DOC 4428: NEW ZEALAND SEA LIONS – DEMOGRAPHIC ASSESSMENT OF THE CAUSE OF DECLINE AT THE AUCKLAND ISLANDS

Data exploration & methodology

Jim Roberts

7 March 2013

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Project objectives & basic approach

Project Objectives:

•To identify which demographic parameters are the key drivers of the observed population decline of NZ sea lions at the Auckland Islands.

•To identify potential demographic mechanisms through which both direct and indirect effects of fishing can impact on sea lion population size at the Auckland Islands, or increase susceptibility of the population to such effects.

1.Do we see temporal variation in survival and breeding at the main rookeries?

2.Relationships to time-varying trends in:

•Fishery-related mortalities

•Pup weights, milk composition

•Prey abundance, trophic ecology & climate (isotopes)

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The Team (overseas collaborators)

Professor Andrew Trites

Director of Marine Mammal Research Unit, Fisheries Centre, Aquatic Ecosystems Research Laboratory (AERL)
University of British Columbia

Areas of special interest:
the interaction between commercial fisheries and marine mammals, including Steller sea lions, northern fur seals and harbour seals; quantitative modelling studies ranging from pinniped population modelling to whole of ecosystem models

Professor Mark Hindell

Program Leader, IMOS Marine and Antarctic Ecosystems
Antarctic Wildlife Research Unit,
School of Zoology,
University of Tasmania

Primary research interests:
foraging ecology, biology, population modelling and management of pinnipeds and other marine apex predators, particularly with respect to Antarctic and sub-antarctic ecosystems

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The Team (New Zealand)

Louise Chilvers (Collaborator, not part of the formal contract)
Marine Mammal Scientist, Marine Species
Collaboration with Department of Conservation

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Ian Doonan

Group manager, Fisheries Modelling

Project leader

Chris Francis

Principle scientist, Fisheries Modelling

Technical advisor on SeaBird

Jim Roberts

Postdoc, Fisheries Modelling

Dan Fu

Scientist, Fisheries Modelling

Coded seabird

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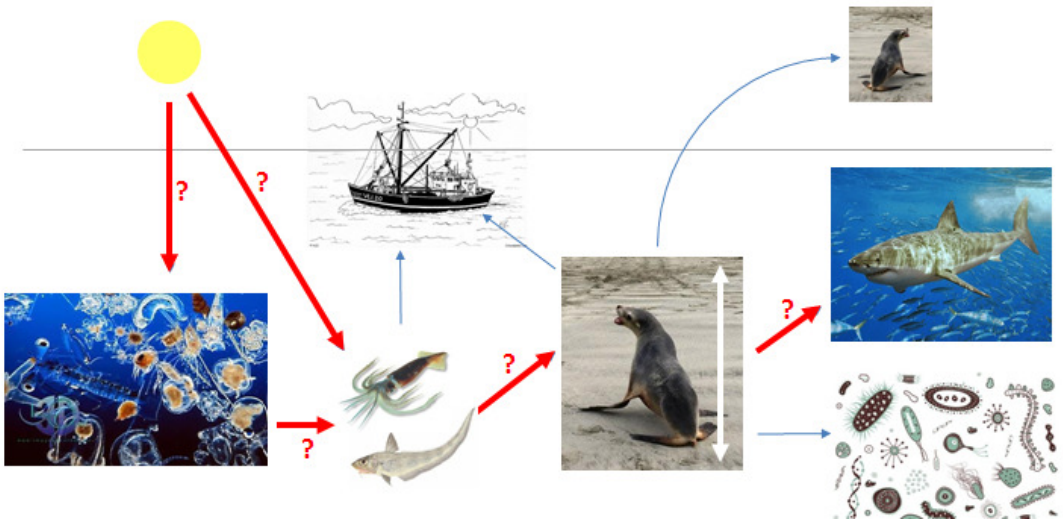
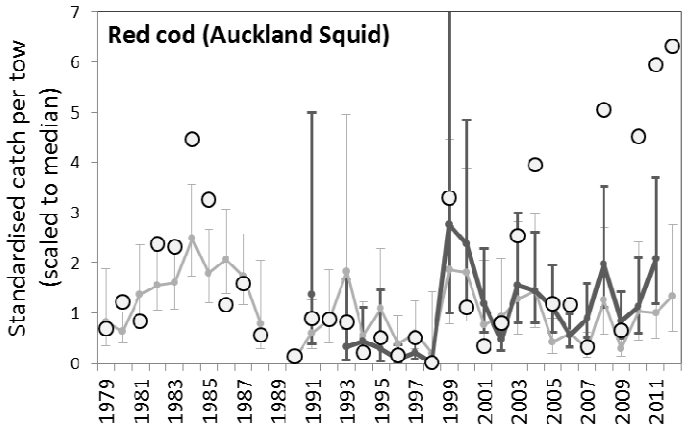
Multispecies modelling postdoc

- Two-year postdoc project
- Funded to 80%; rest from contract work
- Develop conceptual and simulation multi-species modelling to evaluate the direct and indirect effects of fishing on New Zealand sea lions
- Get others to state how they think the causes are, then model these to see how strong the effects must be to see chan





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The Timetable

February 2013: Presentation of data summary and methodology to the CSP Technical Working Group

June 2013: workshop on modelling and analysis with all collaborators
June 2013: Presentation of modelling options to the CSP Technical Working Group

July 2013: Presentation of the final model(s) to the CSP Technical Working Group.

August-December 2013: Another workshop?

December 2013: Presentation of results to the CSP Technical Working Group

April 2014: Final draft manuscript

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Observations – all female only

Initial demographic model

•Tagged as pups from 1998-2012

•Resightings from 1999-2013

•Sandy Bay and Dundas

Extensions of demographic model

•Earlier tagging and resighting series

•Branded animals

•Chipped animals

Population models

•Age distribution lactating females 1998 to 2001 (Childerhouse *et al.* 2010)

•Pup production estimates – all with high level of confidence

Other dataset – causes of demographic variation

•Fishery-related mortalities (Dragonfly capture database**)**

•Pup weights (Chilvers 2012) & milk quality (Riet Sapriza *et al.* 2012)

•Prey abundance (Roberts unpub dat), isotopes and climatic

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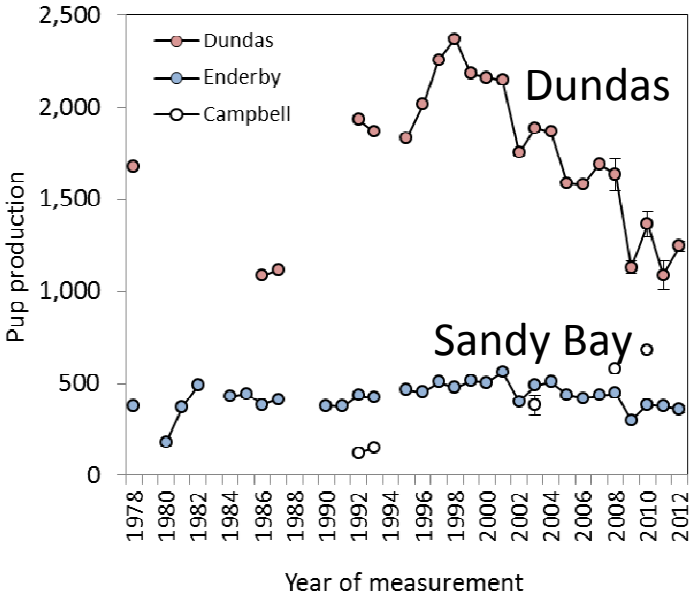
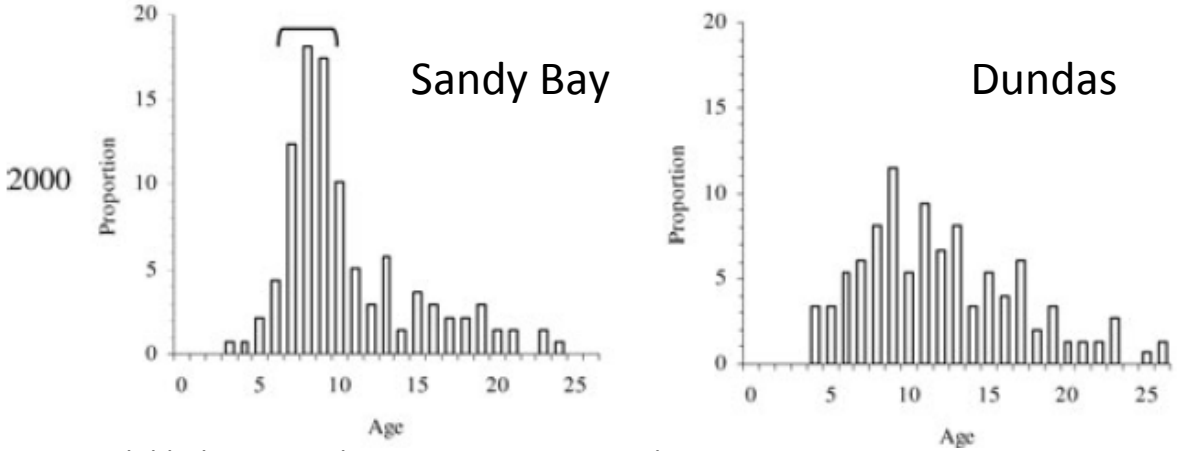
Area differences in population dynamics



Previously estimated survival and breeding rates at Enderby

Dundas the largest breeding rookery

Species assumed to be highly philopatric – evidence for rookery differences in population dynamics



Childerhouse *et al.* 2010 *Marine Mammal Science 26:* 123-139.

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Methodological approach

Previous demographic modelling projects:

•Paul Breen & others: age-structured, but one sex model; started in 2000 and has evolved since then. Used tag-resighting data, pup production estimates, age distributions, and fisheries data. Used to evaluate bycatch control rules in the squid fishery.

•Darryl MacKenzie (2009 – 2011) used a multi-state mark-recapture model to estimate demographic parameters from tag-resighting data.

In this project:

•Estimate time-varying survival and breeding rates of females at Sandy Bay & Dundas; also relocation rates between rookeries

•Multistate demographic model (SeaBIRD) using mark resighting data

•Extended to population model, integrating with age distribution & pup production observations

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Methodological approach

1. **Construct demographic model -** use mark-recapture observations to estimate survival, breeding probabilities and relocation rates
    - Resighting obs of individuals tagged as pups
    - Then of branded animals & those tagged as adults
2. **Develop into a population model** – apply survival rates to pup production estimates and fit to age distribution observations of breeding females
3. Partition mortality to fishery related mortalities and other
4. Relate demographic trends to biological and environmental correlates

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SeaBird modelling software

- SeaBird software already used to conduct demographic assessments of:
  1. Southern Buller's Albatross
  2. Black Petrel
  3. Whitecap albatross
  4. Gibson's Albatross
- SeaBird allows the analysis of individual (*i.e.*, non-aggregated) mark-resighting observations, as we have for New Zealand sea lions.
- Allows integrated analysis to estimate demographic rates from all relevant datasets, i.e. age distributions, pup production estimates *as well as* mark-resighting data.
- User-defined model partitioning (*e.g.* age, area or breeding status), transitions and equations representing demographic processes.

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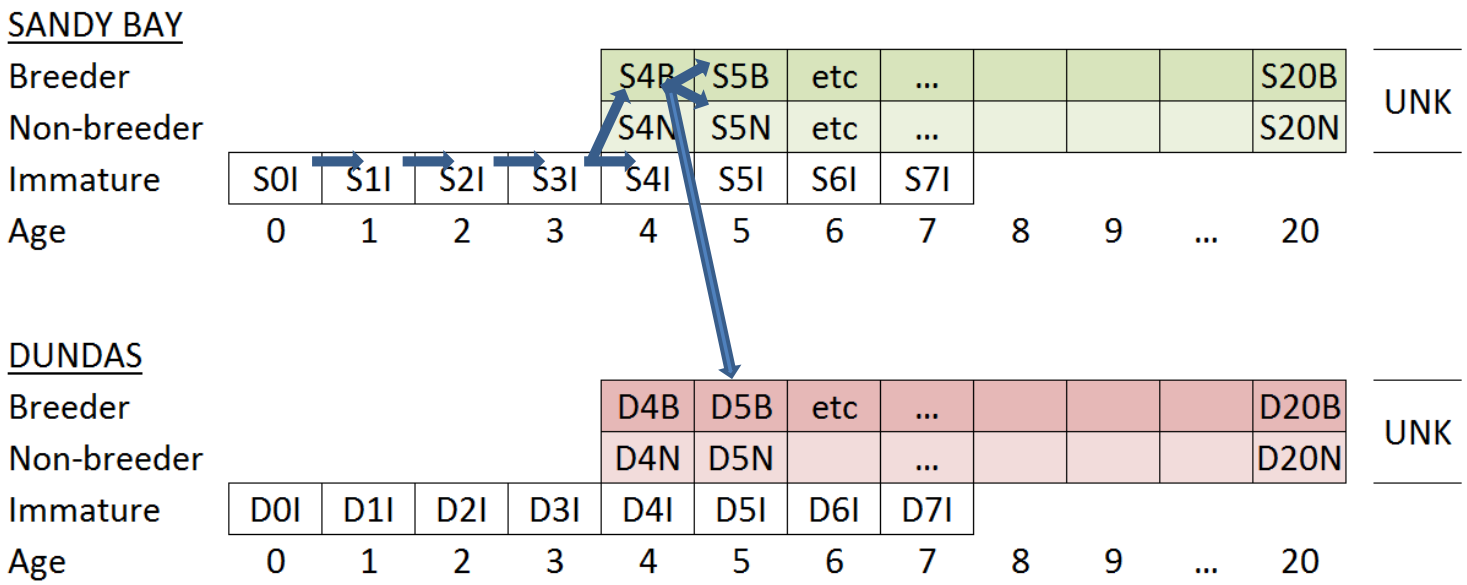
Model partitions & transitions

Three types of partition:

1. Area (**S**andy Bay or **D**undas)
2. Age (**0** to **20**)
3. Breeding status (**I**mmature, **N**on-Breeder, **B**reeder, **U**nknown)

Limited possibilities for transitions from one cell to the next…



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Parameter estimation

Parameters:

1.Survival of pups, juveniles, and adults (time varying and depending on age)
2.Ogive for age at first breeding (unlikely to be possible for Dundas)
3.Breeding rate by age & year and breeding status (not possible for Dundas)
4.Migration rate from Dundas to Sandy Bay
5.Resighting probability (Sandy Bay & Dundas (Dundas; indexed by days resighting effort)

- depends breeding status, age, tag type
- zero inflated
- partly done outside of model?

Tag loss estimated outside of model and depends on tag type.
Parameters 2 to 5 affect transitions between partition states

Estimation

Likelihood based on extension of Cormack_Jolly_Seber model (Cormack 1964; Jolly 1965; Seber 1965)

Individual animal resighting data, but only one observation each year

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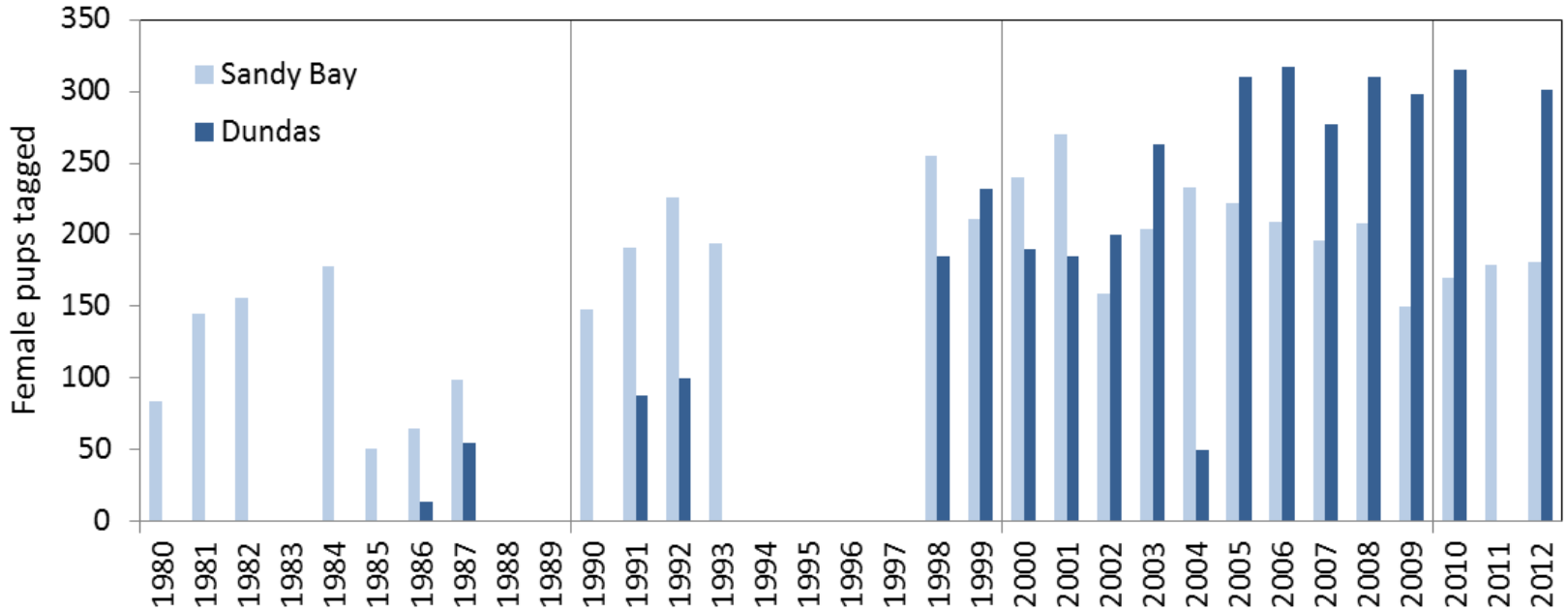
Individuals tagged as pups



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Variation in pup tagging method through time

Year	Type	Colour	Single/Double
1980	Round	Yellow	Single
1981	-	-	-
1982	Round	Yellow	Single
1983	-	-	-
1984	Round	Yellow	Single
1985	Round	Yellow	Single
1986	Round	Yellow	Single
1987	Round	Yellow	Single
1988	-	-	-
1989	-	-	-
1990	Round	Yellow	Single
1991	Round	Yellow	Single
1992	Round	Yellow	Single
1993	Round	Yellow	Single/Double
1994	-	-	-
1995	-	-	-
1996	-	-	-
1997	-	-	-
1998	Round	Blue/Green	Double
1999	Round	Orange	Double
2000	Coffin	White	Double
2001	Coffin	Pink	Double
2002	Coffin	Red	Double
2003	Coffin	Blue	Double
2004	Coffin	Yellow	Double
2005	Coffin	Green/Yellow	Double
2006	Coffin	Orange	Double
2007	Coffin	Purple	Double
2008	Coffin	White	Double
2009	Coffin	Pink	Double
2010	Coffin	Blue	Double
2011	Coffin	Yellow	Double
2012	Coffin	Green	Double
2013	Coffin	Orange	Double

Changes in tagging method impact on readability & breaking/shedding rates:

- Single round tags in early years
- Double coffin tags in later years
- Different colour each year from 1998

- Brandings, chips and adult tagging in some years

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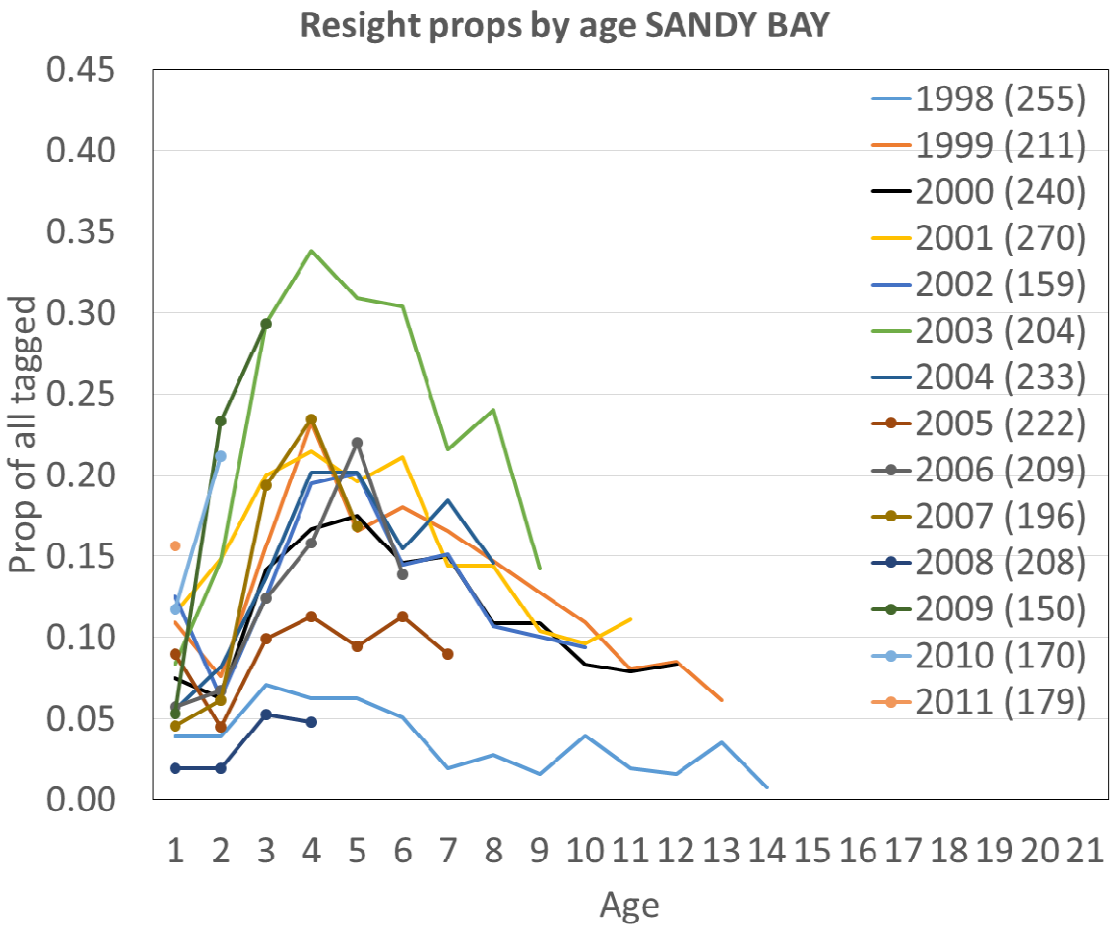
Resighting at age – resights tagged as pups



Some apparent strong juvenile survival

e.g., 2003 , 2010

Some apparent weak juvenile survivals

e.g. 1998, 2005

Partly due differential tag loss or unreadability of tags

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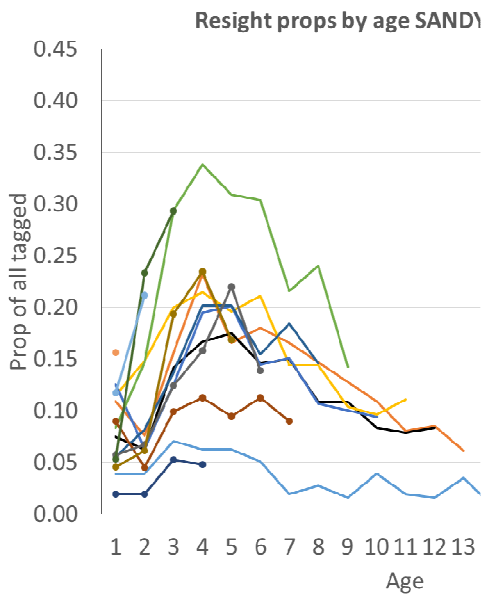
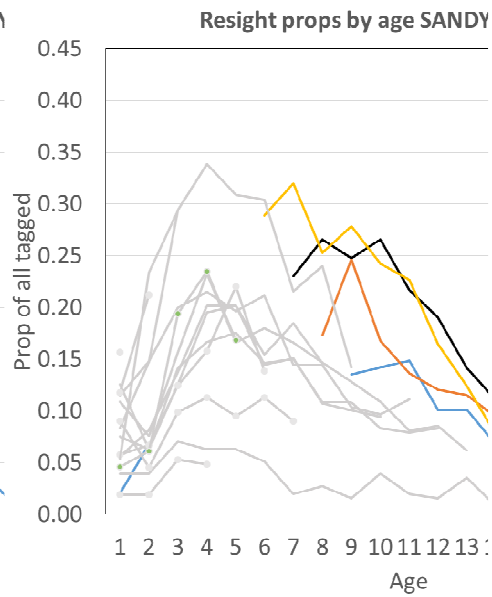
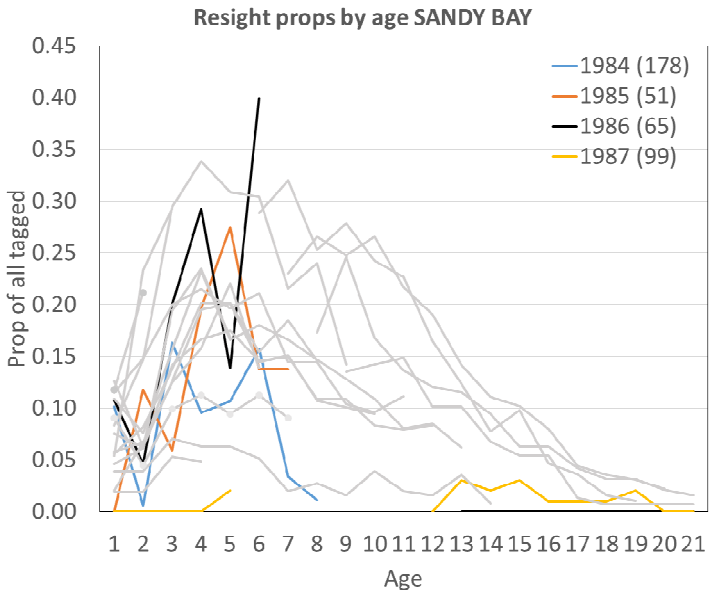
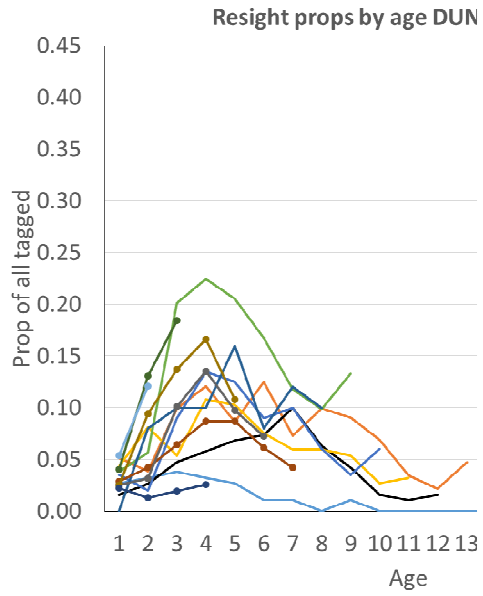
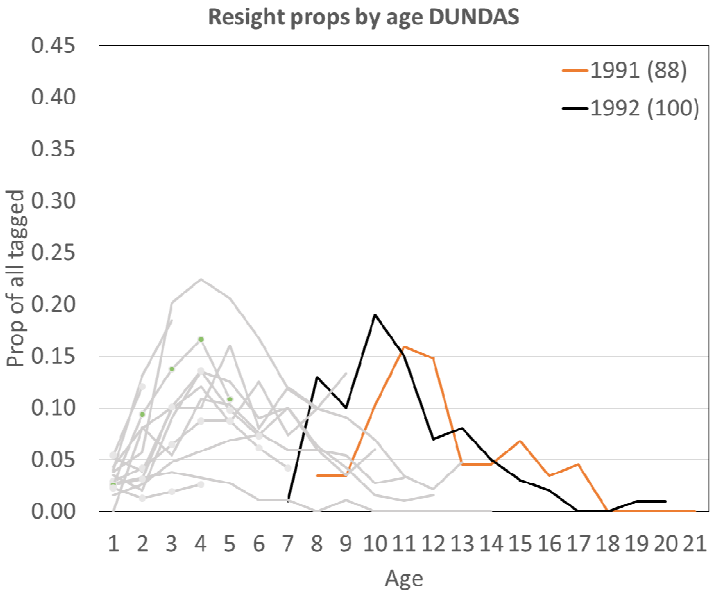
Resighting rates of tagged as pups











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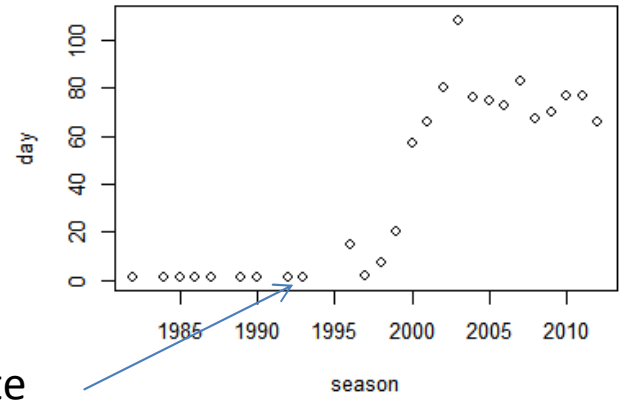
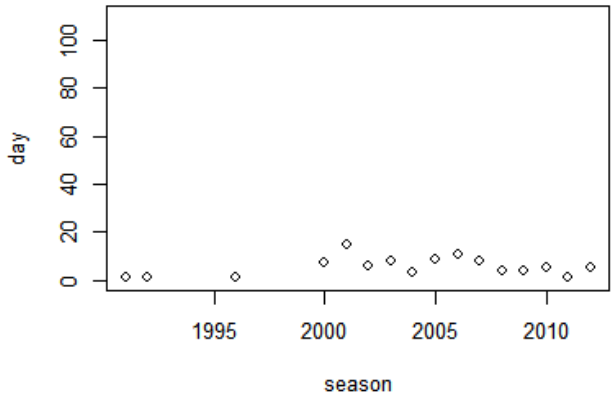
Pup tag resighting effort

Days used for resighting

Sandy Bay

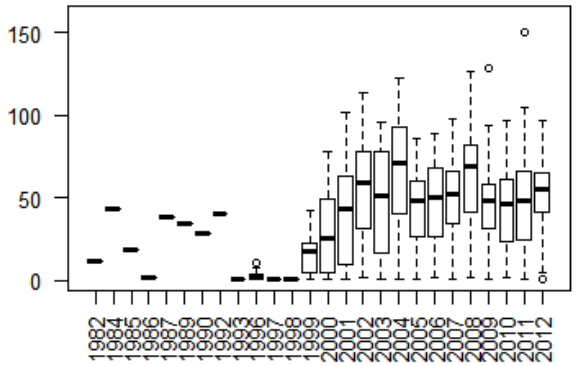


Dundas

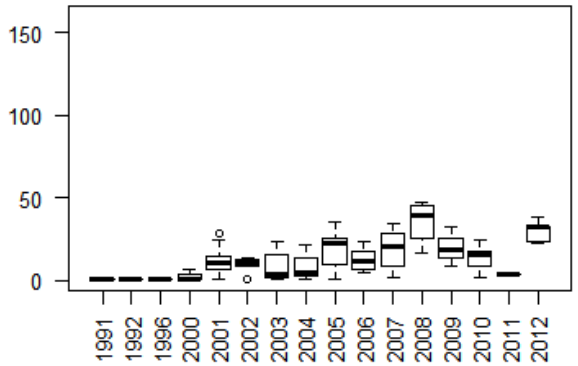


no date recorded

SLs resighted per day - SANDY BAY



SLs resighted per day - DUNDAS



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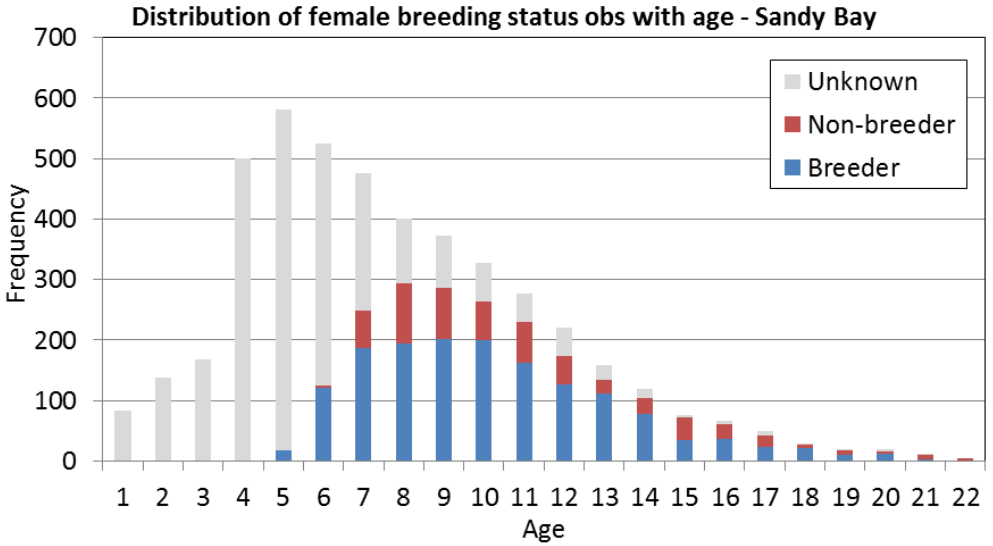
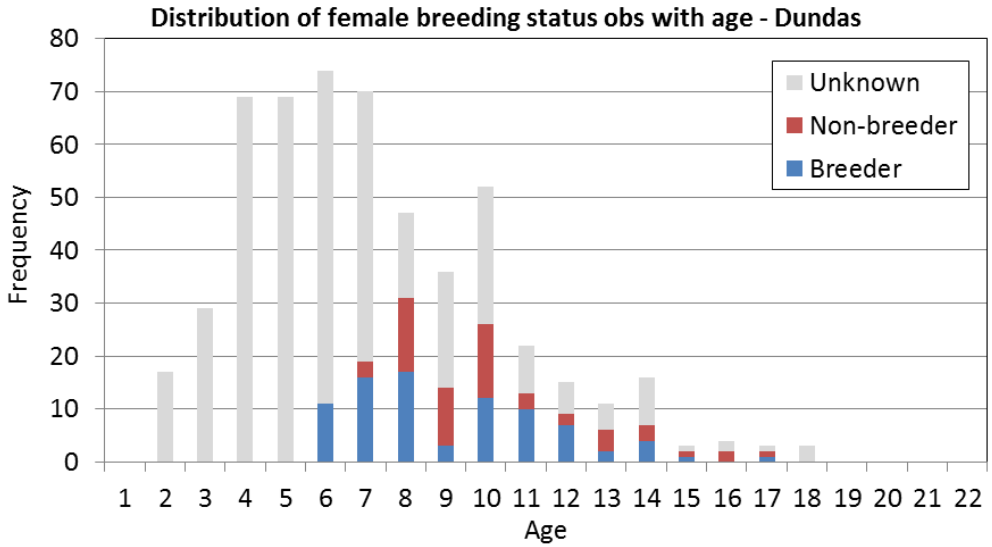
Breeding status





- Confirmed breeding status where 3 or more sightings with pup or without a pup in a season
- Few observations with confirmed breeding status at Dundas
- Including less strict definitions: “probably pupped” and “Female < 3 sightings, no pup” has greatest effect on proportion confirmed breeding at Dundas
- Relates to limited resighting effort at Dundas (days and animals scanned)

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Relocations

- Species likely to be strongly philopatric though some breeding relocations do occur (Chilvers ref)
- Few relocations post first breeding – transition rule
- Cut-off date for location observations

			Age																				
sealion	season_tag	season_last	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
19920131-4018	1992	2012	0DU	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19920131-4019	1992	2012	0DU	0	0	0	0	0	0	0	8DU	9DB	0	11DB	0	0	0	0	0	0	0	0	0	0
19920131-4020	1992	2012	0DU	0	0	0	0	0	0	0	0	0	10SN	11SN	12SN	0	0	15SN	0	0	0	0	0	0
19920131-4021	1992	2012	0DU	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19920131-4022	1992	2012	0DU	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19920131-4028	1992	2012	0DU	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19920131-4030	1992	2012	0DU	0	0	0	0	0	0	0	0	0	0	11SN	0	13DB	0	0	0	0	0	0	0	0
19920131-4031	1992	2012	0DU	0	0	0	0	0	0	0	0	0	10SB	0	0	13DN	14DN	0	0	0	0	0	0	0
19920131-4034	1992	2012	0DU	0	0	0	0	0	0	0	0	0	10SN	0	0	0	0	0	0	0	0	0	0	0
19920131-4036	1992	2012	0DU	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19920131-4039	1992	2012	0DU	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19920131-4041	1992	2012	0DU	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19920131-4042	1992	2012	0DU	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19920131-4044	1992	2012	0DU	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19920131-4046	1992	2012	0DU	0	0	0	0	0	0	0	0	0	0	0	12SN	0	0	0	0	0	0	0	0	0
19920131-4048	1992	2012	0DU	0	0	0	0	0	0	0	8DU	0	0	11DB	0	13DU	0	0	0	0	0	0	0	0
19920131-4050	1992	2012	0DU	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19920131-4052	1992	2012	0DU	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19920131-4053	1992	2012	0DU	0	0	0	0	0	0	0	0	0	10SB	0	0	13DB	0	0	0	0	0	0	0	0
19920131-4054	1992	2012	0DU	0	0	0	0	0	0	0	0	0	10SN	0	0	0	0	0	0	0	0	0	0	0
19920131-4055	1992	2012	0DU	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

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Age distribution observations – lactating females

- Age distribution of lactating females from post-canine teeth at Sandy Bay and Dundas (Childerhouse et al 2010)

	Sample size	
Sample year	Sandy Bay	Dundas
1990	15	28
1991	146	140
1992	138	149
1993	143	149

- Age distribution of breeding females will be a function of relative pup production, survival rates and breeding probability and resighting probability
- Can provide additional information on survival & breeding rates

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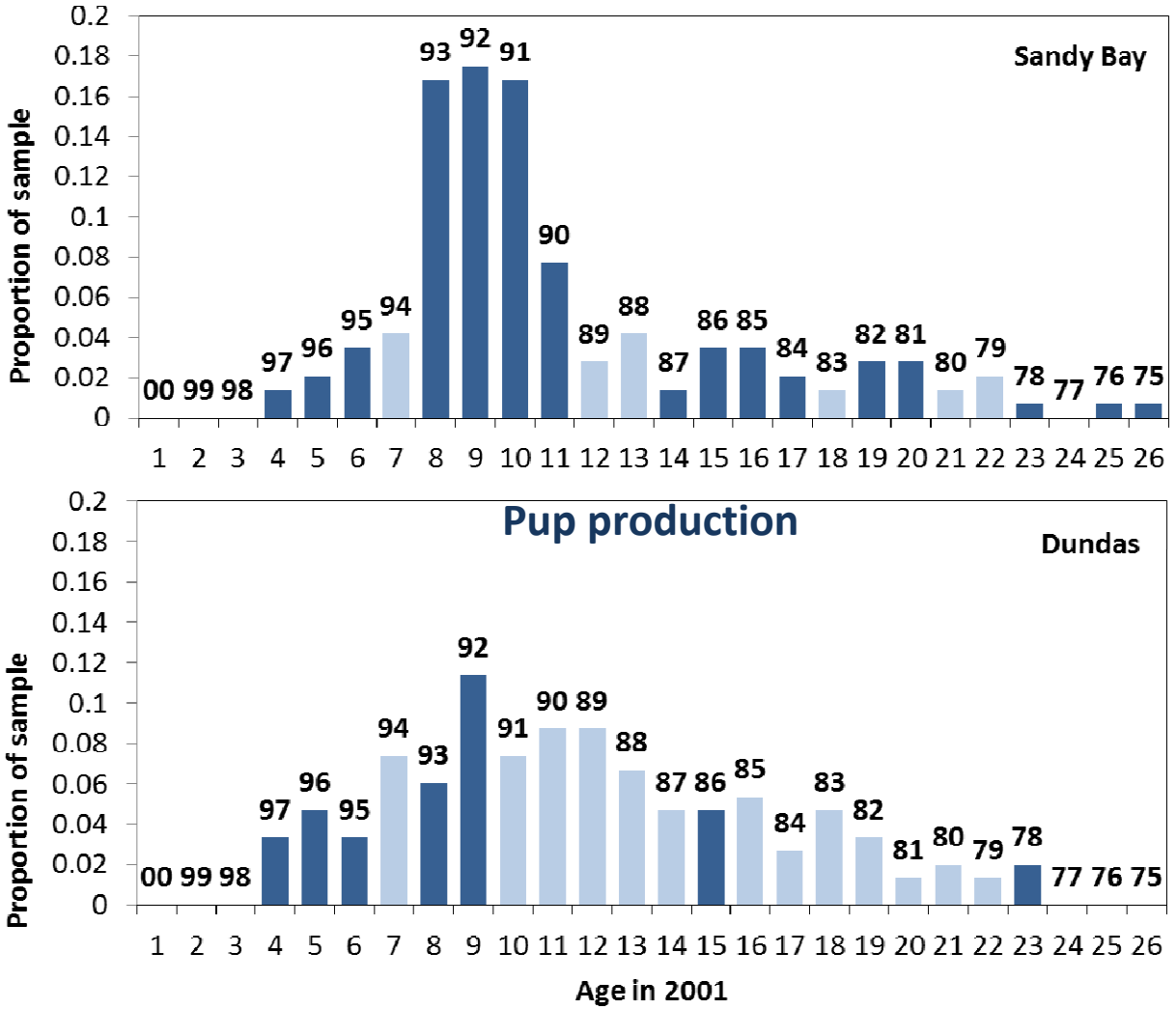
Age distribution observations – lactating females



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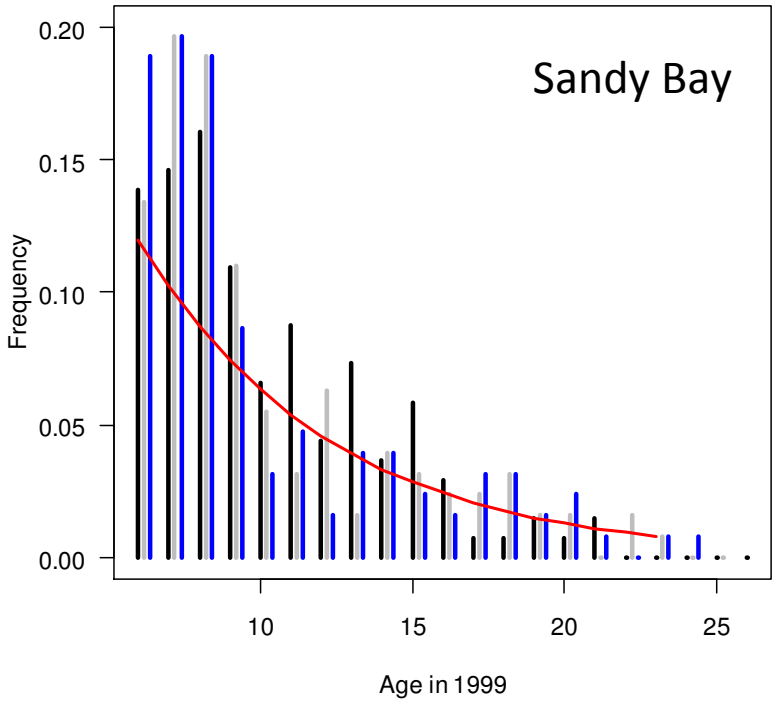
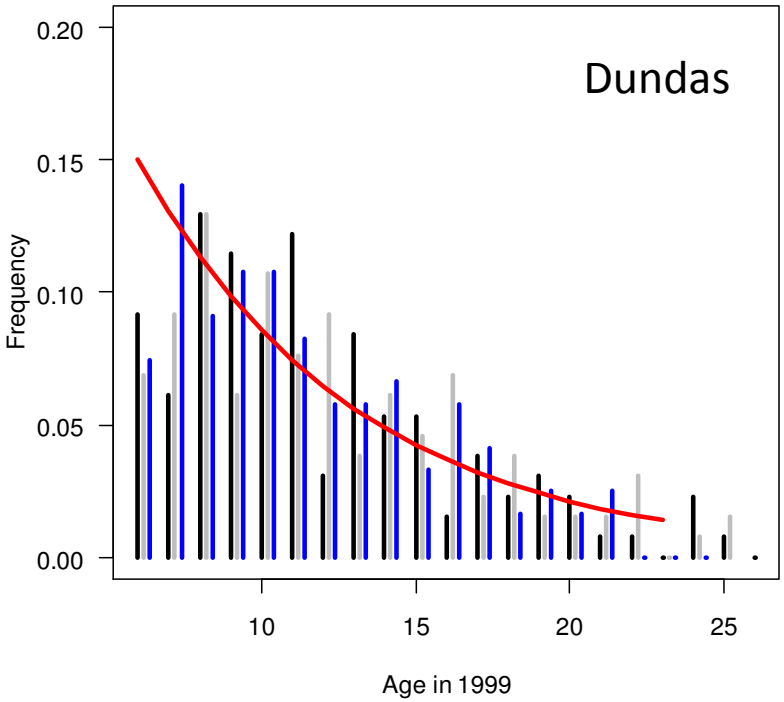
Age distribution observations – strong cohorts





- Age distribution from 1999 (black), 2000 (grey), and 2001 (blue) by cohort
- Frequency renormalized from age 6 in 1999, 7 in 2000, and 8 in 2001
- Red curve represents constant pup production and survival rates fitted by eye

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The next steps; Causes of demographic variation

Phase 1

1.Simple demographic model - estimate survival, breeding and relocation rates using mark-resightings data only

2.Develop integrated population model, including age distribution and pup production

3.Develop candidate modelling options for consideration by CSP

Phase 2

1.Do we see temporal variation in survival and breeding at the main rookeries?

2.Relationships to time-varying trends in:

•Fishery-related mortalities

•Pup weights, milk composition

•Prey abundance, trophic ecology & climate (isotopes)

Workshop with pinniped ecologist/modelling experts

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