A life cycle model and population viability analysis for wild delta smelt

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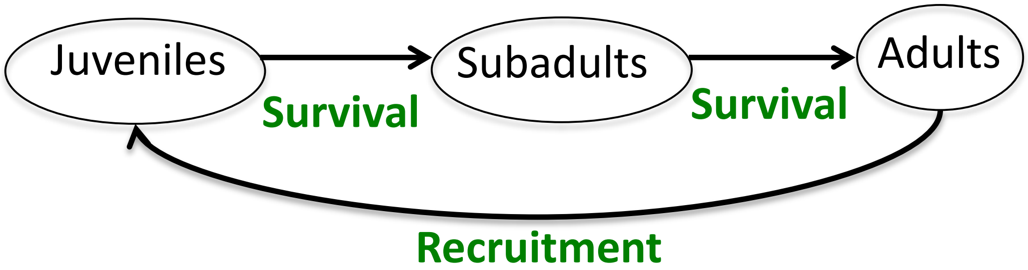
DEPARTMENT OF THE INTERIOR

What affects recruitment and survival in the wild?



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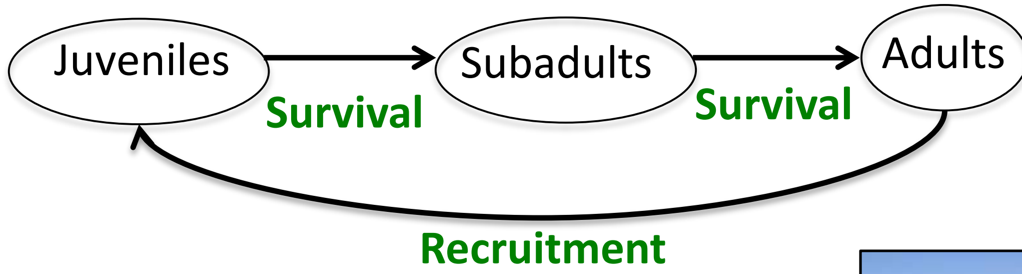
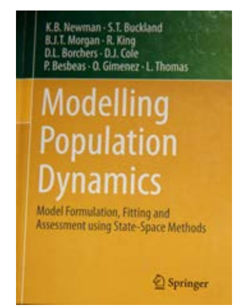
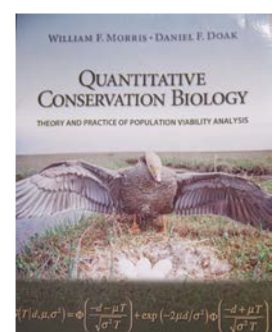


1) Standardize survey data

2) Develop and fit a life-cycle model



3) Do a population viability analysis



1) Standardize survey data

Need abundance estimates for each life-stage from many cohorts

Cohorts: 1995-2012

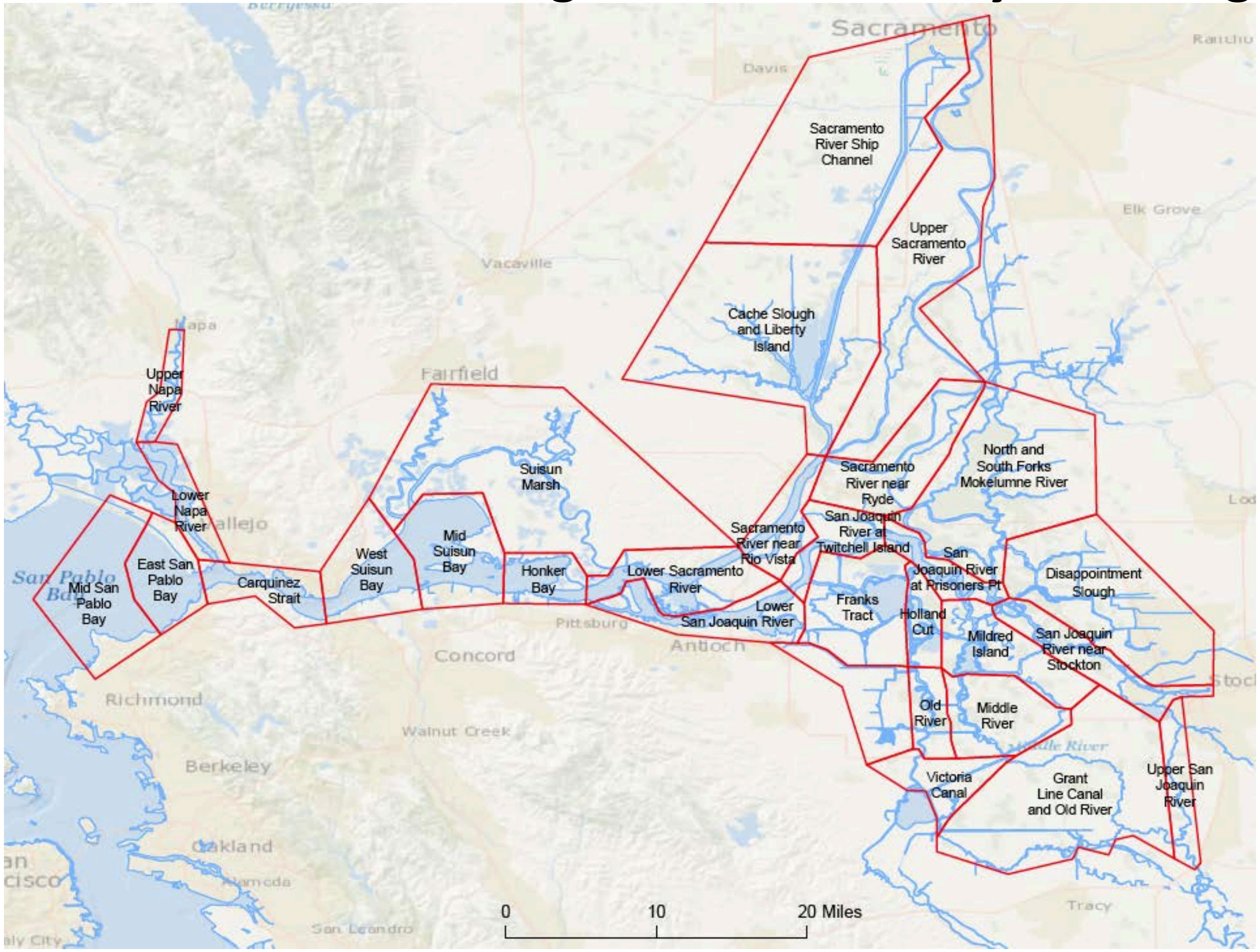
Life-stage	Survey	Month
Juveniles	20mm	June
Subadults	FMWT	Nov (modeled)
Adults	SMWT (1996-2001)	Jan/Feb (of year+1)
	SKT (2002-2013)	

Observations: Design-based abundance estimates

Stratified ratio expansions

Total abundance = Sum of subregion abundances

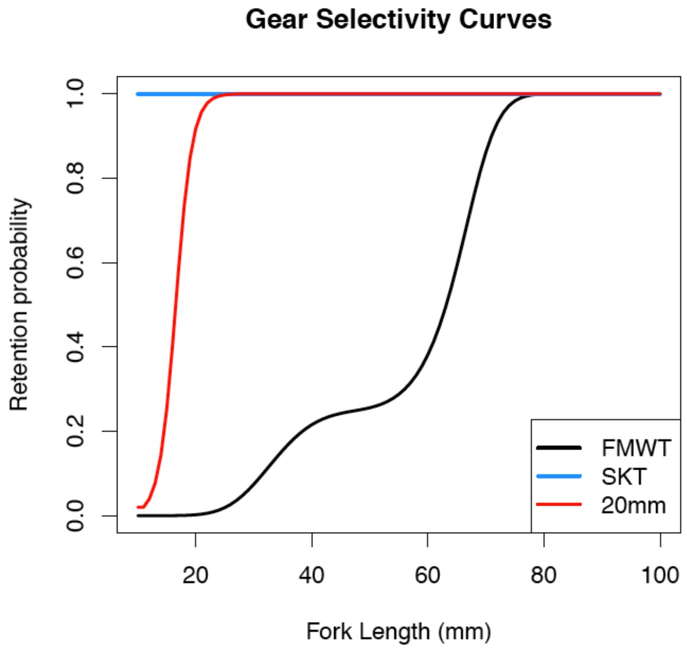
Subregion abundance = Subregion ***Catch density*** * subregion volume



$$\text{Catch density} = \frac{\text{Sum of adjusted catch}}{\text{Sum of effective volume sampled}}$$

Adjusted catch=Catch/Prob(catch)

Adjust according size of fish caught



Effective volume adjusts volume by:

i) How much water was sampled in the top 4m of water

Oblique vs. surface tows

ii) How the density of fish is assumed distributed within this 4m slice

Observed subadult abundance is modeled

Under the hood

Currently using a FMWT specific state-space model to further account for relative FMWT bias

Still, 2005 cohort: Subadult = 374,726, Adult=480,448

Covariate data

Recruitment (9)

Food, outflow, X2 location, previous adult size, OMR, water temperature, temperature, predator abundance indices (ISS and striped bass)

Juvenile survival (8)

Food, outflow, X2 location, predator abundance indices

Subadult survival (4)

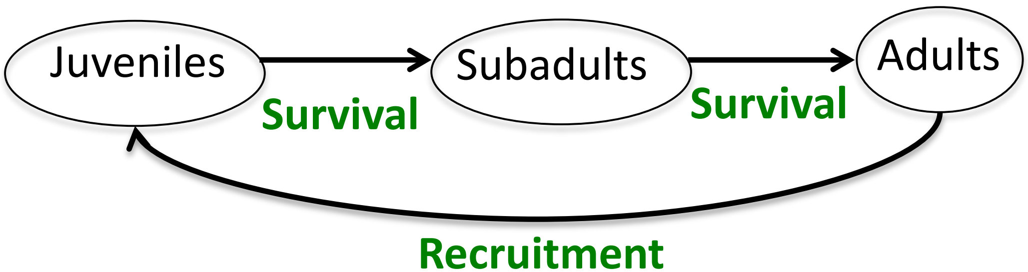
Food, outflow, X2 location, OMR

All together

9*8*4=288 different unique combinations of covariate triplets

2) Develop and fit a life-cycle model

Process (X)



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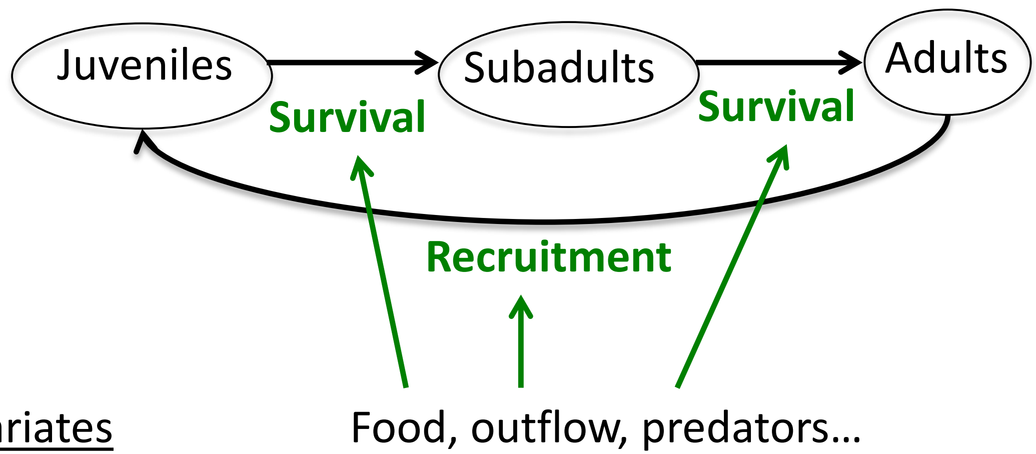
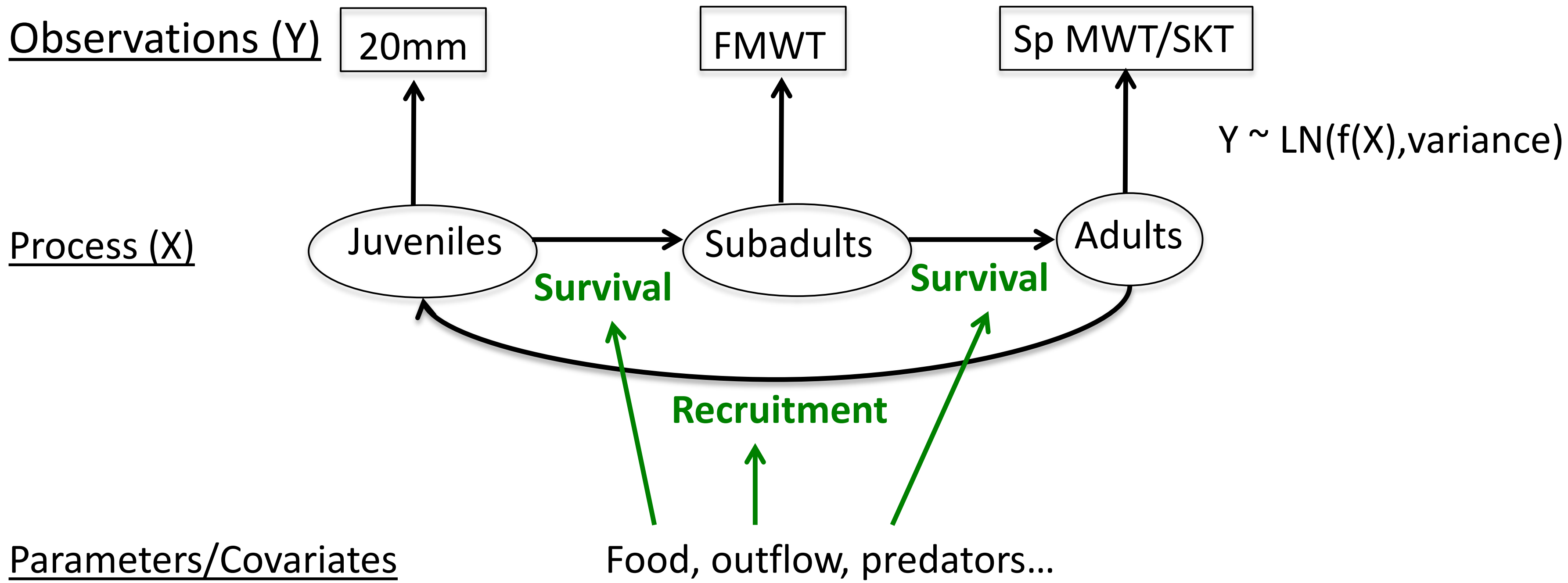


Parameters/Covariates

Survival ~ Logit-normal(mean=f(covariates) ,variance)

Recruitment ~ Log-normal(mean=f(covariates),variance)

2) Develop and fit a life-cycle model



Survival ~ Logit-normal(mean=f(covariates) ,variance)
Recruitment ~ Log-normal(mean=f(covariates),variance)

Hierarchical Bayesian state-space model

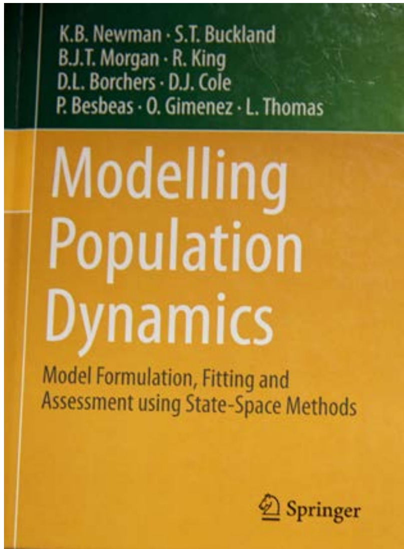
Allows for:
Covariates to influence recruitment and survival

Serial dependence in predicted abundances

Abundance estimate error

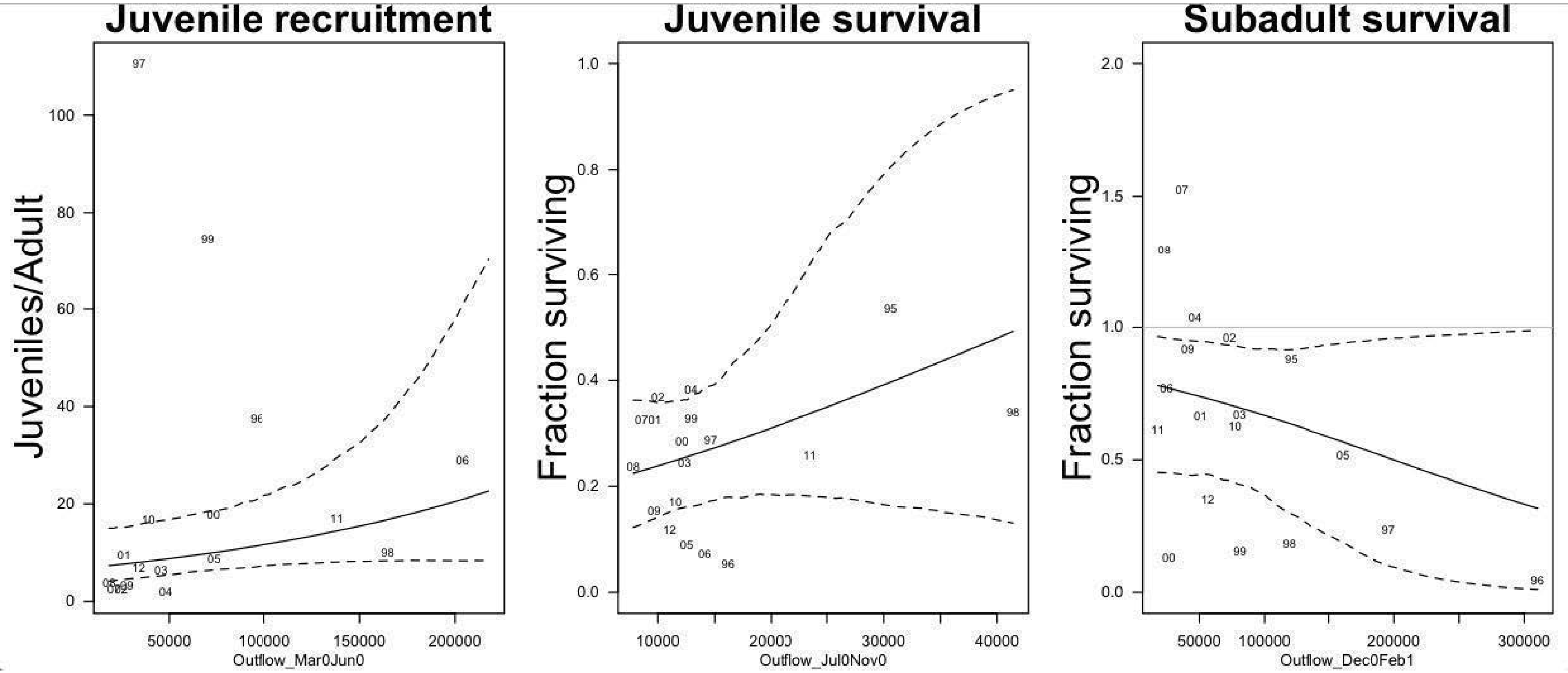
Fit:
Using Bayesian inference (JAGS)

Diagnostics look good



Result from an "all flow" model

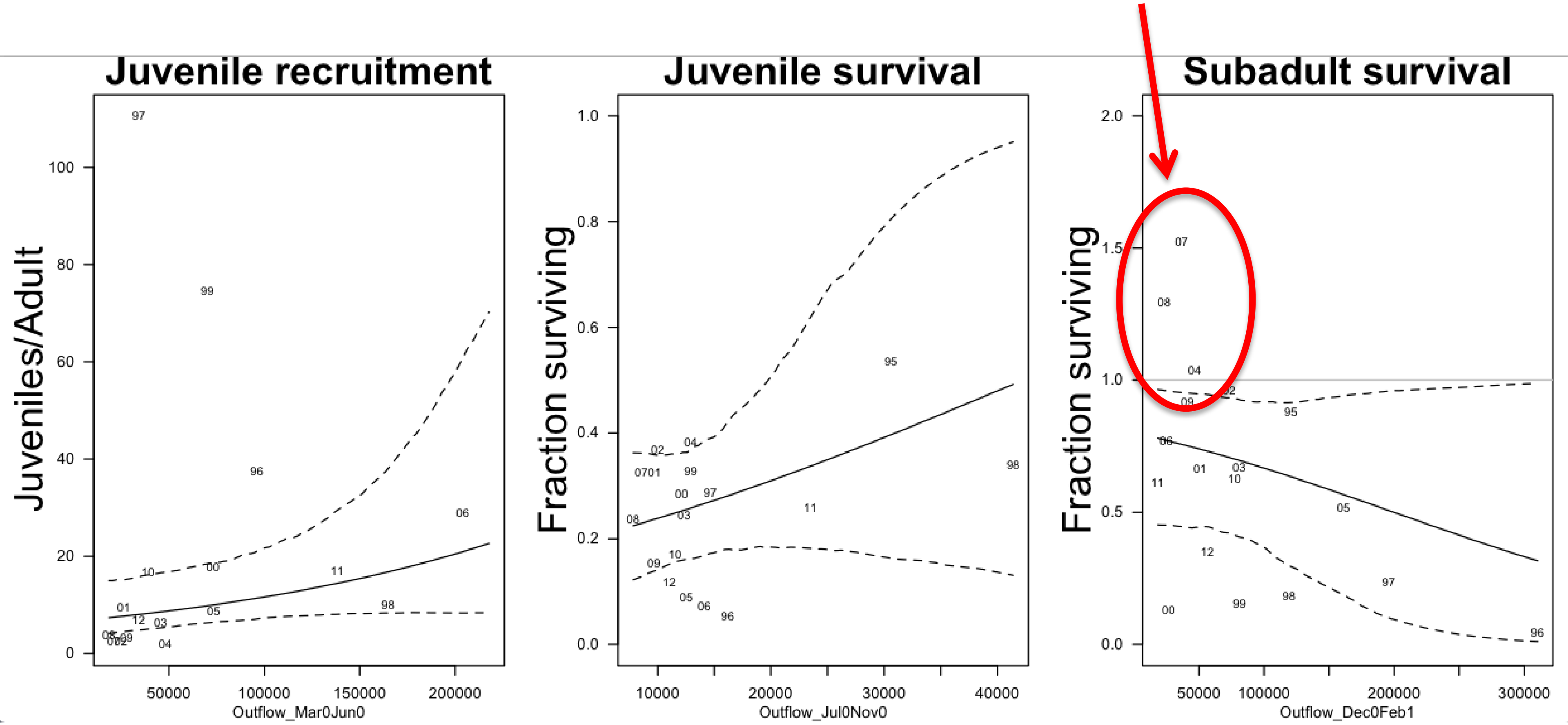
All vital rates depend on mean outflow



Result from an "all flow" model

All vital rates depend on mean outflow

Subadult (FMWT) < Adult (SKT)
Observed survival rate > 1=Observation error
Accounting for observation error required!!!



Evidence across models

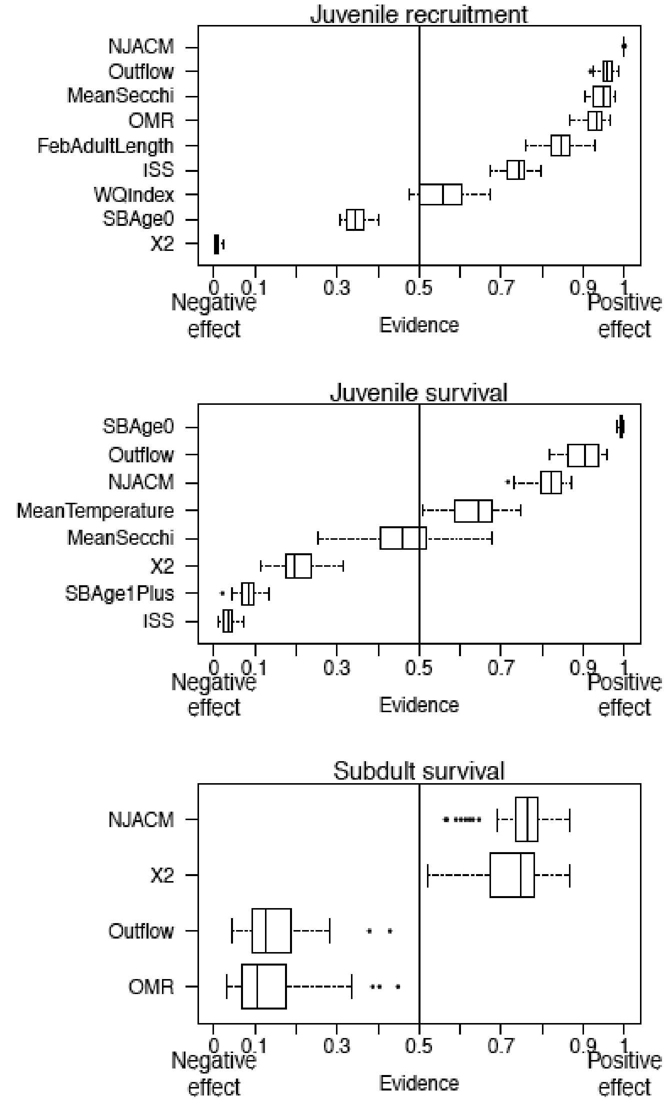
Juvenile recruitment

Good: Food, outflow, spawning adult size

No support: A water temp index

Bad: High X2, lots of age 0 striped bass

Evidence boxplots



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Bad: High X2, age 1 striped bass, inland silversides

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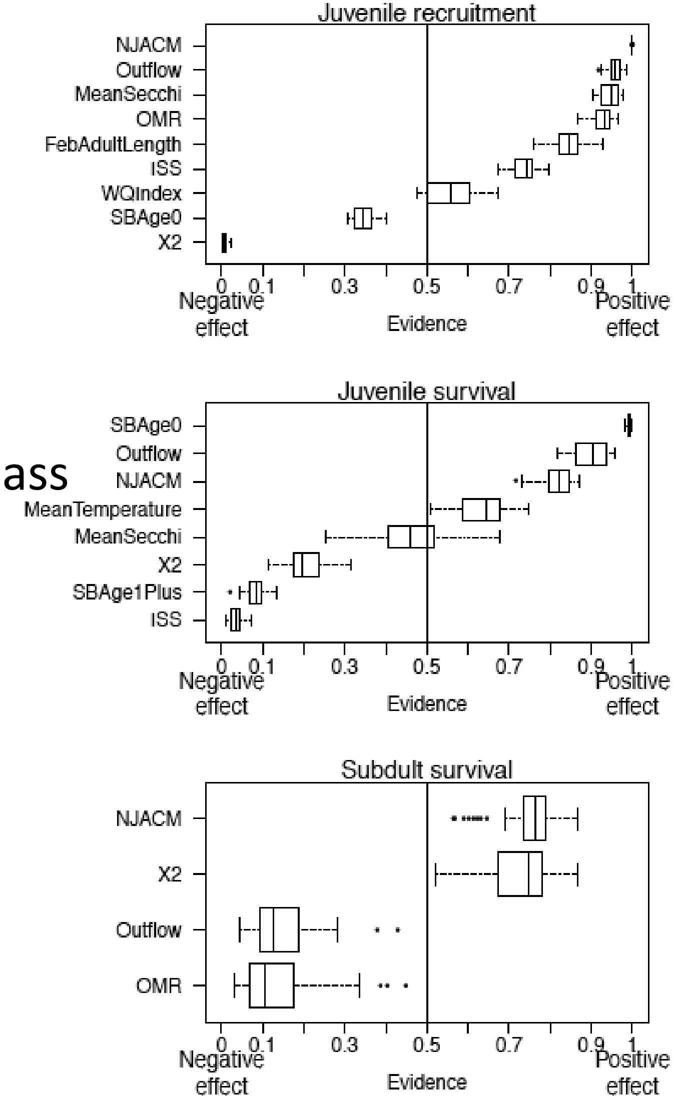

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Juvenile recruitment

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Juvenile survival

Good: Food, outflow, temperature, age 0 striped bass

No support: Mean secchi

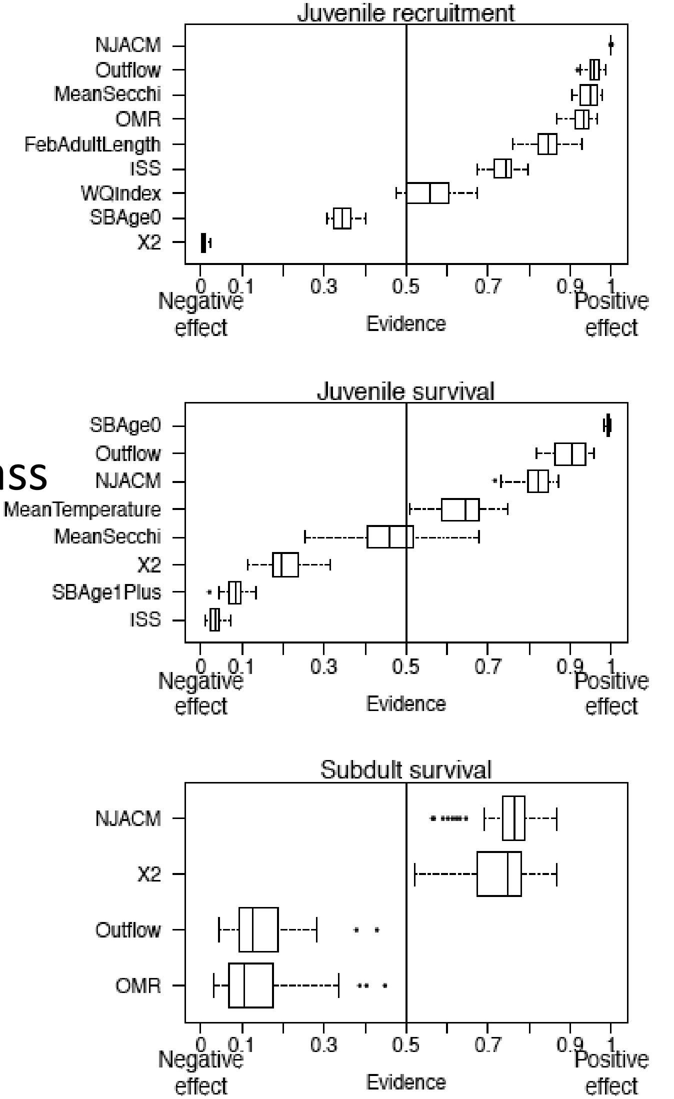
Bad: High X2, age 1 striped bass, inland silversides

Adult survival

Good: Food, high X2

Bad: High outflow and OMR ???

Evidence boxplots

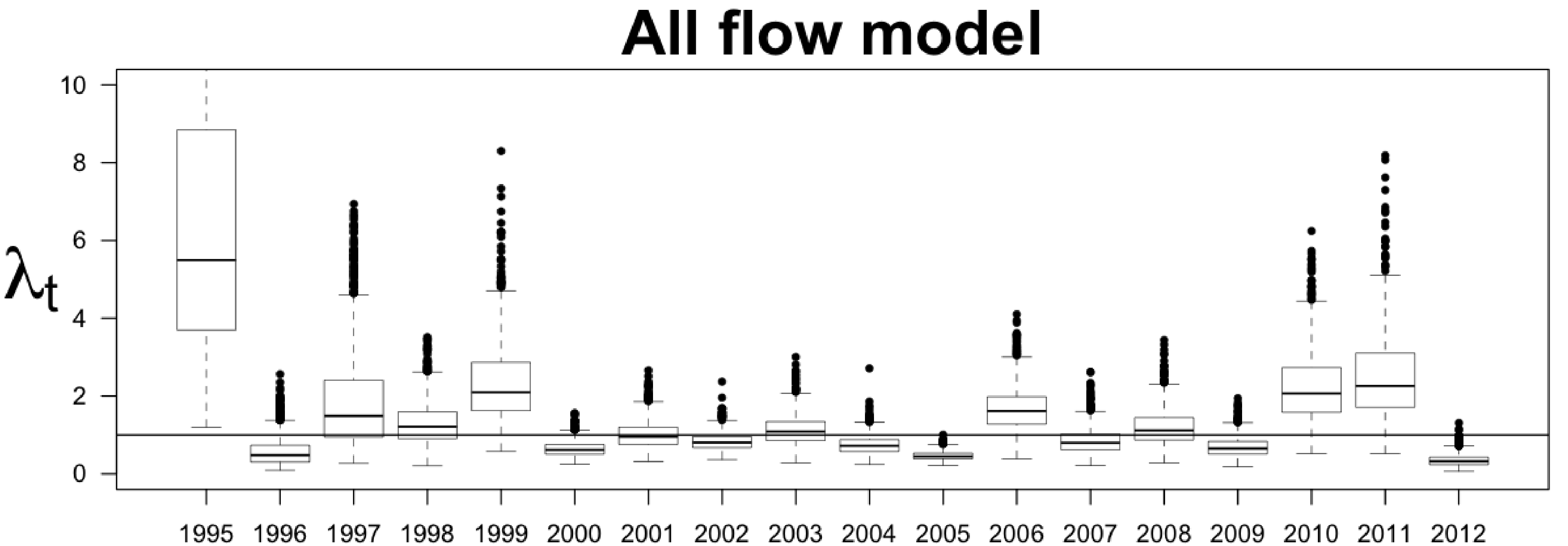


Good years and bad years

$$\text{Population growth} = \lambda_t = \frac{N_{\text{Adults, t}}}{N_{\text{Adults, t-1}}}$$

Good years: 1995, 1997, 1999, 2010, 2011, maybe 2006

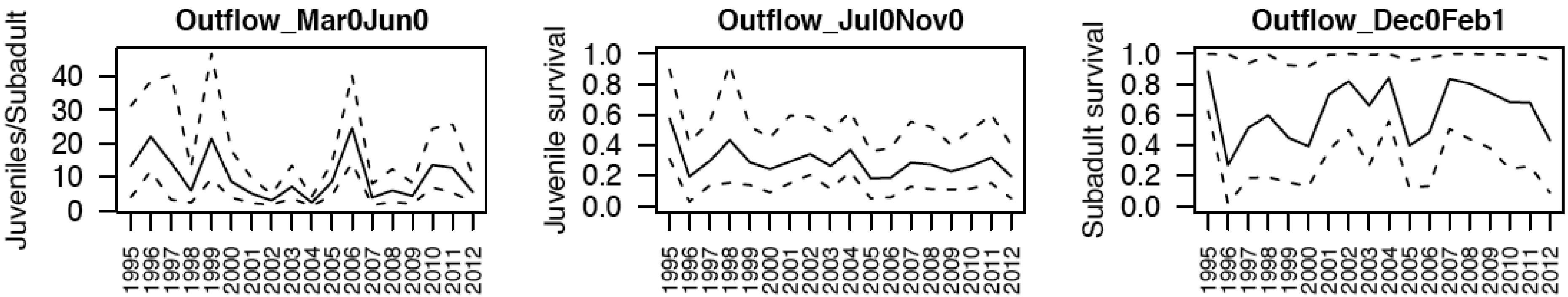
Bad years: 1996, 2002, 2004, 2005, 2007, 2009, 2012



Unpacking good and bad years

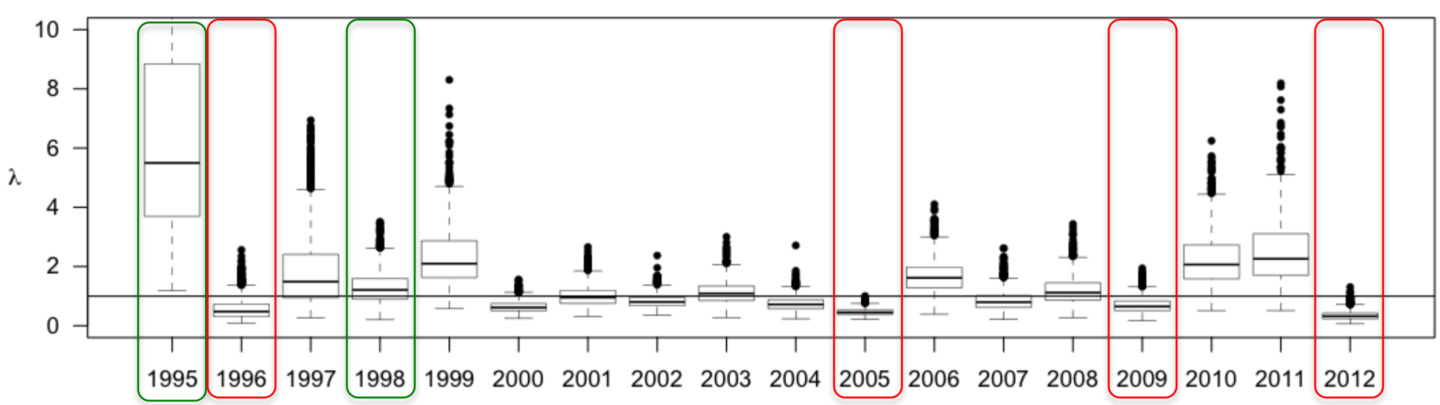
1995 Decent recruitment, high survival

1998 Poor recruitment, decent survival



1996 Great recruitment, poor survival

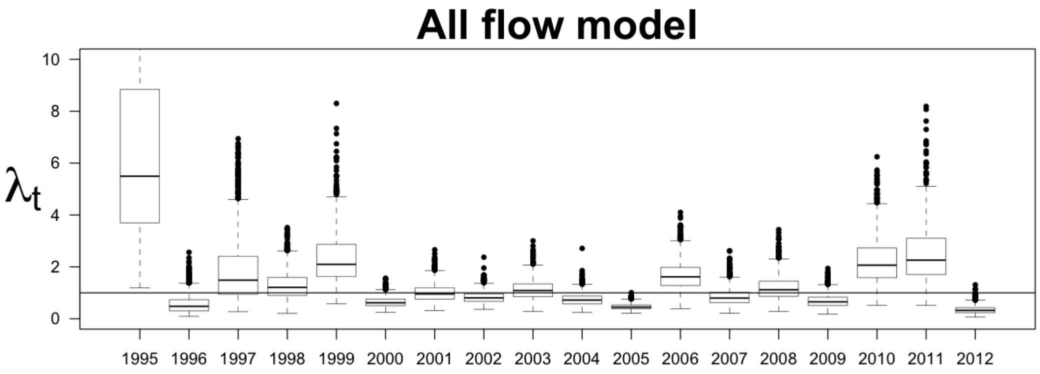
2005, 2009, 2012- Marginal recruitment and survival

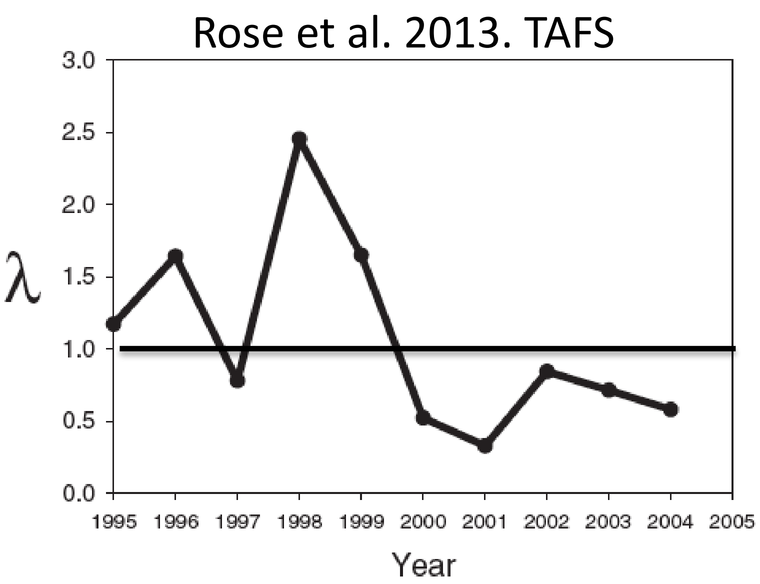


Growth rate comparison SSM vs. IBM of Rose et al.

Growth rate: **- Negative** **~1 Around 1** **+ Positive**

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
All flow model	+	-	+	+	+	-	~1	-	~1	-	-
Rose et al.	+	+	-	+	+	-	-	-	-	-	-



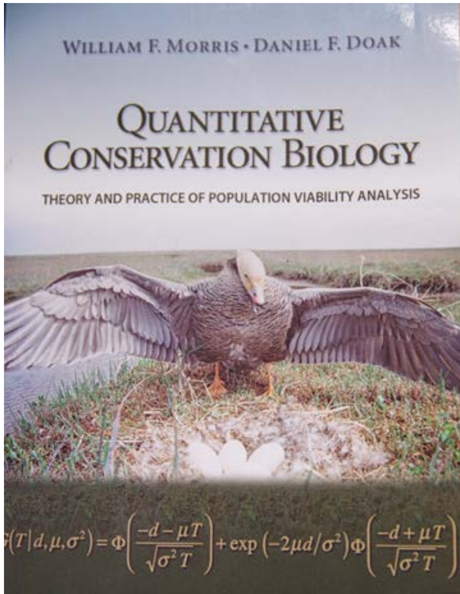


3) Population viability analysis

Simulate future abundances using a fitted model

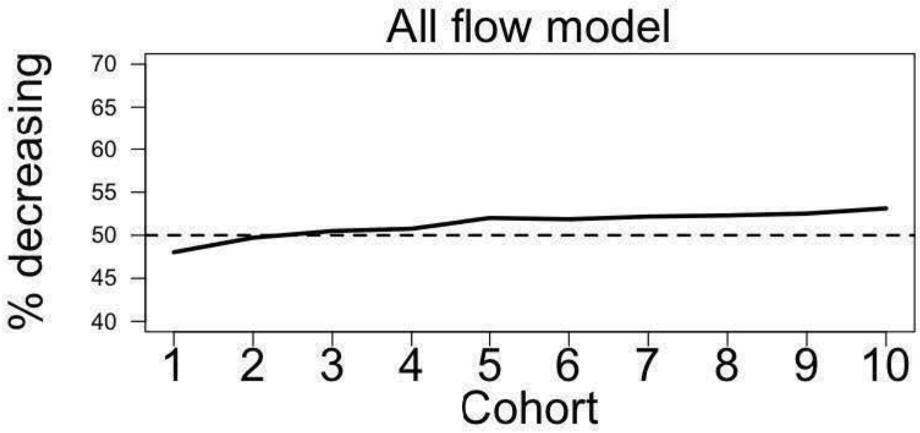
2 future scenarios:

1) The future is stochastically similar to the past
2) What if spring or summer never experience high flows?



Percent of 10,000 simulations declining

1) When the future is like the past



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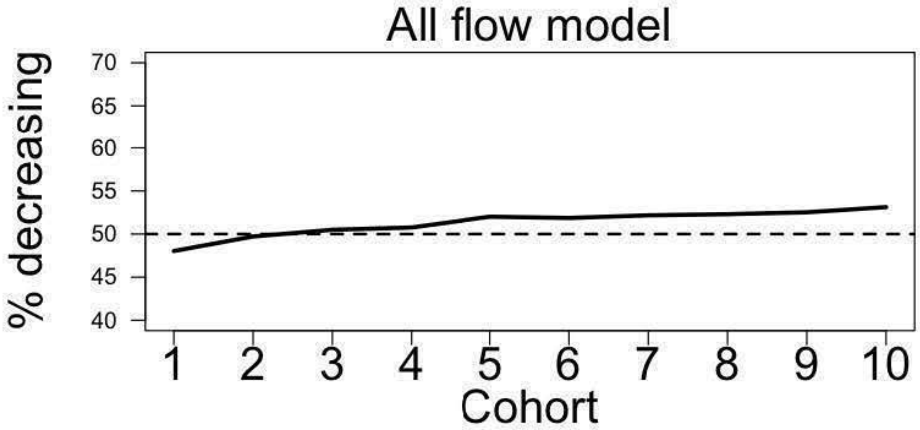

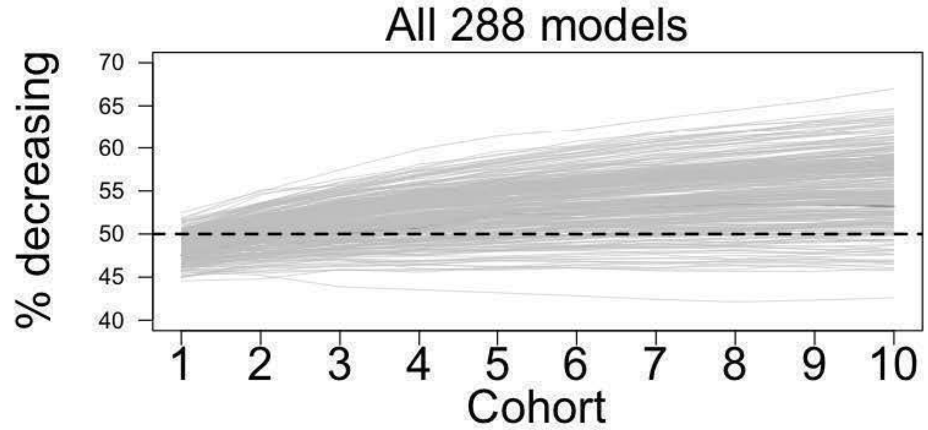

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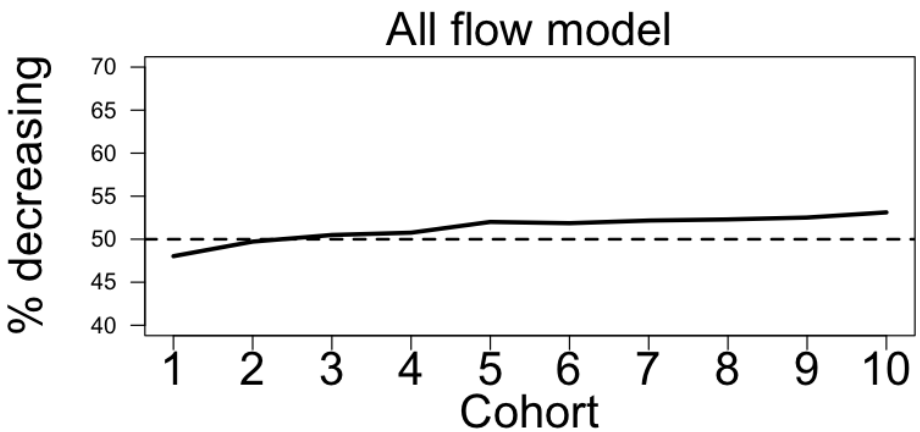
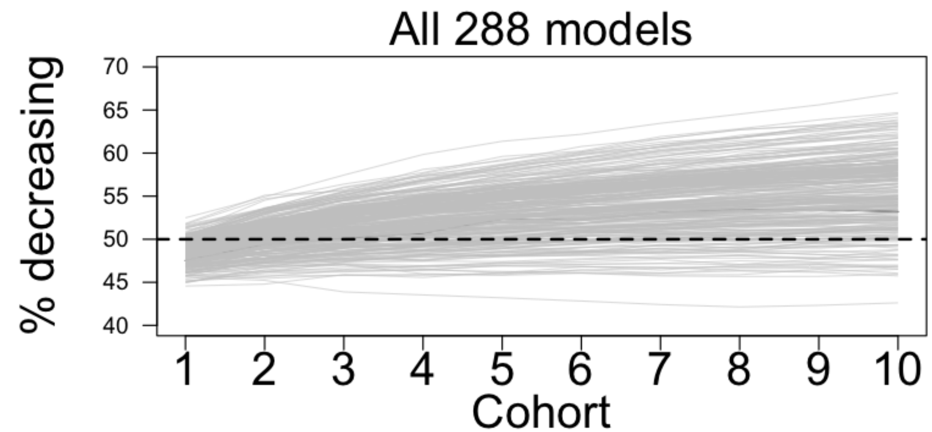
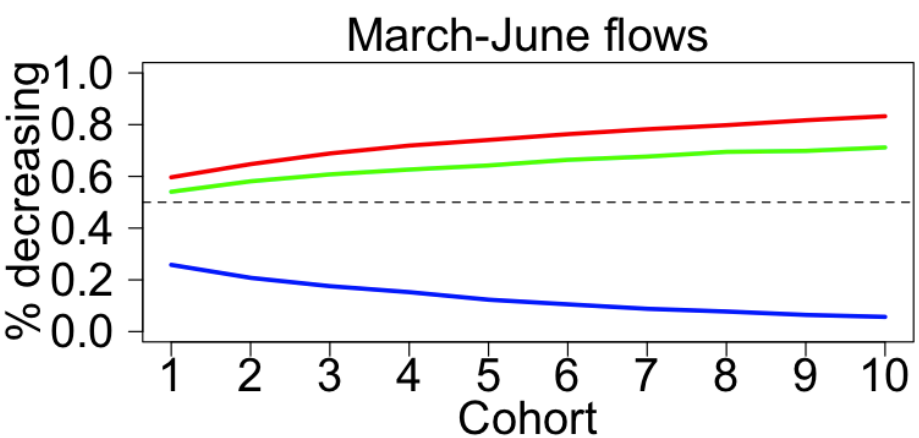




2) When the future is constrained, all flow model

- Low flows - Medium flows - High flows



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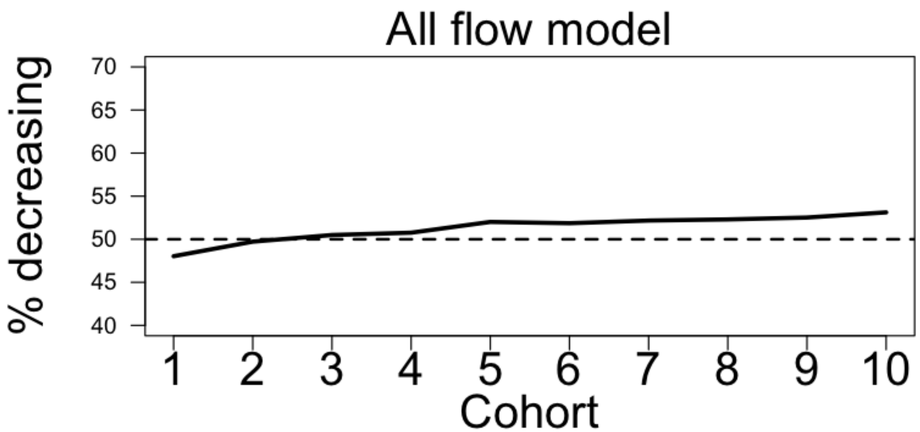

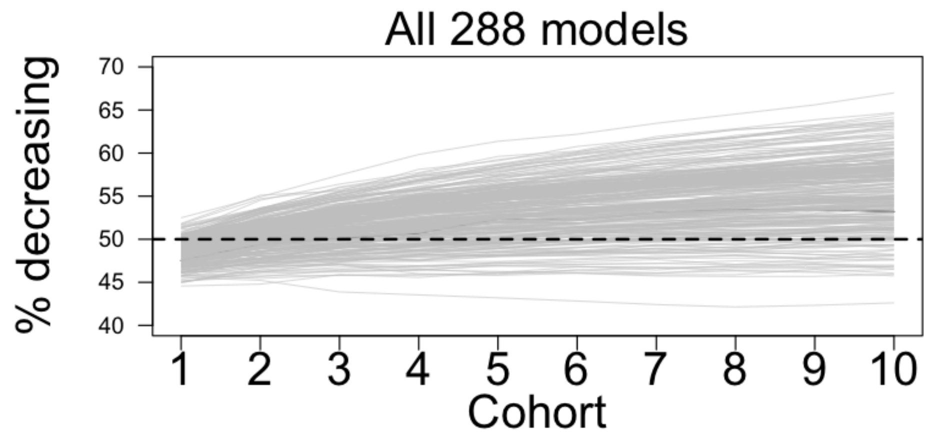

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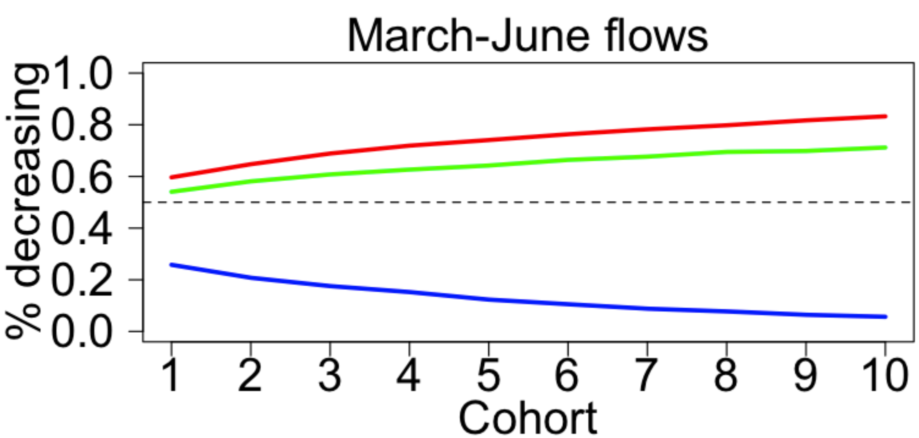

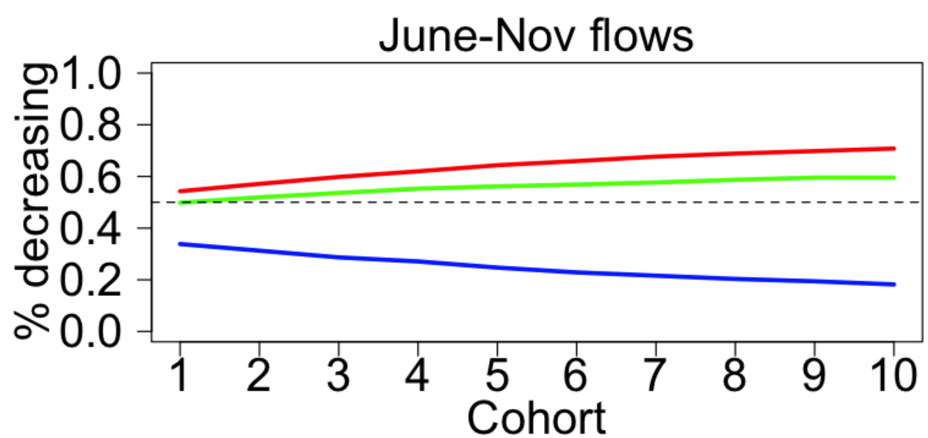

Many elephants

Model is simple, data is noisy, no larva life-stage, drought,…

1) Flow matters

2) Perhaps more so for recruitment than survival

3) Good vital rates for all life-stages needed to realize positive population growth

Acknowledgements: IEP, CA FWS, CA DWR, USGS