Questions 1, 3 and 5

Management questions of interest

- Q1. Is SAR sufficient for 1) NPCC interim 2-6% SAR goal & 2) recovery goals?
- Q3. Is transportation more effective than in-river passage under current configuration?
- Q5. What is the relative survival of transported fish post-BONN, compared to in-river fish (*D*)?

Relevant performance measures

- Q1. SAR from smolts at first dam encountered (LGR) to adults back to LGR. Spring/summer chinook, steelhead, fall chinook, sockeye. Emphasis on wild populations or aggregates.
- Q3. Transport to In-river survival rate (T/I, T/C, or TIR) as measured by SAR(T0)/SAR(C0), C0=fish never detected at a transport dam; T0 = transport from all transport dams. All species, wild and hatchery.
- Q5. *D* = relative post-BONN survival of transported and in-river fish, using C0 as a control. Measured as SAR(T0)/SAR(C0) from smolts at BON and adults back to LGR. All species, wild and hatchery.

Statistical hypothesis tests for annual estimates

1. Q1: Annual estimates (lower X% CI exceed criterion)-- H_0: SAR $\leq$ 2.0%; H_1: SAR > 2.0%
2. Q3: Annual estimates (test if T/I > 1.5, with Power = 1-β = 90%, and α = 0.05, to detect true T/I > 1.0) H_0: T/I $\leq$ 1.0; H_1: T/I > 1.0
3. Q5: Annual estimates (evidence of substantial differential delayed transport mortality if *D* < about 0.7) H_0: D $\leq$ 0.7; H_1: D > 0.7

How is uncertainty in data currently considered in the decision making process?

- **Q1:** NPCC decision process calls for "evaluation of the scientific soundness, achievability and impact of ocean conditions upon these SAR objectives", but no alternative management actions are identified if SARs fail to meet the interim objectives.
- **Q3:** Uncertainty in T/I ratios is used to support spread-the-risk or maximized transportation strategies on an annual basis, and in Updated Proposed Actions in the NOAA 2005 Biological Opinion.
- **Q5:** Uncertainty in *D* not considered in decision making for NOAA 2005 BiOp. *D* is incorporated into the performance measures for system survival, but not clear how a *D* value different than assumed in the BiOp would influence jeopardy framework

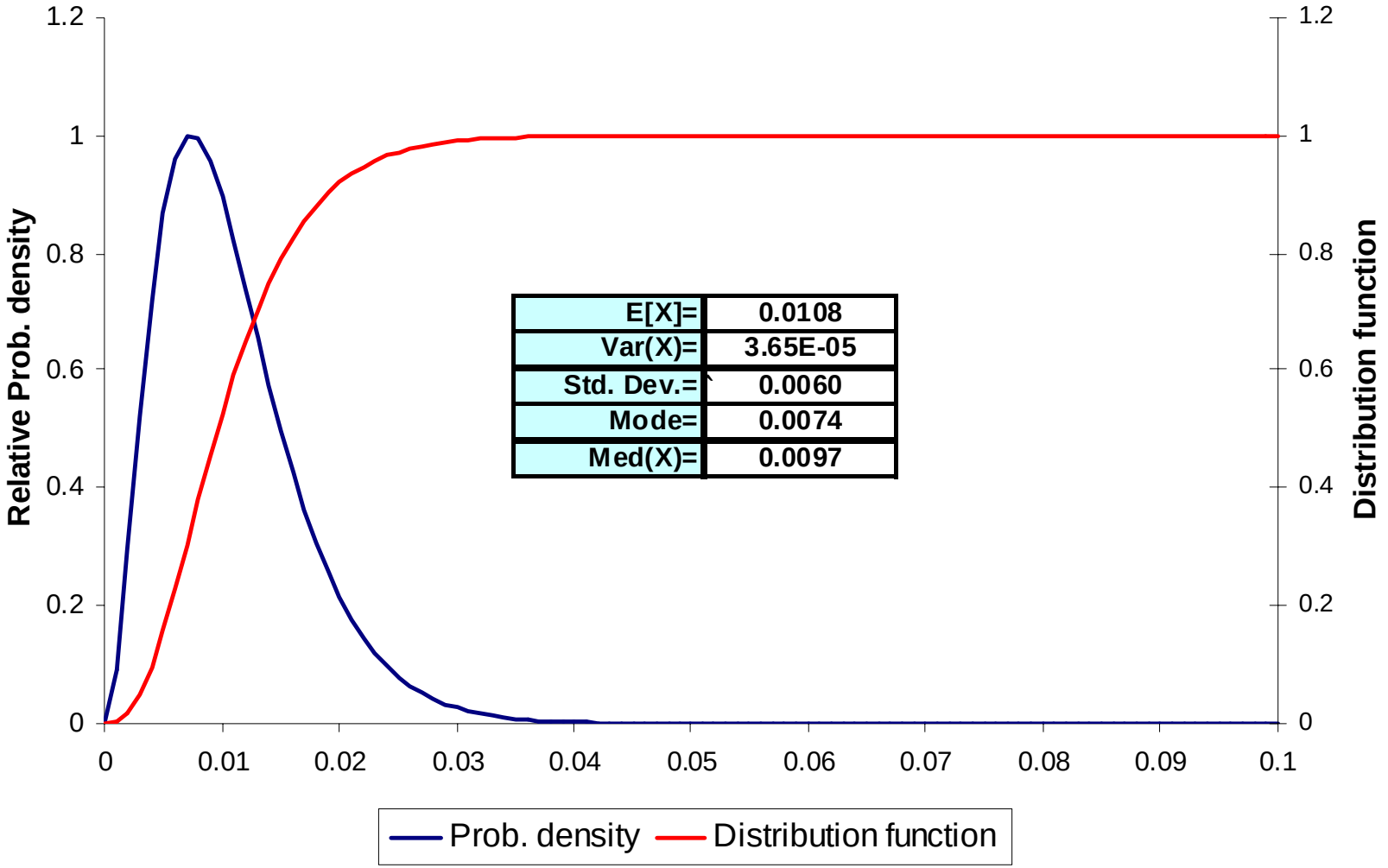
Measures of longer term central tendency

- Great amount of uncertainty in annual estimates obscuring the mean underlying value (for a given time period), due to process error (inter-annual variation in survival rates) and sampling error.
- Combining data from multiple years potentially allows better estimate of long-term distributions and expected values of SARs and ratios of SARs
- Want to remove sampling error from estimates, to get at underlying environmental stochasticity

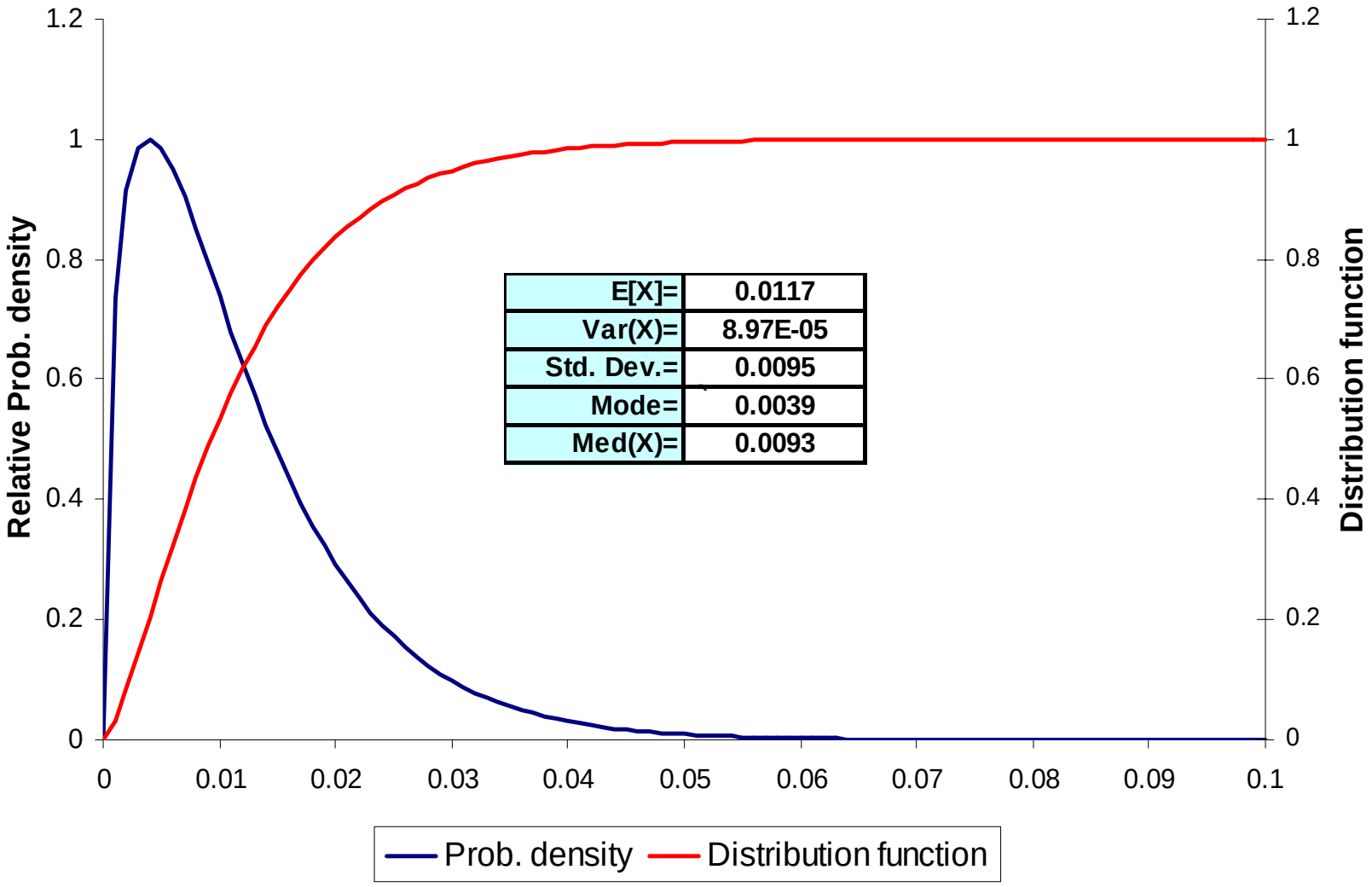
Removing sampling variance

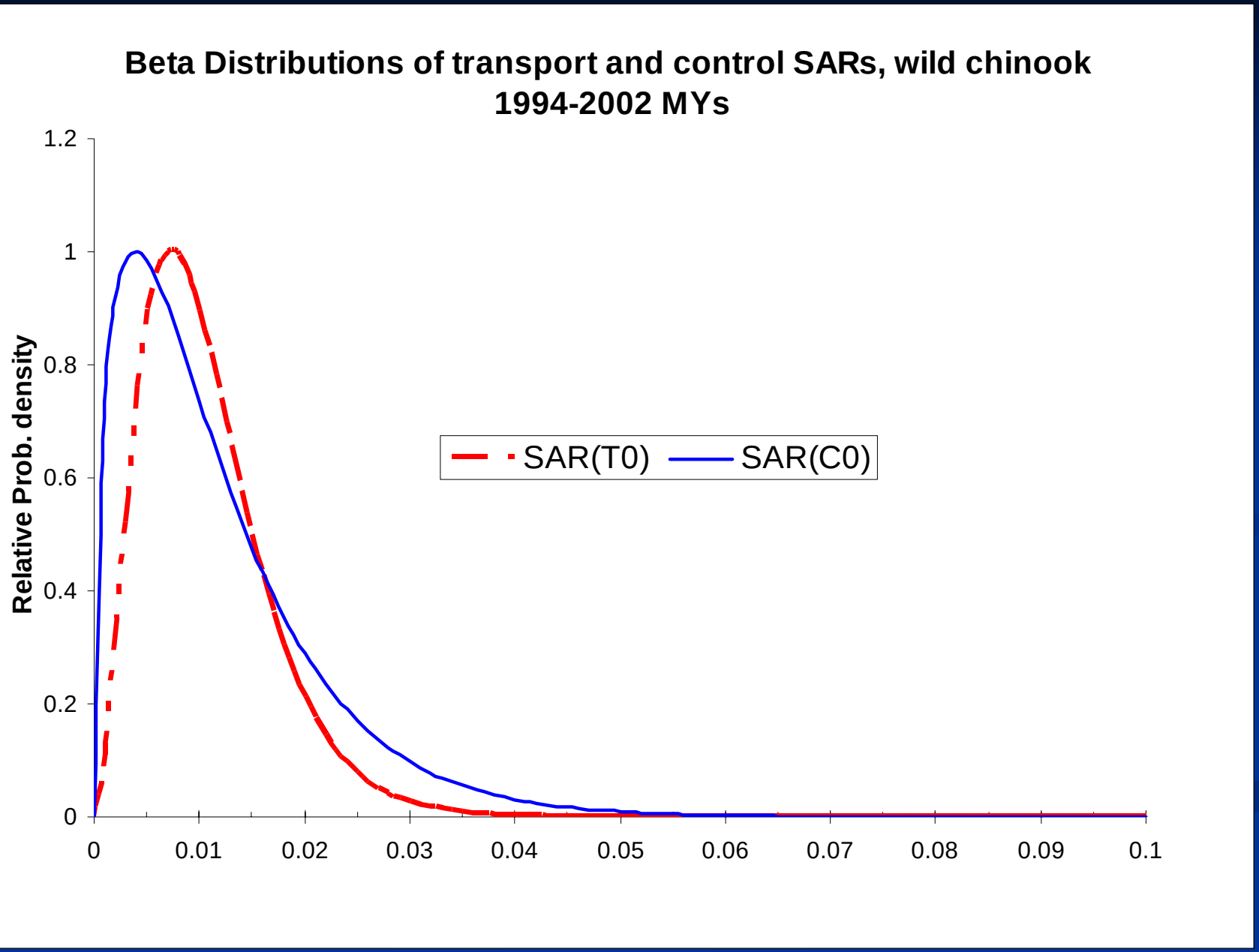
- Under the assumption that the sampling error in SAR estimates is binomial, it can be removed from the variance estimated from a time series SAR estimates.
- One method: use a beta-binomial likelihood function to estimate the parameters of a beta distribution representing distribution of actual survival rates (Kendall 1998 or alternative method)
- Maximum likelihood method could also be used for estimating parameters describing functions of survival rates (e.g. T/C).

Beta Distribution of SAR(T0), wild chinook 1994-2002 MYs



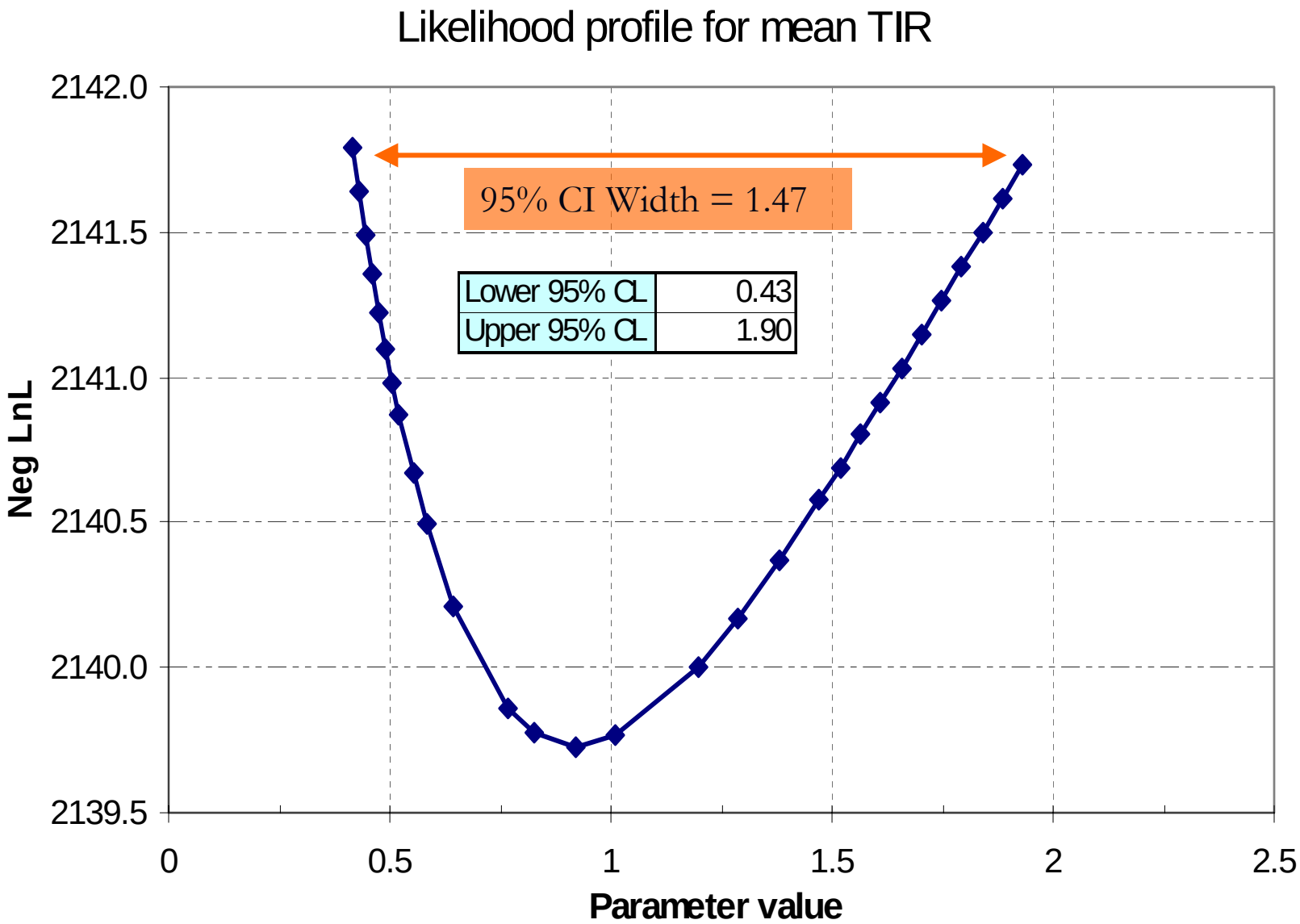
Beta Distribution of SAR(C0), wild chinook 1994-2002 MYs

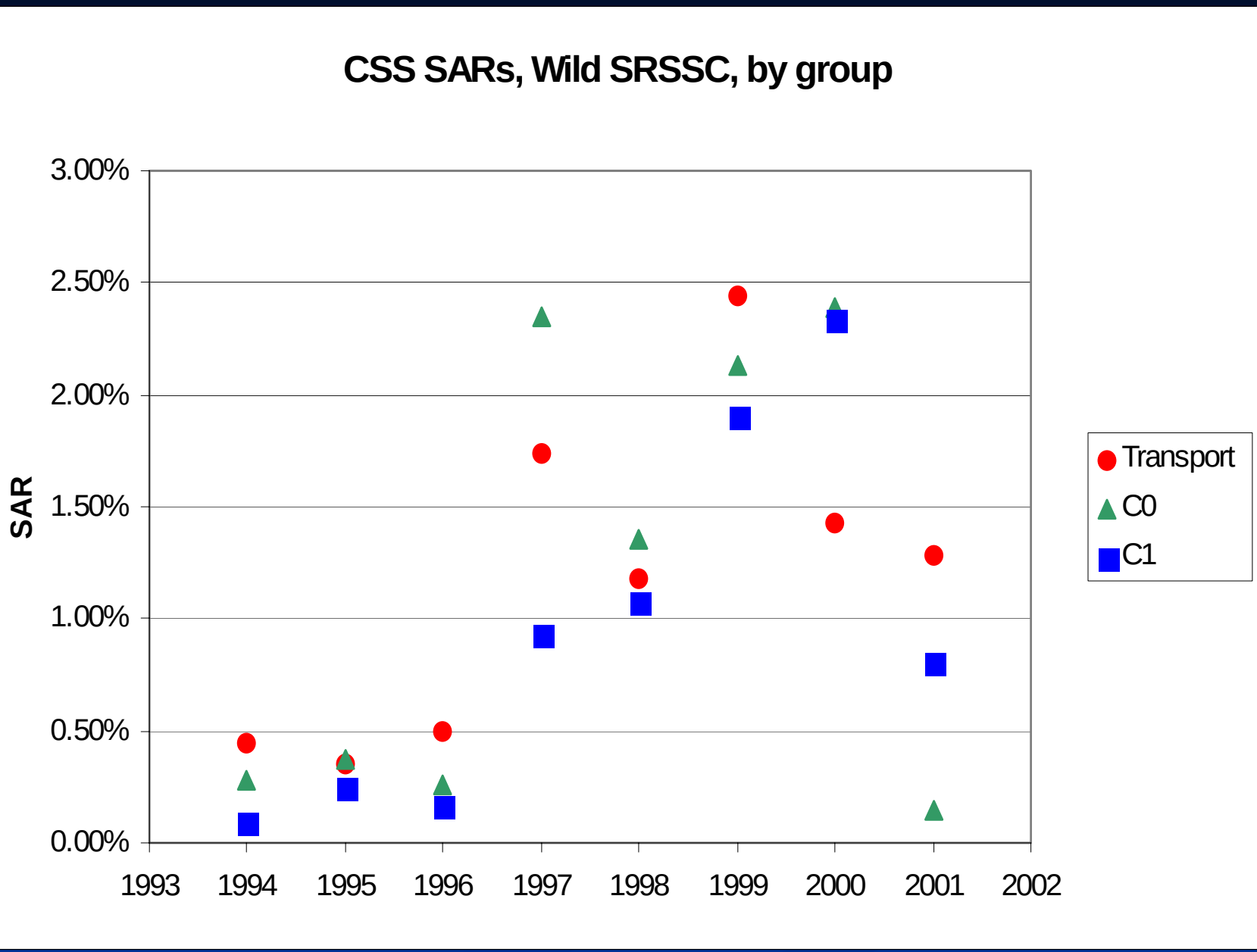



Beta Distributions of transport and control SARs, wild chinook
1994-2002 MYs
Relative Prob. density
1.2
1
0.8
0.6
0.4
0.2
0
0
0.01
0.02
0.03
0.04
0.05
0.06
0.07
0.08
0.09
0.1
SAR(T0)
SAR(C0)

Evaluating monitoring performance

- Proposed measures to evaluate the influence of number of fish tagged and number of years of data collection on inferential ability:
  1. Width of the 95% confidence interval on the estimated mean (expected) value of the parameter
  2. Posterior probability of the alternative hypothesis, given that it is true (or false) at a certain effect size (i.e. true expected value of SAR, T/C, or D)


Likelihood profile for mean TIR
95% CI Width = 1.47
Lower 95% CL 0.43
Upper 95% CL 1.90
Neg LnL
2142.0
2141.5
2141.0
2140.5
2140.0
2139.5
0
0.5
1
1.5
2
2.5
Parameter value


CSS SARs, Wild SRSSC, by group
SAR
3.00%
2.50%
2.00%
1.50%
1.00%
0.50%
0.00%
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
Transport
C0
C1

Simulation of monitoring

- Initial model simulates random variation in SARs of T and C groups, + process of estimating SAR from returning PIT-tagged fish for fixed number of tagged fish at LGR
- SARs modeled as beta r.v.s, with estimated environmental coefficient of variation as above
- Correlation between T and C SARs modeled using data from the 1994-2001 migration years
- Model ignores correlation structure *within* a group, due to cohorts overlapping in ocean and serial autocorrelation in ocean survival rates

Alternative simulation approach

- May be useful to use more realistic simulation model, e.g. based on a stochastic, age-structured projection matrix with a correlation matrix of parameters representing vital rates
- Would likely necessitate alternative approach to removing sampling variance that considers covariance between survival rates, such as the variance-components approach used by Gould and Nichols (1998)
- Incorporating correlation between SARs can dramatically reduce C.I. around T/C – simulations using ratio of Beta r.v.s suggest by half or more

Application to other CSMEP questions?

- Removal of sampling variance to get at environmental stochasticity in vital rate of interest could be applied to other problems

Spring/summer chinook H, M, L

M&E Level	Spring/summer Chinook
High	PIT tag for wild SARs at level of Major Population Groups (MPG); all hatchery releases represented in SAR, T/I and D estimates
Medium	PIT tag wild aggregate SARs from opportunistic tagging (current CSS); PIT tag SARs major production hatcheries. Estimate annual T/I and D for wild and hatchery groups (current CSS)
Low	Run reconstruction SARs: partition wild and hatchery smolts and adults at upper dam (e.g., Petrosky et al. 2001; Raymond 1988)

Fall chinook H, M, L

M&E Level	Fall Chinook
High	Same as medium??
Medium	PIT tag wild fall Chinook above LGR, treat same as CSS fish; PIT tag SARs major production hatchery groups (USFWS/NPT proposal) (NOAA proposal)??
Low	PIT tag hatchery group only as surrogate for wild SAR??

Steelhead H, M, L

M&E Level	Steelhead
High	PIT tag for wild SARs at level of Major Population Groups (MPG) (feasibility ??); all hatchery releases represented in SAR, T/I and D estimates
Medium	PIT tag wild aggregate SARs from opportunistic tagging (current CSS since 2002); PIT tag SARs major production hatcheries (proposed CSS-not funded)
Low	Run reconstruction SARs: partition wild and hatchery smolts and adults at upper dam (e.g., Marmorek et al 1998; Raymond 1988).

Sockeye H, M, L

M&E Level	Sockeye
High	None, due to extremely limited potential sample sizes??
Medium	SARs: PIT tagged migrants from Redfish Lake, treated same as CSS fish in FCRPS (beginning 2005); T/I and D not feasible because extremely limited potential sample sizes
Low	SARs: run reconstruction at Redfish Lake; T/I and D unsampled, assume response similar to or worse than spring/summer chinook??