STATUS AND TRENDS OF HUMPBACK CHUB IN GRAND CANYON

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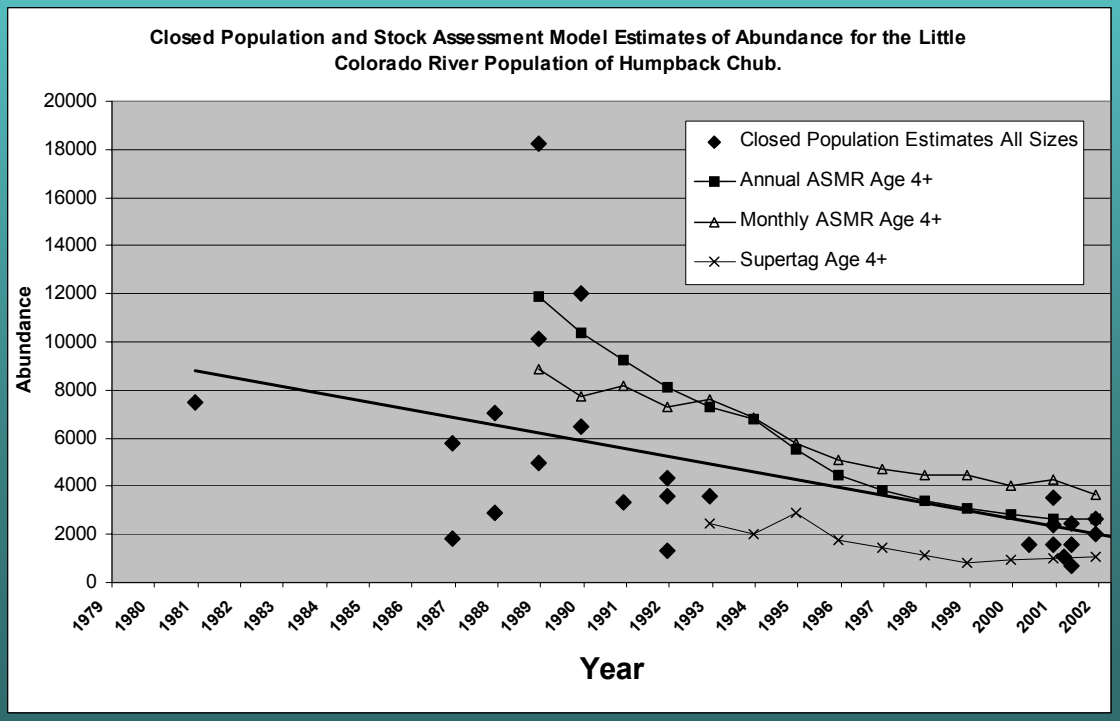
History of population studies

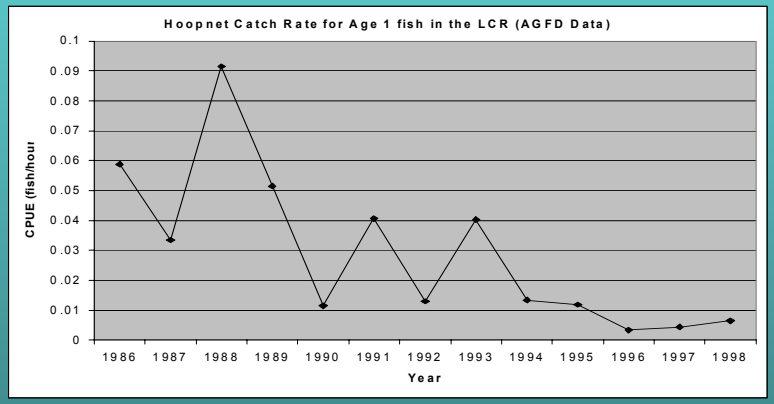
- Scattered mark-recapture estimates prior to early 1990s
- Intensive marking and sampling in LCR during early 1990s
- Very spotty sampling from 1995 to 1999
- Moderately intensive sampling from 2000 to present

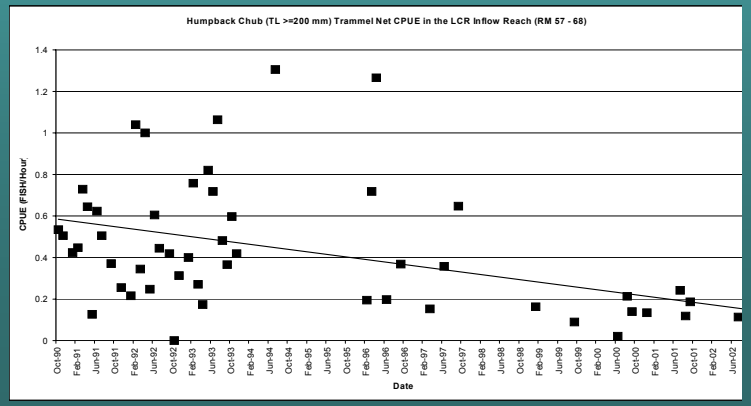
There is uncertainty about current adult abundance, but most data sources indicate a strong declining trend

Mark-recapture population estimates:

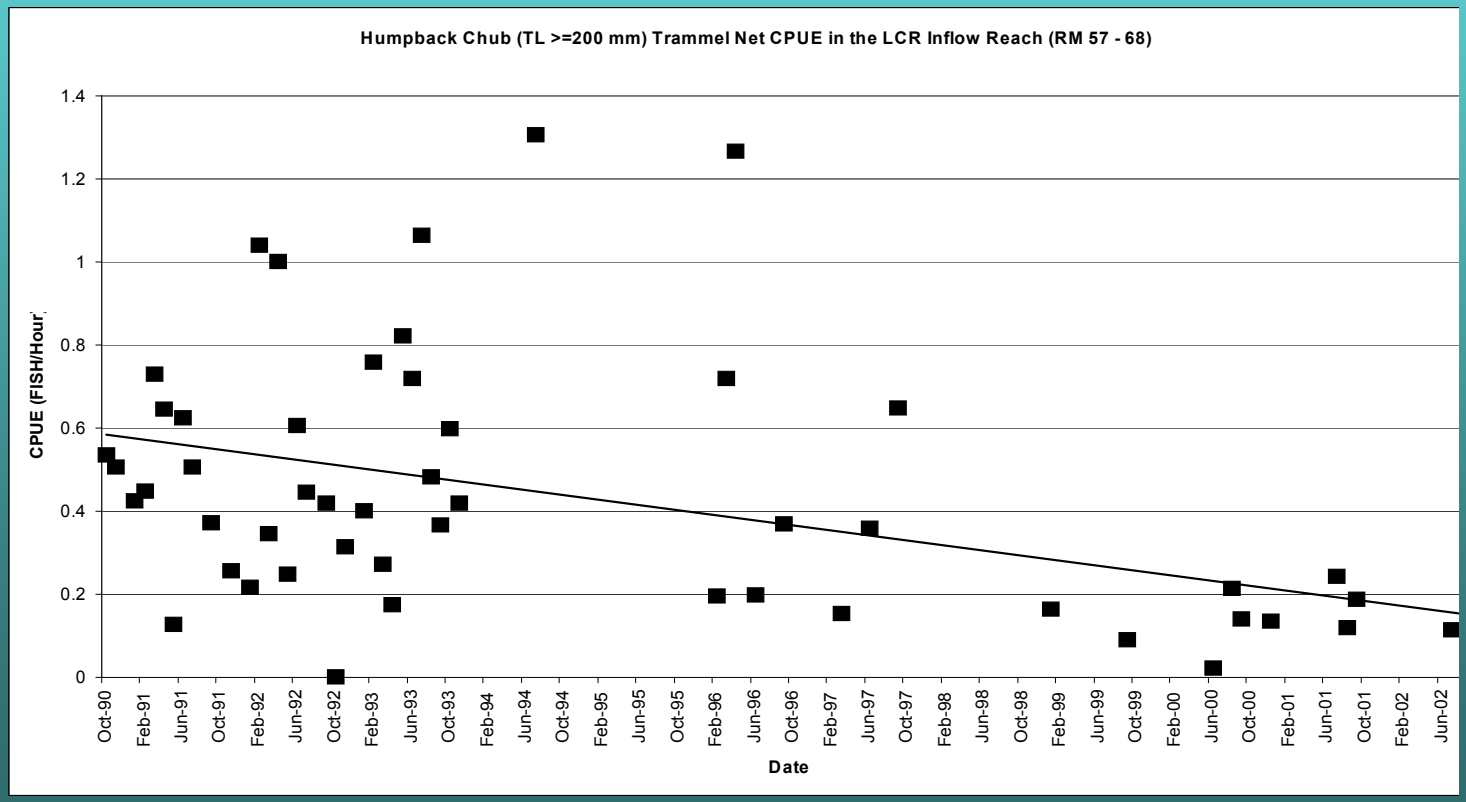


Catch-per-effort indices:





The only indicator that previously suggested stable population size was trammel net catch per effort; recent data show this indicator declining as well



There are two kinds of mark-recapture estimates

- **Closed population**: use short-term marking and recapture sampling to estimate local abundance in one area, e.g. mainstem or LCR; none have been done for the whole system at once

- **Open population**: use long-term data to estimate survival and recruitment rates along with abundances (observations of fish tagged in previous years contribute to estimation of status in any one year)

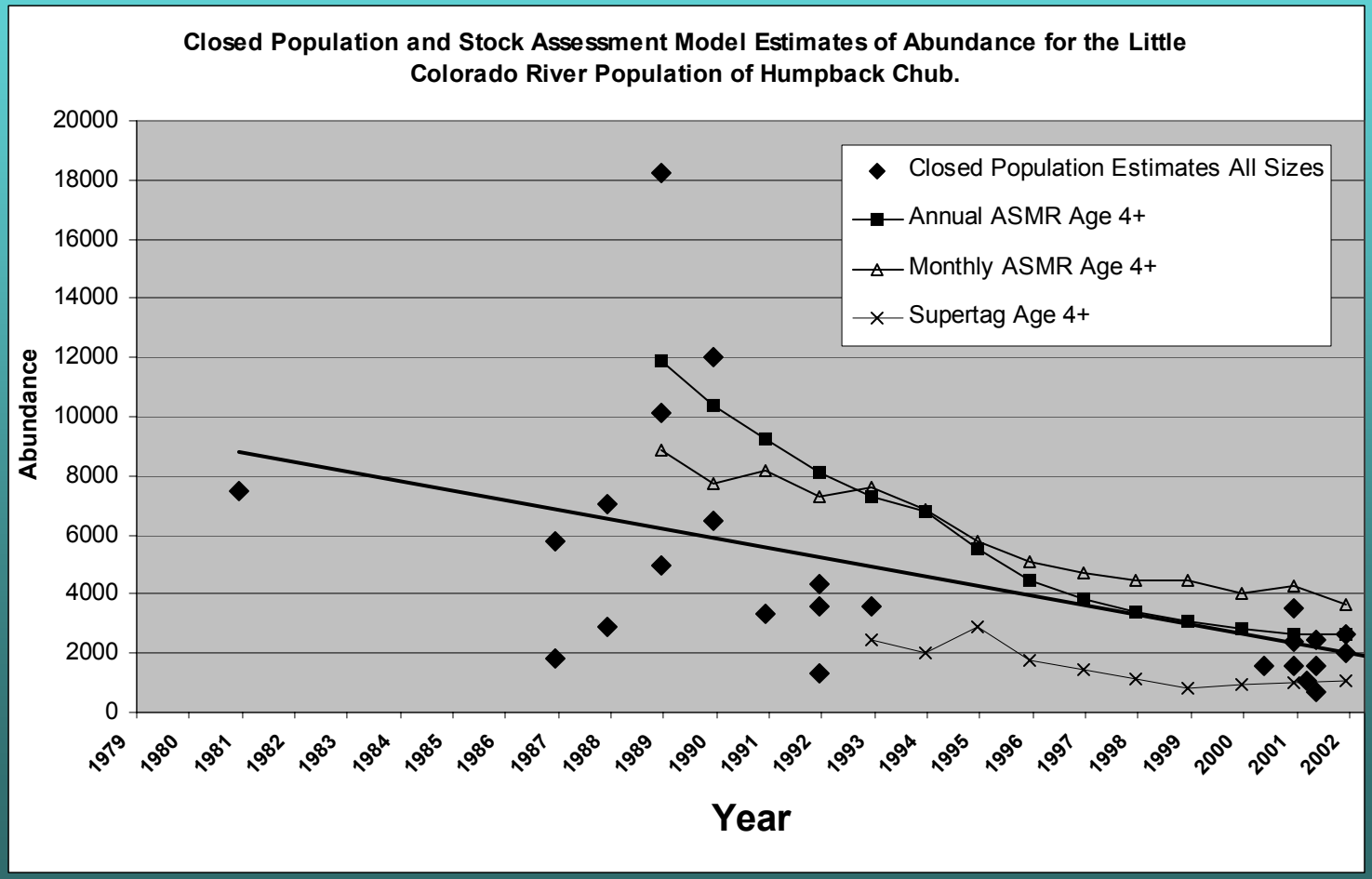
Now we mainly rely upon mark-recapture estimators rather than catch-per-effort trend indices

- Population estimates are based on a ratio assumption:

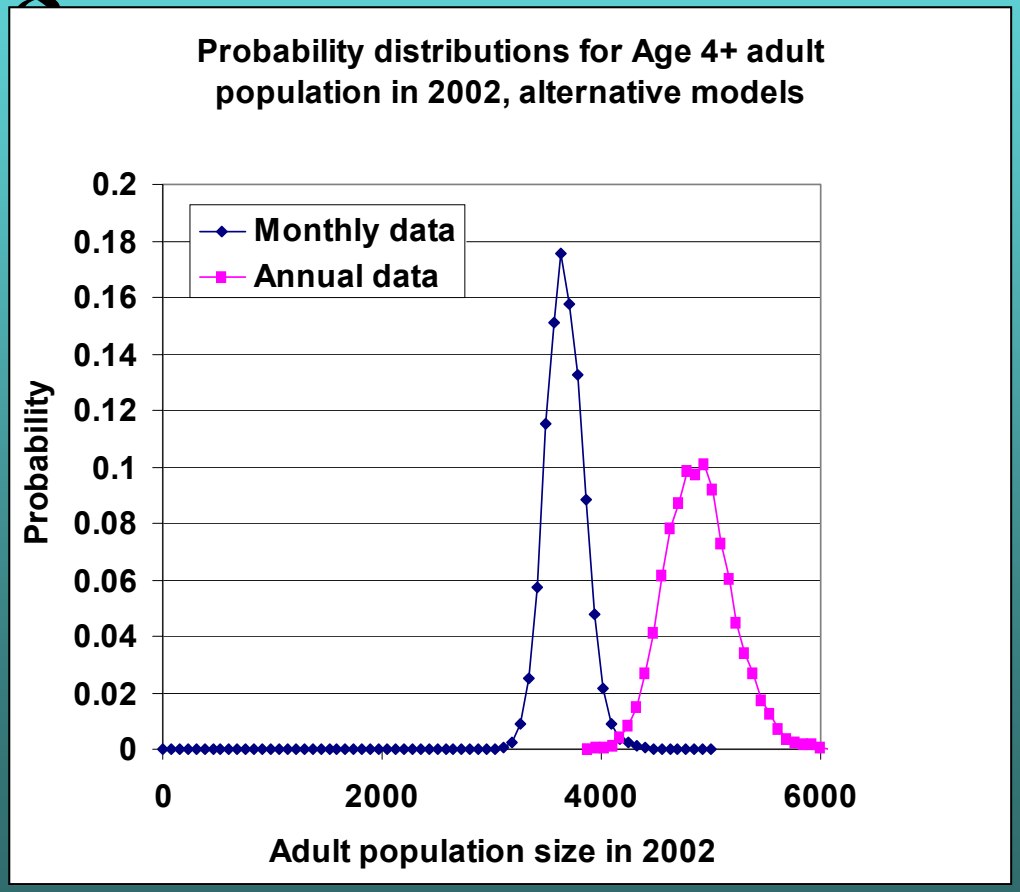
$$N = \frac{(number\_caught)}{(capture\_probabilit\,y)}$$

- Capture probabilities are estimated from recoveries of marked fish

Estimates of the current adult (age 4+) population range from under 2000 to over 4000, depending on assumptions about survival rates

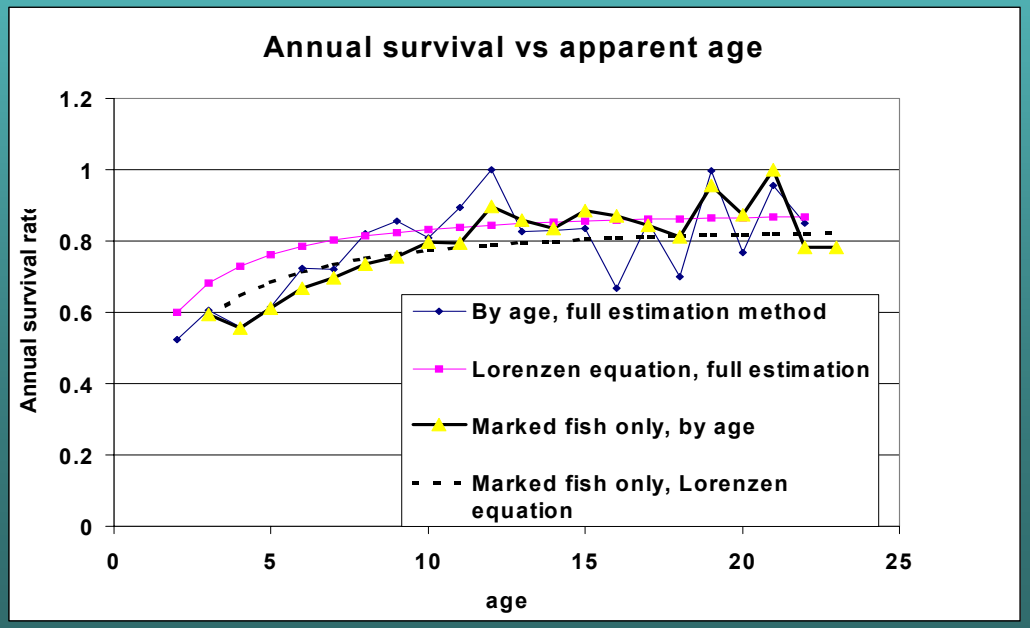


Each variation on the mark-recapture method gives us quite tight limits on population estimates, but the methods do not agree on those limits…

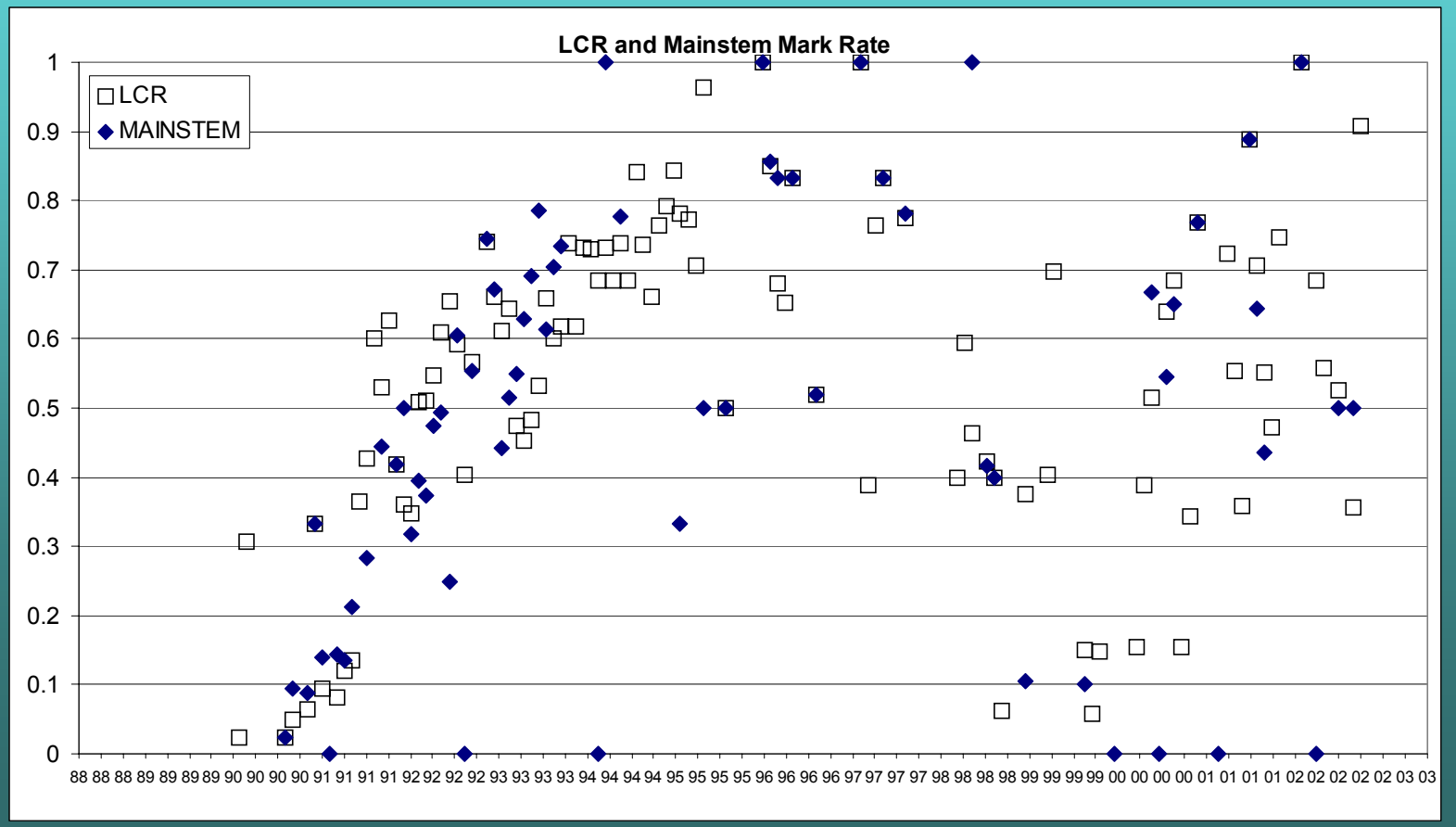


Two factors greatly complicate the open population mark-recapture analysis, and cause methods to disagree about precise numbers

- Size-dependent seasonal and developmental movement between the LCR and the mainstem (spawning runs, juveniles joining adult runs)
- Size/age dependent survival rates

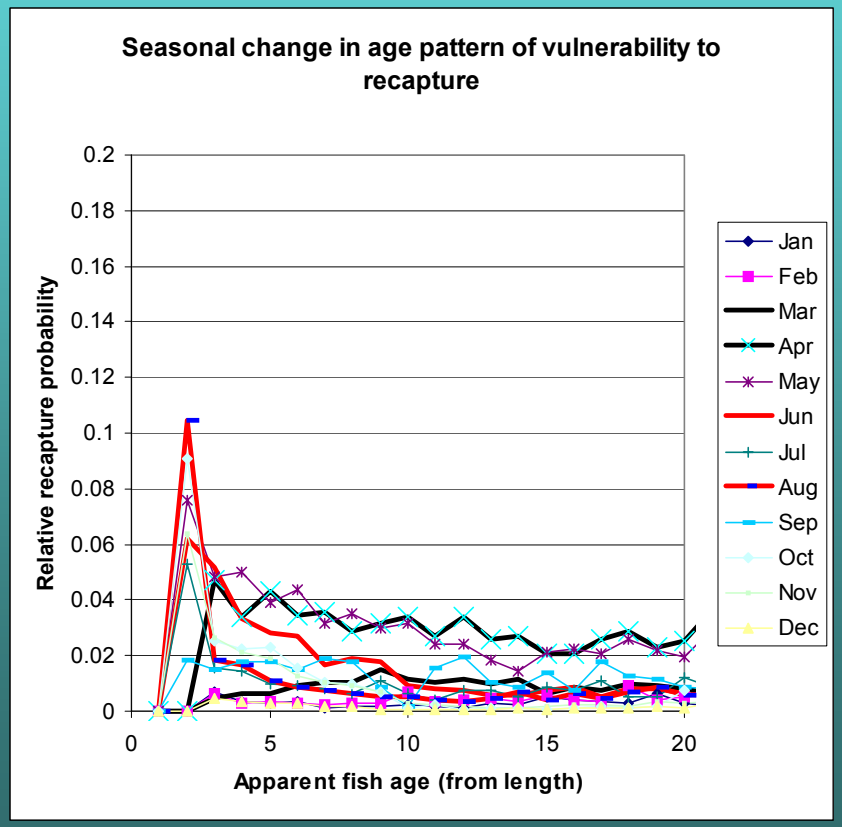


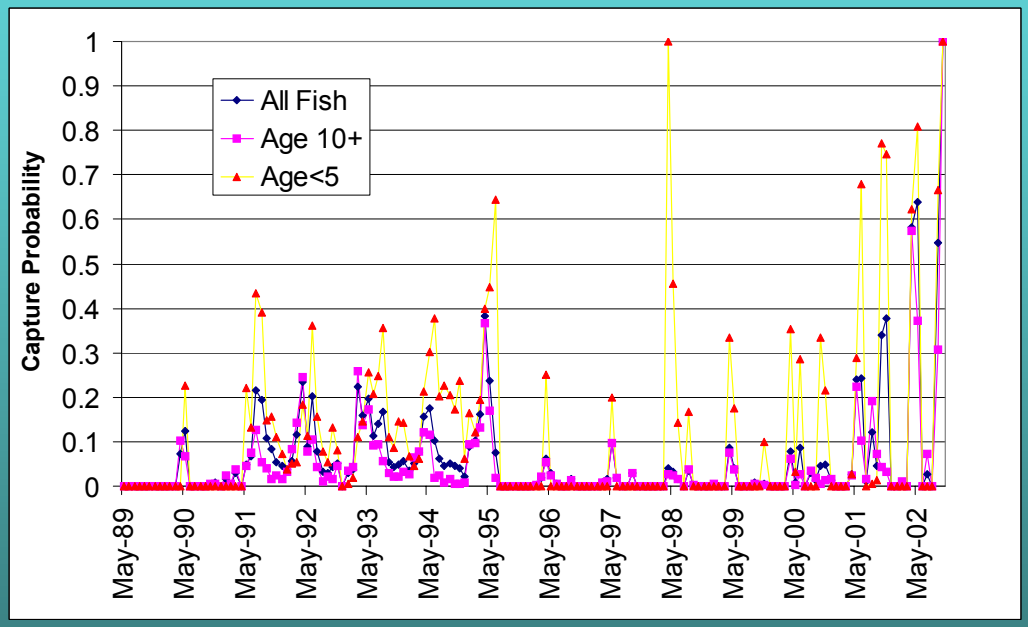
Mark rate patterns indicate that adults sampled in the mainstem near the LCR are not a distinct population (same marks and mark rate pattern as in the LCR; a waste of scarce monitoring resources to do separate estimates)



We believe that bias in some estimators has been caused by our inability to assign accurate ages (and hence accurate recapture and survival probabilities) to fish at the time of tagging. By simulating the sampling process, we find that inaccurate age assignment is likely to cause upward bias in both survival rate and abundance estimates

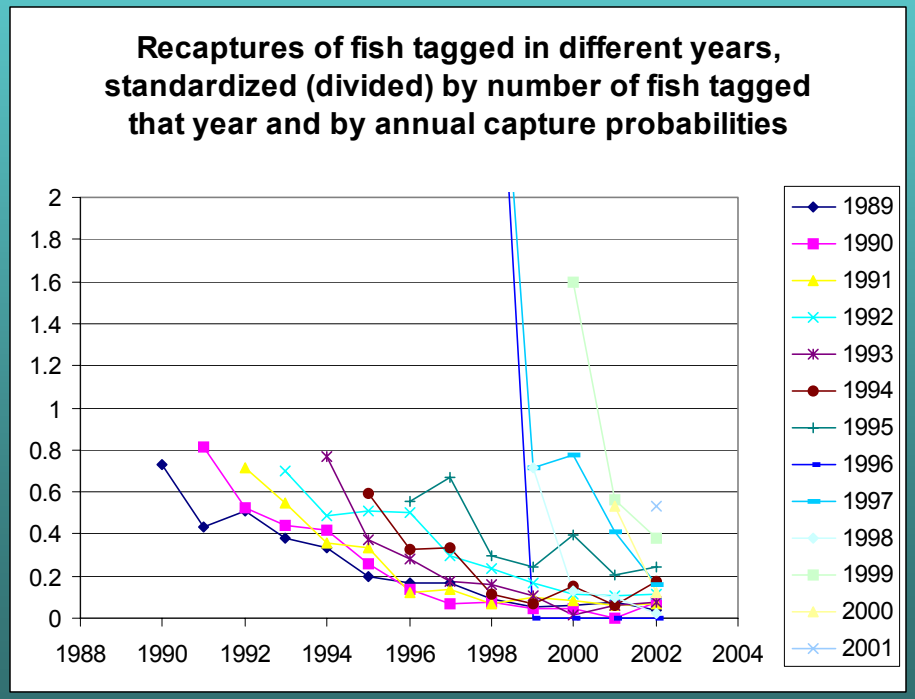
There are complex seasonal and age patterns in capture probabilities



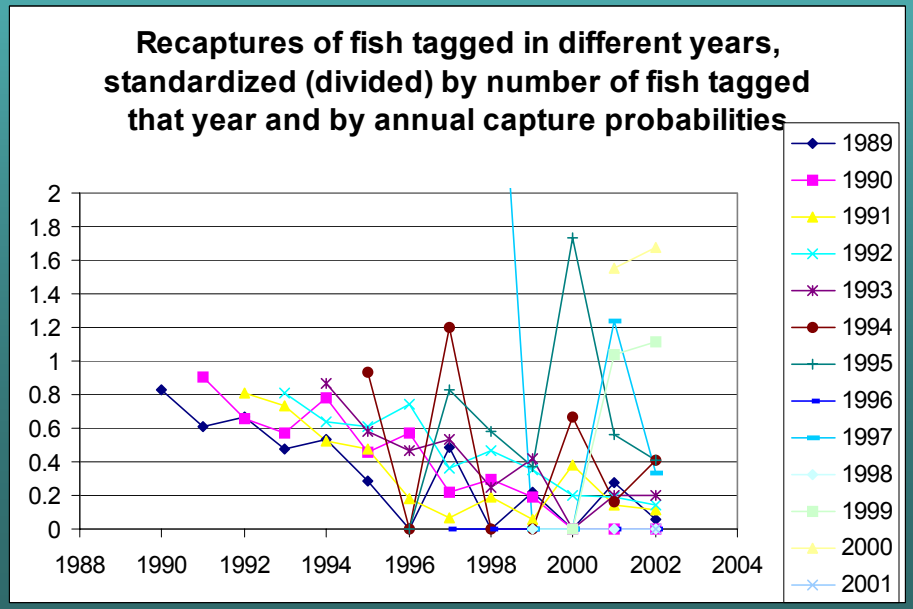


Tracking cohorts of tagged fish shows that older fish may start to "skip spawn", reducing their capture probabilities in LCR sampling

Simple die-off patterns when all fish included:



More complex, jumpy patterns when only older fish are included:



We can back-calculate recruitments prior to 1990 from "age" composition of fish captured in the early 1990s

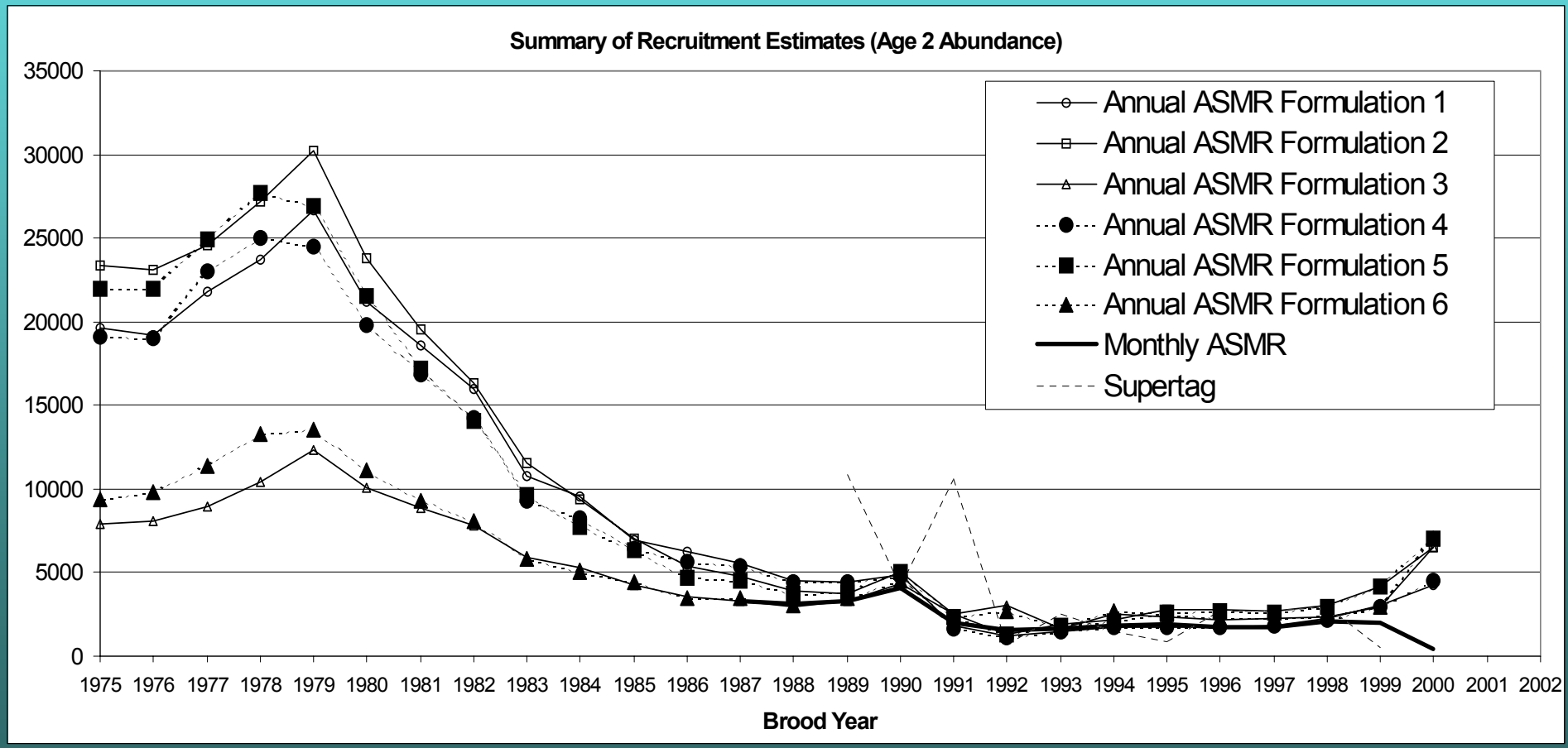
Fish marked by age and year:

1981 recruits

Calculation based on inverse of survival rate to age

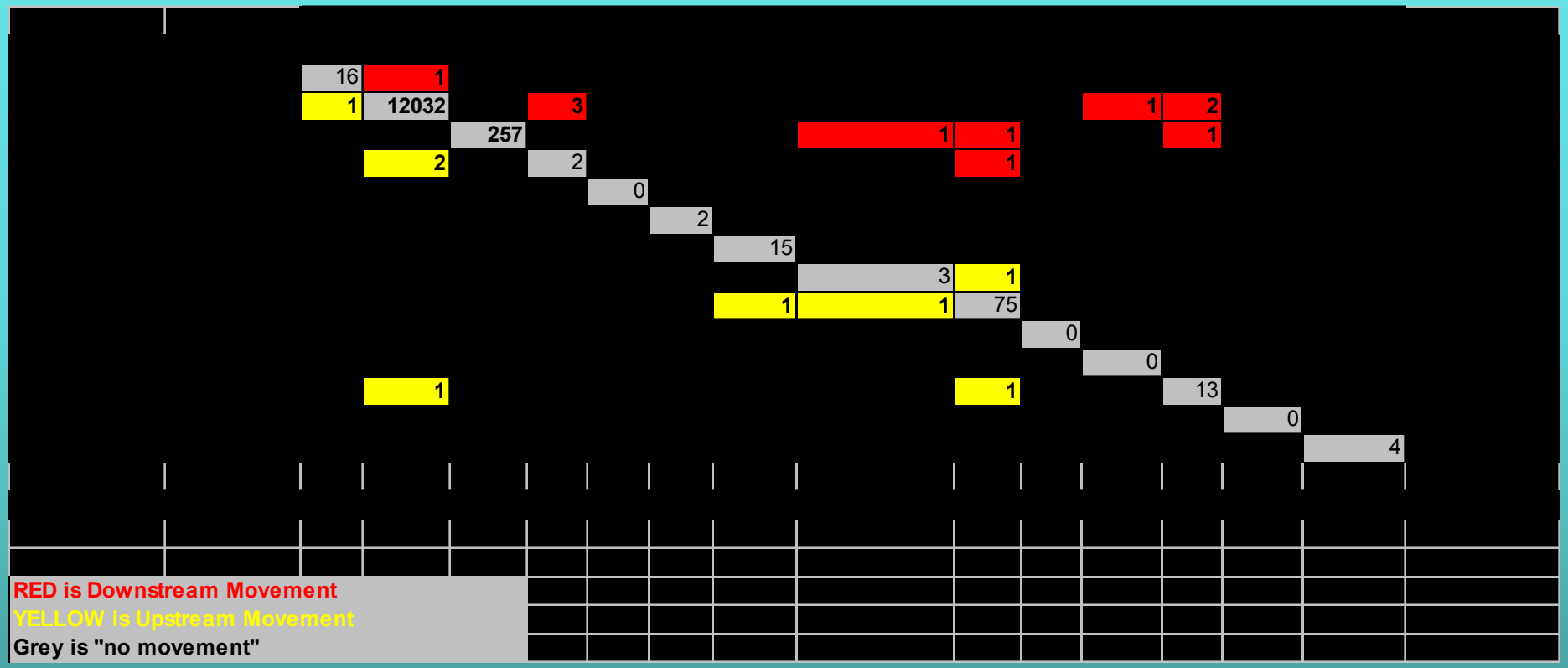
age	1989	1990	1991	1992	1993
2	3	3	96	95	236
3	73	29	650	463	1398
4	66	77	465	228	428
5	32	90	273	194	139
6	12	49	236	145	80
7	11	27	212	142	82
8	16	21	157	126	58
9	30	24	163	164	78
10	41	28	156	175	71
11	31	26	147	157	95
12	25	28	132	175	99
13	29	21	101	181	85
14	15	21	78	141	72
15	24	22	55	88	46
16	21	18	54	72	33
17	7	8	33	31	21
18	6	6	23	32	25
19	1	6	8	21	15
20	1	6	11	17	6
21	1	7	8	13	10

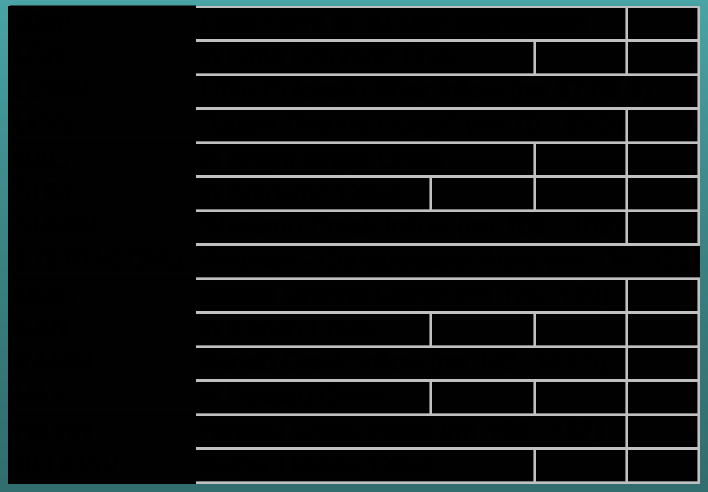
Back-calculation indicates long-term recruitment decline, possible recruitment peak in late 1970s or early 1980s (flood flows?)



Summary

- Low recruitments over the past decade imply that the population will continue to decline for at least a few more years, and may stabilize at around half its present level
- We are very confident about the estimates and predictions of trend, despite uncertainty about the exact numbers of fish present in any past year
- Reversals in trend due to experimental management will be detectable, but only after at least 5 years of monitoring


16 1
1 12032 3
257
2 2
0
2
15
3 1
1 1 75
0
0
1 1 13
0
4
1 2
1 1
1
RED is Downstream Movement
YELLOW is Upstream Movement
Grey is "no movement"



Each estimator appears quite precise in terms of statistical measures of error limits, but these limits are meaningless when we cannot decide whether to trust the assumptions used in deriving the estimator