Australian Government
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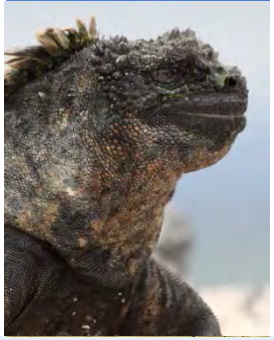
phillipisland
nature parks australia

CSIRO



Phenological Responses of Southern Marine Species to Climate

Impacts and Adaptation Options

L.E. Chambers, P. Dann, A.J. Hobday

Travel Support: PICES … thanks!

Overview

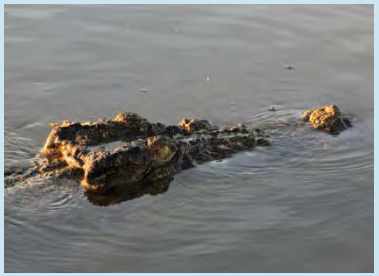
- Why focus on southern species?
- How does climate impact on phenology?
- Adaptation – identifying and prioritizing actions

Phenology

"The study of the timing of recurring biological events, the causes of their timing with regard to biotic and abiotic forces and the interactions among phases of the same or different species"

(Leith 1974)

Phenology



Fundamental ecological process

Major driver of population dynamics, species interactions, animal movement and evolutionary life histories

Consequences for societies and economics

Annual Shearwater Festival Australia

Images: LE Chambers except –
Emma Woodward (crocodile eggs);
deadlysport.com (shearwater festival)

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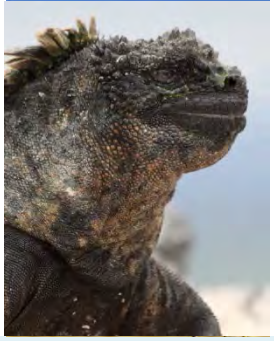
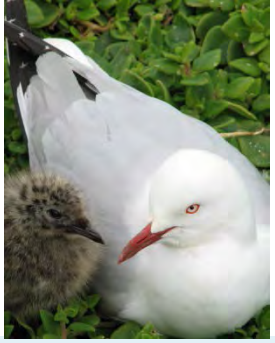
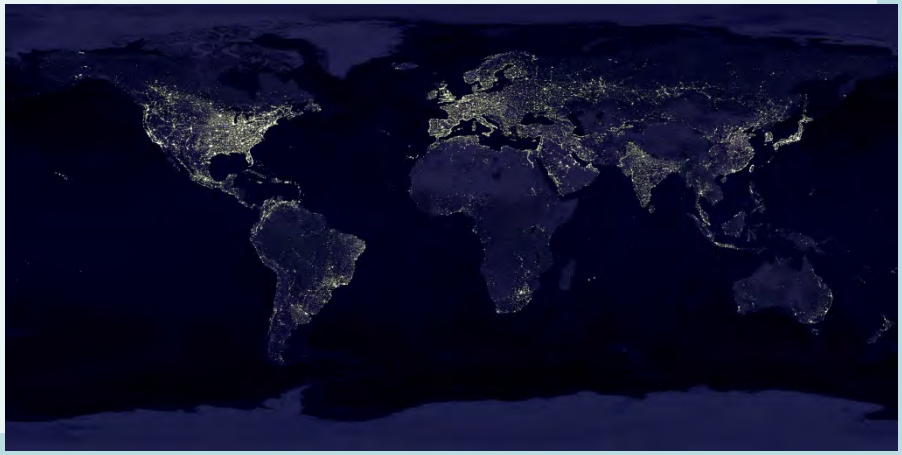
Why Southern Species?


Historical bias towards northern studies

- Long-history of naturalist observations in NH
- Many SH species long-lived, low annual reproduction
- Maritime influences
- Dissymmetry in human population distribution



http://visibleearth.nasa.gov/

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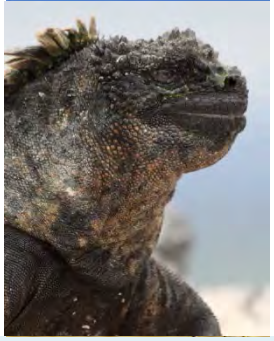
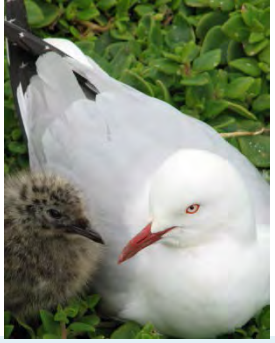
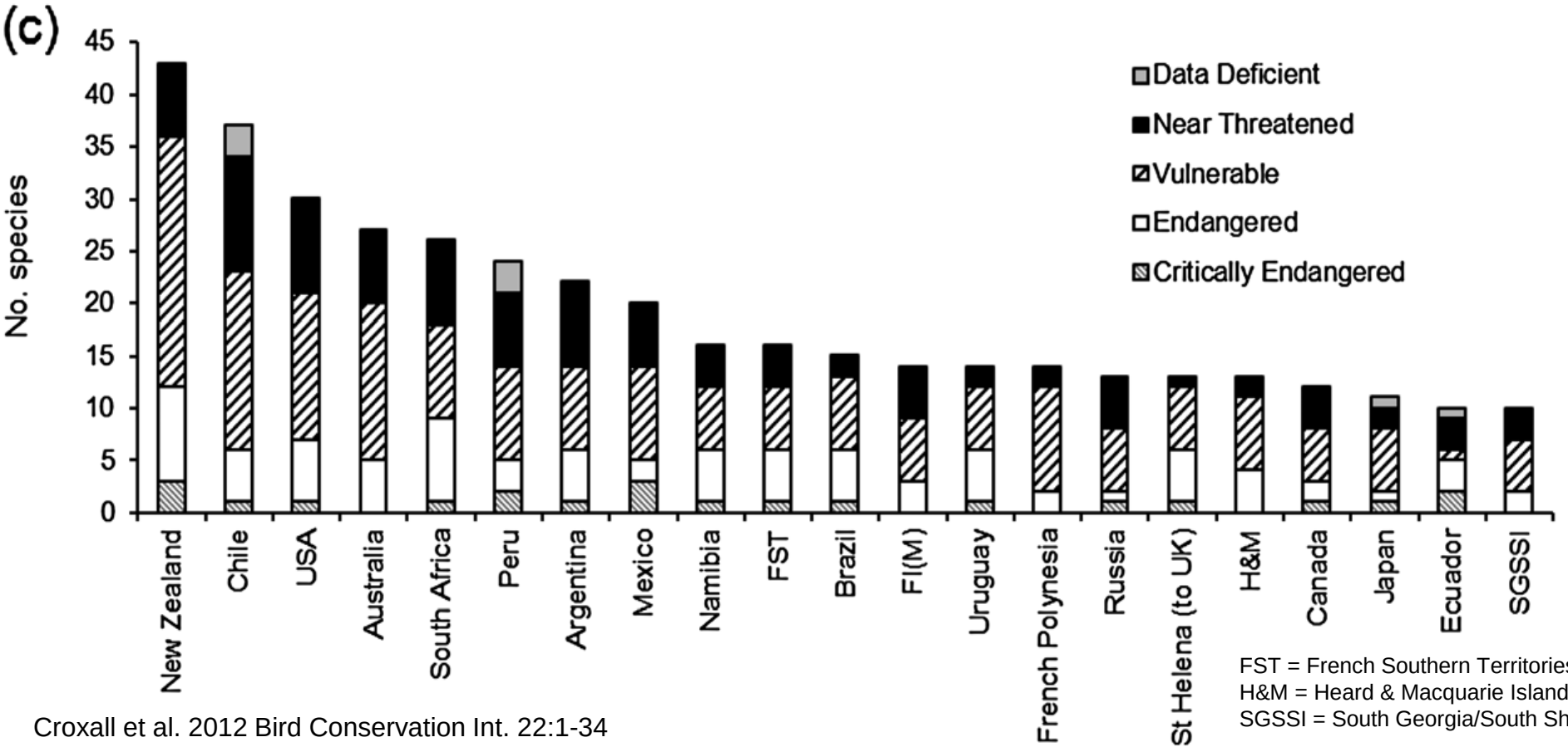
Why Southern Species?


Global Conservation Status of Seabirds



FST = French Southern Territories
H&M = Heard & Macquarie Islands
SGSSI = South Georgia/South Shet.

Croxall et al. 2012 Bird Conservation Int. 22:1-34

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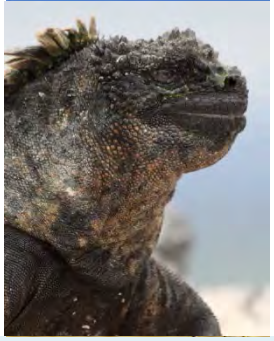
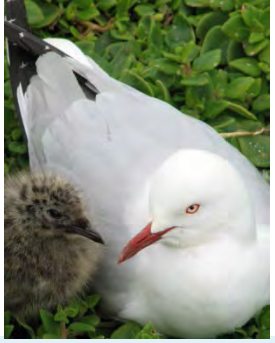
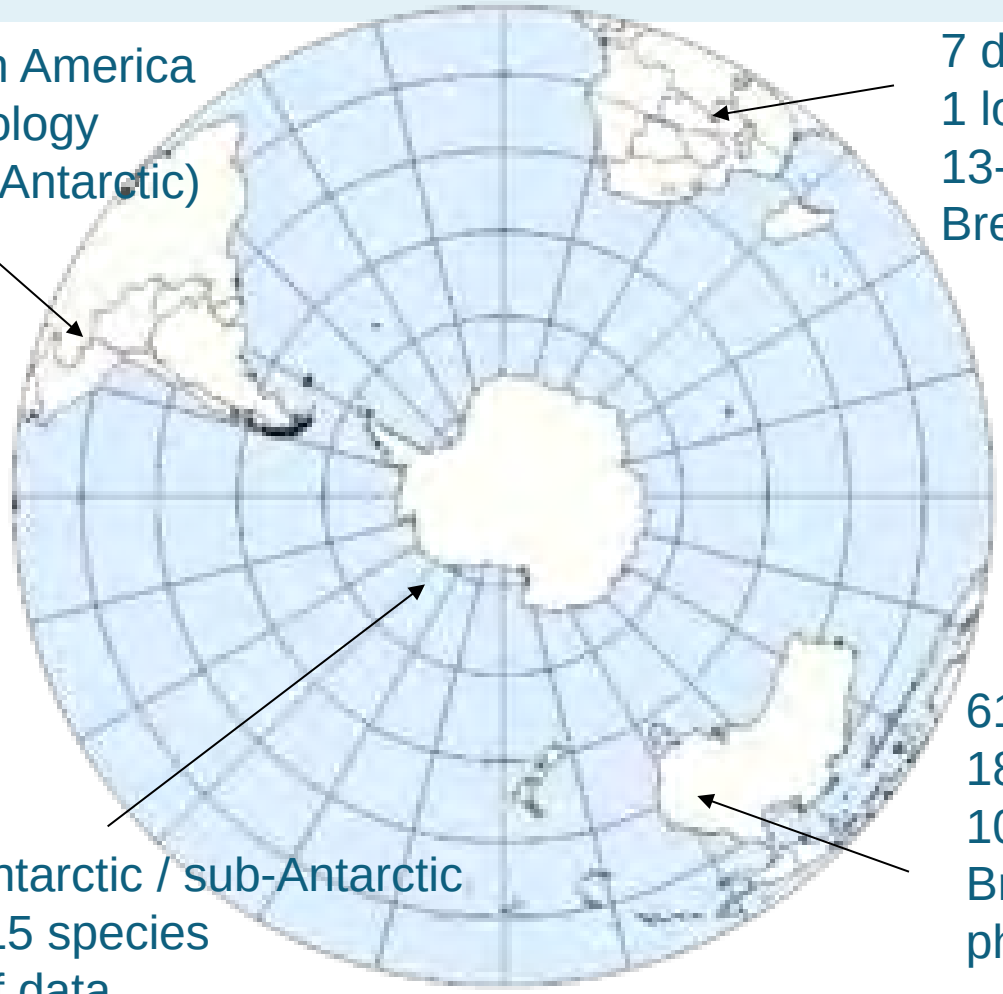
Phenology and Climate


1 dataset South America
Breeding phenology
(excluding sub-Antarctic)



7 datasets Africa
1 location, 1 species
13-23 years of data
Breeding & moult phenology

61 datasets Australia / NZ
18 locations, 22 species
10-63 years of data
Breeding, migration & moult phenology

49 datasets Antarctic / sub-Antarctic
19 locations, 15 species
10-55 years of data
Breeding, migration, Haulout phenology

Based on Chambers et al. 2013 PLOS ONE

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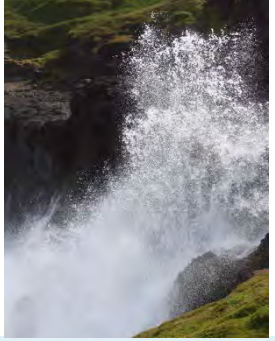
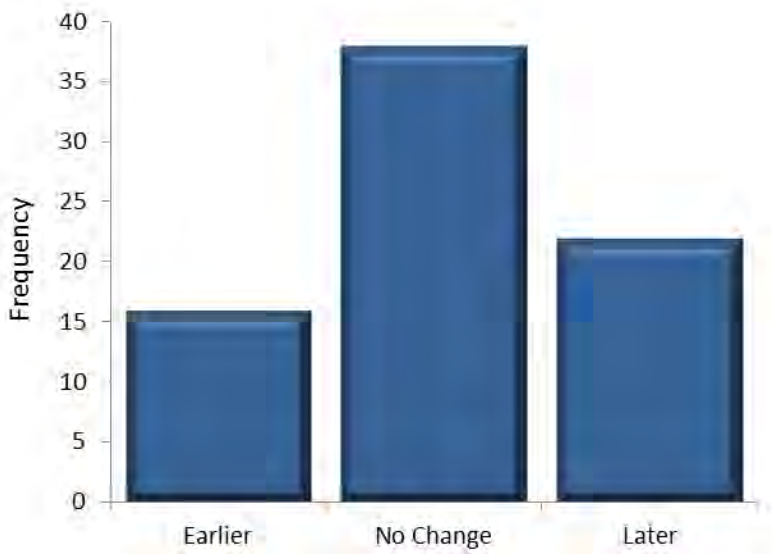
Phenology and Climate

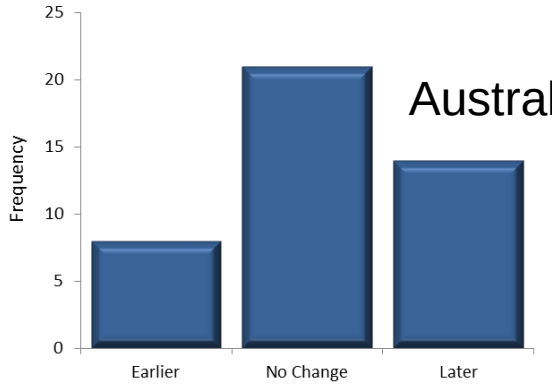



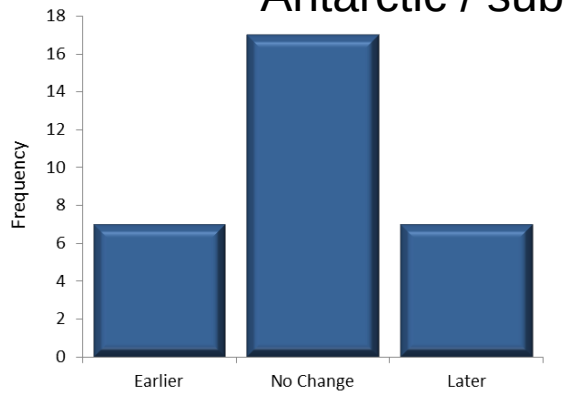

Observed changes in timing of phenology



Overall

(42 datasets not assessed for trends)





Based on Chambers et al. 2013 PLOS ONE

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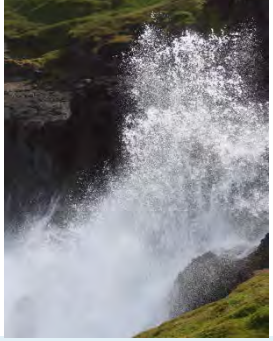
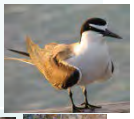
Phenology and Climate


Consistent response by species / family?

Family	No. Studies	No. Species	Earlier	No Change	Later	Breeding	Migration	
Charadriidae	12	4	2	5	4	1	11	 
Laridae	19	7	1	5	9	18	1	 
Procellariidae	14	7	0	6	4	9	5	 
Scolopacidae	7	3	4	3	0	0	7	 
Spheniscidae	58	12	8	17	4	40*	11*	 

Based on Chambers et al. 2013 PLOS ONE

* + 7 moult

Images: LE Chambers, except:

Sharp-tailed Sandpiper Image: Tony Whitehead

Red Knot Image: Eleanor Briccetti

Double-banded Plover, Black-fronted Dotterel Images: Duade Paton

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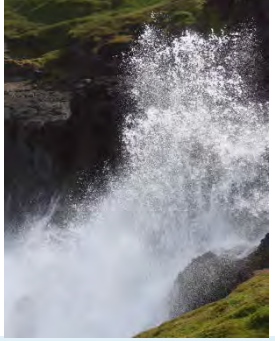
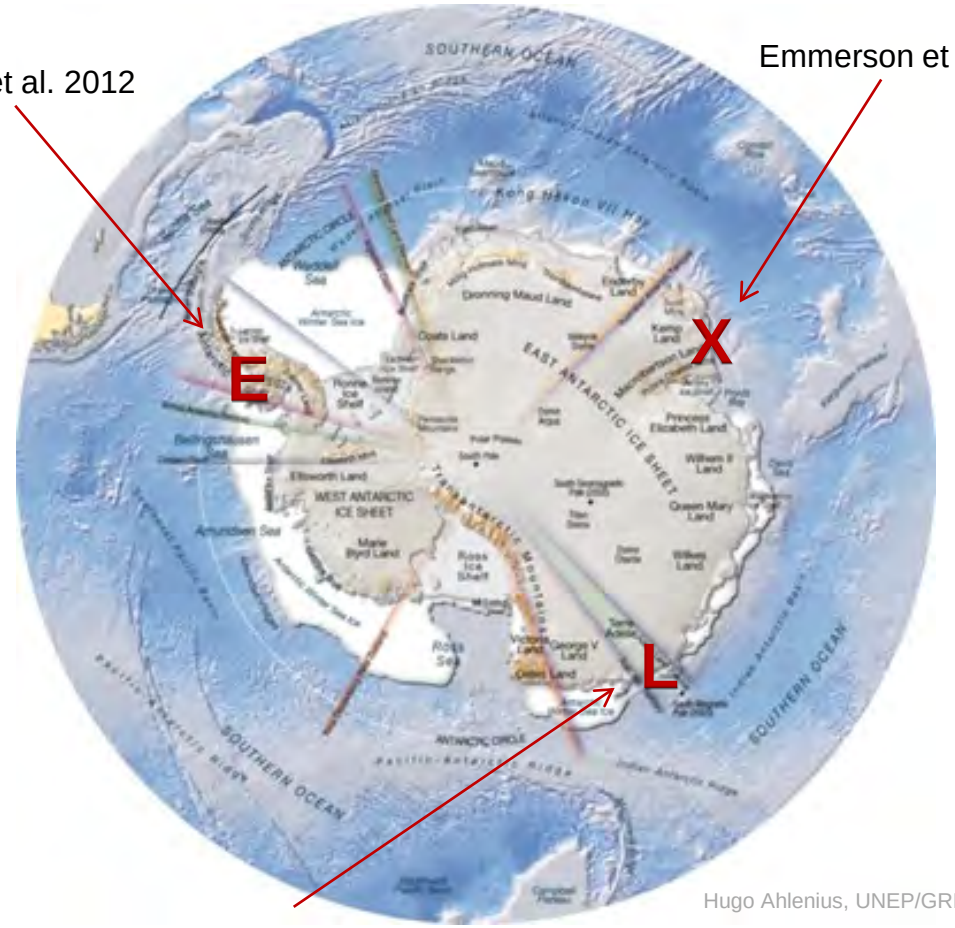
Phenology and Climate


Adélie Penguin

Image: http://en.wikipedia.org/wiki/Ad%C3%A9lie_penguin



Hugo Ahlenius, UNEP/GRID-Arendal

Barbraund & Weimerskirch 2006

Based on Chambers et al. 2014 Int J Biometeorol

Australian Government
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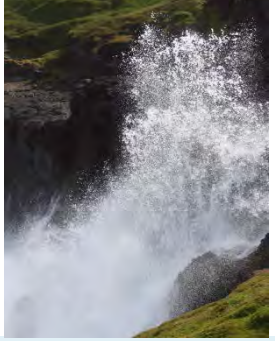
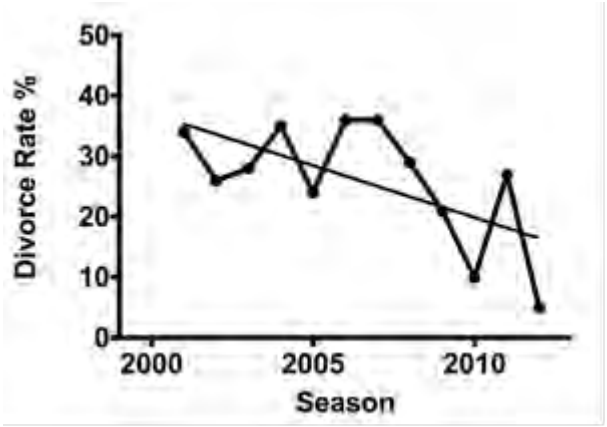
Phenology and Climate


Little Penguin

Chambers et al. 2014
Int J Biometeorol

Simpson 2014. Hons.
Monash University



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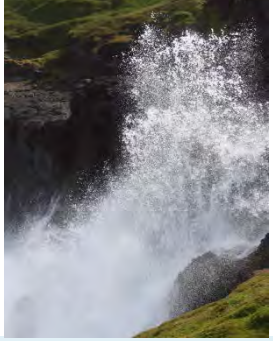
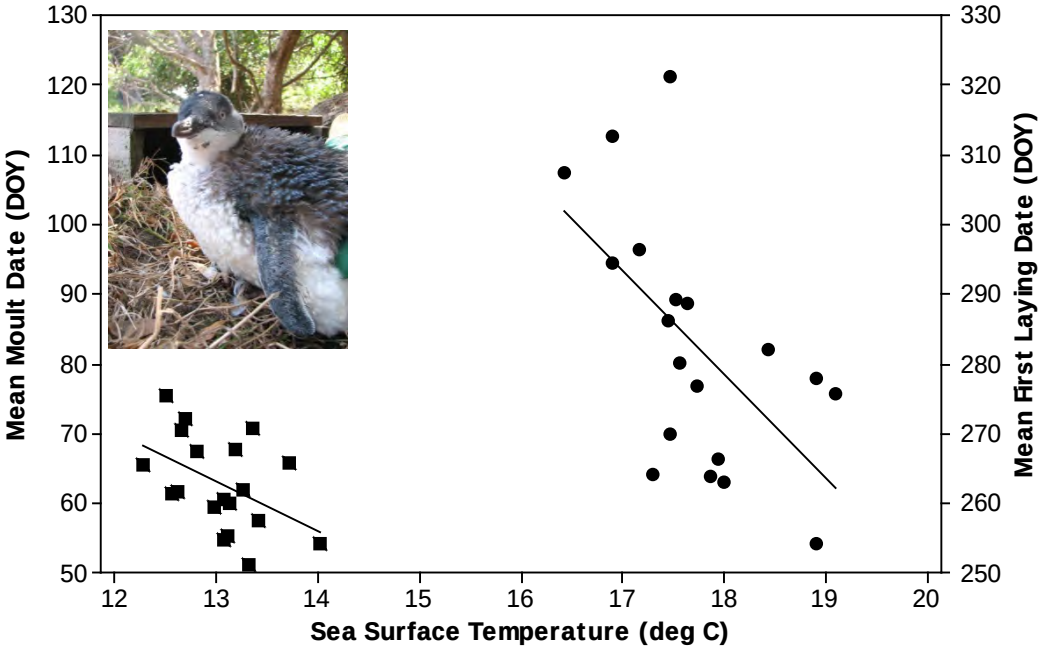
Phenology and Climate


Heat-related mortality – 25/2/12
MaxT 36ºC (climatological mean for Feb 23.8)



Images copyright:
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Chambers and Dann, in review

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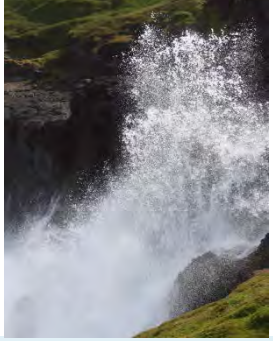


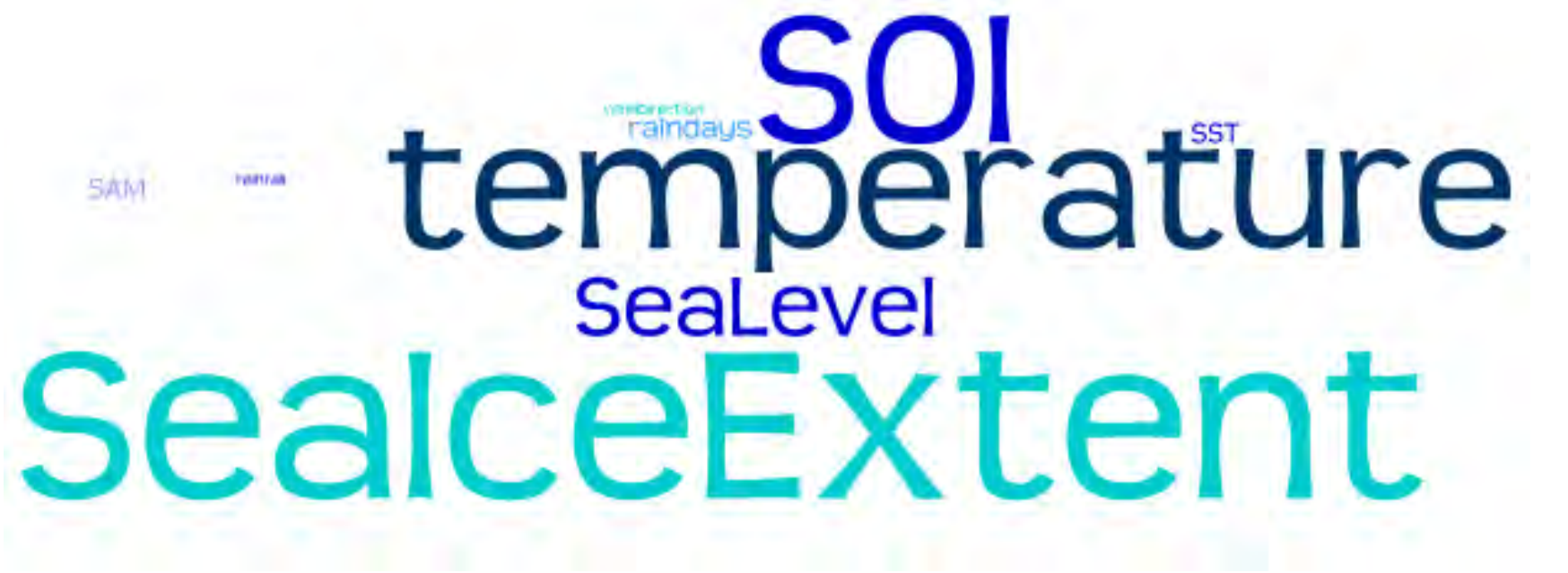

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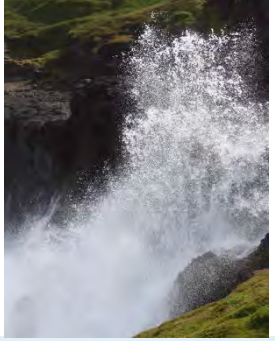
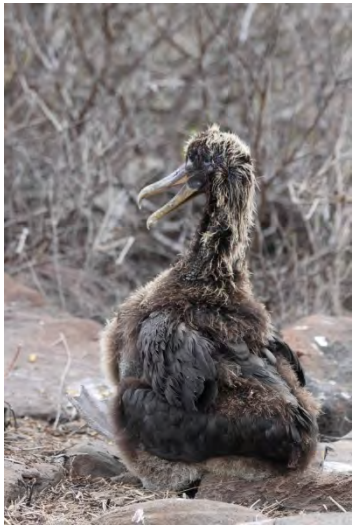



Short-tailed Shearwater
Fixed migration and breeding timing?

Heat stressed seabirds

Rock pools aid cooling in fur seals



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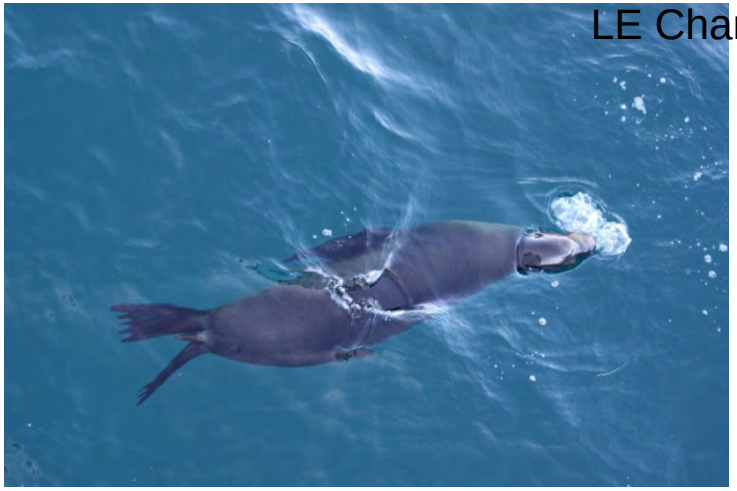
Adaptation



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Adaptation

Sequential Adaptation Prioritization for Species (SAPS)

- Stage 1
  - Generate Options
- Stage 2
  - Technical Assessment
- Stage 3
  - Institutional Assessment
- Stage 4
  - Social Assessment

Hobday et al. (in review)

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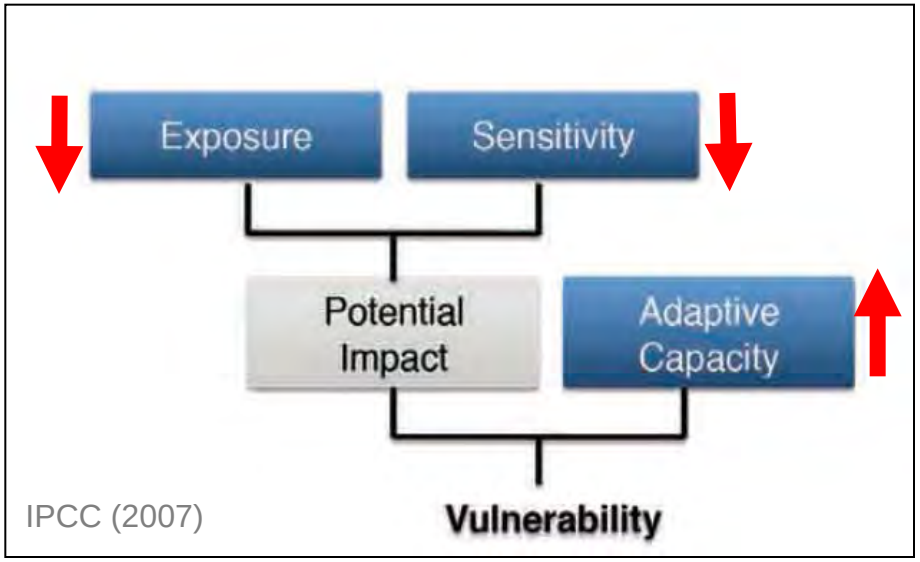
Adaptation

Stage 1: Generating Options



IPCC (2007)

- Reduce exposure
  - Translocation
  - Habitat modification
- Reduce sensitivity
  - Selective breeding
  - Nest modification
- Enhance adaptive capacity
  - Population enhancement
  - Reduce stressors (e.g. predator control)
  - Habitat enhancement

Hobday et al. (in review)

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Adaptation

Stage 1: Generating Options

Image: Jane McKenzie

Build rock pools for cooling during breeding

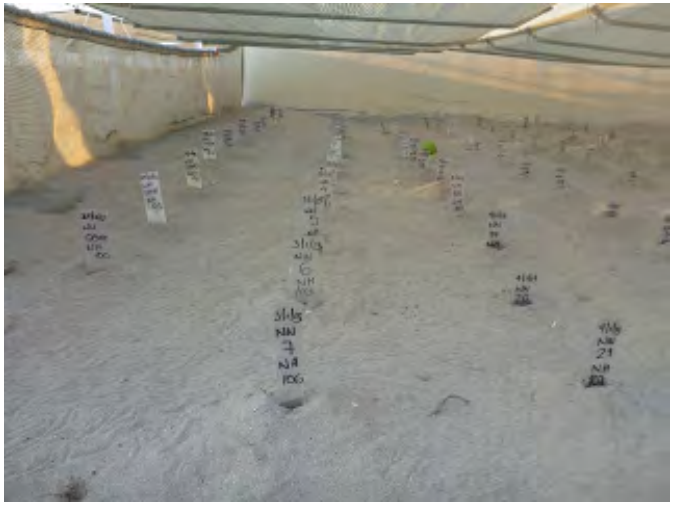

Image:shindigsailing.com (Mexico)

Shade cloth over nests during turtle or seabird breeding periods

Shading breeding and moult sites using vegetation

Hobday et al. (in review)

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Adaptation

Stage 1: Generating Options

Cull competitor species

Shark deterrents near seal colonies

Hobday et al. (in review)

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Adaptation

Stage 2: Technical Assessment

Box 2. Criteria used to score the adaptation scenarios (low=1, medium =2, high =3) in three categories (cost, benefit, risk)

Cost

1. Implementation cost
   <$10K = L, 10K-1M =2, > 1M$ = H
2. Ongoing cost
   <5 years=L, 5-10 years=M, >10 years=H
3. Time to implement – lead time till action can begin
   Now=L, 1-5 years=M, >5 years=H

Benefit

4. Persistence of action
   1 season, <5 seasons, >5 seasons
5. Scale of benefit
   Individual/colony/population
6. Benefit of action to target group
   Minimal improvement, partial solution, solve problem
7. Benefit of action to wider ecosystem
   Low, medium, high

Risk

8. Risk of action failing
   <33%, 33-66%, >66%
9. Risk of mal-adaptation - negative outcome on another strategy for target group
   Low, medium, high
10. Risk of adverse impacts to wider (eco)system
    Low, medium, high

Hobday et al. (in review)

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Adaptation

Stage 2: Technical Assessment

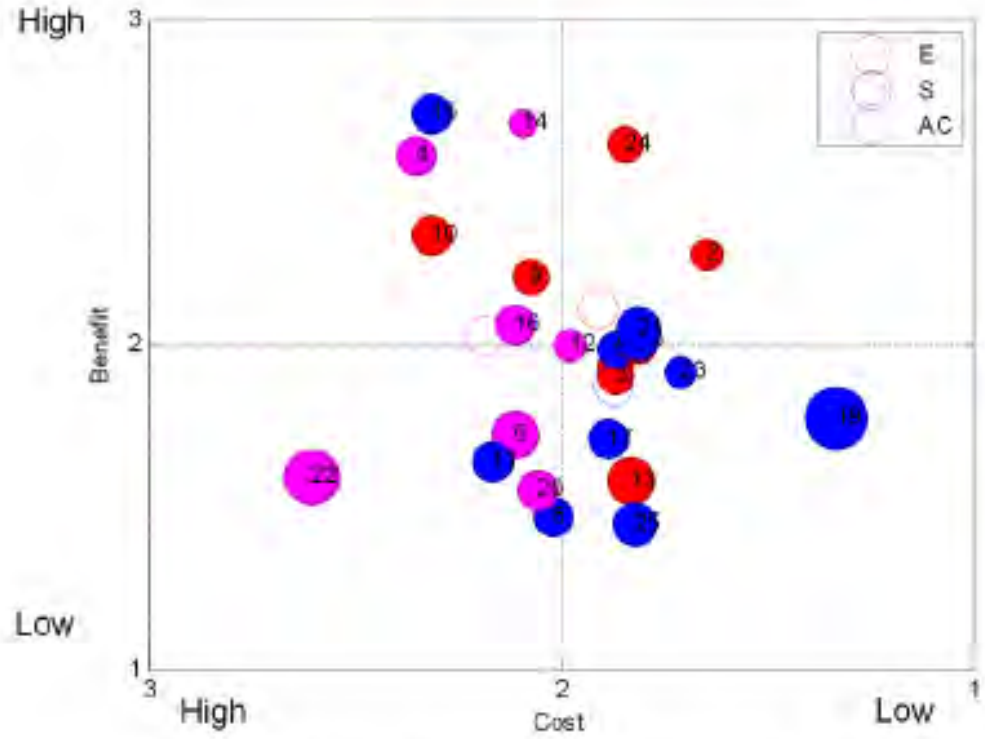

Figure 16. Summary cost-benefit-risk plot for 25 adaptation options evaluated in the project, (numbered, as in **Table 13**). Open circles represent the mean value for the exposure (E), sensitivity (S) and adaptive capacity (AC) options. The size of the bubbles represents the risk score (small represent low risk, large is higher risk).

Hobday et al. (2014)

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Bureau of Meteorology

Adaptation

Stage 2: Technical Assessment – low benefit, high cost

- Fish farming for marine species to feed on (also seen as high risk)
- Artificial feeding of female seals during gestation period (low-mid risk)

Images: modernfarmer.com; Peteroshkai.com

Hobday et al. (2014)

Australian Government
Bureau of Meteorology

Adaptation

Stage 2: Technical Assessment – high benefit, low cost

- Translocate seabird chicks to new location (site fidelity) (medium risk)
- Shade burrows with shrubby vegetation (low risk)

Images copyright LE Chambers

Hobday et al. (*in review*)

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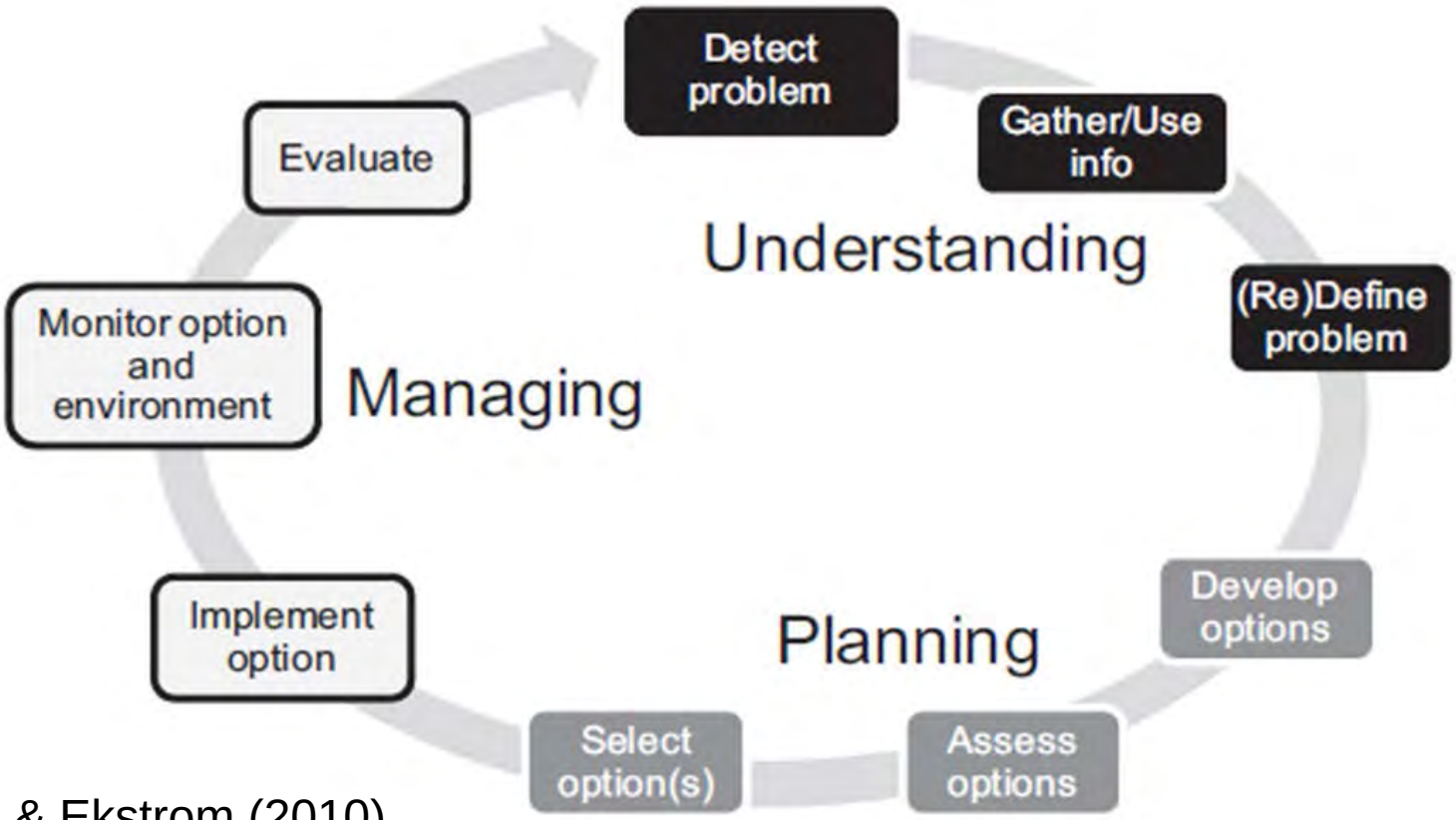
Adaptation

Stage 3: Institutional Assessment



Moser & Ekstrom (2010)

Hobday et al. (in review)

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Adaptation

Stage 3: Institutional Assessment

Build rock pools for cooling during breeding

Fish farming for marine species to feed on

Reduce brood size to increase condition and survival of remaining chick

Shark deterrents near seal colonies

Hobday et al. (in review)

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Adaptation

Stage 4: Evaluating Social Acceptability

- Technical experts
- Technical experts as public
- Public

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Adaptation

Overall Ranking of Adaptation Options

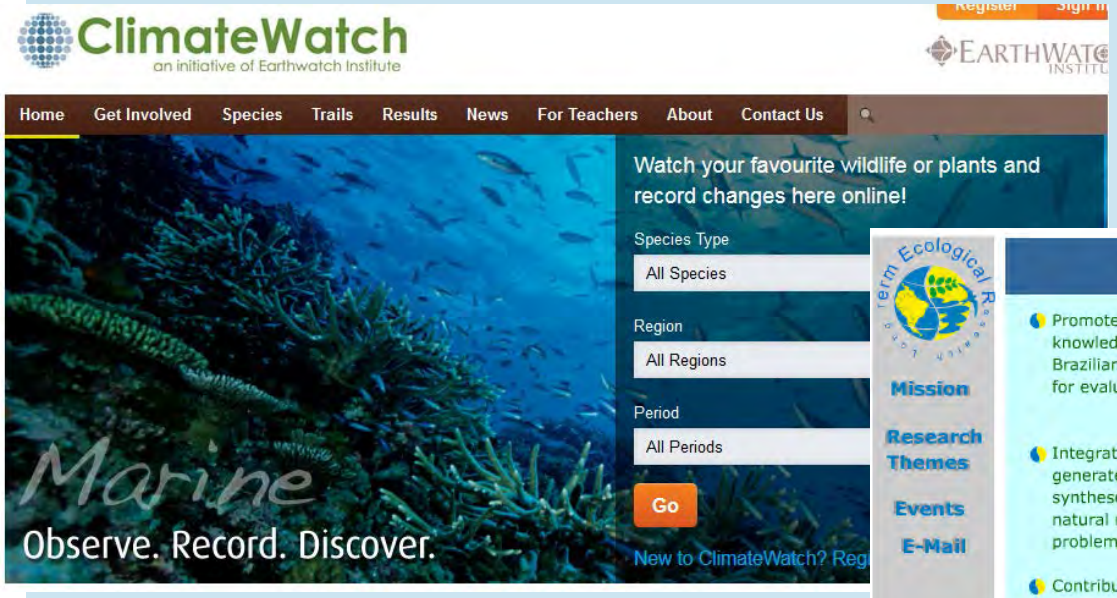
Rank	Scenario	Taxa	Average rank	Stage 2 Technical	Stage 3 Barriers	Stage 4 Acceptability	Vulnerability Category
1	2	B	2.00	3	2	1	E
2	4	B	5.33	6	5	5	AC
2	24	B	5.33	1	1	14	E
4	14	B	6.67	2	16	2	AC
5	23	M	7.33	8	7	7	S
6	18	M	7.67	9	3	11	S
7	7	B	8.00	10	8	6	E
8	10	B	8.33	13	4	8	E
8	15	M	8.33	5	17	3	S
10	21	B	9.00	7	10	10	S
11	1	M	11.00	14	6	13	E
12	3	M	13.00	15	12	12	E
13	12	M	13.67	16	21	4	AC
14	5	M	14.33	12	23	8	S
14	9	M	14.33	11	11	21	E
16	19	B	14.67	4	15	25	S
17	16	B	16.00	17	9	22	AC
17	25	B	16.00	20	13	15	S
19	13	B	18.33	19	18	18	E
20	8	B	20.33	23	14	24	S
21	6	B	20.67	21	24	17	AC
21	11	B	20.67	24	19	19	S
21	20	B	20.67	22	20	20	AC
24	22	B	21.00	25	22	16	AC
25	17	B	22.00	18	25	23	S

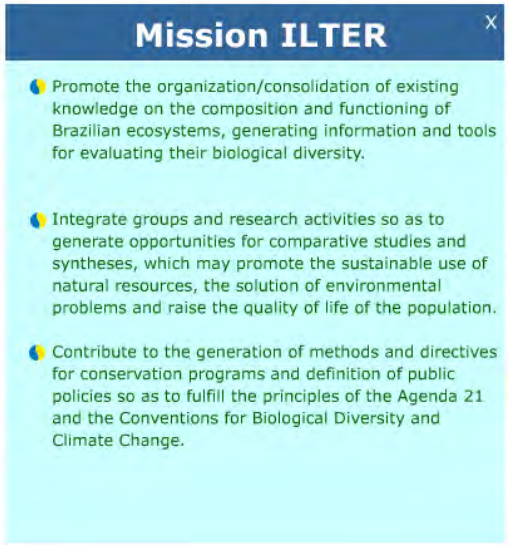
* Green shading indicates the option was in the upper third for the stage, orange indicates it was in the lower third, and yellow indicates the middle third.

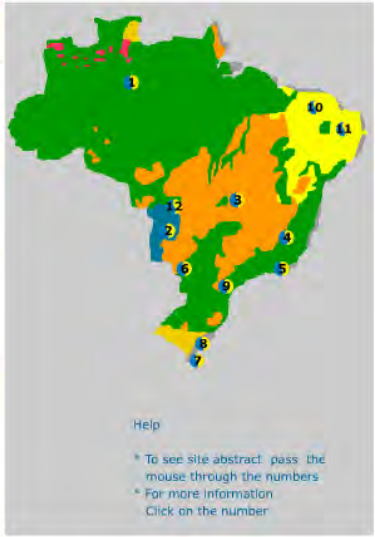
Hobday et al. (in review)

Summary
and ways forward

- Knowledge of phenology of southern marine species improving
- Climate an important driver







Summary
and ways forward

Australian Government
Bureau of Meteorology

phillipisland nature parks australia

CSIRO

Adaptation – identifying and prioritizing actions

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phillipisland
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CSIRO

Thank you…

Dr Lynda Chambers
Bureau of Meteorology, Environment and Research Division
L.Chambers@bom.gov.au