POP2012-02

MS4 Correlative assessment (Presentation 1) Introduction & hypothetical model relating datasets

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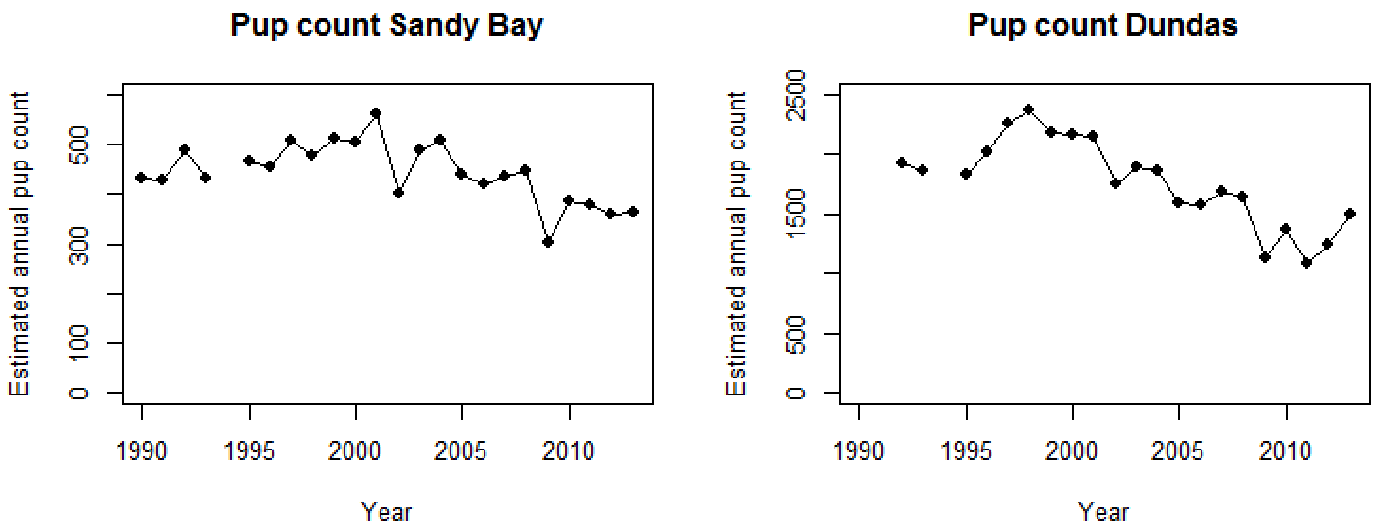
DOC CSP, May 2014

POP2012-02 Project objectives



Project Objectives:

1. Identify which demographic parameters driving population decline of NZ sea lions at the Auckland Islands (Phase 1)

2. **Identify demographic mechanisms through which direct or indirect effects of fishing can impact on population size, or increase susceptibility to such effects (Phase 2)**

Candidate drivers of population change

Fishery-related:

1. Direct effects of fishery captures/gear interactions
2. Indirect effects through resource competition or alteration of food web structure

Other:

3. Climate driven variation in prey abundance
4. Disease-related mortality of pups
5. Predation
6. Relocation

Candidate drivers of population change

Fishery-related:

1. Direct effects of fishery captures/gear interactions
2. Indirect effects through resource competition or alteration of food web structure*

Other:

3. Climate driven variation in prey abundance *
4. Disease-related mortality of pups
5. Predation**
6. Relocation**

***Nutritional stress hypothesis**

****Not investigated**

Methodology

1. Take annual demographic rate estimates from first project phase (Females at Sandy Bay and Dundas)
2. Develop hypothetical models relating demographic rates to candidate drivers of population change

   (avoid retrofitting of hypotheses to relationships)
3. Simple correlative assessment between demographic/biological/ environmental/fishery-related datasets
4. Are relationships consistent with a particular candidate driver of population change?
5. Identify research/data needs

Phase 2 activities

Work in this project component

1. Preliminary correlative assessment at workshops with NZ and International experts (Mark Hindell & Andrew Trites):
   - Workshop 1 – June 2013
   - Workshop 2 – December 2013
2. Revised assessment
3. **Presentation to DOC CSP technical working group**
4. Address feedback in final report (draft due end July 2014)

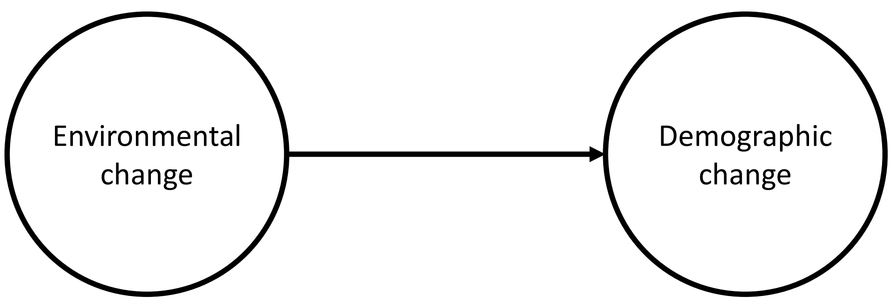
Scope of presentations

1. **Hypothetical models relating datasets**
2. Presentation of datasets
3. Correlative assessment

Relating demographic rates to candidate drivers

How are demographic and environmental causes of population variation related?

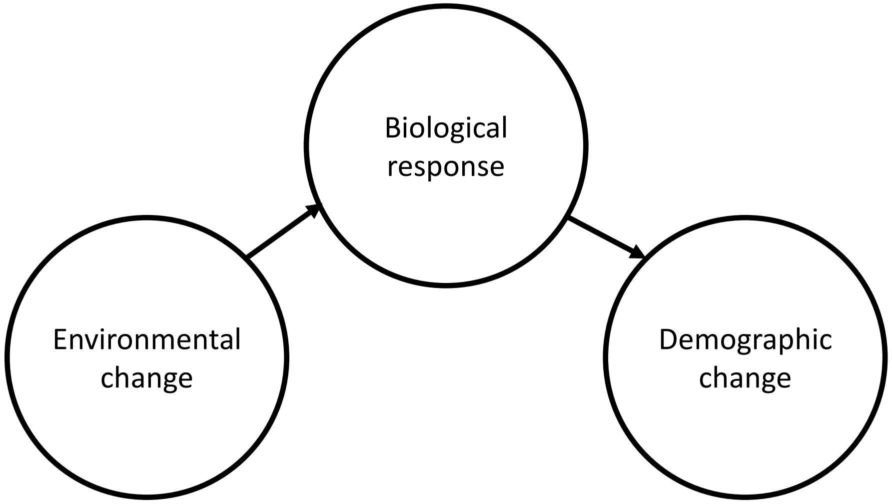
Top-down driver
(e.g. predation or fishery-related mortalities)



Relating demographic rates to candidate drivers

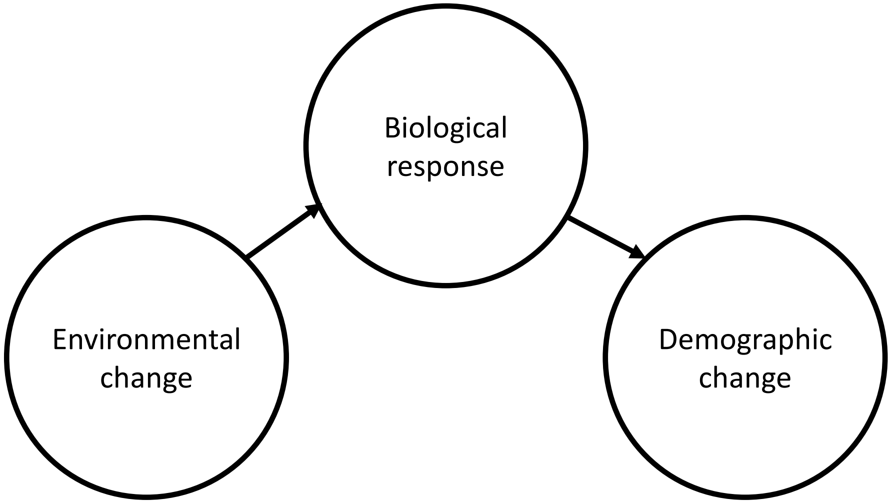
How are demographic and environmental causes of population variation related?

Bottom-up driver
(e.g. change in prey abundance)



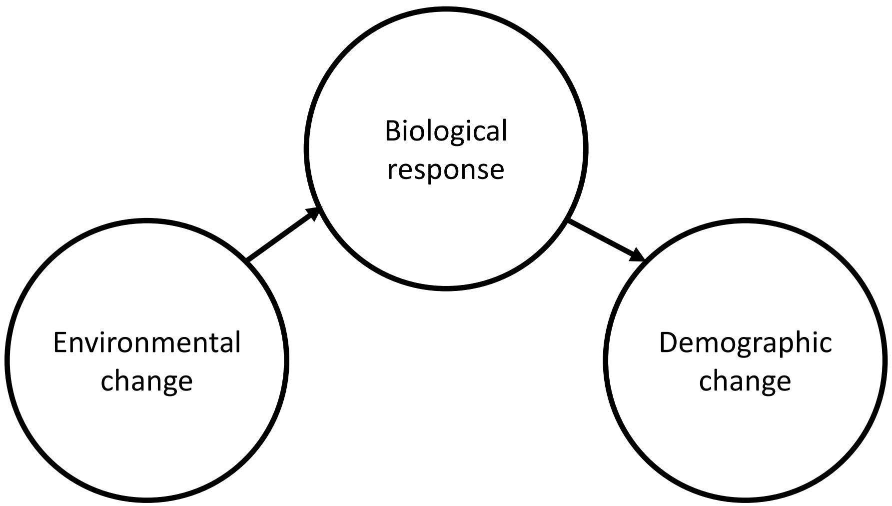
Relating demographic rates to candidate drivers

- Adaptive biological response to environmental change:
  - Buffer against adverse conditions
  - Take advantage of optimal conditions
  - Maximise lifetime reproductive output and survival of offspring



Relating demographic rates to candidate drivers

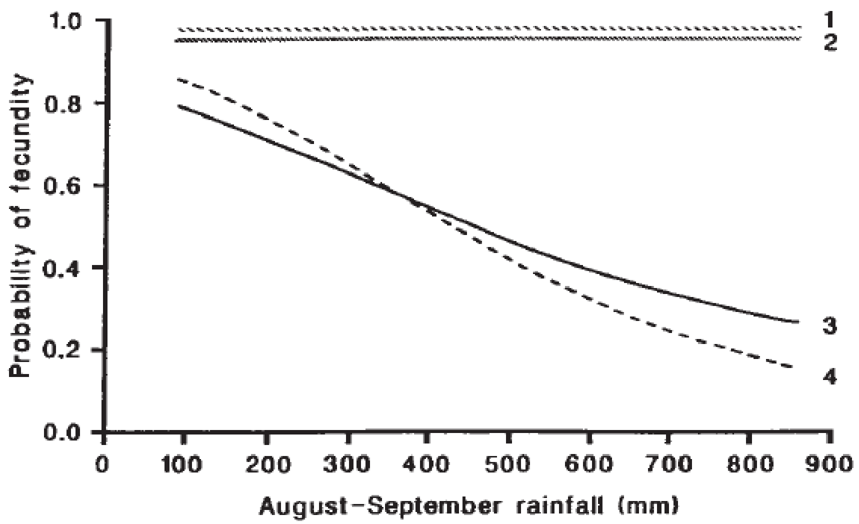
- May dampen/obscure relationships between environment & demographic rates
- **Predict response of reproductive biology to environment, then predict how this will affect changes in demographic rates**



Relating demographic rates to environment

E.g. red deer of Rum

Clutton-Brock (1989) **Nature 337**: 260-262



1. Barren
2. Calf died shortly after birth

Previous year's

calving status

3. Calf died after 6 months of lactation
4. Reared calf successfully

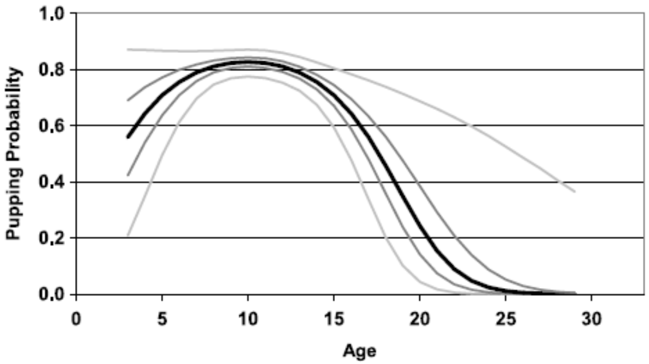
- Probability of producing a calf depends on climate and calving status in the previous year
- Adverse climate reduces probability of calving, though only if previous year's calf is reared for a substantial period of time

Relating demographic rates to environment

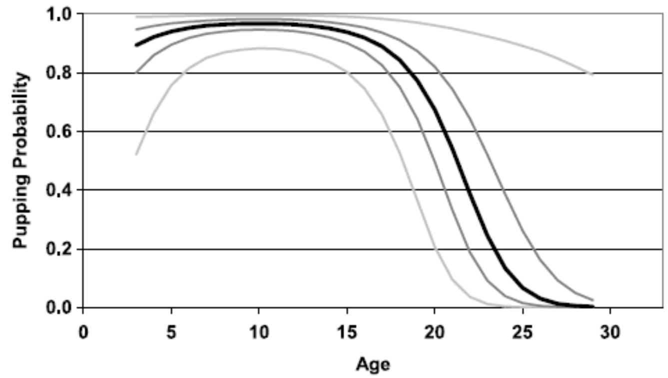
E.g. NZ sea lion

Chilvers et al. (2009)

Pup in yr-1 survived to 8 weeks



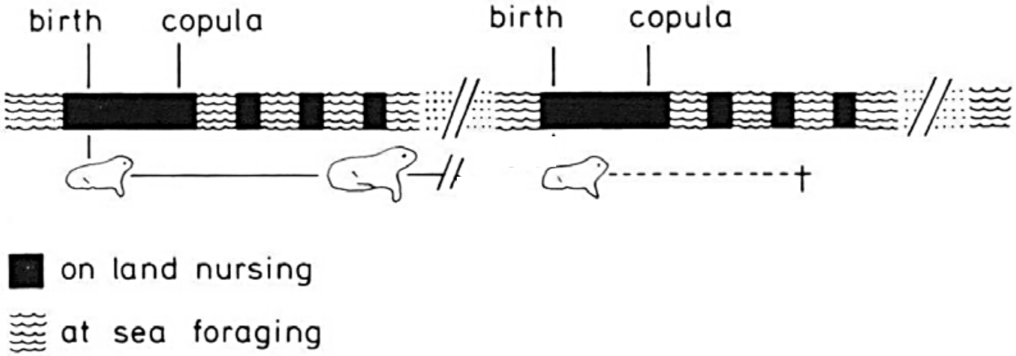
Pup in yr-1 died <8 weeks



- Probability of NZSL pupping decreased by survival of pup born in previous year
- Relationship to environment unknown, though pupping status in previous year should be considered in correlative assessment

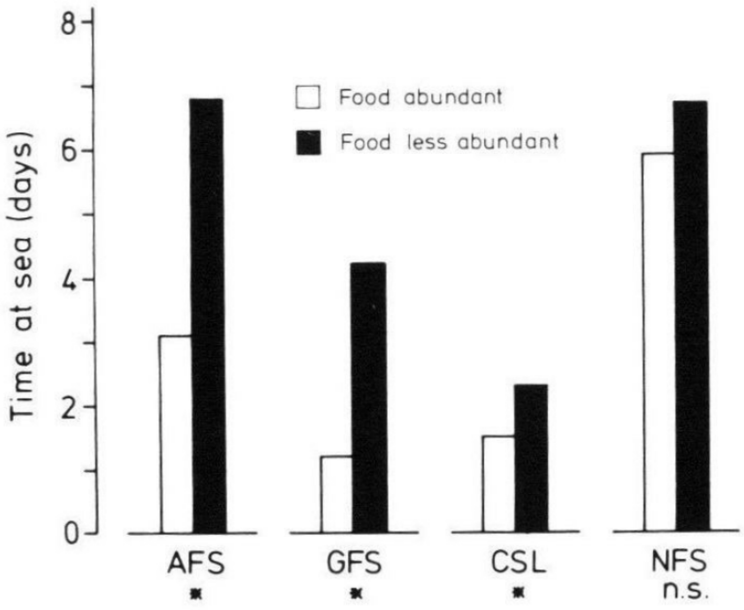
Maternal expenditure on reproduction

- Sea lions are *income breeders* - they continue to accumulate resources whilst nursing pup
- Lactation the greatest energetic cost of reproduction, much more expensive than pregnancy
- 80% increase in food consumption of Northern fur seals whilst lactating (Perez & Mooney, 1986)

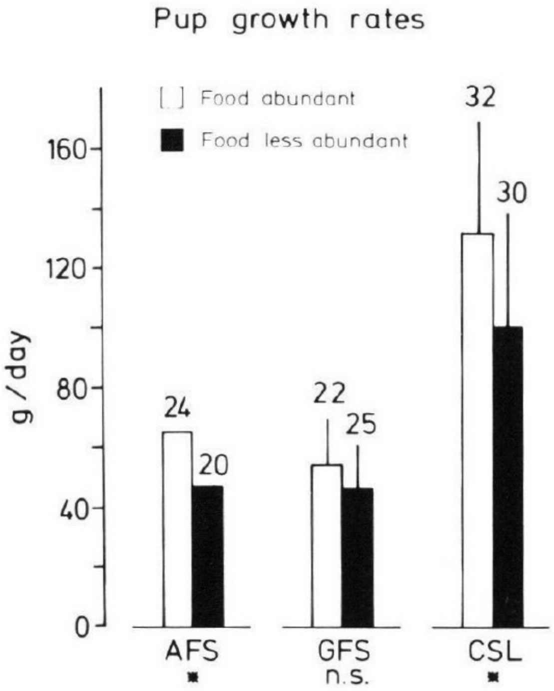


Maternal foraging & pup growth when food is scarce

Increased time foraging at sea relative to nursing pup



Reduced pup growth rates



AFS = Antarctic fur seal, GFS = Galapagos fur seal, CSL = California sea lion, NFS = Northern fur seal (Trillmich, 1990)

Plastic reproductive biology of income breeders

- Reproduction is energetically expensive & could reduce maternal survival during adverse conditions
- A number of options available to females in years with poor conditions to maximise lifetime productivity:

  1. Delay age at first breeding

E.g. Soay Island sheep (Tavecchia et al., 2005)

Probability of breeding at age 1 depends on environmental conditions & population density

Plastic reproductive biology of income breeders

- Reproduction is energetically expensive & could reduce maternal survival during adverse conditions
- A number of options available to females in years with poor conditions to maximise lifetime productivity:

1. Delayed age at first breeding
2. **Abort foetus**

E.g. Steller sea lions (Pitcher et al., 1998)

97% of Steller Sea lions pregnant after breeding, reduced to 55% by late gestation in year when body condition was poor

Plastic reproductive biology of income breeders

- Reproduction is energetically expensive & could reduce maternal survival during adverse conditions
- A number of options available to females in years with poor conditions to maximise lifetime productivity:
  1. Delayed age at first breeding
  2. Abort foetus (can affect birth sex ratio)
  3. **Vary quality and supply of milk and/or extend lactation**

E.g. Steller sea lions

Weaning typically at 11-12 months, though some at 2 or 3 years

Plastic reproductive biology of income breeders

- Reproduction is energetically expensive & could reduce maternal survival during adverse conditions
- A number of options available to females in years with poor conditions to maximise lifetime productivity:

1. Delayed age at first breeding
2. Abort foetus (can affect birth sex ratio)
3. Vary milk quality, offspring growth & extend lactation
4. **Abandon offspring**

Can be a consequence of extended foraging times or conscious abandoning

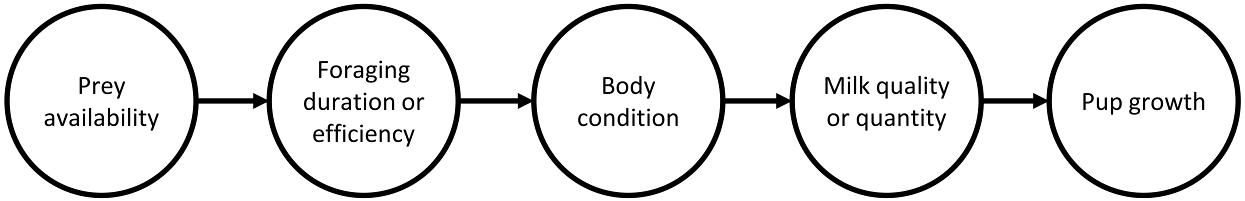
Demographic consequences of variable reproductive biology

- Variable age at first pupping
- Variable pupping rate
- Variable pup growth rate affecting pup survival
- Variable maternal survival

Develop hypothetic models relating environment, biology and demographic rates

Does correlative modelling assessment support the hypothetical model for each driver of population change?

Hypothetical model
relating environment, biology & demographic rates



Hypothetical model
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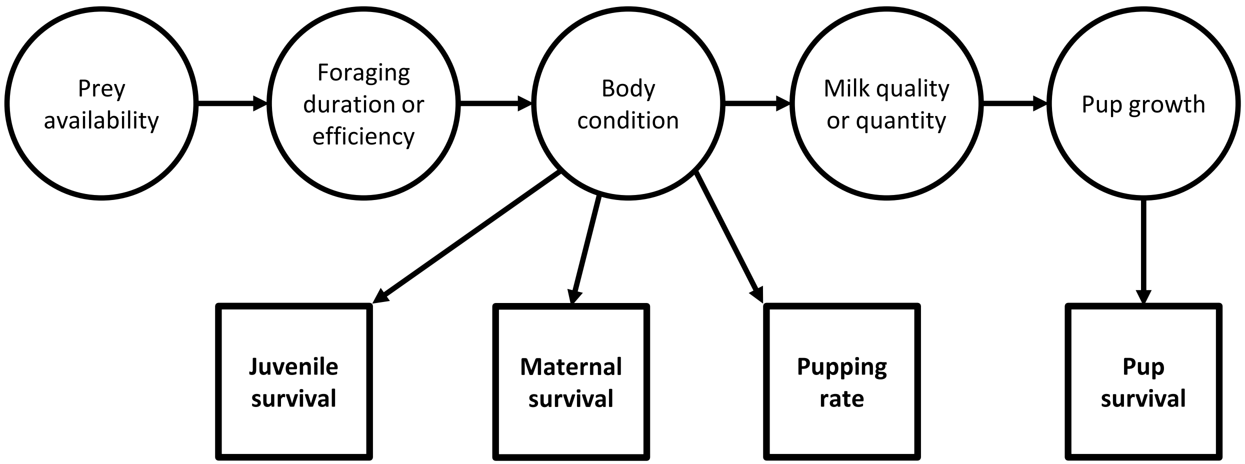
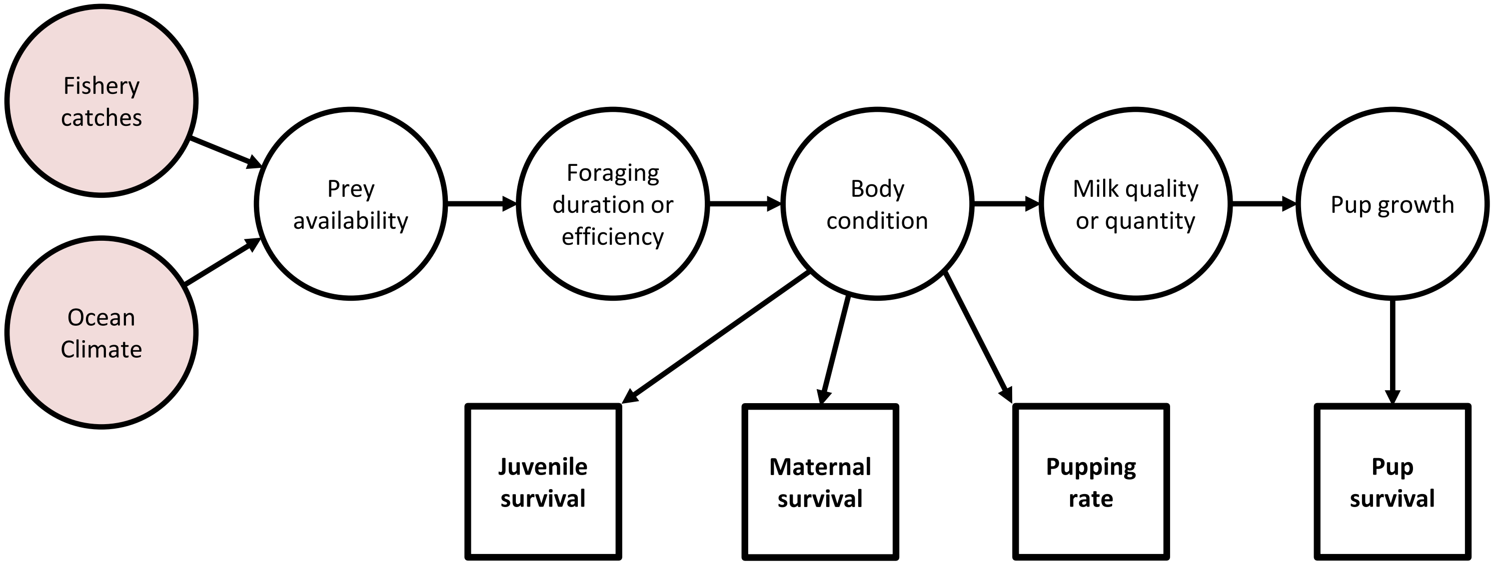


Hypothetical model relating environment, biology & demographic rates

1) Responses to variation in prey availability – very low availability



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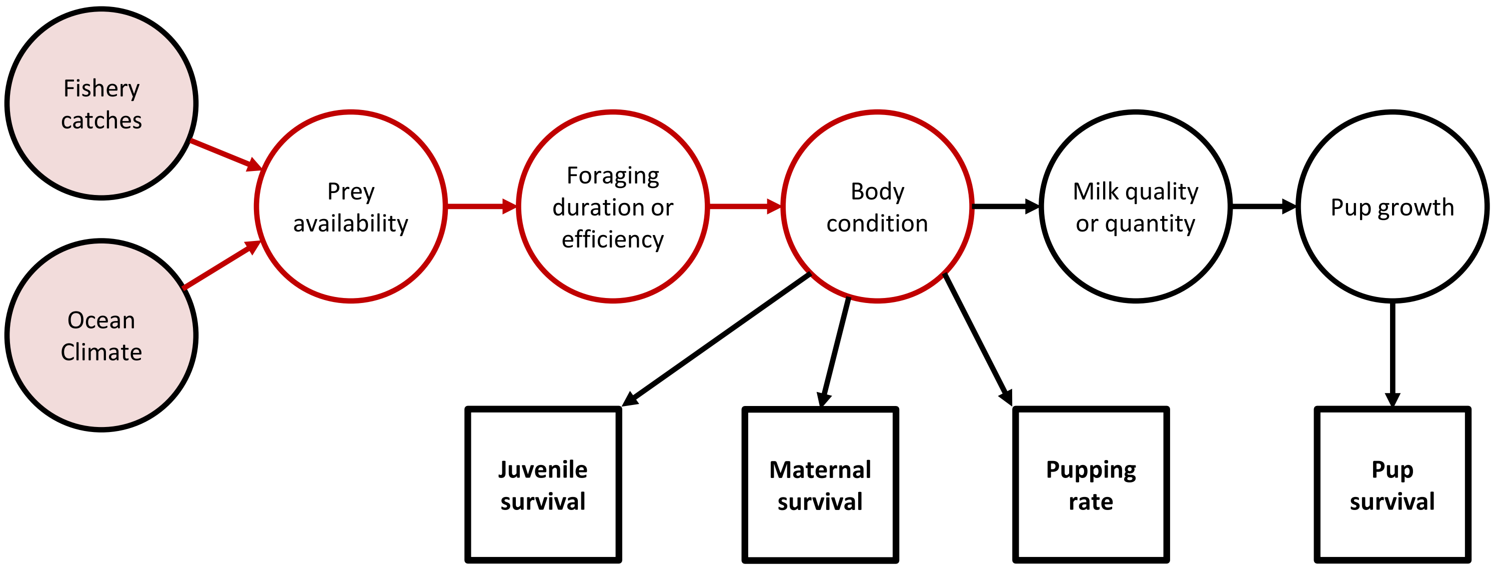
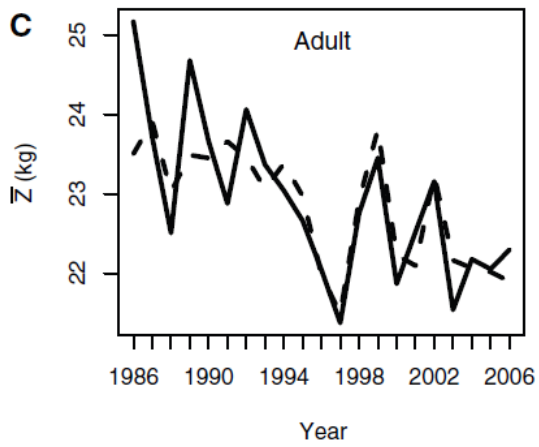


Environment & maternal condition

Soay Island sheep (Ozgul *et al*., 2009)

Decreased adult condition when population density is high



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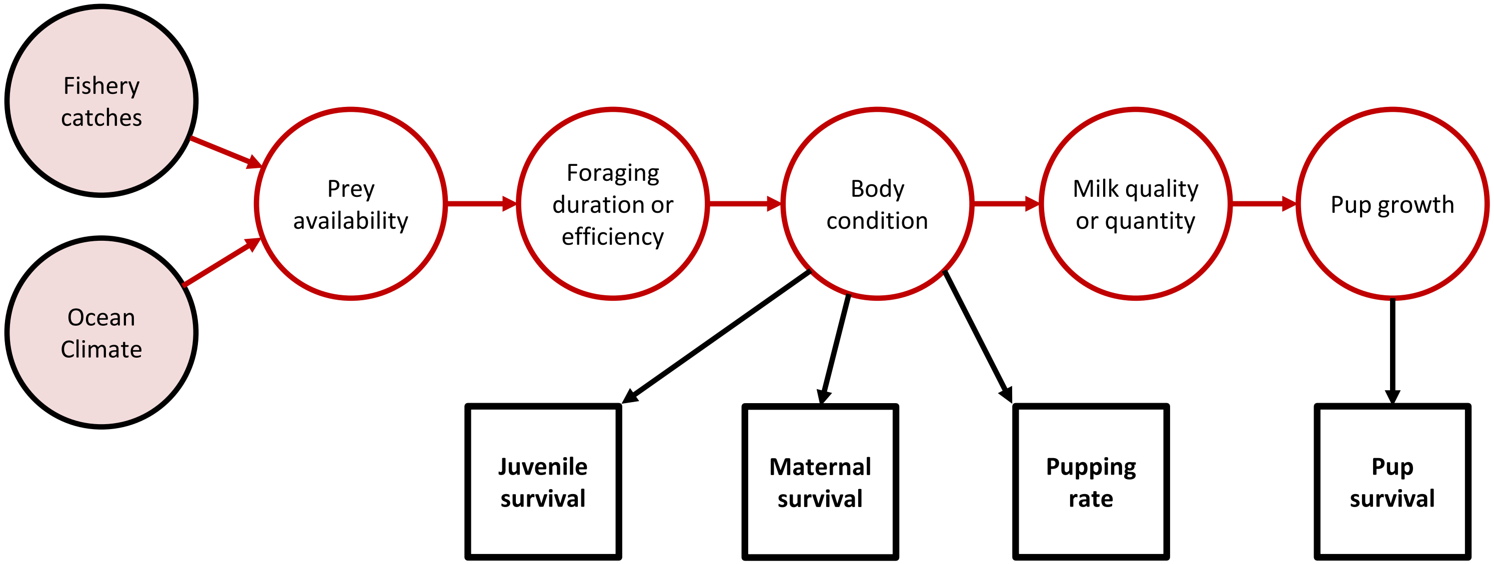
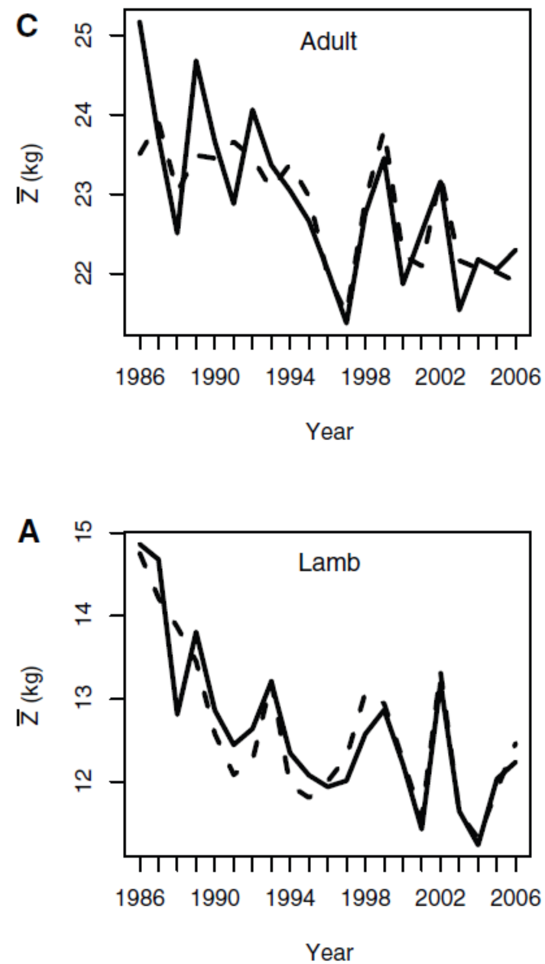


Condition of mother & offspring

Soay Island sheep (Ozgul *et al*., 2009)

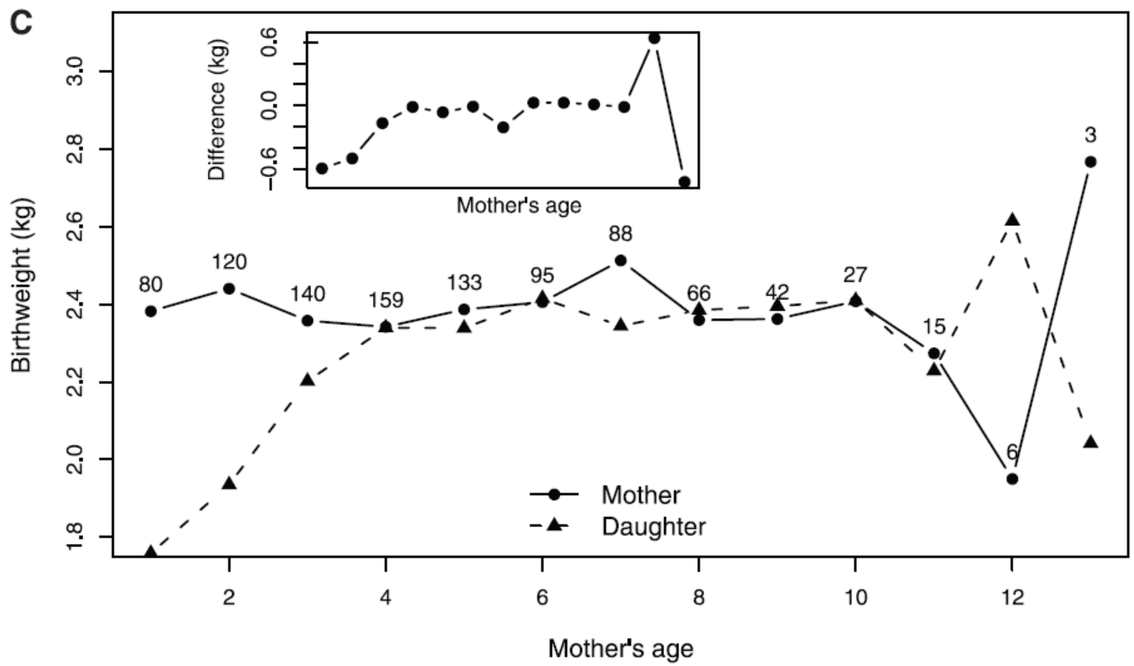
Lamb condition correlated with maternal condition



Maternal age & growth of offspring

Soay Island sheep (Ozgul *et al.*, 2009)

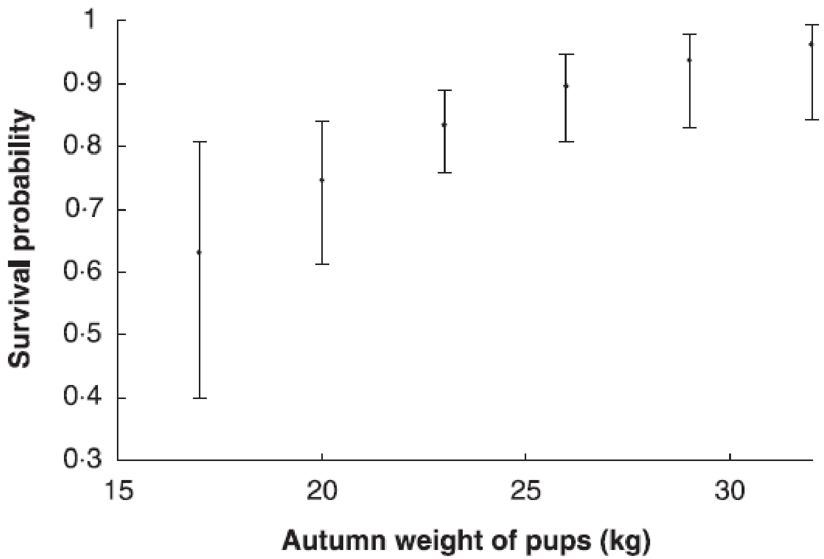
Low birth mass of lambs born to young mothers



Offspring mass & survival

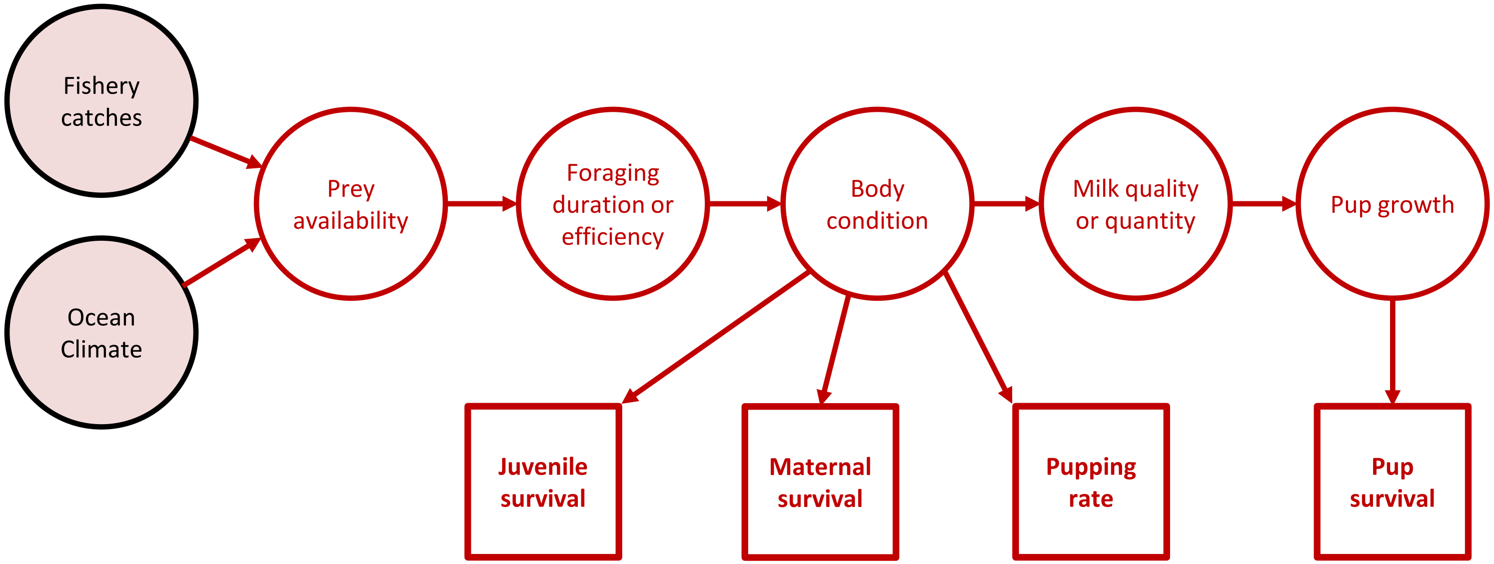
Harbour seals (Harding *et al.*, 2005)

Pup survival increases with growth rate



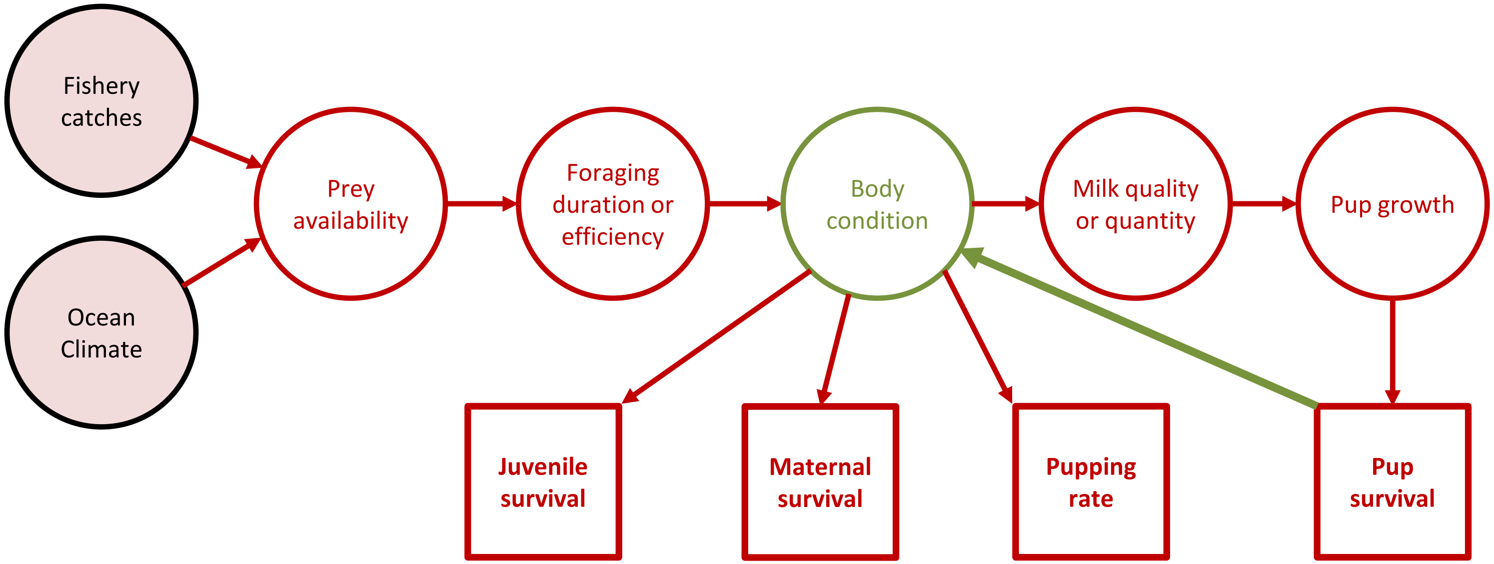
Hypothetical model
relating environment, biology & demographic rates

1) Responses to variation in prey availability – high nutrient stress



Hypothetical model
relating environment, biology & demographic rates

1) Responses to variation in prey availability – intermediate nutritional stress



- If pup lost early then mother able to recover condition (intermediate stress)
- Positively affects maternal survival, pupping rate, pup growth in next year

Offspring mass conditional on maternal reproductive history

Clutton-Brock et al. (1989). *Nature 137*. p. 260

- Red deer (Clutton-Brock 1989)
- Bigger calves when lactation cut short in the previous year
- Demographic response staggered from environmental change

Table 1 Mean calving dates and offspring birth weights of red deer hinds

	Subsequent calving date		Birth weight of next calf (kg)	
Barren	5 June	NS (Barren vs Calf dies)	6.614	* (Barren vs Calf dies)
Calf produced but dies soon after birth	3 June	*** (vs Lactating)	7.029	*** (vs Lactating)
Lactating:				
Calf reared for at least 6 months but died between 6 and 12 months	14 June	NS (between Lactating groups)	6.300	NS (between Lactating groups)
Calf survives to 1 year old	14 June		6.466	

enhancing the benefits of New Zealand's natural resources

NIWA Taihoro Nukurangi

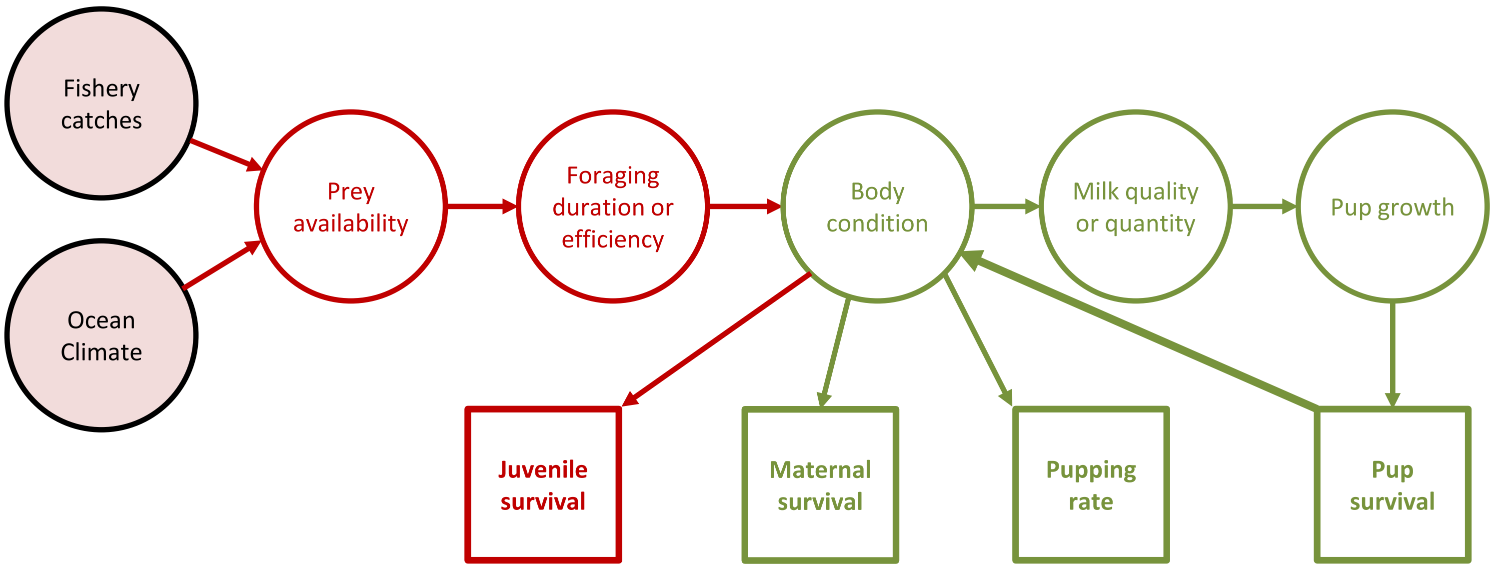
Staggered biological/demographic responses

If nursing cut short in the previous year….

1. Increased maternal condition in the present year
2. Increased maternal survival
3. Increased probability of pupping
4. Increased pup mass and pup survival

Hypothetical model
relating environment, biology & demographic rates

1) Responses to variation in prey availability – intermediate nutritional stress



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Hypothetical model
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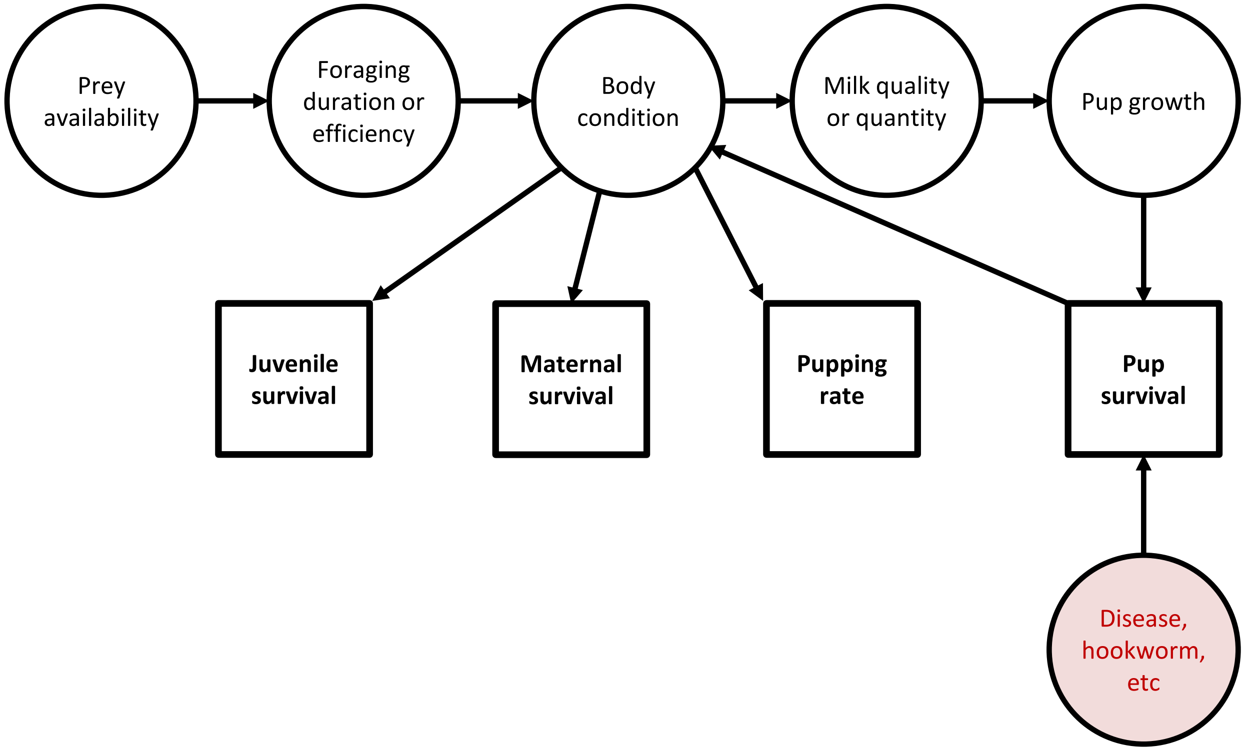
2) Responses to pup mortality (e.g. disease) not driven by resource availability



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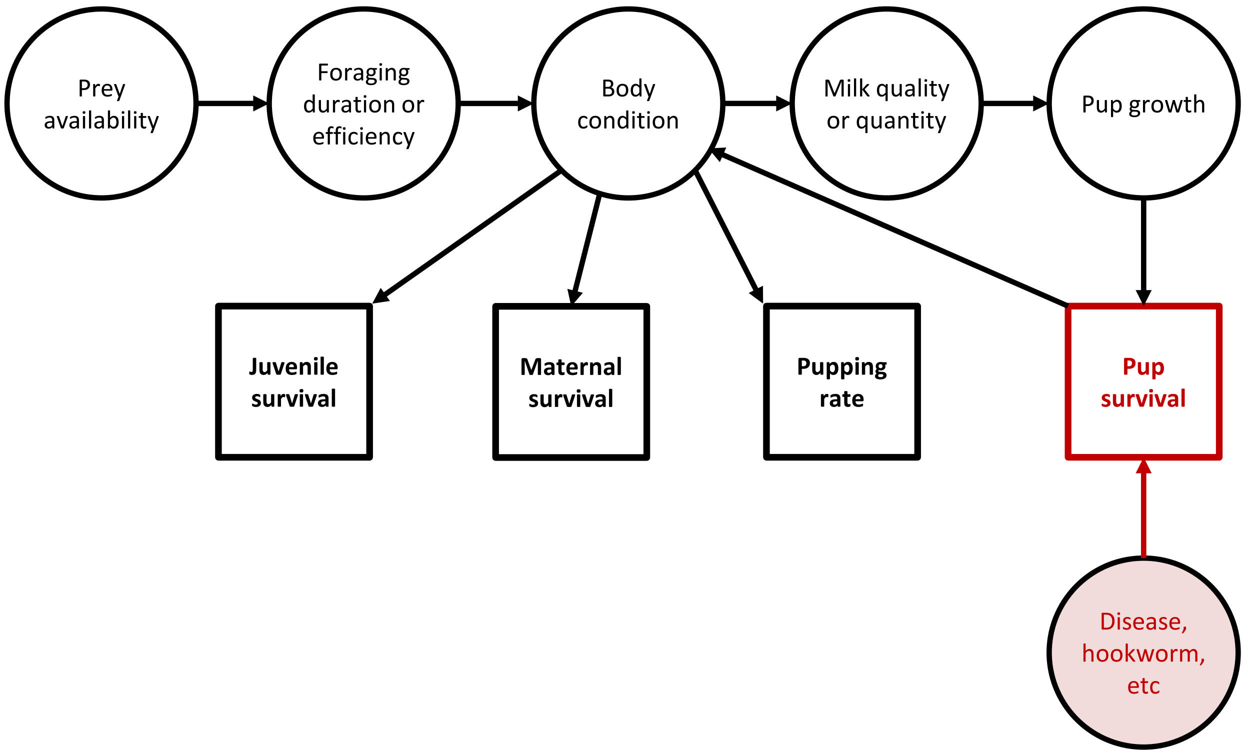

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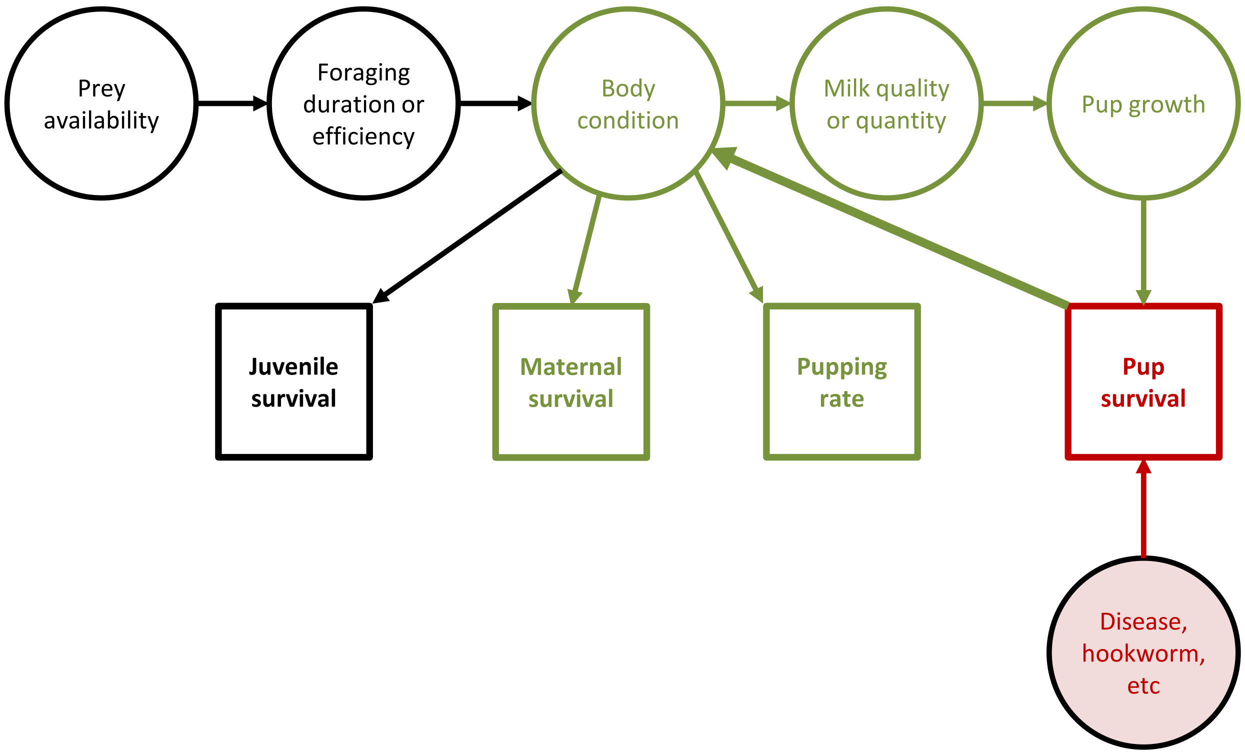
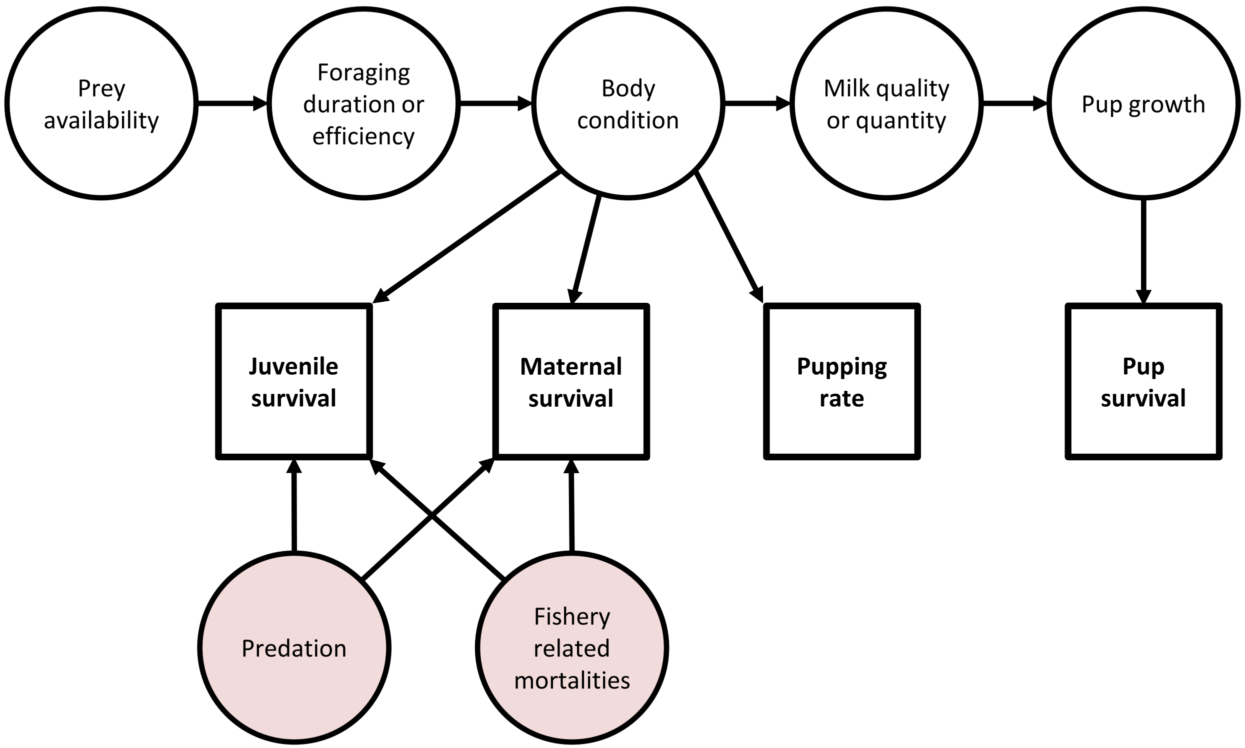


Hypothetical model relating environment, biology & demographic rates

3) Responses to fishery-related mortalities or predation



Hypothetical model relating environment, biology & demographic rates

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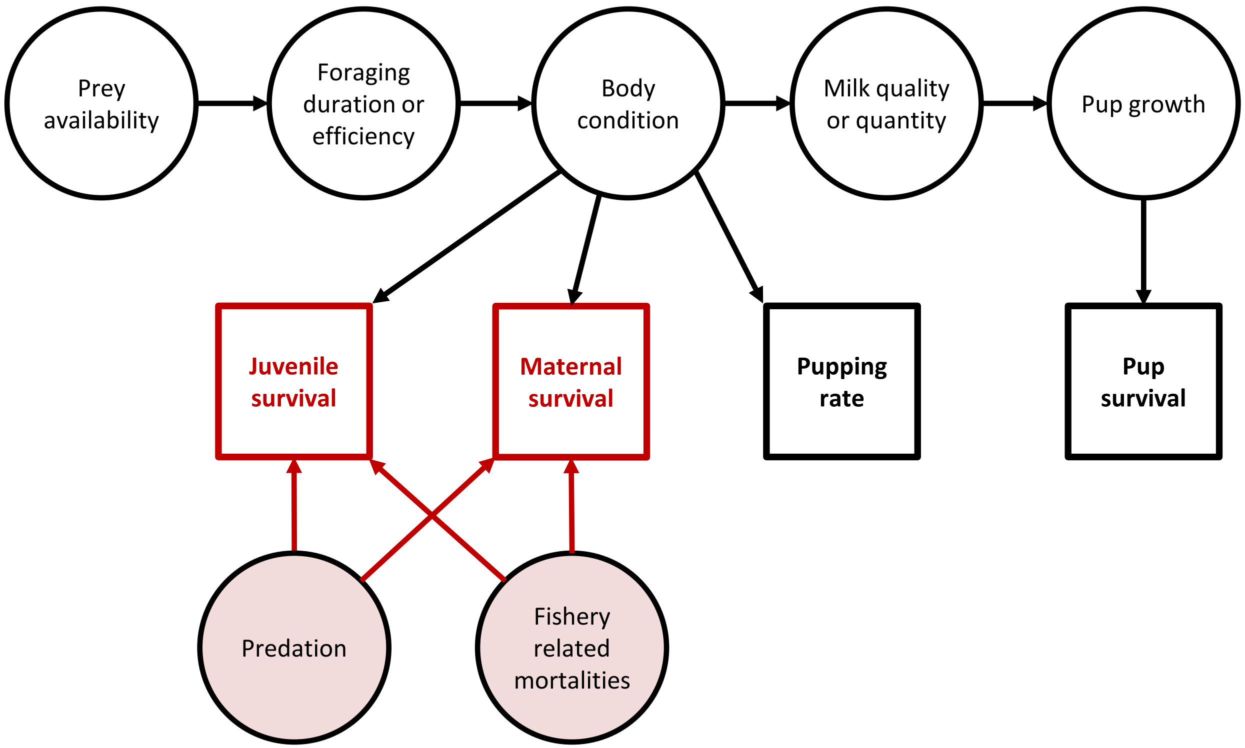

Summary of biological/demographic responses to drivers of population change

Response variable	Predation or fishery captures	Nutritional stress (climate or fishery driven)	Pup disease (but non-nutritional stress driven)
Adult condition			
Adult survival			
Pupping rate (includes age at first pupping)			
3-week pup mass (pup growth)			
Milk quality			
Pup/post-weaning survival			

Summary of biological/demographic responses to drivers of population change

Response variable	Predation or fishery captures	Nutritional stress (climate or fishery driven)	Pup disease (but non-nutritional stress driven)
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Adult condition			
Adult survival	Affects age classes vulnerable to fishery captures or predation	Will vary in response to changing resources & reproductive success in yr-1	Increased adult survival in response to reduced reproductive success in yr-1
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3-week pup mass (pup growth)	Reduced pup mass/growth of pups affected by mortality of mother	Will vary in response to changing resources & reproductive success in yr-1	No effect prior to infection
Milk quality			
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Pup/post-weaning survival	Reduced survival of pups affected by mortality of mother	Will vary in response to pup growth rate & resources available to pup on weaning (disease may be a consequence)	Reduced pup or post-weaning survival of affected cohort

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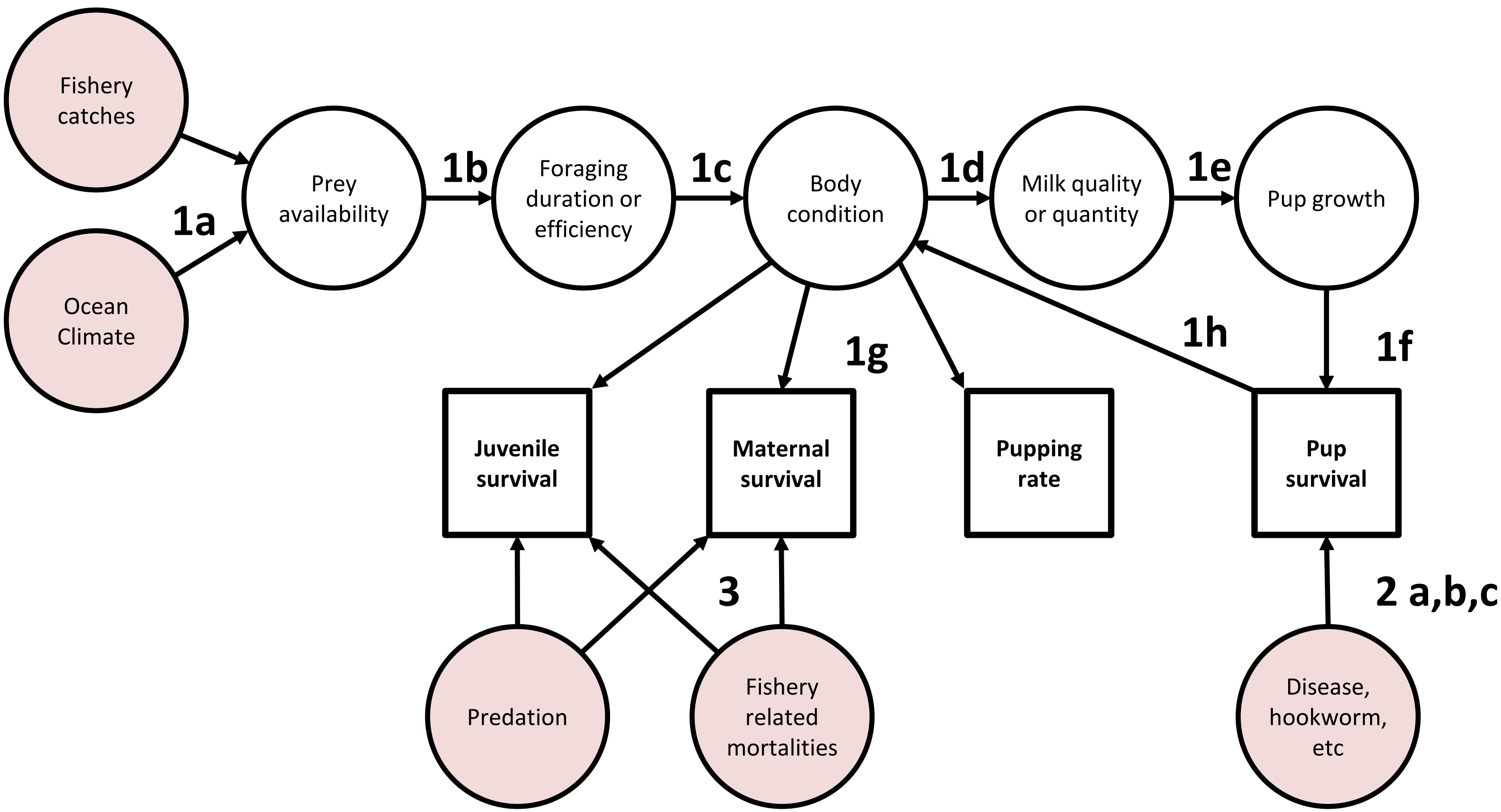
Hypothetical model
relating environment, biology & demographic rates



Hypothetical models – detailed relationships assessed

Candidate driver of population change	Identifier	Relationships assessed
Nutritional stress	1a	Climate and prey abundance/diet
	1b	Prey abundance and diet
	1c	Diet and maternal condition
	1d	Diet and milk quality
	1e	Maternal condition/milk quality/breeder age and pup mass
	1f	Pup mass and pup/yearling survival
	1g	Maternal condition and maternal survival/pupping rate
	1h	Pup/yearling survival and demographic response in yr+1
Disease-related pup mortality	2a	Pup mortality at 3 or 7 weeks and pup/yearling survival
	2b	Pup mortality by diagnosis and pup/yearling survival
	2c	Bacterial disease-related mortality and pup/yearling survival
Direct fishery-related mortality	3	Estimated fishery interactions/captures and juvenile/adult survival

Purpose of correlative assessment

- Does the correlative assessment support the hypothetical model for each candidate driver of population change?
- Is there evidence for fisheries impacting directly or indirectly on sea lion populations at the Auckland Islands?
- Can we identify demographic mechanisms that may increase susceptibility to fishing effects?

End of presentation 1

1. **Introduction & hypothetical models relating datasets**
2. Presentation of datasets
3. Correlative assessment

Plastic reproductive biology of income breeders

- Reproduction is energetically expensive & could reduce maternal survival during adverse conditions
- A number of options available to females in years with poor conditions to maximise lifetime productivity:
  1. Delayed age at first breeding
  2. **Abort foetus (can affect birth sex ratio)**

E.g.2 Red deer (Kruuk et al., 1999)

Greater proportion of males born to dominant females when population density was low

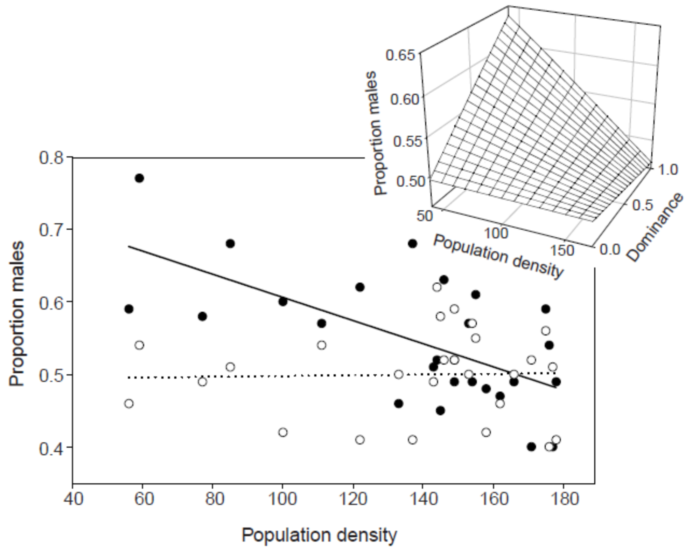


Figure 2 Proportion of males born to dominant versus subordinate females in each year. Dominant females (filled circles and full line) are those with above-median dominance scores; subordinates (open circles and dotted line) are those