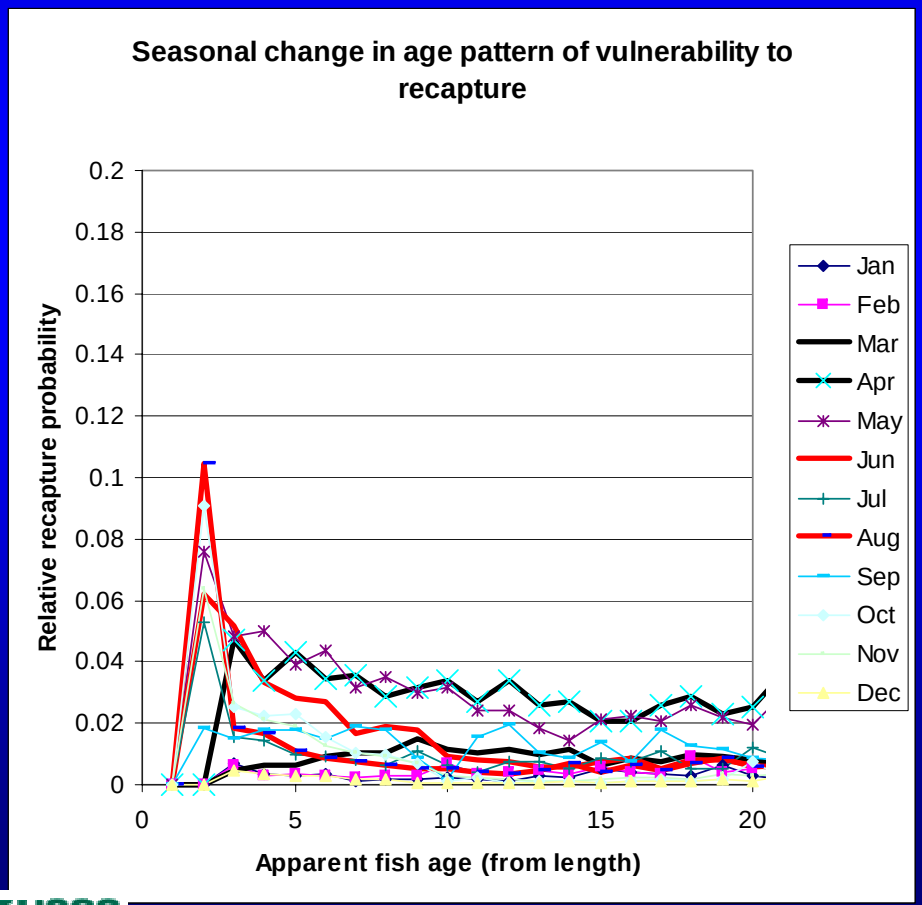
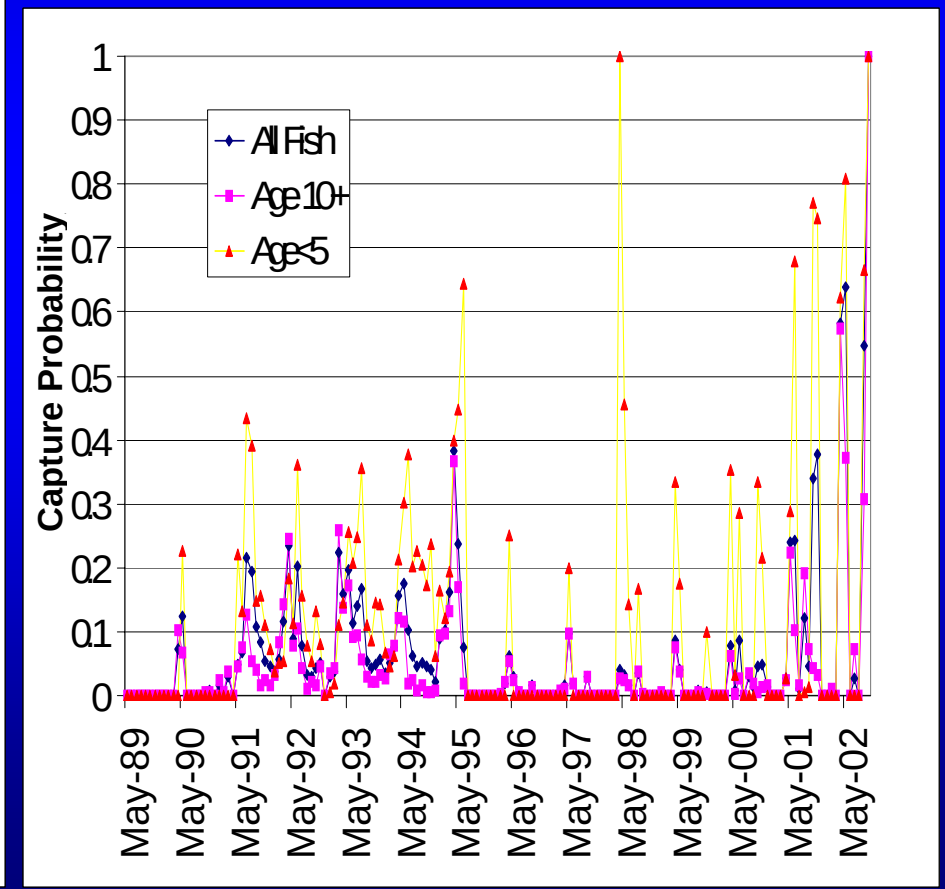
Model Performance

There are complex seasonal and age patterns in capture probabilities





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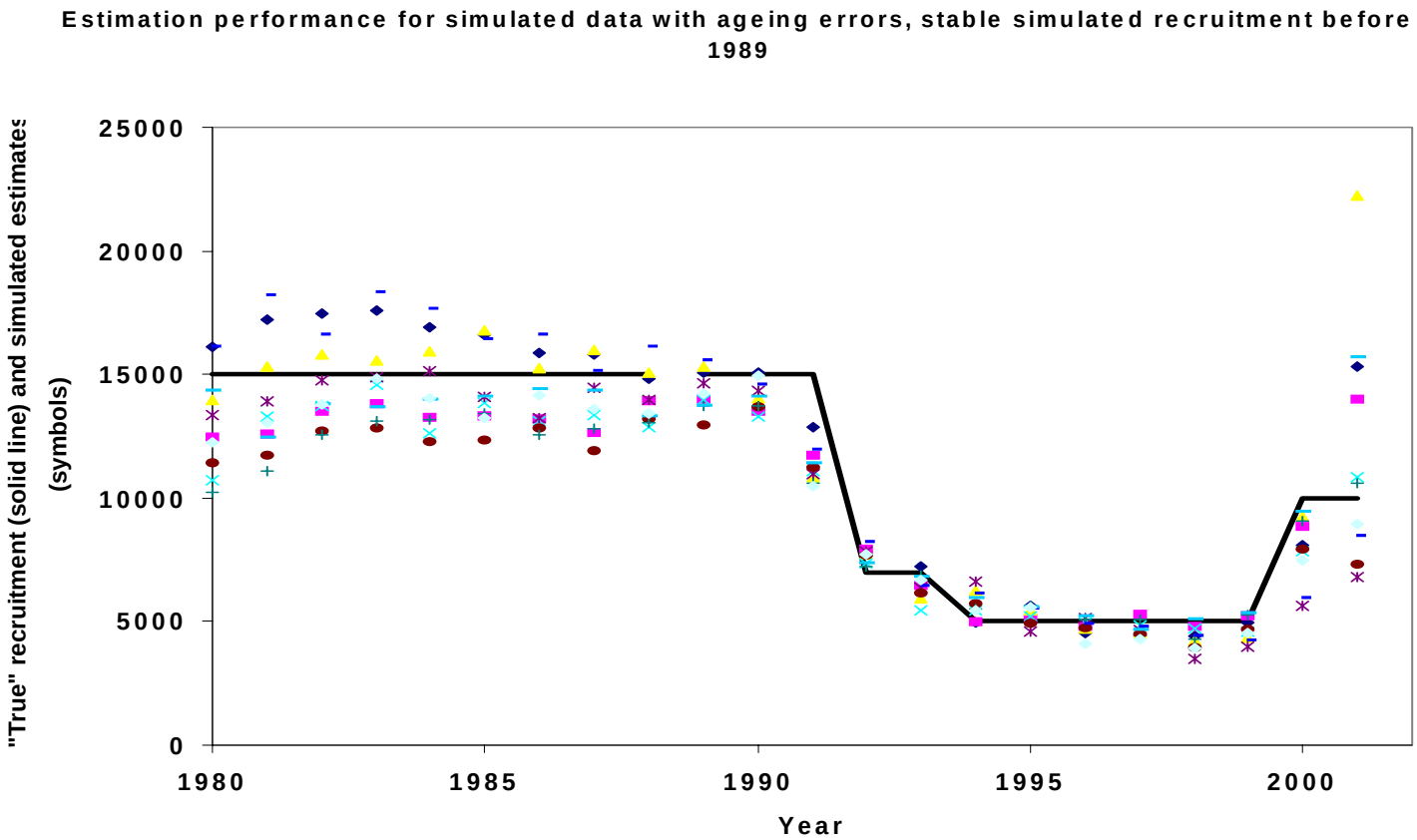
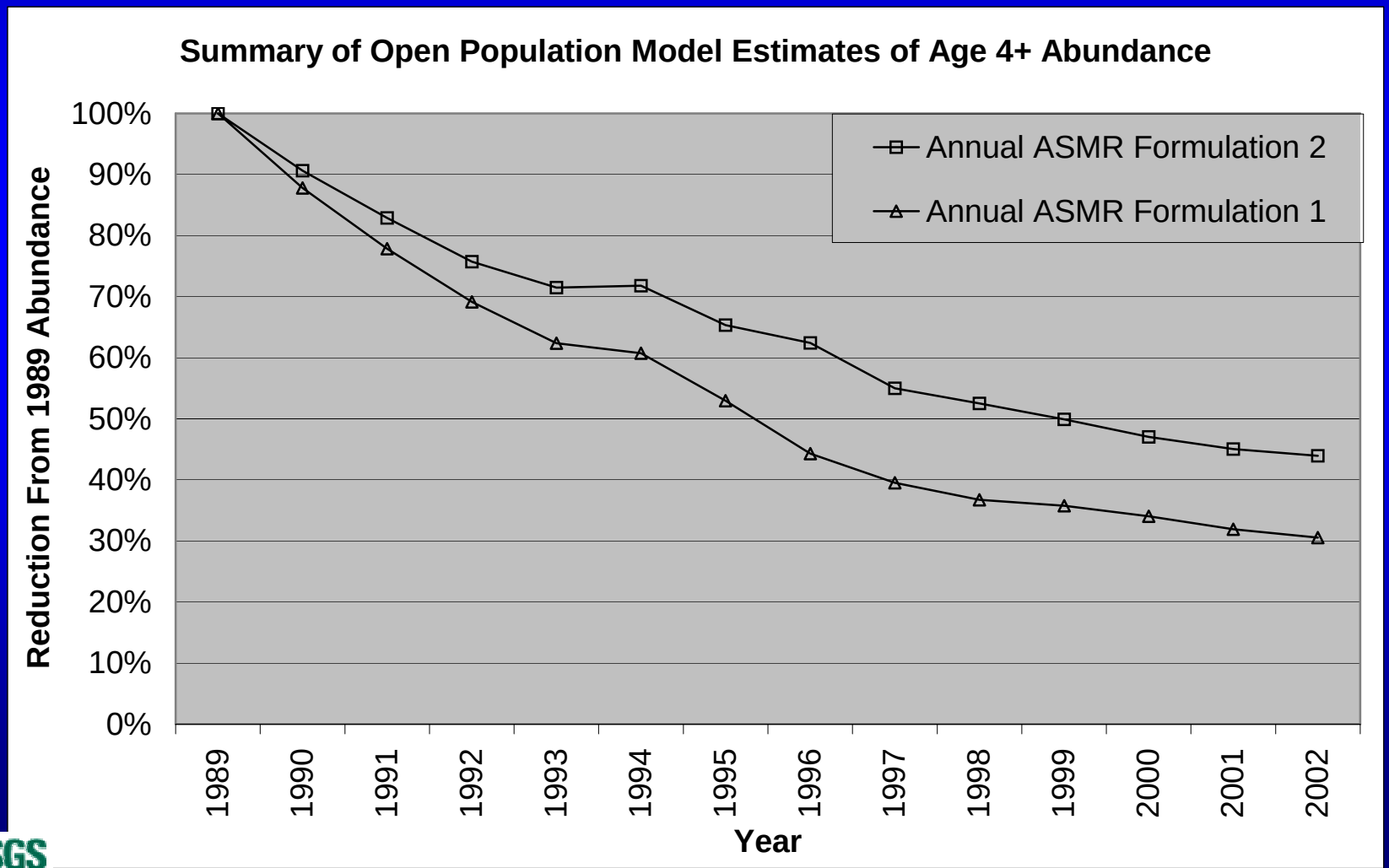
Model Performance

Assigning age with random error causes variability, but not large bias



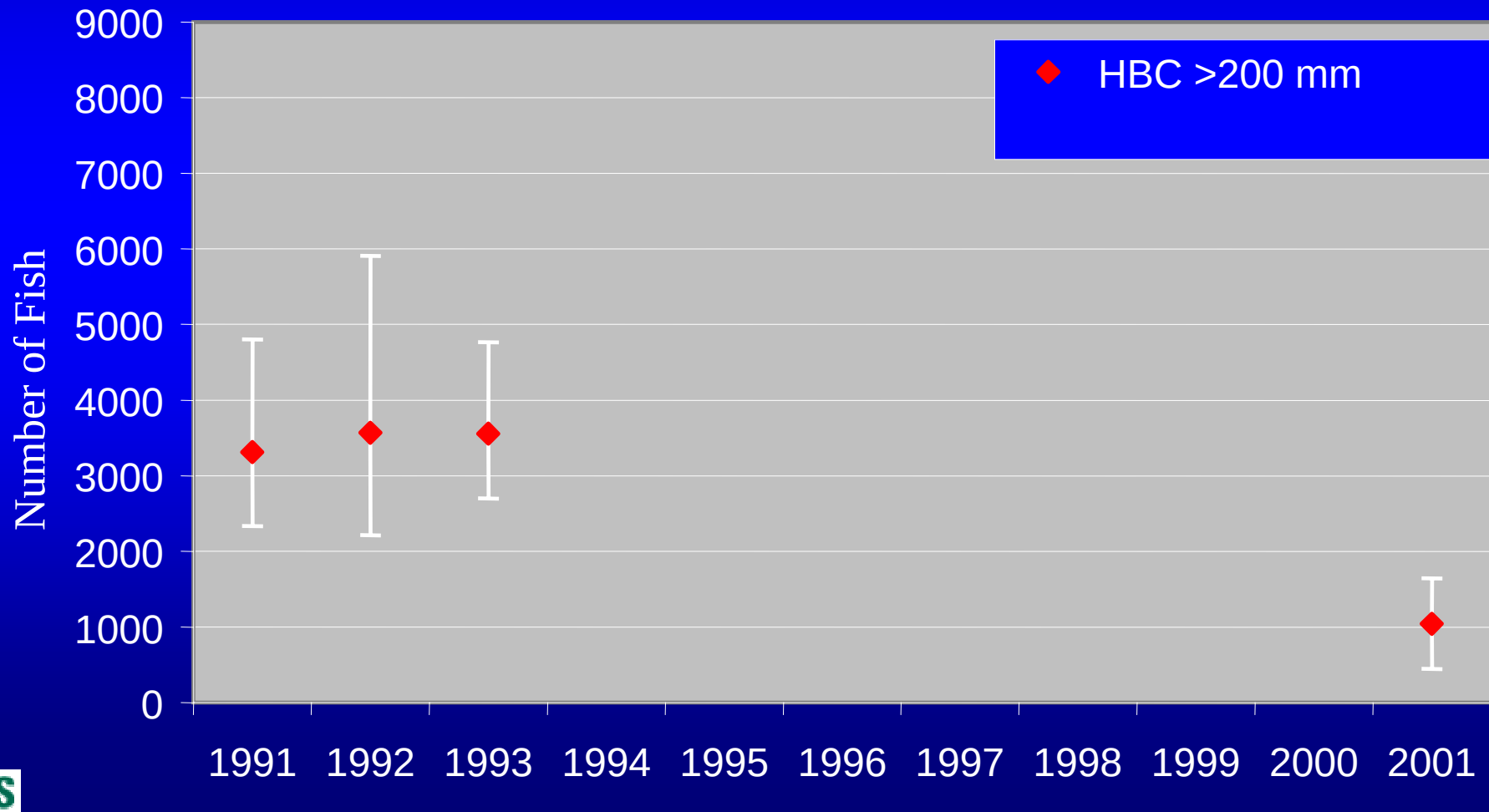
Model Performance

- Which model is “Right”? Which model is useful?
  - Neither ?? Both ??



Model Performance

- Bio/West and SWCA Estimates of Abundance for HBC>200mm in the LCR Inflow Reach



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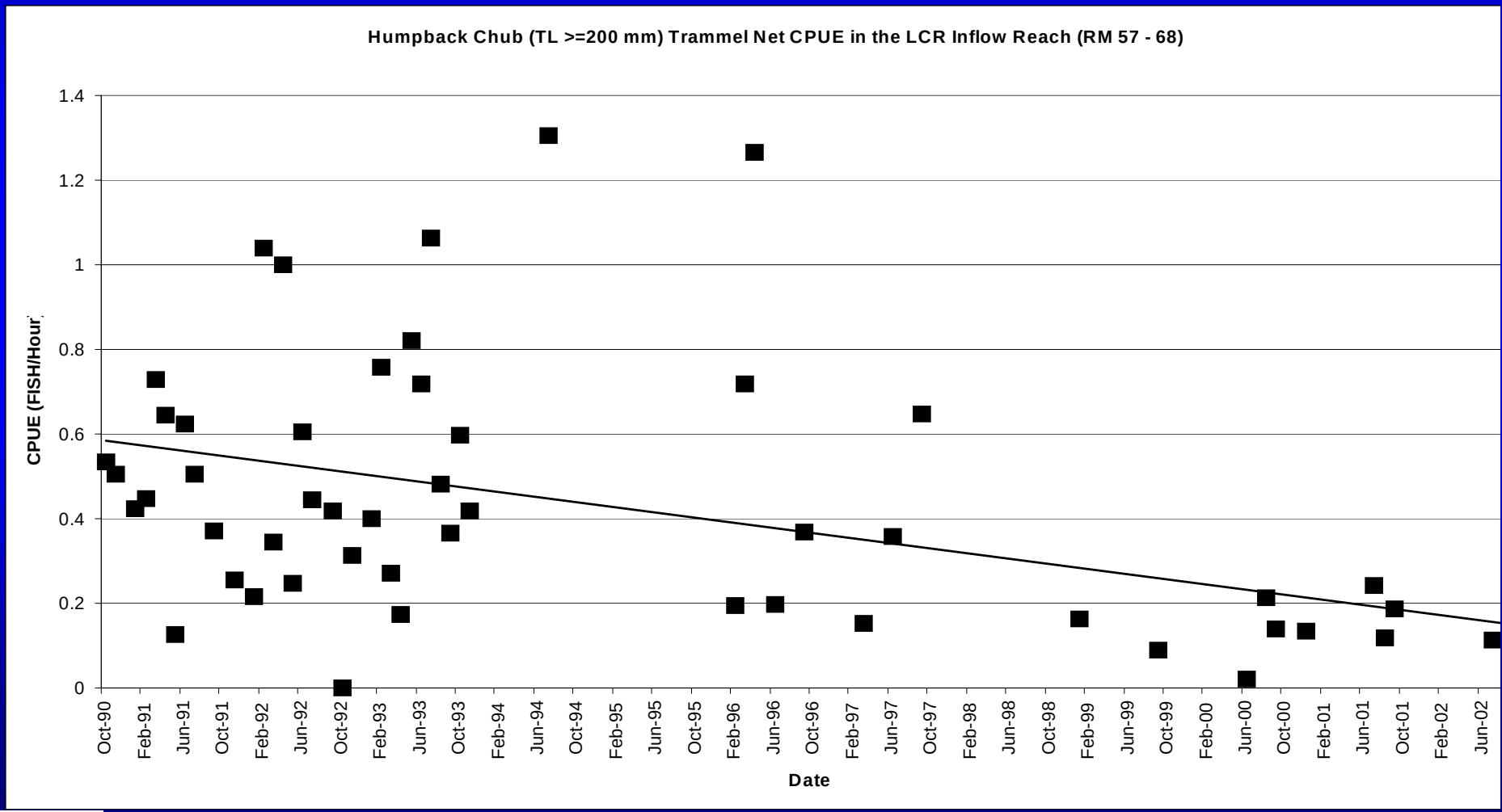
Model Performance

- Relative abundance trend of HBC>200mm in the LCR Inflow Reach



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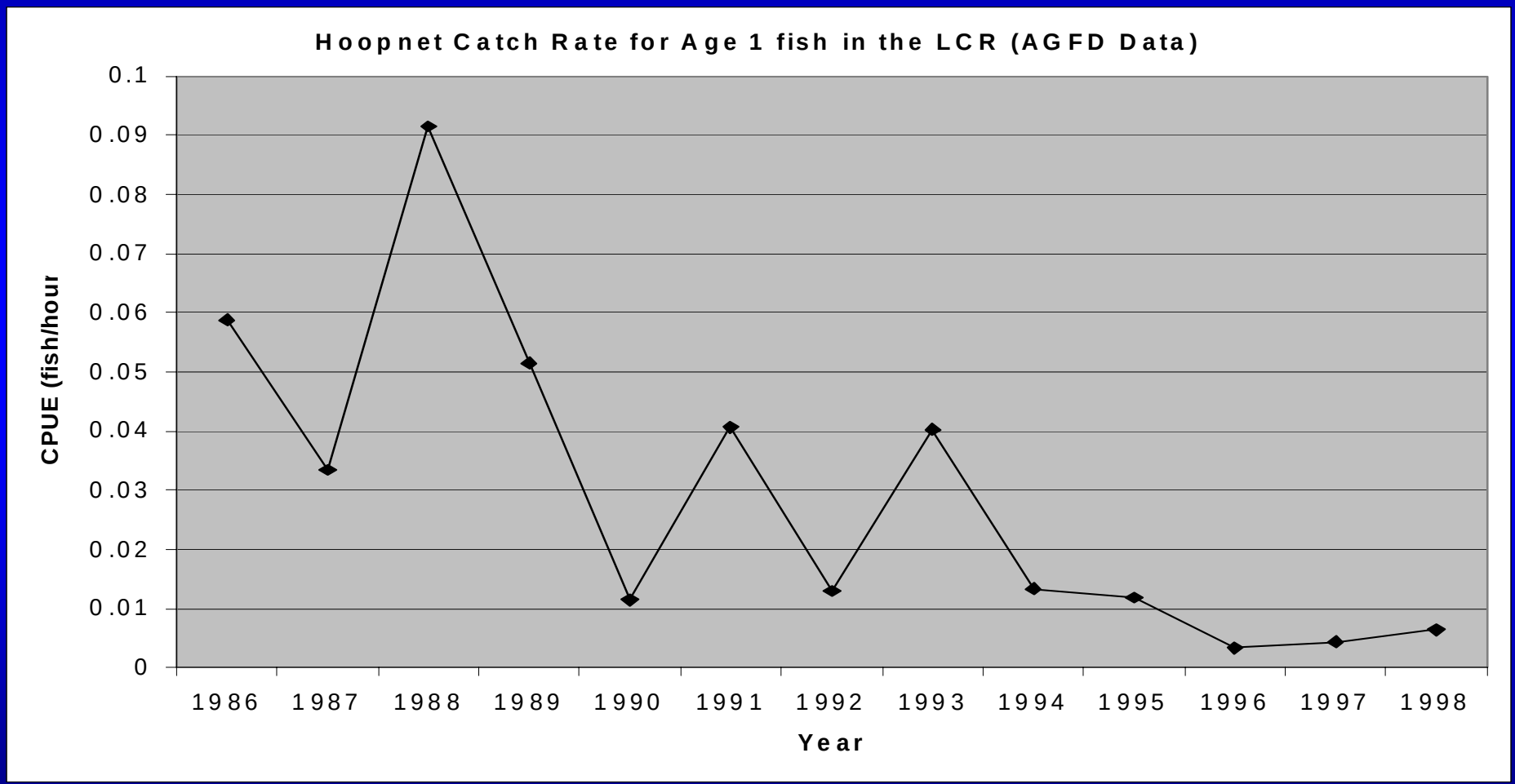
Model Performance

- Relative abundance trend of age 1 fish in the LCR



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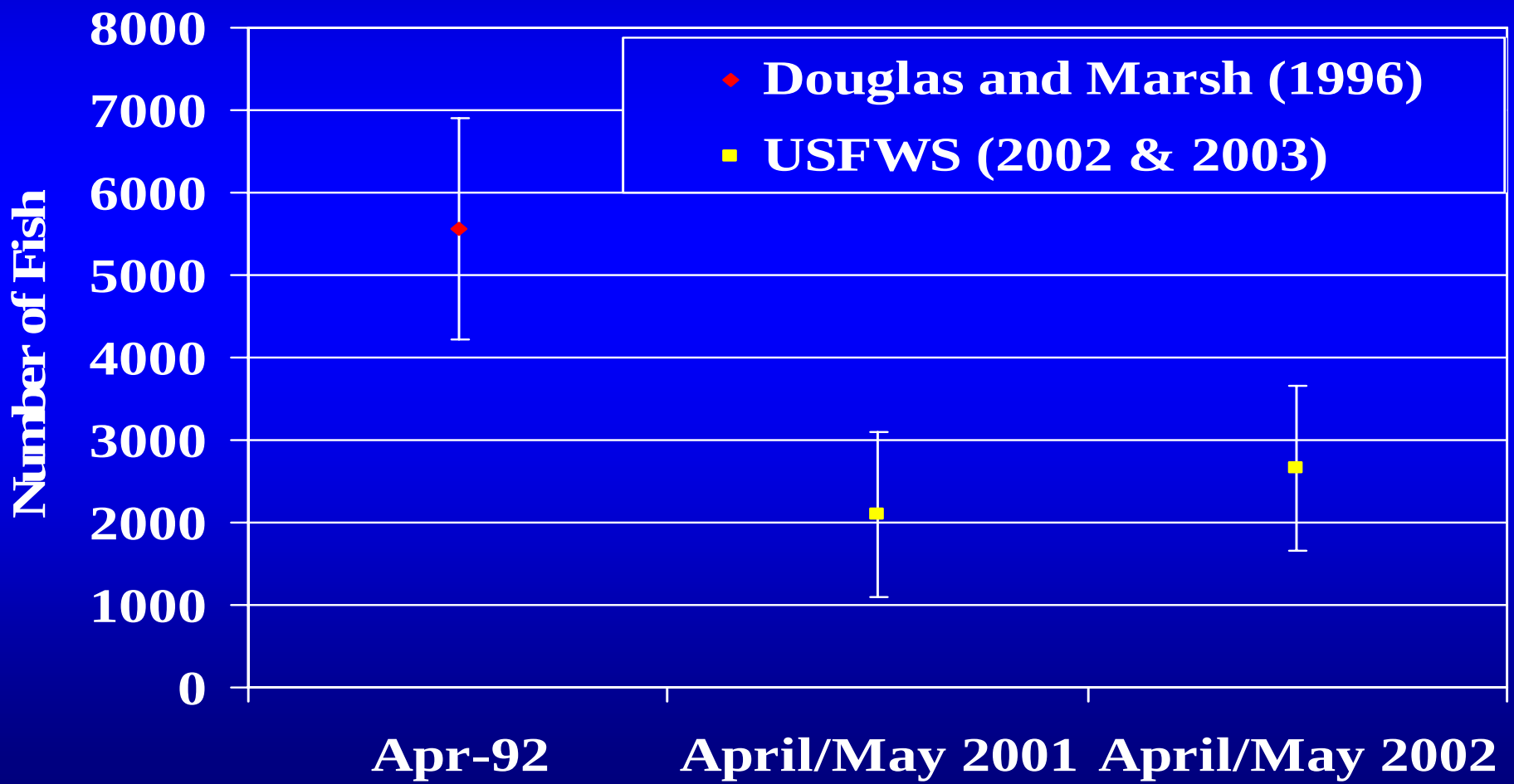
Model Performance

- Closed Population Abundance Estimates for HBC>150mm in the LCR



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Model Performance

- We feel confident that the pattern of decline in adult abundance is true.
- Can the model detect a future deviation from the declining trend?
  - Only way to know for certain is to wait and see.
  - Can use simulation to help predict.

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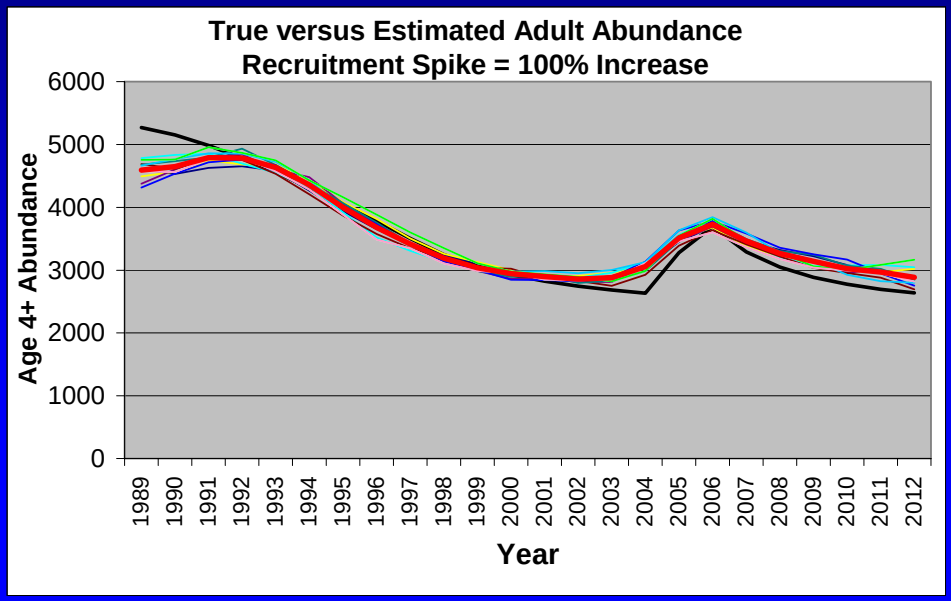
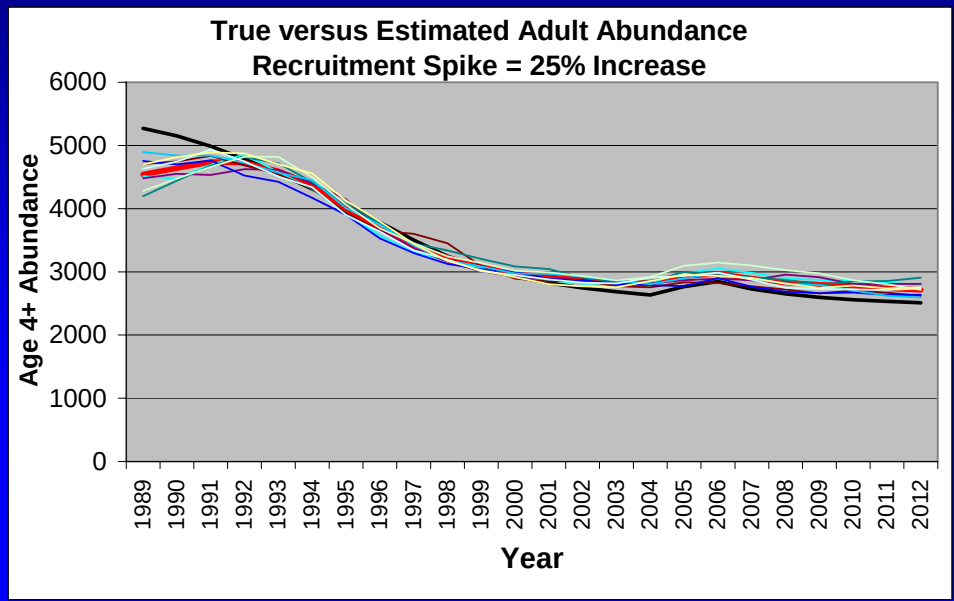
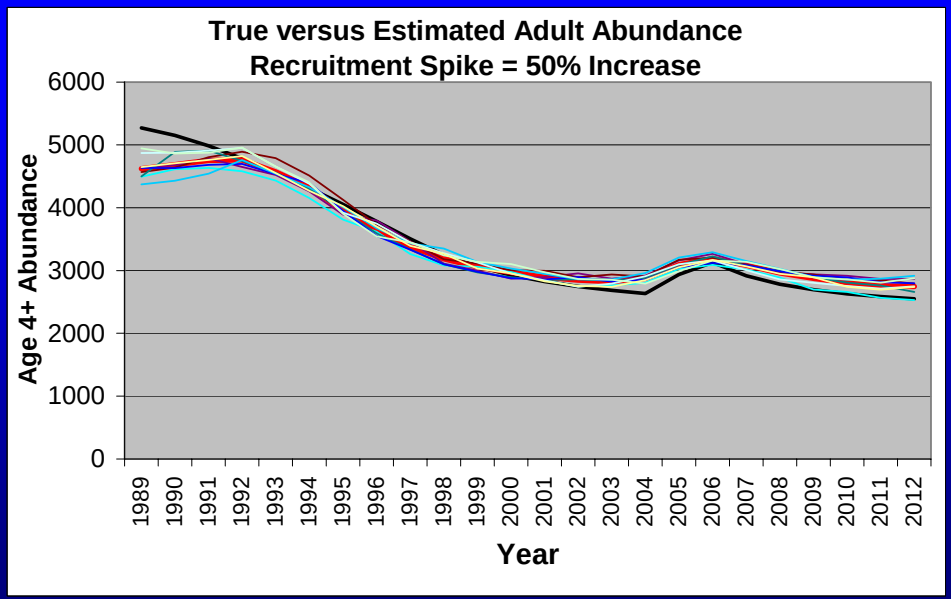
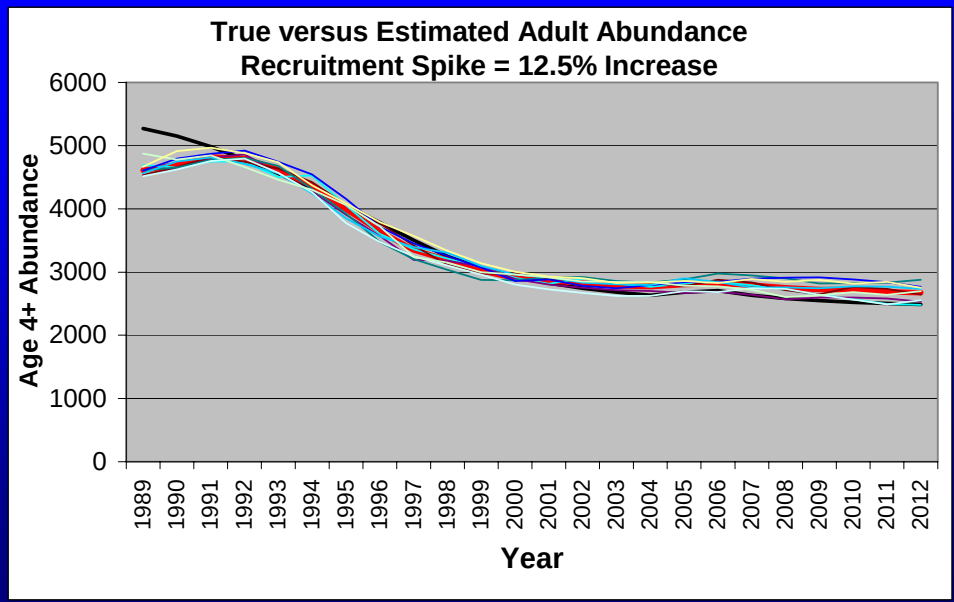
Model Performance









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Conclusions

- All data sources suggest that adult humpback chub abundance has been in decline for over a decade.
- If current recruitment persists, adult abundance will continue to decline, probably to approximately ½ current level.
- Model is useful to managers
  - Can recreate historic trends in recruitment and adult abundance.
  - Based on simulation, can detect future changes in trend if large enough.

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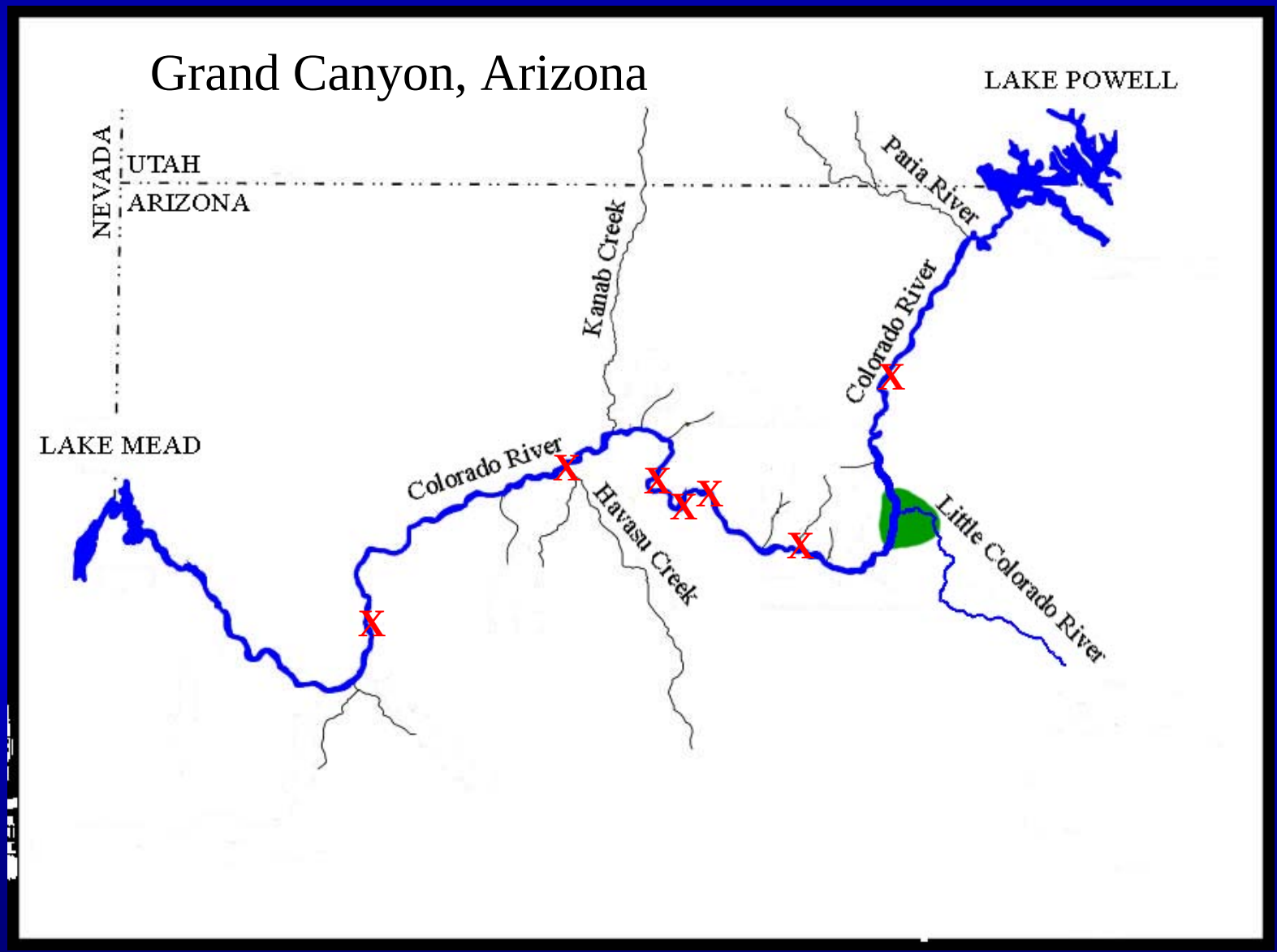
Acknowledgements

- Major contributors the Grand Canyon humpback chub database
  - Arizona State University
  - BioWest, Inc.
  - Arizona Game and Fish Department
  - SWCA, Inc.
  - Grand Canyon Monitoring and Research Center
  - US Fish and Wildlife Service

HBC Distribution in Grand Canyon



Fundamental Mark-Recapture Relationship

- Population estimates are based on a ratio assumption:

$$N = \frac{(number\ \_\ caught)}{(capture\ \_\ probabilit\ y)}$$

- Capture probabilities are estimated from recoveries of marked fish

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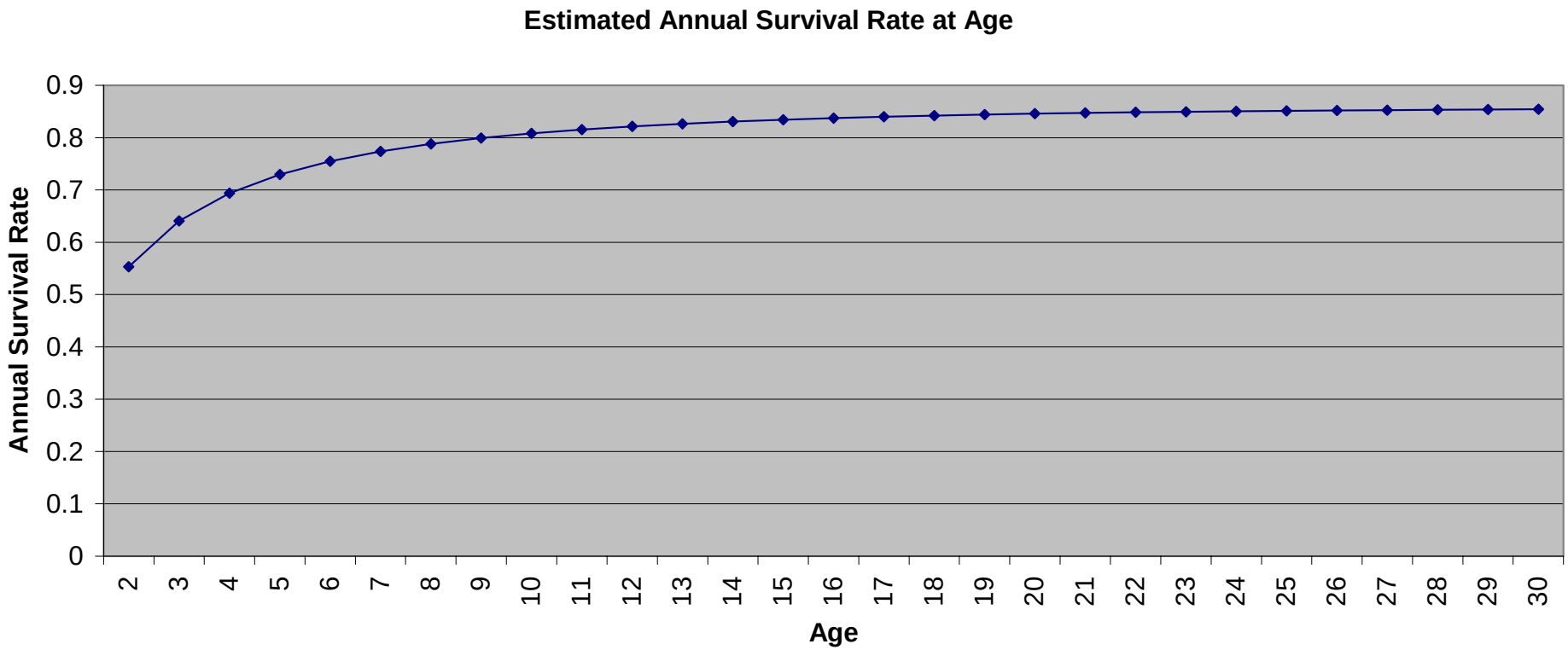
Model Structure - ASMR

- Lorenzen (2000) type Mortality Schedule
  - Mortality rate proportional to 1/length using von Bertalanffy growth parameter k



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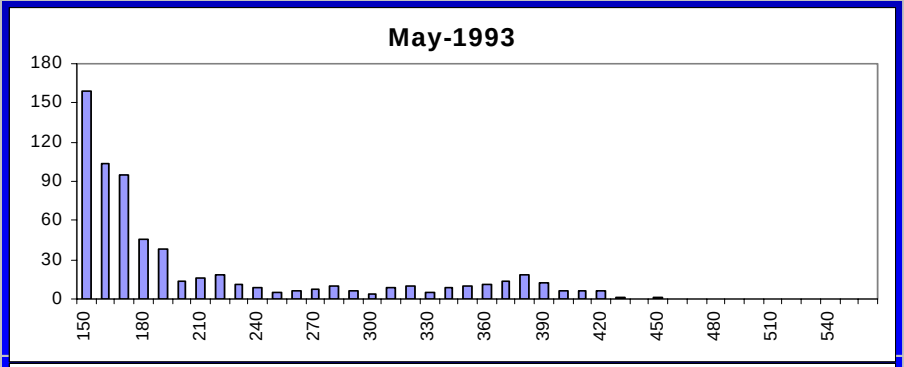
Conclusions – Population Dynamics

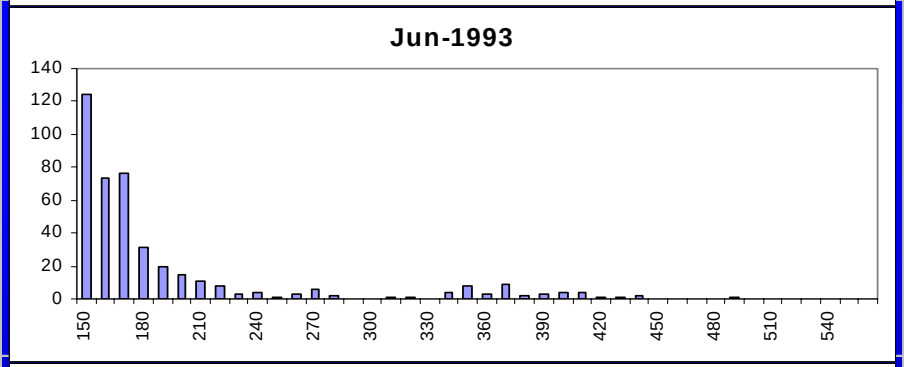
- Data sources suggest that post-1993 recruitment events are lower than pre-1992 recruitment events.
- A Few Hypotheses :
  - Predation or Competition
    - Mainstem Colorado
    - Little Colorado River
  - Hydrology
    - Dam Operations (Interim flows August 1991, GCD EIS)
    - Little Colorado River Hydrology (1992 poor year class)
  - Parasitism
    - Asian Tapeworm

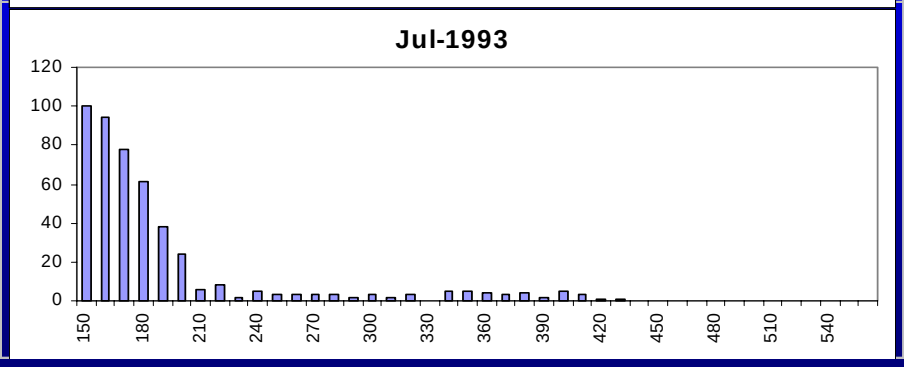
Conclusions – Population Dynamics

Results – 1991 Cohort vs 1993 Cohort

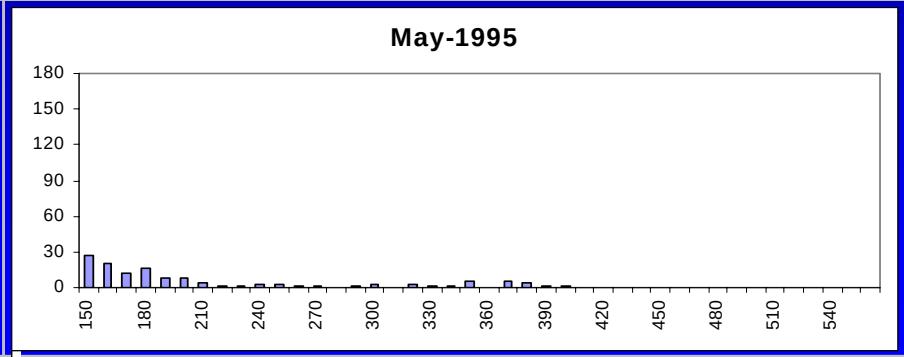
1991 Cohort

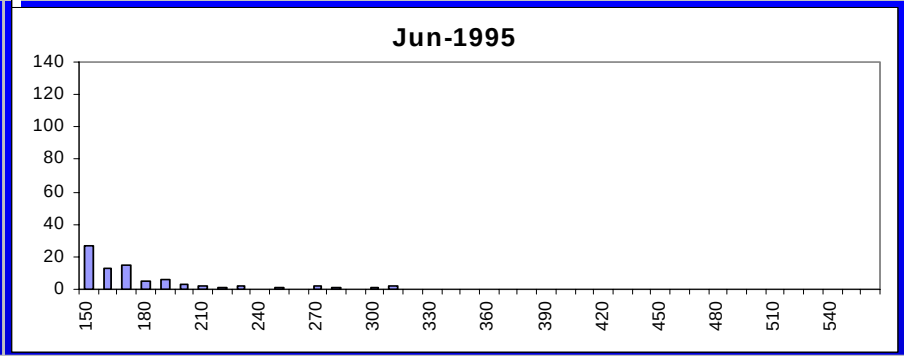






1993 Cohort





HBC Distribution in Grand Canyon

Tag-Recapture Matrix

-Pit Tag Data from 1989-2000

30MI	Lees Ferry to 30 Mile aggregation
LCR	In Little Colorado River
LCRIN	Little Colorado River Inflow (rm 57-68.5)
UGG	"Upper Granite Gorge" (rm 70 - 92.3)
BAC	In Bright Angel Creek
SHM	In Shinumo Creek
SHMIN	Shinumo Creek Inflow (rm 108 - 109)
STEPH-CONQ	Stephen - Conquistador Aisle (rm 114 -125)
MGG	Middle Granite Gorge (rm 125 -129)
KAN	In Kanab Creek
KANIN	Kanab Creek inflow (rm 142 -143.5)
HAV	In Havasu Creek
HAVIN	Havasu Creek inflow (rm 155 - 157)
BLOHAV	Below Havasu Creek

		Recapture Location														
Tag Location	Total Tagged	30MI	LCR	LCRIN	UGG	BAC	SHM	SHMIN	STEPH-CONQ	MGG	KAN	KANIN	HAV	HAVIN	BLOHAV	Total Recaptured
30MI	34	16	1	0	0	0	0	0	0	0	0	0	0	0	0	17
LCR	11779	1	**12032**	**766**	3	0	0	0	0	0	0	1	2	0	0	12805
LCRIN	1158	0	**883**	**257**	0	0	0	0	1	1	0	0	1	0	0	1143
UGG	43	0	2	0	2	0	0	0	0	1	0	0	0	0	0	5
BAC	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SHM	18	0	0	0	0	0	2	1	0	0	0	0	0	0	0	3
SHMIN	47	0	0	0	0	0	0	15	0	0	0	0	0	0	0	15
STEPH-CONQ	32	0	0	0	0	0	0	0	3	1	0	0	0	0	0	4
MGG	181	0	0	0	0	0	0	1	1	75	0	0	0	0	0	77
KAN	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
KANIN	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HAV	42	0	1	0	0	0	0	0	0	1	0	0	13	1	0	16
HAVIN	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BLOHAV	8	0	0	0	0	0	0	0	0	0	0	0	0	0	4	4
Total	13354	17	12919	1023	5	0	2	17	5	79	0	1	16	1	4	14089

RED is Downstream Movement
YELLOW is Upstream Movement
Grey is "no movement"

Species Description

- Described by R.R. Miller in 1944.
- Most highly specialized member of genus *Gila*.
  - Morphology adapted to turbulent water.
  - Found in narrow canyon-bound river reaches.
- Added to the Federal list of endangered species in 1967
- 6 Known populations
  - 5 above Lees Ferry
  - 1 in Grand Canyon