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# The recovery of North Atlantic right whales has been constrained by human-caused mortality

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# Collaborative effort

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# Peter Best & John Bannister



- British scientists, moved to South Africa (PB) and Australia (JB) in early 1960s
- Both started right whale calving surveys: SA in 1969, Aus in 1976
- Maintained these surveys despite significant hurdles

# Perspective

- I first worked at the Head of the Bight in 1991
- 1991: NARW, 17 calves; HoB: 18 calves
- 2017: NARW 5 calves; HoB 110 calves (thx Claire Charleton!)

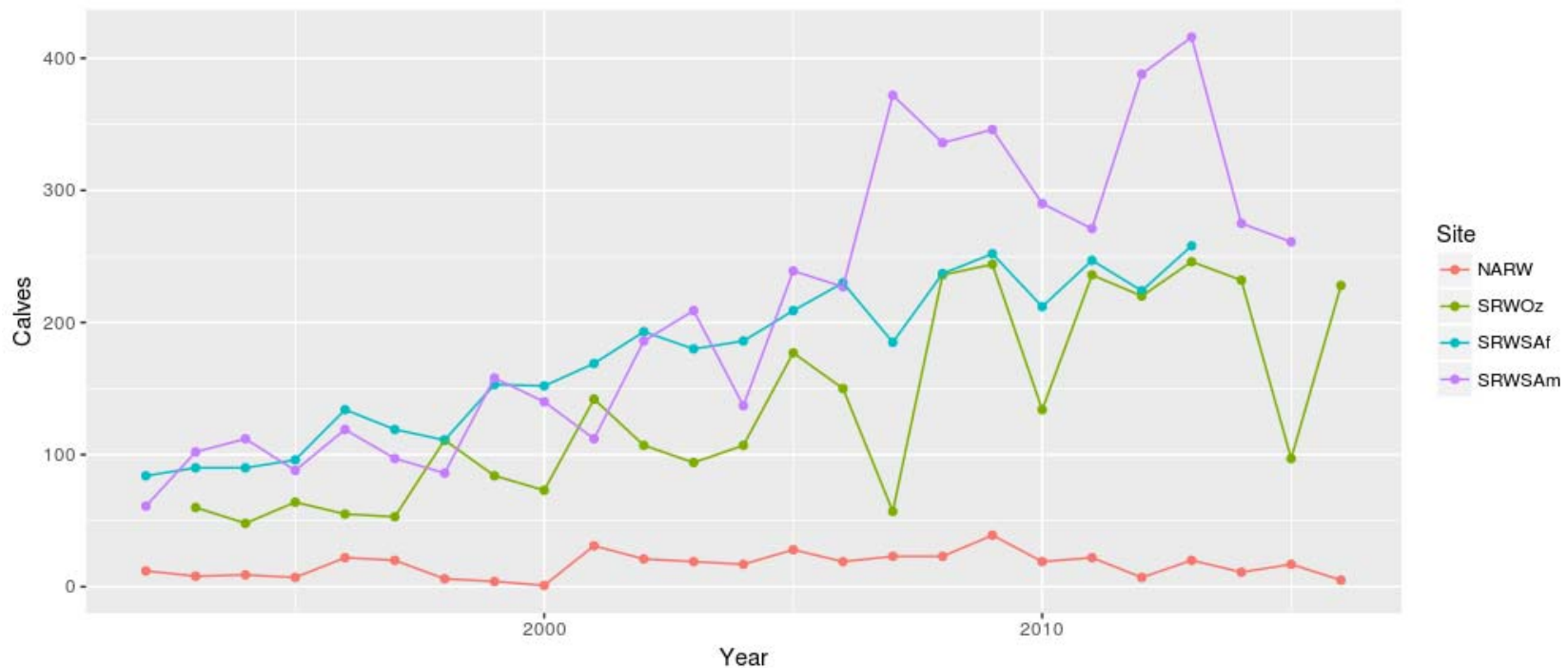


## Peter Best's question

- At a SMM Biennial (2003 in Greensboro NC?)
- Showed
  - SA SRW increasing @ ~6%/year
  - Used PPM to show how this is possible
- “The question isn't ‘can right whales increase at this rate’, the question is ‘why aren't North Atlantic right whales doing the same thing’
- Here we give a two-part answer this question

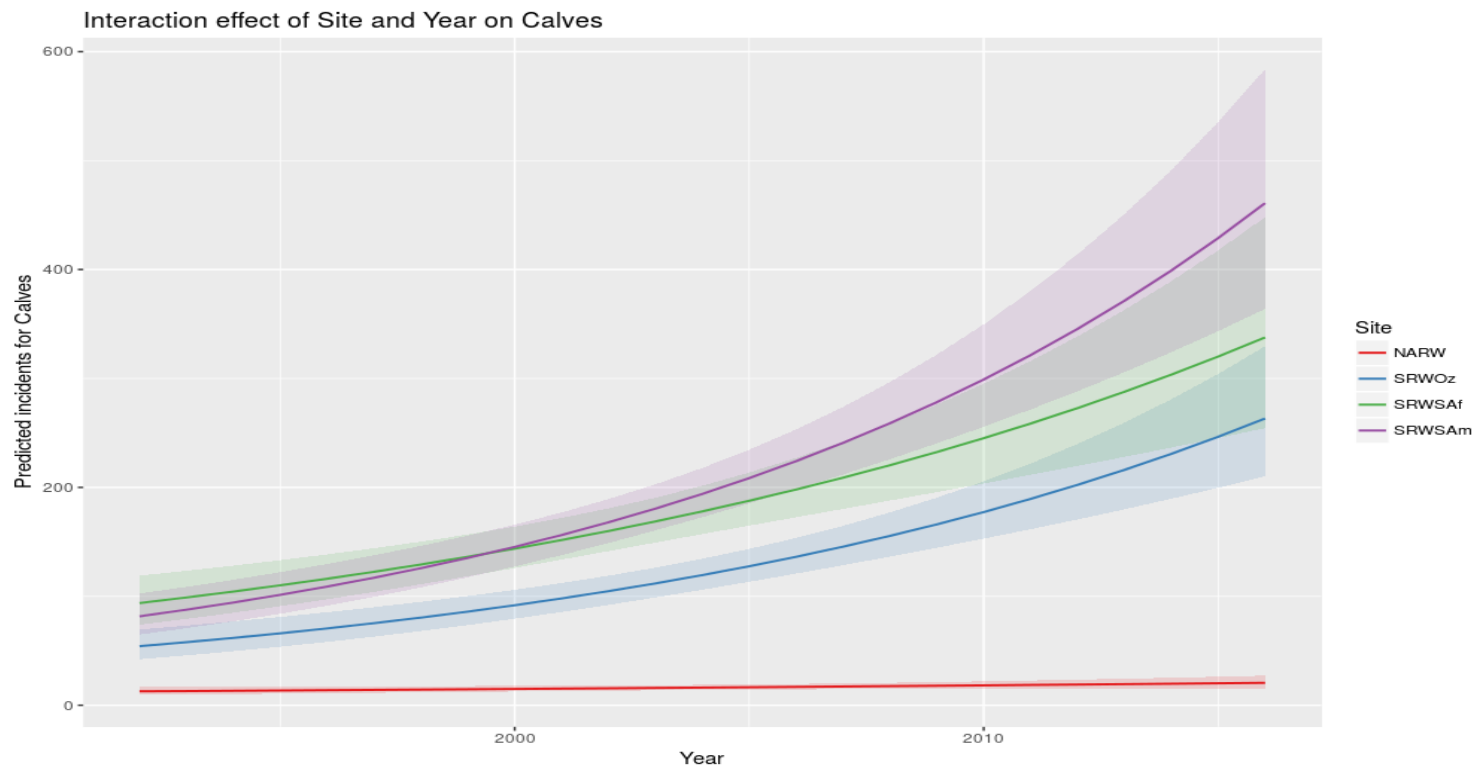
# First: are rates of increase different?

- Calf counts 1992-2016
- $NARW < SRW$  from 3 sites: Sth Africa, SW Australia, Argentina & Brazil

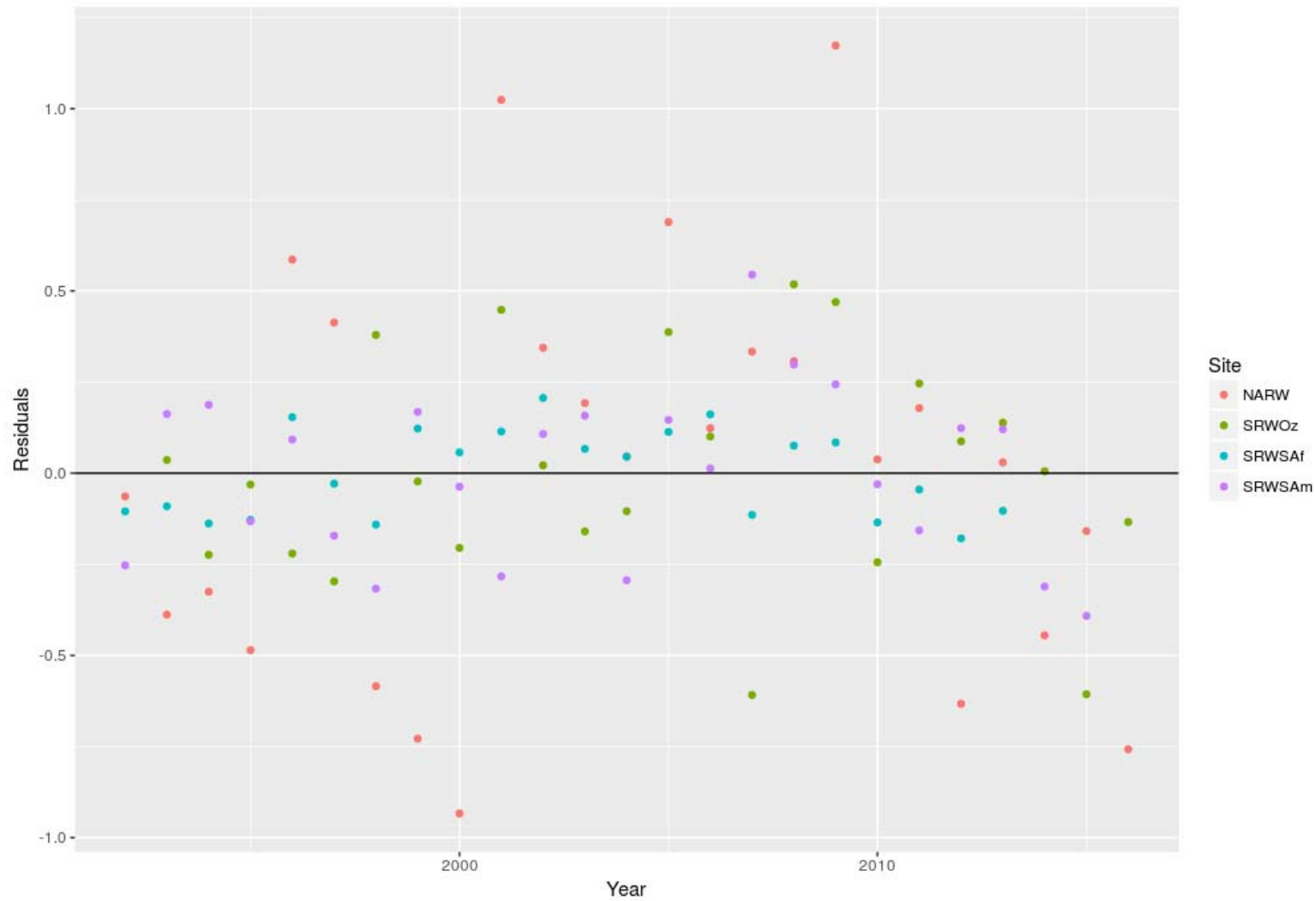


# Run a NegBin GLM

- SRW increases: 5.3 – 7.2%/year. NARW 2.0%/year
- NARW < all SRW, all SRW NSD, NARW NSD from 0



# NARW calving also more stochastic



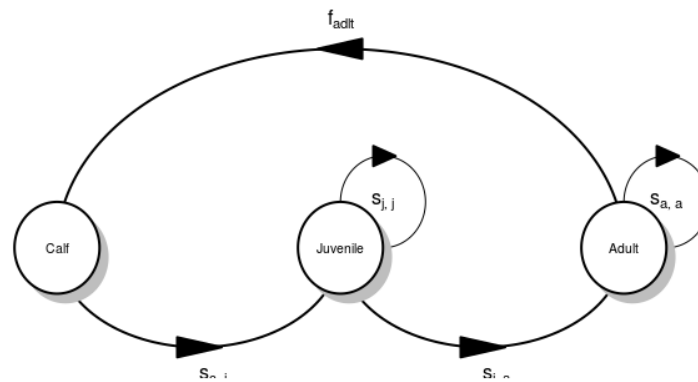


# Second: why is NARW increase ~2%

What could ROI be?

Construct very simple PPM

Simple stage-structured NARW individual model



# Another way to show the life cycle: Matrix format – give PPM

$$\begin{bmatrix} 0 & 0 & F_{\text{adlt}} \\ S_{c,j} & S_{j,j} & 0 \\ 0 & S_{j,a} & S_{a,a} \end{bmatrix} .$$

# So how fast could NARW increase?

- North Atlantic is not the Southern Ocean
  - Productivity
  - Human impacts
- Best known (possible?) values for NARW
  - Survival – from best year's survivals in Pace et al 2017 (2008)
  - Reproduction: assume 4-year calving interval
- PPM allows calculation of several intrinsic population measures
  - R language allows this to be done easily

From this model, the intrinsic rate  
of increase is estimated:  
4%/year

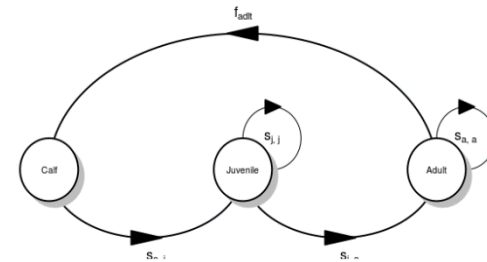
(or, twice what's been observed)

# What drives intrinsic rate of increase?

Elasticity analysis of the PPM

Adult female survival, then  
juvenile female survival

Simple stage-structured NARW individual model



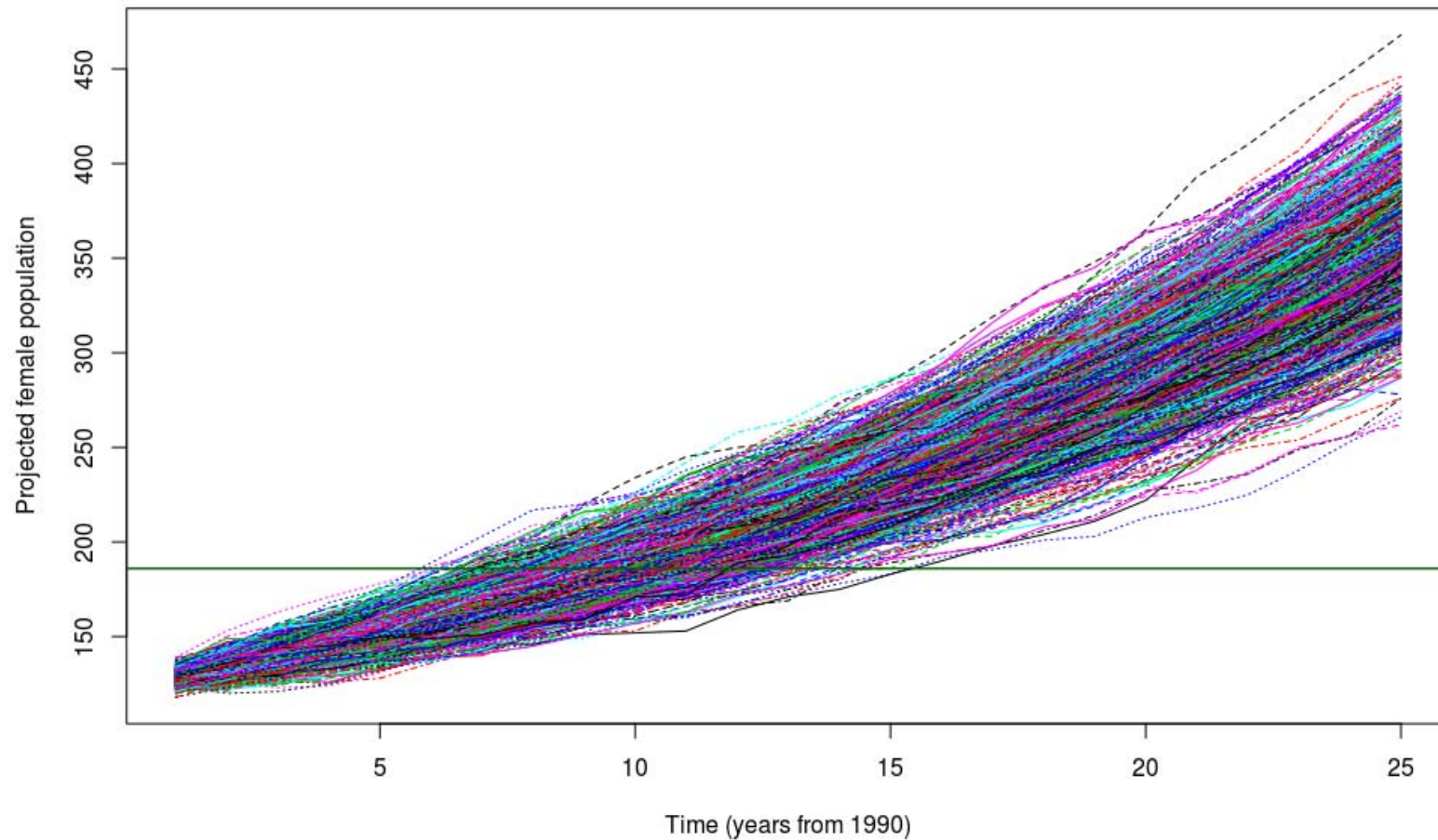
$$\begin{bmatrix} 0 & 0 & F_{adlt} \\ S_{c,j} & S_{j,j} & 0 \\ 0 & S_{j,a} & S_{a,a} \end{bmatrix}.$$

	calf	mat	adlt
calf	0	0	0.047
mat	0.047	0.233	0
adlt	0	0.047	0.625

# What causes adult & juvenile mortality?

- NARW: 1970-2009, 80% (70 of 87) for which the cause of mortality is known were anthropogenic.
  - (Proportion likely biased low as it does not differentiate calves of the year, that are more prone to natural mortality from other age cohorts)
- SRW SA (1963-1998) & SWOz (1950-2006):
  - Calves of the year mortalities: SA: 31 of 53 SWOz 16 of 28.
  - Definitively anthropogenic: SA: definitely 8, possibly 16 of 55 SRW deaths, and 3 of 28 off Australia

# What if NARW had increased at 4%/year?



NARW are increasing more slowly than (at least) 3 SRW populations

Lack of increase mostly due to adult (& to a lesser degree, juvenile) female mortality

Mortality primarily anthropogenic

If NARW had increased at the rate at which they are capable, there would be about twice as many females as there are now