



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

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and

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# Presentation Outline

- Stock Assessment/Population Dynamics  
Primer
- Partial History of HBC Research in Grand  
Canyon
- Program Supertag

# Definitions

- Stock Assessment
  - Stock assessment involves the use of various statistical and mathematical calculations to estimate the past and current abundance and productivity of a fish population. The ultimate goal of stock assessment is to construct quantitative predictions about the reactions of fish populations to alternative management choices.
- Population Dynamics
  - Population dynamics is the study and mathematical representation of how and why a population changes.

# Definitions

- Cohort or Year Class
  - Animals resulting from reproduction during a single year.
  - Principle: Once established, cohorts can only diminish in number.
- Recruitment (Recruits)
  - All animals entering a particular size or age class of the population.
  - For program supertag, recruits are defined as age-1.
- Recruitment Anomalies
  - Deviations from an average recruitment.
  - $R_i = R_o * Recanom_i$
- Brood Year
  - Year in which a particular cohort was spawned.

# Stock Assessment Elements

- Clear definition of the stock
  - Geographic boundaries, movement, spawning and rearing locations, etc.
- Abundance and demography
  - Catch per unit effort indices
  - Mark-recapture population estimation
- Recruitment and recruitment variability
  - Spawner-recruit relationships
  - Spawner abundance, fecundity, maturity, spawning frequency information, early life mortality.
- Mortality
  - Early-life, juvenile, adult
- Effect of management actions on recruitment and mortality
  - Allows projections

# Assessing Abundance

- Catch per unit effort (CPUE) index
  - $C = qEN$
  - $U = \frac{C}{E} = qN$
  - C is catch, q is catchability coefficient, E is Effort, N is abundance, U is CPUE
  - Problem is that q is not always constant
    - q can be a function of time, abundance, environment, etc.
  - Basing management decisions solely on CPUE trends (or lack of trend) can be dangerous

# Assessing Abundance

- Estimating Abundance via Mark-Recapture
  - Closed population models
    - Estimate abundance but not mortality or recruitment.
    - Chapman-Peterson, Schnabel, Program Capture
  - Open population models
    - Estimate abundance, mortality, or recruitment
    - Jolly-Seber, Cormack-Jolly-Seber, Hilborn's Method

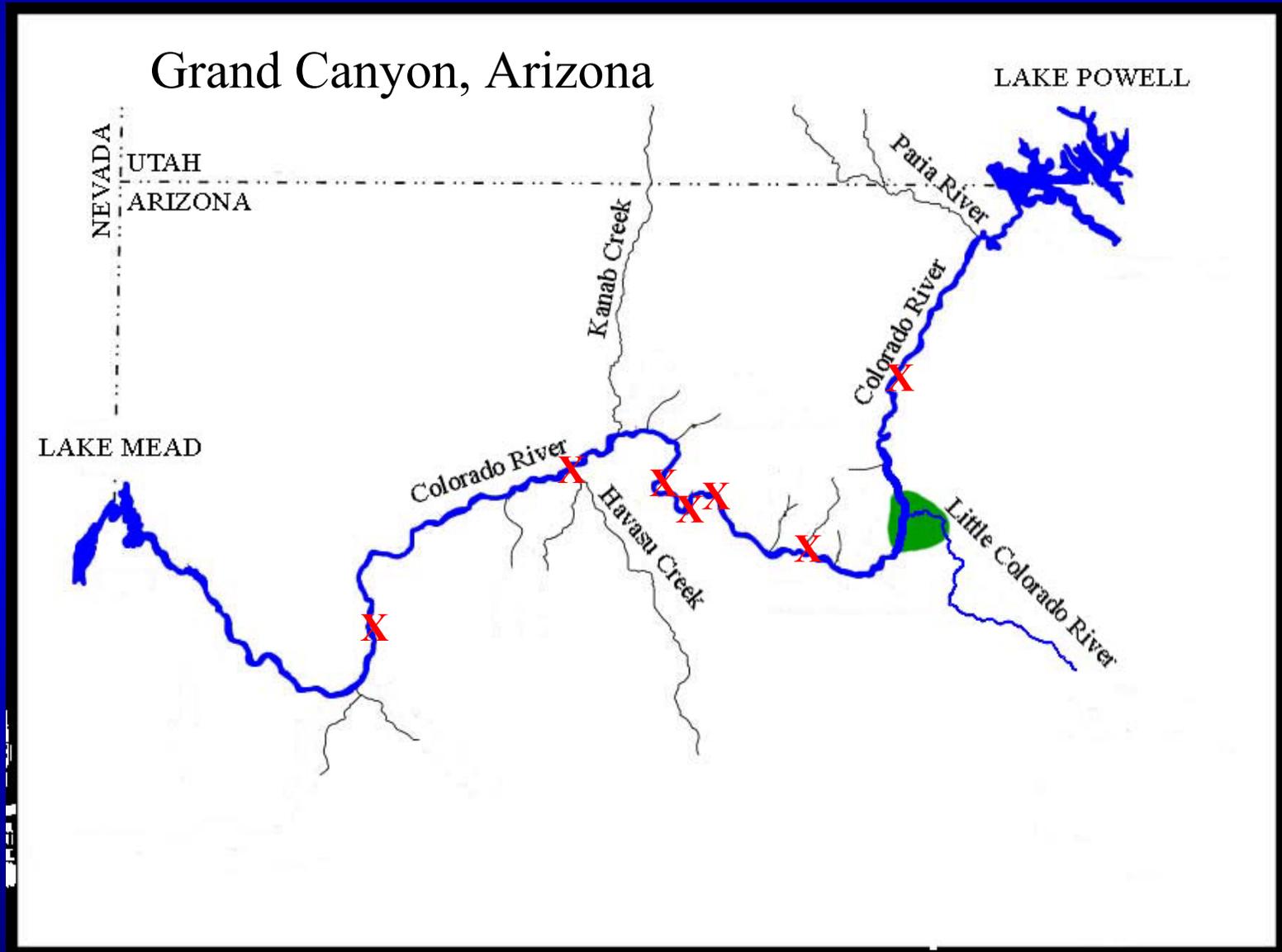
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# HBC Research in Grand Canyon

- 1944 Species Description (Miller 1946).
- 1944-80 Various researchers documenting HBC occurrence and distribution (Stone and Rathbun 1967-69; Holden and Stalnaker 1975; Suttikus and Clemmer 1977; Minckley and Blinn 1976; Minckley 1975,1977, 1979; Carothers et al. 1981).
- 1980-82 LCR Investigations (Kaeding & Zimmerman 1983)
- 1984-87 GCES Phase I (Maddux et al. 1987)
- 1987-90 LCR Investigations (Minckley 1988,89,90; Kubly 1990)
- 1990-95 Phase II (BioWest, USFWS, AGFD, ASU)
- 1995-01 Transitional/Monitoring (AGFD, USFWS, SWCA, ASU, Hualapai)

# HBC Research in Grand Canyon



# HBC Abundance Estimation Grand Canyon

Year	Month	Location	Size	Estimate	Source
1982	May	LCR	>200 mm	7500	Kaeding & Zimmerman (1982)
1987	May	LCR Confluence	>120 mm	5783	Minckley (1988)
1987	May	LCR Confluence	>140 mm	1800	Kubly (1990)
1988	May	LCR Confluence	>120 mm	7060	Minckley (1988)
1988	May	LCR Confluence	>140 mm	2900	Kubly (1990)
1989	May	LCR	>150 mm	18253	Minckley (1989)
1989	May	LCR Confluence	>150 mm	10120	Minckley (1989)
1989	May	LCR	>140 mm	25000	Kubly (1990)
1990	May	LCR Confluence	>150 mm	6492	Minckley (1990)
1990	May	LCR	>150 mm	11985	Minckley (1990)
1992	May	LCR Confluence	>150 mm	1320	Douglas and Marsh (1996)
1992	May	LCR	>150 mm	4508	Douglas and Marsh (1996)
2000	Oct.	LCR	>135 mm	1600	Coggins and Van Haverbeke (2001)
2001	May	LCR	>150 mm	2000	USFWS In Prep.

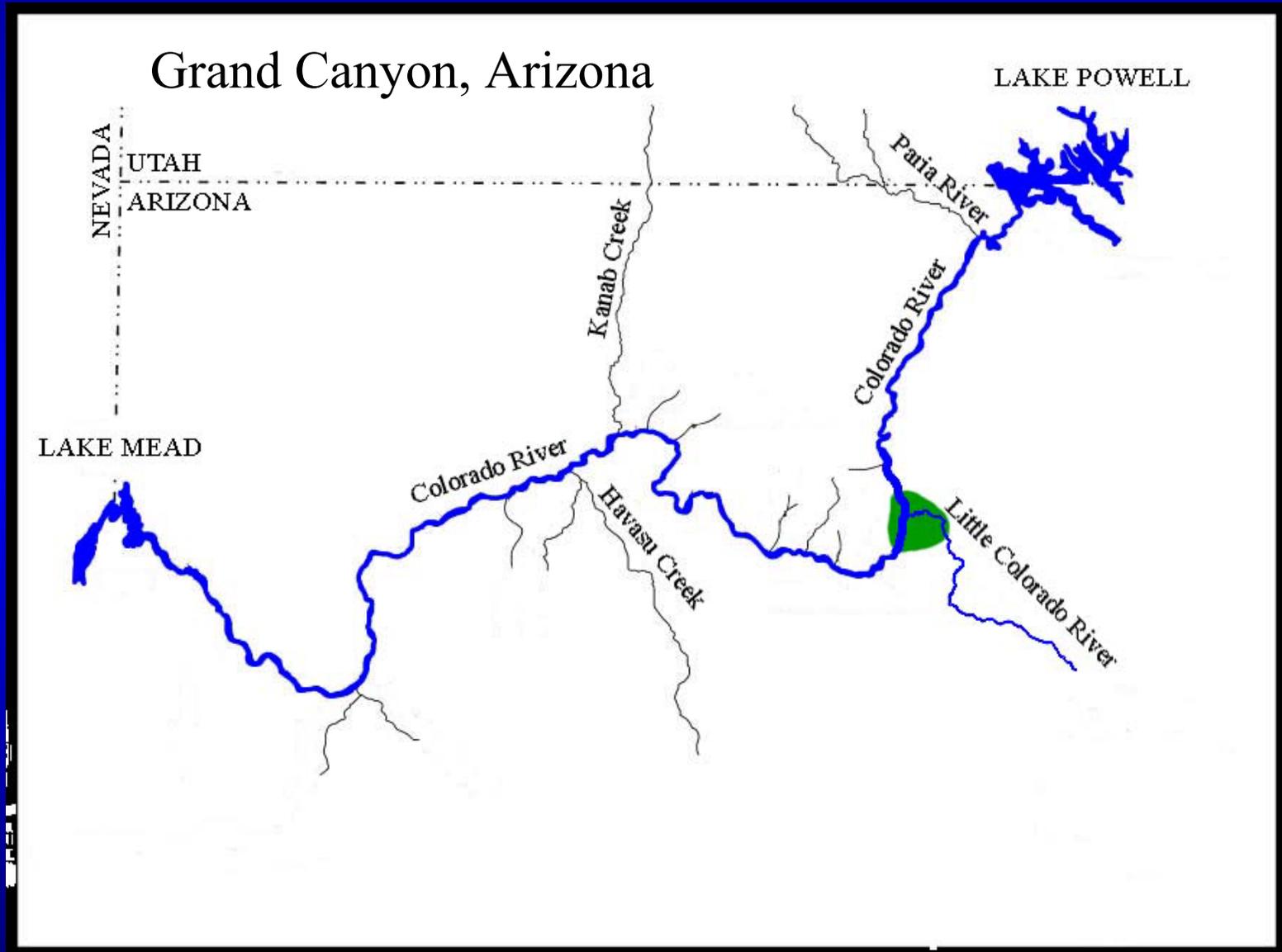
# HBC Abundance Estimation Grand Canyon

Year	Month	Location	Size	Estimate	Source
1991-93	All	LCRI Aggregation	>200 mm	3000-4000	Valdez and Ryel (1995); Closed Population Model
1991-93	All	LCRI Aggregation	>200 mm	3200	Valdez and Ryel (1995); Open Population Model
1993	?	MGG Aggregation	>200 mm	68-155	Valdez and Ryel (1995); Closed Population Model
1991-93	All	30-Mile Aggregation	>200 mm	55	Valdez and Ryel (1995); Closed Population Model
1991-93	All	Shinumo Inflow Aggregation	>200 mm	55	Valdez and Ryel (1995); Closed Population Model
1991-93	All	Havasu Inflow Aggregation	>200 mm	10	Valdez and Ryel (1995); Closed Population Model
1991-93	All	Pumpkin Spring Aggregation	>200 mm	5	Valdez and Ryel (1995); Closed Population Model

# Presentation Outline

- Stock Assessment/Population Dynamics Primer
- Partial History of HBC Research in Grand Canyon
- Program Supertag

# Background



# Motivation

- Little Colorado River Humpback Chub Population
  - After 20+ years of study, we did not have a clear understanding about the status and trends of the population
  - Need to reanalyze existing data to determine if it was possible to reconstruct population trends

# Background



# Background



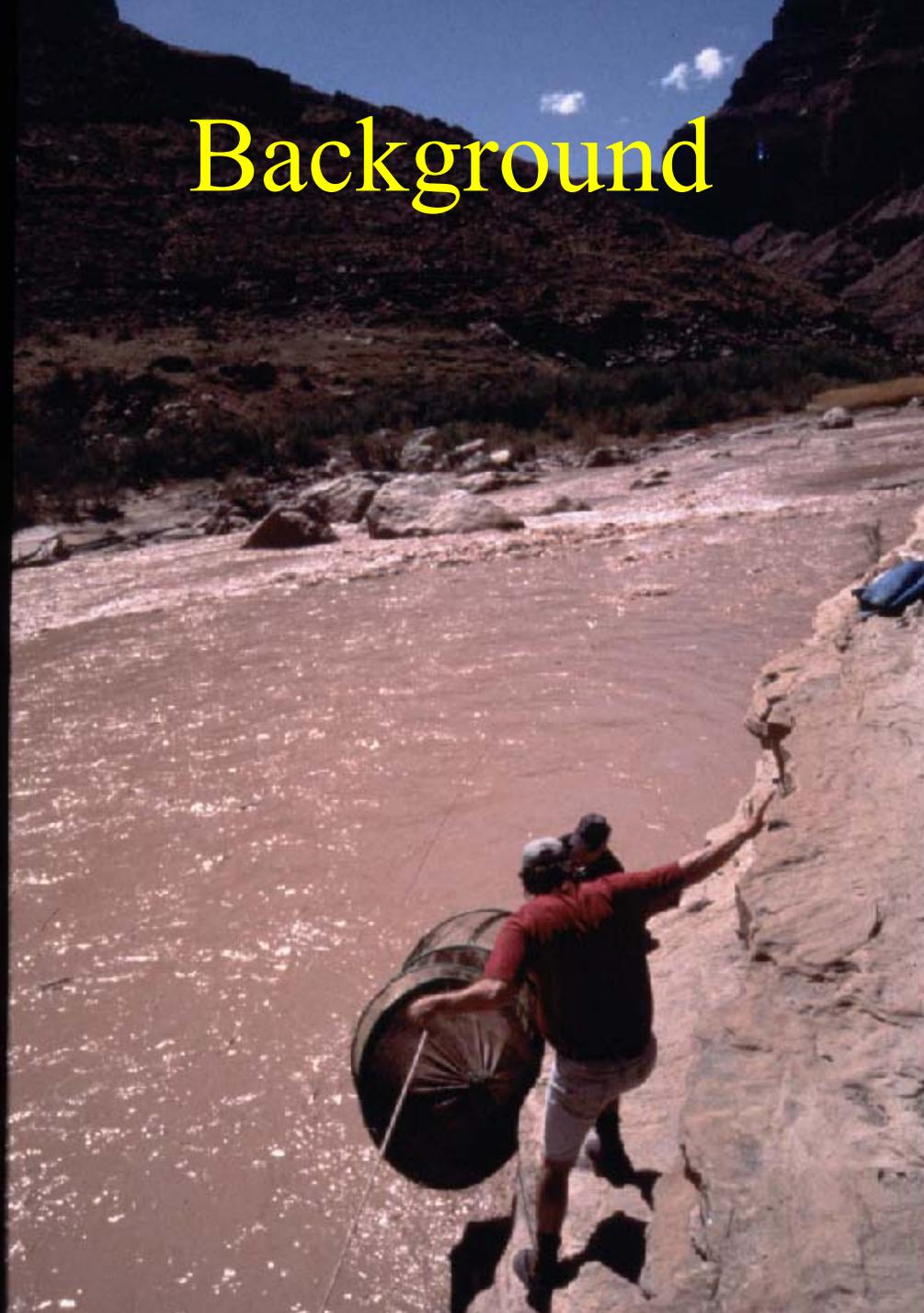
# Background



# Background



# Background



# Stock Definition

## 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	Havasus Creek inflow (rm 155 - 157)
BLOHAV	Below Havasu Creek

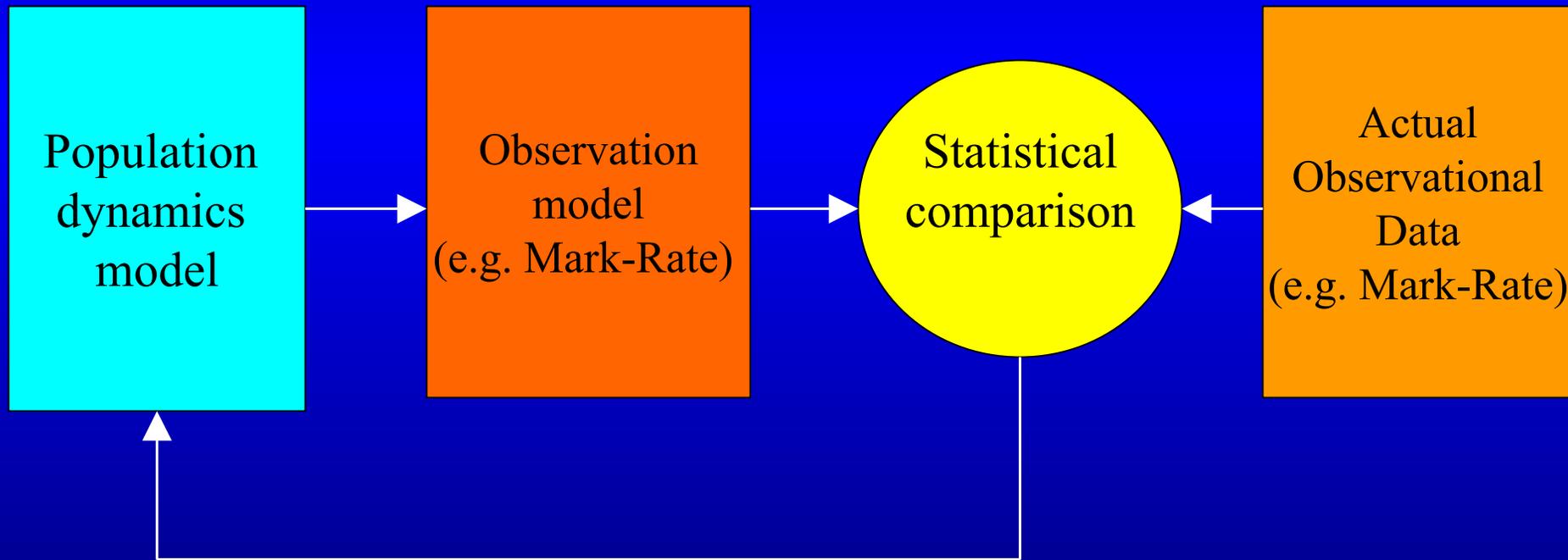
Tag Location	Total Tagged	Recapture Location														Total Recaptured	
		30MI	LCR	LCRIN	UGG	BAC	SHM	SHMIN	STEPH-CONQ	MGG	KAN	KANIN	HAV	HAVIN	BLOHAV		
30MI	34	16	1	0	0	0	0	0	0	0	0	0	0	0	0	0	17
LCR	11779	1	12032	766	3	0	0	0	0	0	0	1	2	0	0	0	12805
LCRIN	1158	0	883	257	0	0	0	0	1	1	0	0	1	0	0	0	1143
UGG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

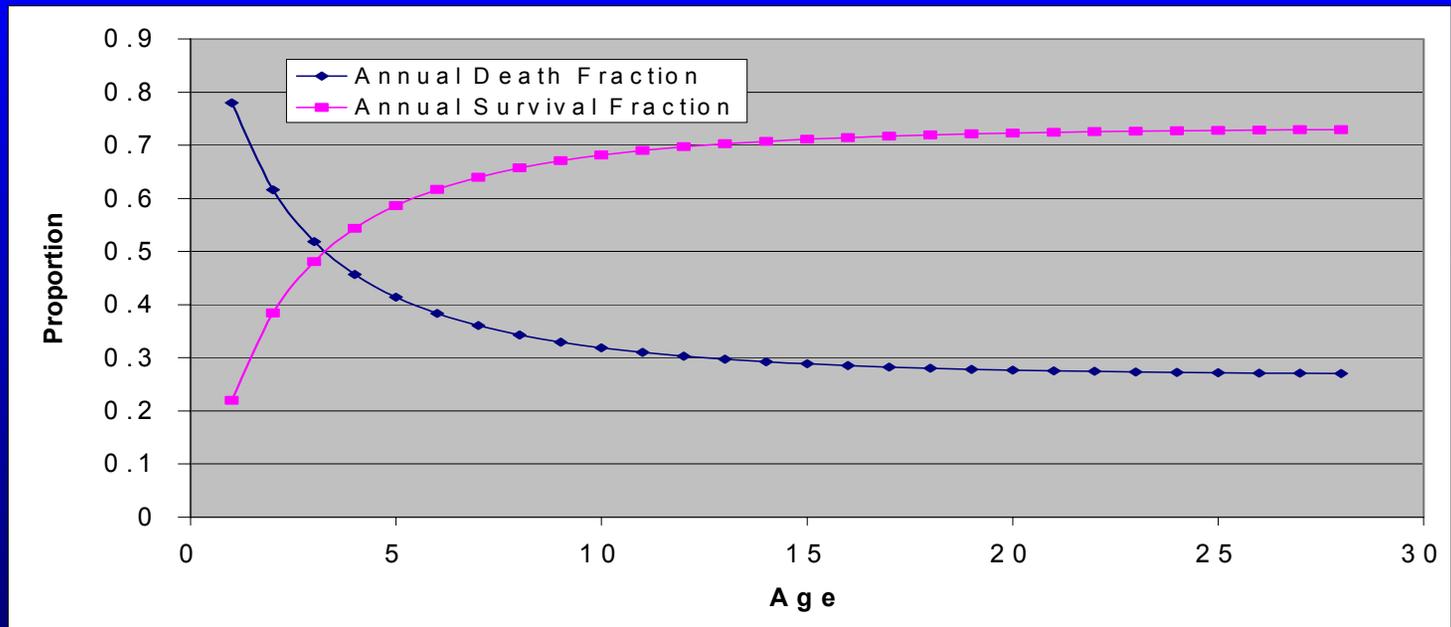
# Methods–Supertag Model Development

## Hilborn's Method (1990)



# Methods–Supertag Model Development

		Age							
		1	2	3	4	5	6	7	...
<b>Recruitment Anomaly</b> 1.919 1.278 2.435 0.167 0.594 0.364 0.216 0.853 0.648 1.000 1.000	<b>Year</b>								
	<b>1989</b>	18540	4080	1567	754	410	240	148	...
	<b>1990</b>	35571	4080	1567	754	410	240	148	...
	<b>1991</b>	23695	7831	1567	754	410	240	148	...
	<b>1992</b>	45147	5215	3007	754	410	240	148	...
	<b>1993</b>	3098	9938	2003	1447	410	240	148	...
	<b>1994</b>	11006	682	3816	964	787	240	148	...
	<b>1995</b>	6740	2422	262	1837	524	461	148	...
	<b>1996</b>	4002	1484	930	126	998	307	284	...
	<b>1997</b>	15820	882	570	448	68	585	189	...
<b>1998</b>	12012	3508	339	274	243	40	361	...	
<b>1999</b>	18540	2690	1347	163	149	143	25	...	
<b>2000</b>	18540	4202	1033	648	89	87	88	...	

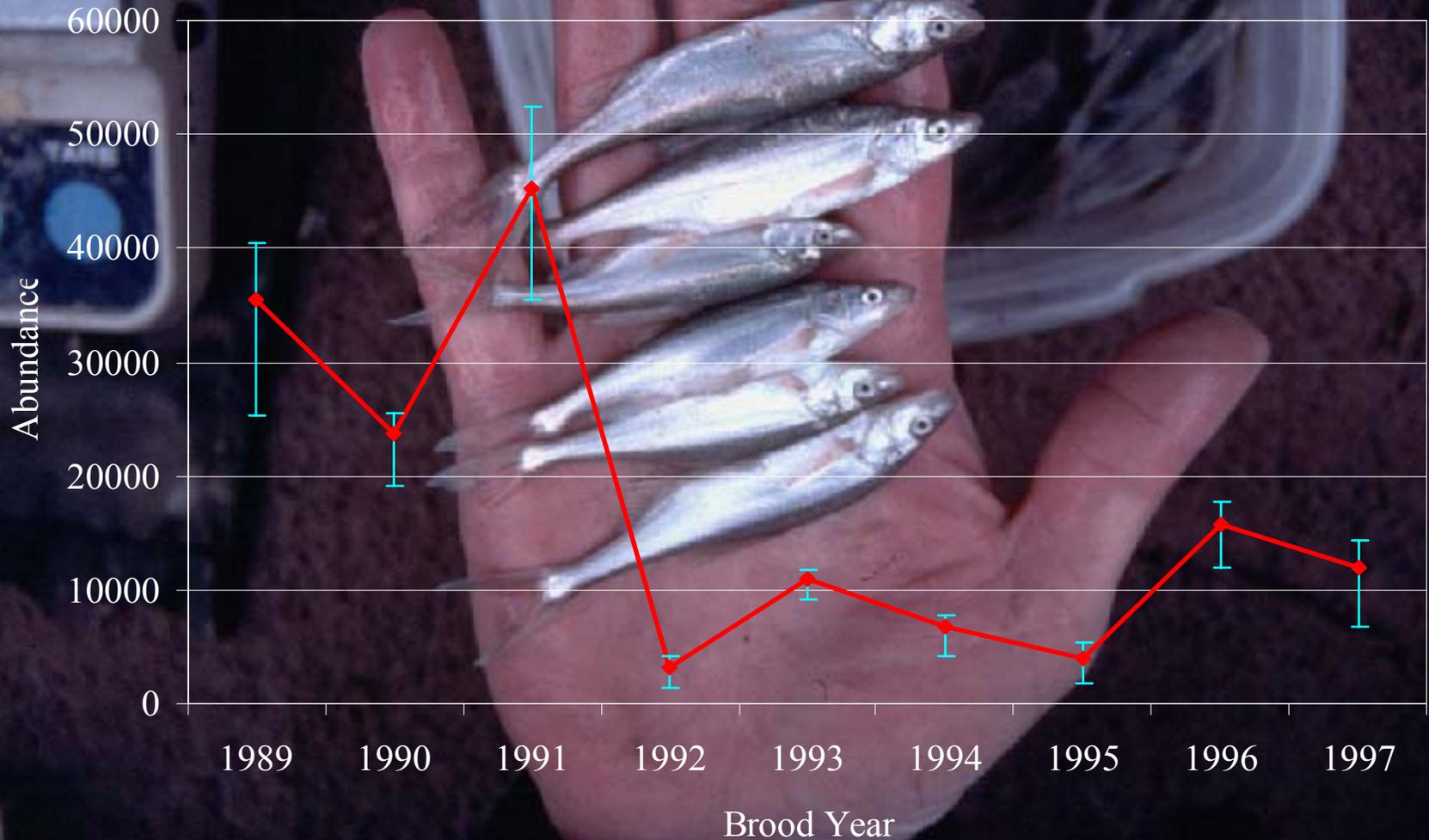


# Methods – Data Types

- Length Frequency and Catch Rate (CPUE)
  - Did not use due to inconsistencies in sampling protocols
- Mark-Recapture (PIT Tags)
  - 1989 – 2000 mark-recapture data from the Little Colorado River and mainstem Colorado River (RM 57 to 68).
  - 12,937 fish marked, 13,948 recaptures (includes multiple recaptures)

# Results – Recruitment Trend

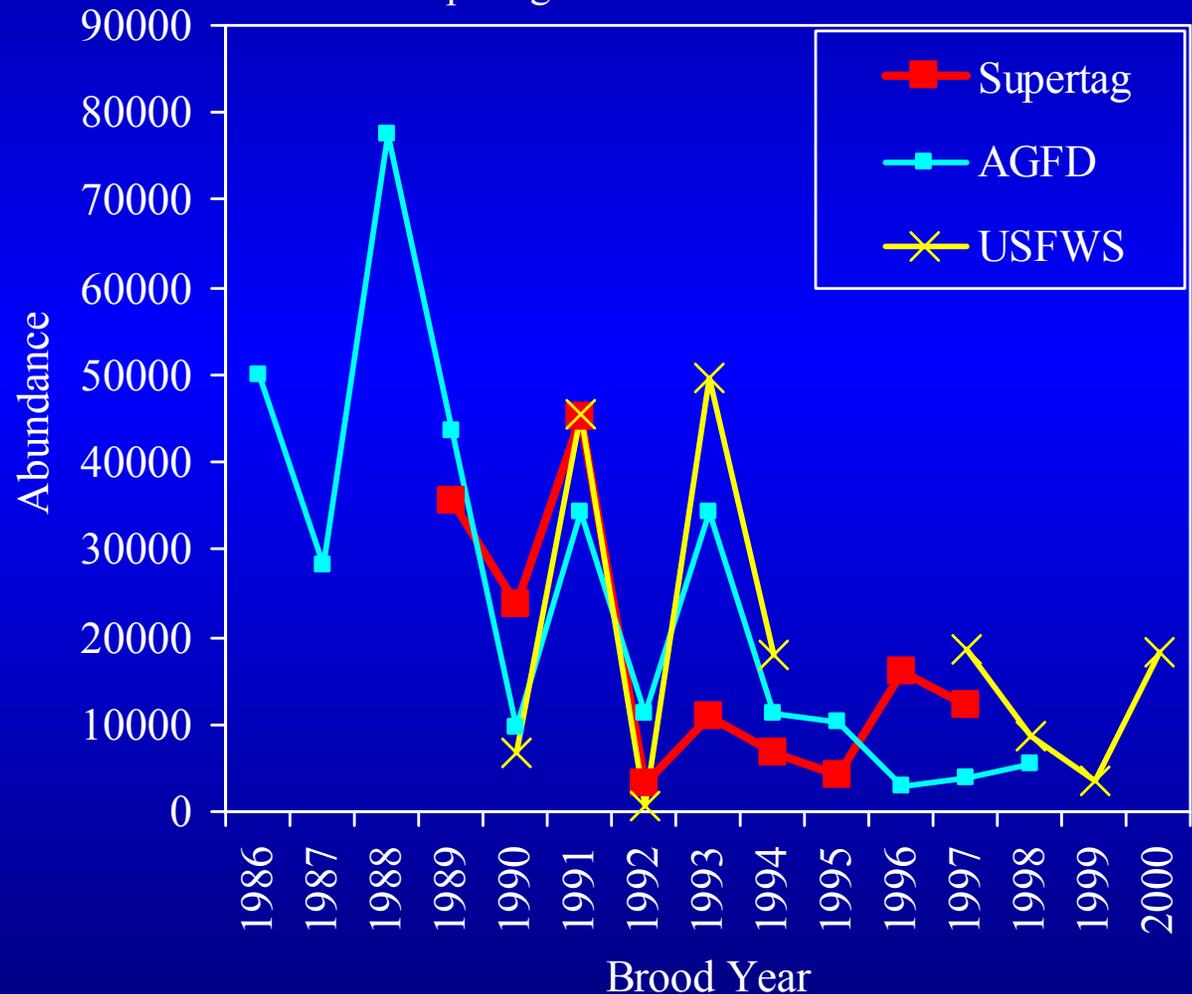
Supertag Estimates of Age-1 HBC Recruitment by Brood Year



# Results – Recruitment Trend

- Spring/Summer hoopnet CPUE indices of AGE-1 in the Little Colorado River
- AGFD data is longest and most consistent sampling protocols over time (lower 1200 meters)
- USFWS data primarily from two locations in the Little Colorado River (3 km and 11 km)
- Catch-rate scaled to abundance by calculating catchability coefficient

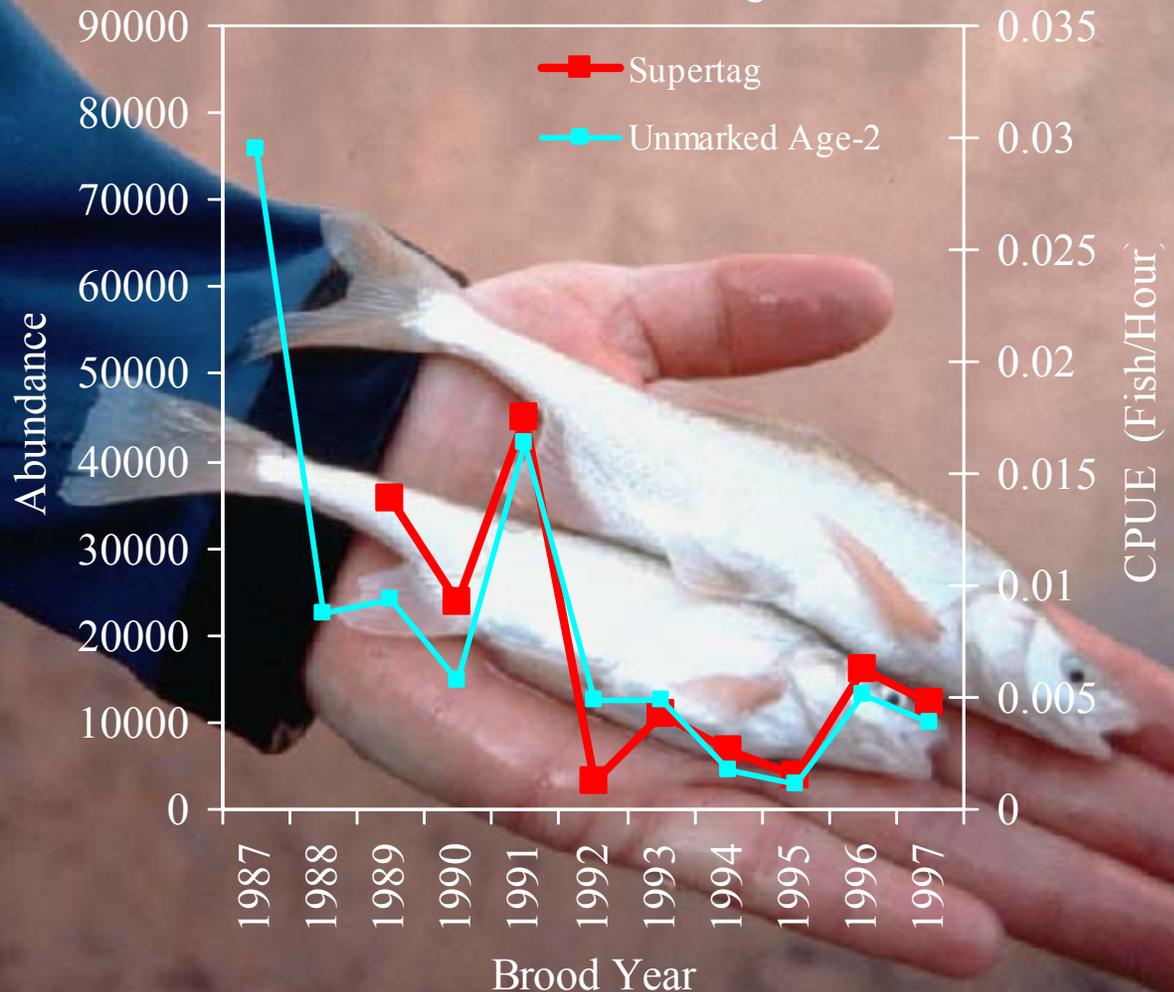
AGE-1 HBC Recruitment Trends  
Supertag versus CPUE



# Results – Recruitment Trend

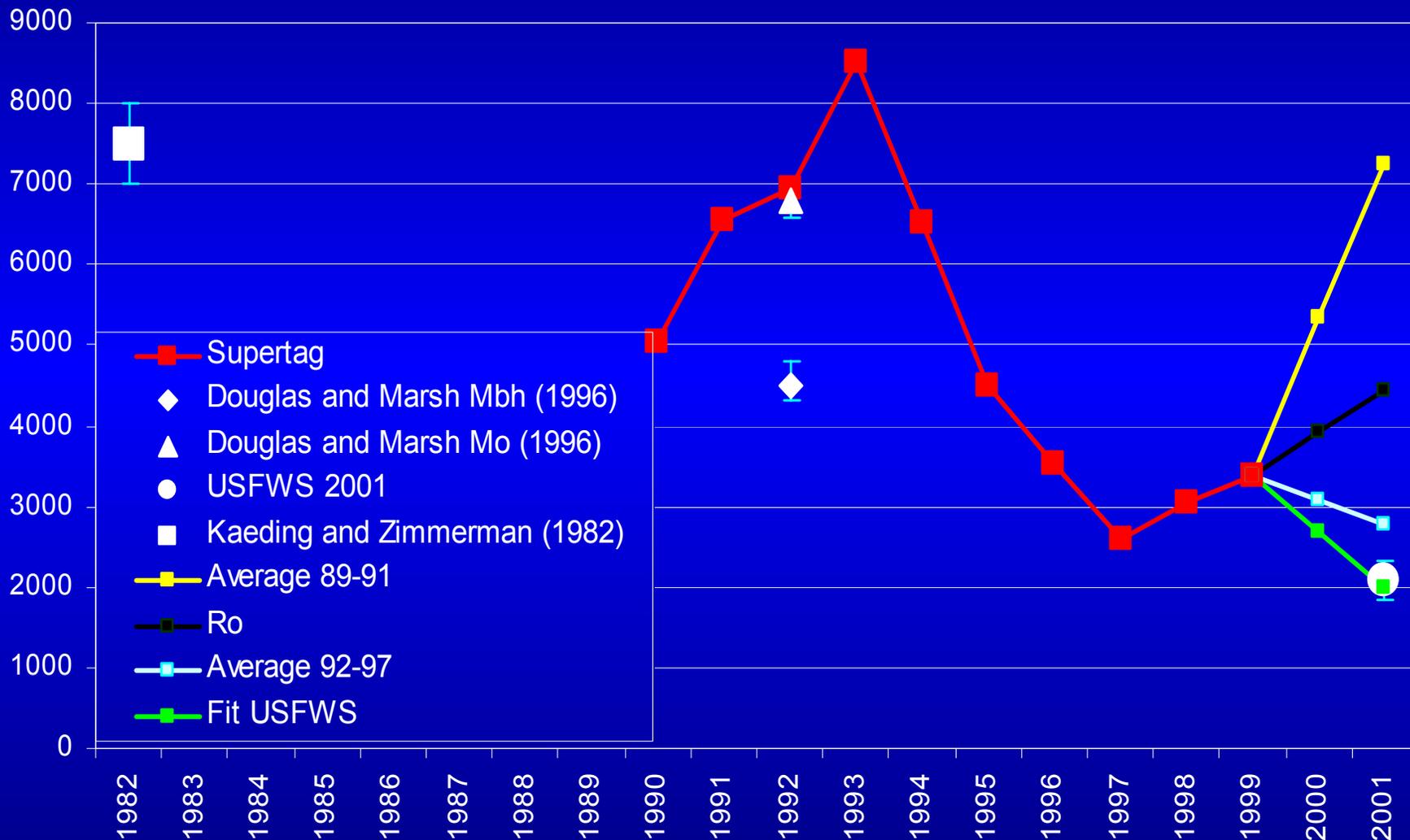
- Annual hoopnet CPUE of unmarked AGE-2 fish in the Little Colorado River
- Humpback chub reach tagging size (150 mm) at Age-2.
- Suggests 1993 cohort suffered increased mortality as compared to the 1991 cohort

Supertag Estimates of Age-1 HBC Recruitment versus CPUE of Unmarked Age-2



# Results – Abundance Trend

Estimated Abundance of Humpback Chub > 150\*\* mm during May



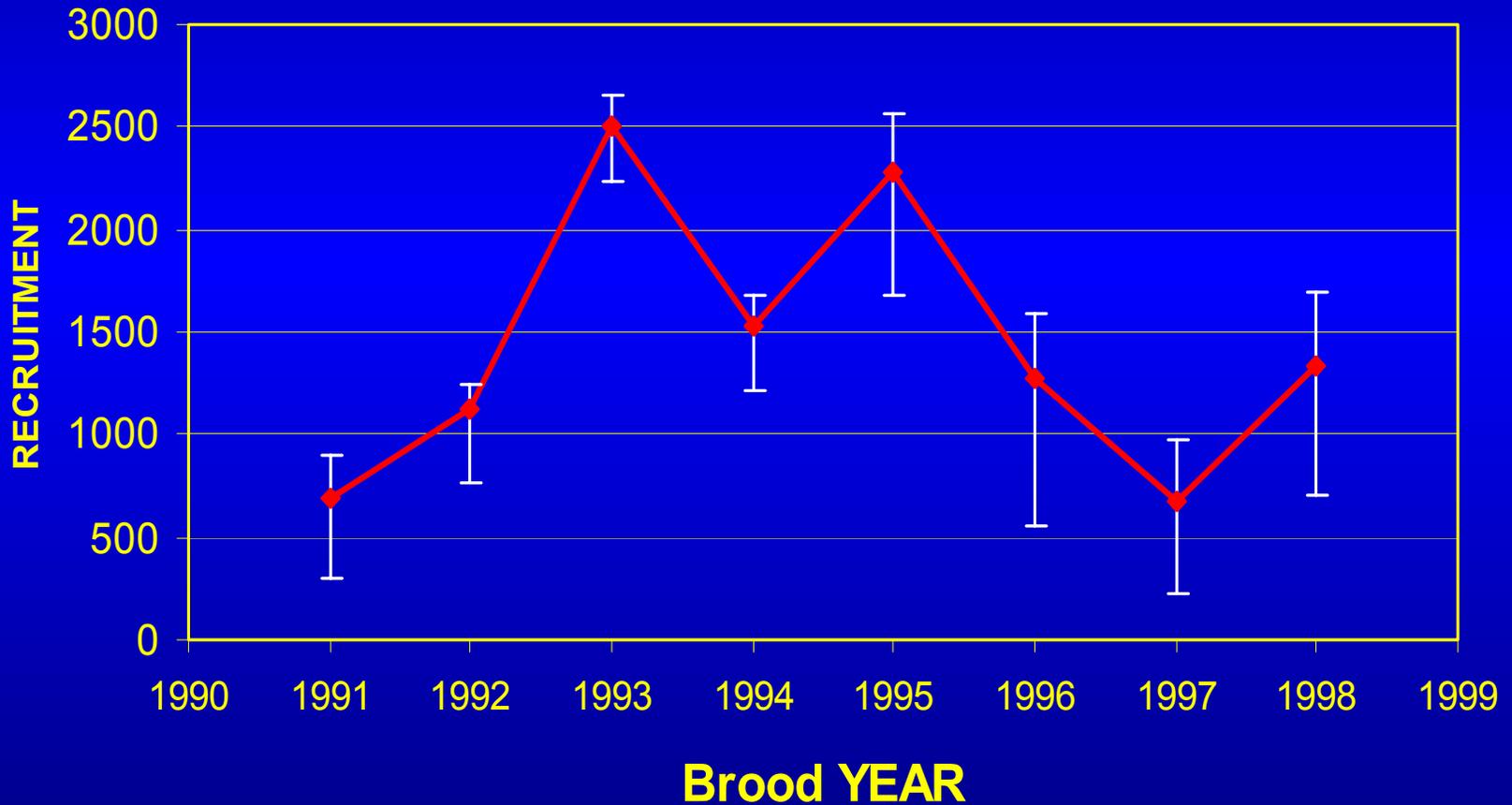
\*\* Kaeding & Zimmerman estimate for HBC >200 mm

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- Stock Assessment/Population Dynamics Primer
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  - Background and Motivation
  - Development and methods
  - Results Humpback Chub
  - Results Flannelmouth Sucker
  - Conclusions

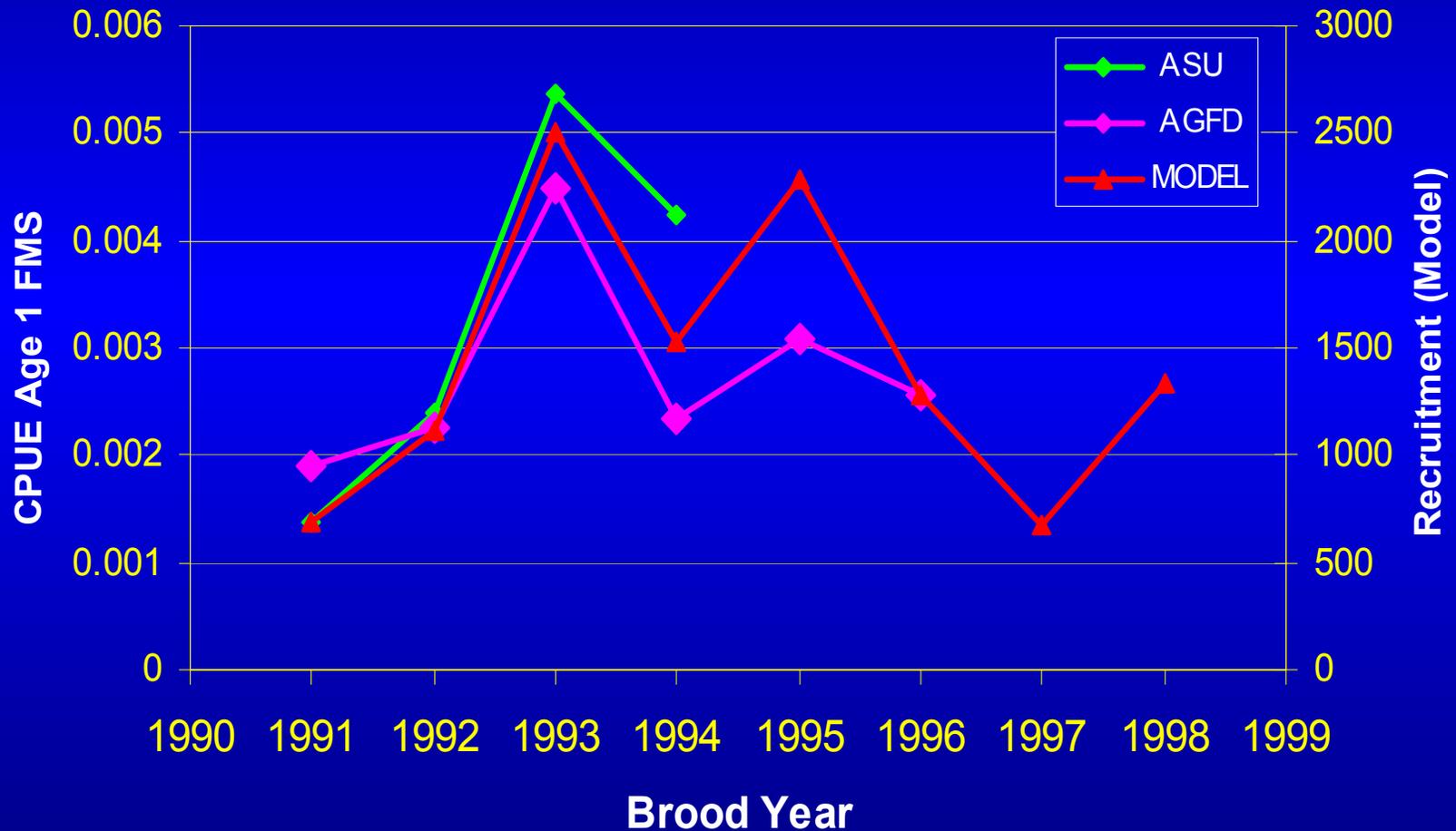


# MODELED FMS RECRUITMENT (LCR SECTION)

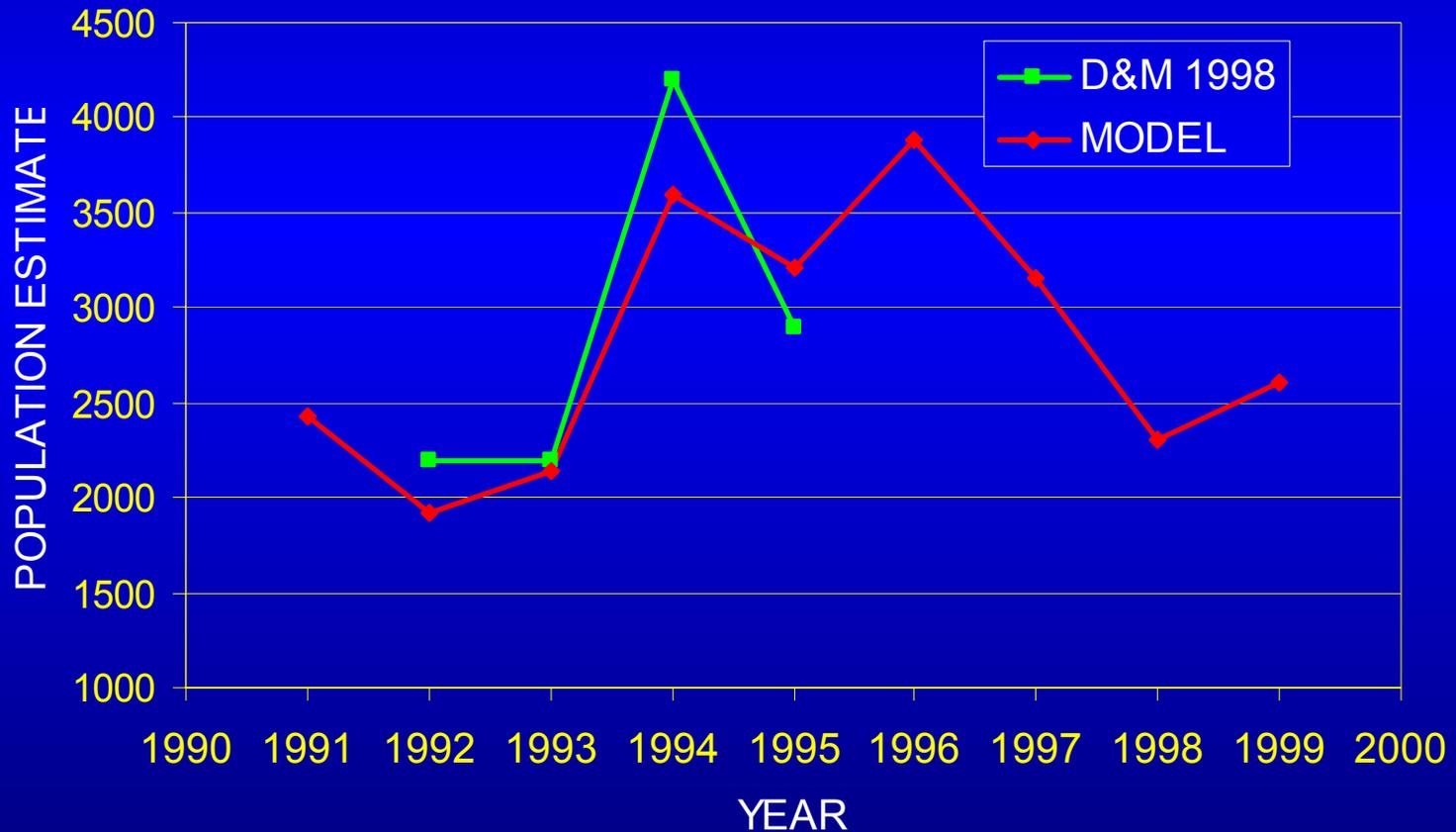


# MODEL RECRUITMENT AND CPUE OF AGE 1 FMS

(ASU LCR HOOP NET DATA AND AGFD LOWER 1200M HOOP NET DATA)



# LCR ESTIMATION OF FMS POPULATION >150 mm (Douglas and Marsh 1998)

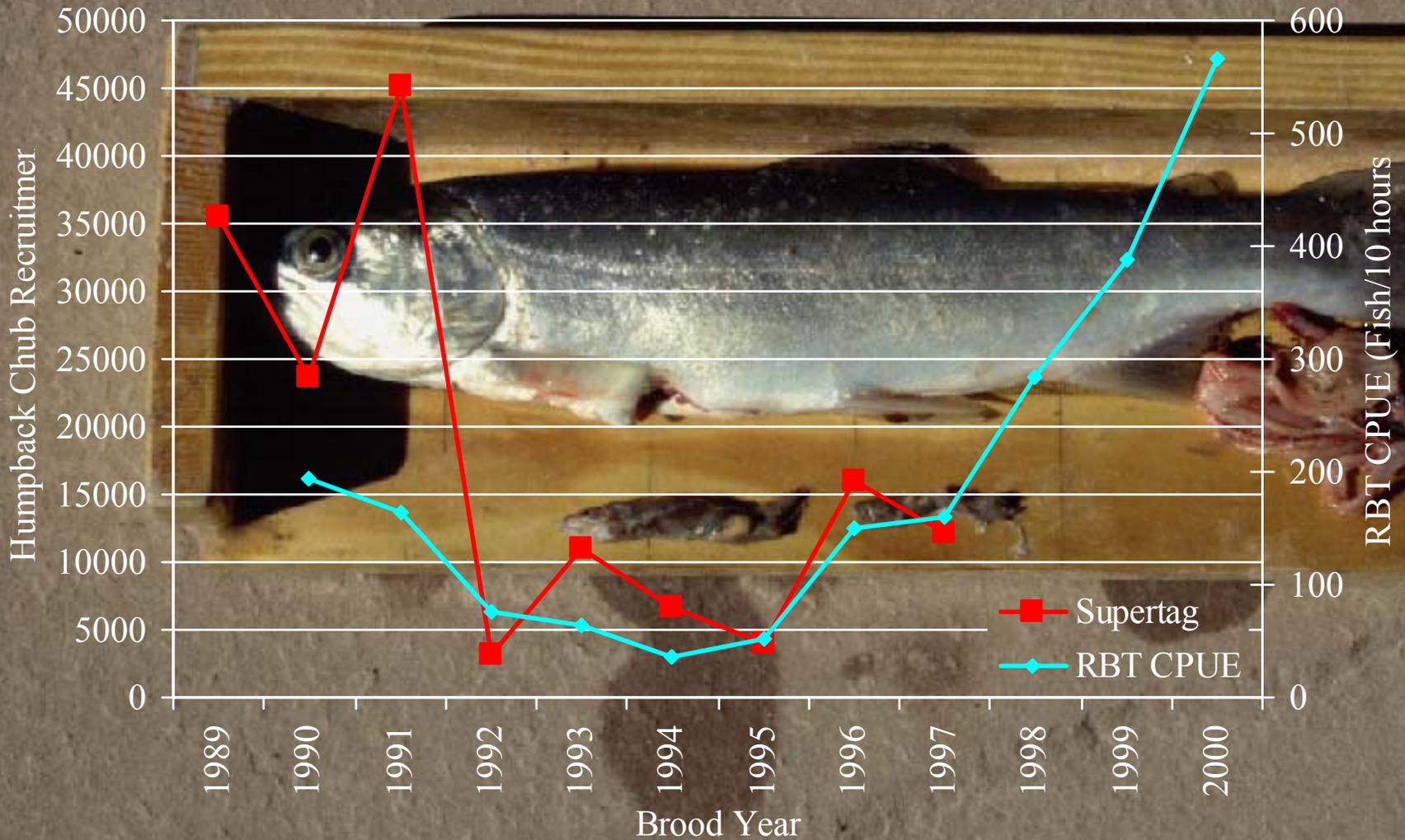


# Conclusions – HBC Population Dynamics

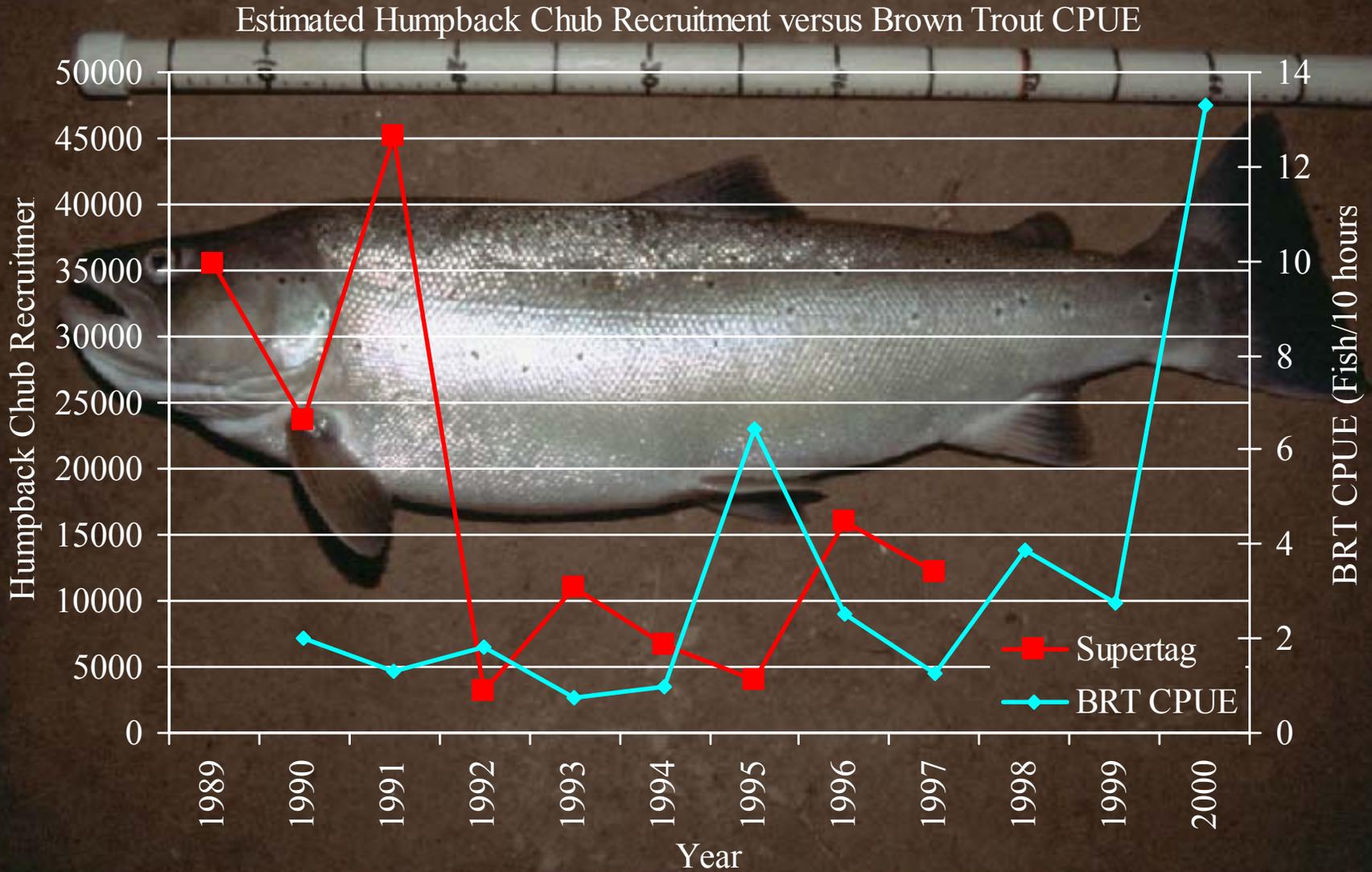
- Data sources suggest that post-1993 recruitment is lower than pre-1992 recruitment.
- A Few Hypotheses :
  - Predation or Competition
    - Mainstem Colorado
    - Little Colorado River

# Conclusions – HBC Population Dynamics

Estimated Humpback Chub Recruitment versus Rainbow Trout CPUE



# Conclusions – HBC Population Dynamics



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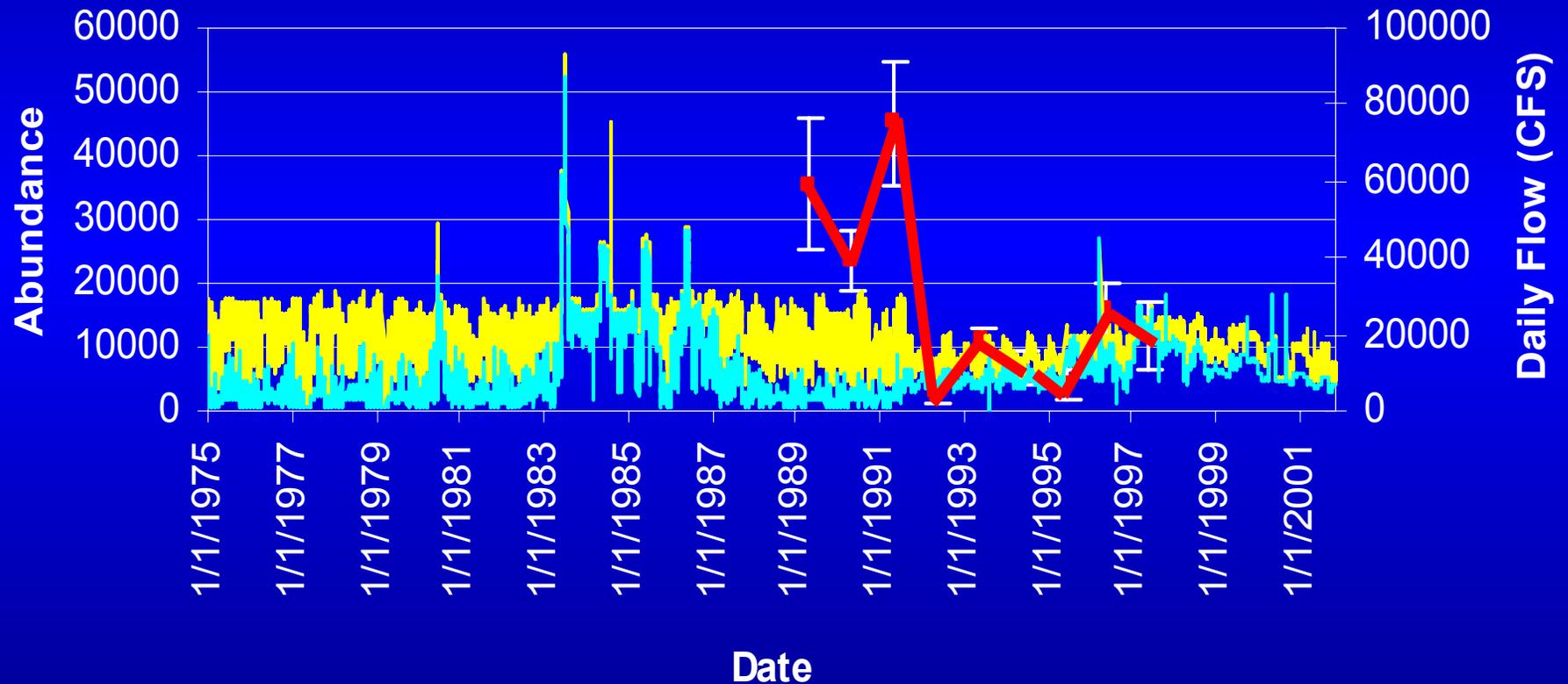


# Conclusions – HBC Population Dynamics

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    - Dam Operations (Research & interim Flows 1990-01, GCD EIS ROD)

# Conclusions – HBC Population Dynamics

Supertag Estimates of Age-1 HBC Recruitment by Brood Year versus Mainstem Flow

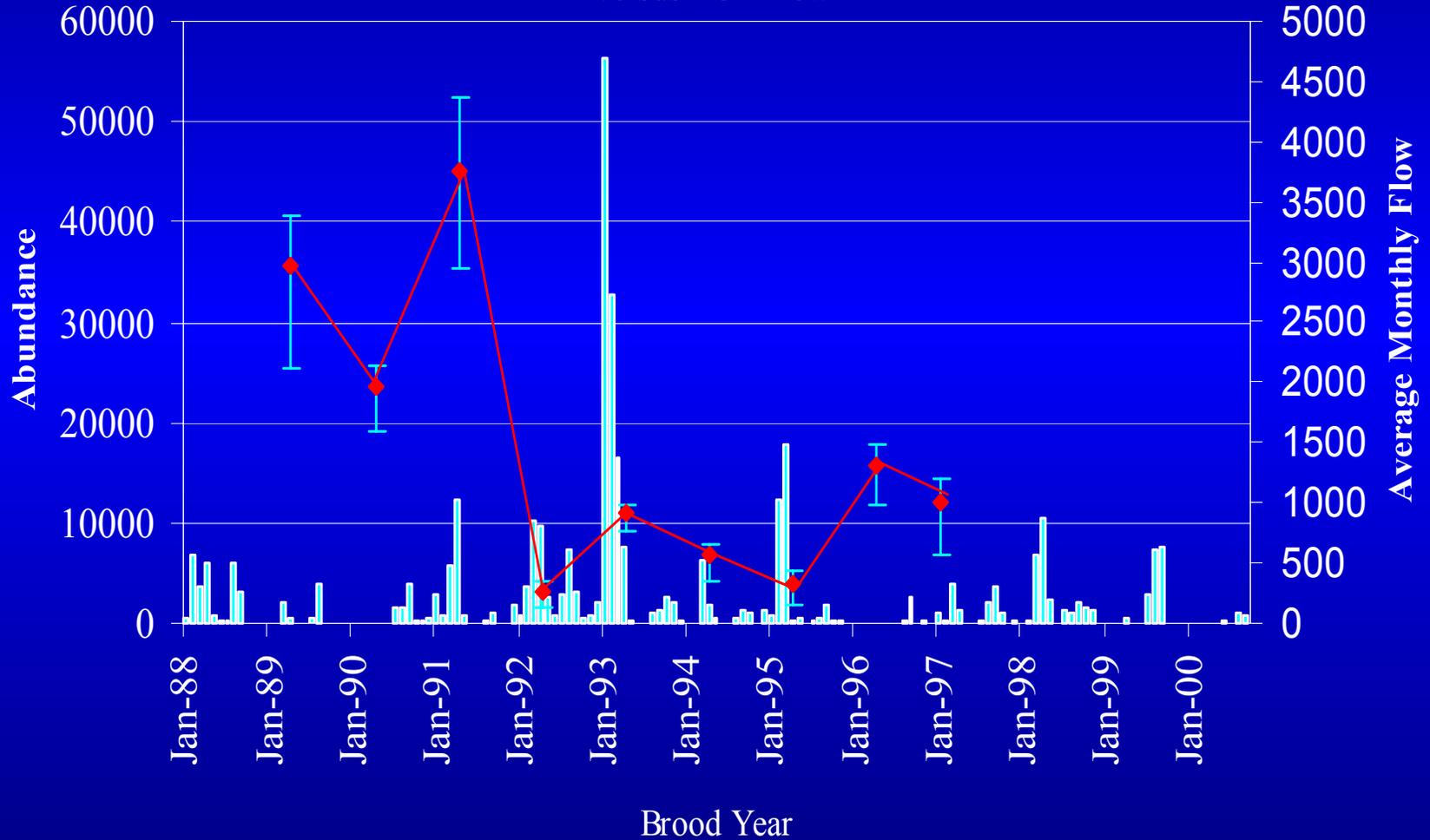


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    - Little Colorado River Hydrology (1992 poor year class)

# Conclusions – HBC Population Dynamics

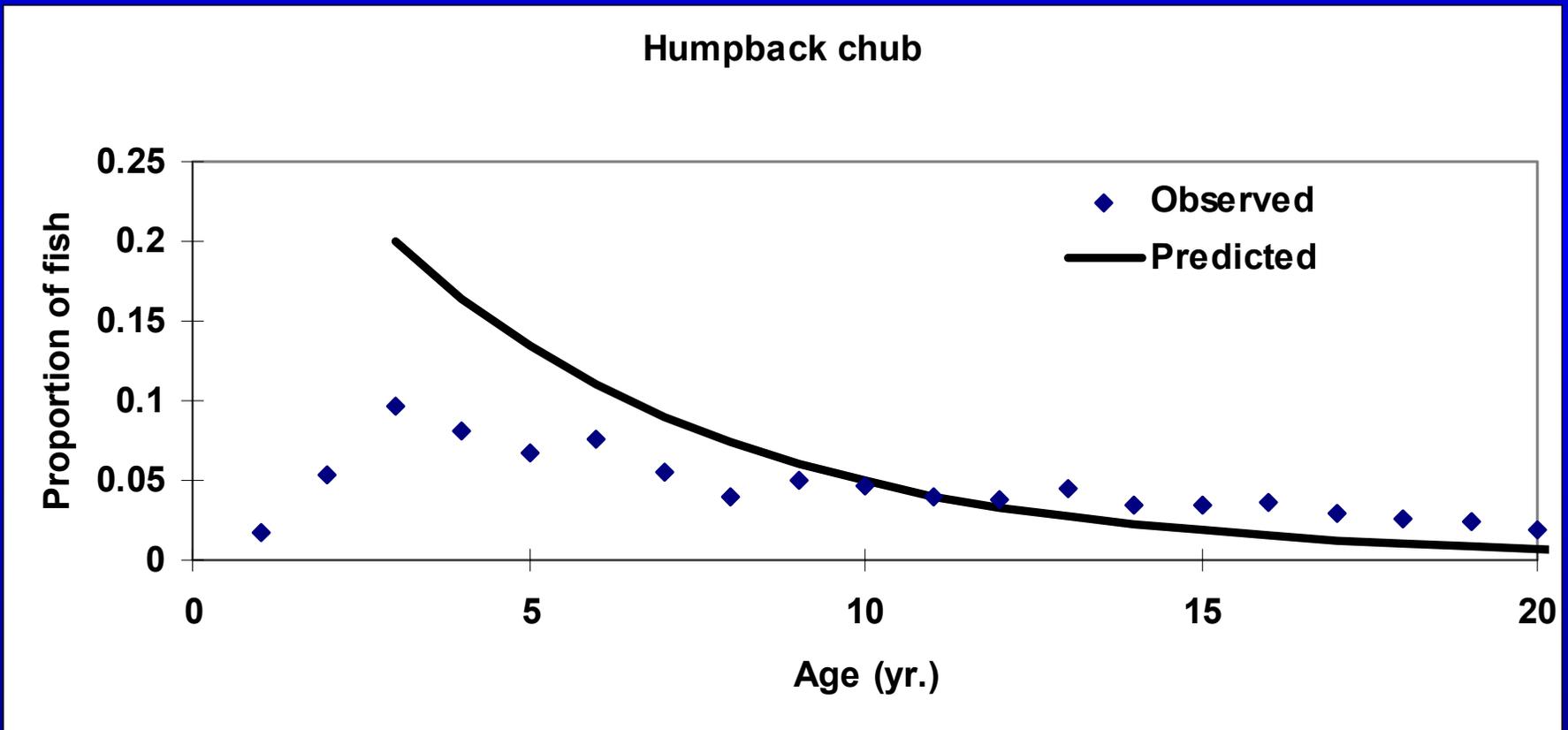
Supertag Estimates of Age-1 HBC Recruitment by Brood Year  
versus LCR Flow



# Conclusions – HBC Population Dynamics

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- 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
  - Is this just natural variability?

# Conclusions – HBC Population Dynamics



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  - Parasitism
    - Asian Tapeworm
  - Is this just natural variability?
  - **Others and interactions**

