Further analyses of New Zealand sea lion tag-resighting data

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for SeaFIC
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Levels of analysis

Level	Example	Description	Properties
1. Simple	This work	Each process treated alone	Easy to examine hypotheses; estimates may be biased
2. Tag-resight model	MacKenzie (2010) Gilbert (2008)	Processes affecting tag-resight integrated	Better than 1; estimates may be slightly biased; must include the right processes
3. Full population model	Breen et al.	All processes integrated	Preferred; complex & slow; must include the right processes

Aim of simple analyses is to discover the processes that must be included in 2 and 3.

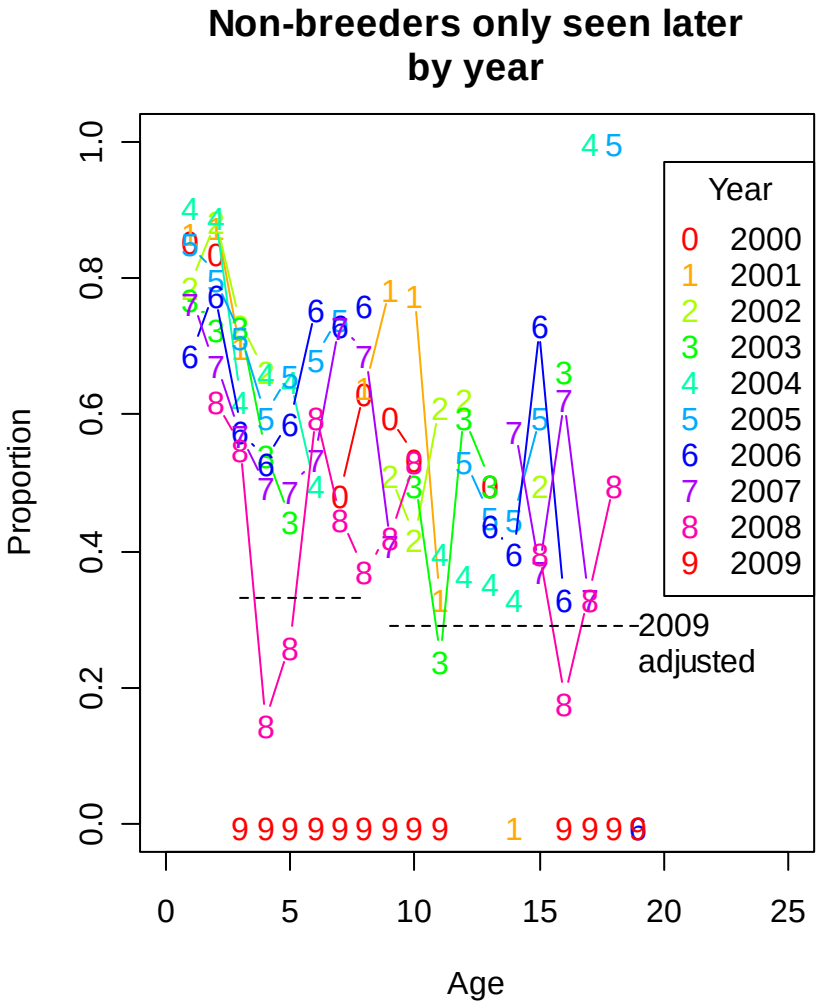
Re-sighting observations

1993 cohort

Year	Breeders seen	Non-breeders seen	Non-breeders seen only in later years	Total known alive
2000	44	18	17	79
2001	43	10	18	71
2002	37	16	17	70
2003	38	13	13	64
2004	39	12	8	59
2005	21	13	15	49
2006	14	14	11	39
2007	12	8	11	31
2008	16	6	4	26
2009	6	6	0	12

- Only 50% of non-breeders are seen each year
- Non-breeders seen only in later years is 0 in 2009 (last year of data)
- We must adjust 2008 & 2009 to avoid bias, but this involves some uncertainty

Animals only seen later



- Approx. 50% of adult non-breeders only seen later
- Higher for younger animals
- Very variable
- To avoid bias I will adjust (conservatively):

29% for 2009 adults

33% for 2009 3-8-yr-olds

9% for 2008 adults

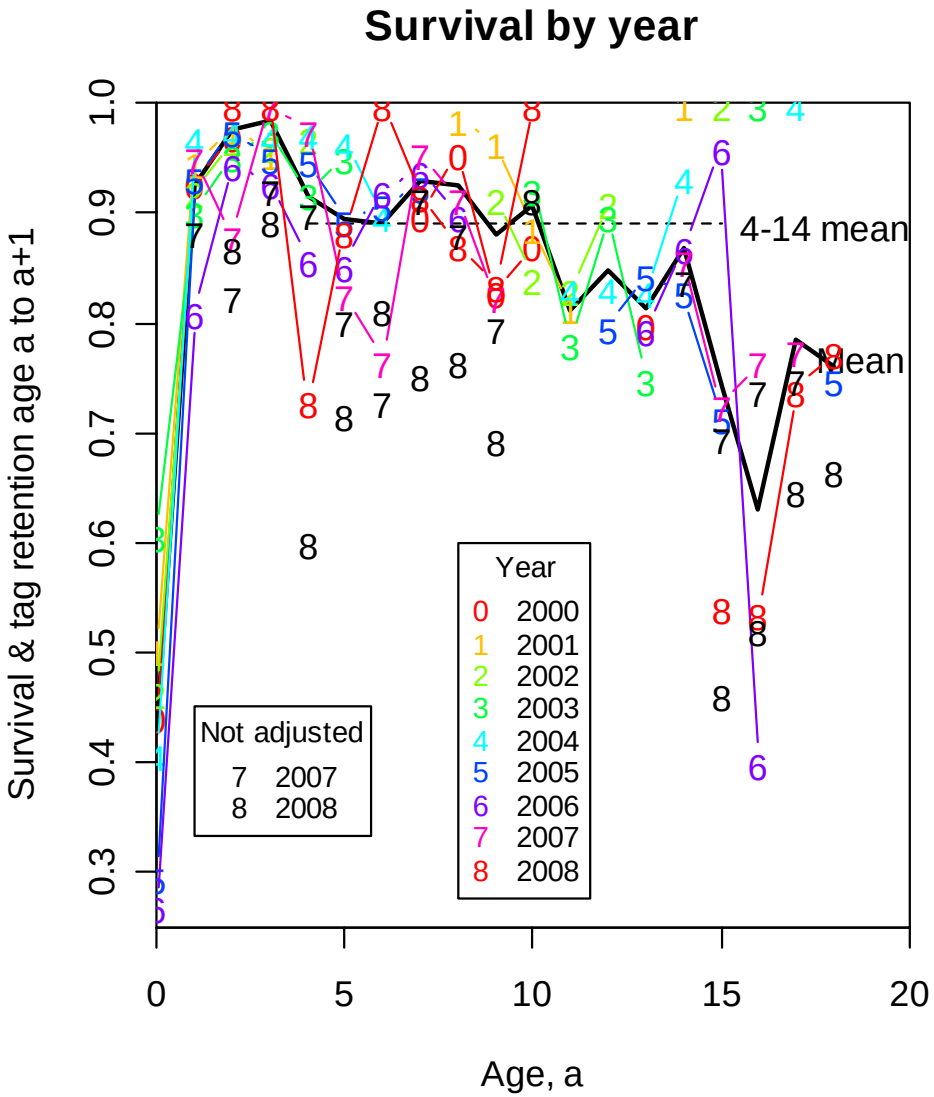
13% for 2008 3-8-yr-olds

Simple calculations

Pupping rate = $\frac{Breeders}{Total}$

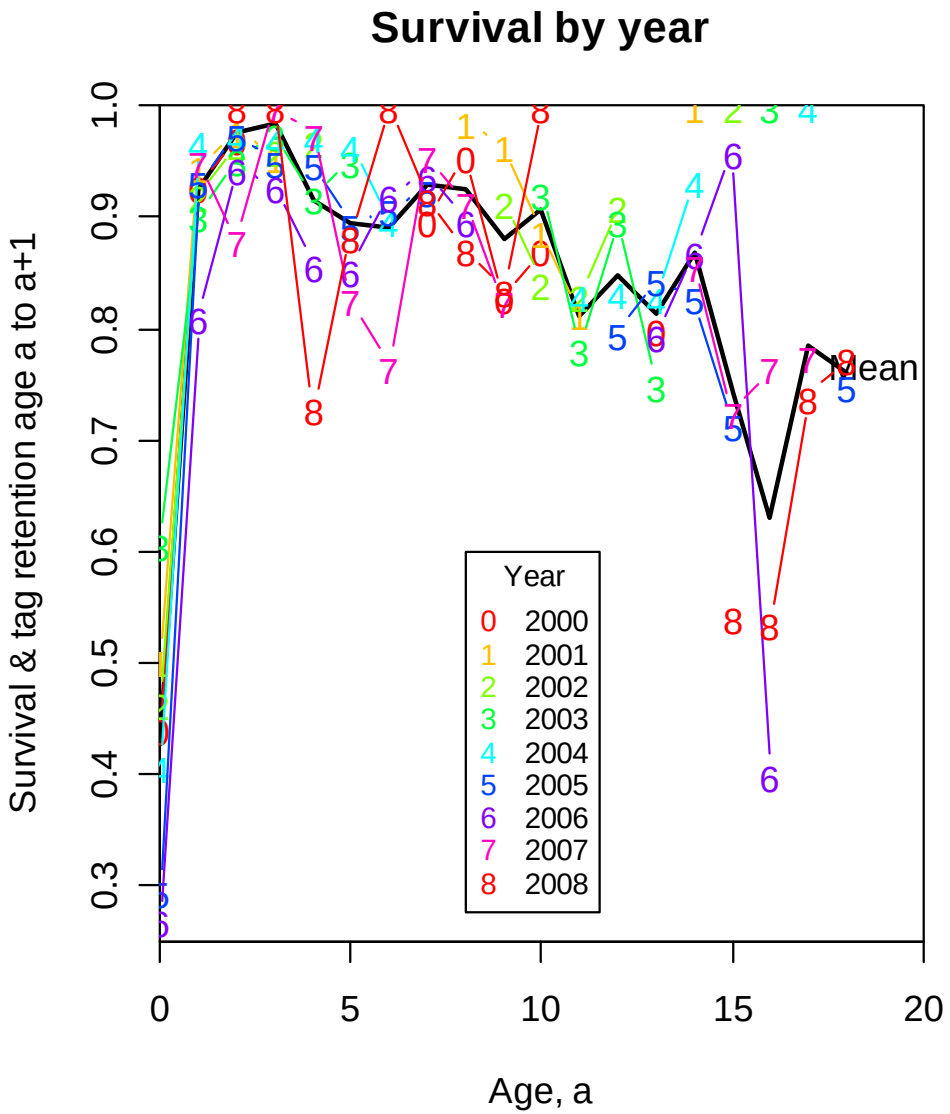
Survival = $\frac{Next\ year\ '\ s\ total}{Total}$

Survival



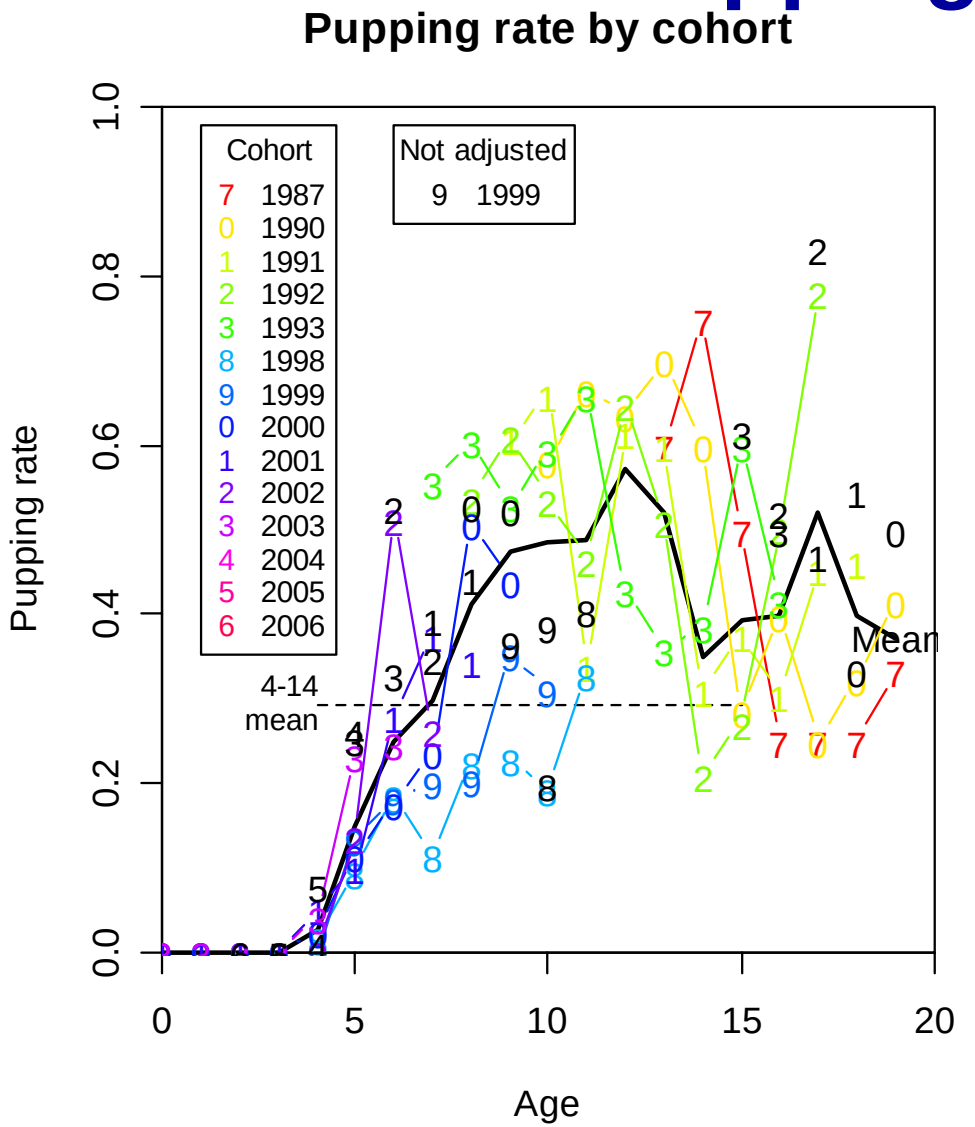
- Domed curve
- Darryl's mean for 4-14 yrs will be too low for 4-10 yrs and too high for 11-14 yrs
- 2008 & 2009 have been adjusted

More on survival



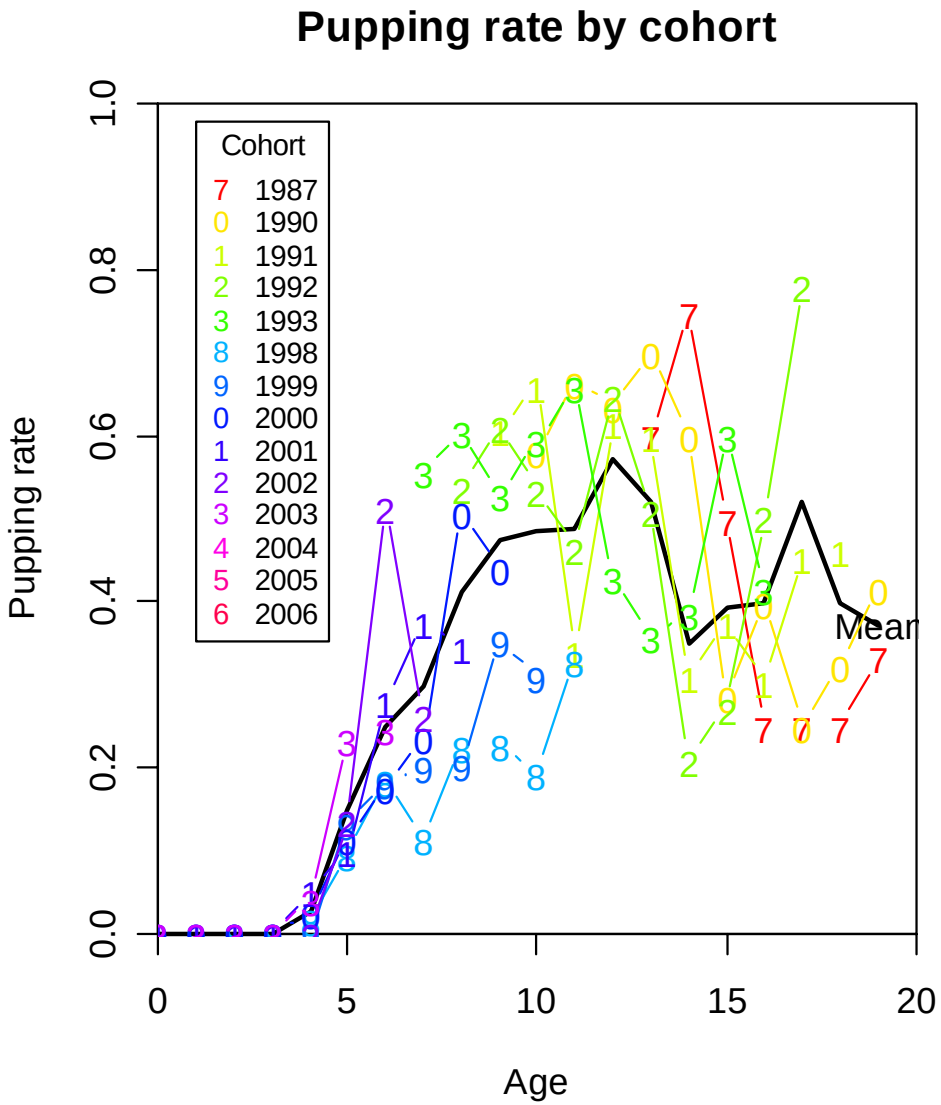
- Because juveniles are seen infrequently 0-3 yrs survival may be attributed to wrong ages
- Survival may reach only 0.95 and year survival may be correspondingly higher
- No obvious good or bad years
- No evidence of Darryl's low 2008 survival

Pupping rate



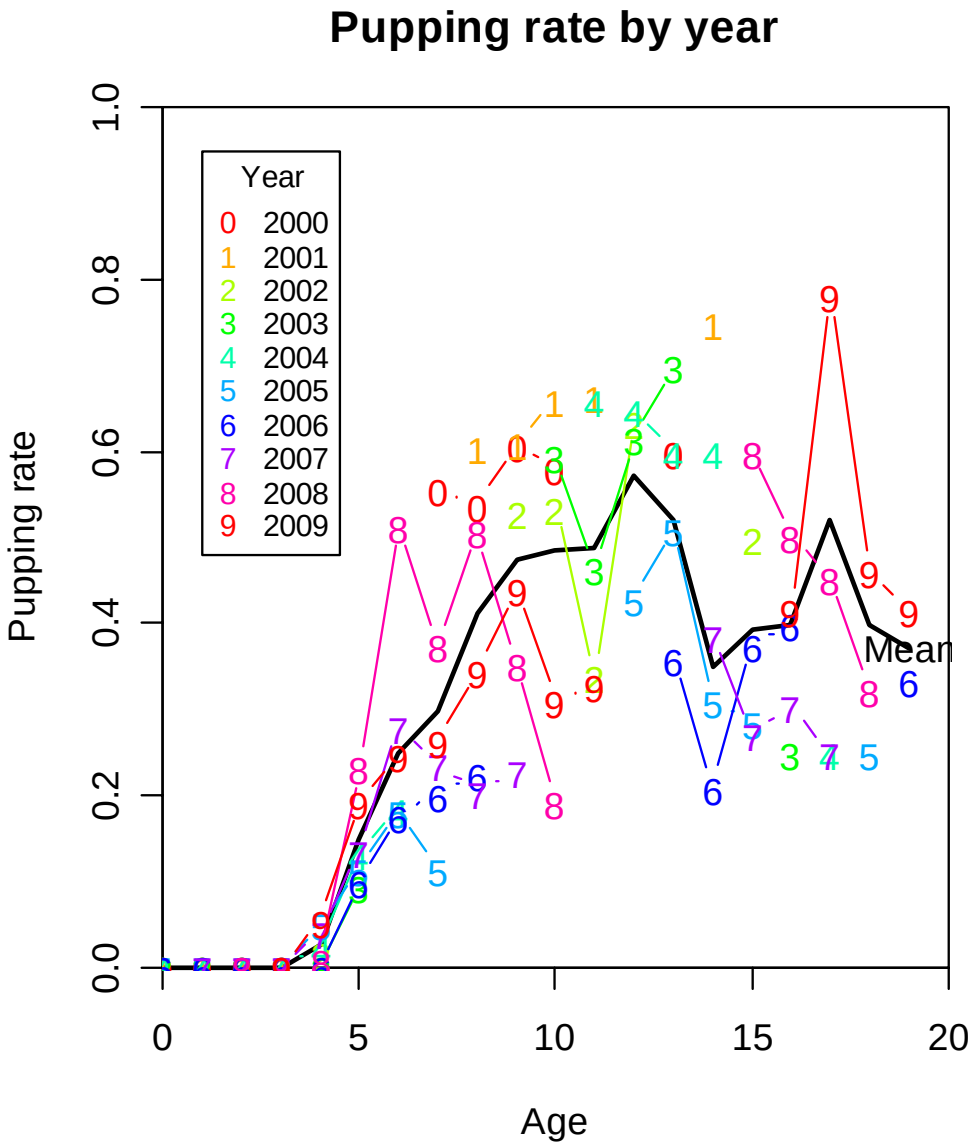
- Domed curve
- Darryl's mean for 4-14 yrs will be too low for 4-7 yrs and too high for 8-14 yrs
- 2008 & 2009 points have been adjusted (from black points)

Pupping rate by cohort



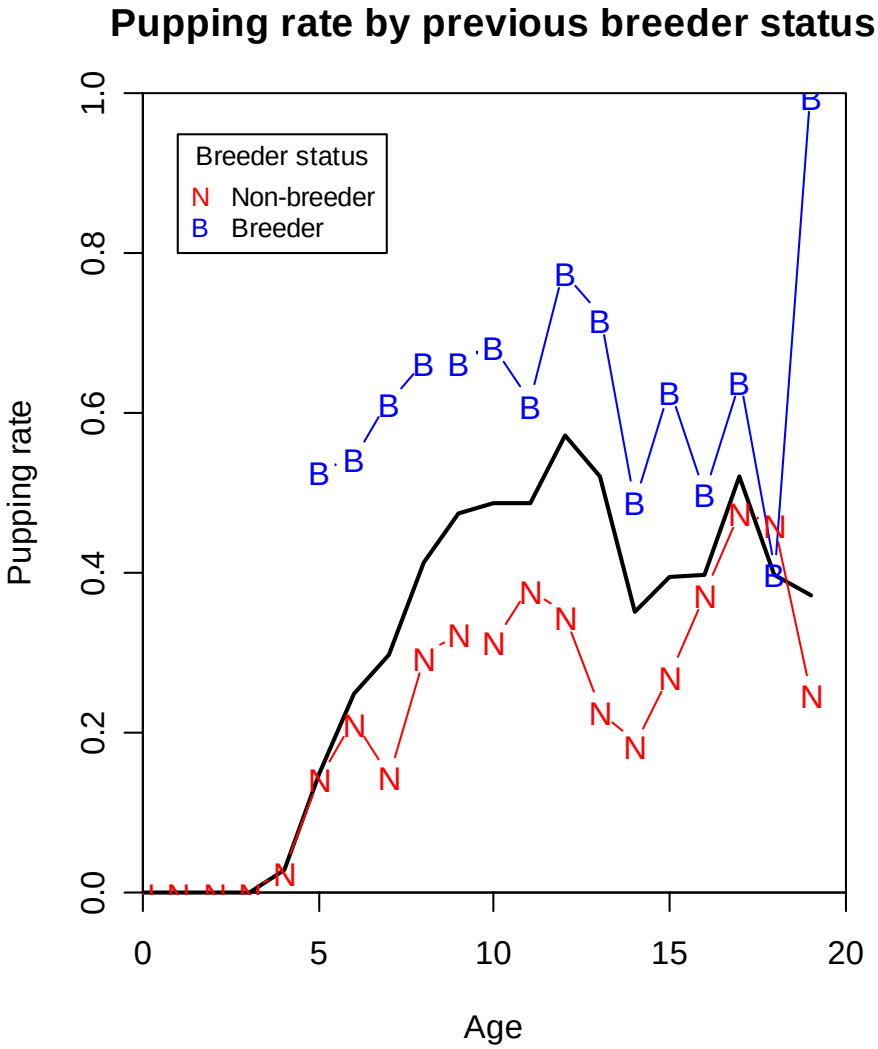
- 1998 and 1999 cohorts have HALF the fertility of normal cohorts
- 1993 cohort has above average fertility

Pupping rate by year



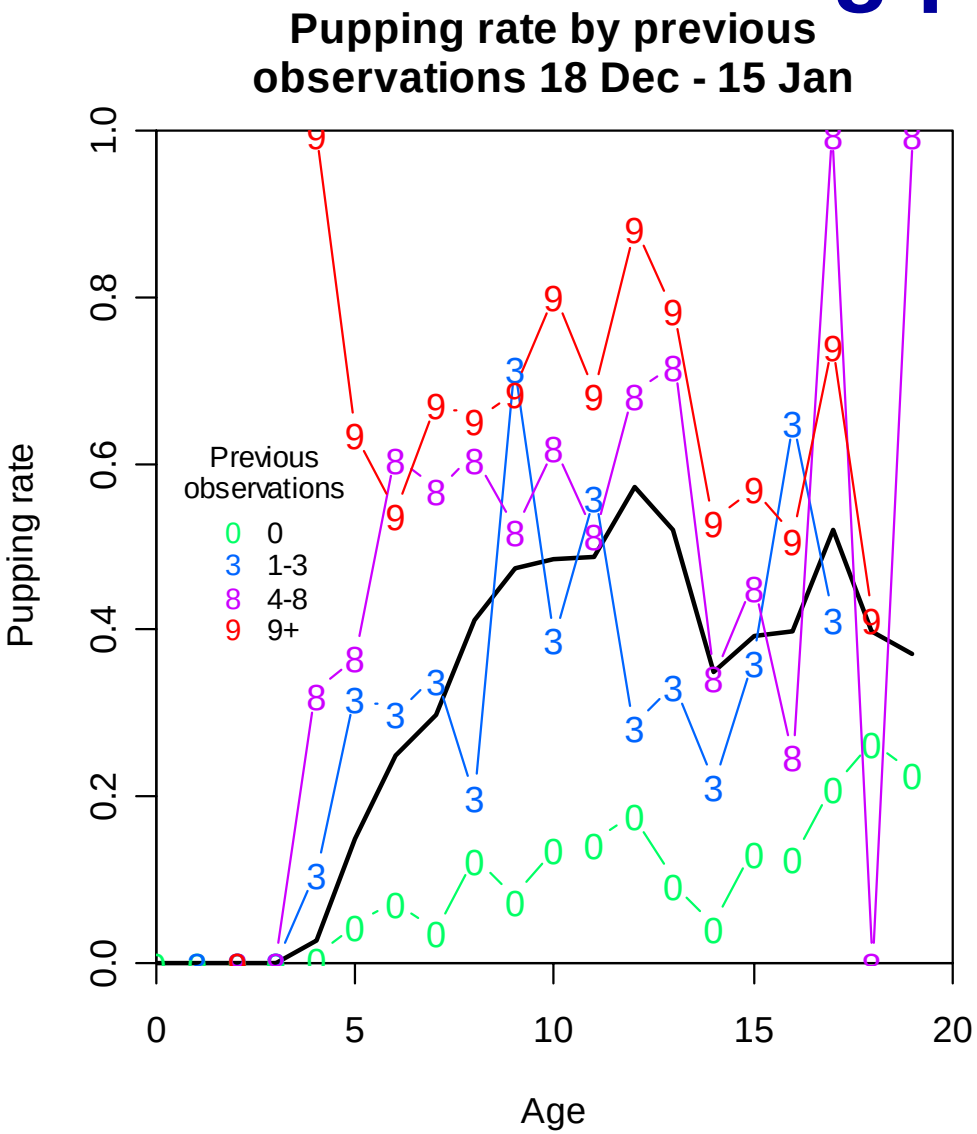
- 2000 & 2001 are good pupping years (Darryl's result)
- 2005 and 2006 are possibly poor years (Darryl's result) but infertile 1998 & 1999 cohorts contribute

Pupping rate by breeder status



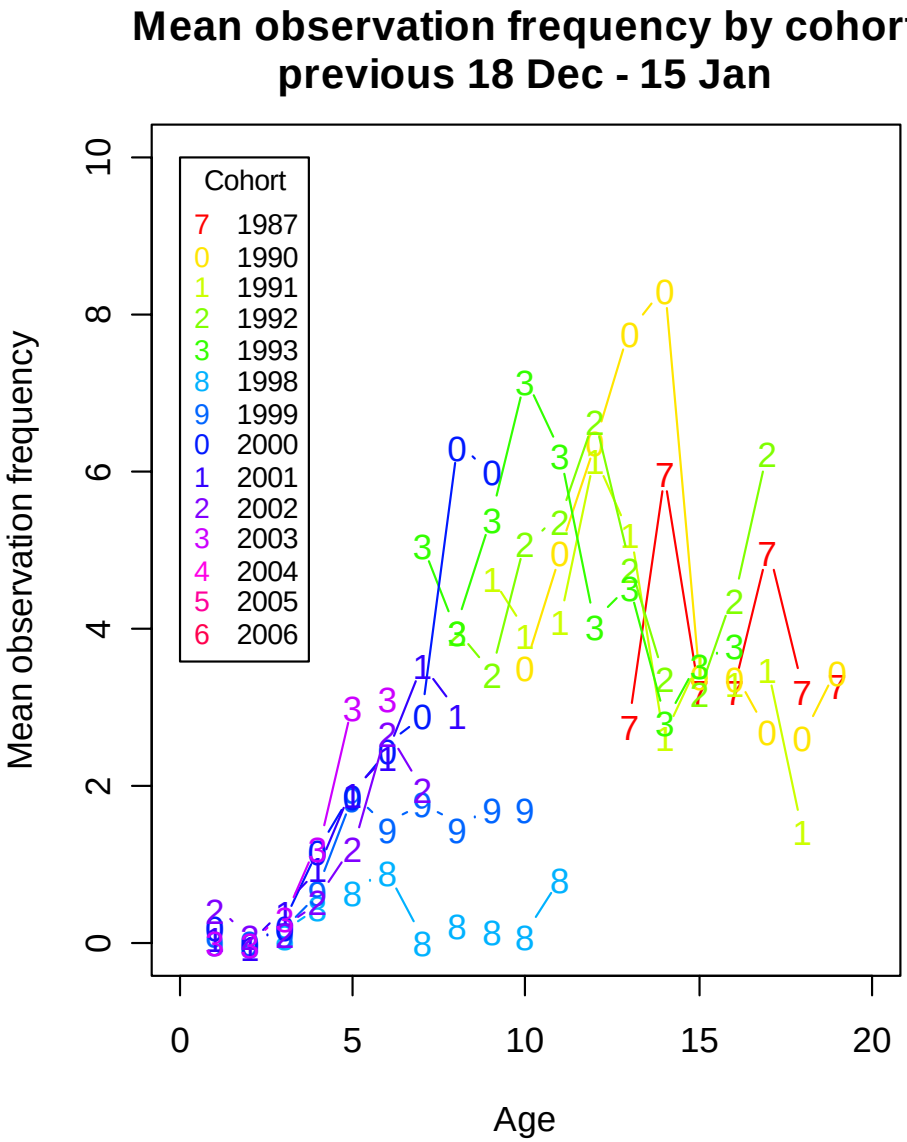
- Breeders have a higher pupping rate next year than non-breeders

Pupping rate by observations during mating period



- Observation frequency during mating period is a better predictor of pupping rate than breeder status
- 4-yr-olds seen at least 4 times in previous year have 40% pupping rate
- 4-yr-olds never seen in previous year have 1% pupping rate

Number of observations during mating period



- 1998 & 1999 cows don't put out
- We can therefore exclude failure to implant a fertilised ovum and spontaneous abortion as reasons for low pupping rates for the 1998 & 1999 cohorts

Identifying breeders

	Birth/ dead pup	Nurse	Call	With pup + 2 obs	With pup + 0 or 1 obs	Nil	Total
All ≥ 4 yrs	293	878	20	109	89	1571	2690
Certain breeders - single birth obs omitted	14	249	5	13	1	11	293
Breeders - single birth /nurse obs omitted		859	25	147	13	127	1171

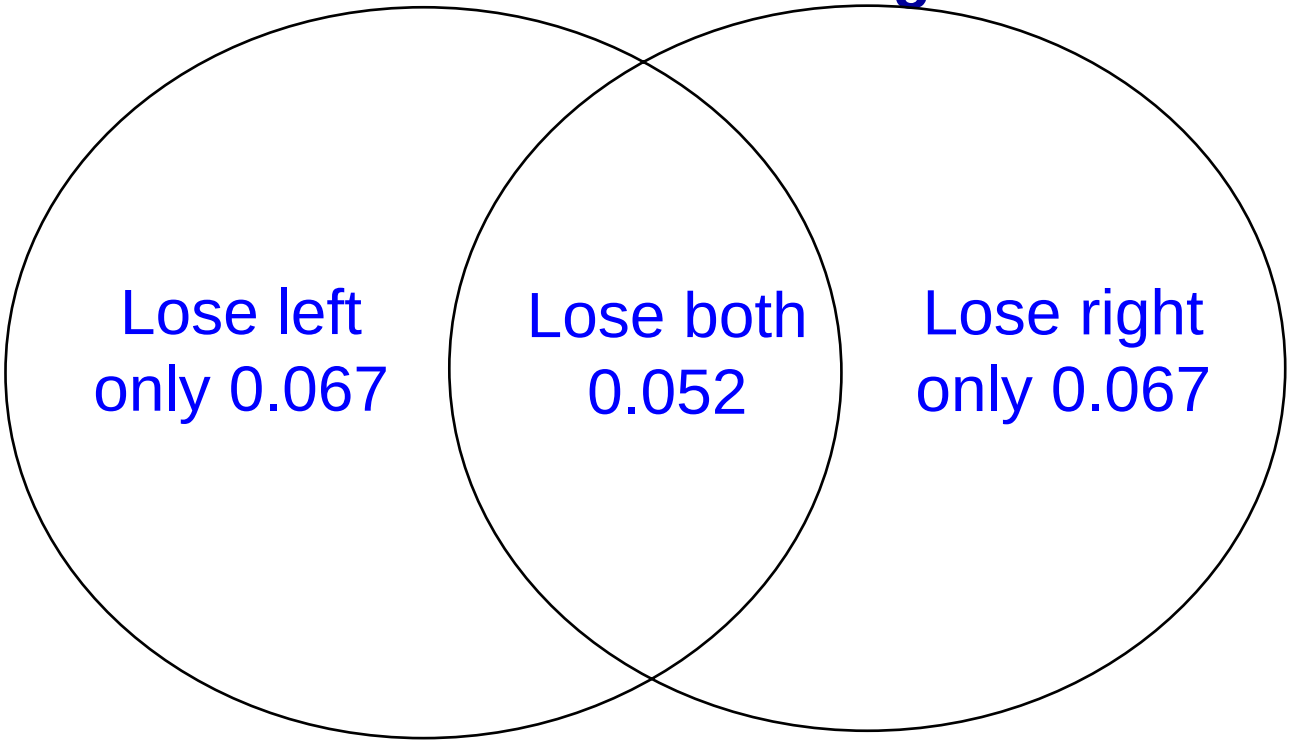
- My criterion (pinks) is a birth, nurse, call or with pup observation. It gives 47% breeders. More liberal than Louise's.
- Pink rows are observations of definite breeders if a single 'breeder observation' has been not been made.

Errors in identifying breeders

- If we had failed to make a single birth/dead pup observation we would have classified 11/293 (4%) of these breeders as non-breeders
- If we had failed to make a single birth/dead pup/nurse observation we would have classified 127/1171 (11%) of these breeders as non-breeders
- There are 198/2690 (7%) of all cows $\geq$ 4 yrs classified as breeders by 'with pup' observations alone. Some will be false positives
- False negatives probably outweigh false positives by 1-5% of TOTAL COWS, i.e. we are under-estimating pupping rates but only a little

Tag loss probability

branded cows with 2 tags



- Total probability of losing left tag (whole circle) is 0.119 /yr
- If tags were independent, lose both probability would be 0.014
- Darryl discovered this non-independence, which affects survival estimates (his numbers differ slightly)

Tag loss probability

branded cows with 1 tag left

Lose left only + lose both ?=? lose left when right already gone

Variability in tag loss probability

		Lose left of 2	Lose both	Lose left (right gone)
Branded	All	0.067	0.052	0.119 ✓
	2000 cohort ≤ 2 y	0.032†	0†	0.016†✖
	2000 cohort ≥ 3 y	0.058†	0.047†	0.196 ✖
Branded retagged	1987-93 cohorts up to 2002	0.119	0.095†	0.094†✖
	1987-93 cohorts from 2003 onwards	0.024†	0.024†	0.074†✖
Non-branded	All	0.020		
	Non-retagged ≤ 2 y	0.009		
	Non-retagged 3-7 y	0.026		
	Non-retagged ≥ 8 y	0.036†		

† fewer than 10 losses - implies low precision

✖ probability of loss from 2 not consistent with loss of last tag

Tag loss

- Tag loss is highly variable
- Tag loss in first 3 years after retagging is at least double that of non-retagged cows. This has little effect here but suggests retagging should be avoided if possible
- Tag loss appears to increase with age or perhaps with age of tag
- Losing both tags in same year is almost as probable as losing only the left tag

Correcting survival for tag loss effect

- Branded cows – no correction (Darryl's model is right). Therefore no adjustment above age 9 y.
- Retagged cows (except branded) must have large upwards adjustment in first 3 years (~10%). Not many cases.
- All other data (0-8 y) need small upwards adjustment perhaps increasing with age of tag (0.5-2%). (Darryl's adjustment may be too large here)

Conclusions

- Survival and pupping rate are domed functions of age
- No exceptional survival years
- 1998 & 1999 cohorts have very low pupping rate because they don't attend the rookery
- 2000 & 2001 are good pupping years and 2005 & 2006 are poor
- Pupping rates are probably 1-5% more than estimated due to a few breeders not being identified
- Tag loss adjustment to survival 0.5-2% for cows 0-8 y
- 1998 & 1999 cohorts only partly explain recent low pup counts