OBAN: ONCORHYNCHUS BAYESIAN ANALYSIS

A STATISTICAL LIFE-CYCLE MODEL FOR SALMON

PREDATION WORKSHOP
JULY 20, 2013
UC DAVIS

NOBLE HENDRIX, QEDA CONSULTING

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Correigh Greene, Tim Beechie, NOAA Fisheries

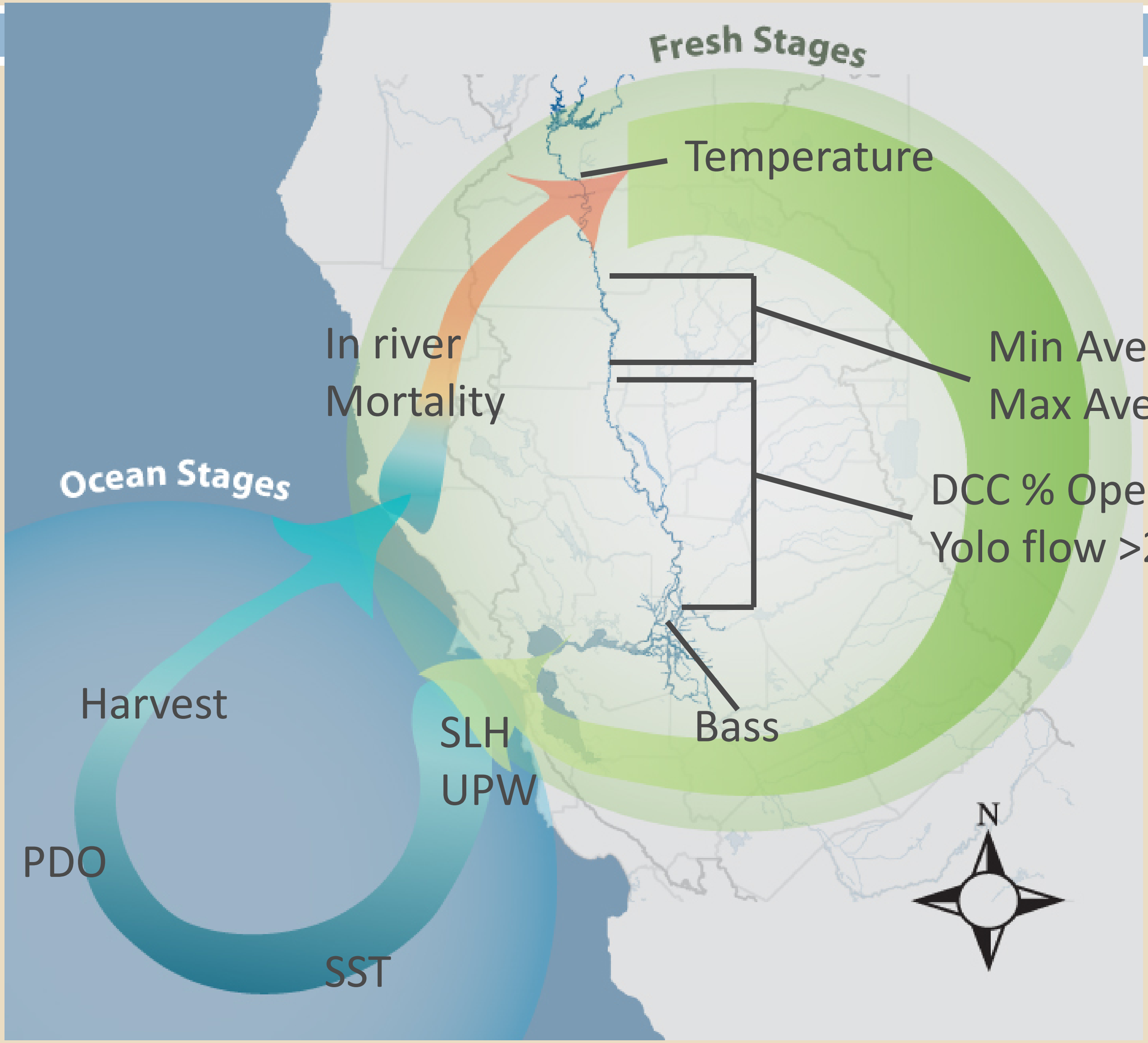
Acknowledgements

- Delta Stewardship Council
- NMFS
- CDFW
- USFWS
- DWR
- USBR

Central Valley spring-run Chinook

MOTIVATION:

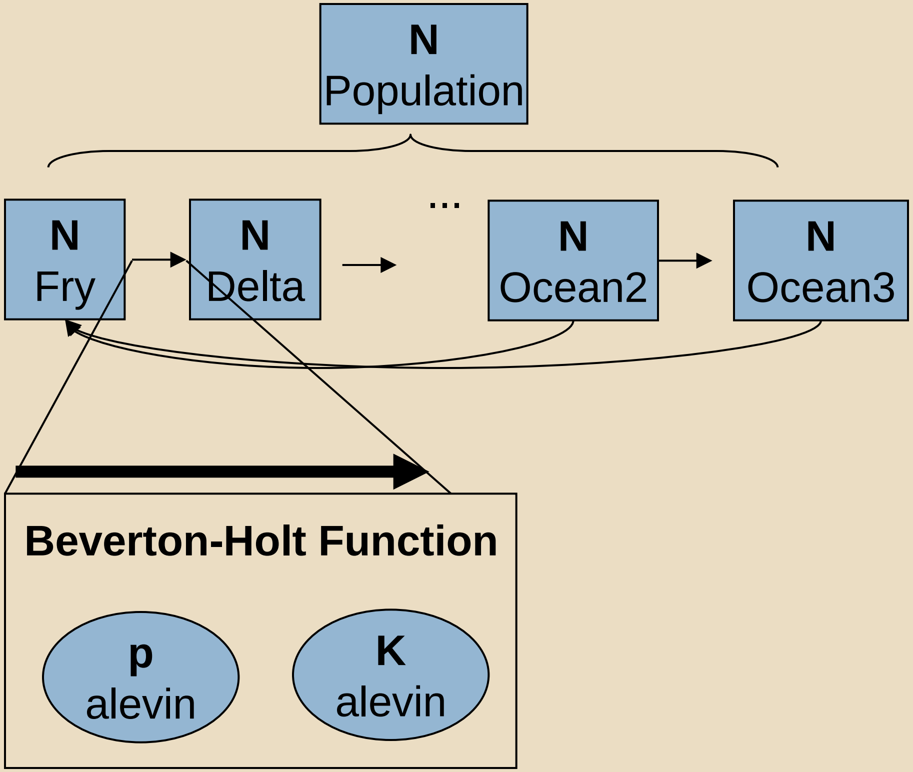
Factors hypothesized to affect WR population dynamics



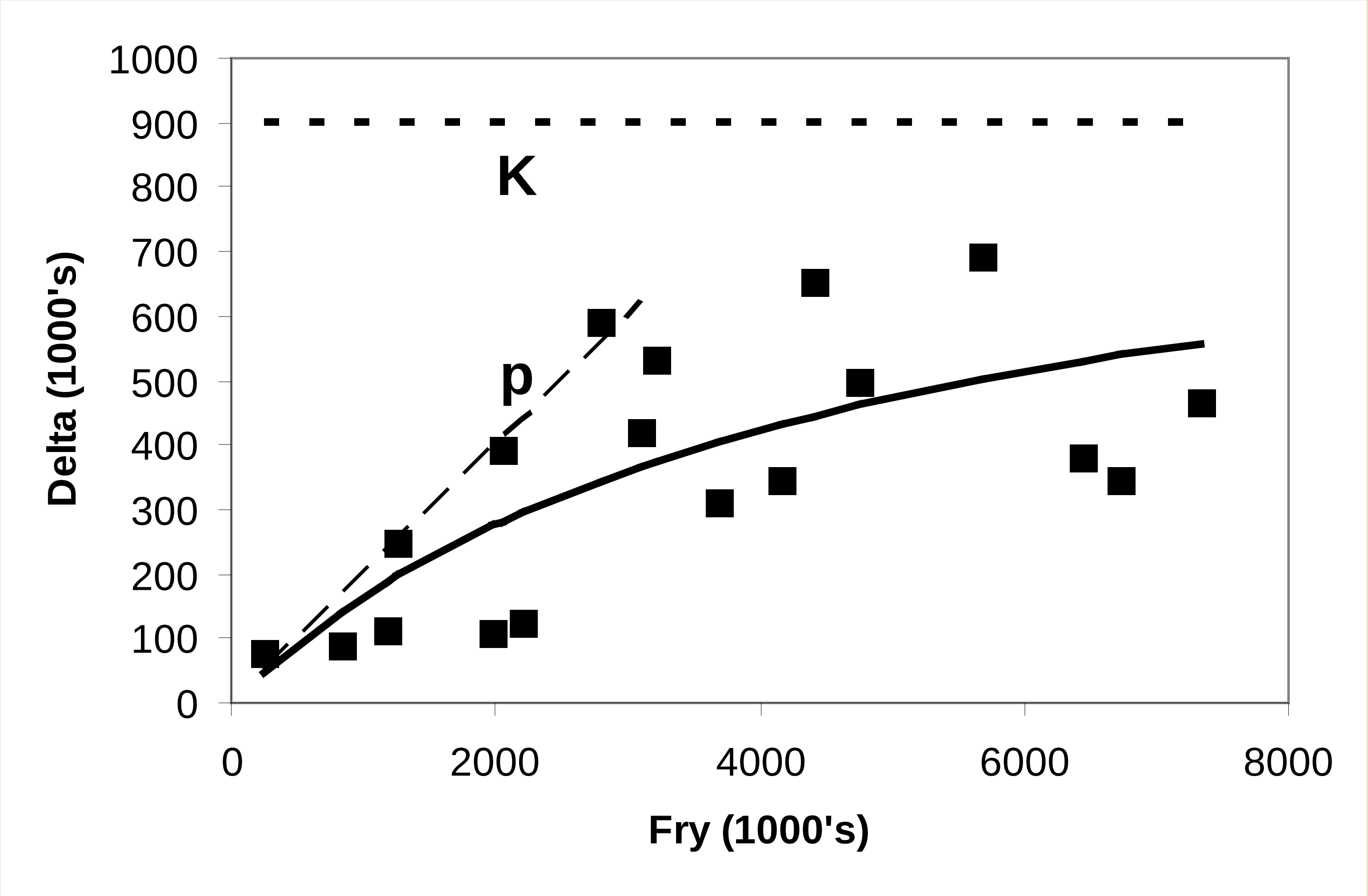
OBAN objectives:

- Evaluate whether hypothesized factors explain dynamic vital rates (e.g., survival) through the entire life-cycle
- Estimate effects of factors by statistically fitting predictions of the population dynamics model to observed indices of abundance
- Explicitly incorporate uncertainty in the estimation procedure by using a Bayesian framework

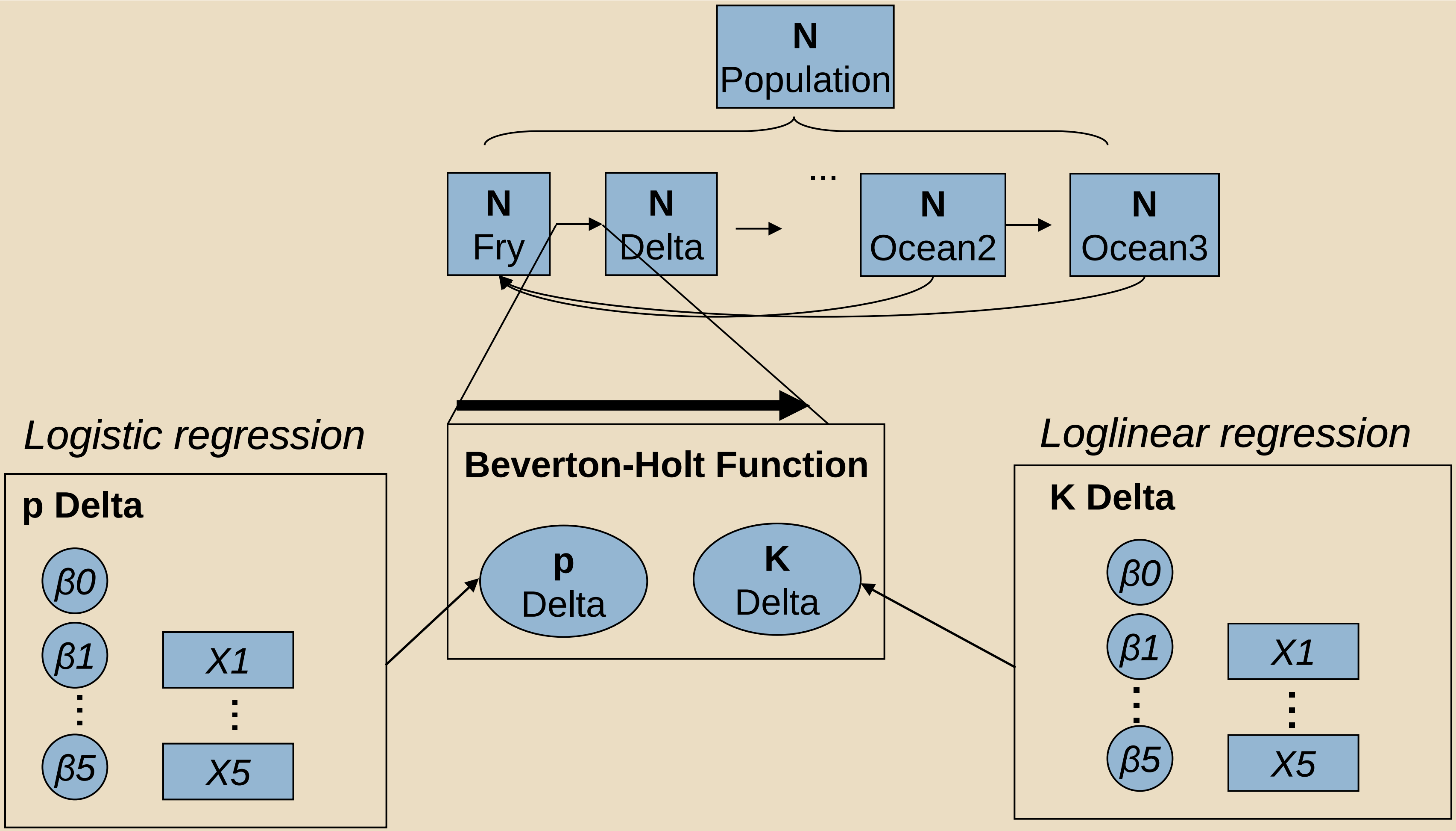
1st Level: Stage Transitions



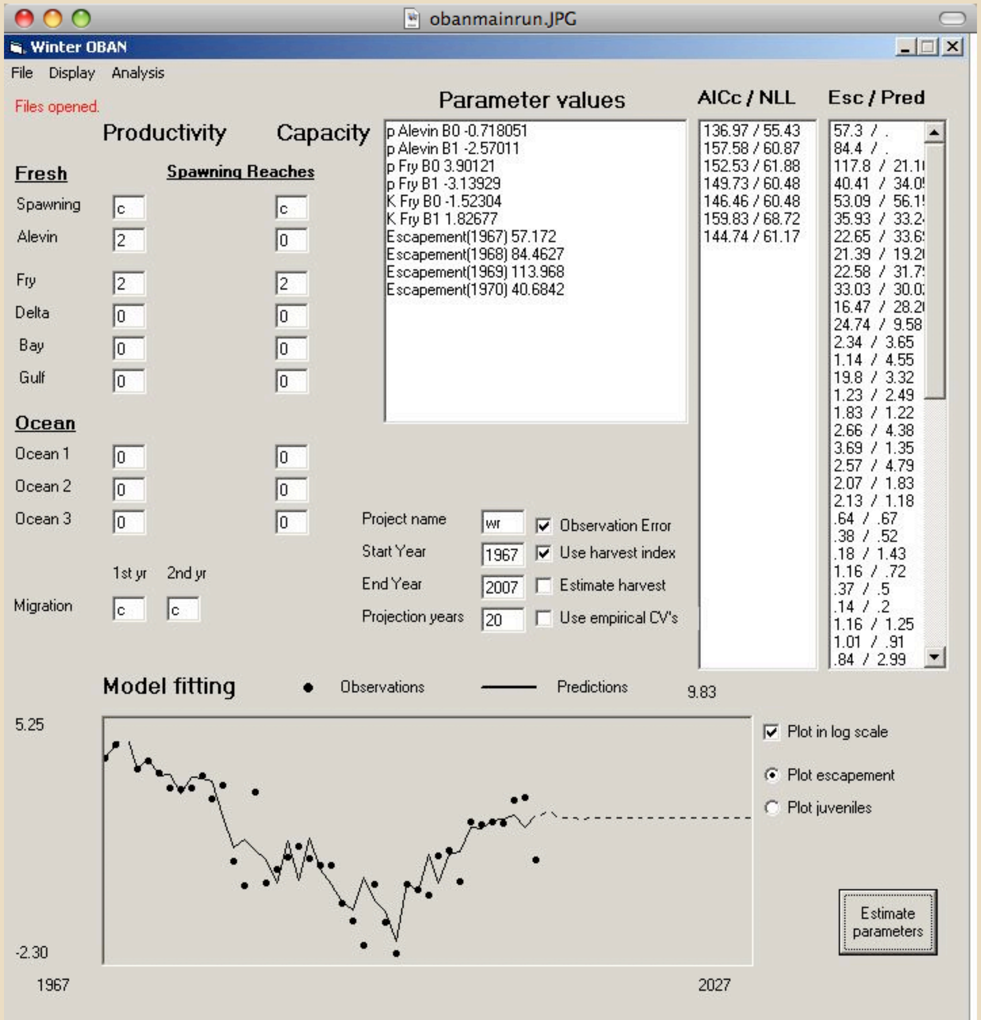
Beverton-Holt Function for Transitions



Full Hierarchy



Maximum Likelihood Modeling Tool



- Delivers point estimates (MLE)
- Estimation via ADMB
- Stable and available to public
- Easy to convert competing hypotheses into model structural forms (GUI based)
- Easy to compare competing hypotheses with AIC

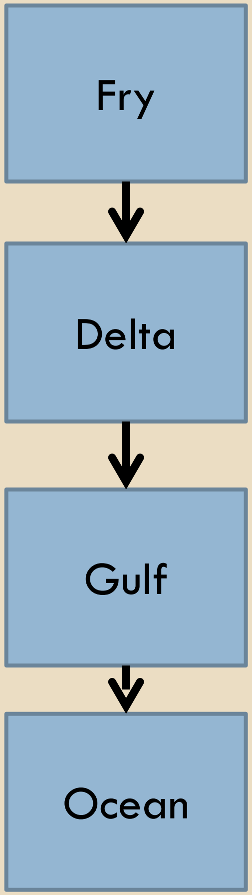
Model Assumptions and Limitations

- Assumptions similar to generalized linear models:
  - Identify relationships, but does not specify the underlying causal mechanism
  - Multicollinearity of factors
  - Distributional assumptions
- Forecasting Limitations
  - Large changes to the ecosystem that are not captured in the historical conditions are difficult to forecast

Butte Creek spring-run

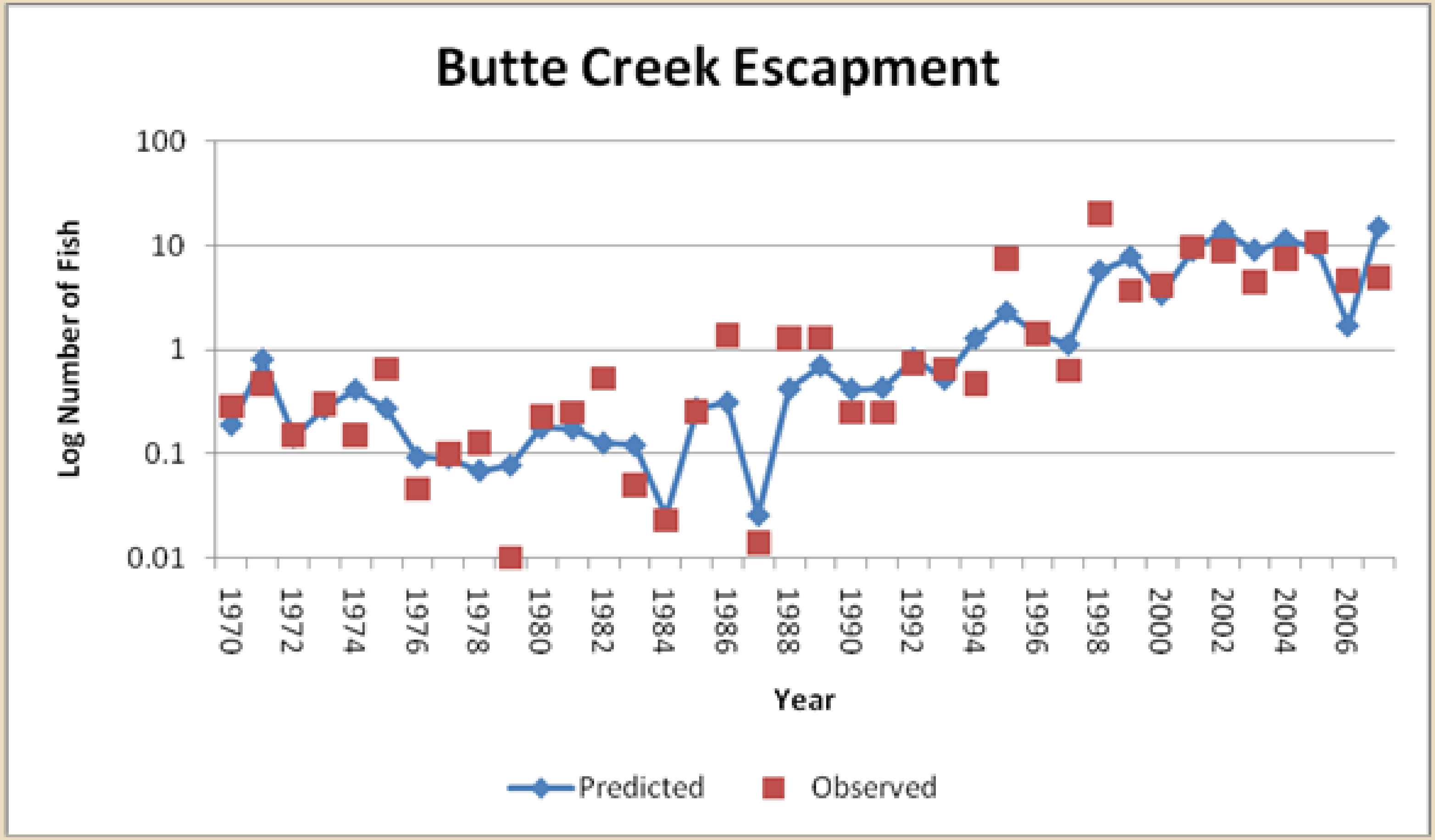
Photo Credit: UC Davis (aacook@gmail.com)

Butte Creek Potential Factors



- Fry stage: Flow and Temperature (y-1) metrics
- Delta stage: **BASS** (Catch), YOLO, DCC, EXPT
- Gulf stage: UPW, SLH, SST, and CURL
- Ocean 2 and Ocean 3 stages: Harvest

Model Fit (lowest AIC)



Model structural uncertainty

Delta Stage	Gulf Stage	AIC_C Score	Δ AIC_C
BASS;	CURL; SLH;	110.33	0.00
	CURL; SLH;	112.76	2.43
EXPT; BASS;	CURL; SLH;	113.62	3.29
BASS;	PDO; UPW;	115.97	5.64
YOLO;	PDO; UPW;	116.55	6.22

Model selection weights (Burnham and Anderson 2002), of approximately 0.57, 0.17, and 0.11 for the top three models.

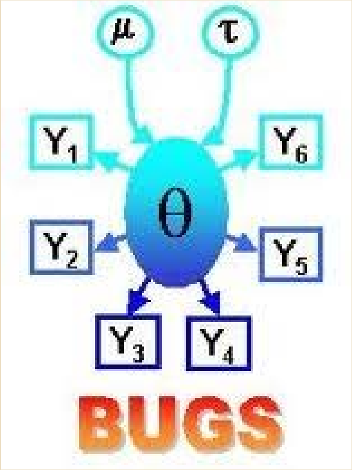
Influence of Factors on Butte Creek SR

Factor	Model 1	Model 3
BASS	-1.24 (0.51)	-1.39 (0.60)
CURL	6.75 (1.5)	6.65 (1.49)
SLH	-3.65 (0.94)	-3.63 (0.92)
EXPT		-3.09 (0.71)

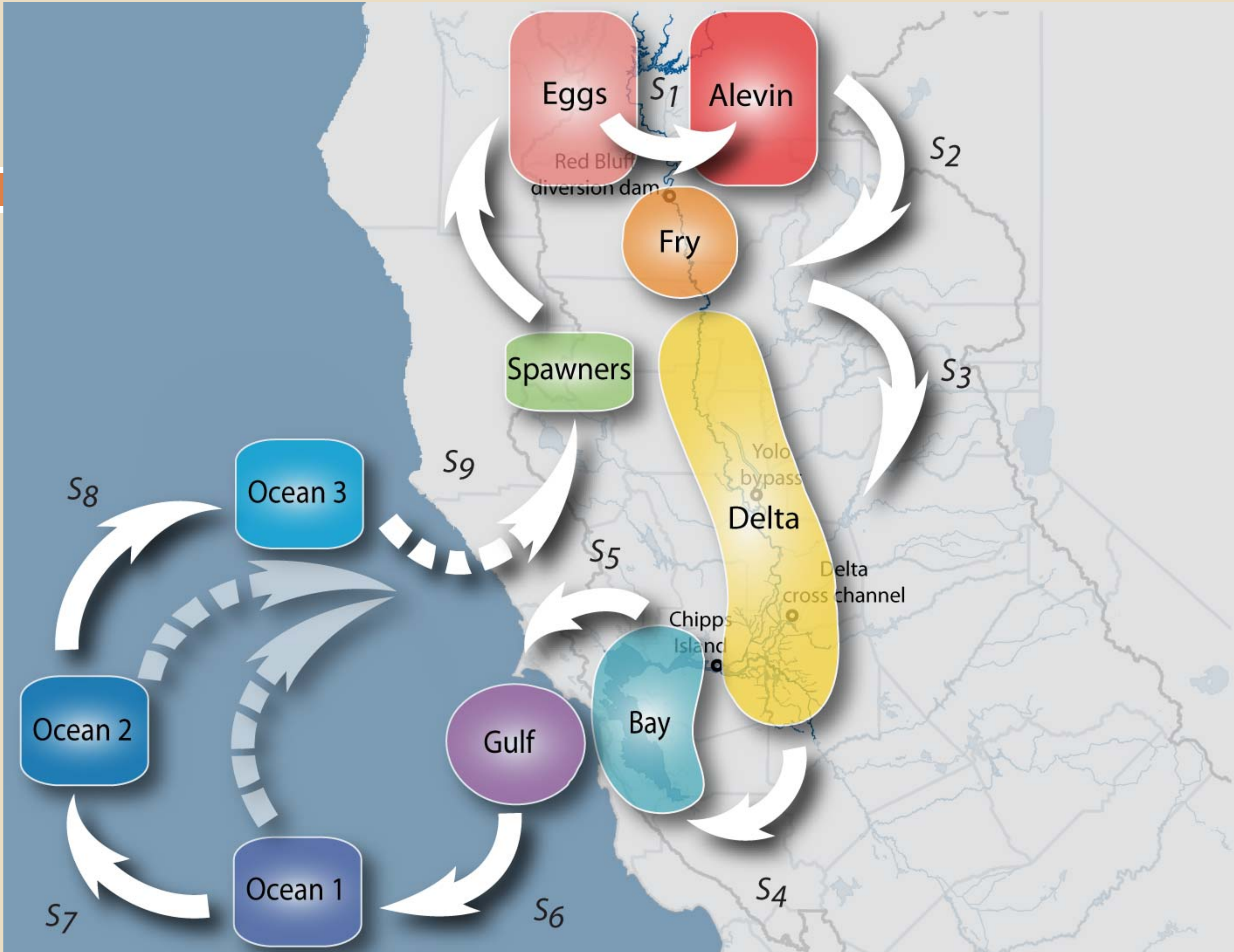
- SR survival increases when:
  - Striped bass abundance is low
  - Curl is positive (i.e., periods of more offshore upwelling)
  - SLH is low (i.e., El Niño years are bad)
  - Exports are lower than average

Winter OBAN

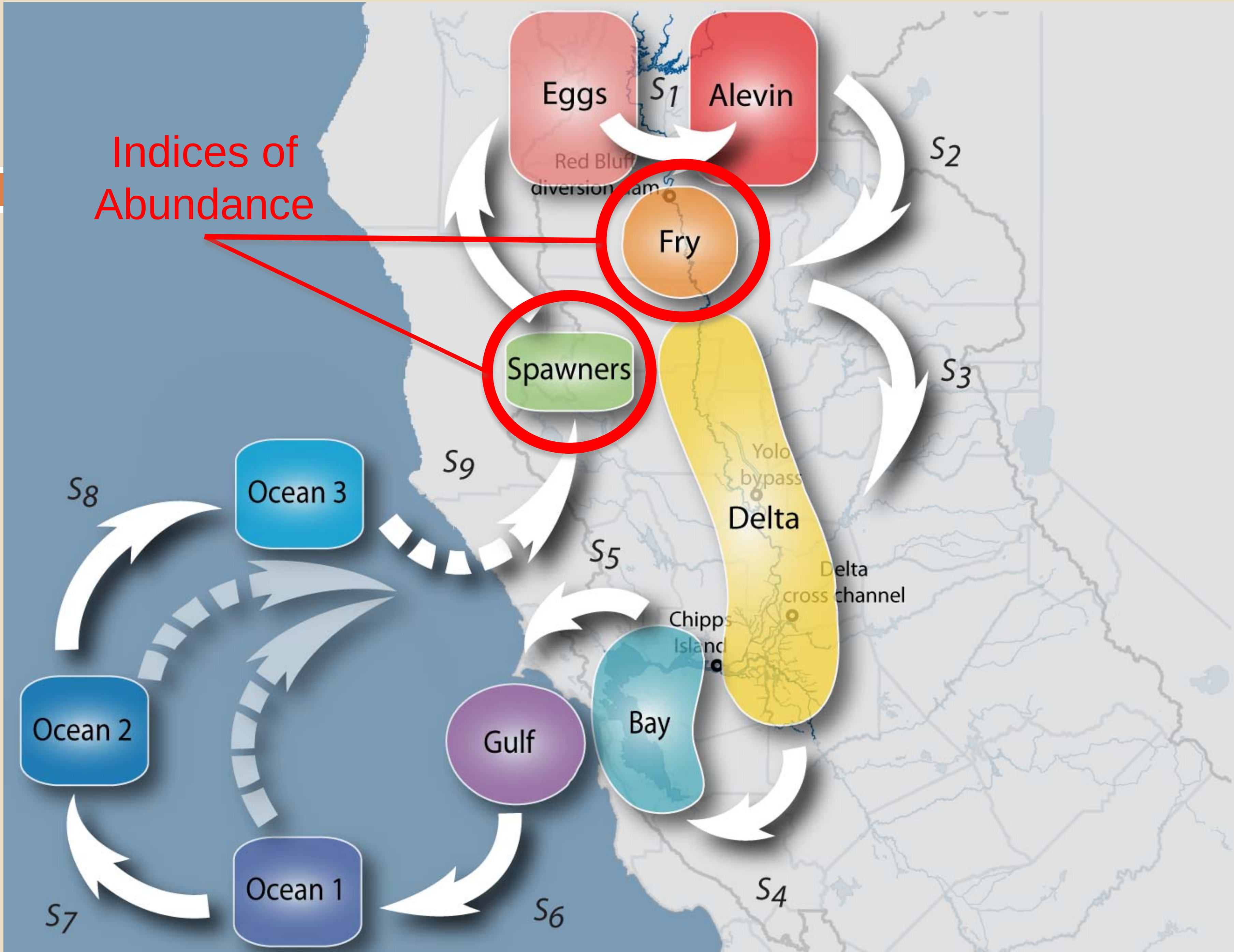
- Bayesian state-space model
- Estimation via MCMC – Metropolis and distribution free adaptive rejection steps (log concave densities) in WinBUGS
- 50,000 (50% burn-in) samples from 3 chains with diagnostics via the Brooks-Gelman- Rubin statistic (Brooks and Gelman 1998)



CDFG



Eggs
S_1
Alevin
S_2
Red Bluff
diversion dam
Fry
Spawners
S_3
Yolo
bypass
Delta
S_9
S_8
Ocean 3
S_5
Delta
cross channel
Chipps
Island
Ocean 2
Gulf
Bay
Ocean 1
S_7
S_6
S_4


Indices of
Abundance
Eggs
S_1
Alevin
S_2
Red Bluff
diversion dam
Fry
Spawners
S_3
Yolo
bypass
Delta
Delta
cross channel
S_9
S_8
Ocean 3
S_5
Chipps
Island
Ocean 2
Gulf
Bay
Ocean 1
S_7
S_6
S_4

Winter Run Model details

- Period of retrospective analysis: 1967 – 2008
- Data
  - Annual escapement: 1967 – 2008
    - 1967 – 1987 counts conducted via a weir type setting
    - 1988 – 2001 expansion assuming 15% of the run after May 15th
    - 2002 – 2008 carcass surveys
  - Juvenile production indices: 1995 – 1999, 2002-2007
- Assumptions:
    - Harvest rates reflect relative levels of exploitation
    - Maturation rates from analysis of '98, '99, '00 CWT data

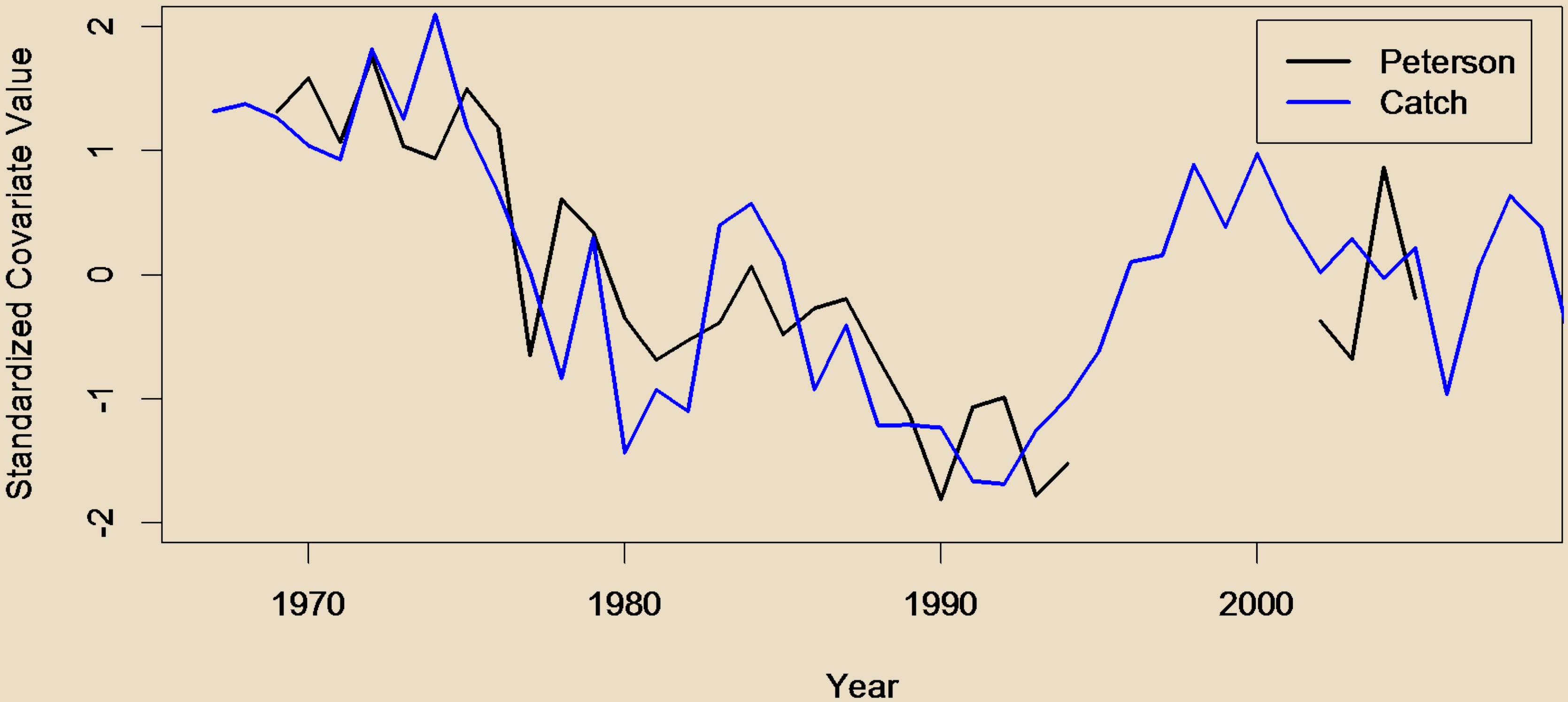
Winter OBAN

Factors affecting survival transitions:

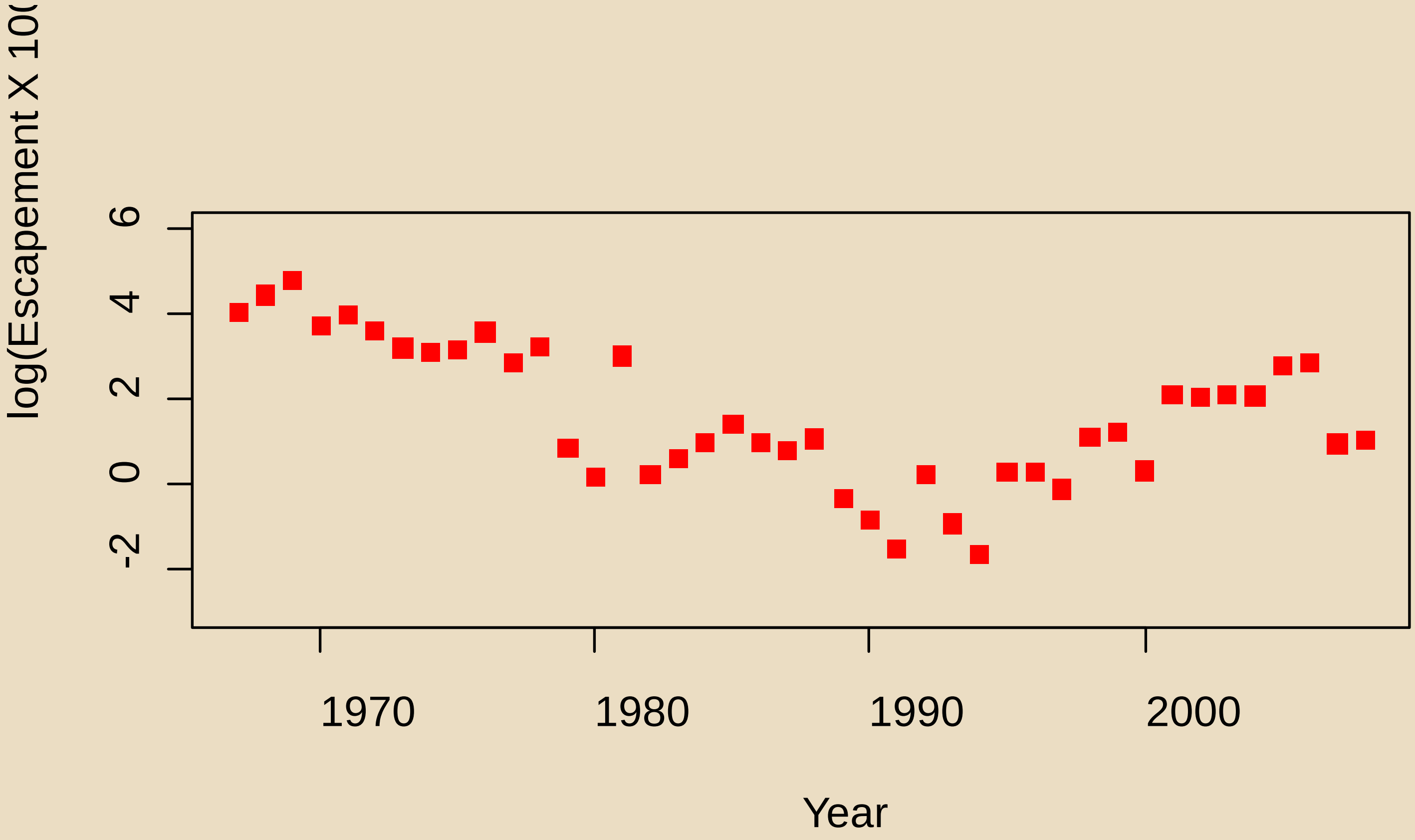
- Covariates incorporated into Winter OBAN
  - Alevin: TEMP- Temperature in spawning reaches
  - Fry: MINFLOW - Minimum Flow at Bend Bridge
  - Delta: EXPT, YOLO, **BASS**
    - Two BASS covariates were evaluated
  - Gulf: CURL - upwelling index
  - Ocean: Harvest

BASS:
Standardized Predation Covariates

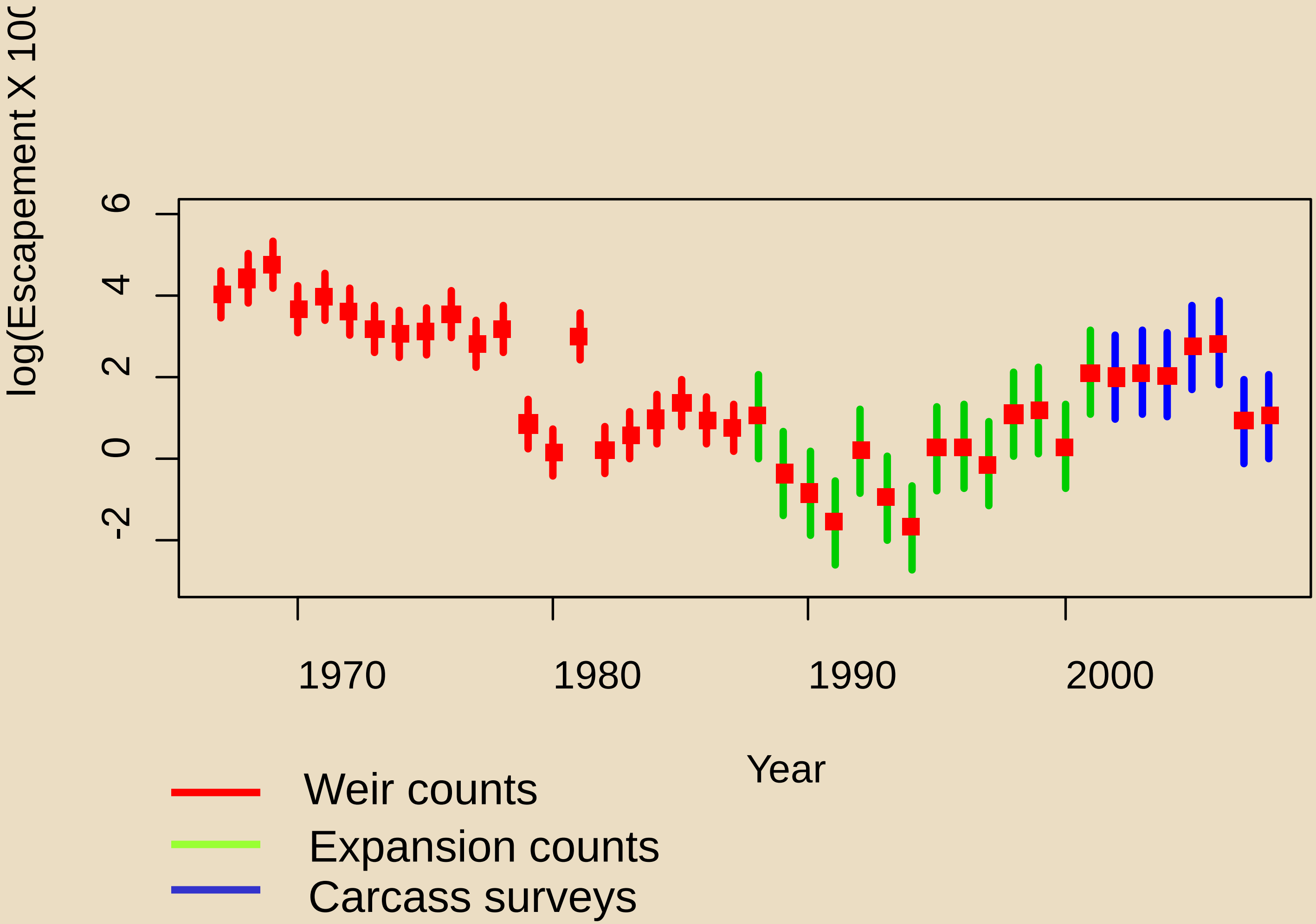
- Log Striped Bass Catch
- Log Striped Bass Peterson Abundance Estimate



WR escapement

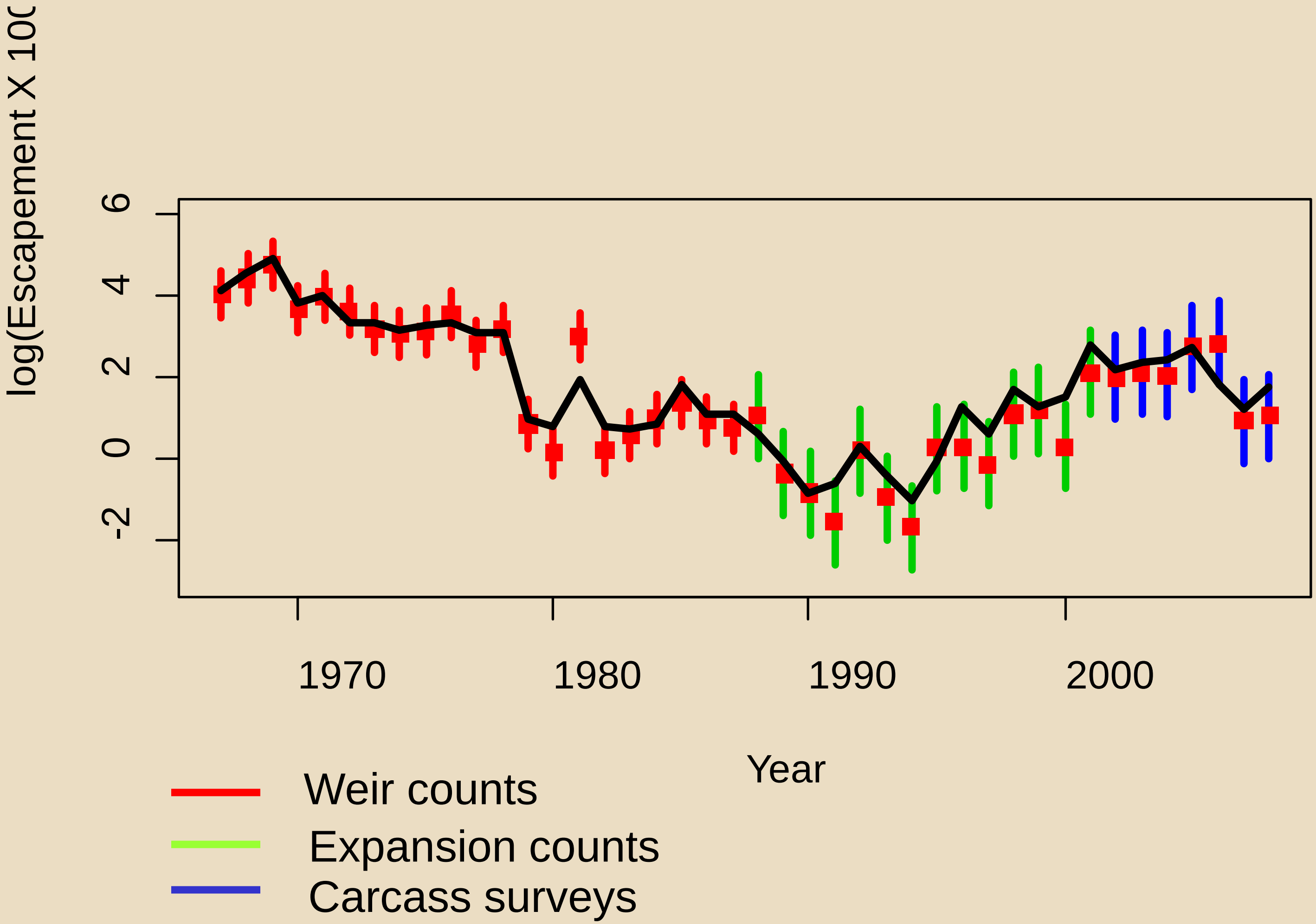


Escapement with measurement error



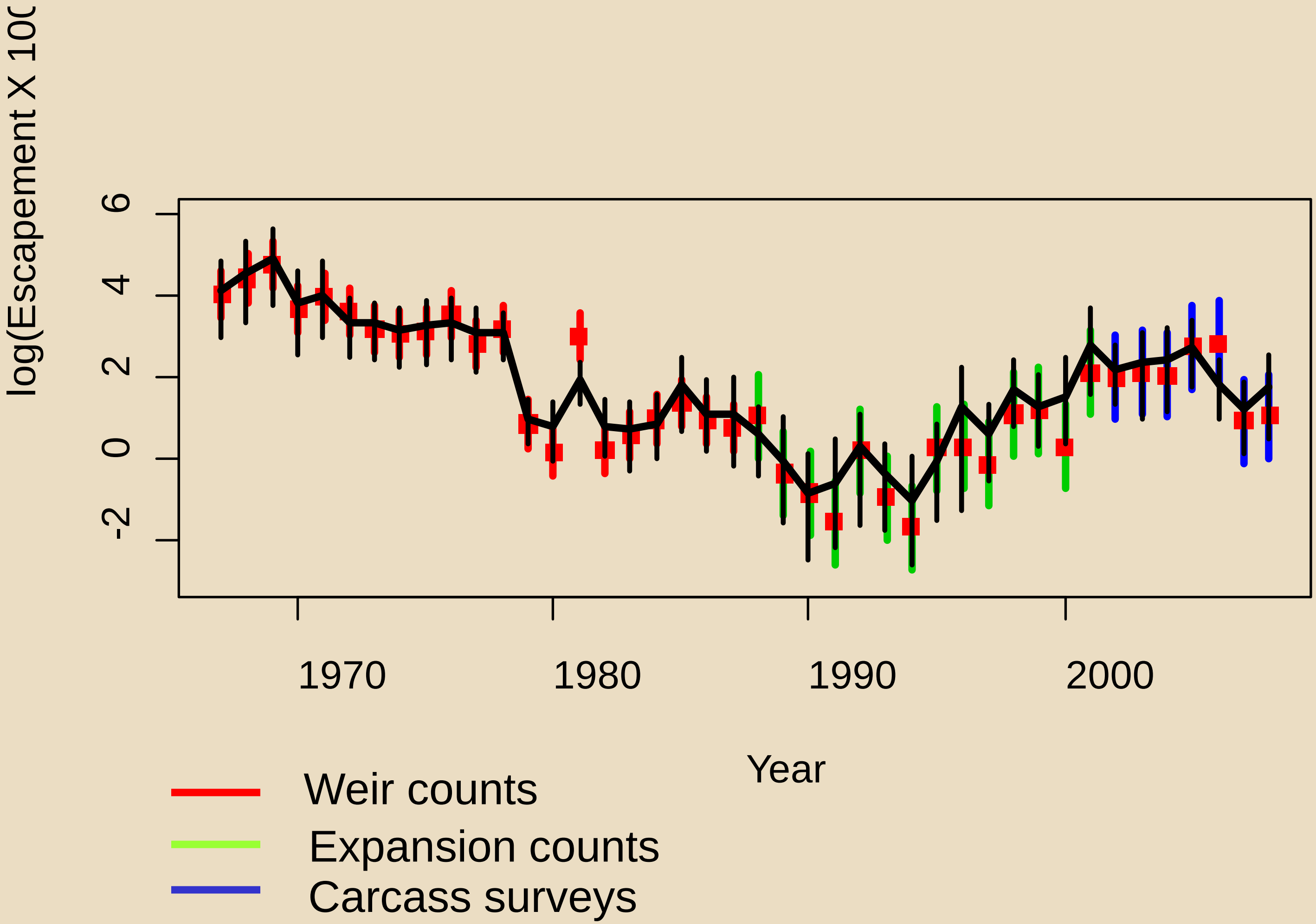
OBAN fit to WR escapement

mean predictions

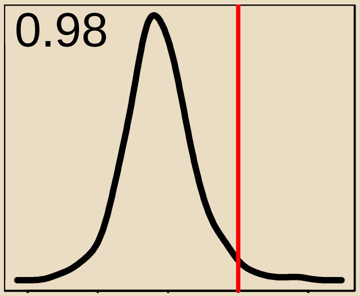


OBAN fit to WR escapement

mean predictions with 95% credible intervals



Posterior distributions of coefficients BASS log Catch



0.96

0.32

0.18

0.62

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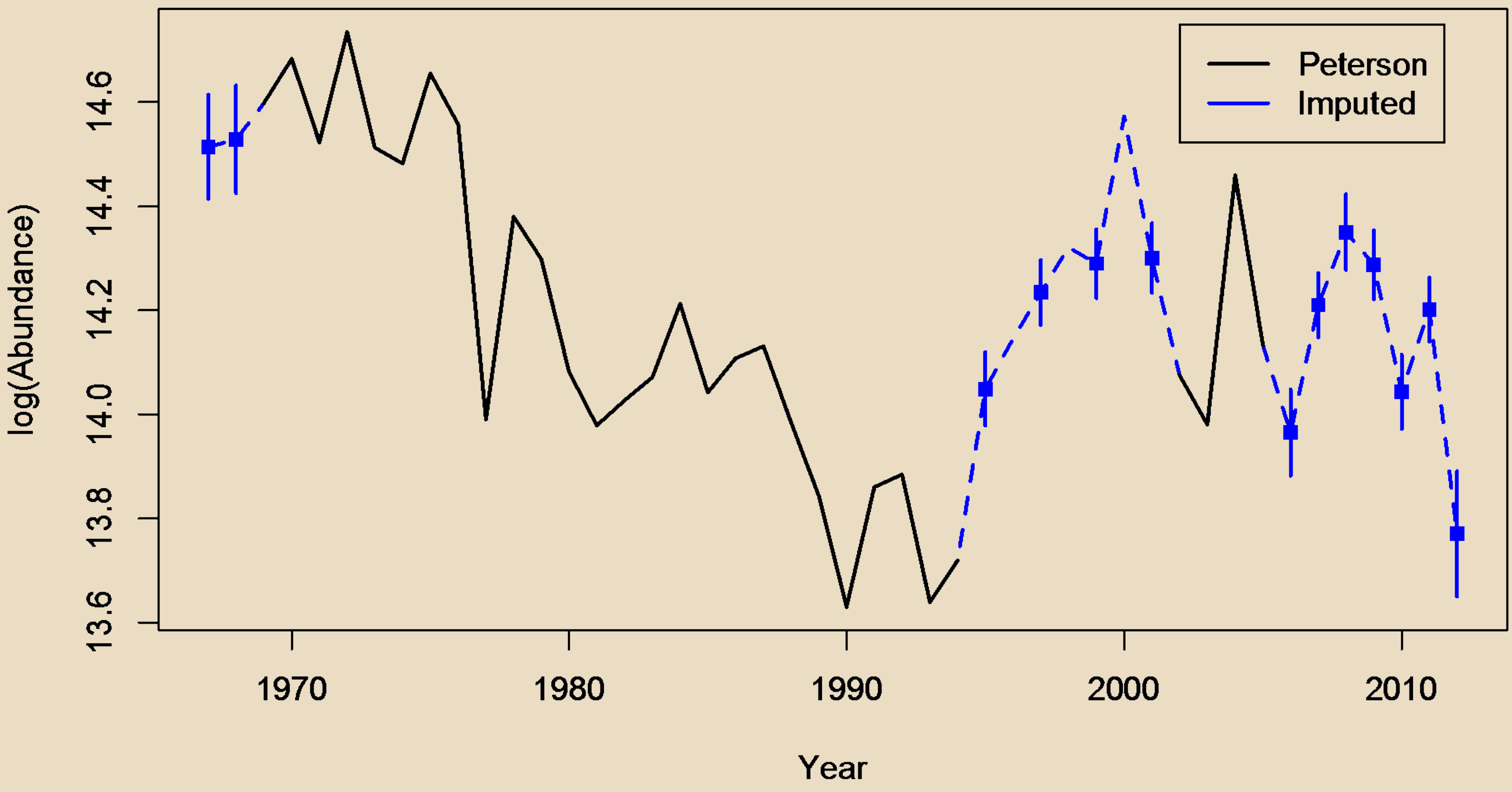
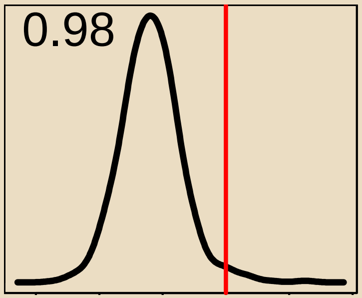
0.18

BASS:

Imputing the Peterson Abundance Index for missing years



Posterior distributions of coefficients BASS log Abundance



0.94

0.26

0.17

0.51

Probability Density

0.18

Winter-run Summary

- Winter OBAN factors hypothesized to increase abundance (posterior probabilities):
  - Lower temperatures in spawning reaches (0.98)
  - Increased flows during outmigration (0.82)
  - Reduced exports (0.94)
  - Increased access to Yolo bypass (0.6)
  - Decreased wind stress curl/upwelling (0.6 – 0.7)
  - Decreased striped bass (0.18)

Discussion

- Differential response to striped bass:
  - Winter-run are weakly related to striped bass Catch or Abundance*
  - Spring-run in Butte Creek negatively related to striped bass Catch
- Chinook abundance and timing of outmigration
  - Winter-run is a small component of salmon production and timing is asynchronous with other runs
  - Spring-run outmigration timing more similar to fall-run, which may be targeted by striped bass

*Abundance includes imputed values for missing years

Discussion II

Catch and Abundance* reflecting predation pressure?

- Metrics available that are better correlated to Peterson Abundance estimates – CPUE, trip success, etc.
- Striped bass predation pressure related to population dynamics
  - Catch affects abundance of striped bass adults
  - Recruitment dynamics – temporal mismatch between Peterson estimates (ages 3 to 8+) and juvenile predation
  - Juvenile bass abundance estimates and predation pressure

*Abundance includes imputed values for missing years

QUESTIONS?

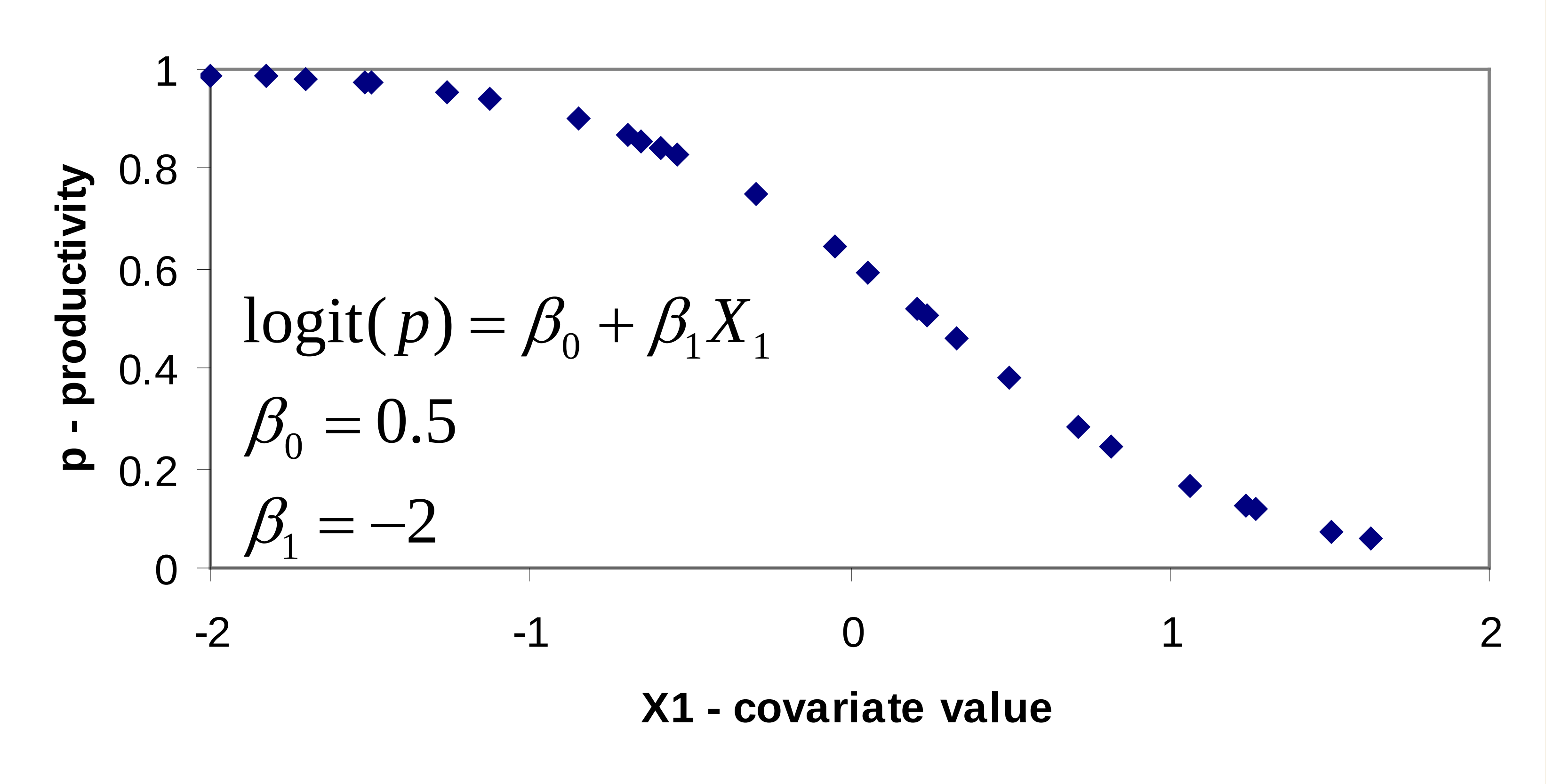
Contact:
noblehendrix@gmail.com

Quartz Pool, Butte Creek
Photo Credit: Allen Harthorn, Friends of Butte Creek

Additional Slides OBAN Structure

Modeling the BH **p** parameter

logit() transformation



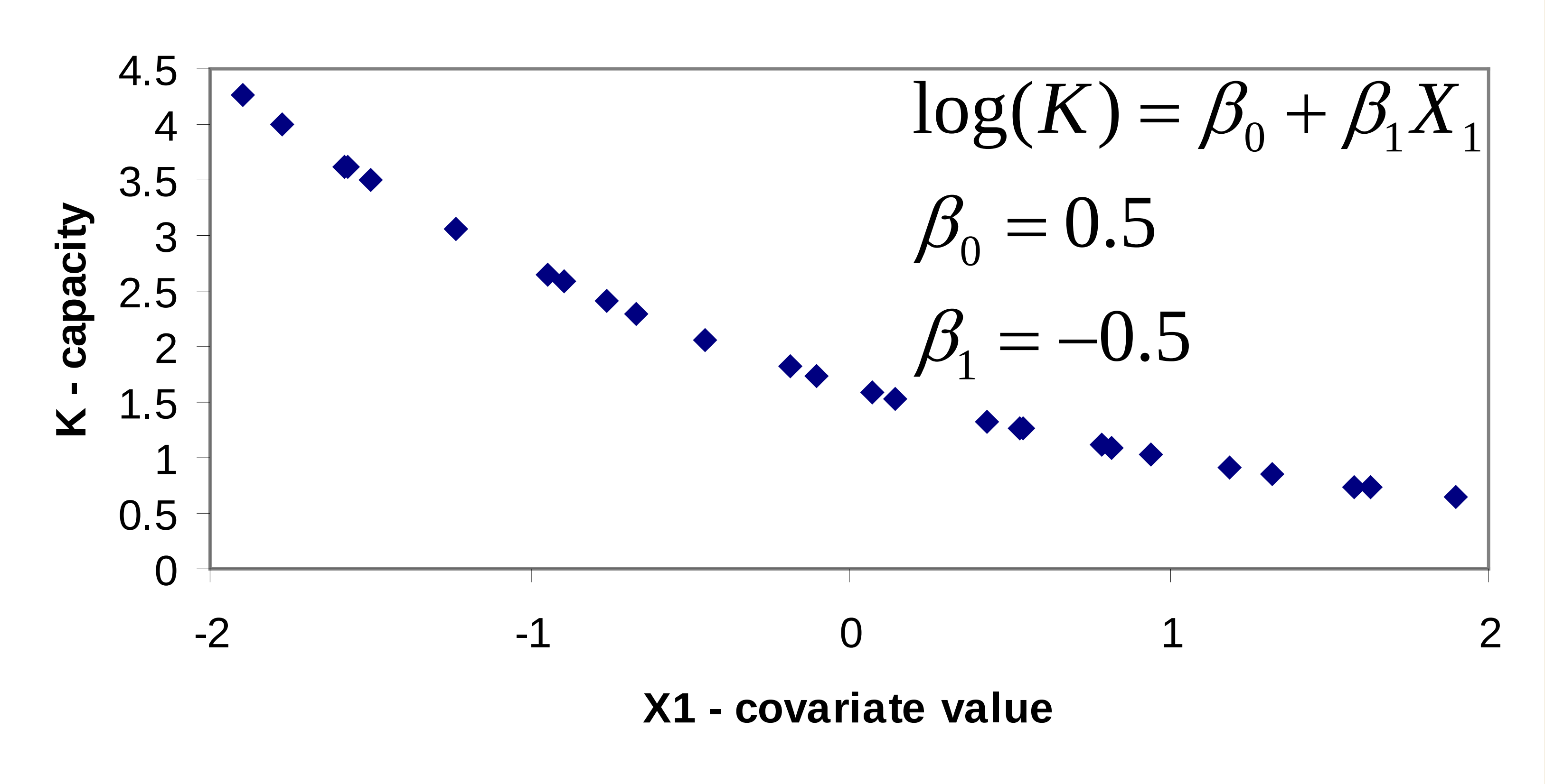
$$\text{logit}(p) = \beta_0 + \beta_1 X_1$$

$$\beta_0 = 0.5$$

$$\beta_1 = -2$$

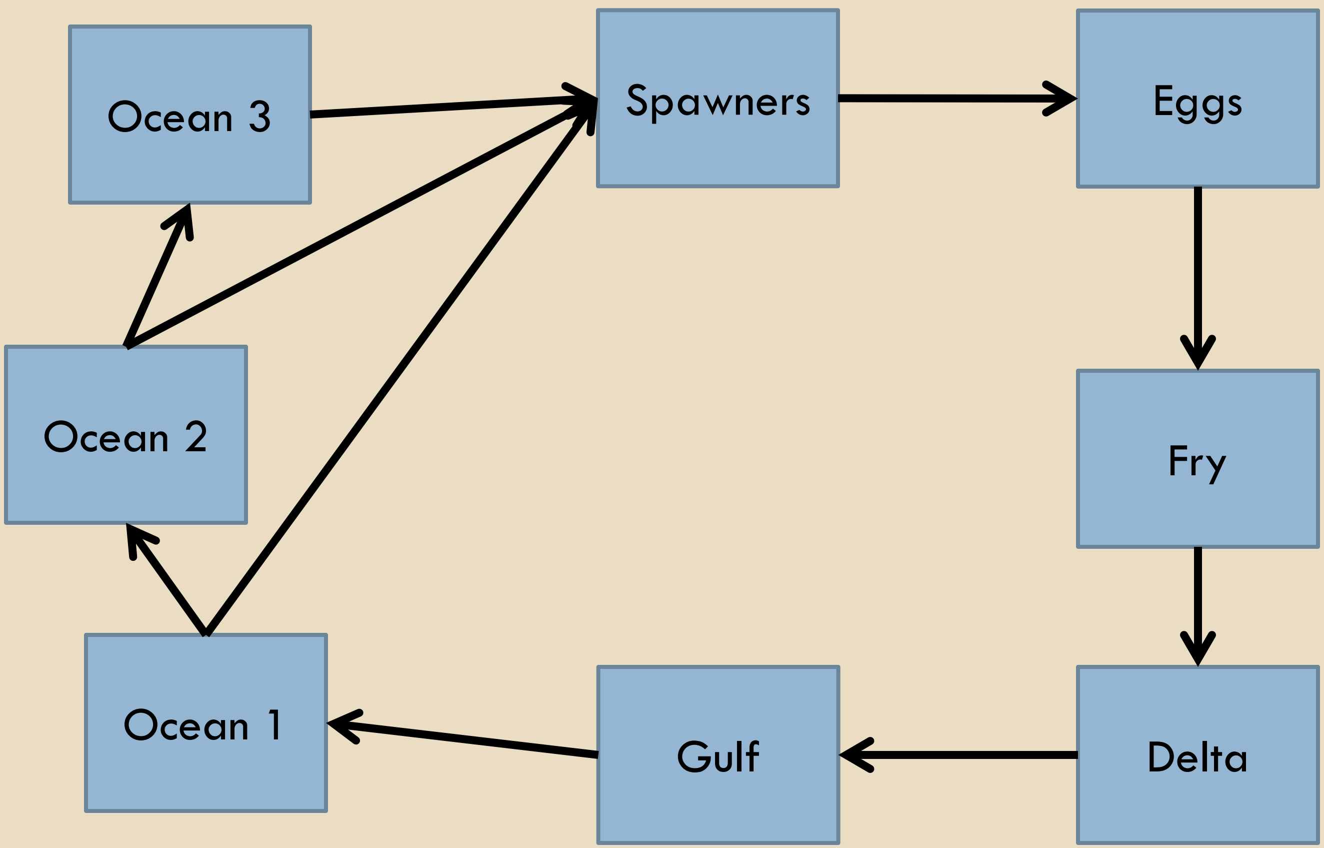
Modeling the BH **K** parameter

log() transformation



Additional Slides Spring-Run

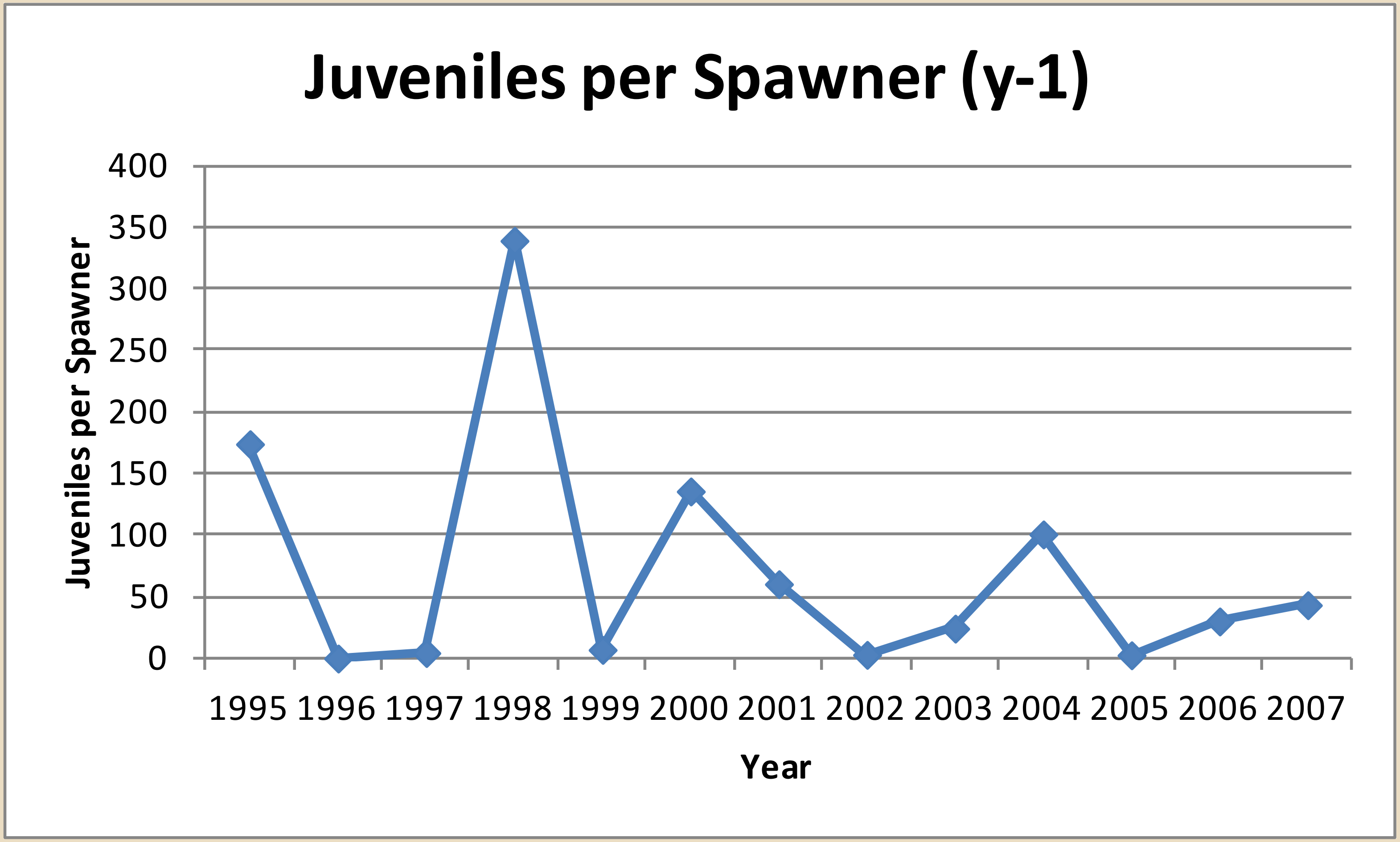
Butte Creek spring-run life-cycle



Data

- Adult escapement from 1970 to 2007 (missing 1991)
- Juvenile screw trap data (not used)
- Conditional Maturation schedule (Grover et al. 2004)
  - Age 2 - 1%
  - Age 3 - 35%
  - Age 4 - 100%

Butte Creek Juvenile data



Additional Slides Winter-Run

Additional Information

- *Conditional Maturation rates*
  - *Age 2 ~ Beta(1,10), [95%CI: 0.002, 0.31]*
  - *Age 3 ~ Beta(10,1), [95%CI: 0.69, 0.99]*
  - *Age 4 = 100%*
  - Consistent with Analysis of CWT 1998 – 2000 brood years (Grover, A. 2004)
    - 0.01 – 0.17 Age 2 Maturation
    - 0.96-0.97 Age 3 Conditional Maturation Rate
    - 1.0 Age 4 Conditional Maturation Rate
- *Structuring of escapement measurement error*

$$\sigma_{weir} \leq \sigma_{carcass} \leq \sigma_{expansion}$$

Measurement error estimates from different escapement data sources