Evidence of declining fecundity in the Central Gulf of Alaska

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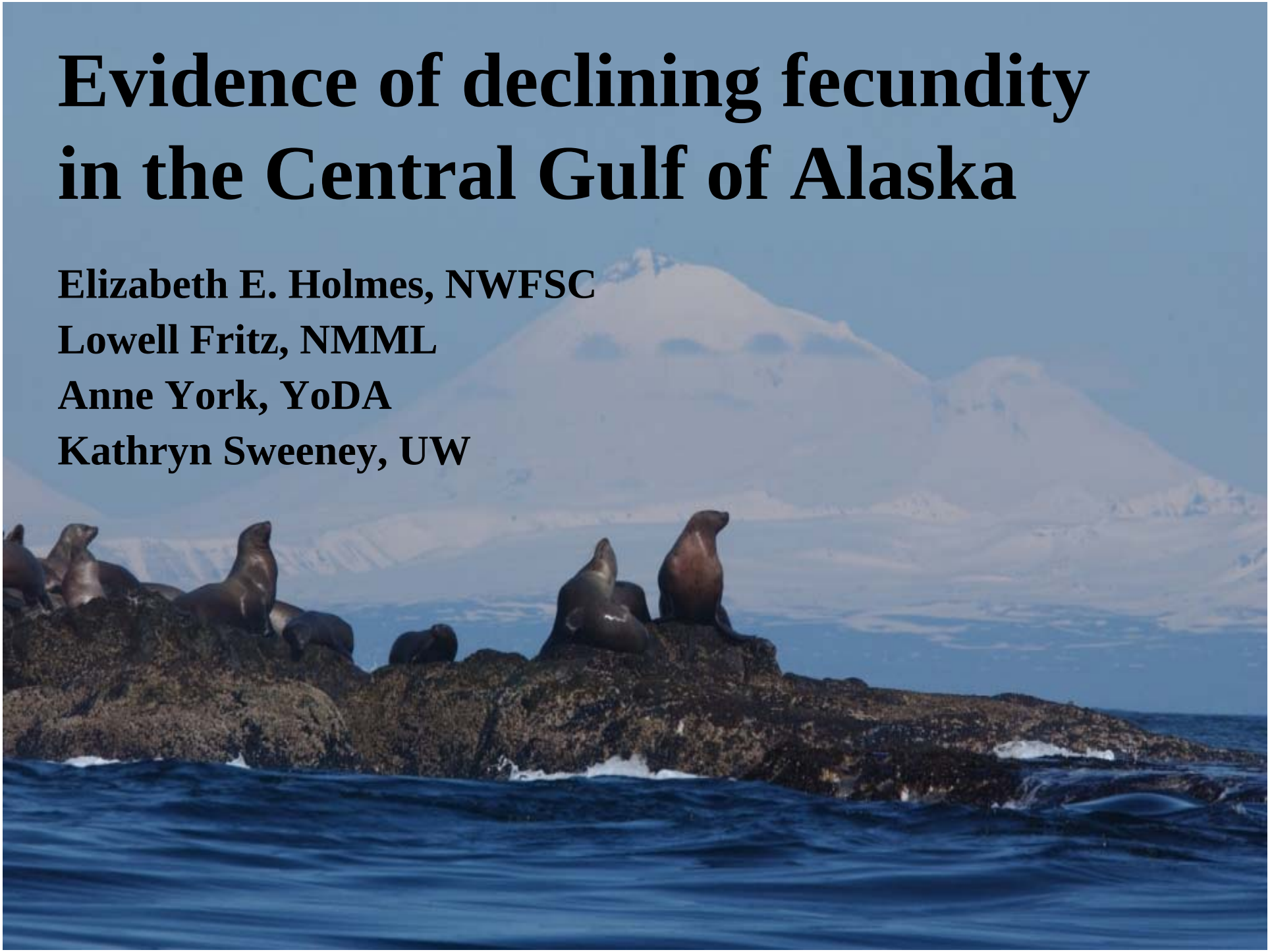
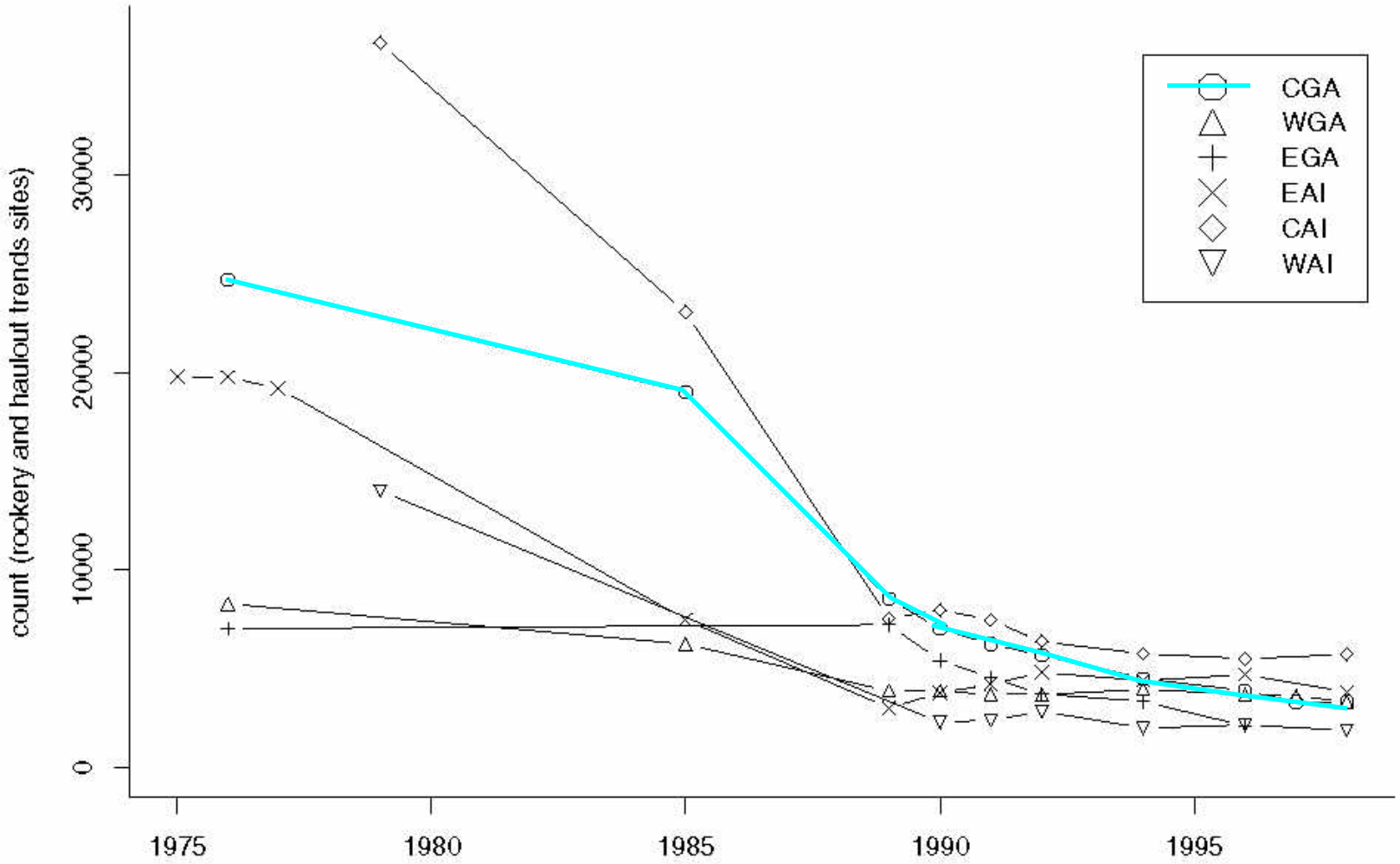
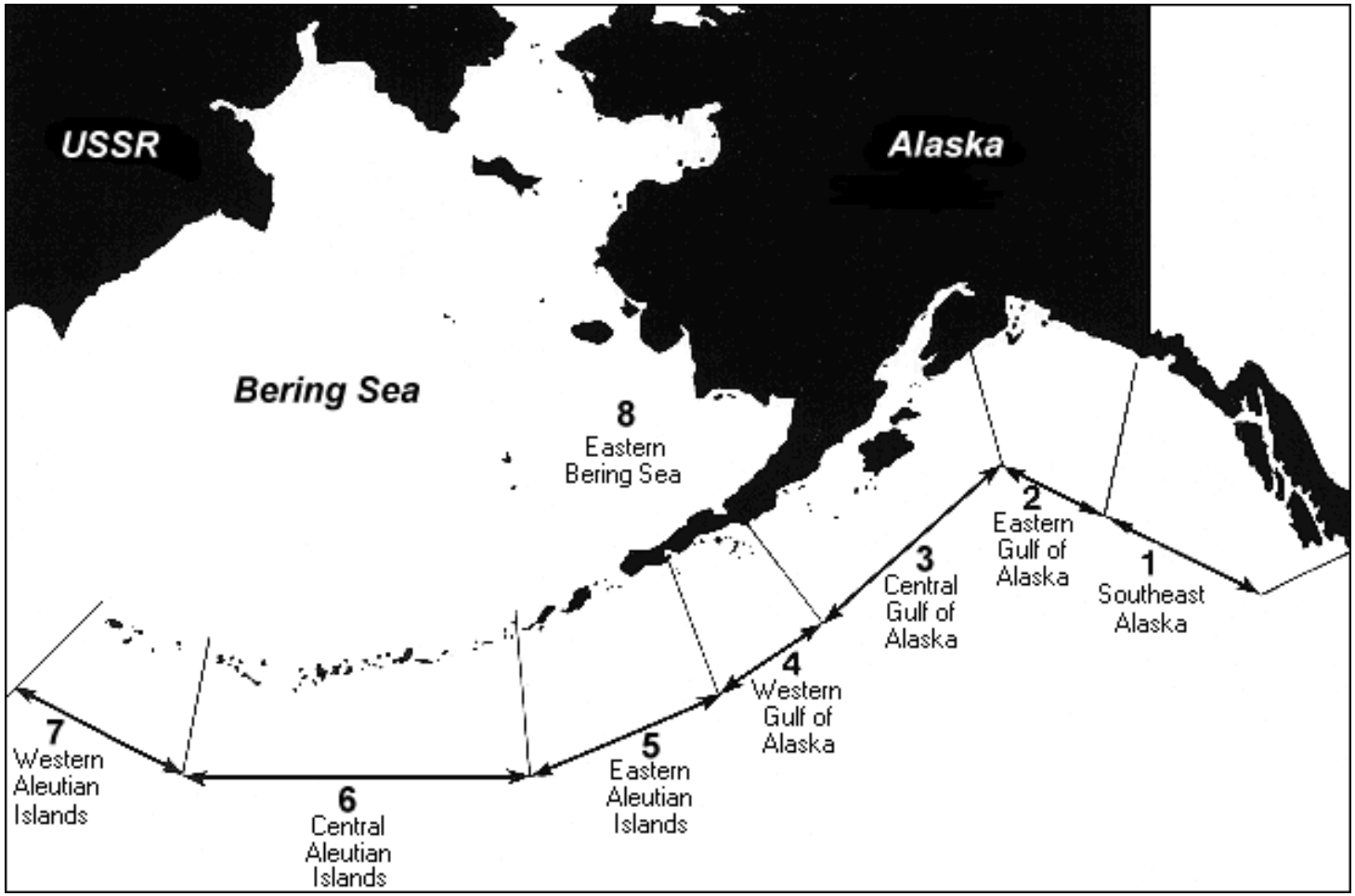
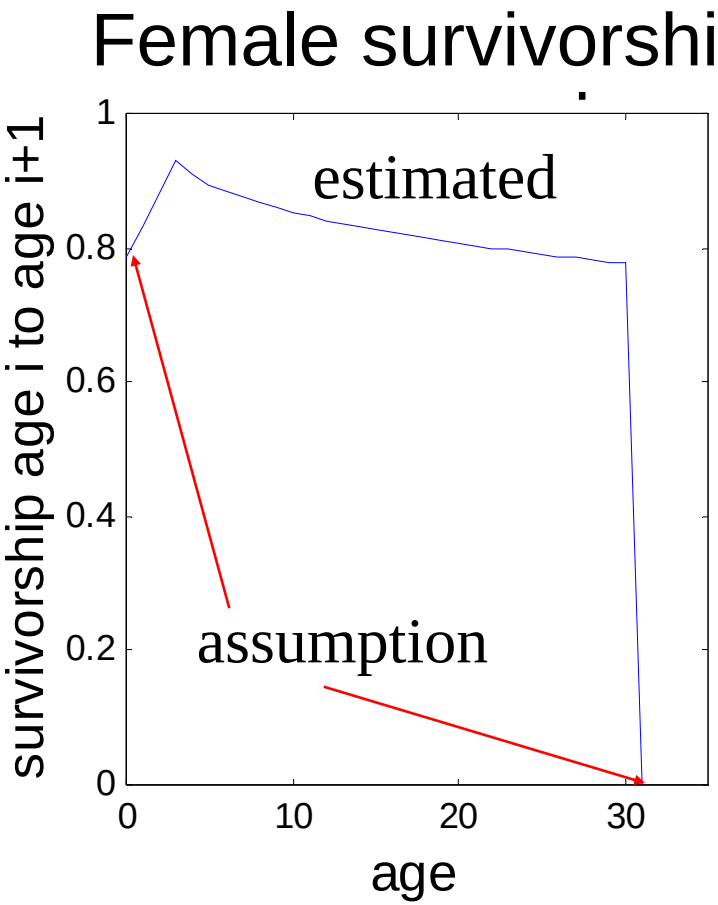


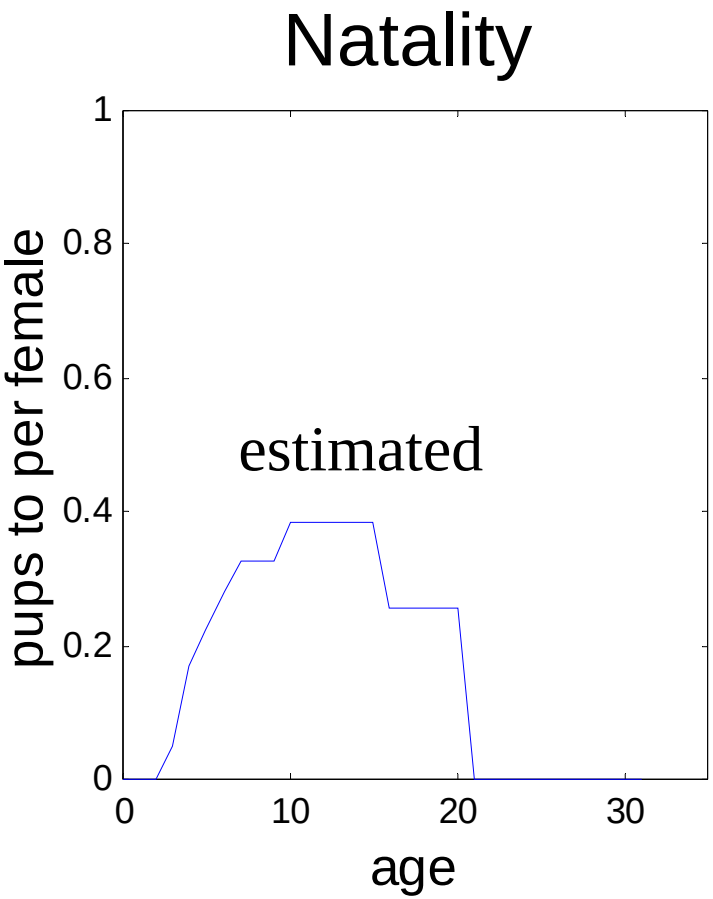

count (rookery and haulout trends sites)
0
10000
20000
30000
1975
1980
1985
1990
1995
CGA
WGA
EGA
EAI
CAI
WAI

This study is for the CGOA only. Other regions may show different patterns.



CGOA provides basic life history data from the 1970s age and pregnancy data from Marmot Is.





What is the definition of natality here?

Average number of 1-month old female pups produced by a female at age i

It equals

Maturity rate (percent of females at age i that are sexually mature)

X Fraction of mature females that are impregnated

X Fraction of early pregnancies that make it to late-term pregnancy (just before birth)

X Survival of late-term fetus to 1-month old pup (the fraction of those late-term pregnancies that lead to a pup counted in the pup survey)

What is the definition of juvenile survivorship here?

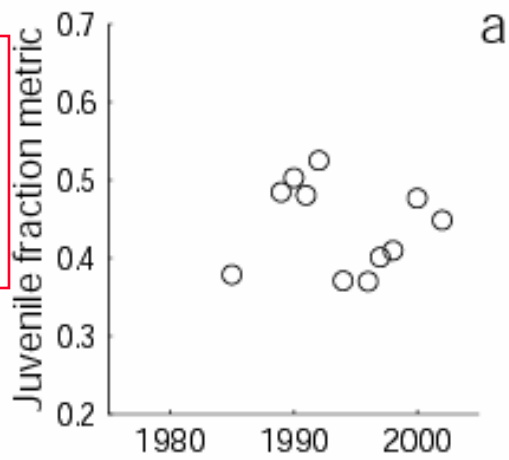
Survival of females from 1-month of age (at pup census) to 3 years of age at June/July nonpup census.

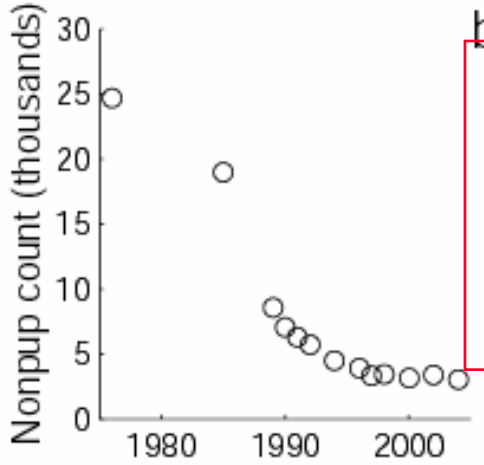
What is the definition of adult survivorship here?

Survival of females from than age 3 years at June/July nonpup census and older.

CGOA has good time series data from the aerial survey data and pup counts

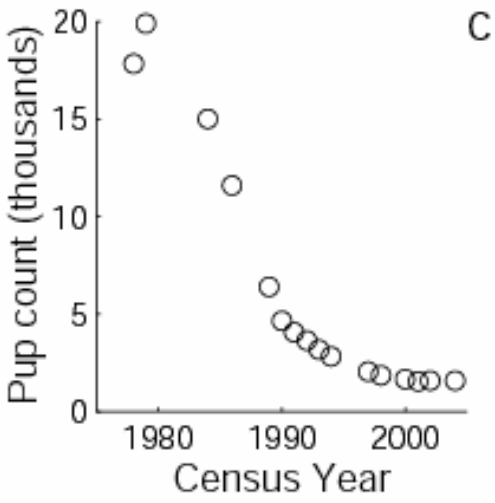
AN AGE-STRUCTURE METRIC





NON-PUPS on TREND SITES (Br SEASON)

TOTAL CGA PUP COUNT



The juvenile fraction metric is from measurements of SSLs on haul-outs.

Many SSLs were measured.

11 years
7000-2000 animals per year
15-20 haul-outs
31,000 total measurements

The rate of decline has been changing, but why is not obvious.

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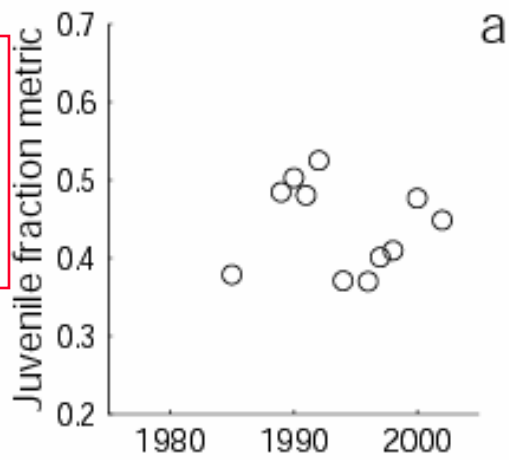

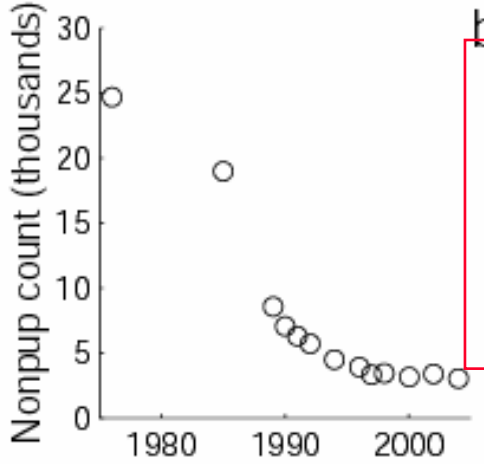

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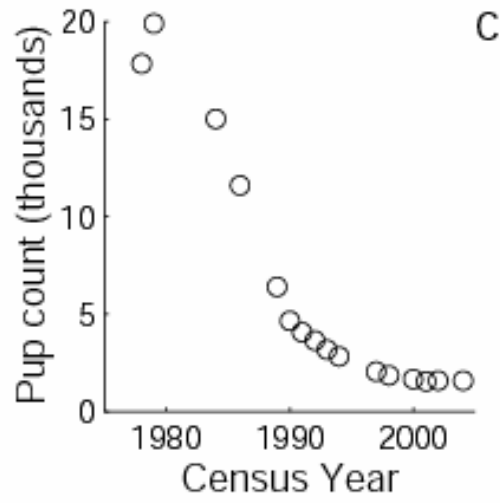
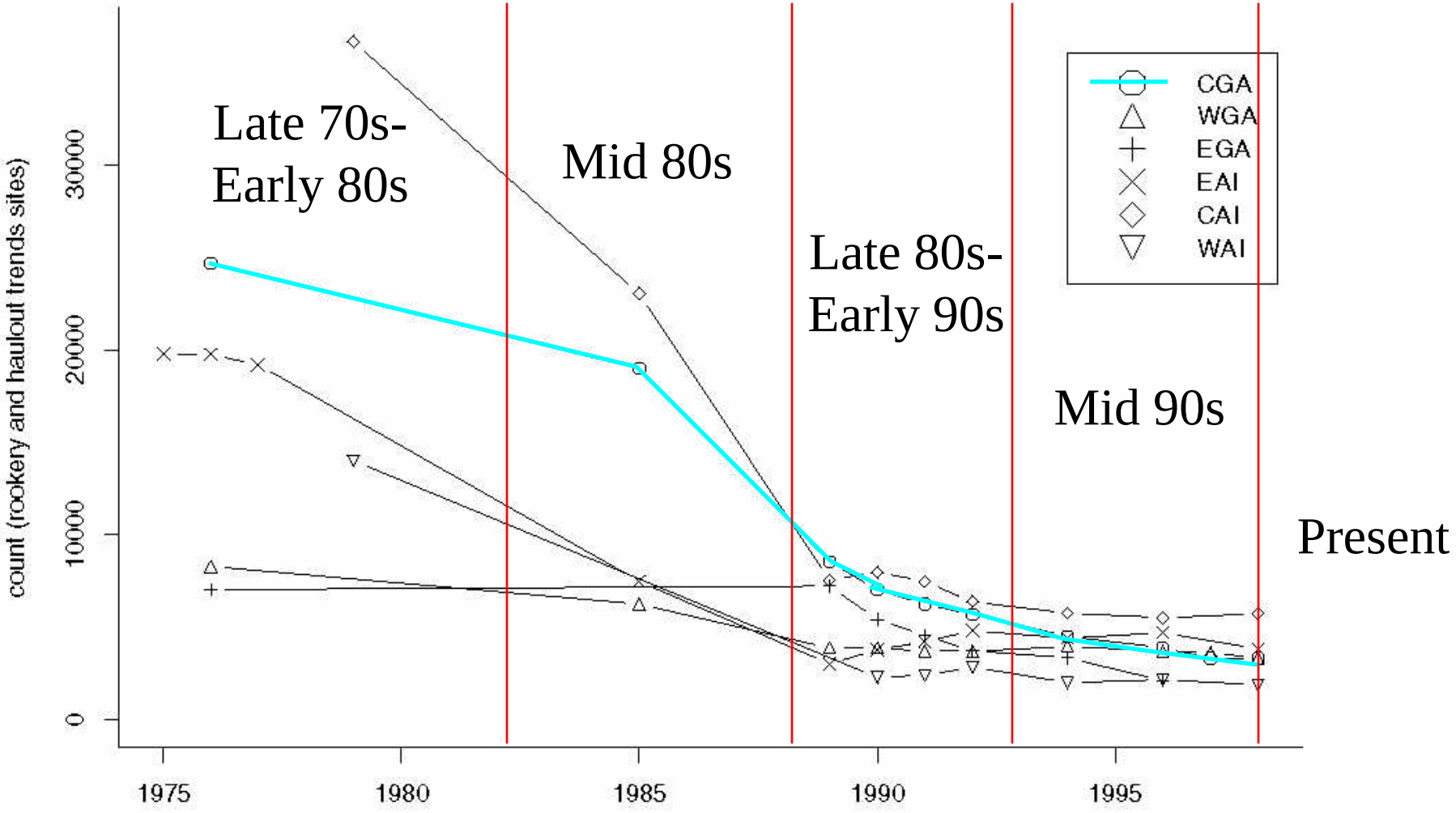


Using models to tease apart the survival and natality changes 1970s to 2004.

- Develop models for the population based on data and knowledge about SSL life-history.
- Fit to time series data 1976 to 2004: pup, non-pup, and juvenile fraction
- Estimate maximum likelihood fits for juvenile survivorship, adult survivorship and natality in different time periods
- Statistically quantify the fits

Previous studies showed four periods when juvenile survival, adult survival and natality changed .



We allowed demographic rates to change through the 1980's and 1990's

$$\text{For } t = 1976 \text{ to } 1982,$$

$$\vec{N}_{t+1} = \mathbf{Y}_{76} \cdot \vec{N}_t$$

$$\text{For } t = 1983 \text{ to } 1987,$$

$$\vec{N}_{t+1} = \mathbf{Y}_{83} \cdot \vec{N}_t$$

$$\text{For } t = 1988 \text{ to } 1992,$$

$$\vec{N}_{t+1} = \mathbf{Y}_{88} \cdot \vec{N}_t$$

$$\text{For } t = 1993 \text{ to } 1997,$$

$$\vec{N}_{t+1} = \mathbf{Y}_{93} \cdot \vec{N}_t$$

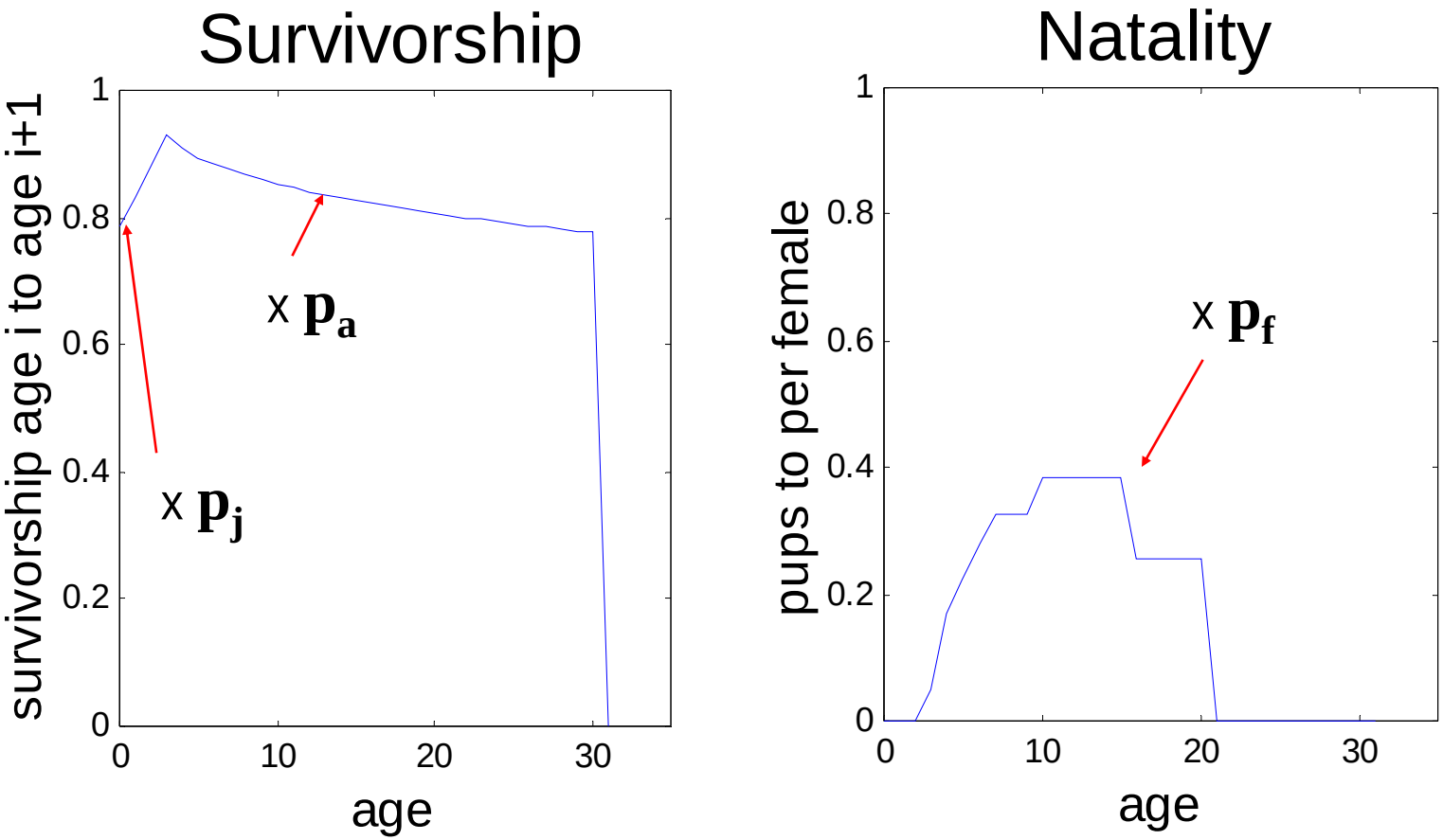
$$\text{For } t = 1998 \text{ to } 2004,$$

$$\vec{N}_{t+1} = \mathbf{Y}_{98} \cdot \vec{N}_t$$

Matrices with period specific juvenile surv., natality, adult surv.

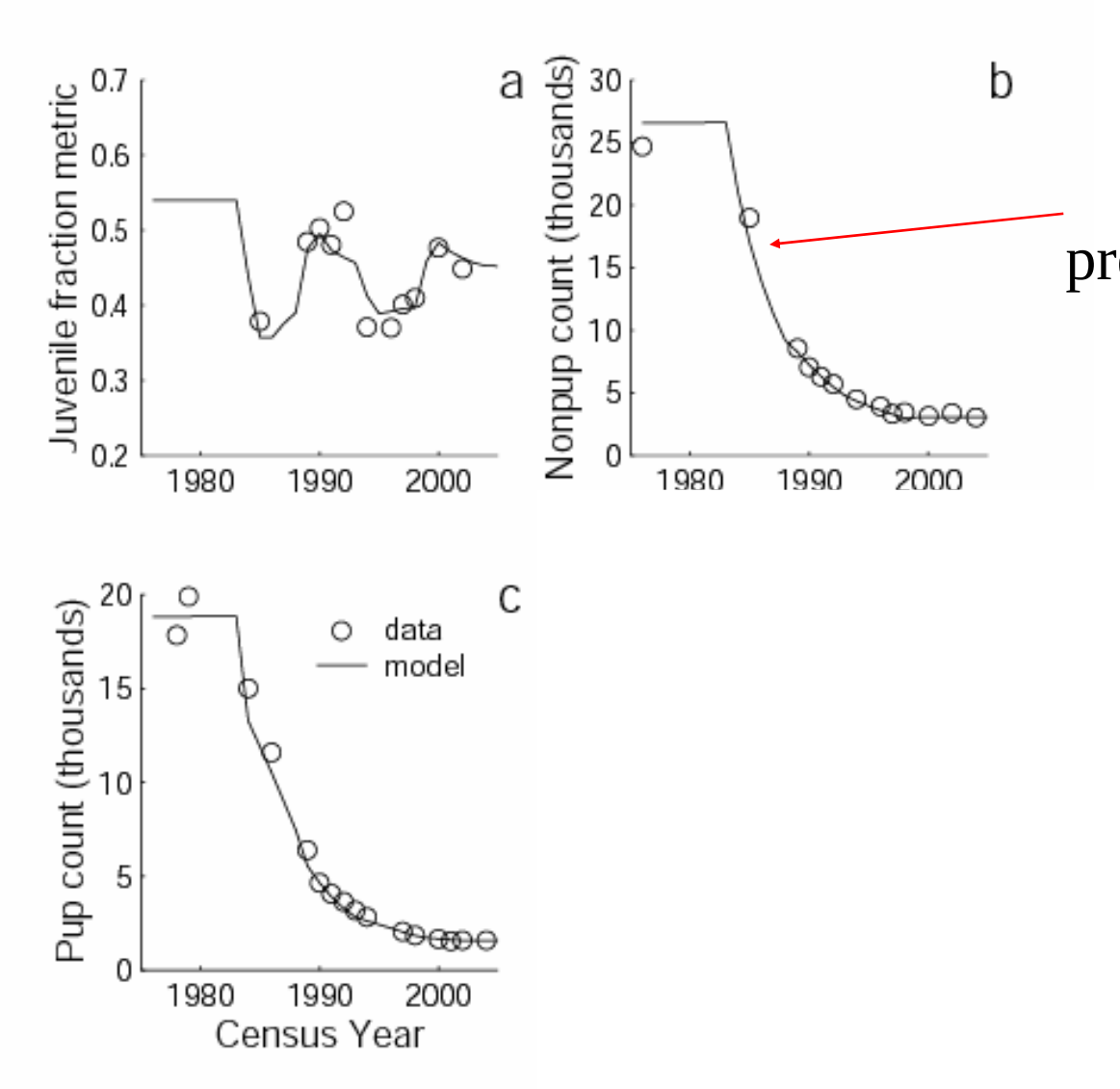
14-17 free parameters

At each time period, three things were allowed to change.



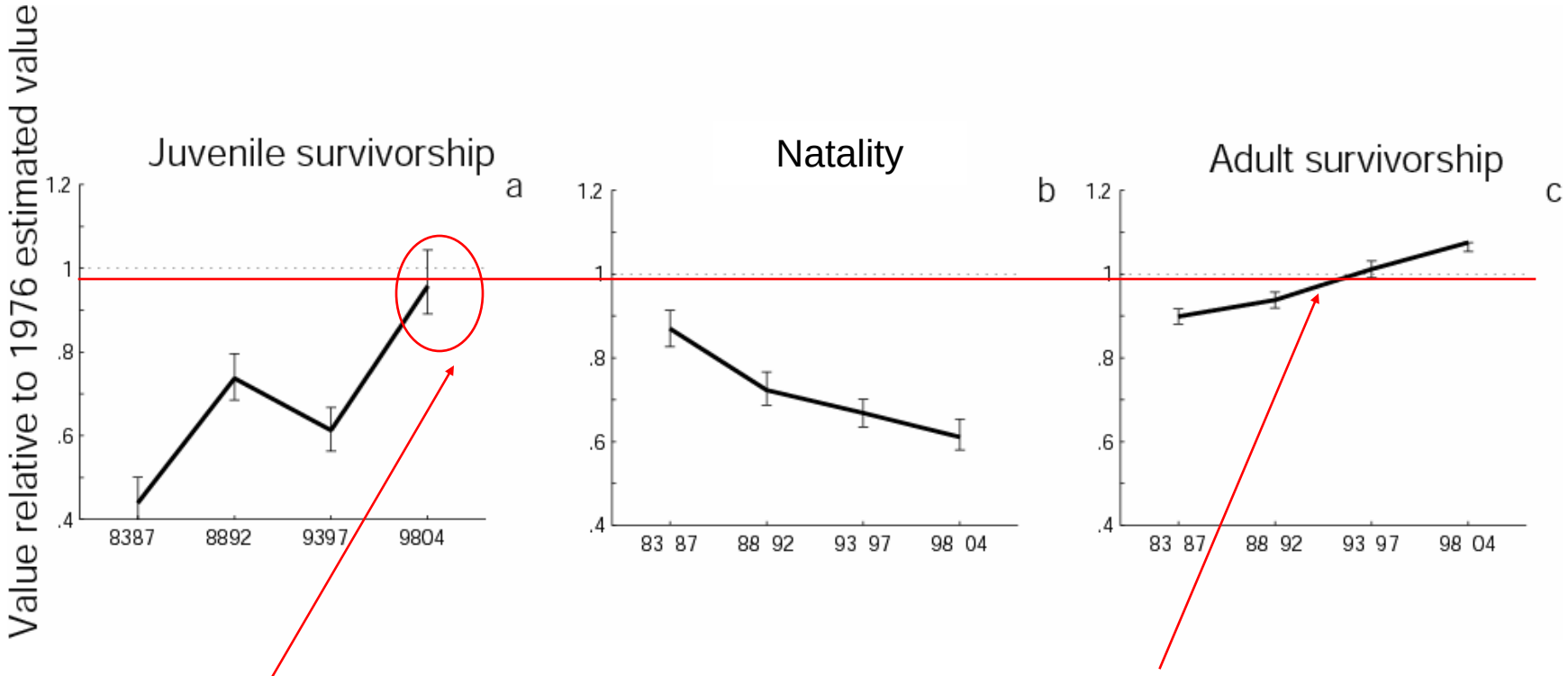
9-12 scaling parameters per model

The model is able to fit the data.



Model predictions

The fit of the best model indicates rising survivorship and declining natality.

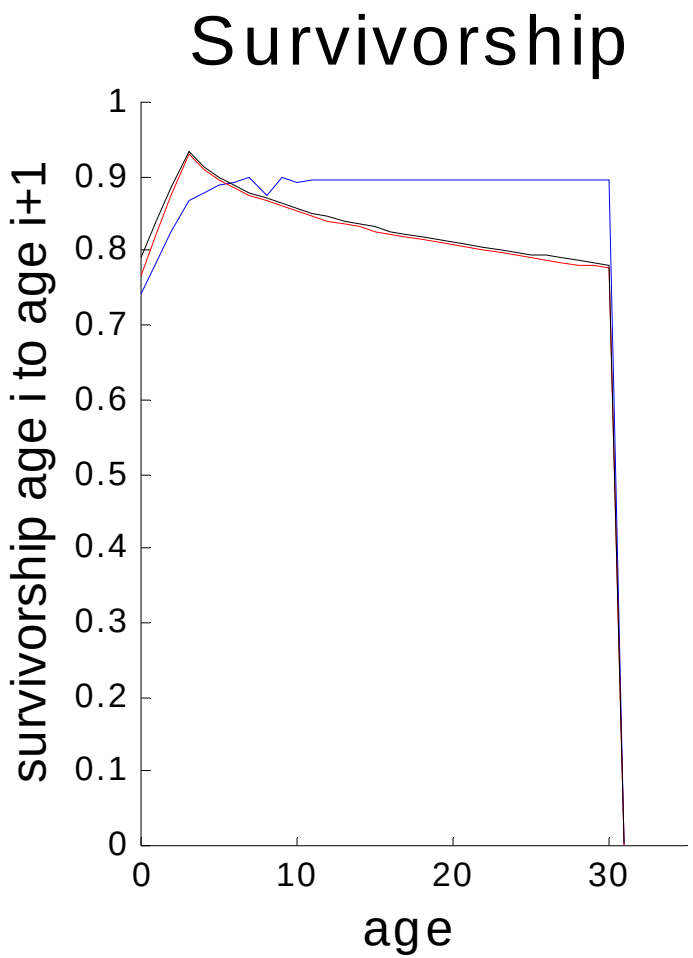


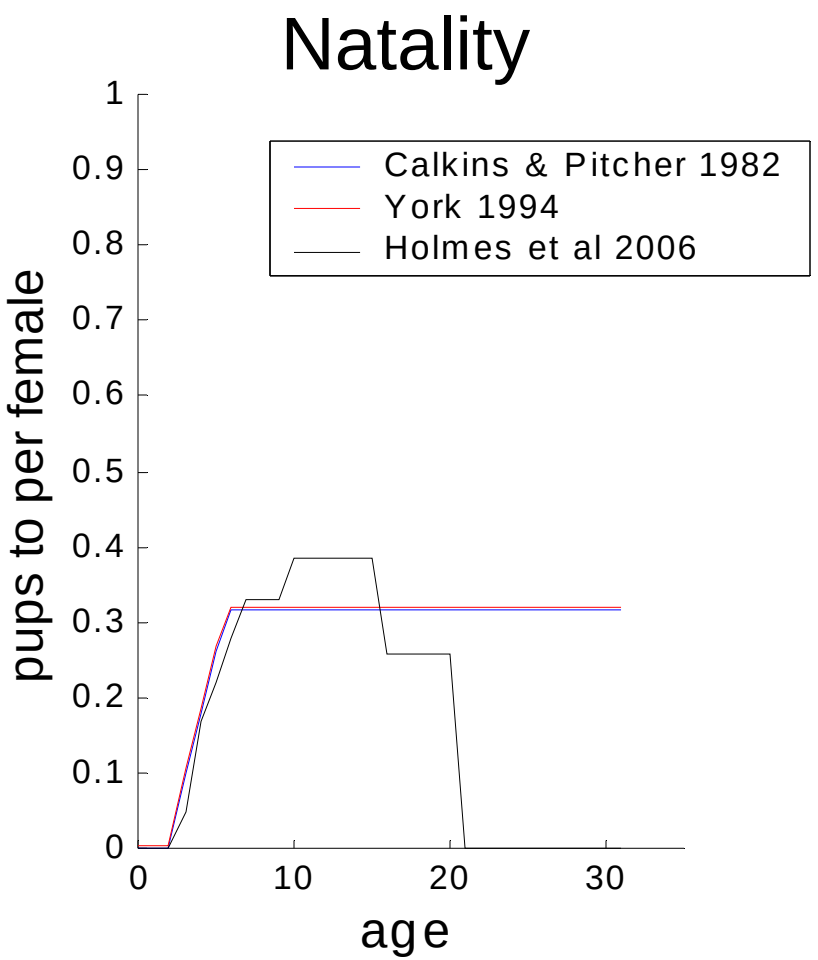
Near pre-decline survivorship

Increases in adult survivorship are outpacing those of juvenile survivorship a bit.

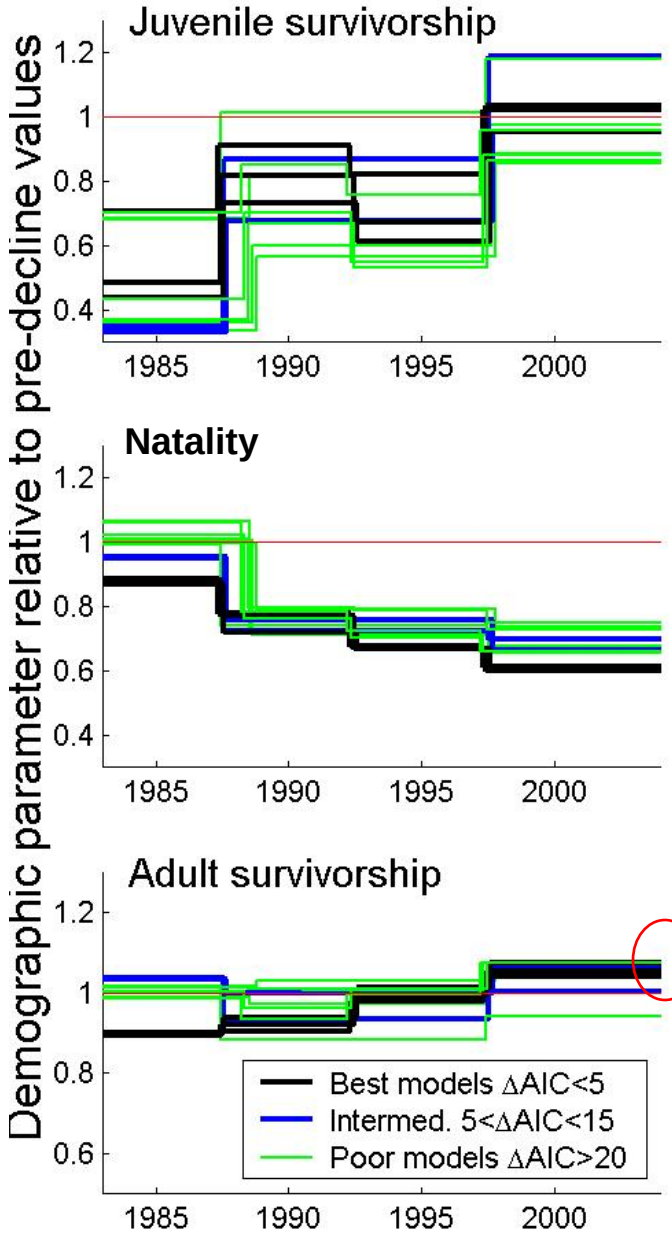
Is the analysis sensitive to the model?

We compared 3 life-history models, all based on the 1970s Marmot Island data.





Models agree on declining natality and rising juvenile survivorship.

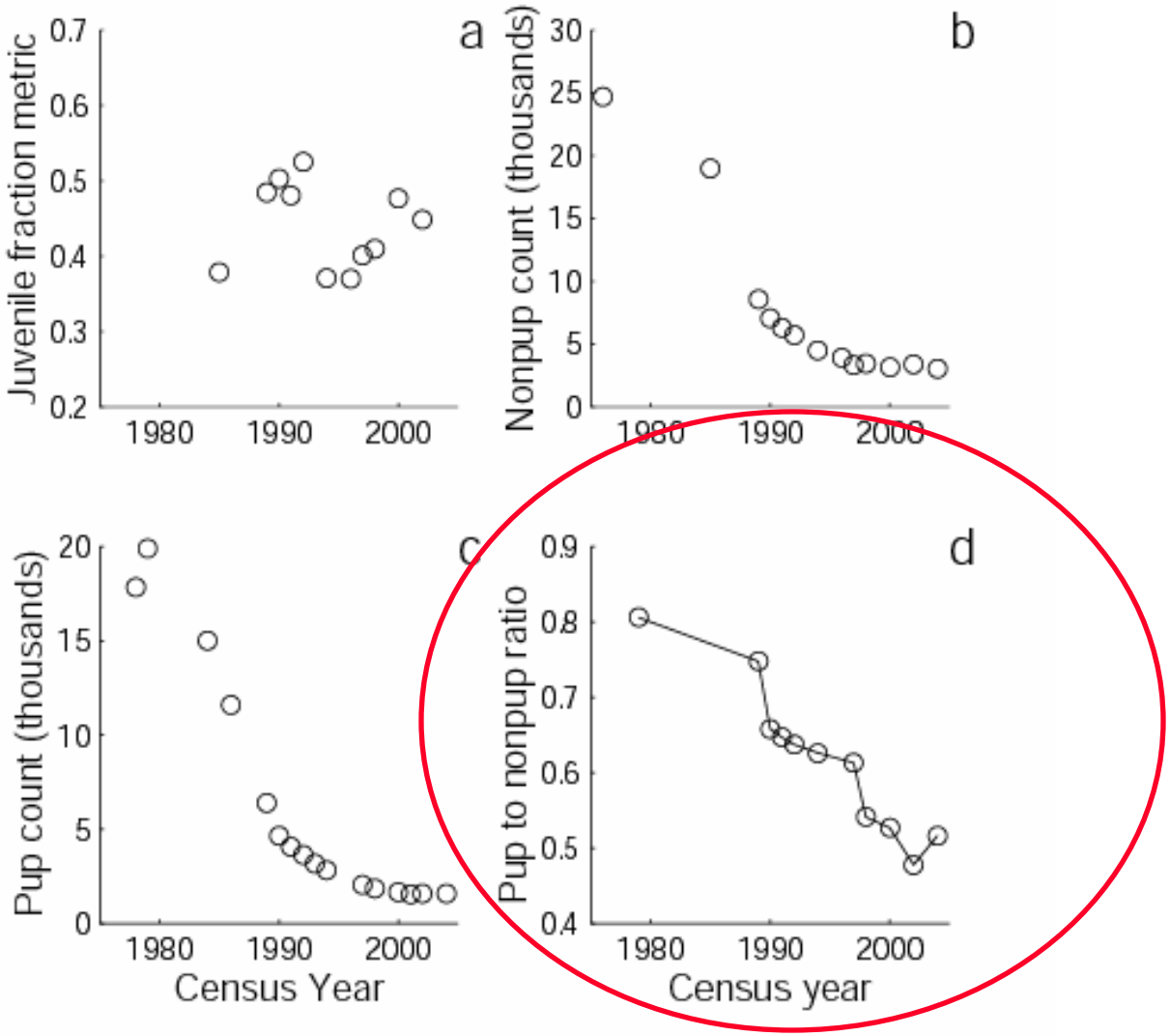


Juv. surv. increasing

Natality decreasing

Adult surv. near pre-decline levels

Agreement among models is driven by declining pup-to-non-pup ratios



Model predictions are corroborated by independent field studies.

1. % of females that are juvenile measured in the 2004 medium format data versus the model prediciton
   - Model predicts 21% in 2004 (versus 32% in late 1970s)
   - From 2004 MF photos (1990s trend sites): 21% (if only 70% of haul-outs counted this increases to 23%)
2. % of females that are censused predicted by the model versus observed % of time females spend hauled-out and thus visible.
   - Model predicts that 44% of females are photographed in the 1990s trend counts. This compares with observations that lactating females spend ca. 59% of time at land and non-lactating females spend less.
3. Model prediction of a severe drop in juvenile survival followed by steady increases is also seen from analyses of the 1980s and 2000-2004 branding data.

Summary.

It is difficult to explain the sum total of CGOA demographic data available since 1980 without a drastic decline in SSL natality combined with a steady increase in juvenile survivorship since the late 1980s.

What might be causing the declines in natality?

- Lower impregnation rate
  - Lower sperm counts
  - Lower maturity rates in females
  - Some factor limiting impregnation in females
- Higher abortion rate
- Higher neonate mortality
- Later 1st age of reproduction

What can we rule out?

- The missing cohort of juveniles from the 1980s.
- Other shifts in the reproductive female age-structure

Factors known to affect reproduction without affecting survival as much.

- Food
  - Mammals known to respond to food limitation by curtailing reproduction.
  - Prey base of SSLs is known to have changed.
  - However evidence of current food limitation is debated.
- Disease
  - Disease agents are present in SSLs that are known to be associated with increased abortion.
  - However, same agents may have been present in 1980s also.
- Contaminants
  - Known problem in arctic predators.
  - Known effects on reproduction
  - However, contaminant survey not yet extensive enough to determine if population levels of contaminants in SSLs are enough to cause population-level impacts.