Metapopulation tracking juvenile penguins reveals an ecosystem-wide ecological trap

Richard B. Sherley, K. Ludynia, B. M. Dyer, T. Lamont, A. B. Makhado, J-P. Roux, K. L. Scales, L.G. Underhill & S. C. Votier

Email: r.sherley@exeter.ac.uk Twitter: @rbsherley Web: http://richardsherley.com

UNIVERSITY OF EXETER | ENVIRONMENT AND SUSTAINABILITY INSTITUTE

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Biological Sciences

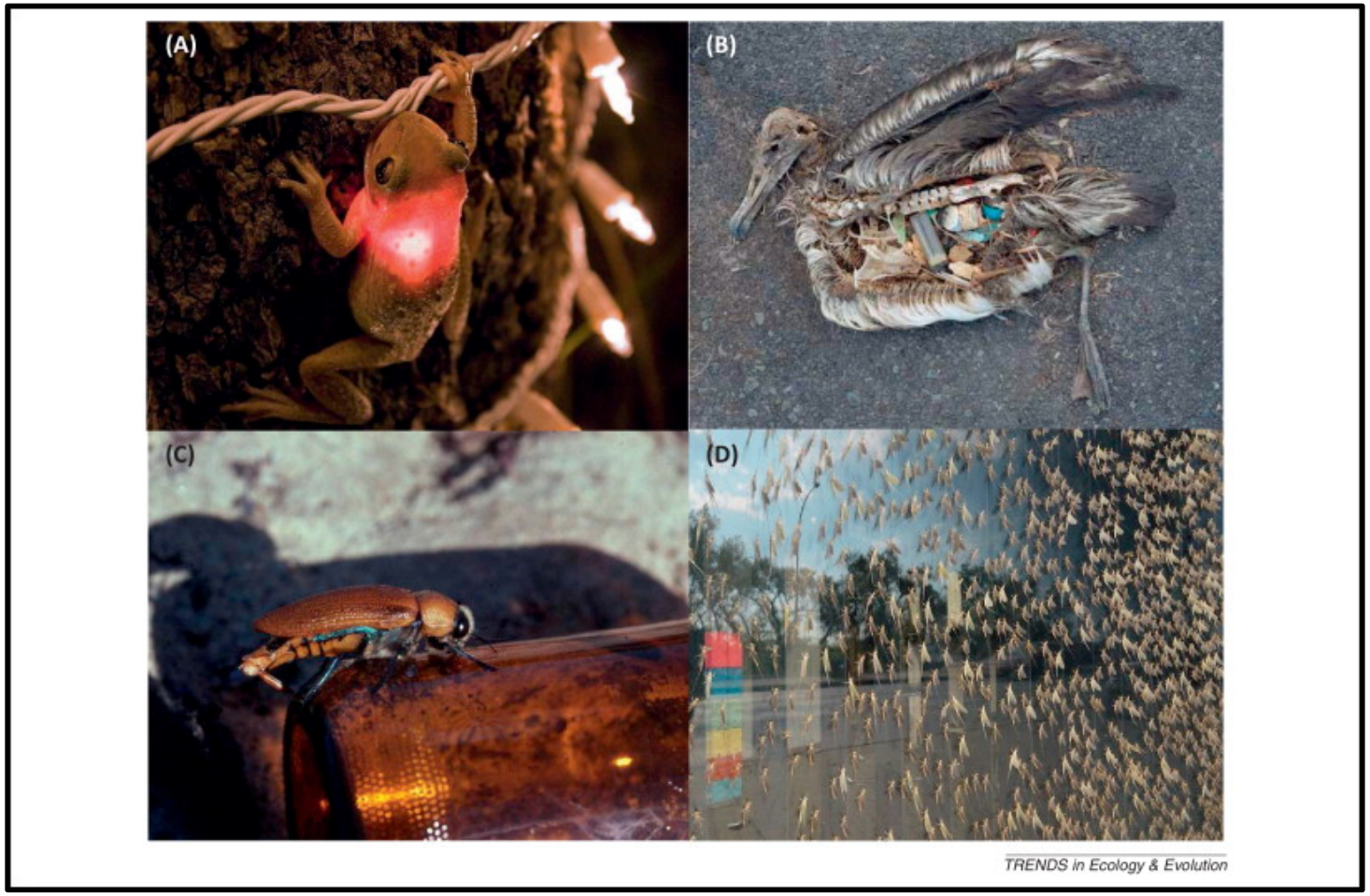
Bristol Zoological Society
Saving Wildlife Together

Human-induced rapid environmental change

From McCauley et al. 2015, Science 347: 1255641.

- Humans are rapidly altering marine systems

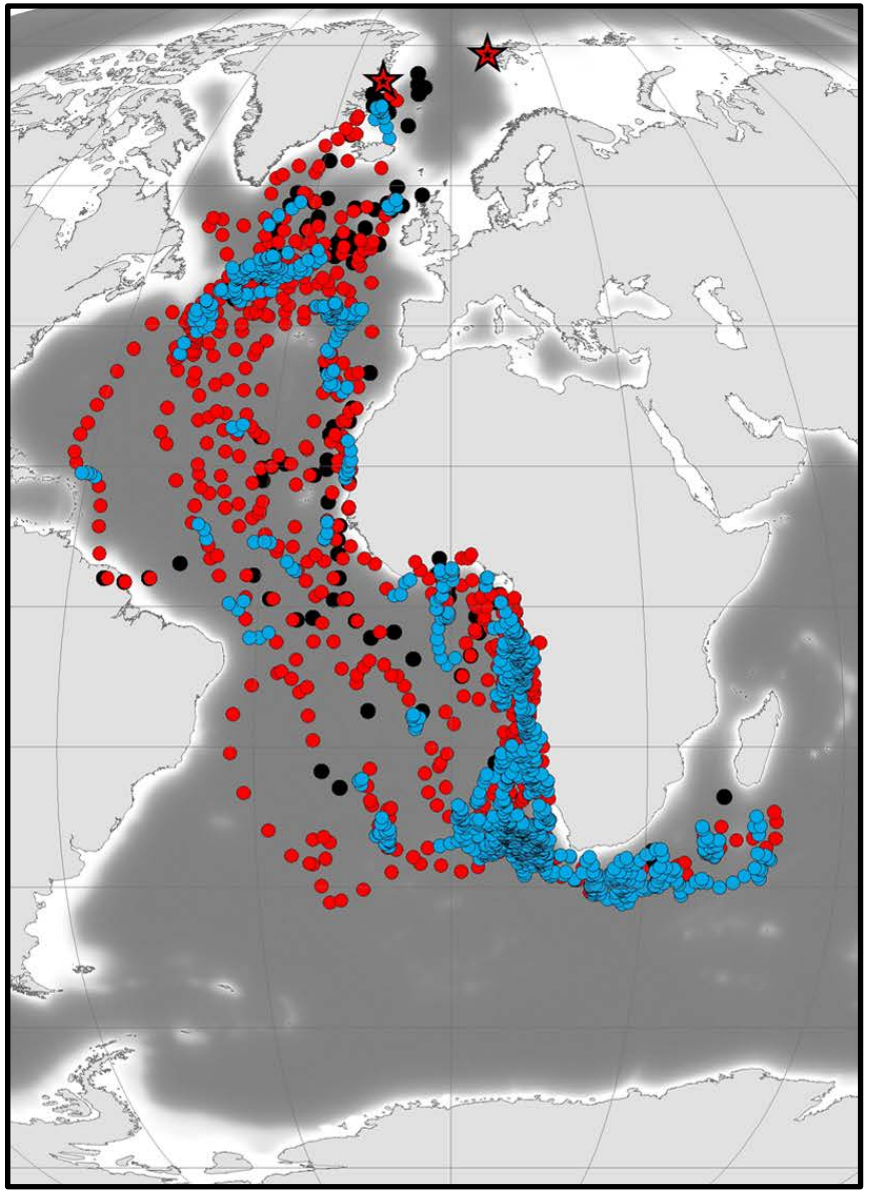
Ecological traps



From Robertson et al. 2013, TREE 28: 552–560.

- Mismatches between cues and fitness
- Can induce rapid population decline

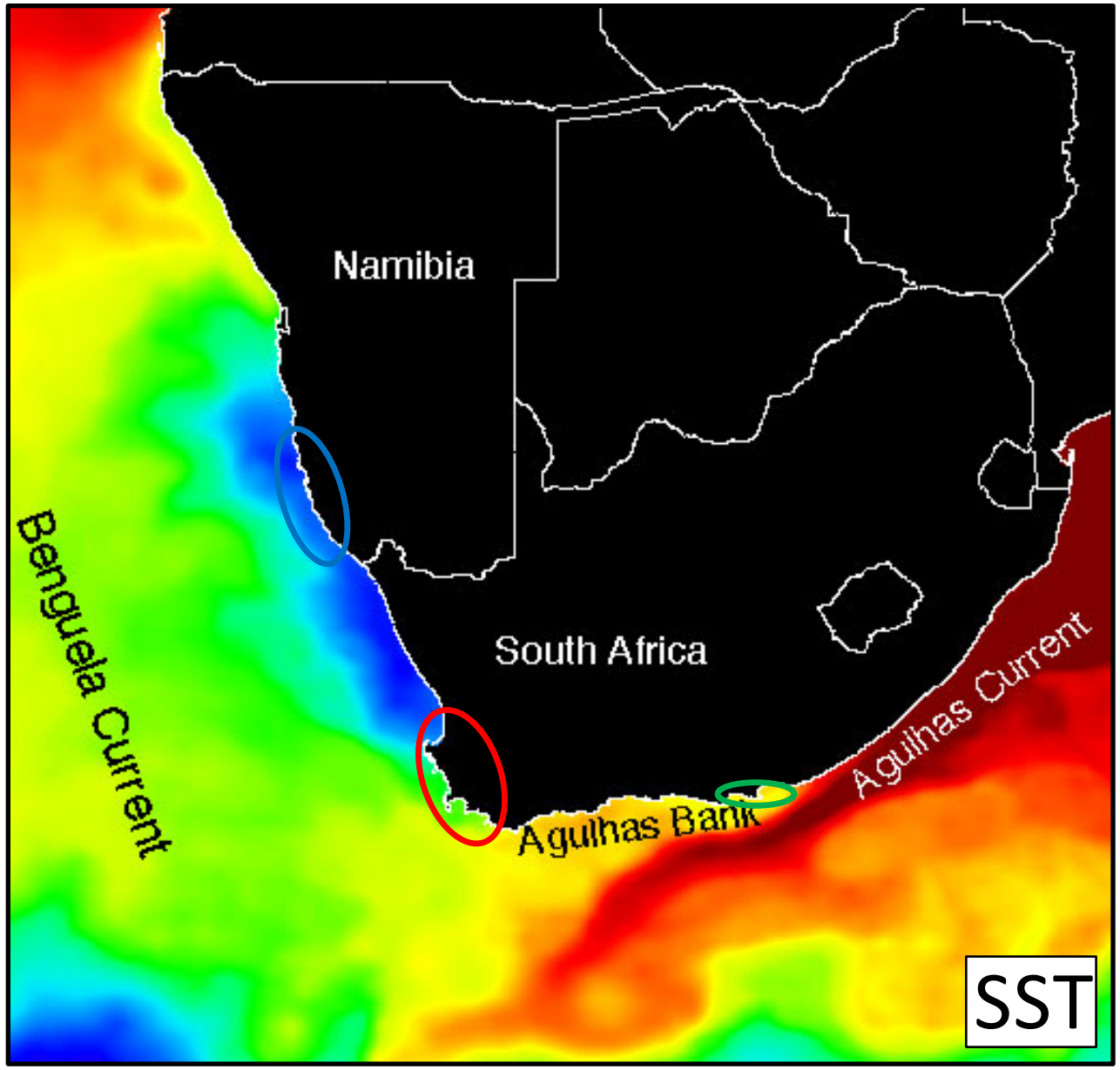
Tracking migratory and mobile marine species



From Glig et al. 2013, PLoS One 8: e64614.

- Focused on adults/breeders
  - Risk differs over life-cycle
- Flexible or vulnerable to change?

Rapid environmental change in the Benguela

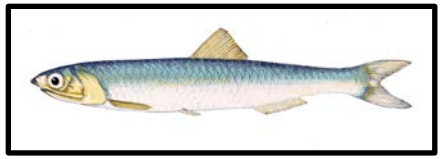


African penguin

Spheniscus demersus

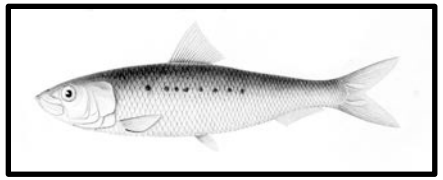
Breed in Namibia, the Western Cape and the Eastern Cape

And eats:



Cape anchovy

Engraulis encrasicolus



Sardine

Sardinops sagax

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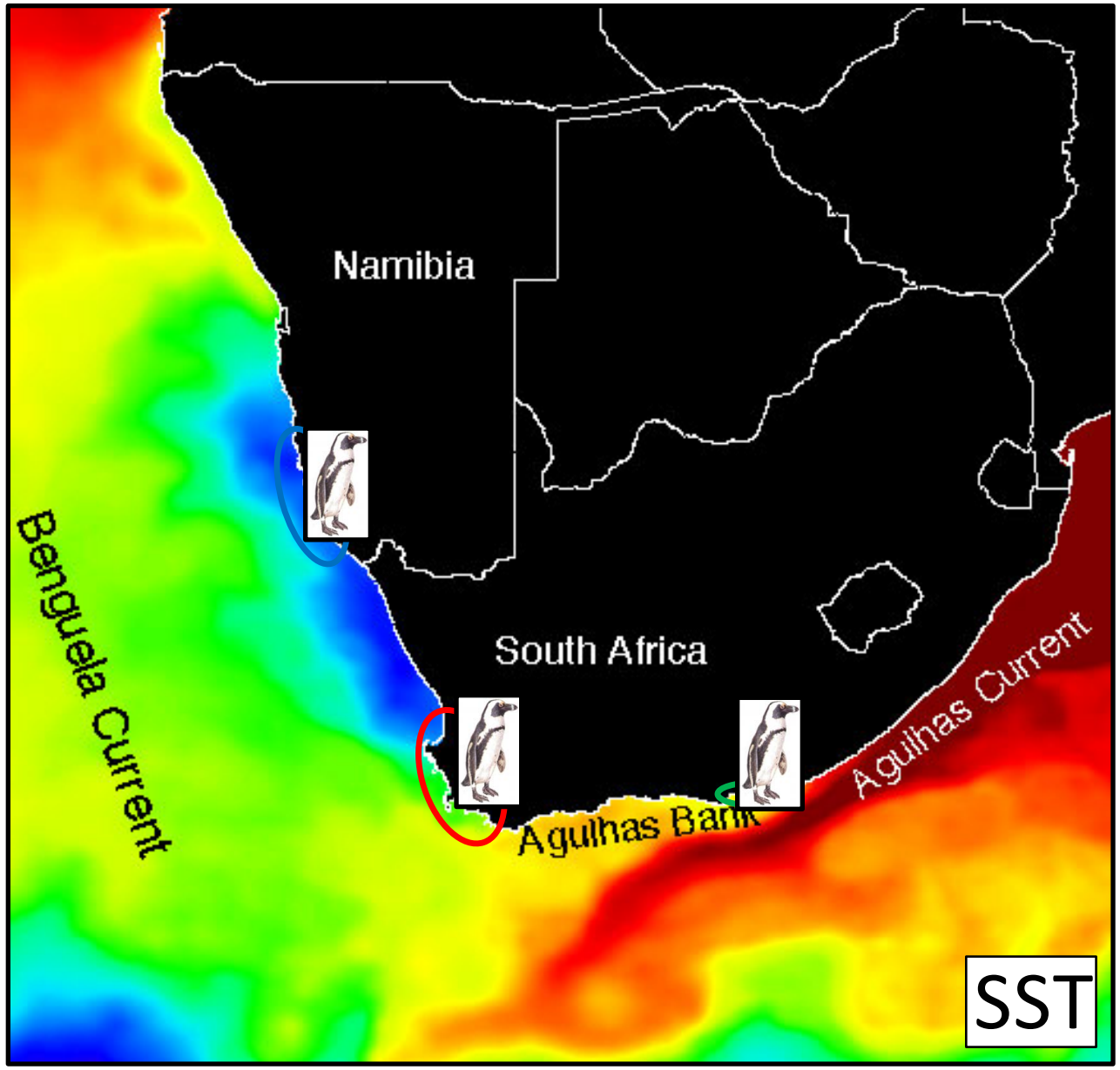

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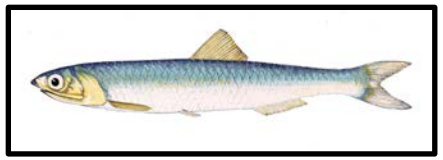

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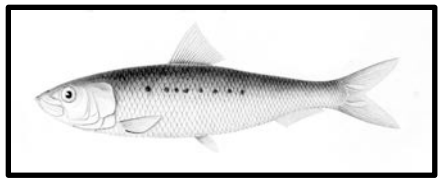

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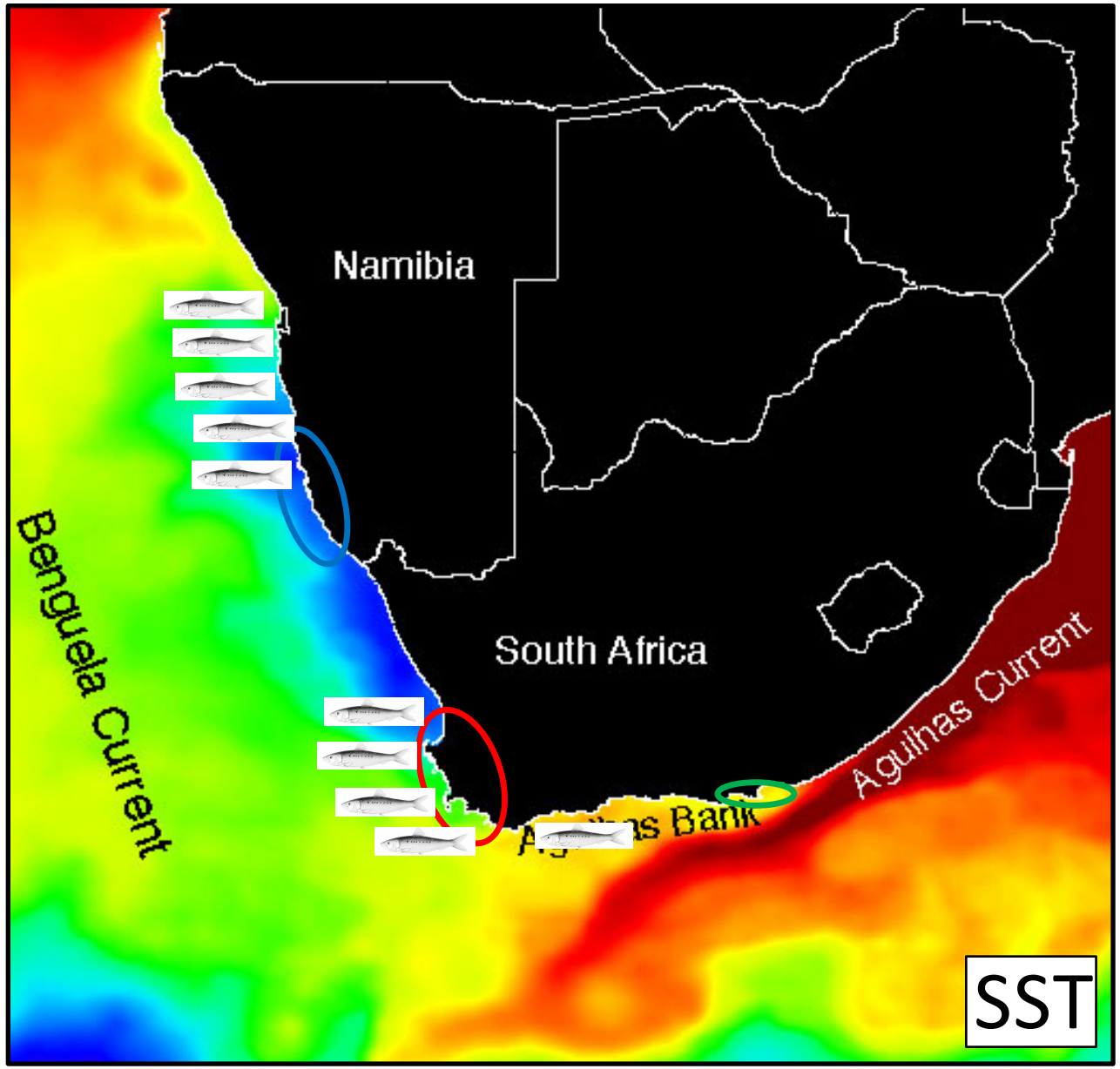

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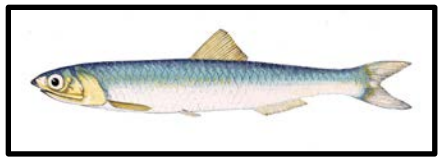

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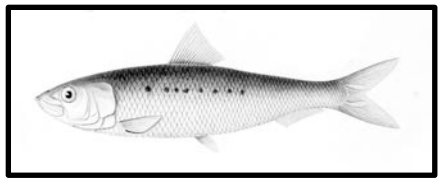

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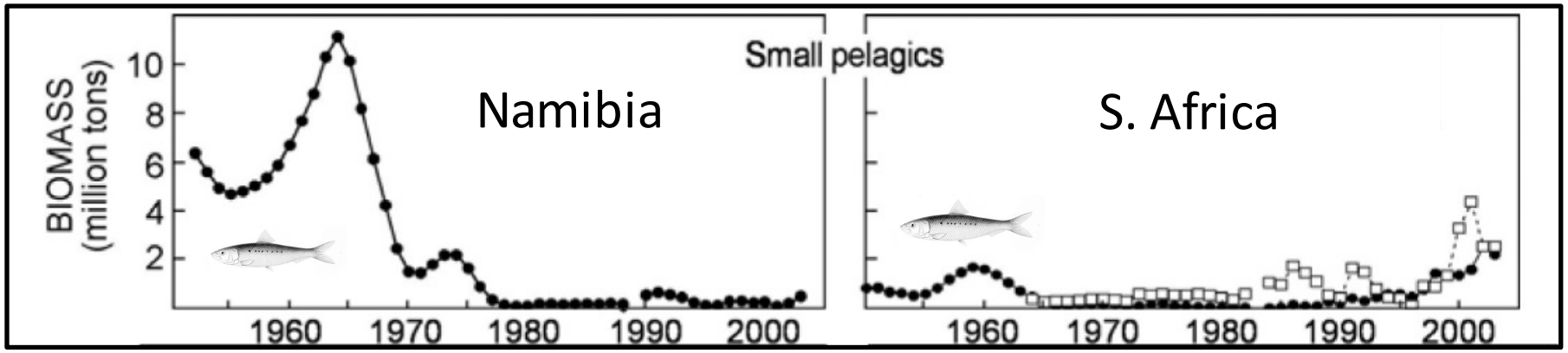

Modified from van der Lingen et al. 2006, Large Marine Ecosystems Vol 14, Elsevier

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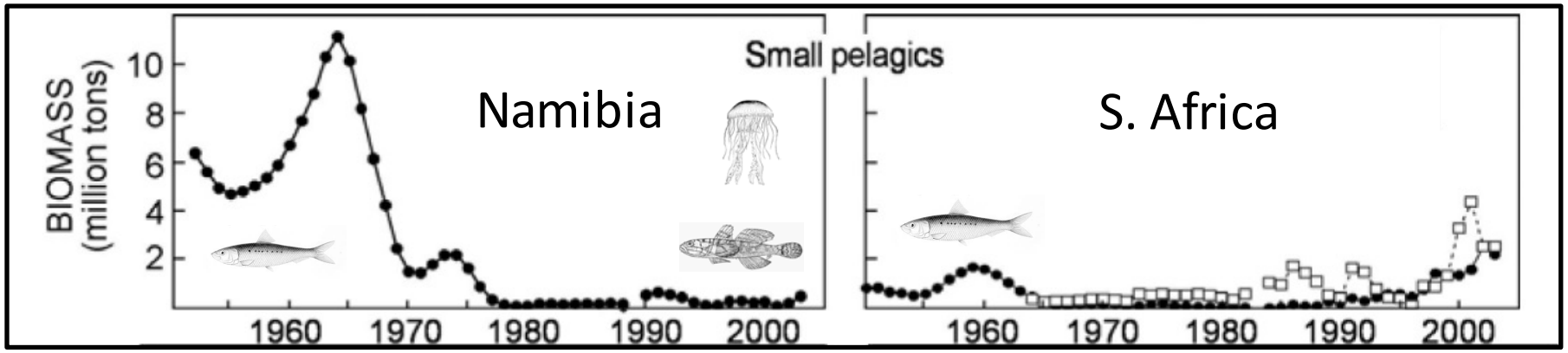

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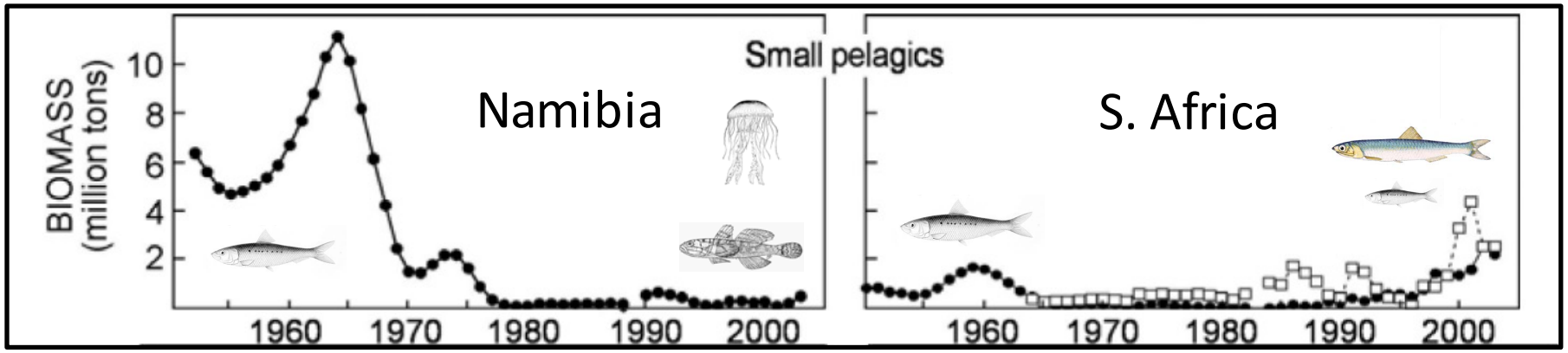

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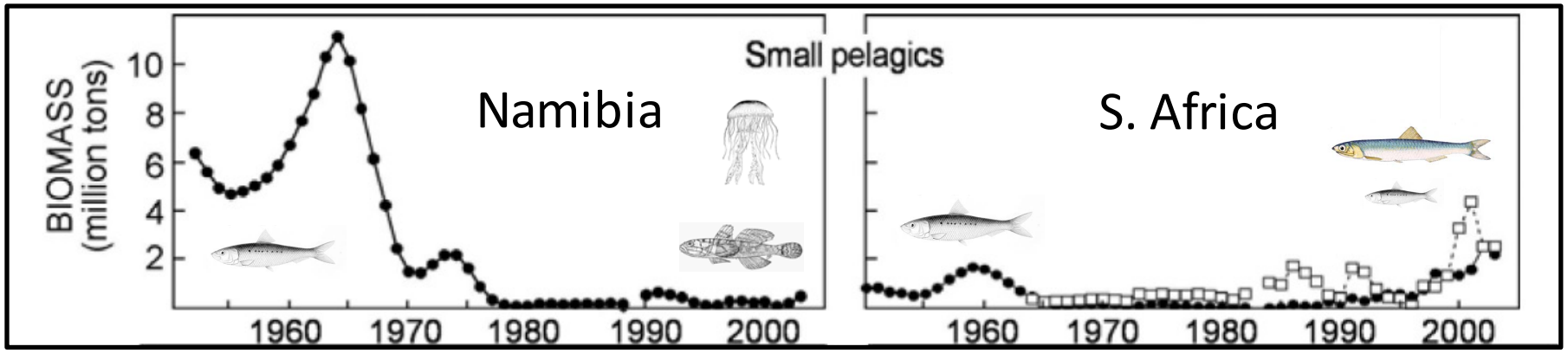

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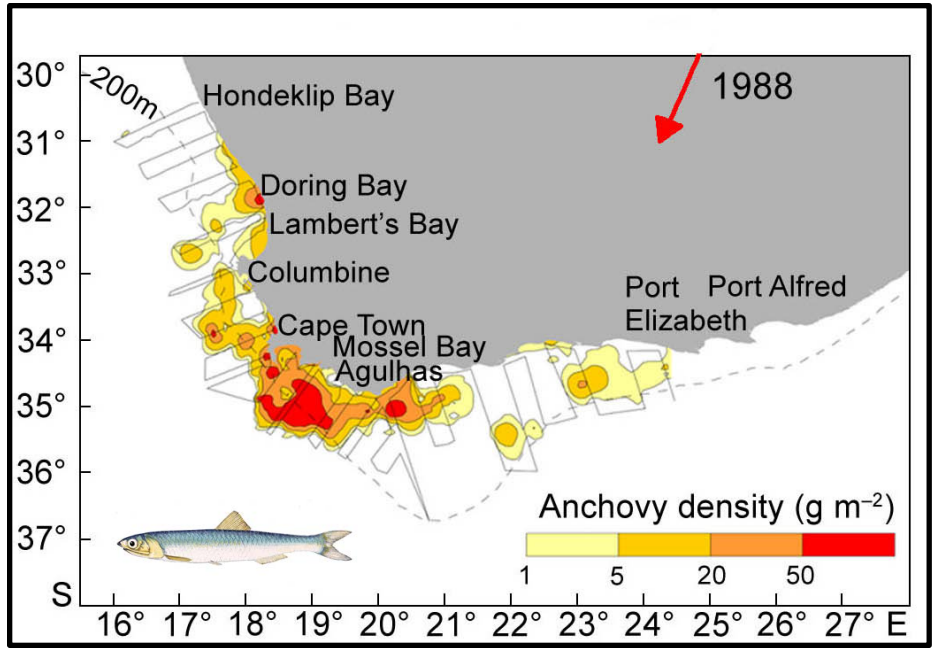

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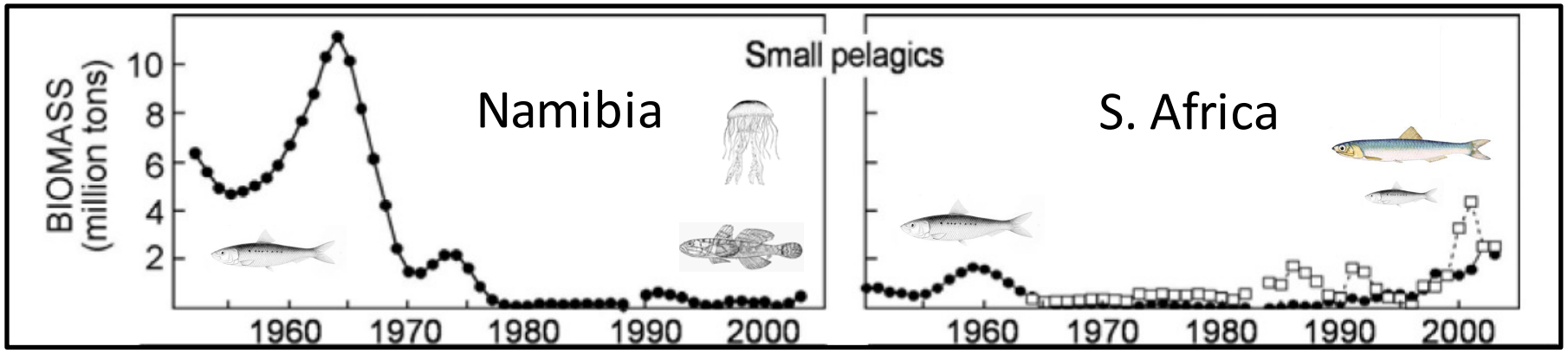

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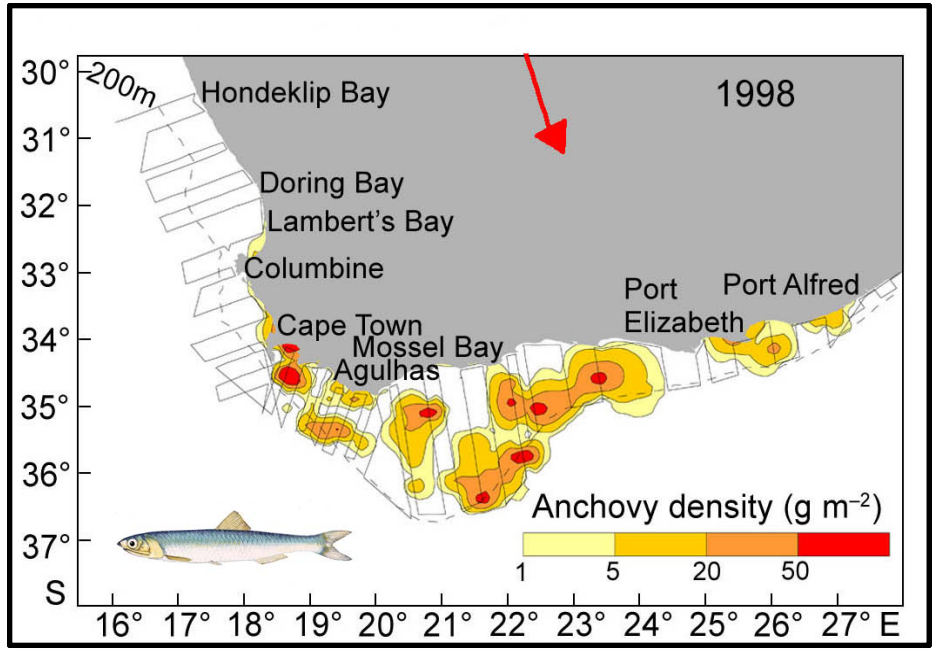

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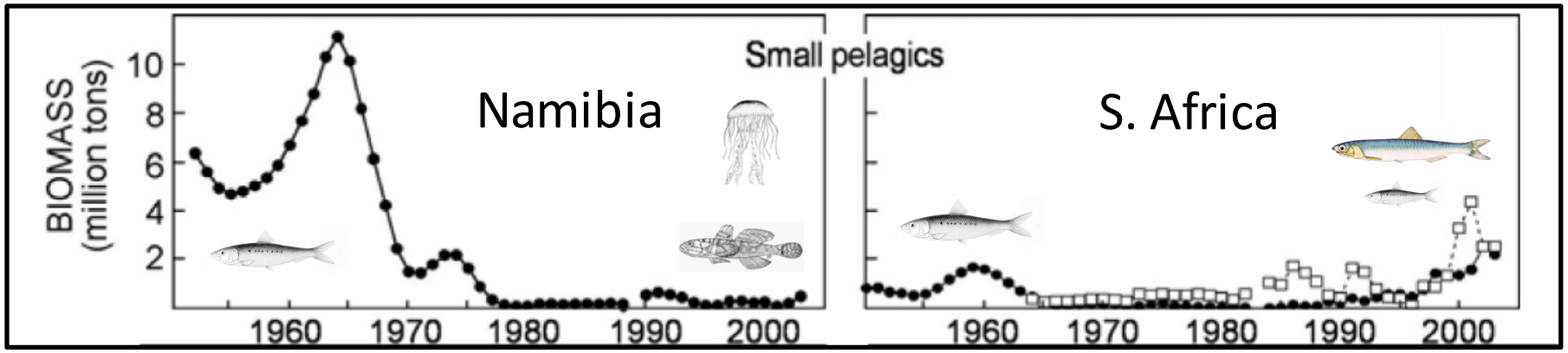

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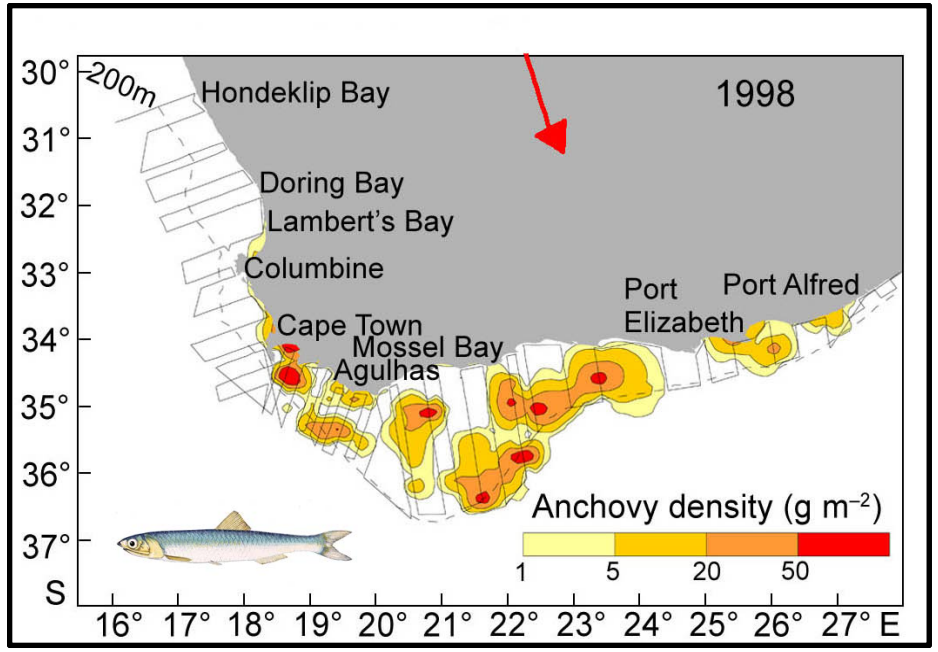

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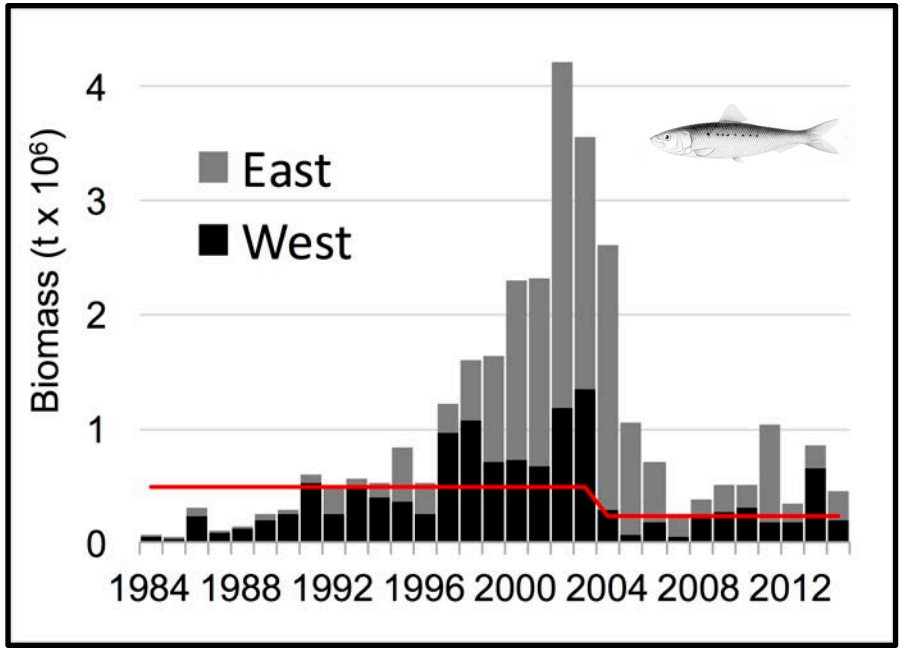
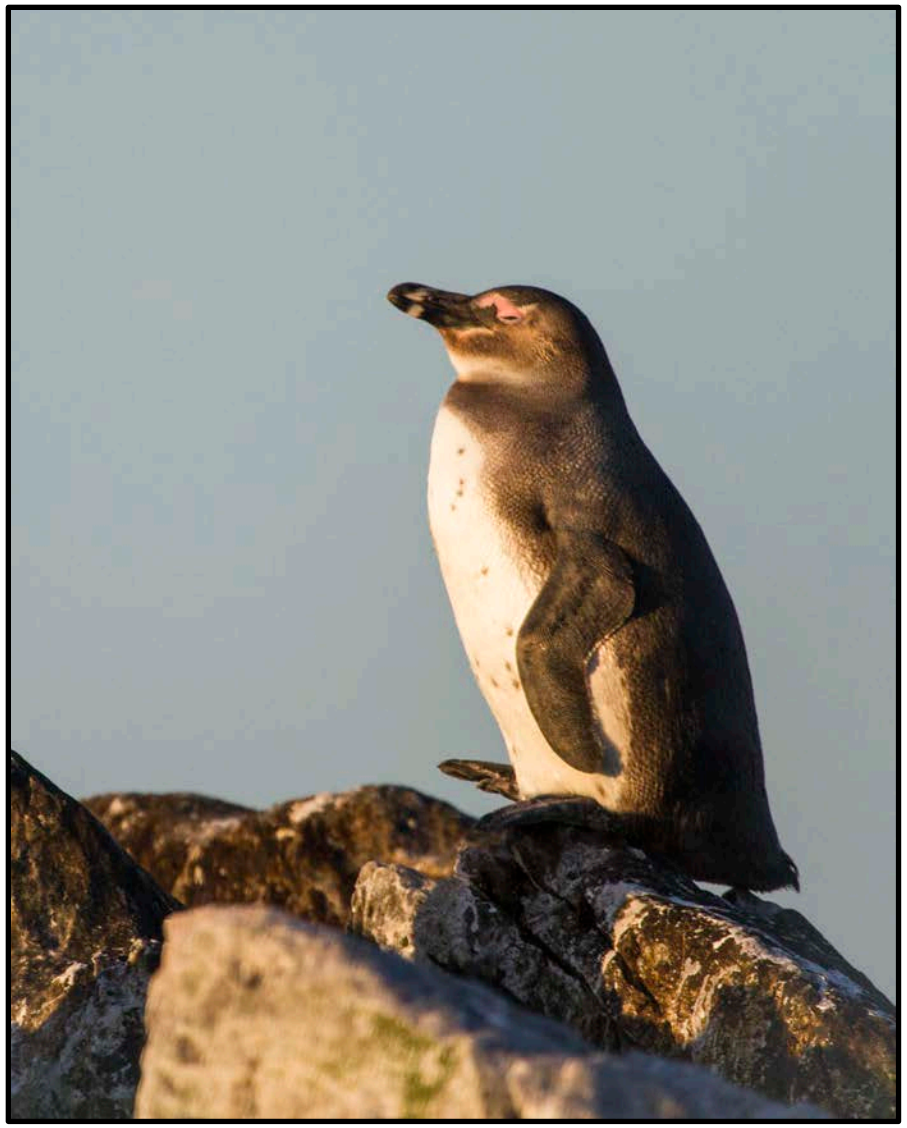


Updated from Coetzee et al. 2008, ICES J. Mar. Sci. 65: 1676–1688

Aims



- Identify critical foraging habitat for juveniles

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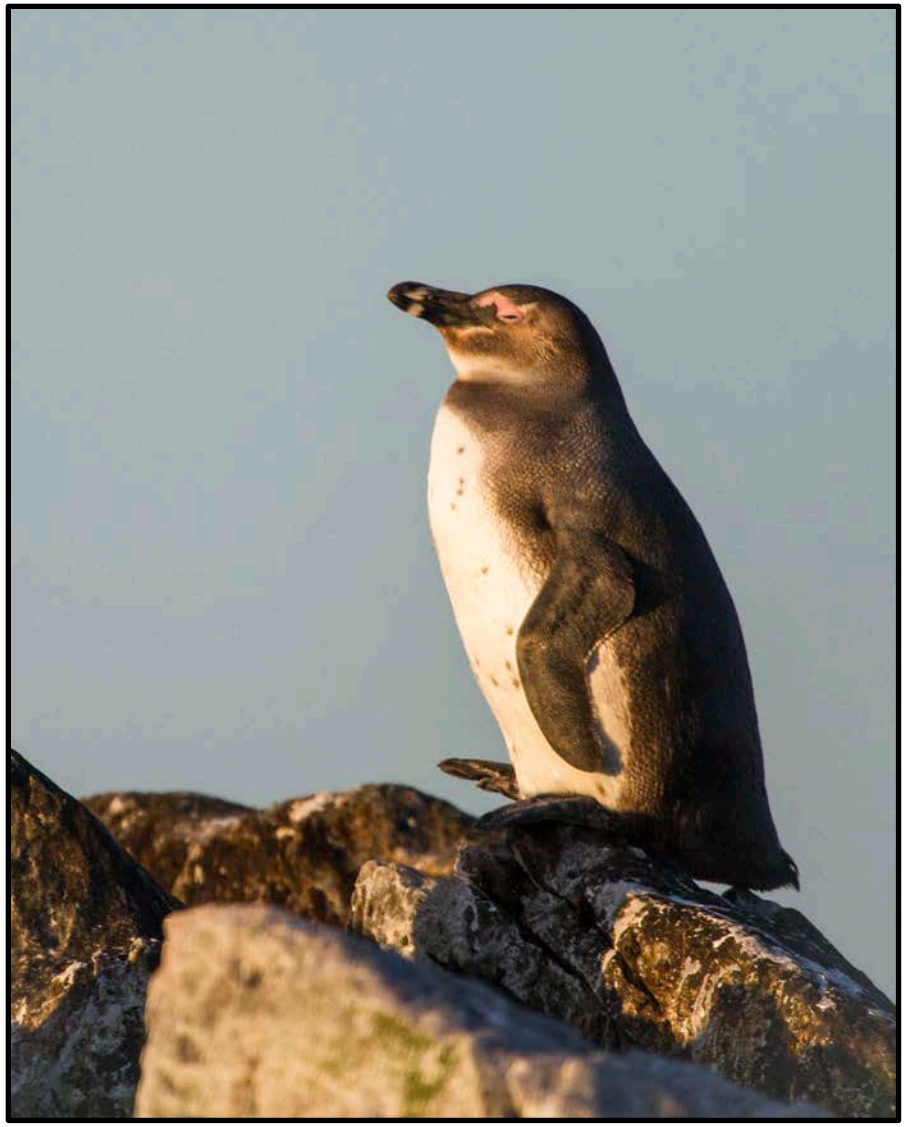

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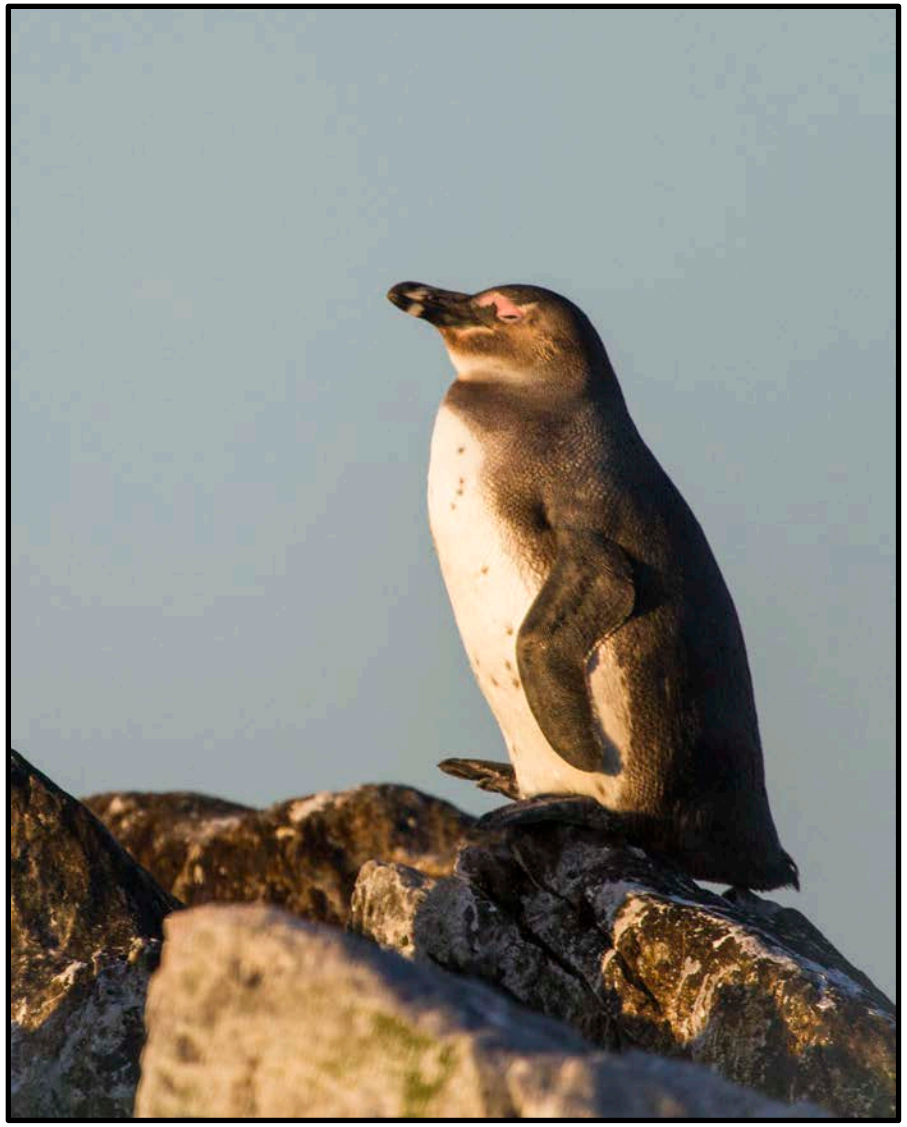

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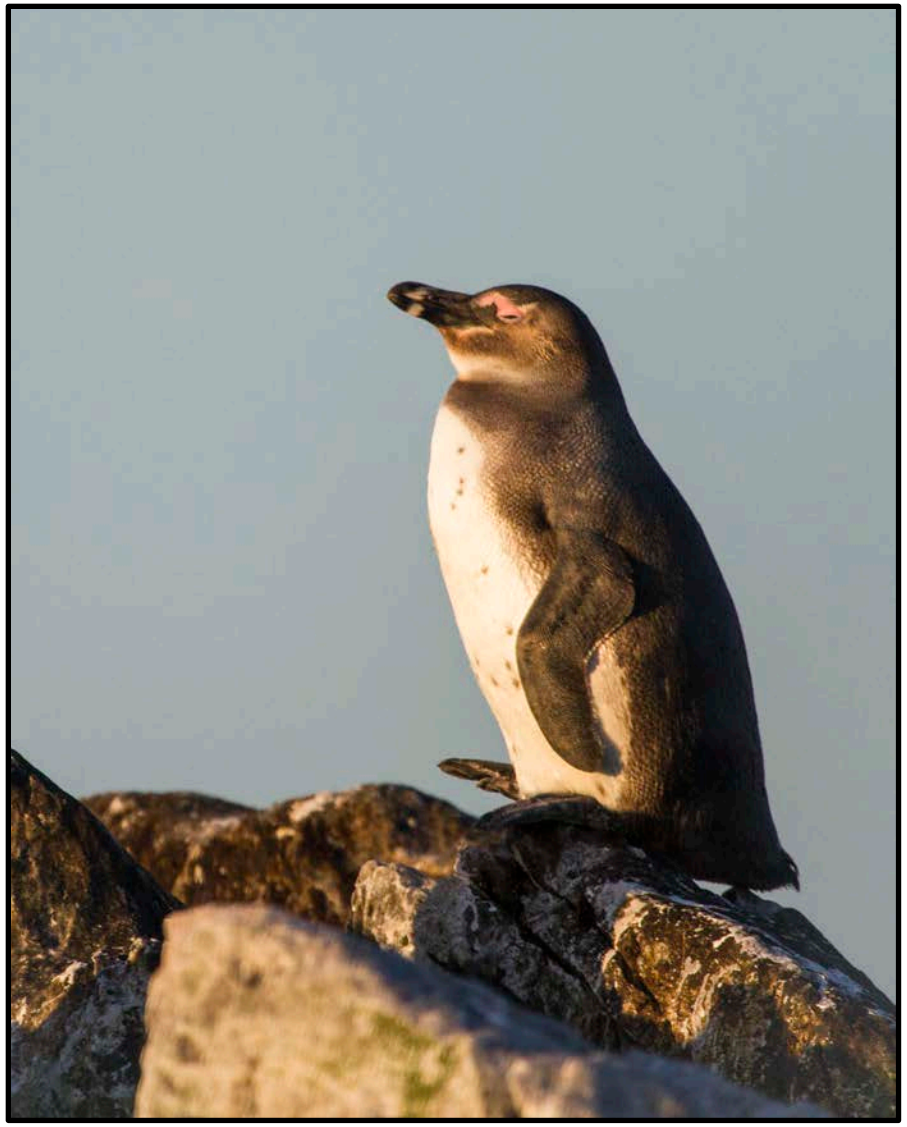
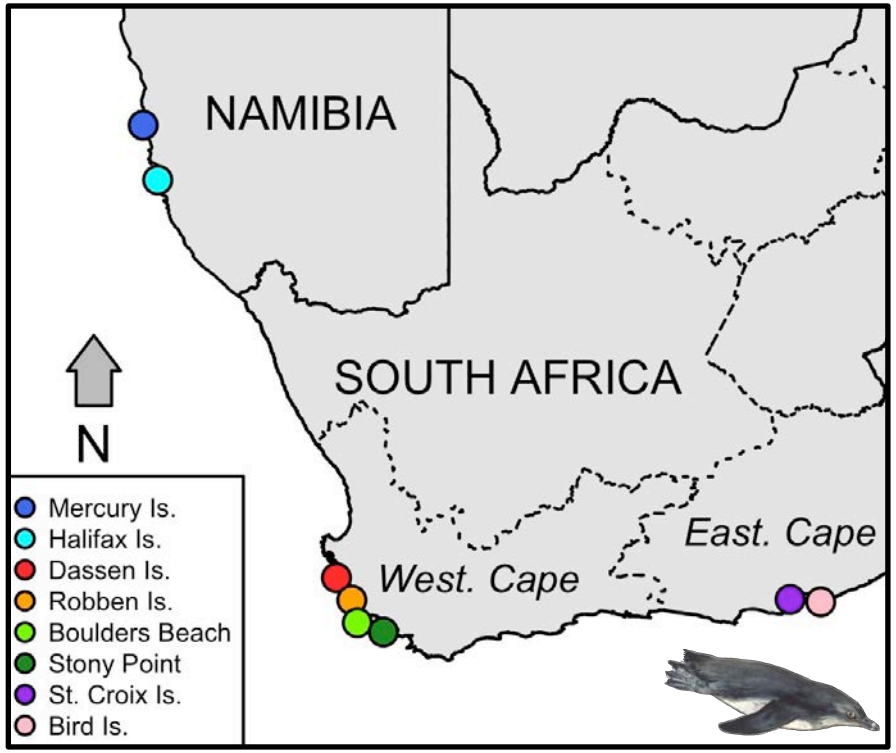


- Identify critical foraging habitat for juveniles
- Characterise habitat selection at metapopulation scale
- Assess vulnerability or flexibility to change
- Examine population-level impact

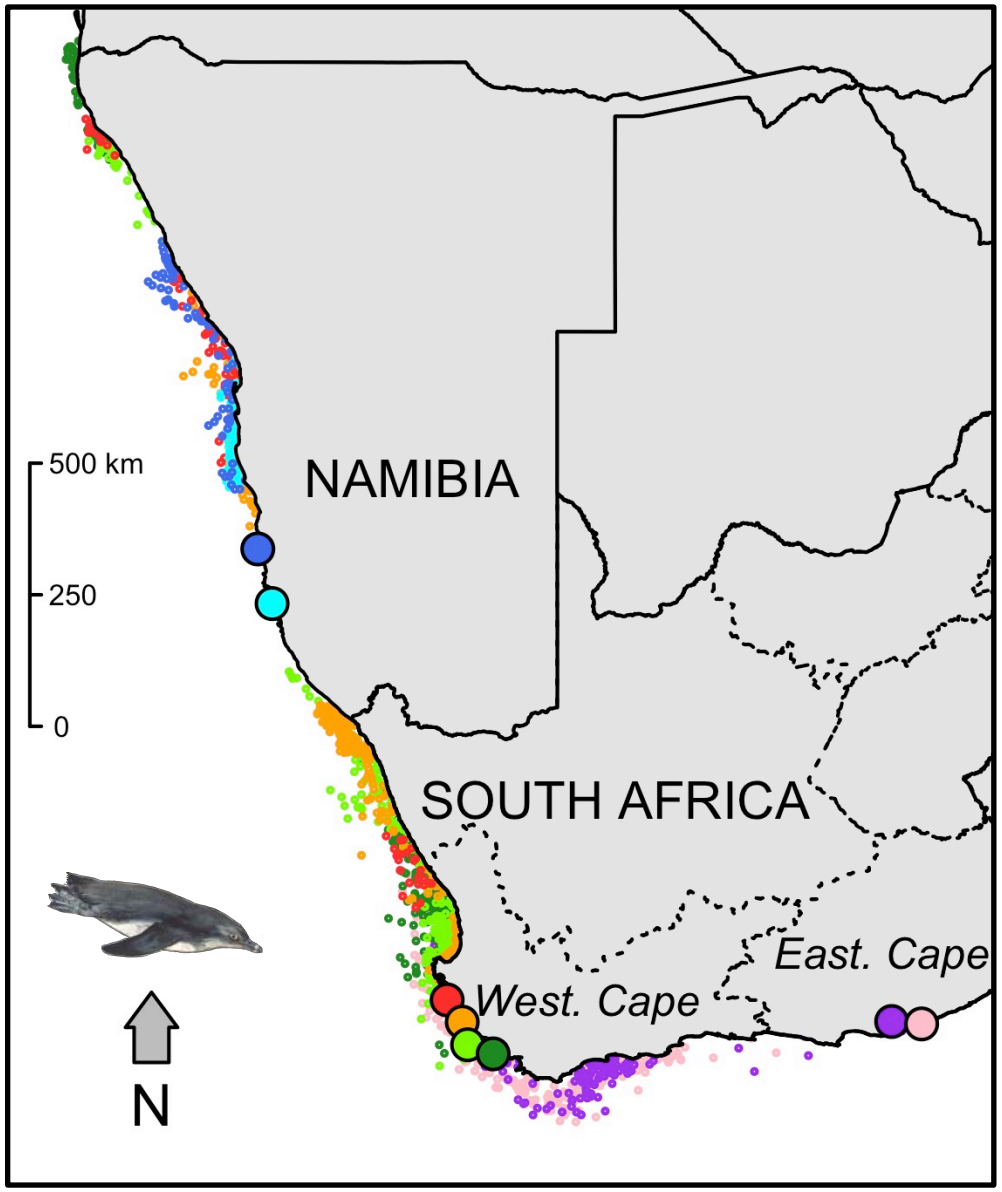
Methods

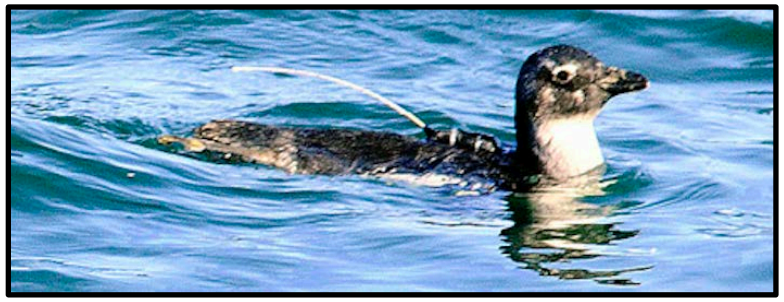
- Bayesian State-space model
  - Ocean current data
    – active vs passive
  - Habitat selection functions
    – SST, Chl *a*, prey
- Stochastic population models
  – vulnerable vs flexible



- 54 fledglings, 8 colonies over 3 years

Results 1: Post-natal dispersal





- Consistent ‘clockwise’ movement

Sherley et al. 2017, Curr. Biol. 27: 563–568

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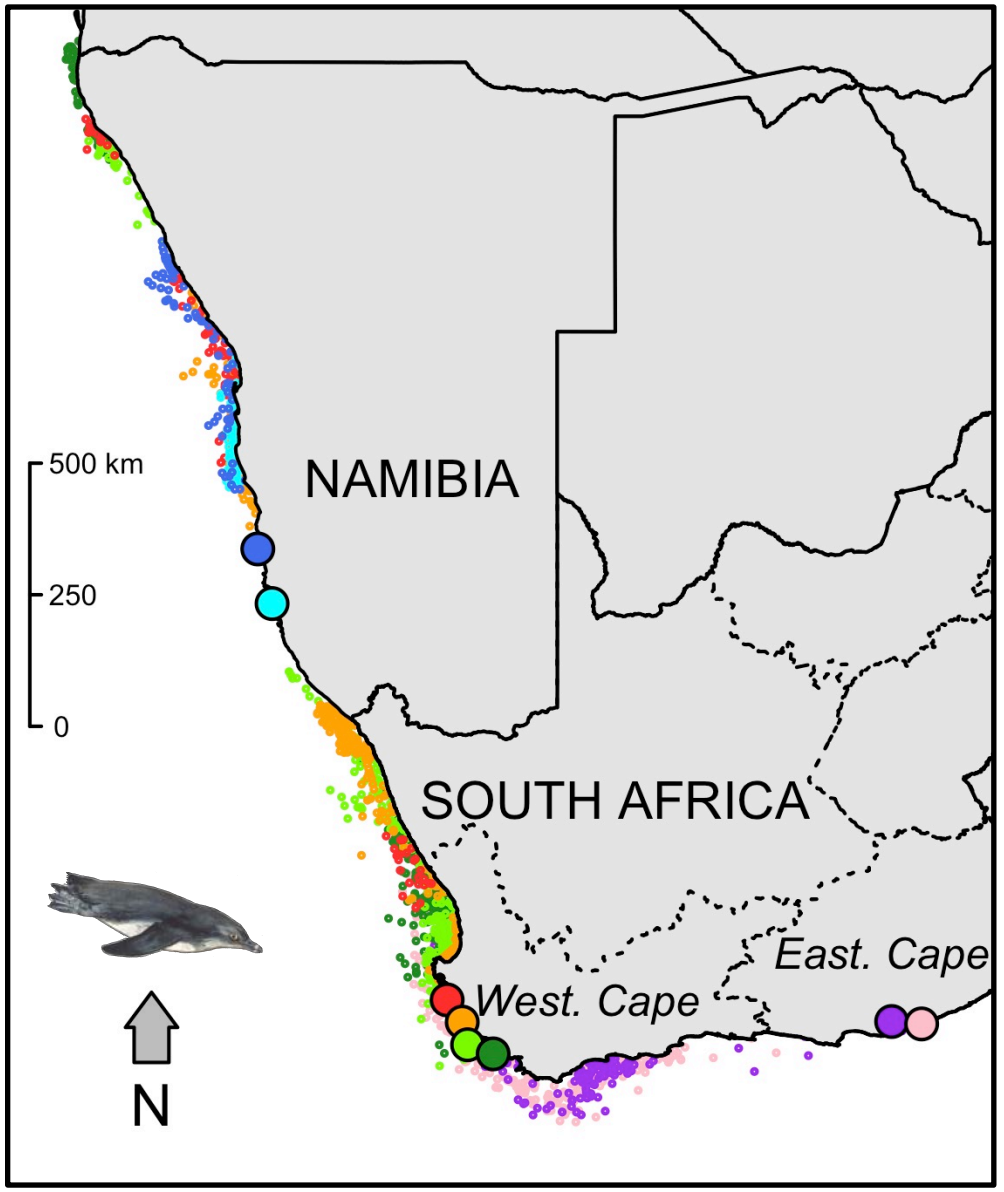

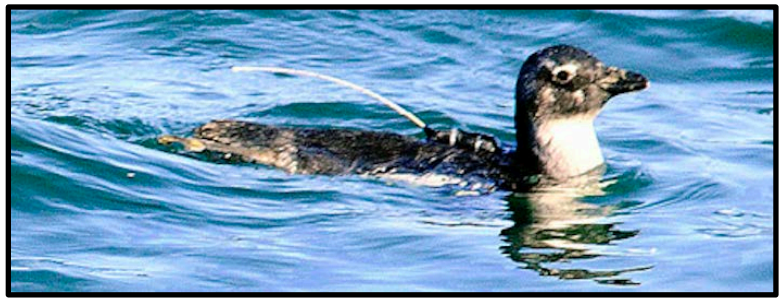

- Consistent ‘clockwise’ movement
- Foraging west or north of natal colony

Sherley et al. 2017, Curr. Biol. 27: 563–568

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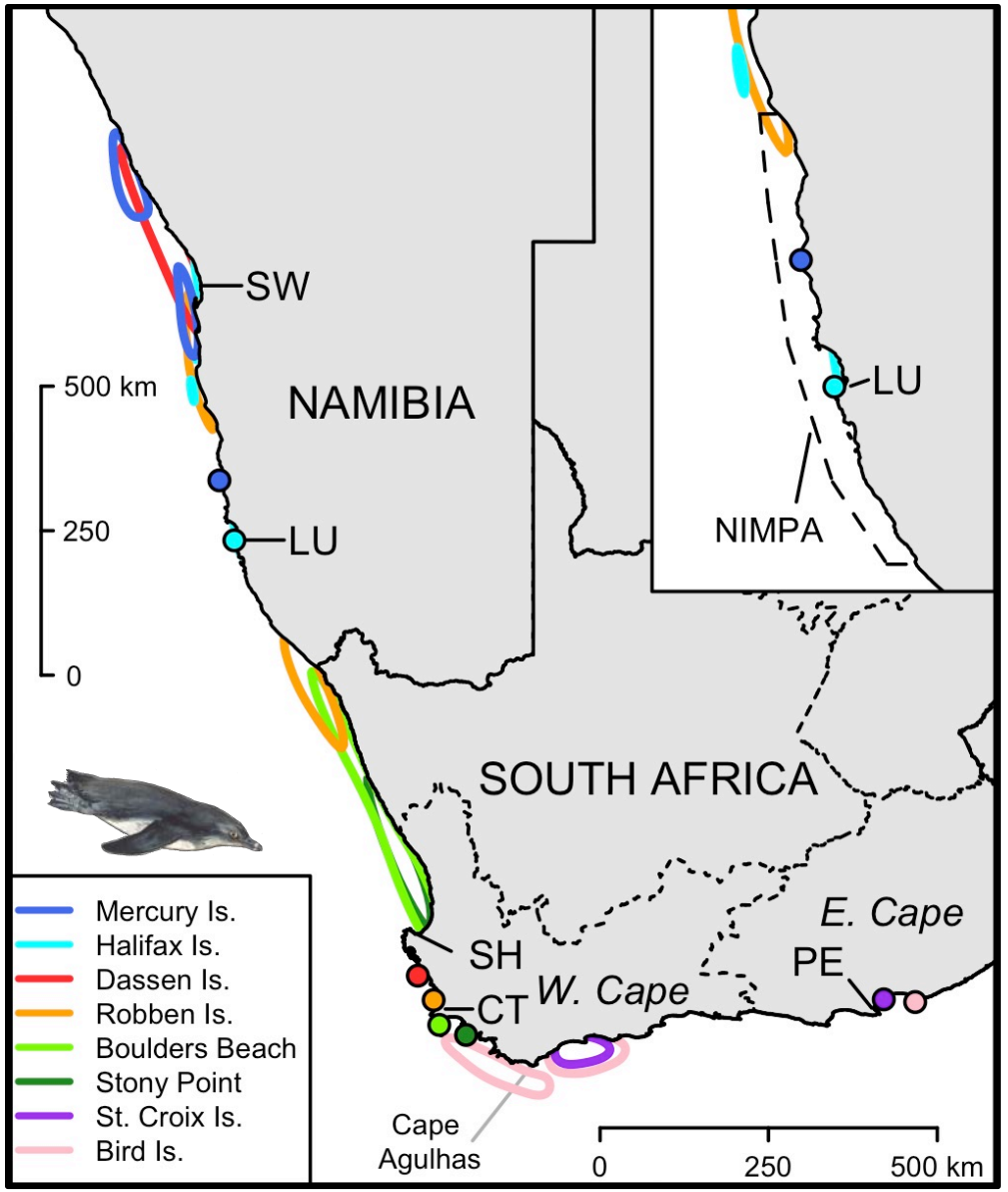

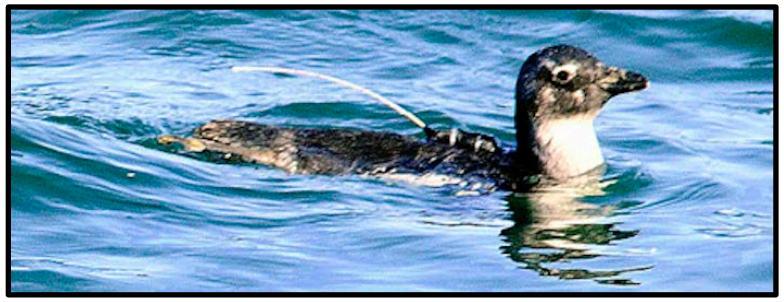

- Consistent 'clockwise' movement
- Foraging west or north of natal colony
- Most core foraging areas west of Cape Agulhas

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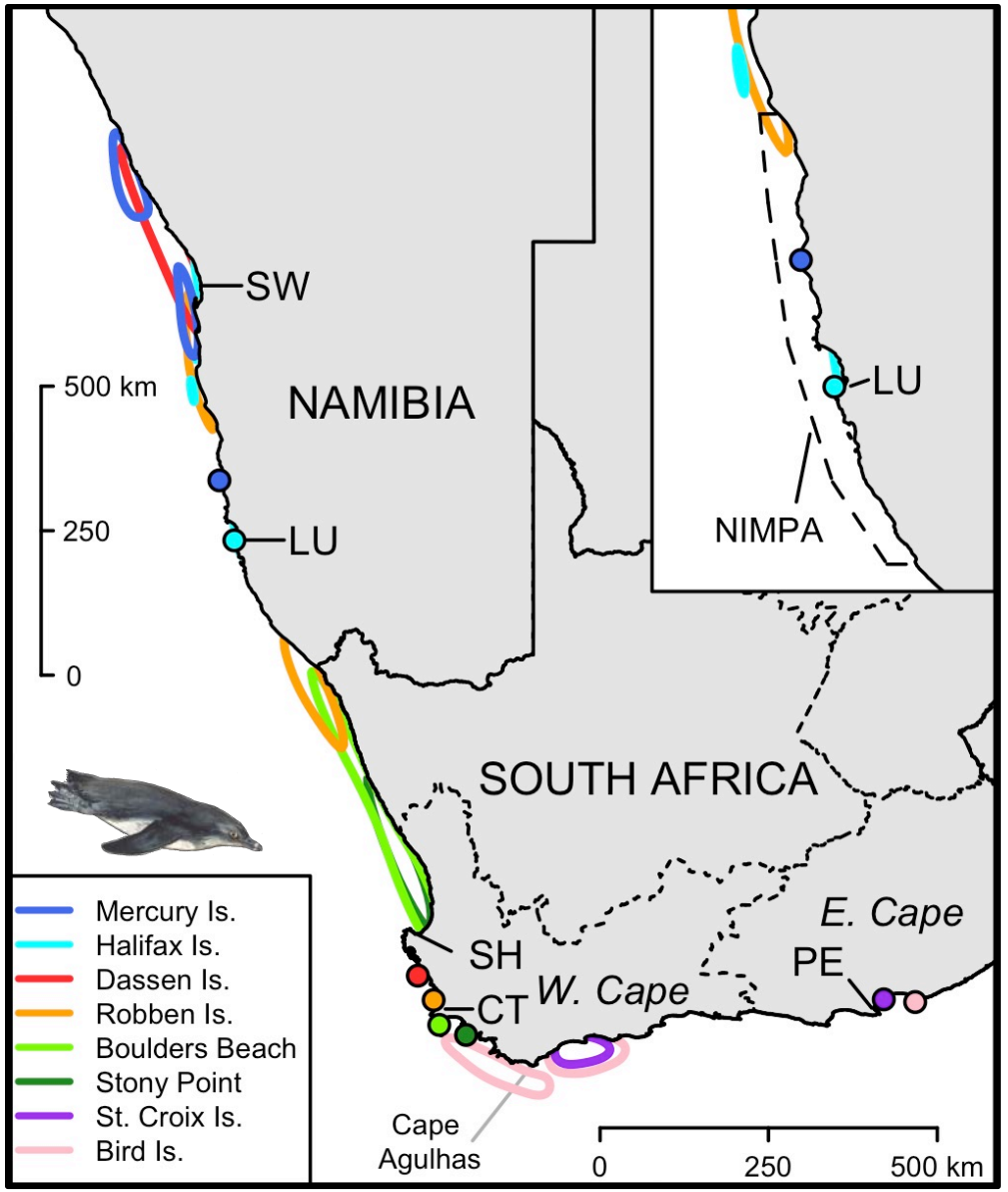

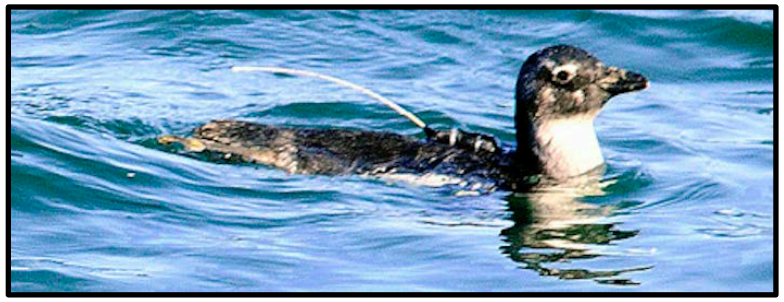

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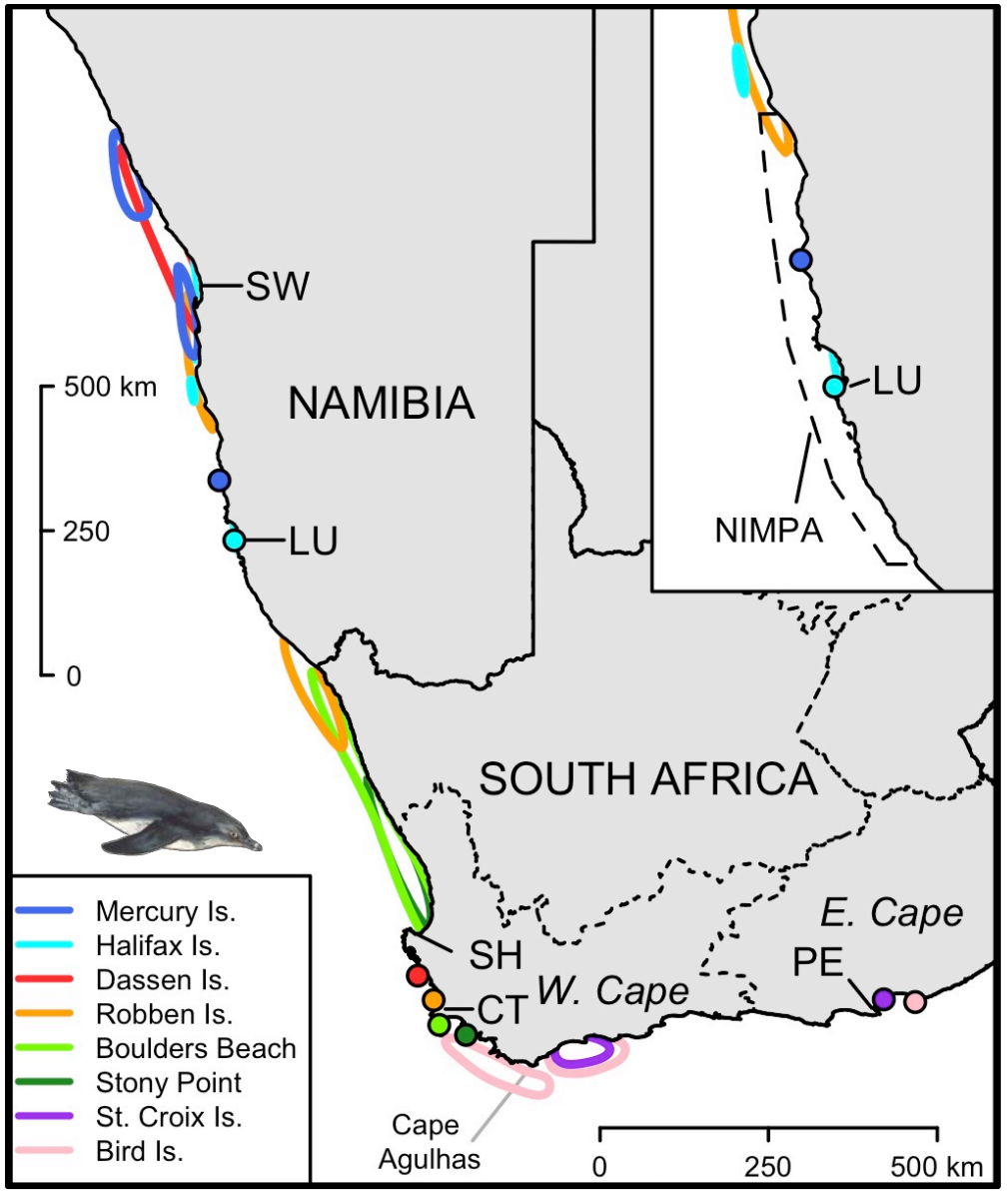

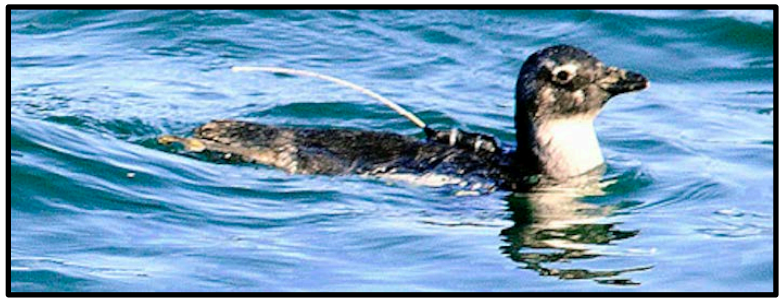

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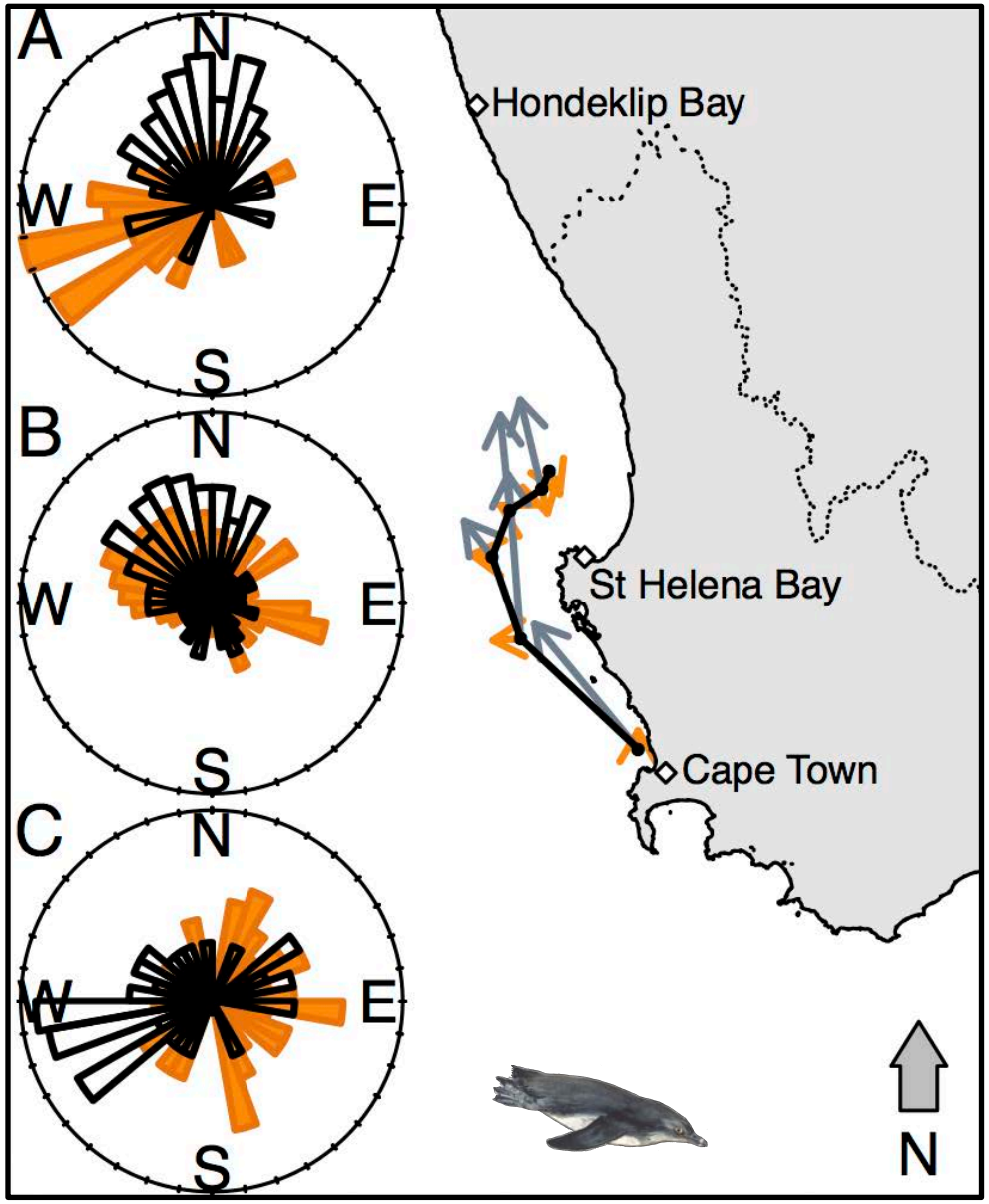
- Most core foraging areas west of Cape Agulhas
- Movement of SA birds into Namibia
- <u>Why not follow the fish…?</u>

Sherley et al. 2017, Curr. Biol. 27: 563–568

Results 2: Active or passive?



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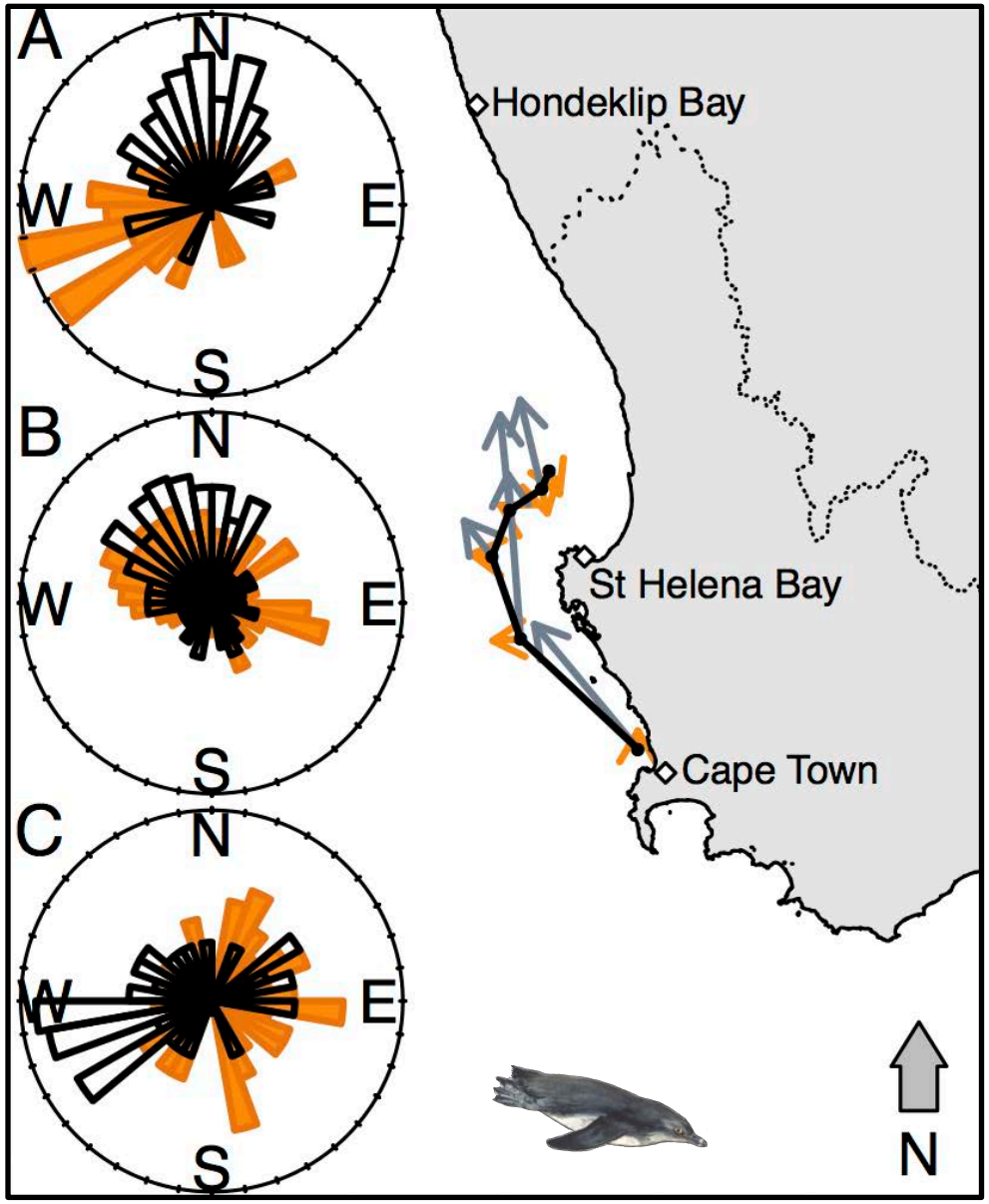

- Penguins' tracks (black) and ocean currents (orange) **not correlated**

(circular correlation, p >0.05)

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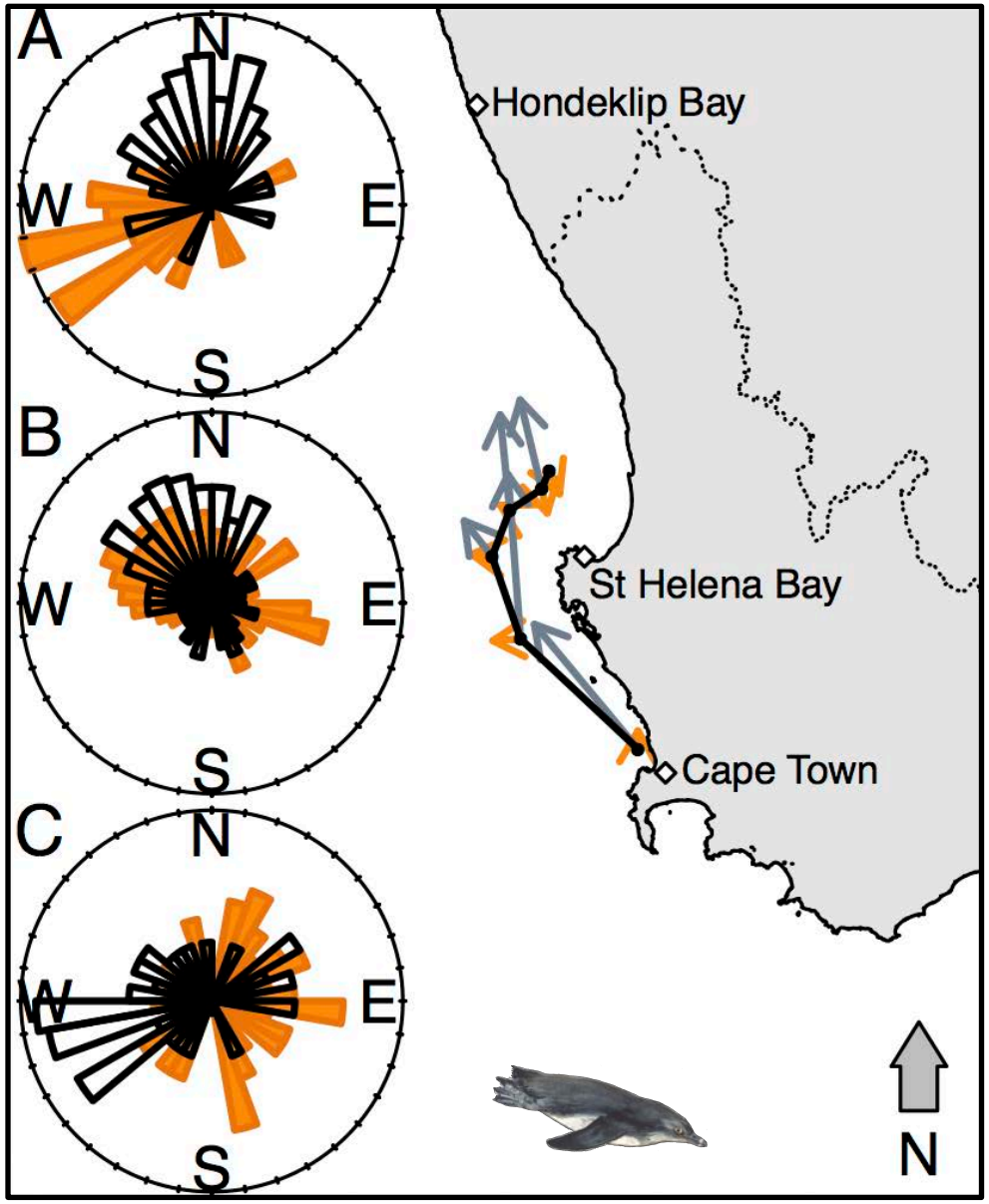

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(permutations test: $p < 0.001$)

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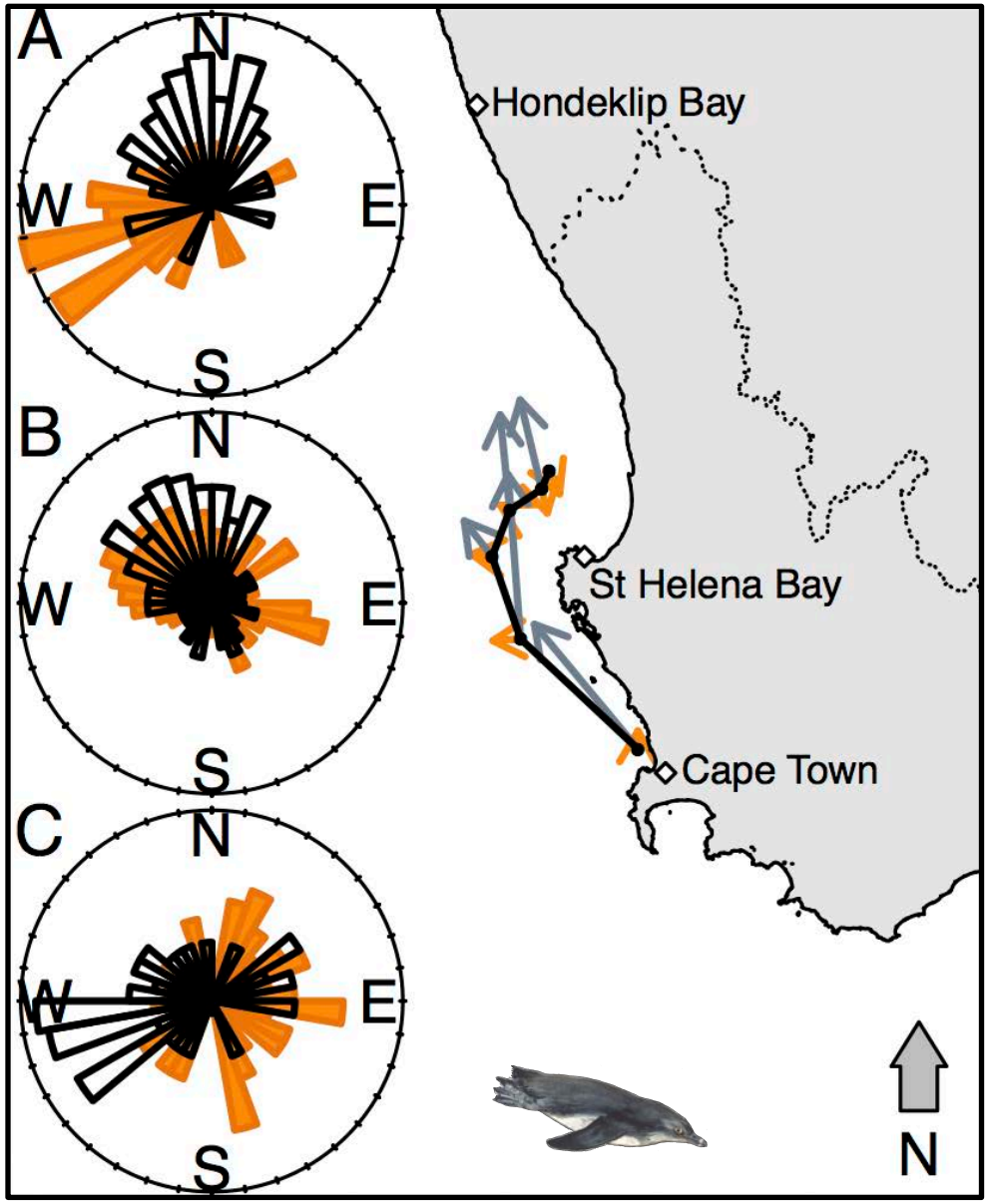

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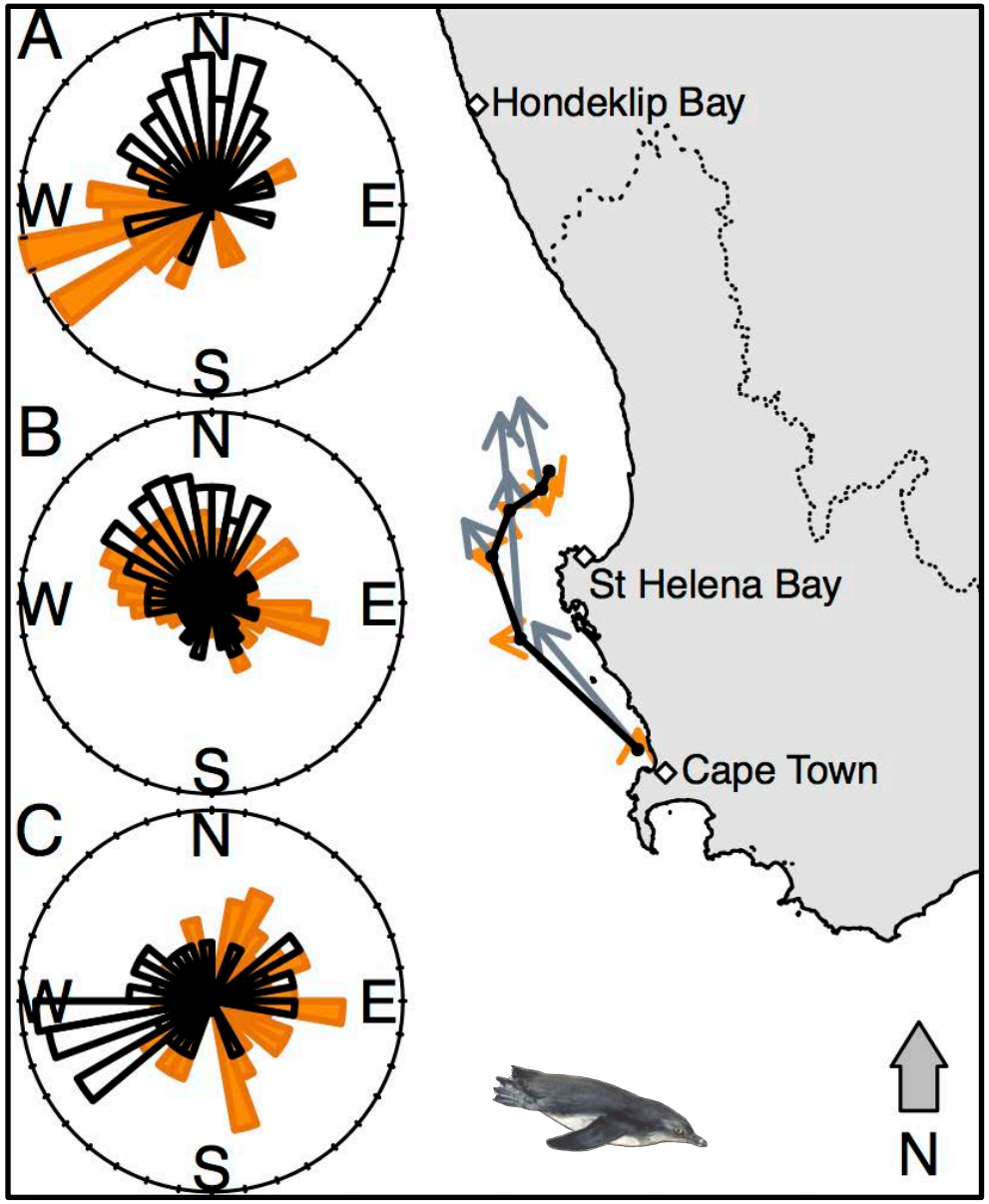

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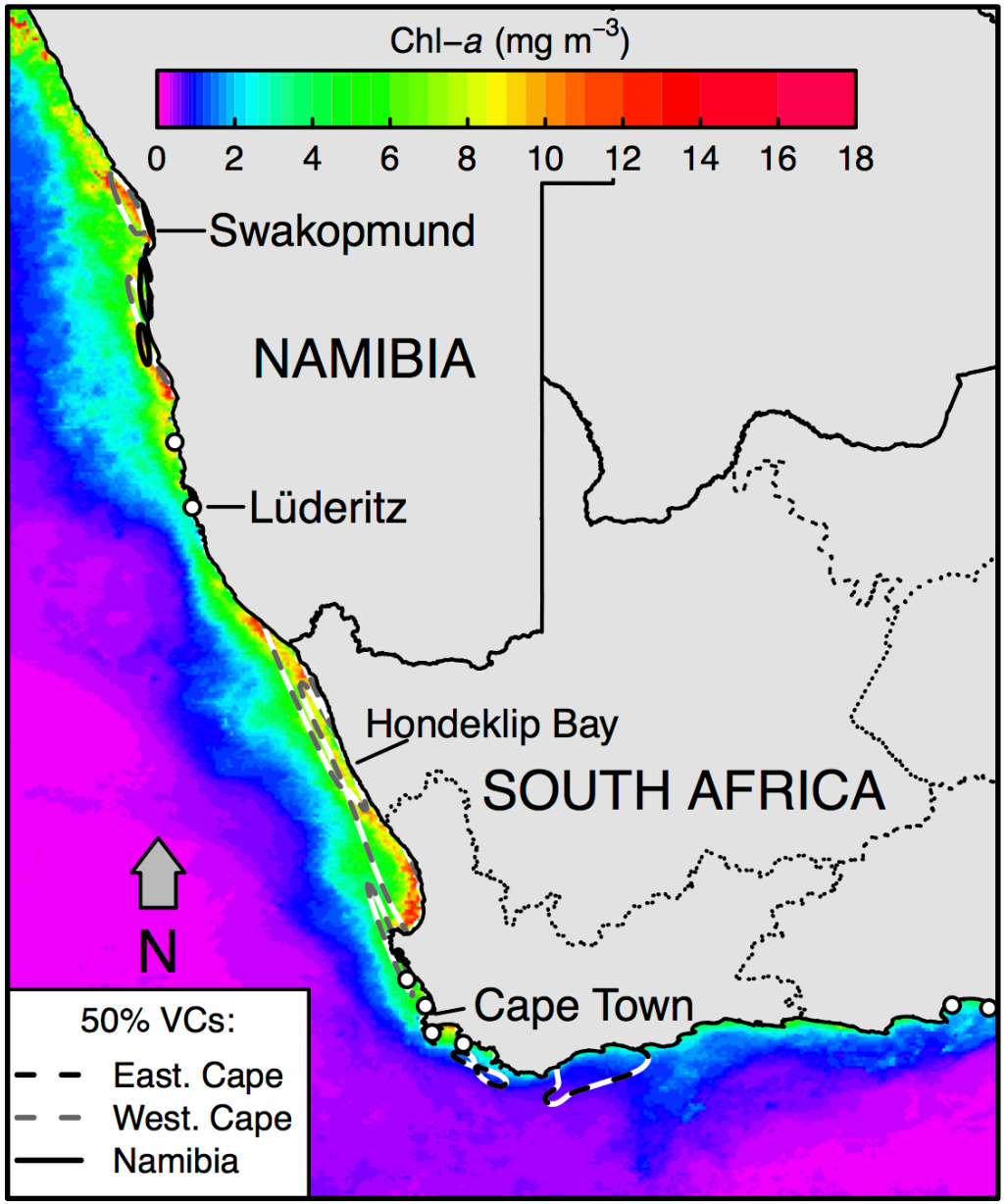
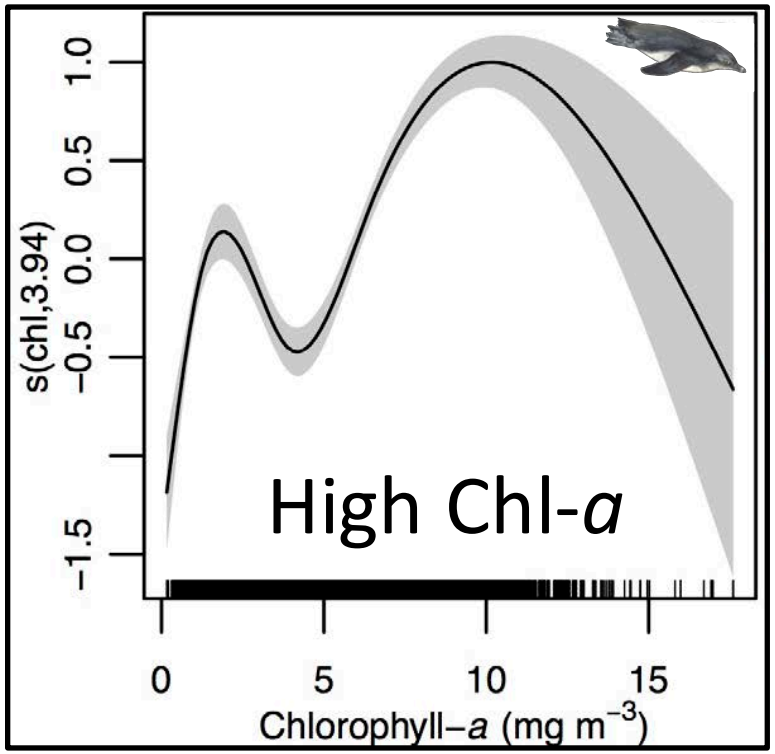
Why?

Sherley et al. 2017, Curr. Biol. 27: 563–568

Results 3: Habitat selection





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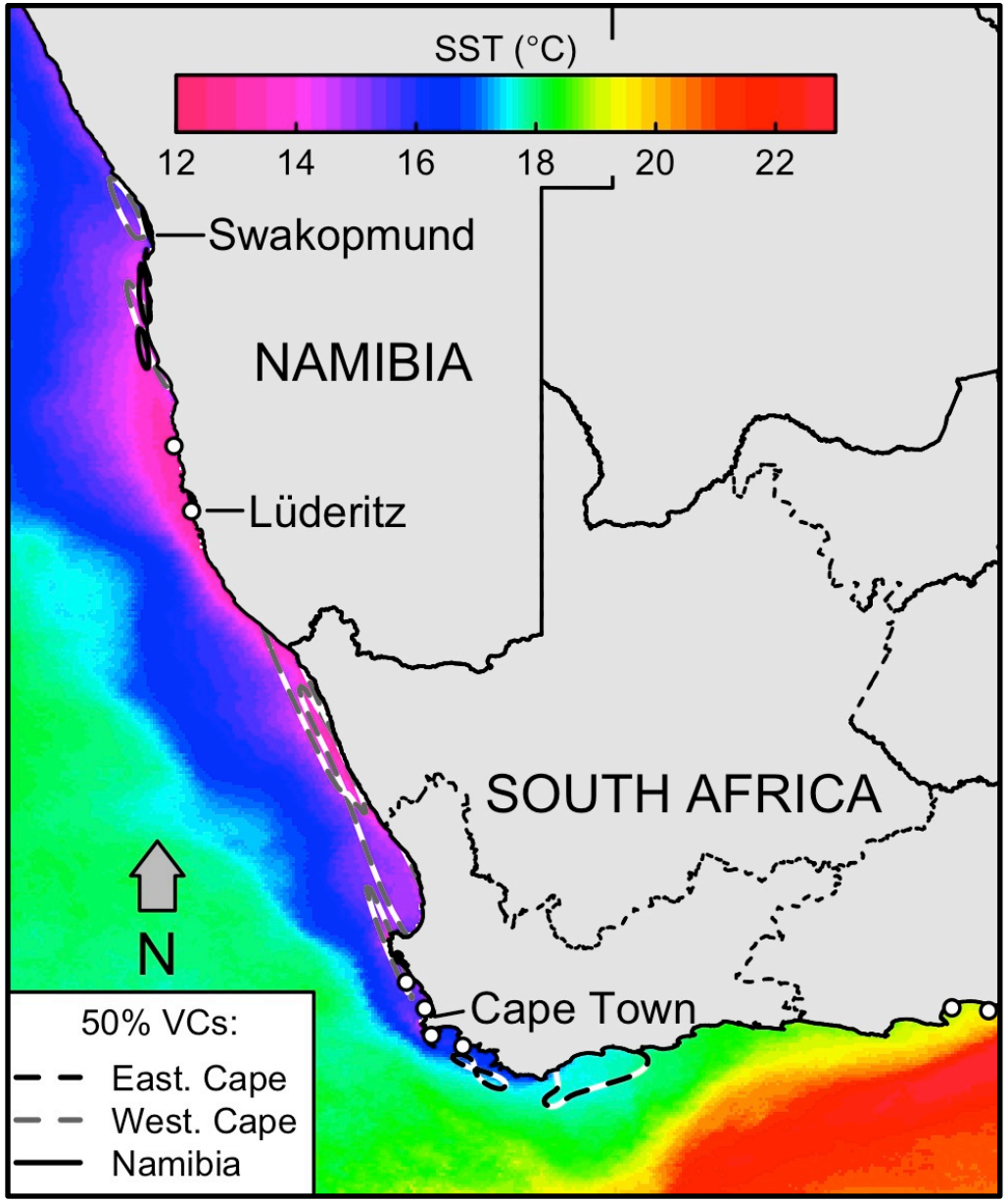

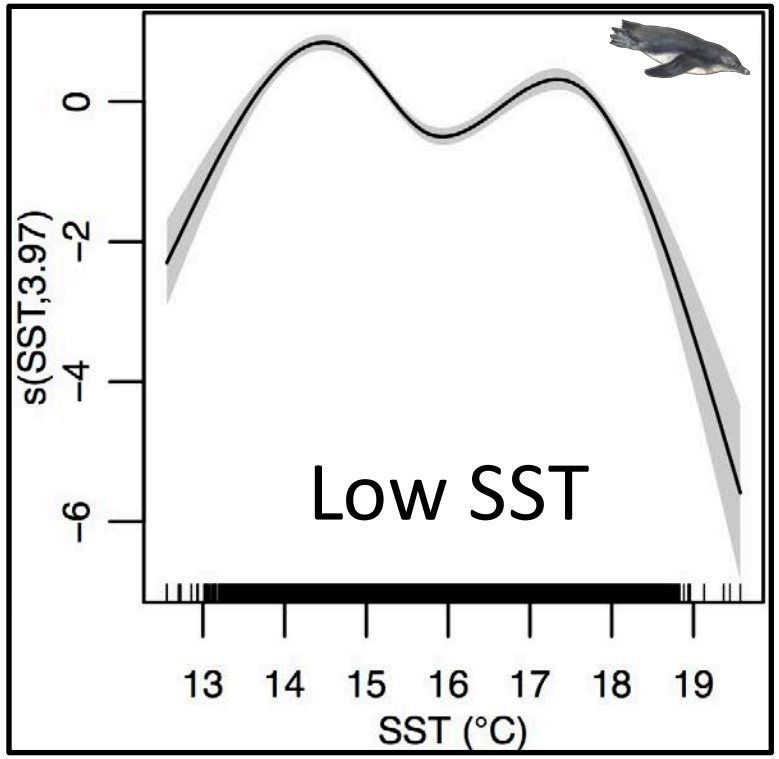

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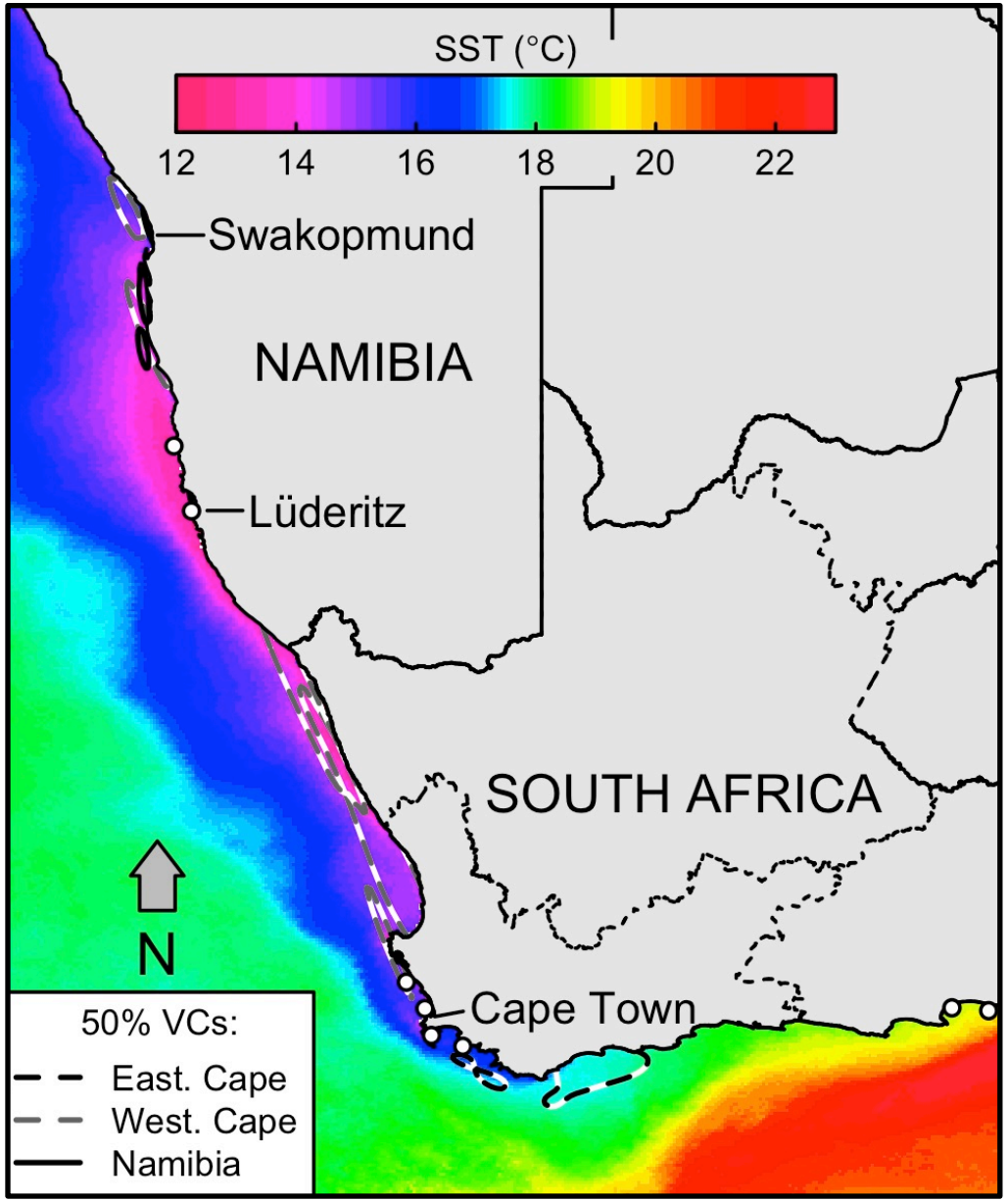

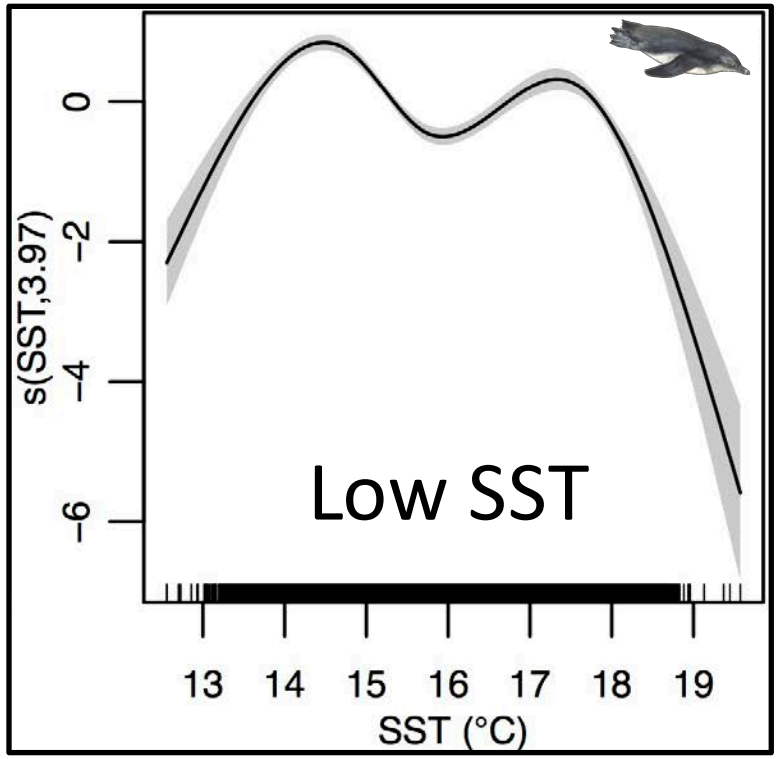

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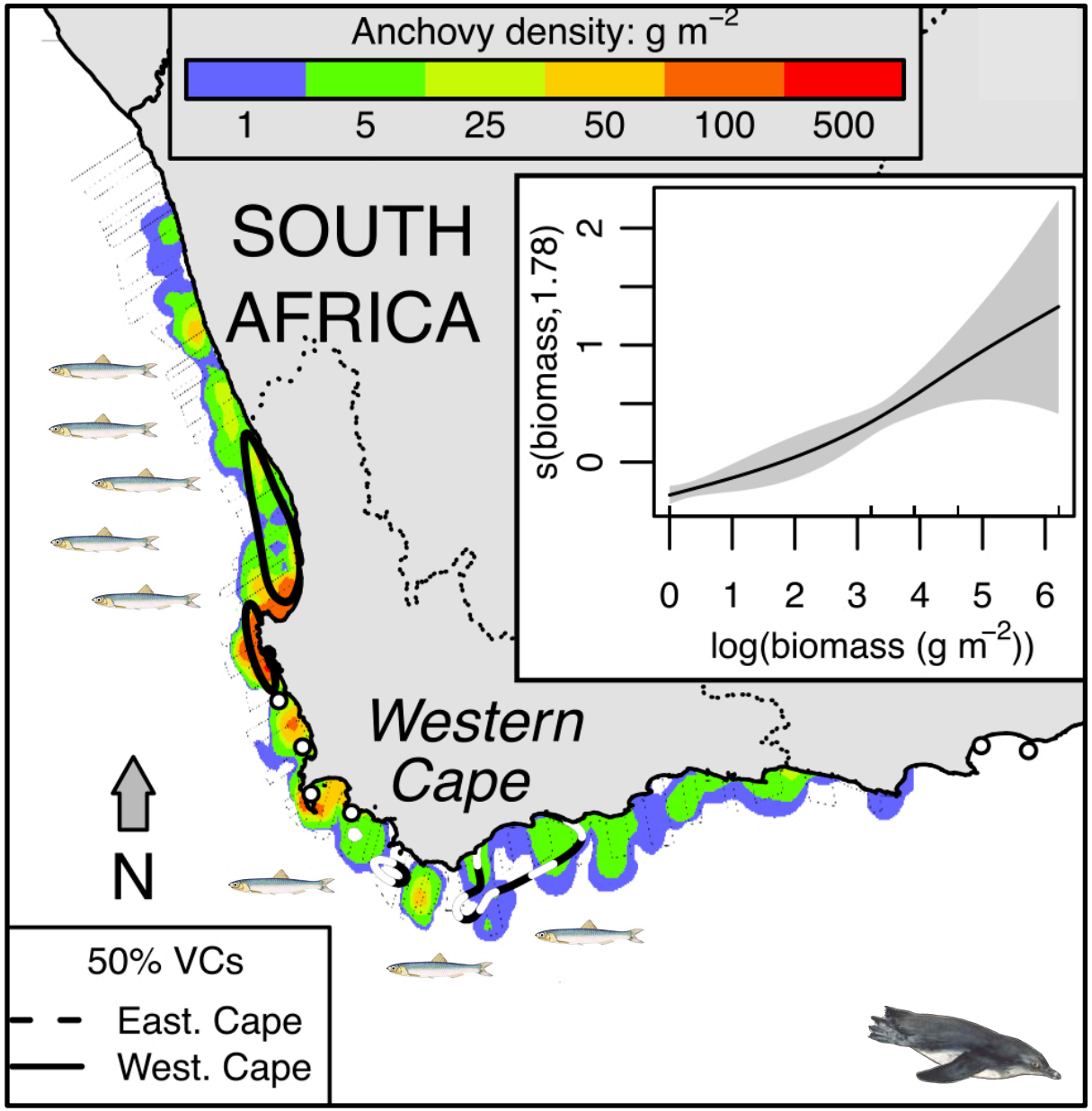
- But high forage fish abundance???

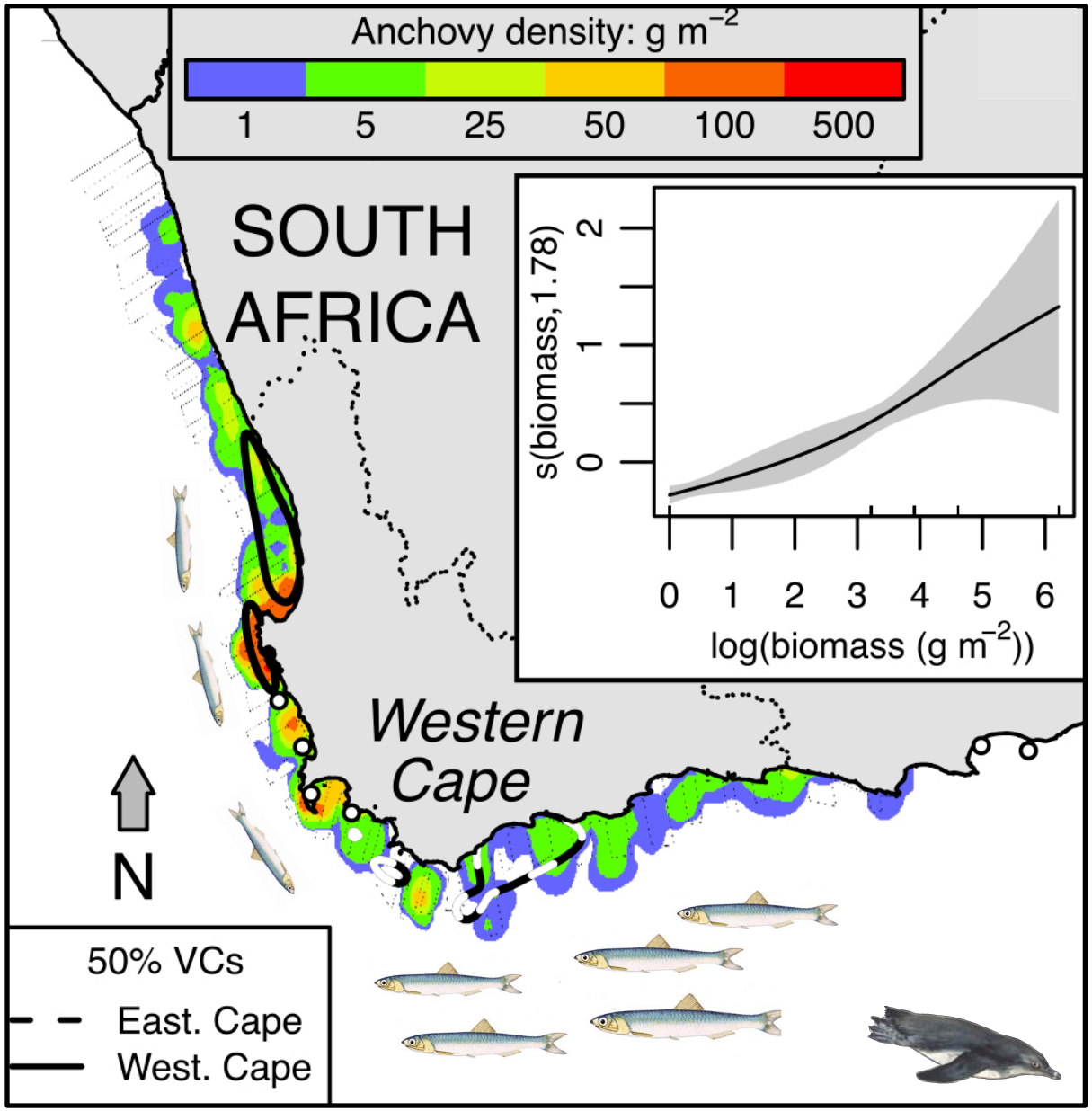
Results 4: fish-penguin mismatch



- Access to recruits initially

Sherley et al. 2017, Curr. Biol. 27: 563–568

Results 4: fish-penguin mismatch



- Access to recruits initially
- <u>But</u> fish go south, penguins go north…

Sherley et al. 2017, Curr. Biol. 27: 563–568

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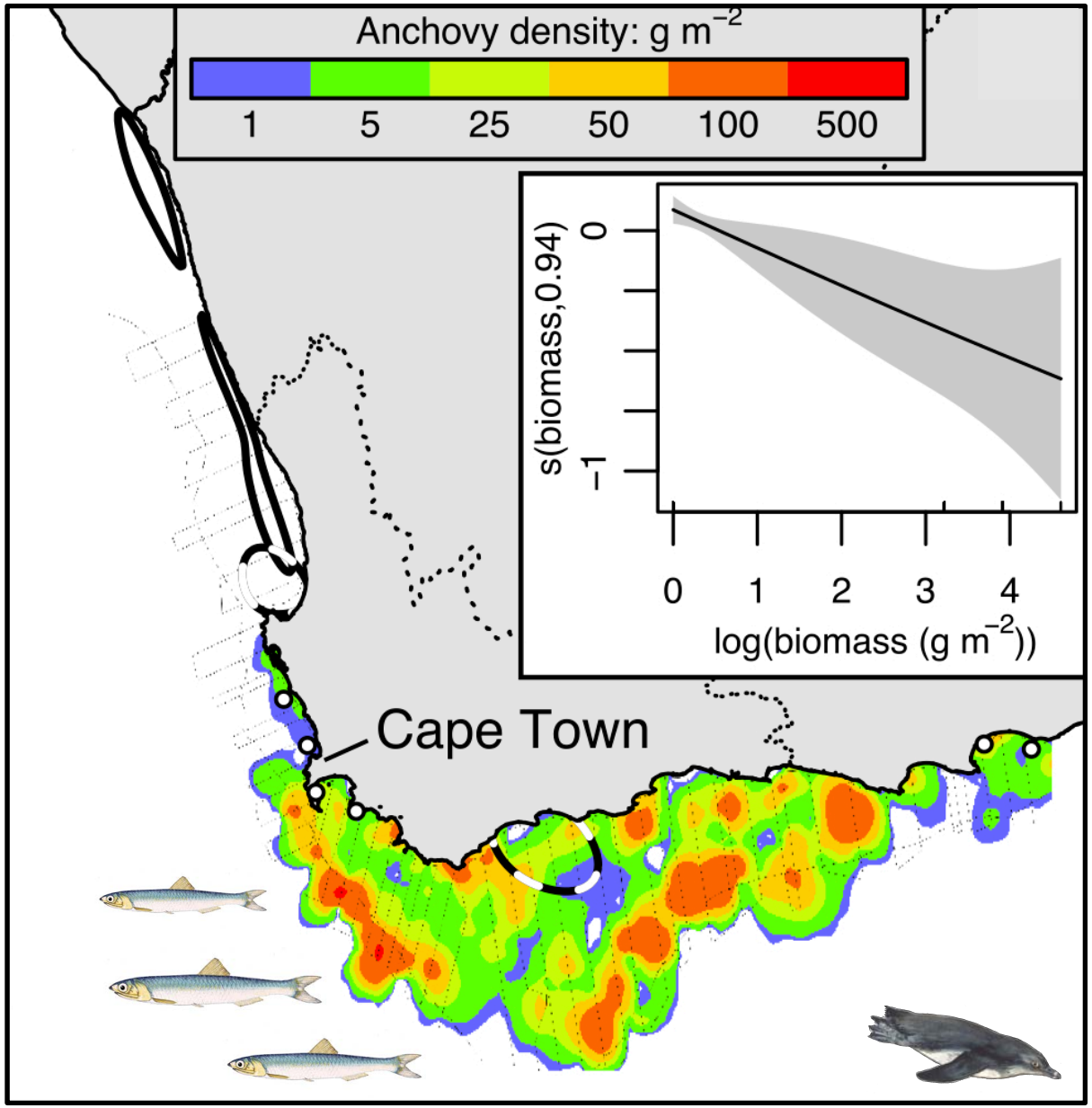

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- Few anchovy in summer foraging areas

Sherley et al. 2017, Curr. Biol. 27: 563–568

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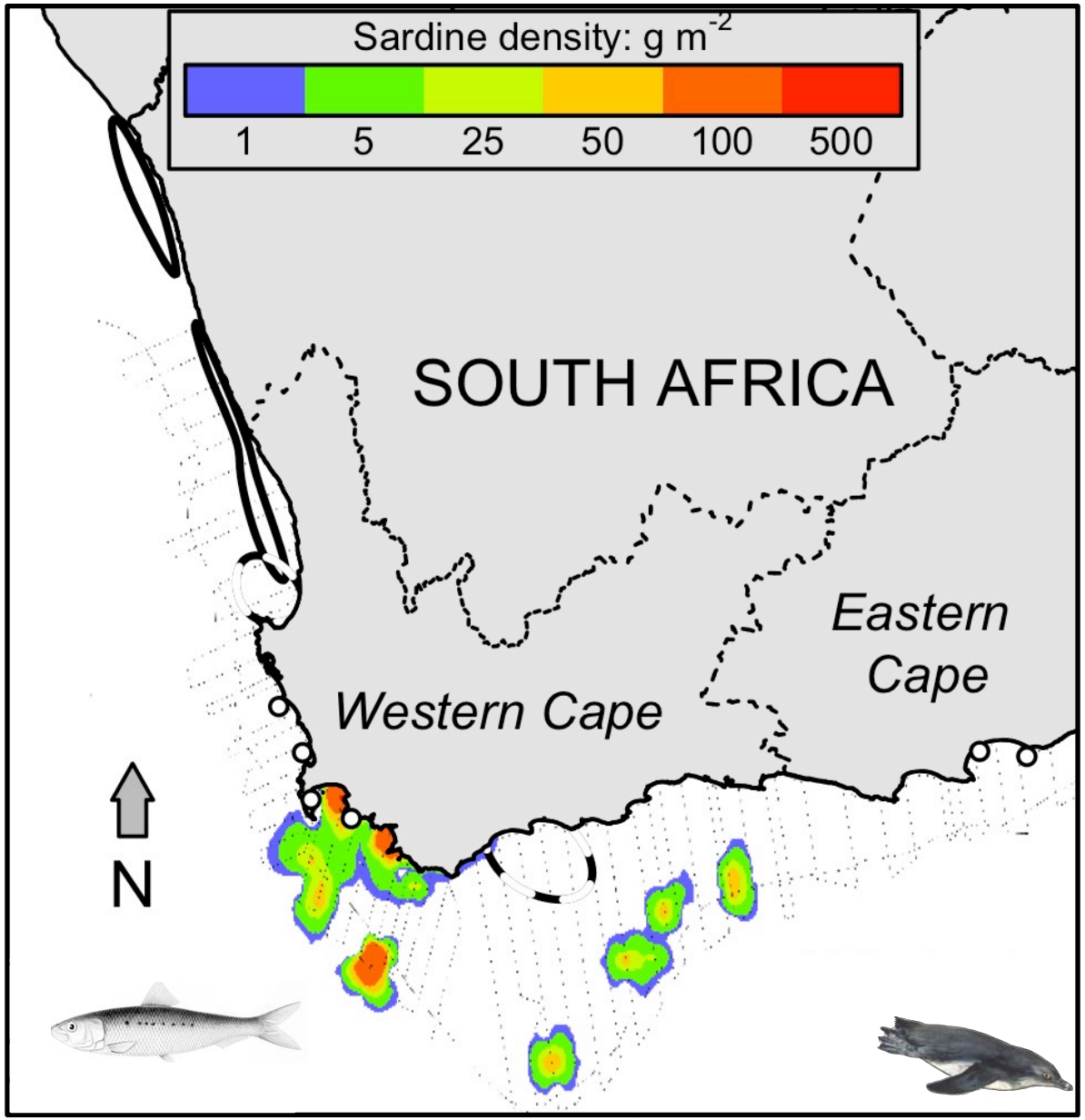

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Sherley et al. 2017, Curr. Biol. 27: 563–568

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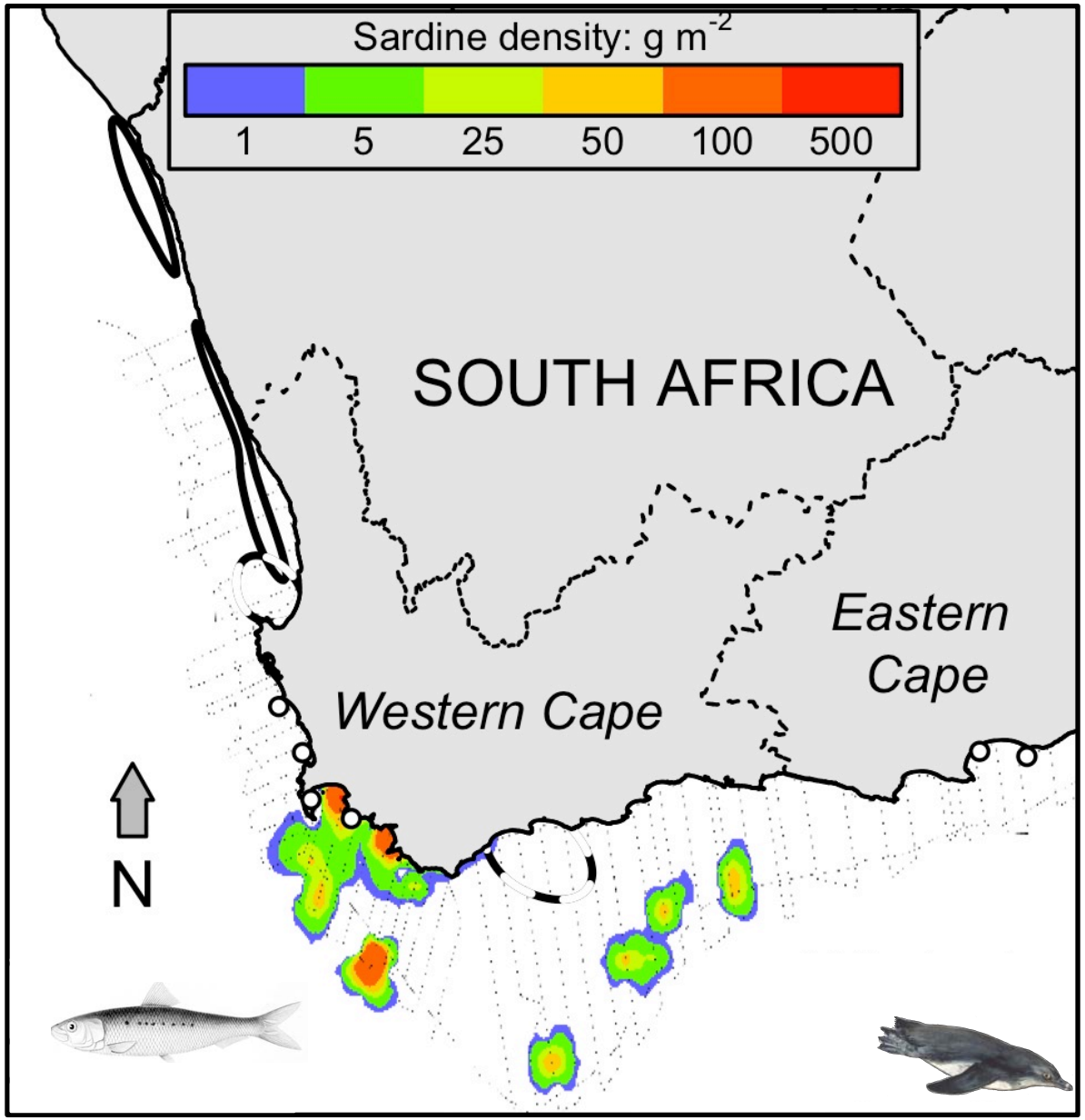
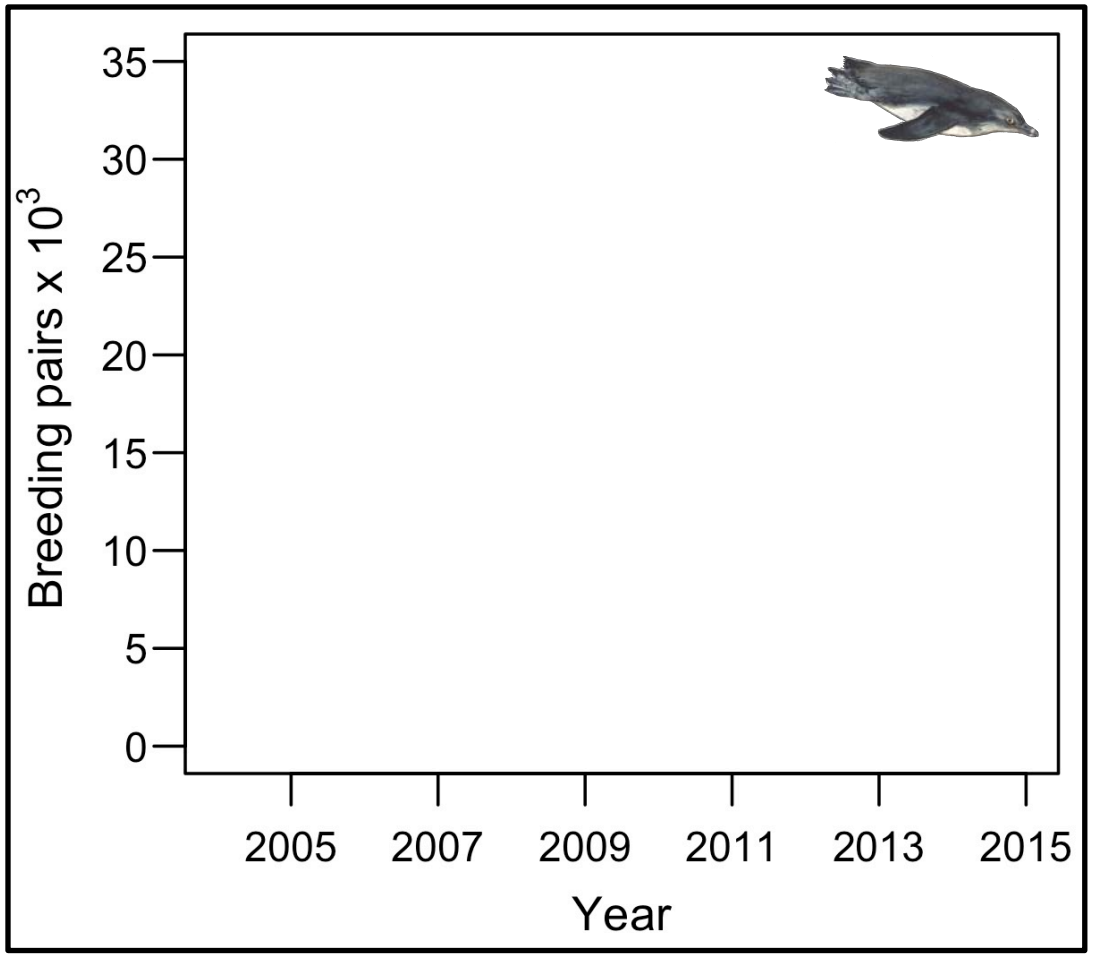


- Access to recruits initially
- But fish go south, penguins go north…
- Few anchovy in summer foraging areas
- Sardine scarce to absent
- Not adapted to local habitat degradation

Sherley et al. 2017, Curr. Biol. 27: 563–568

Results 5: population level impact



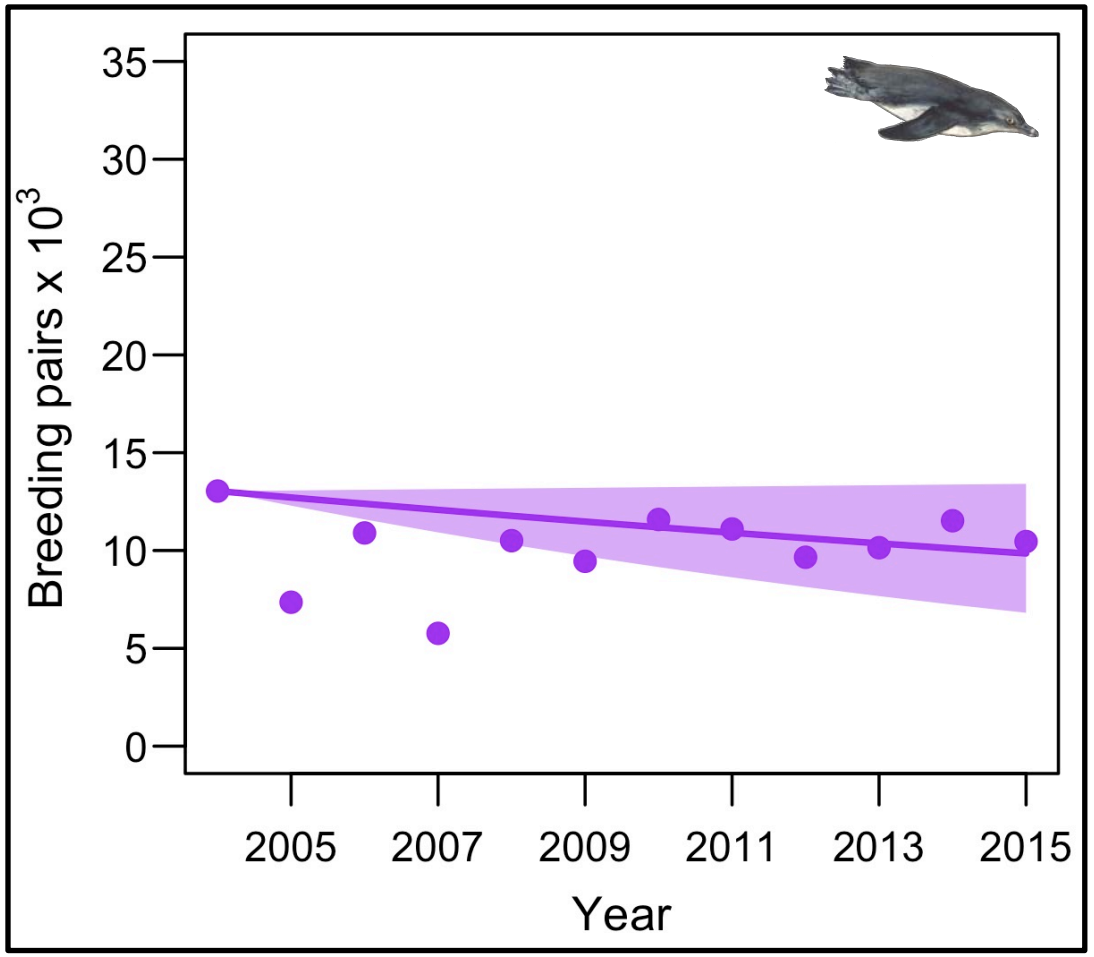
First-year survival:

> 0.4 before 2000

< 0.2 since 2006

Sherley et al. 2014, Ibis 156: 716–728

Results 5: population level impact



Points = observed; Lines = modelled

First-year survival:
> 0.4 before 2000
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Eastern Cape:

$\phi_a = 0.88$, $F = 0.56$,
$\phi_j = 0.51$

Sherley et al. 2017, Curr. Biol. 27: 563–568

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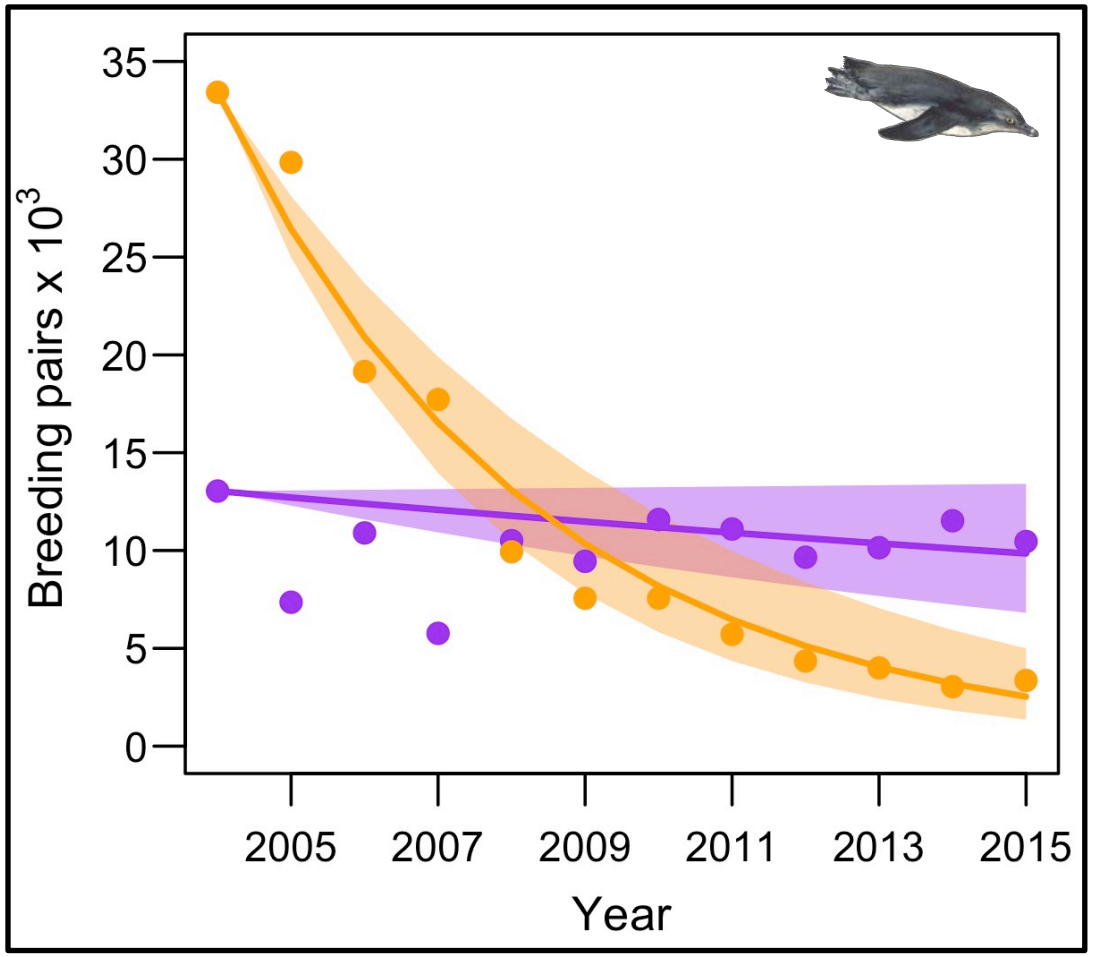

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Eastern Cape:

$\phi_a = 0.88$, $F = 0.56$,
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Western Cape:

$\phi_a = 0.74$, $F = 0.68$

Vulnerable: $\phi_j = 0.19$

Sherley et al. 2017, Curr. Biol. 27: 563–568

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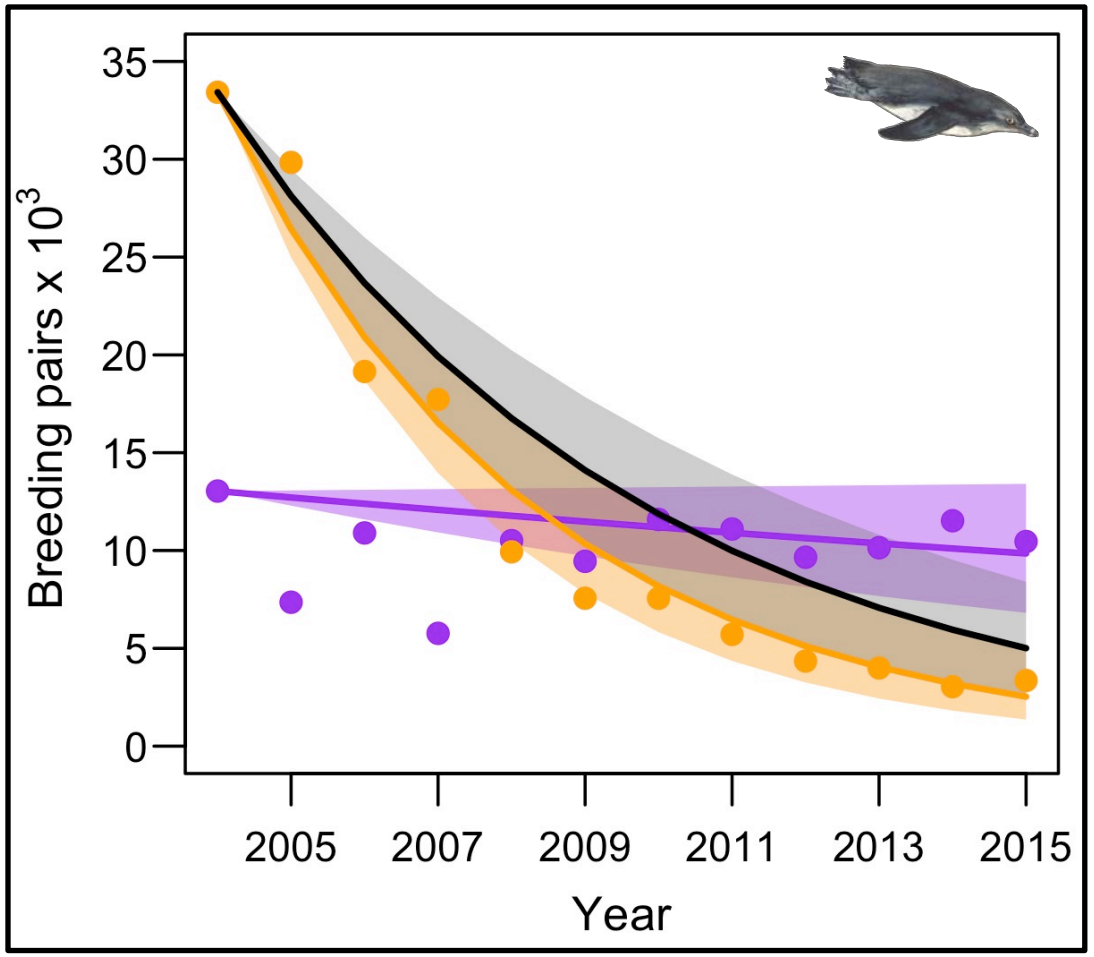

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Eastern Cape:

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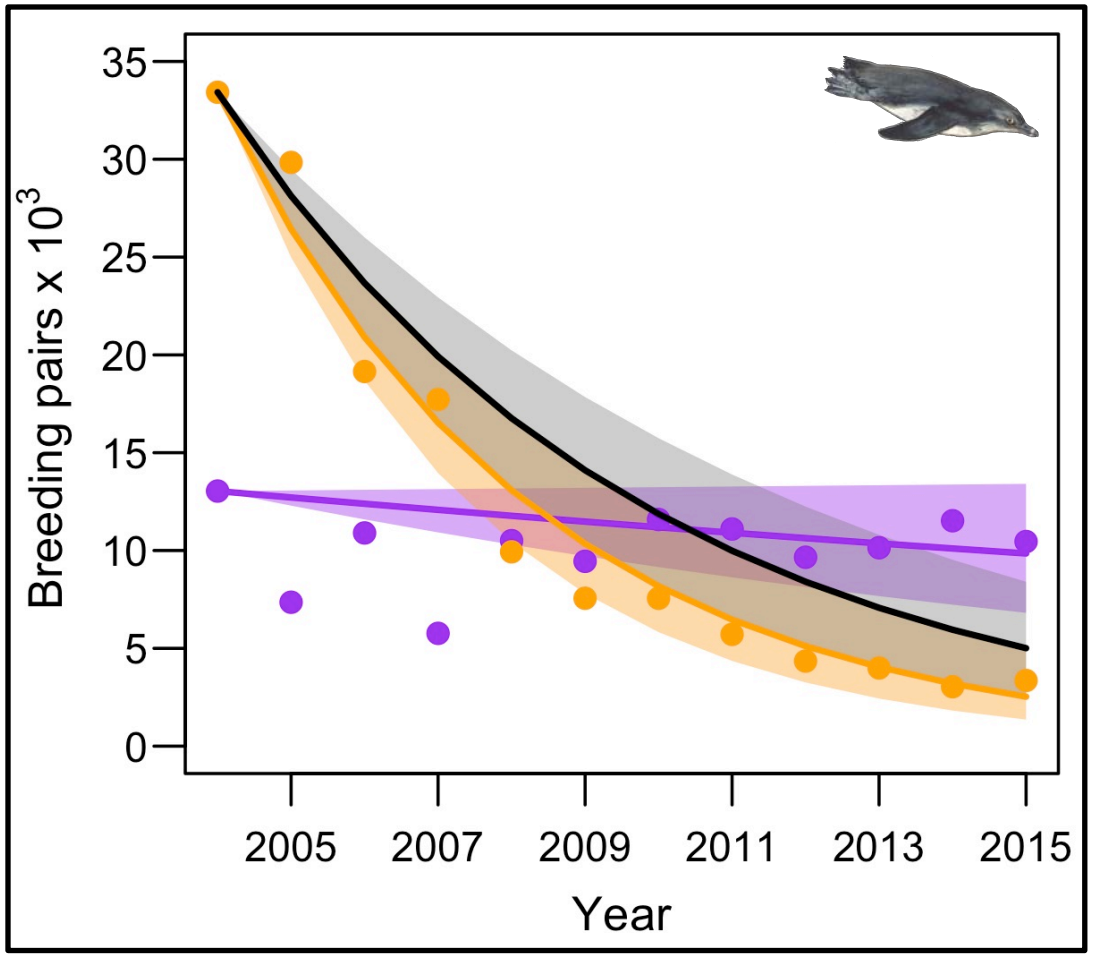
Vulnerable: $\phi_j = 0.19$

Flexible: $\phi_j = 0.50$

Sherley et al. 2017, Curr. Biol. 27: 563–568

Results 5: population level impact



Points = observed; Lines = modelled

~98% higher

First-year survival:
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Eastern Cape:

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Summary

- Actively select areas of high productivity

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Summary

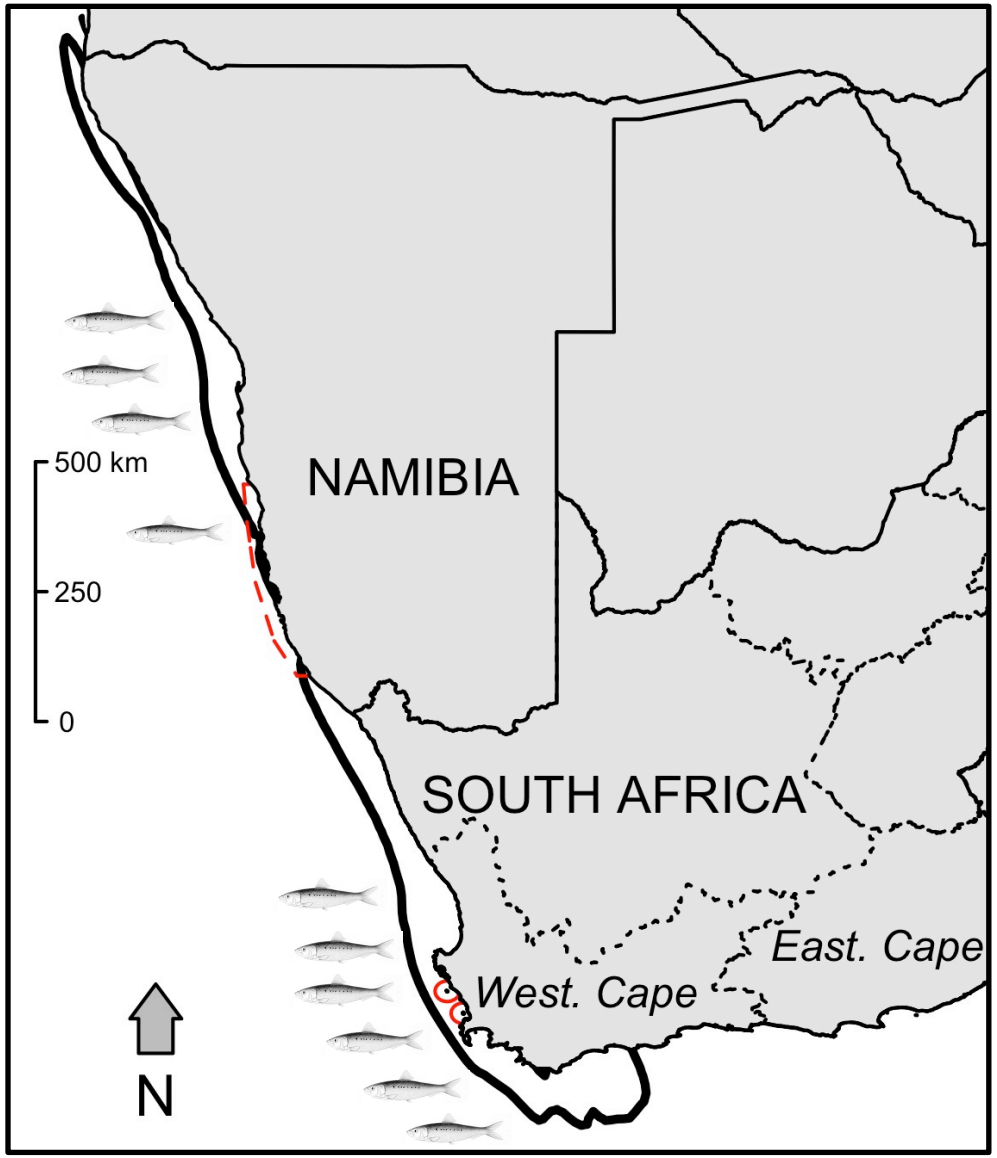
- Actively select areas of high productivity
- Penguin forage-fish mismatch
- High juvenile mortality
- Ecosystem-wide ecological trap
- Important population-level impact

Acknowledgments: Thanks to SANCCOB, DAFF, DEA, SAN Parks, Robben Island Museum, Overstrand Municipality, CapeNature, Janet Coetzee, Nola Parsons and numerous funders.

Co-authors: Katrin Ludynia, Bruce M. Dyer, Tarron Lamont, Azwianewi B. Makhado, Jean-Paul Roux, Kylie L. Scales, Les G. Underhill and Stephen C. Votier.

Image credits: Cheryl-Samantha Owen, Rebecca Scott, Davide Gaglio (http://davygaglio.wix.com), Jessica Kemper, RSPCA, Barbara Wienecke, Tesa, Loctite, Timothée Cook, John Morgan Guiding.

Mitigation…



Spatial protection…

Conservation translocations…

Large-scale management…

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