



# Census & individual size of NZ fur seal/kekeno pups on the West Coast South Island from 1991 to 2016

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Presentation to DOC, 16<sup>th</sup> Nov 2016

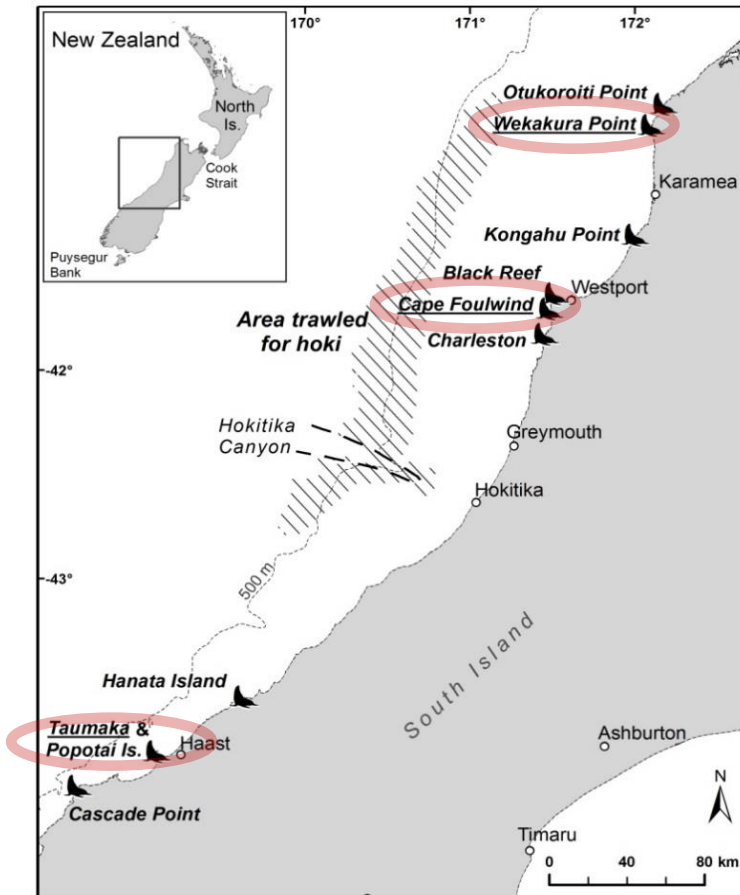
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# This presentation

- Study rookeries
- Pup census – methods & results
- Pup size – methods & results
- Discussion of threats
- Recommendations

# Study rookeries



- Three breeding rookeries spread out along WCSI
- Approx. third of pup production along WCSI including Fiordland (Baird 2011)
- Continuous monitoring 1991-2016, with focus on pups
- Upwelling system
- Close proximity to hoki spawning grounds/fishery since early 1970s

# Field based research

Closed population mark recapture for live pups



Marking:

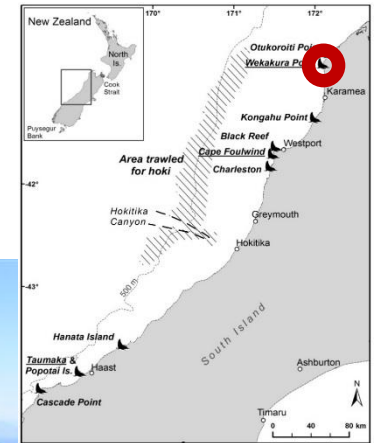
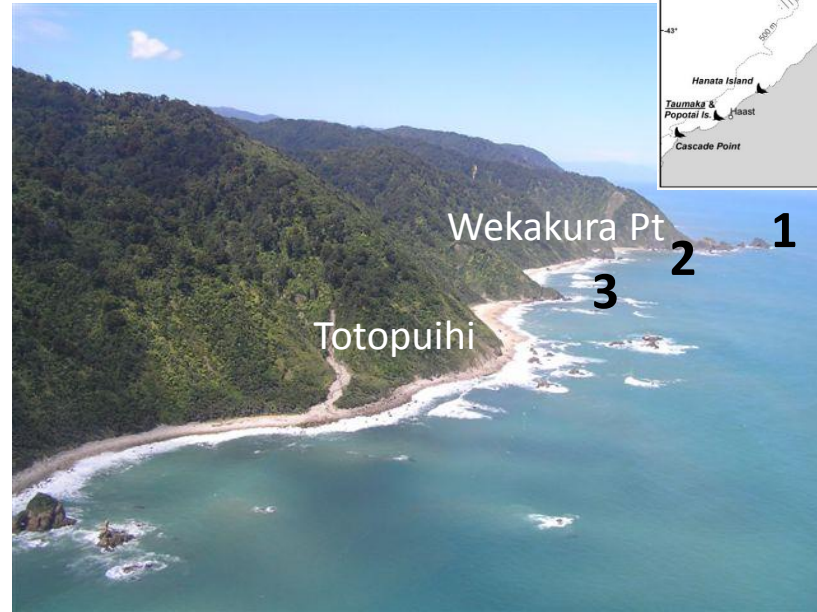
- Pups double flipper marked at end of January
- >50 % of pups marked each year
- Spatial spread consistent with distribution of pups
- Standard length & mass of 200 pups
- Dead pup counts during marking

Resighting:

- 5 samples at least 12 hours after end of marking
- Method varied by rookery, e.g. walk through colony (Wekakura Point & Taumaka Island) or cliff-edge viewing from 5 vantage points (Cape Foulwind)

# Field based research Wekakura Point

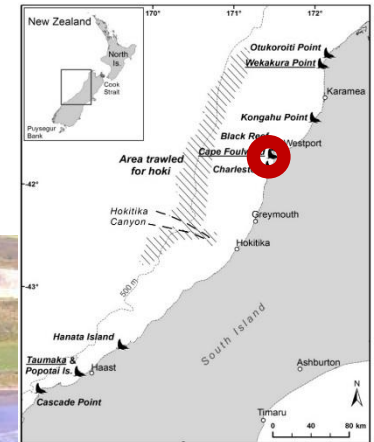
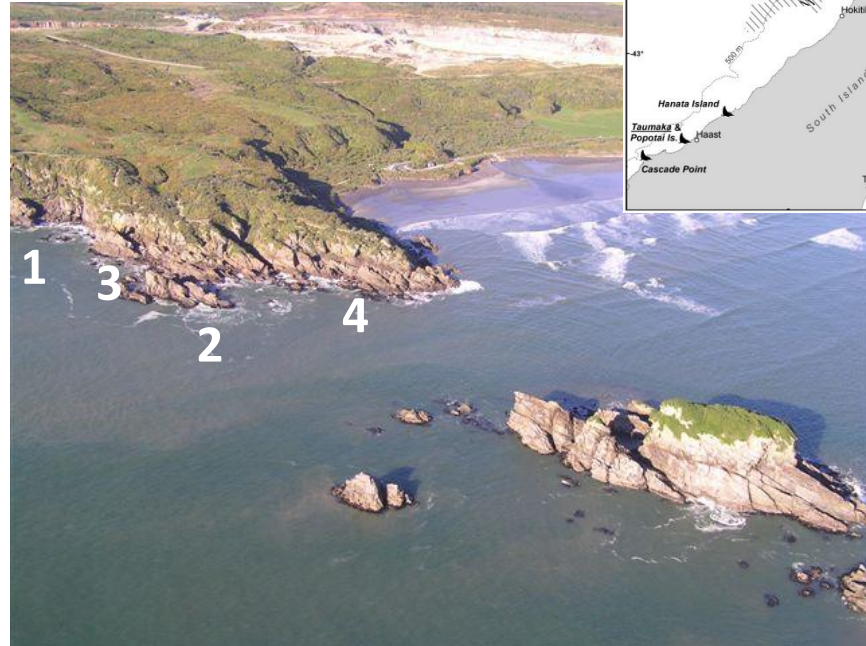
- Kahurangi National Park
- Headlands North of Wekakura Point
- “Walk-through” resight sampling by 4 people over 4/5 days at 3 headland sectors (marked on image)





# Field based research Cape Foulwind

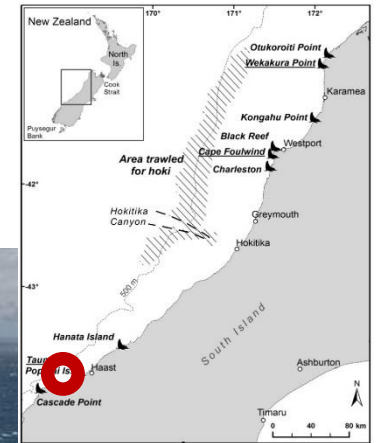
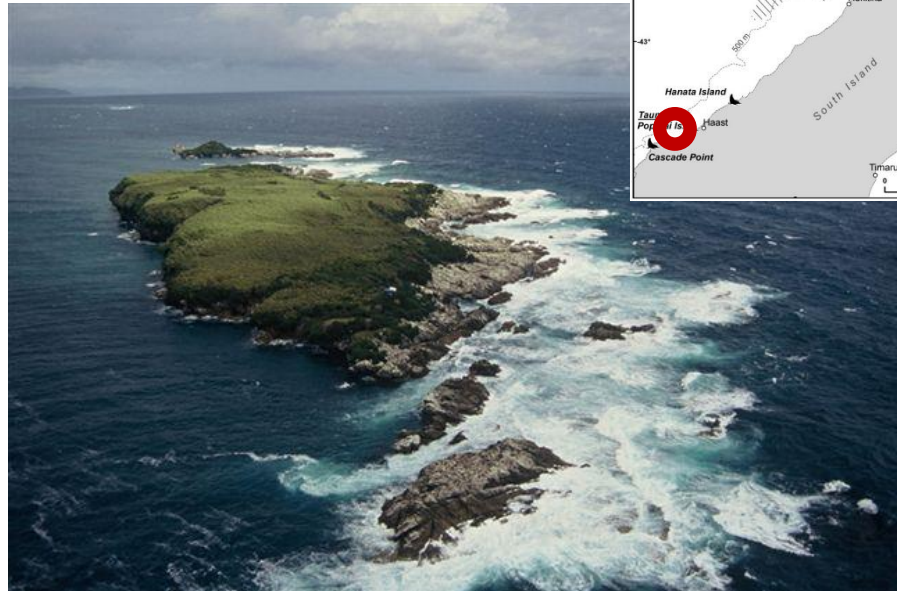
- Mainland conservation land
- “Cliff-top” resight sampling from set vantage points above the colony
- 5 people over 2 days in 4 defined sectors (marked on image)



**Sector 1:** Block Field  
**Sector 2:** Central Boulder  
**Sector 3:** North Gut  
**Sector 4:** South Gut

# Field based research Taumaka Island (Open Bay Islands)

- Private Maori-owned
- Pups monitored along NW (RHS of image)
- “Walk-through” resight sampling by 4/5 people over 4/5 days in 7 defined sectors (S1 in foreground, S7 at back)



**Sector 1:** Eastern Stack

**Sector 2:** Eastern end of Taumaka to Hut Gut

**Sector 3:** Hut Gut to Penguin Gut

**Sector 4:** Penguin Gut to creek from Billy Bunter Gorge

**Sector 5:** Creek exit to first cobbled beach west of Point

**Sector 6:** First Beach to Impassable Gut

**Sector 7:** The Amphitheatre

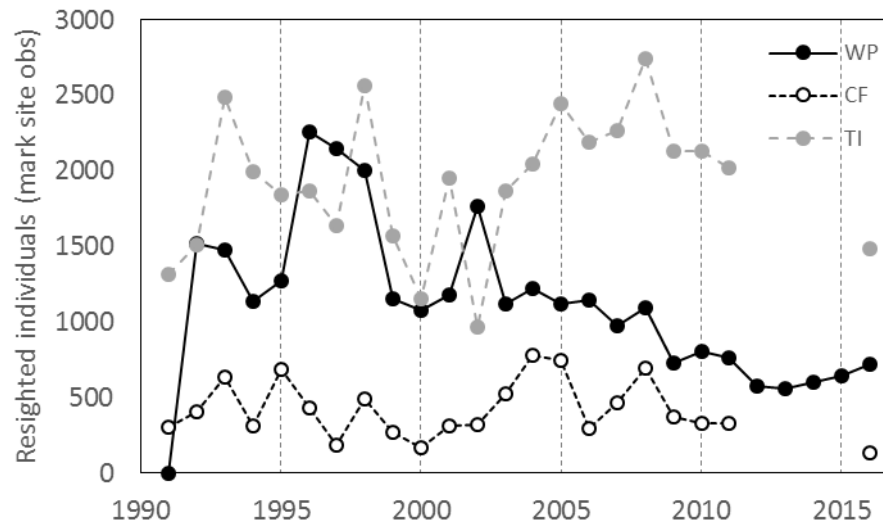
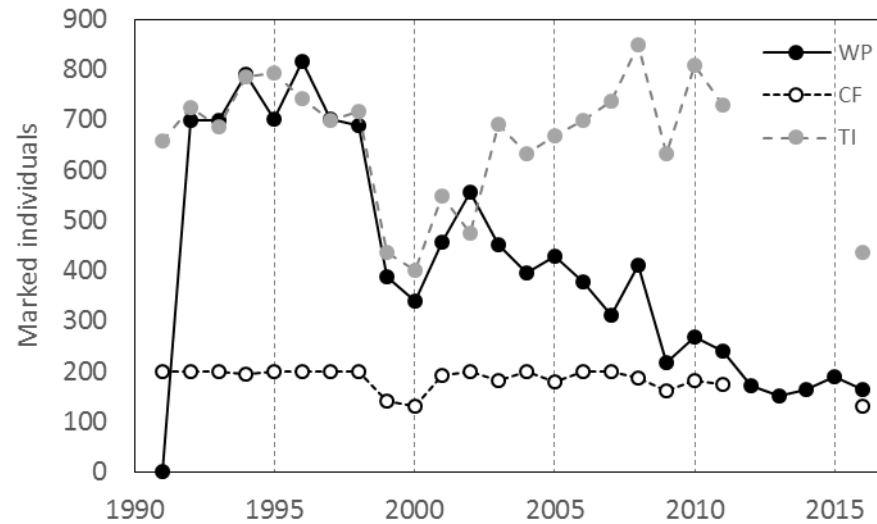
# Mark recapture database

- Database of all field data developed and maintained by Dragonfly Data Science
- Data grooming traceable to source
- Will shortly be publicly available



Pup census

# Mark recapture sample size



# Mark recapture estimation of population size

Modified Petersen Estimate assuming closed population (as Shaughnessy et al. 1995)

Estimate of pups on the colony at the time of recapture is...

$$\hat{N}_i = \frac{(M + 1)(n_i + 1)}{(m_i + 1)} - 1$$

$M$  = marked population

$m_i$  = number of marked pups counted in recapture sample

$n_i$  = number of pups in the recapture sample

The variance of each estimate is...

$$Var(\hat{N}_i) = \frac{(M + 1)(n_i + 1)(M - m_i)(n_i - m_i)}{(m_i + 1)^2 (m_i + 2)}$$

The mean of the annual estimates per colony is...

$$\hat{N} = \frac{1}{q} \sum_{i=1}^q \hat{N}_i$$

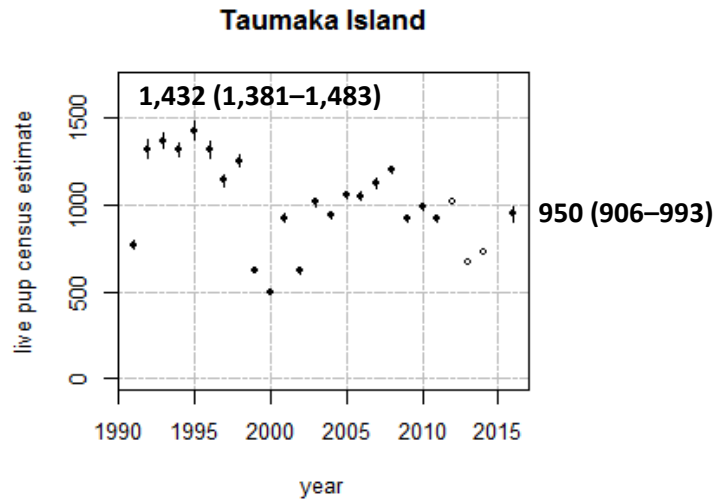
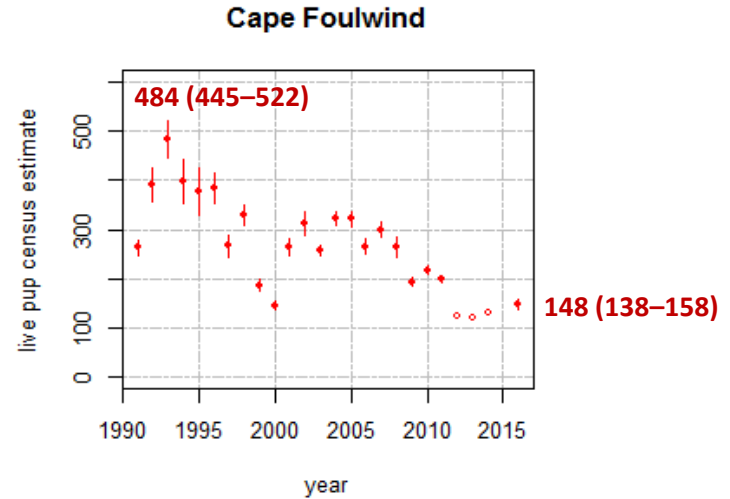
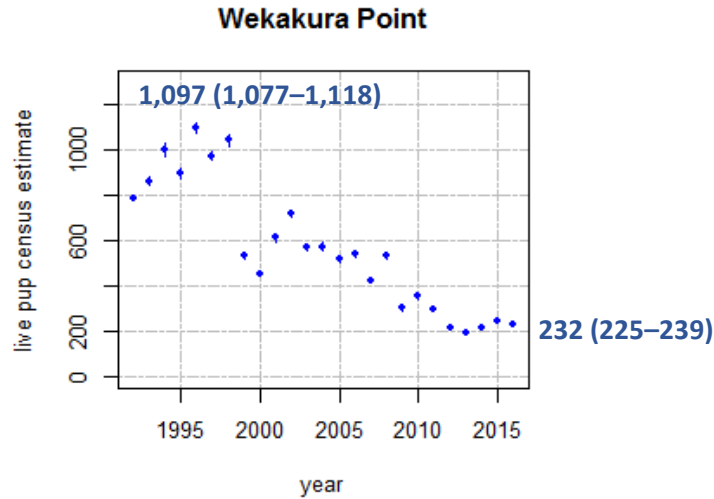
$q$  = is the number of recapture sessions

The standard error (SE) of each colony estimate was calculated as...

$$\sqrt{\frac{1}{q^2} \sum_{i=1}^q Var(\hat{N}_i)}$$

95% CI =  $\pm 1.96 * SE$

# Results live pup census

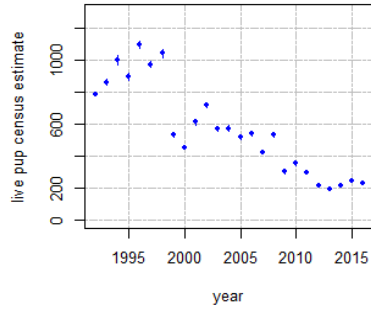


Decline from mid-90s max to 2016:

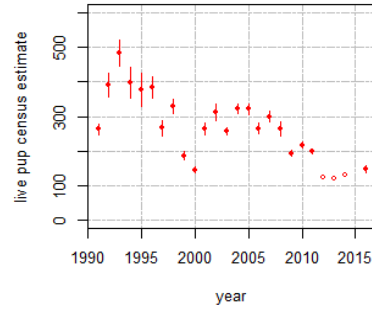
- 79% at Wekakura Point
- 69% at Cape Foulwind
- 34% at Taumaka Island

# Results dead pup census

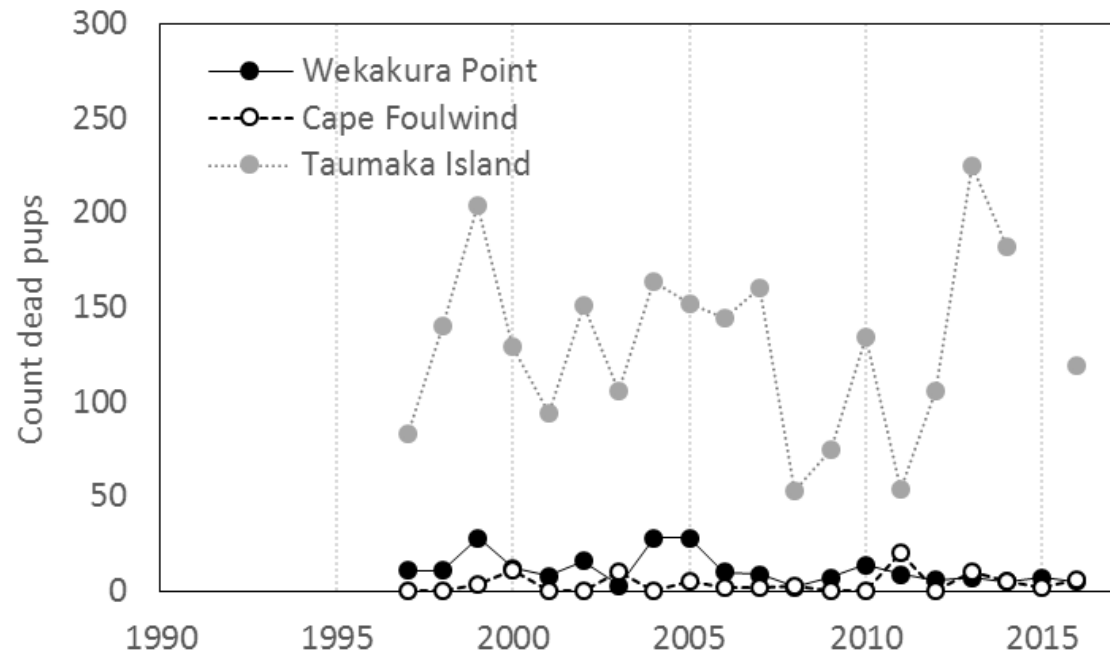
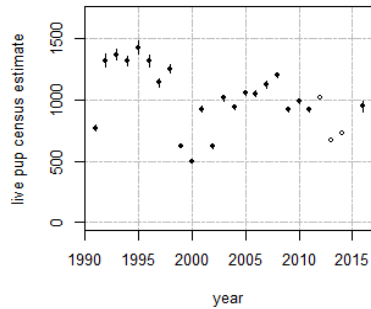
Wekakura Point



Cape Foulwind



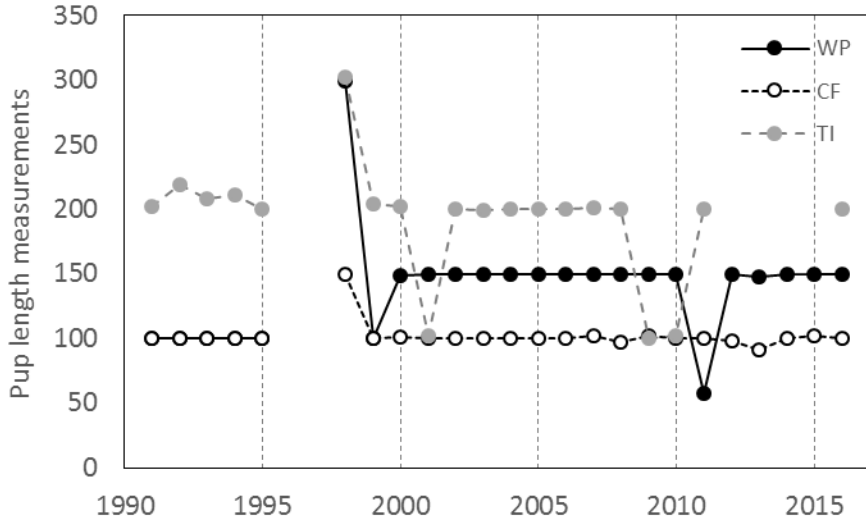
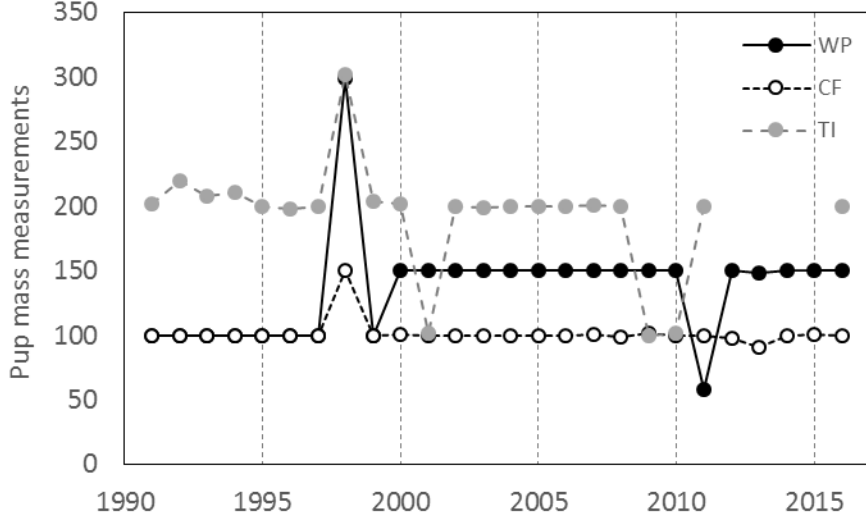
Taumaka Island





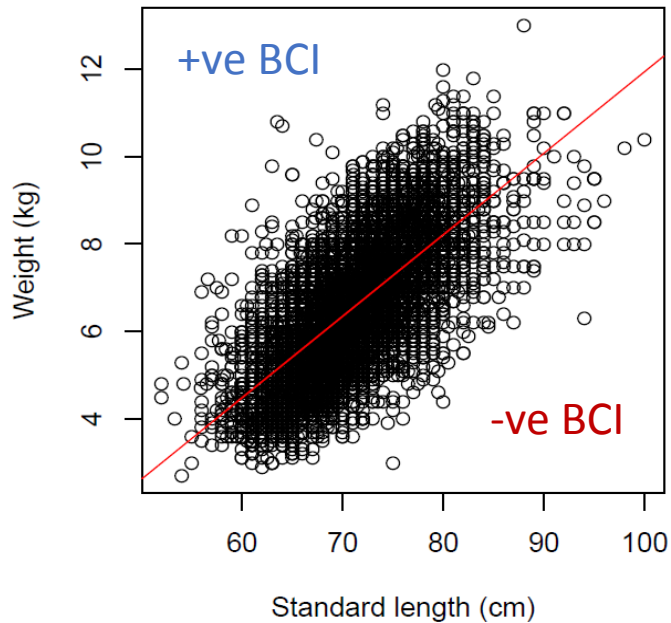
Individual pup size

# Pup measurements



# Calculating BCI

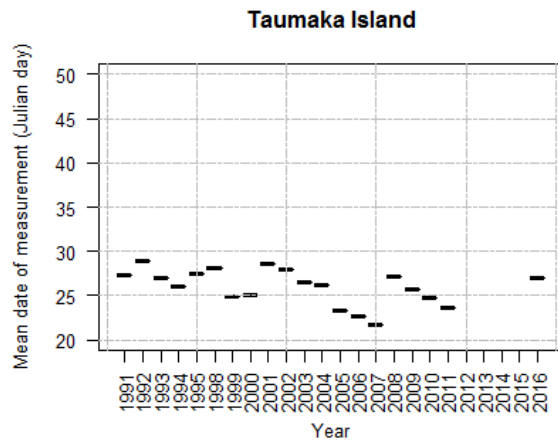
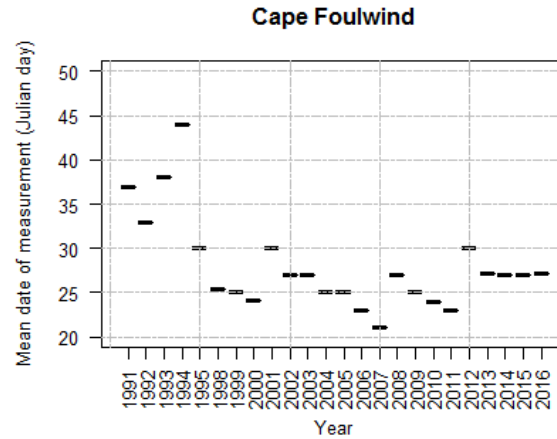
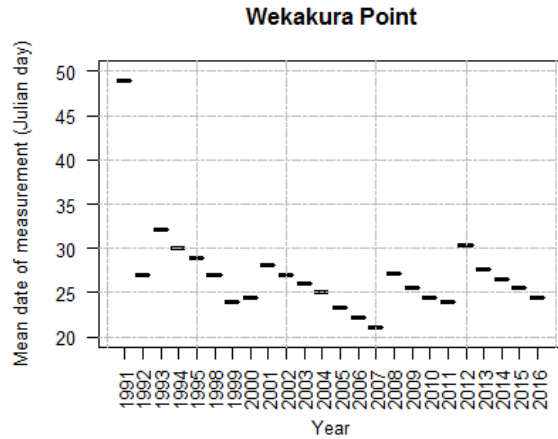
## Predicting mass from length



Predicted mass =  $0.187 \times \text{standard length} - 6.73$

BCI = Observed mass – predicted mass

# Date of measurement effect?



# Standardised individual measurements

- Linear models fitted in *R* to predict either pup mass, standard length or BCI in response to candidate explanatory variables
- For standard length, mass, and BCI the most complex structure considered was:

*lm (measurement ~ sex + season + colony + day + colony : sex + sex : day)*

- Model selection by second-order Akaike's Information Criterion AICc



# Individual size model structure

## Optimal standard length model

lm (*length* ~ *sex* + *day* + *colony* + *season* + *colony* : *sex*)  
( $r^2 = 0.195$ ,  $F_{9,713} = 81.19$ ,  $p < 0.001$ )

## Mass

lm (*mass* ~ *sex* + *colony* + *season* + *day*)  
( $r^2 = 0.230$ ,  $F_{9,715} = 107.6$ ,  $p < 0.001$ )

## Body condition index

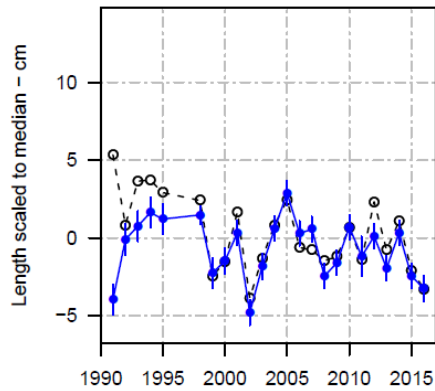
lm (*BCI* ~ *sex* + *colony* + *season* + *day*)  
( $r^2 = 0.159$ ,  $F_{9,713} = 63.13$ ,  $p < 0.001$ )

Estimated day effect (3.8 mm d<sup>-1</sup> & 37 g d<sup>-1</sup>) consistent with previous longitudinal growth studies

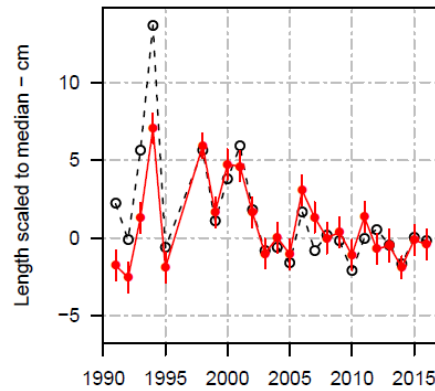
Colony term then removed for individual colony models, fixing day to estimate from model with all colonies

# Results individual pup length

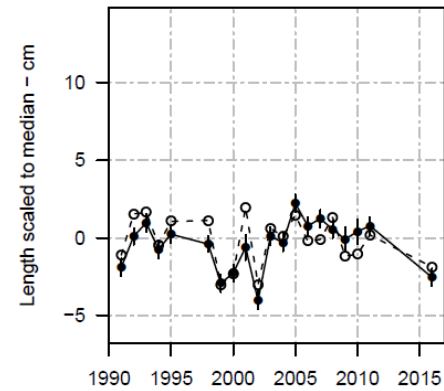
Wekakura Point



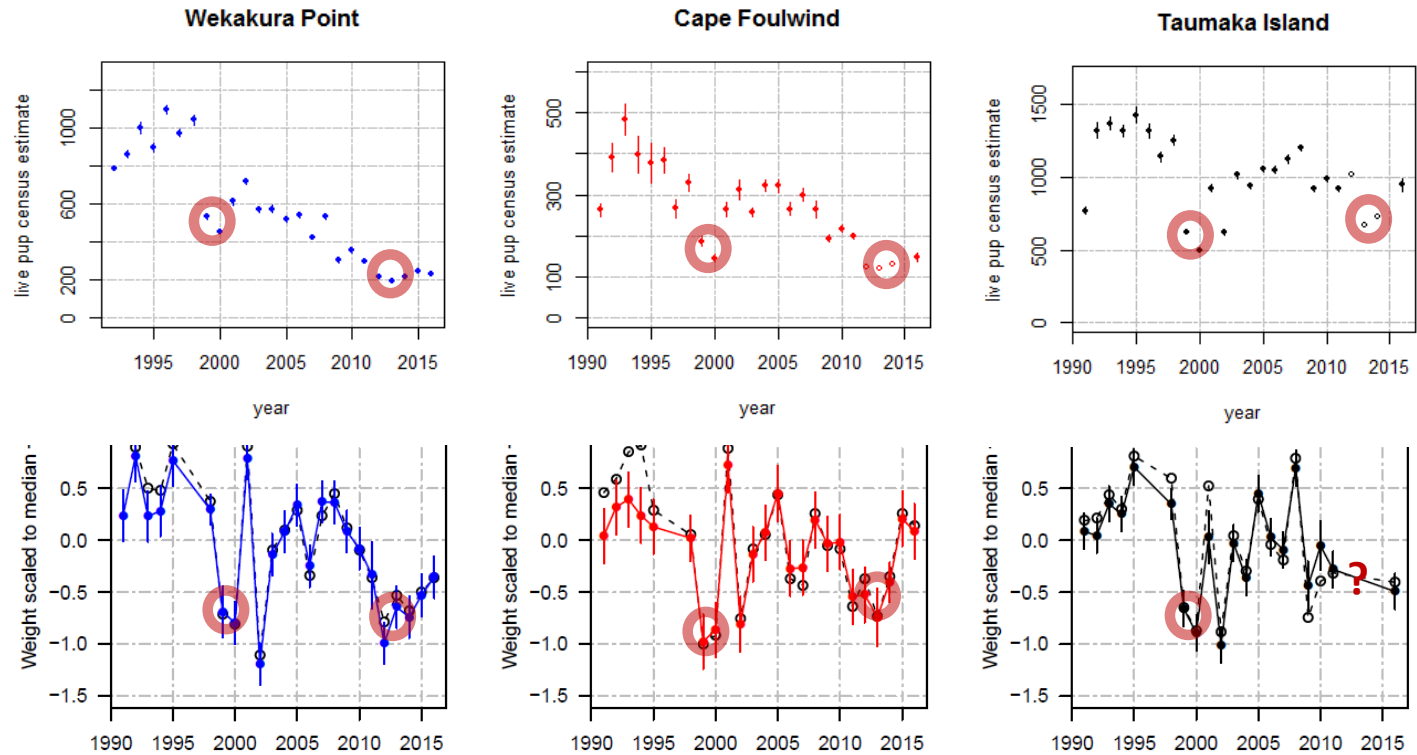
Cape Foulwind



Taumaka Island

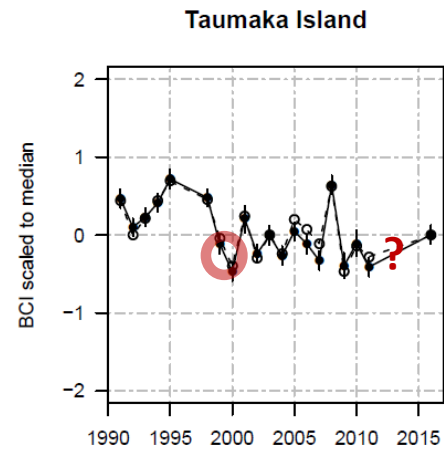
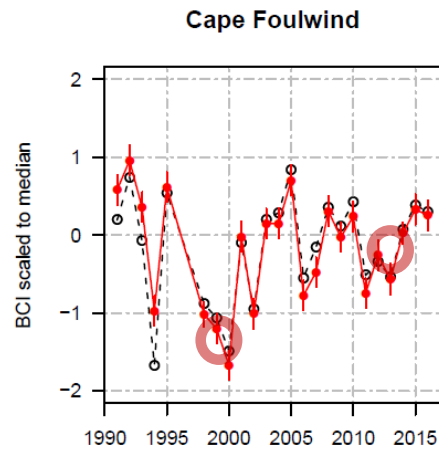
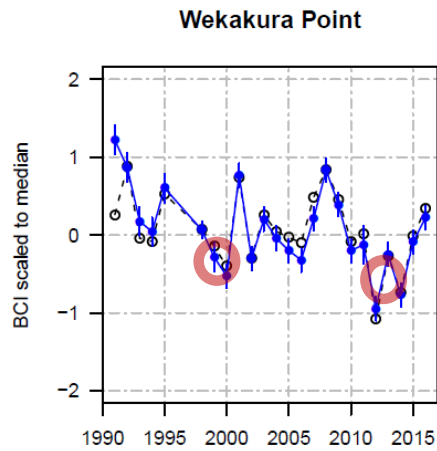


# Results individual pup mass



**Simultaneous dip in pup counts  
in these years**

# Results individual pup BCI



**Dip in pup counts**

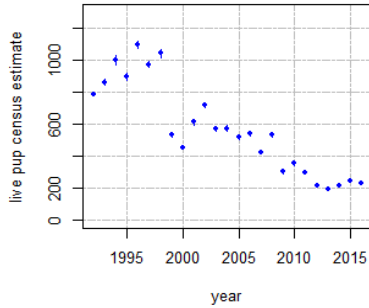
# Discussion of threats



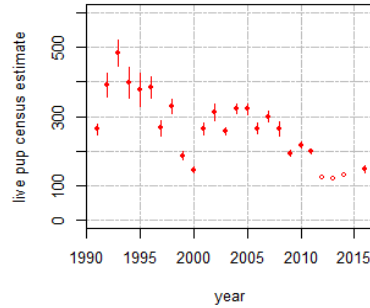
# Threats to WCSI fur seal populations

## direct fishery mortality

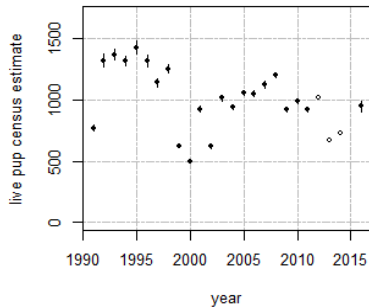
**Wekakura Point**



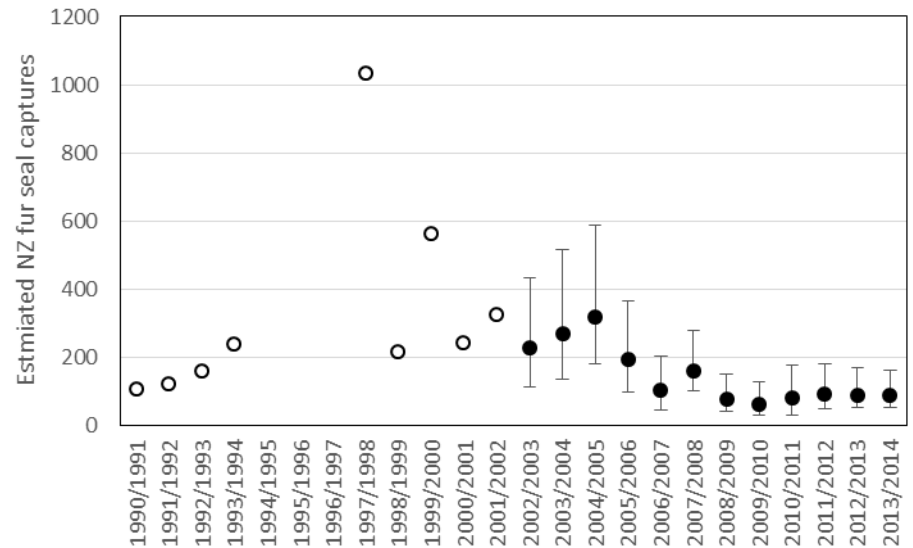
**Cape Foulwind**



**Taumaka Island**



**Estimated NZ fur seal captures WCSI trawl**

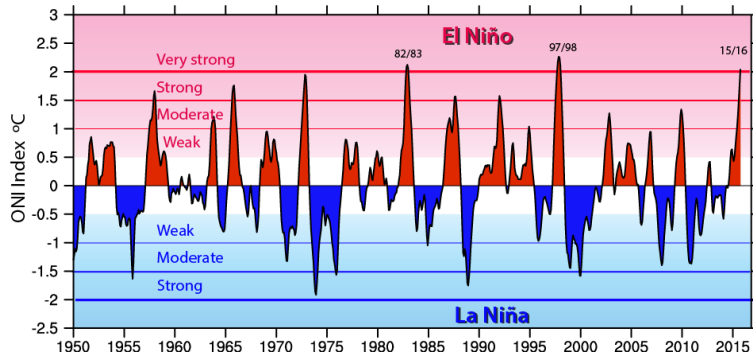


Baird (2005) 1991-2002

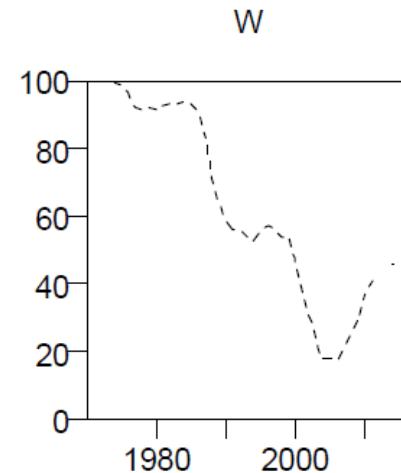
Dragonfly (2016) 2003-2014

# Threats to WCSI fur seal populations climate/fishery effects on prey availability

## Ocean climate

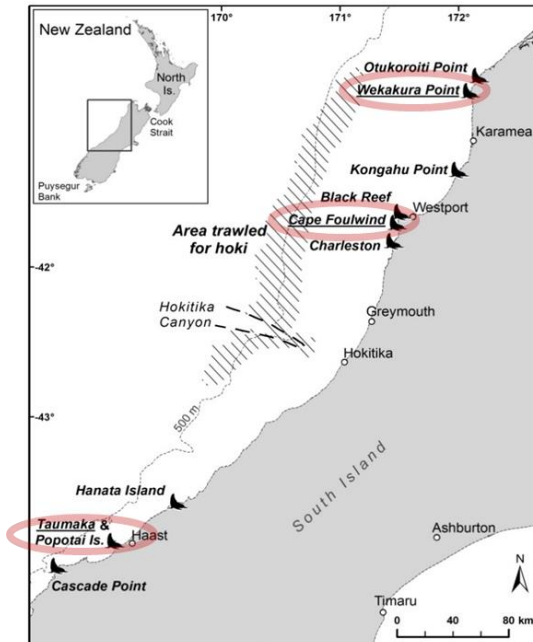


## Status of fished stocks, e.g. hoki



McKenzie (2016)

# Summary - populations



Northern rookeries worst-affected:

- What is different about Taumaka Island population?
- Foraging overlap with fishery?
- Relative prey availability?

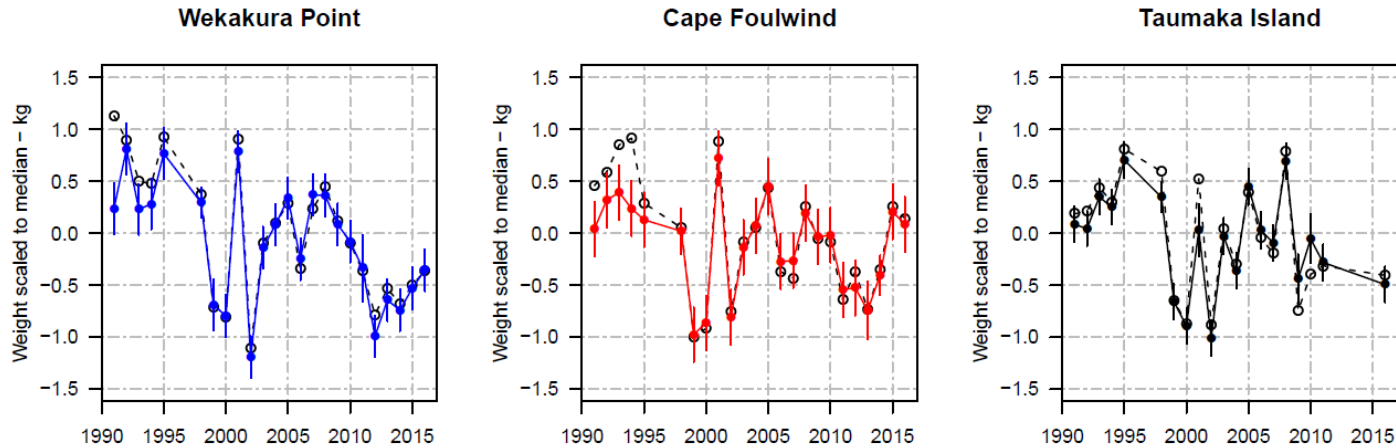
Decline at all 3 study rookeries:

~80% at Wekakura Point

~70% at Cape Foulwind

~35% at Taumaka Island

# Summary – pup size



- Taumaka Island pups half kg lighter
- Same years of low pup mass/condition across rookeries, coincide with dips in pup numbers – nutrition and pupping rate and pup survival?
- Declining trend at Wekakura Point – the fastest declining pop.

# Future research

We recommend:

- Continuation of mark-recapture study at all 3 rookeries
- Resighting at ages 1+ to identify demographic causes of population decline
- Spatial/temporal/seasonal variation in diet composition
- Correlate pup size with climate/prey indices
- Extent of foraging overlap with fisheries

# Acknowledgements

- Numerous DOC staff, tangata whenua representatives and volunteers who have partaken in fieldwork at the WCSI rookeries.
- Dr. Mana Stratton, Nathaniel Scott and Scott Freeman.
- DOC West Coast/Tai Poutini, the Hoki Fishery Management Company, ALLFLEX NZ, HeliVentures and Morrow Bassett & Co. made contributions towards operational funding of the study
- Demographic database for WCSI NZ fur seals developed and maintained by Dragonfly Data Science
- This analysis was funded by DOC

# References

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