

Climate impacts on biological systems in the Western Australian region

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Centre for Australian Climate and Weather Research
A partnership between CSIRO and the Bureau of Meteorology
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Seabirds as bio-indicators

Bio-indicators of trophic (food & productivity) conditions within marine ecosystems

- Higher order predators
 - Near top of marine food-chains
 - Integrate bio-physical processes operating in those ecosystem
- Colonial nesters
 - Facilitating repeated sampling for monitoring programs



JN Dunlop



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Seabirds as bio-indicators

- Central-place foragers when breeding
 - Different species different foraging ranges
 - Opportunities to monitor changes on range of scales
- Occupy a range of marine ecosystems
 - Species range from estuarine to coastal, continental shelf to oceanic
 - Provide information on changes in different marine ecosystems – monitor from one focal location





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Seabirds as bio-indicators

- Breeding performance robust indicator of prevailing, within-season, oceanographic and trophic conditions
 - High energy demands associated with rearing young gives marked variation in reproductive output
- Pelagic seabirds have conservative life histories
 - Strongly philopatric, long-lived delayed maturity, low capacity for increase and rest years
 - Change in population size / distribution reflect trends in marine ecosystems and not short-term spikes





Seabirds as bio-indicators

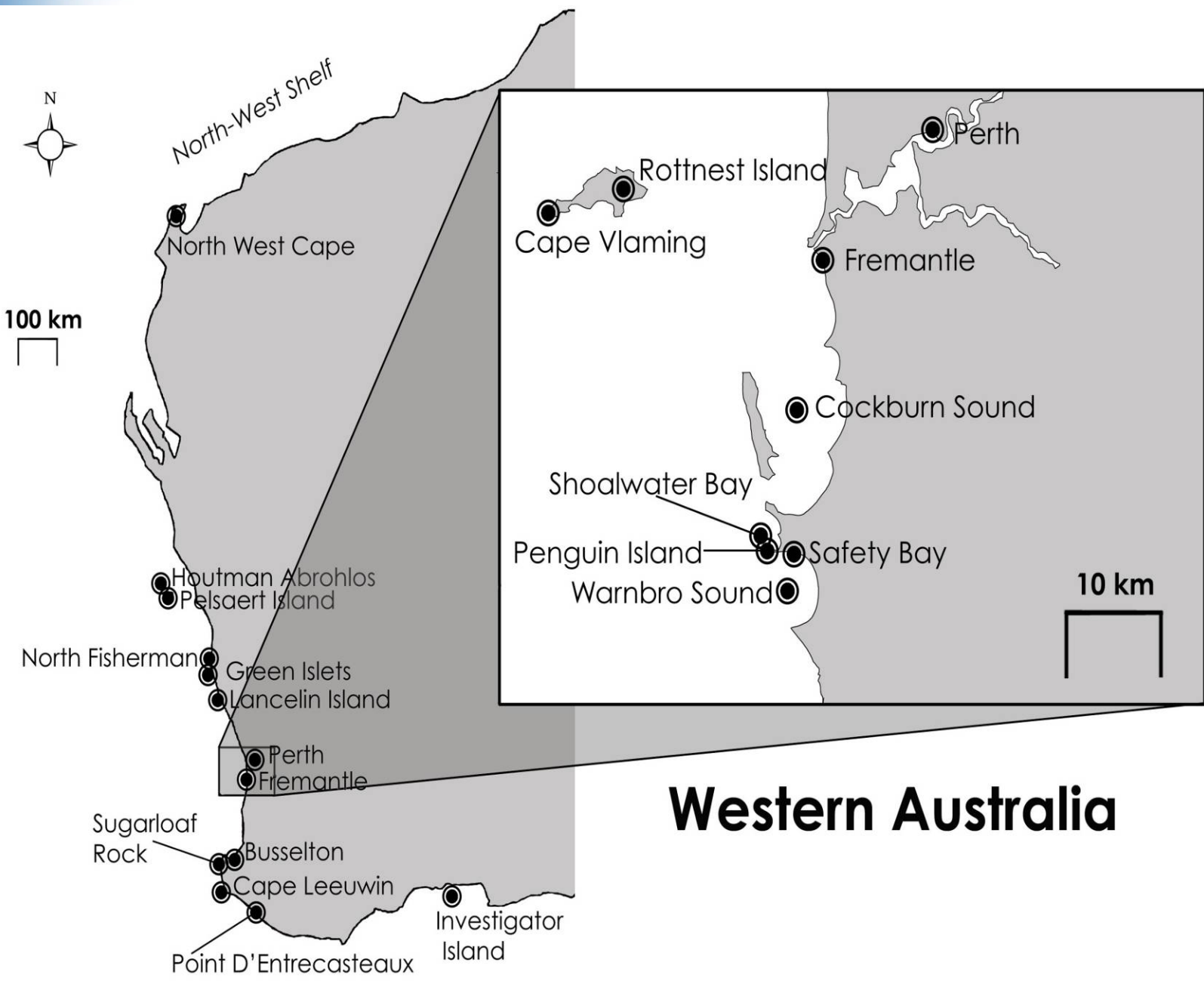
- Central & sw WA mix of tropical and temperate cool-water species
 - Due to Leeuwin Current
 - Change in seabird community composition and structure potential indicator of shifts in ocean climate
- Visible and popular subjects for observation
- Historical record of breeding distributions back to colonial period





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Seabird study sites



Western Australia



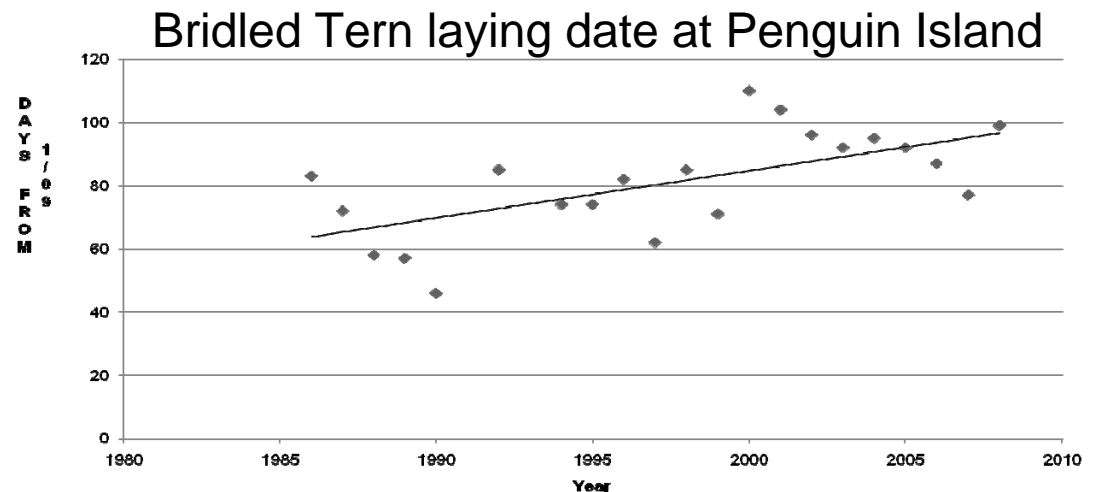
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Sea Surface Temperature Changes

Expect: southward expansion or shifts, altered reproductive success & timing, foraging areas & possibly prey species

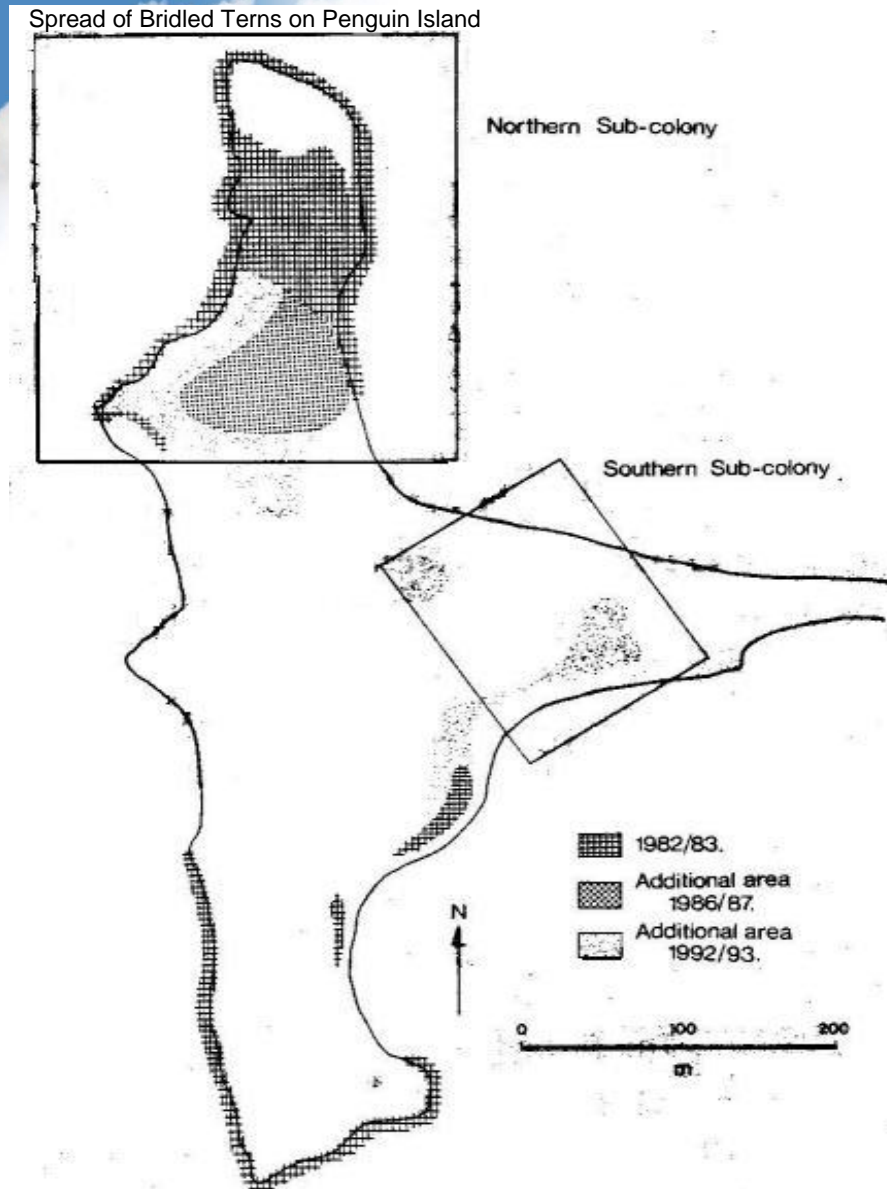
Observed:

- Southward expansion of tropical seabirds
 - Rapid growth of southern colonies of 7 species in last 3-4 decades
- Later breeding (post 2000)
 - Bridled Tern, Sooty Tern, Common Noddy and Less Noddy
- Reduced breeding participation and success in ENSO years





Spread of the Bridled Tern Rapid growth of southern colonies in recent decades



Southern-most distribution

- 1843 Abrolhos
- 1889 Rottnest Is
- 1921 breeding Shoalwater Bay
- 1956 Cape Leeuwin islands
- 1990s Point d'Entrecasteaux
- 2008 Albany and Recherche Archipelago



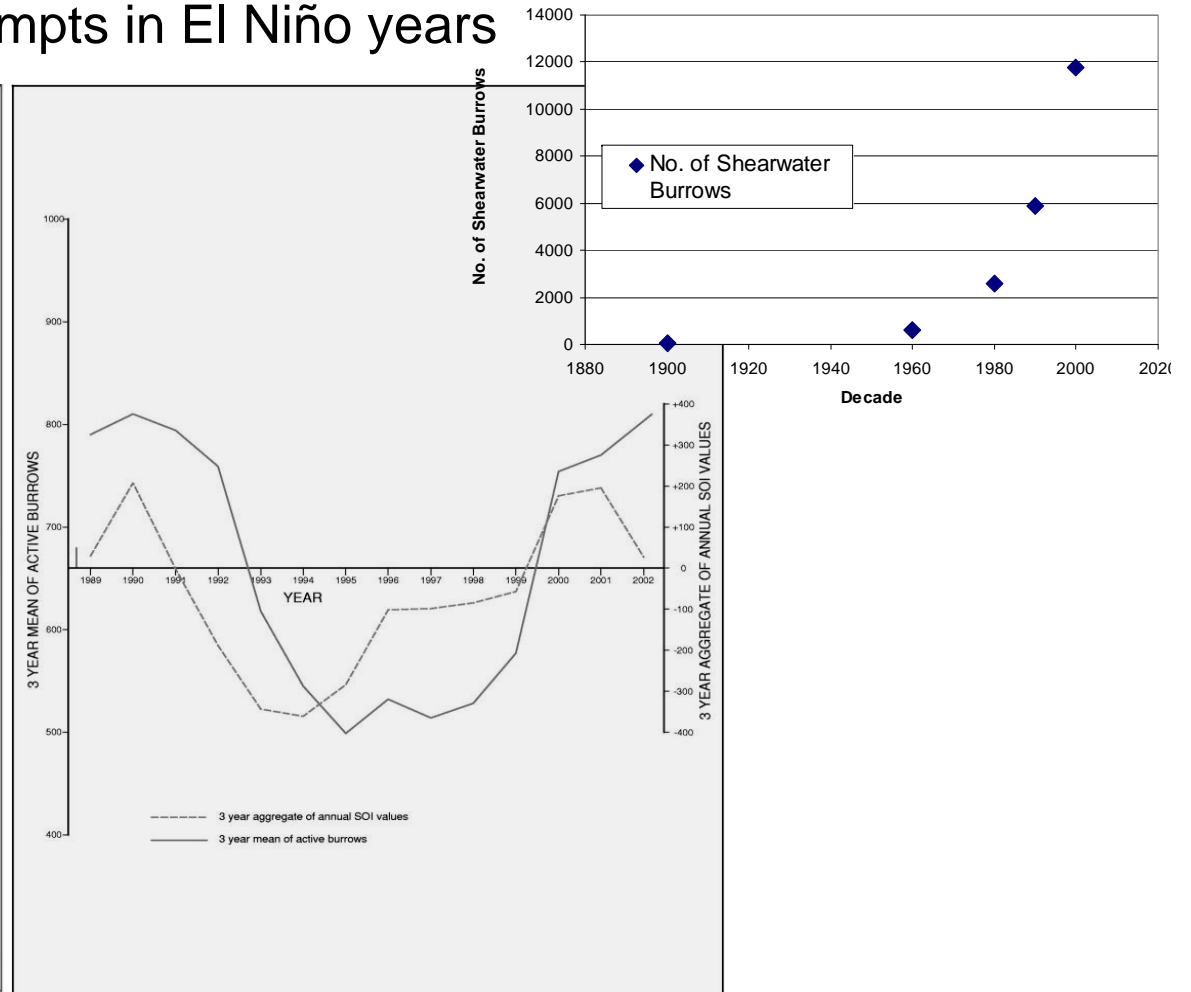
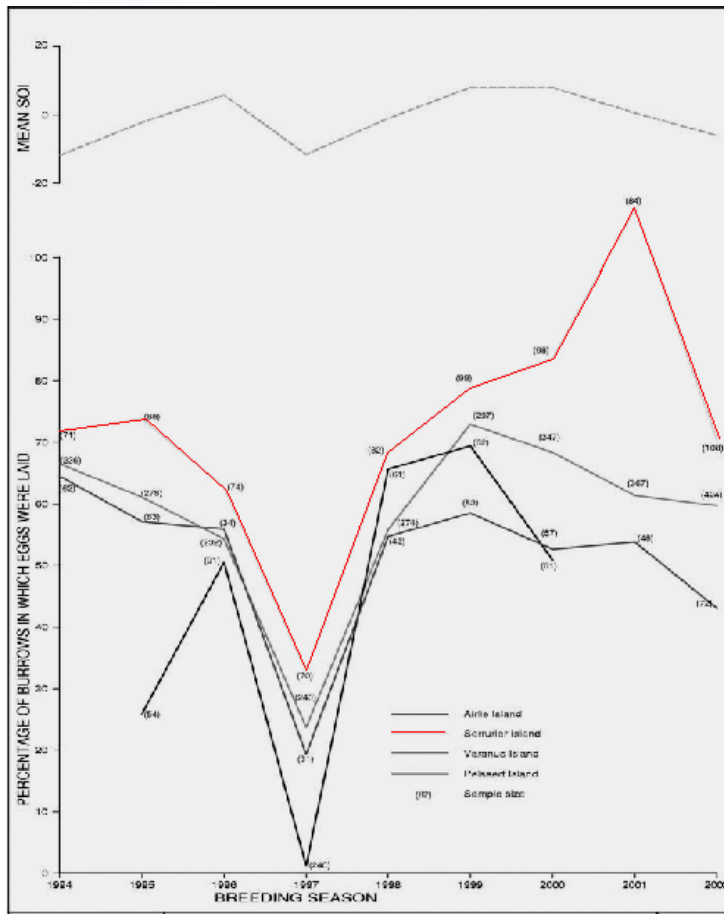


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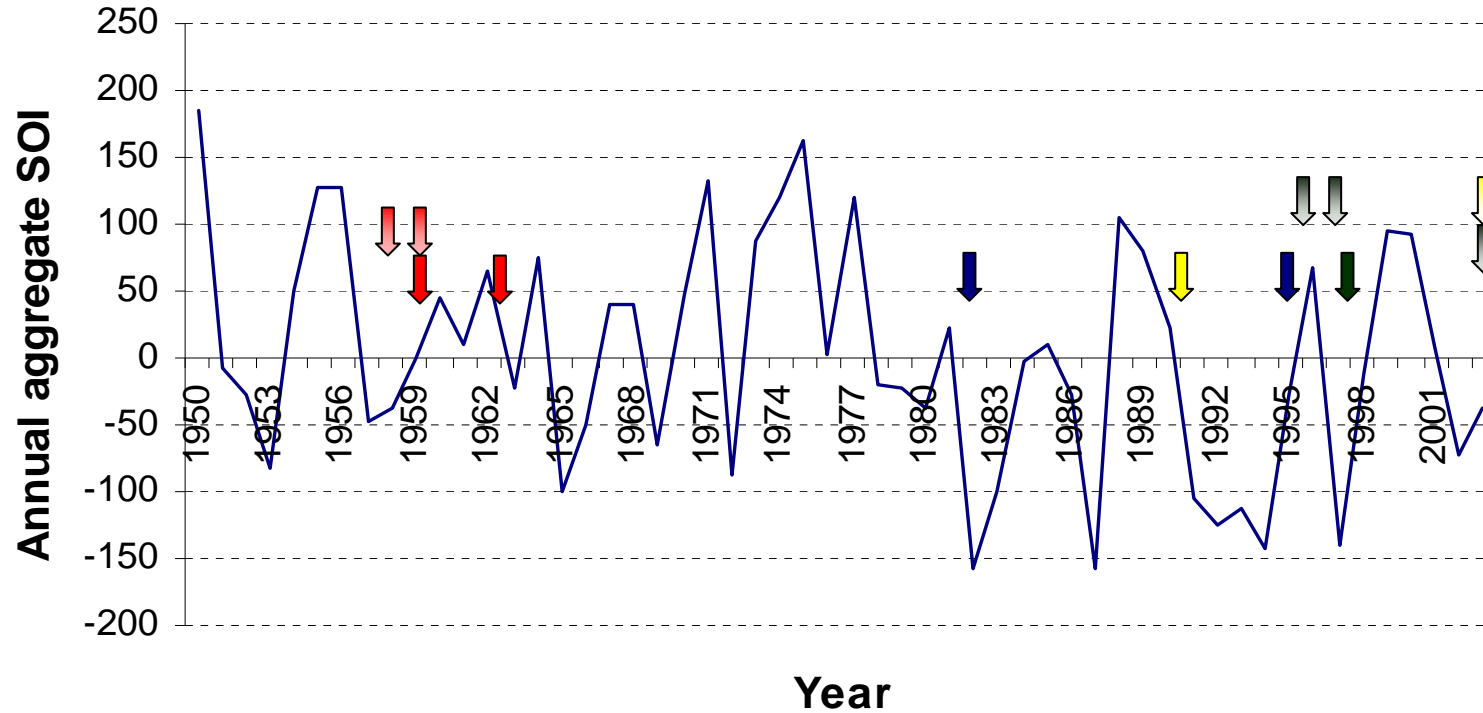
Wedge-tailed Shearwater and ENSO



- Rottnest Popⁿ growing in period of declining breeding performance (driven by immigration from northern colonies) – attributed to increased ENSO frequency
- Reduced breeding attempts in El Niño years



Tropical Seabird Responses to ENSO- 1950-2003



- Red-tailed Tropicbird prospecting/breeding ↓ ↓
- Roseate Tern prospecting/breeding ↓ ↓
- Sooty Tern prospecting/breeding ↓ ↓
- Brown Noddy prospecting/breeding ↓ ↓



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Ocean currents, mixed layer depth, ocean stratification

... potential to impact seabird distributions, migration and foraging through impacts on supply of nutrients and light and, therefore, prey species and subsurface predators that force and maintain prey at the surface

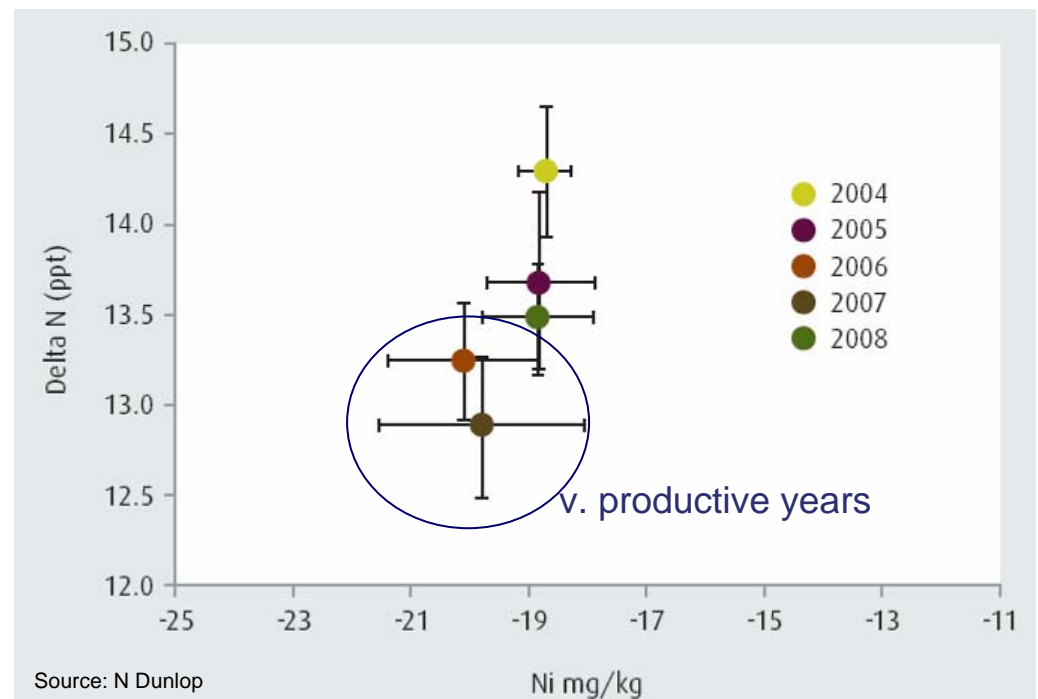
- Negative relationship between number breeding Sooty Terns (GBR) and precursor changes in depth of 20 °C thermocline
- Foraging and breeding success in Little Penguins linked to ocean stratification (prey more dispersed in poorly stratified waters)
- No WA studies so far





Seabird feathers as environmental indicators

- Pilot project monitoring inter-annual changes in diet and prey availability
- carbon stable isotope and nitrogen ratios
- C ratio – indicator of carbon source at base of food chain
- N ratio – sources marine upwelling, sewage, mineralisation of guano, etc
- Confirms differences seen in breeding performance linked to diet (or prey location)





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Surface Air Temperature

Increased land temperatures can increase heat stress and mortality, leading to reduced breeding success (esp. surface dwelling birds)

Many seabirds unable to withstand prolonged exposure to surface air temperatures $> 35^{\circ}\text{C}$, which lead to dangerously high body temperatures and heat stress





Precipitation, floods and terrestrial runoff

- Few direct effects on survival or breeding success
- Occasional heavy rain may flood burrows
- Indirect (potential effects) include: impact on prey availability, quality of breeding habitat, fire risk
- Anchovy productivity (important prey of LP) associated with streamflow in coastal areas in Victoria
- Whitebait (prey for LP in WA) recruitment and growth affected by rainfall & Leeuwin Current

Ocean Acidification

- No known direct or indirect effects





Sea level rise

- No known quantitative links between observed SLR & changes in the distribution & abundance of seabirds – future impact will vary with breeding habitat

However

- Preliminary research on Little Penguins of Penguin Island
- Warmer ocean temperatures may correspond to reduced chick mass and later median laying
- Earlier laying tends to correspond to months of higher sea levels, i.e. a stronger Leeuwin Current in the preceding year





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Future changes

- Many uncertainties
- Rising SST projected to decrease prey availability to many seabirds at current breeding sites
- Background rises in SSTs may foster persistence of tropical seabirds at more southern latitudes
- Potential for seabirds to shift breeding locations as result of inundation and/or degradation of breeding sites is unclear & highly dependent on resilience of coral reef ecosystems and other breeding locations to CC





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Knowledge gaps

- Understanding drivers of change in seabird populations, including relative role of natural variability and CC
- Understanding factors determining resilience and adaptive capacity of marine ecosystems. E.g. How do seabirds respond to climatic changes: gradual vs trigger vs thresholds
- Knowledge of existing non-climatic threats and how these will interact with CC





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Seabird Bio-indicators & WAMSI

Role for continued monitoring of oceanographic impacts on seabirds

Number of seabird colonies closely monitored since 1980s
– model role of oceanographic changes on population size and productivity and prey species

Input from ocean models – fine scale oceanographic information, currents, upwelling, thermocline depth, SLR etc – historic and projected



E Chambers



Conclusions

- Changes in oceanographic and climatic processes are impacting on seabirds
 - Changes in distribution, success & timing of breeding
 - Some uncertainty in future impacts
 - Southward expansion limited by available habitat & distribution of prey species
 - SLR likely to reduce existing breeding habitat





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Conclusions

- For many seabirds & regions we have limited information on prey distributions, foraging & movement patterns & ability of species to alter prey species or life-cycle timing – all of which influenced by ocean conditions
- Further research & monitoring of key species required
 - Determine which species and systems more vulnerable to CC
 - Where generalisations about impacts & adaptation can be made
 - Which species are most effective indicators of climate impacts on higher trophic predators
 - Seasonal (and longer term) predictions of productivity





Further Information

- **Marine Climate Change in Australia 2009**

http://www.oceanclimatechange.org.au/content/index.php/site/report_card_extended/category/seabirds/

- J.N. Dunlop 2009. The population dynamics of tropical seabirds establishing frontier colonies on islands off south-western Australia. *Marine Ornithology* 37:99-105.
- C.A. Surman, L.W. Nicholson. 2009. The good, the bad and the ugly: ENSO driven oceanographic variability and its influence on seabird diet and reproductive performance at the Houtman Abrolhos, Eastern Indian Ocean. *Marine Ornithology* 37: 129-138.