Impacts of climate change on seabirds in the Benguela Ecosystem

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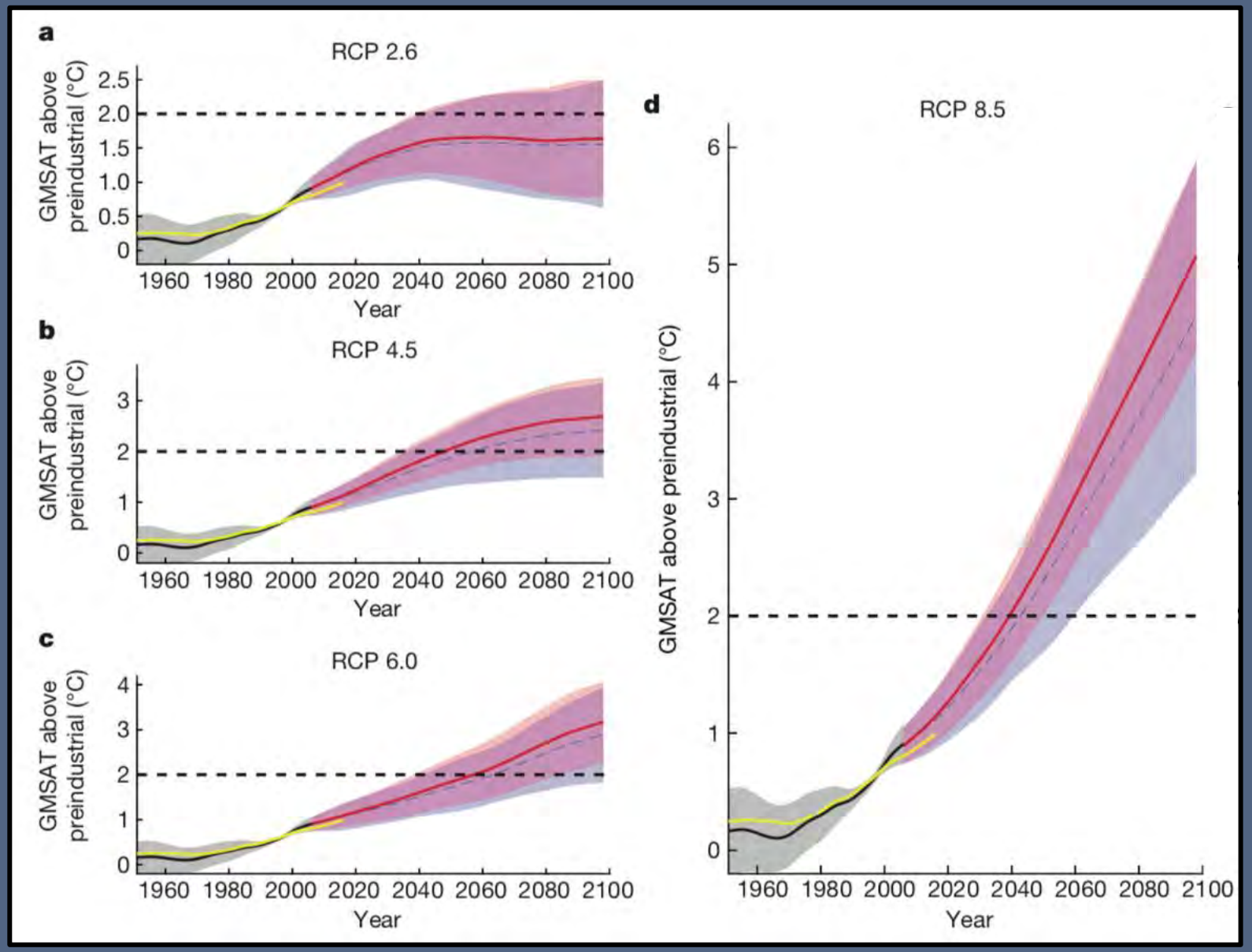
Biological Sciences

50th Anniversary 1960-2010 Percy FitzPatrick Institute

Bristol Zoological Society
Saving Wildlife Together

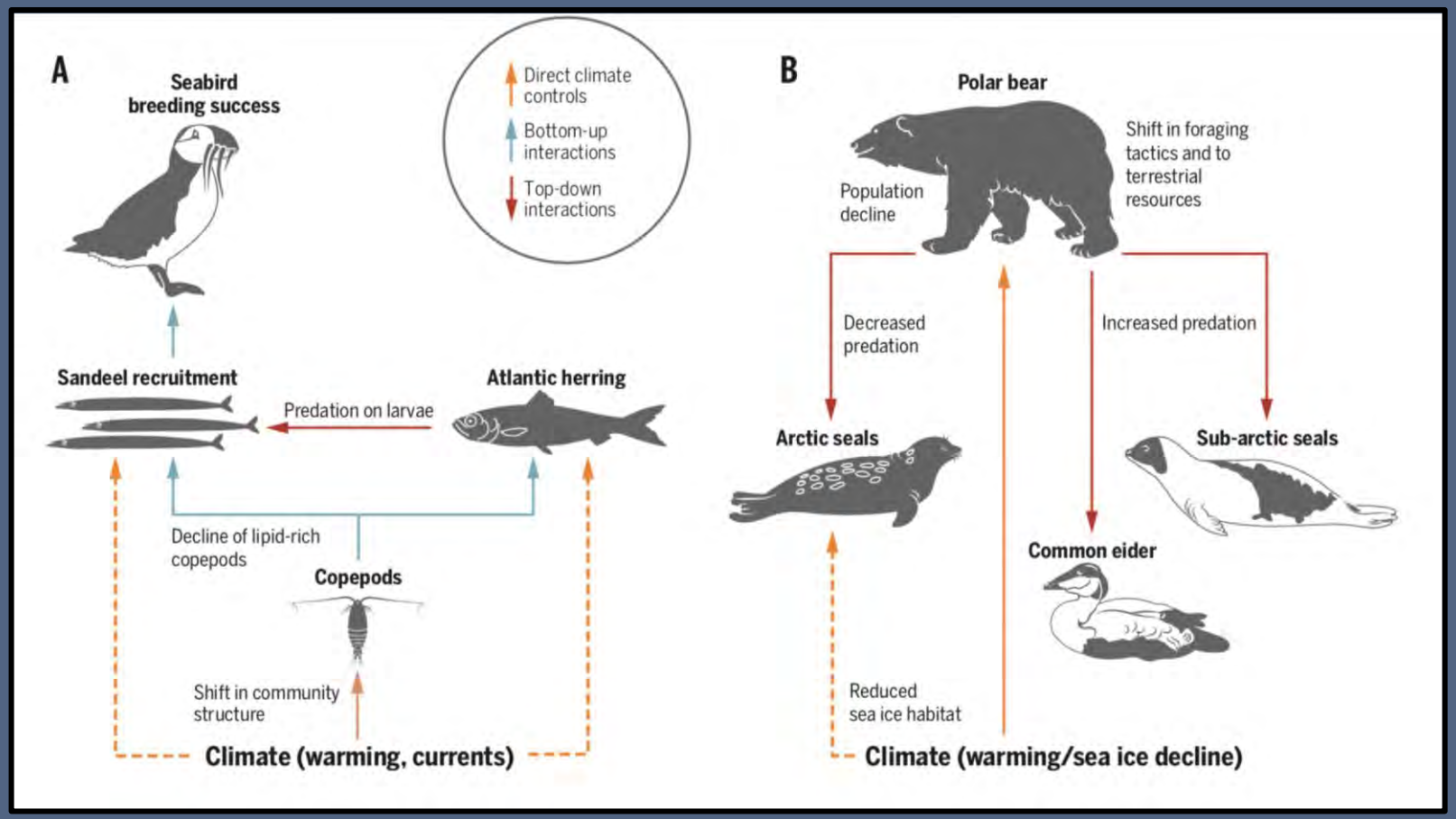
The climate is changing…



Brown & Caldeira 2017, Nature 552: 45-50.

Impact on organisms

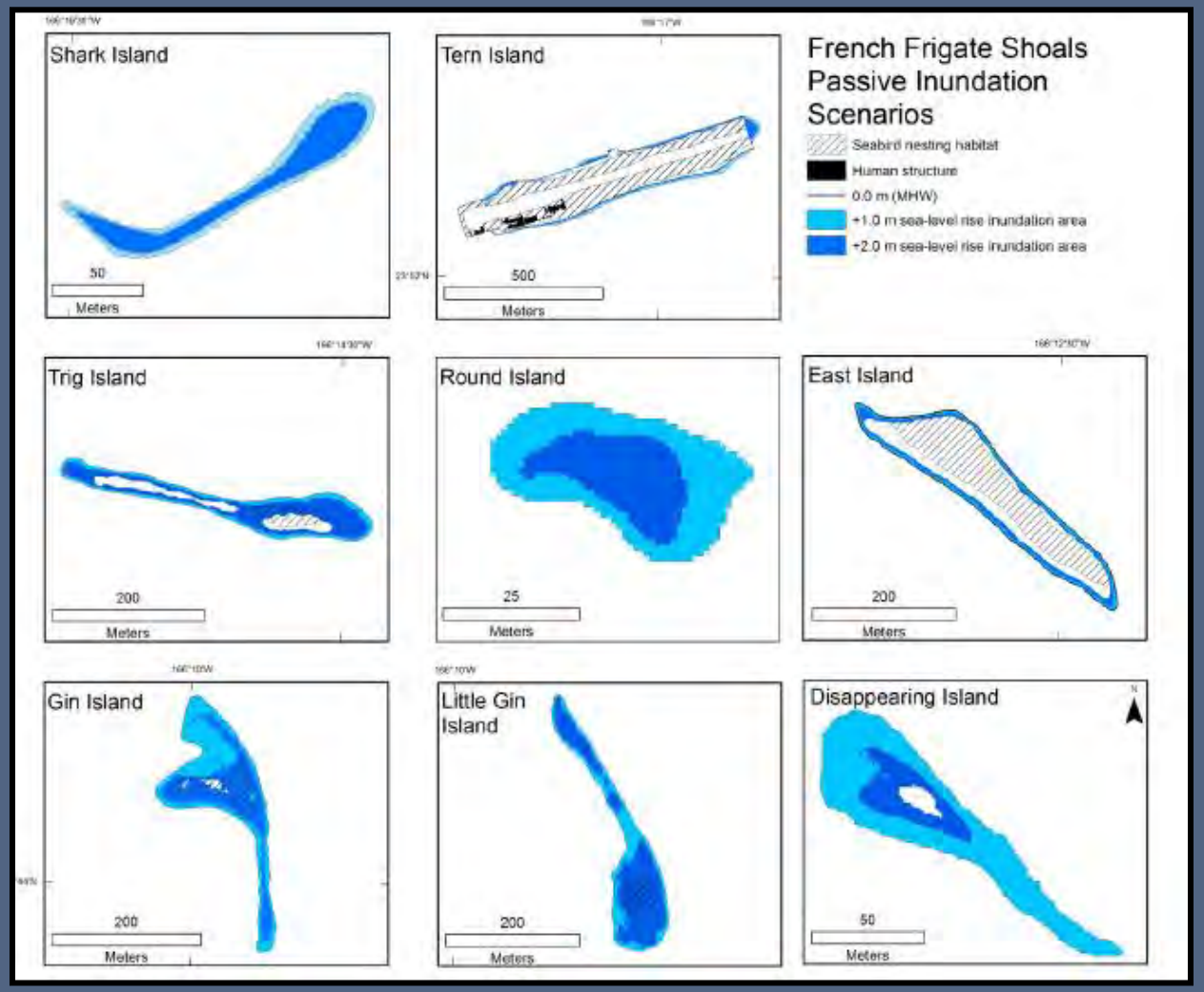
- Indirect effects
  - **Shifts in phenology**
  - **Impacts of trophic cascades**



Sydeman et al. 2015, Science 350: 772-777.

Impact on organisms

- Direct effects
  - **Habitat change (sea ice loss, rising sea levels)**
  - **Increased storms/precipitation**
  - **Increased temperature**



Hatfield et al. 2012, Conserv. Biol. 26: 667-678.

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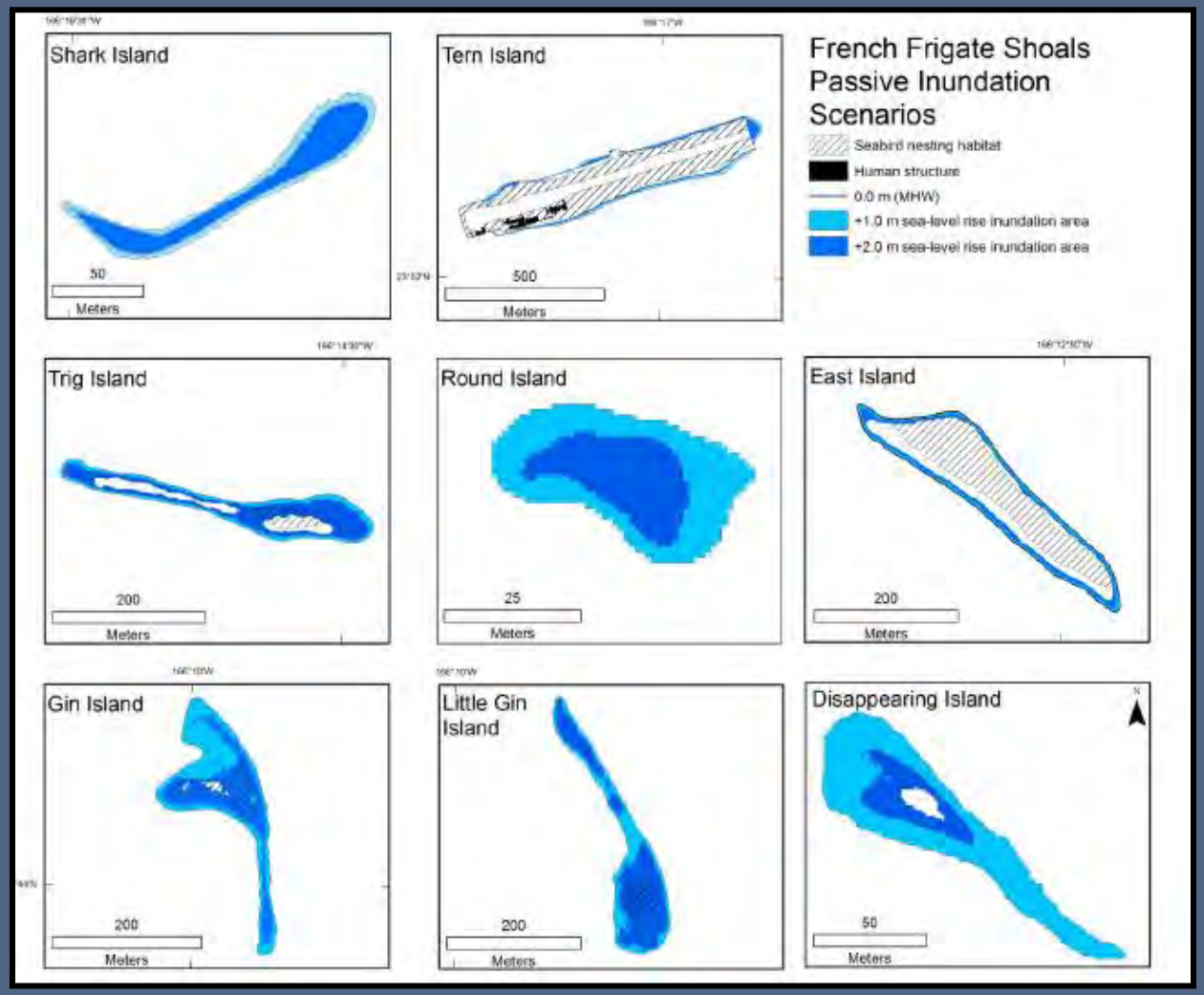
Mostly studied in ecotherms...



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Seabirds and climate change

- Seabirds are good study models

  Must satisfy a range of conflicting requirements across their lives.

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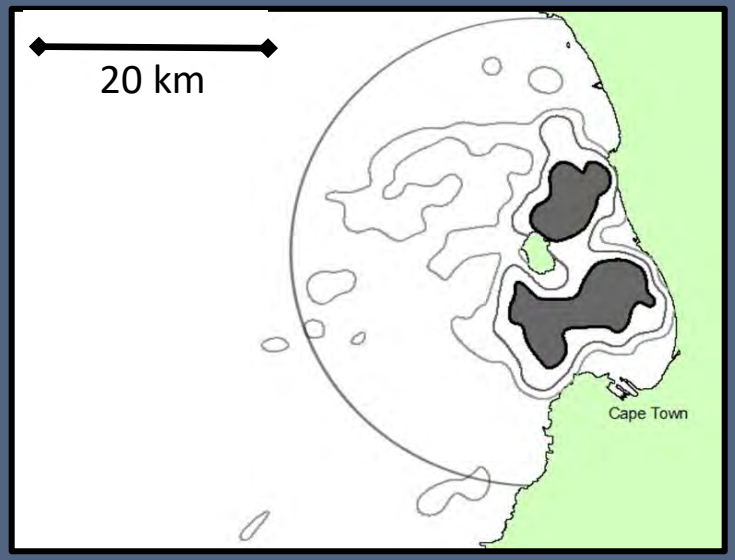

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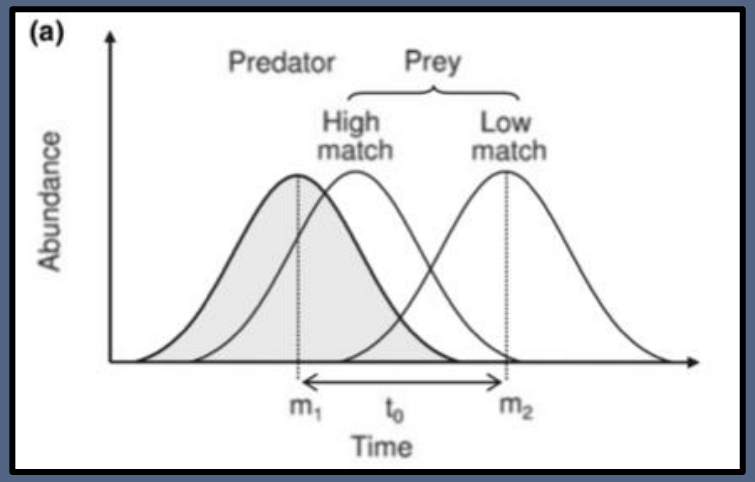
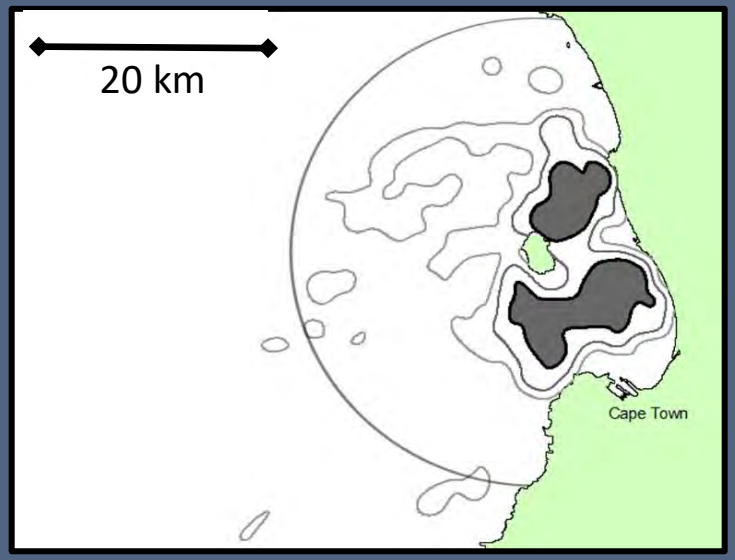
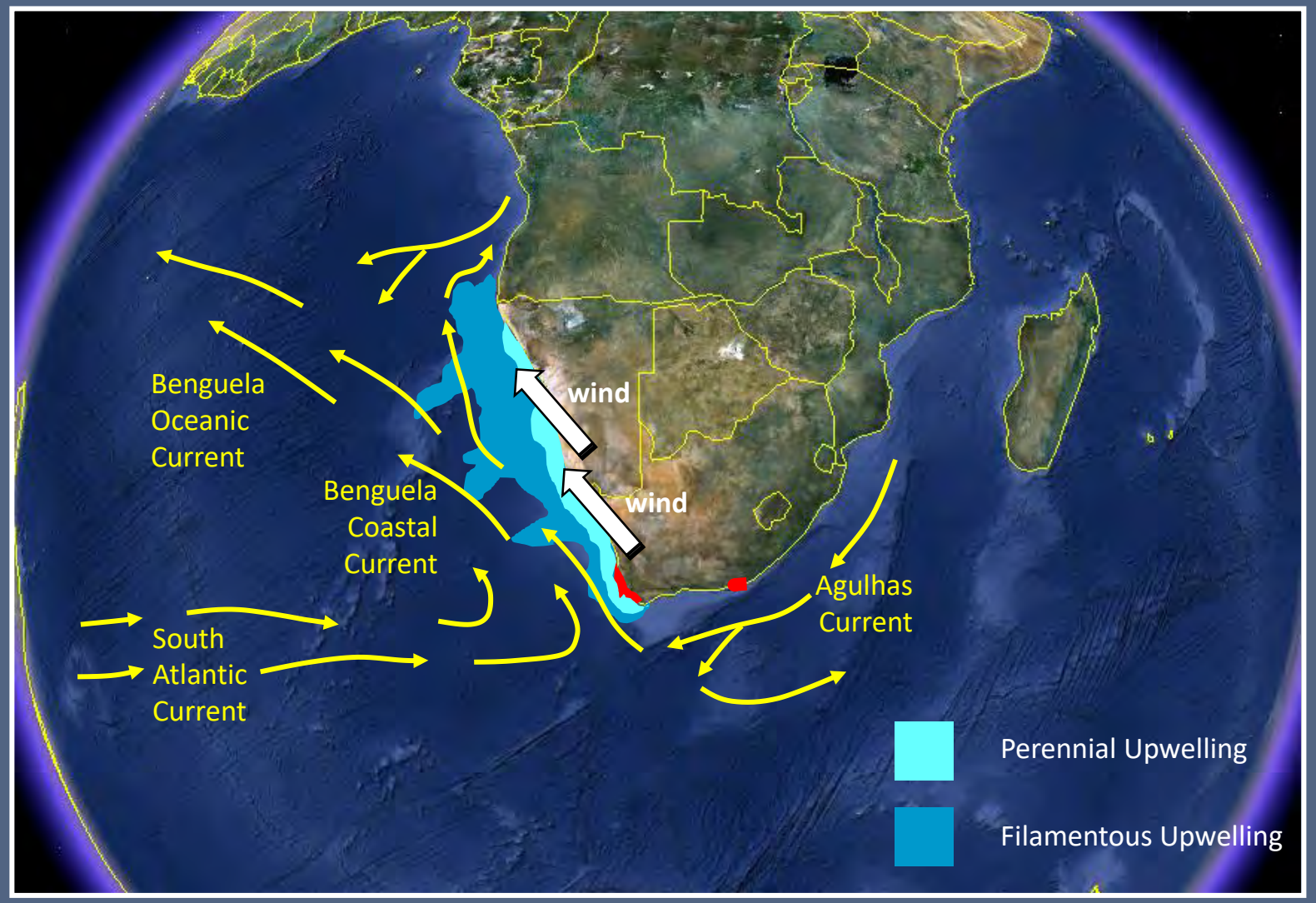


Durant et al. 2005, Ecol. Lett. 8: 952-958.



Seabirds in the Benguela



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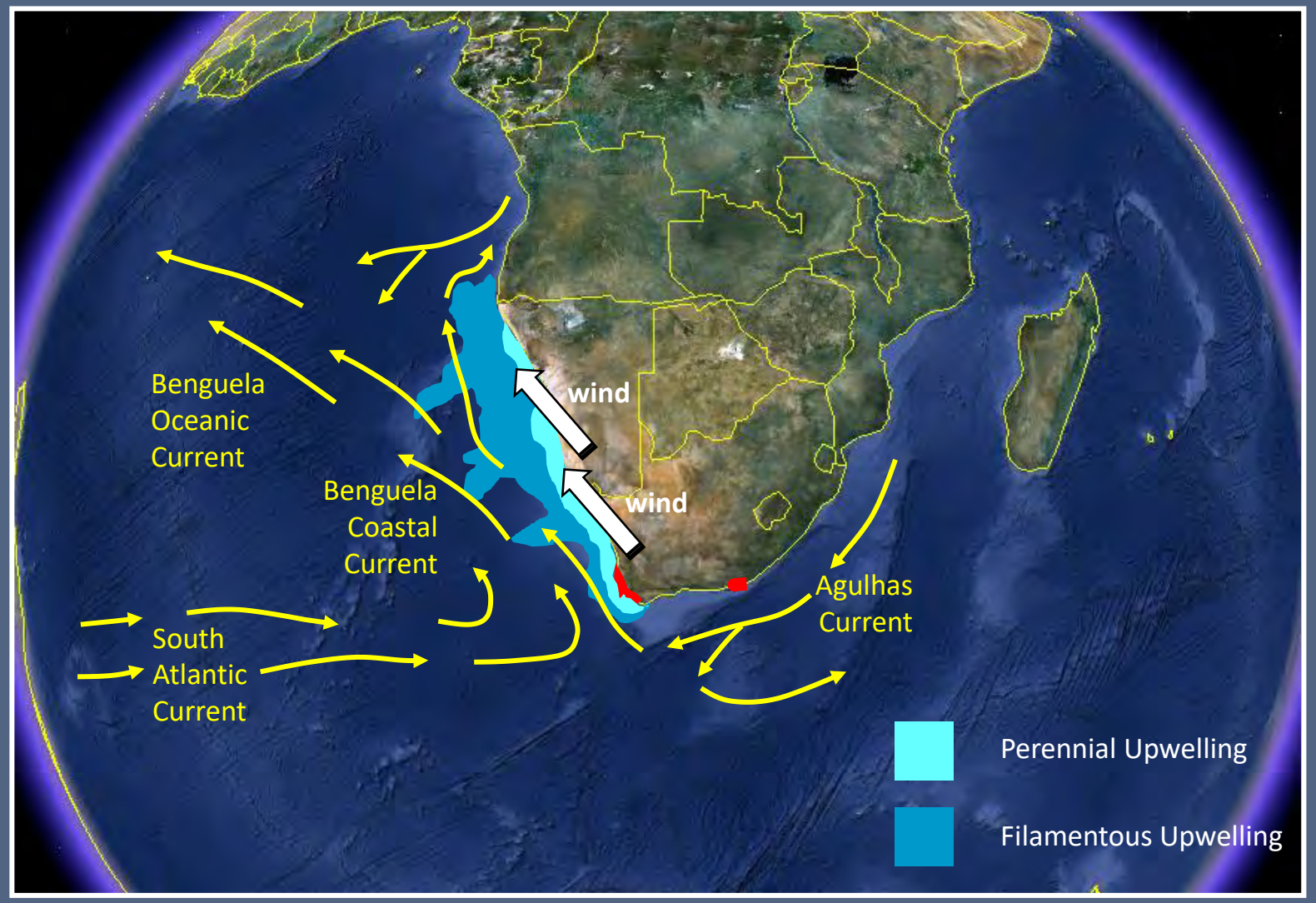
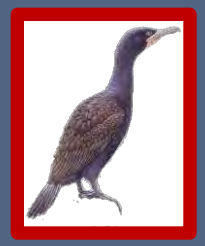


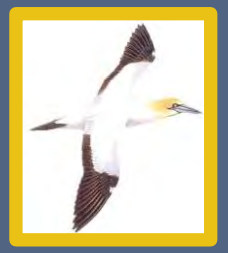
Seven endemic seabirds, **four** are globally endangered

Seabirds in the Benguela

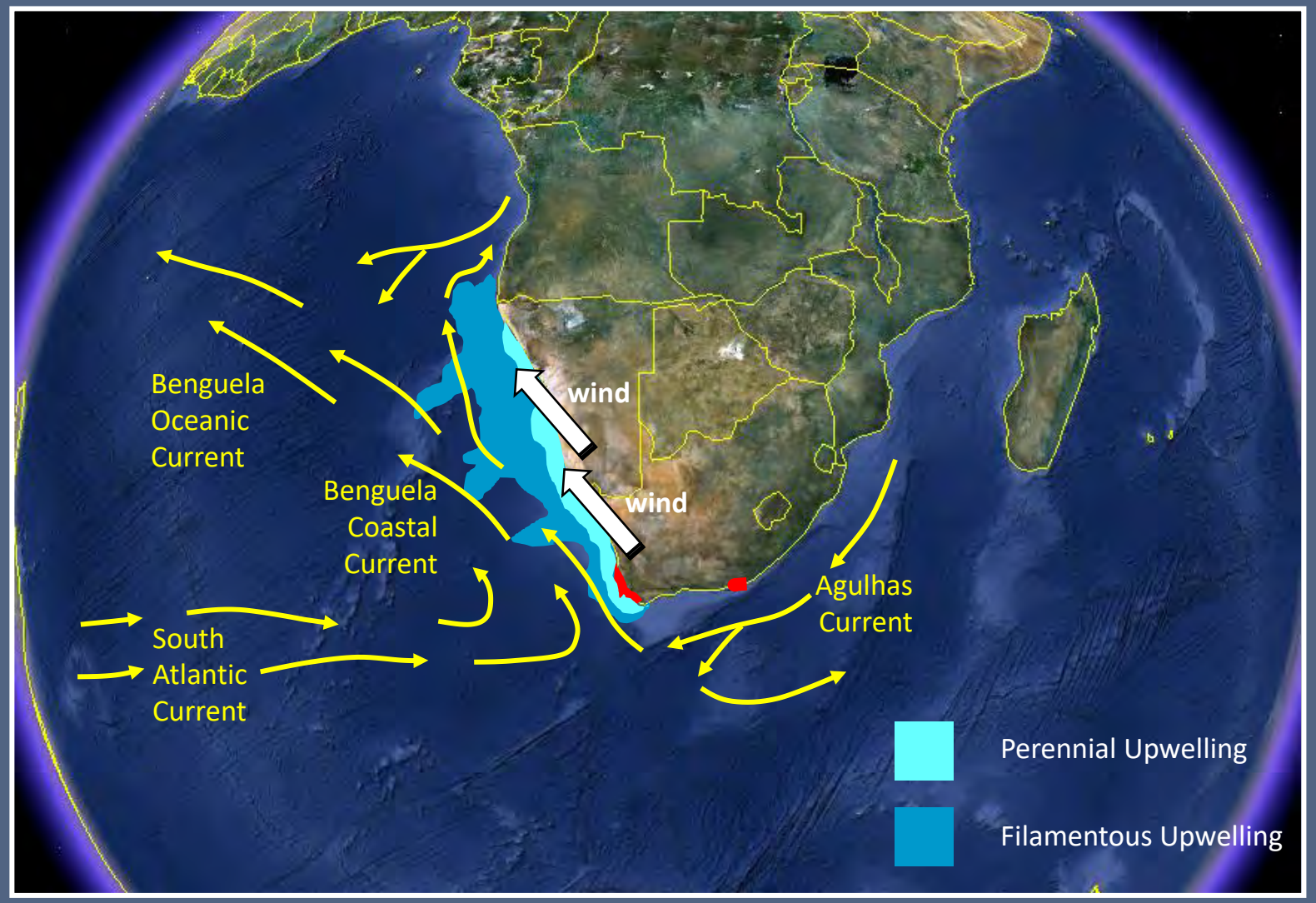
African penguin
Spheniscus demersus



Cape cormorant
Phalacrocorax capensis



Cape gannet
Morus capensis



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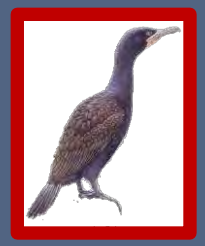

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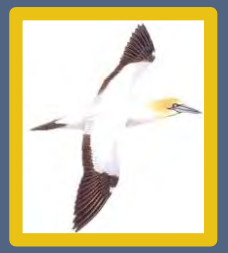

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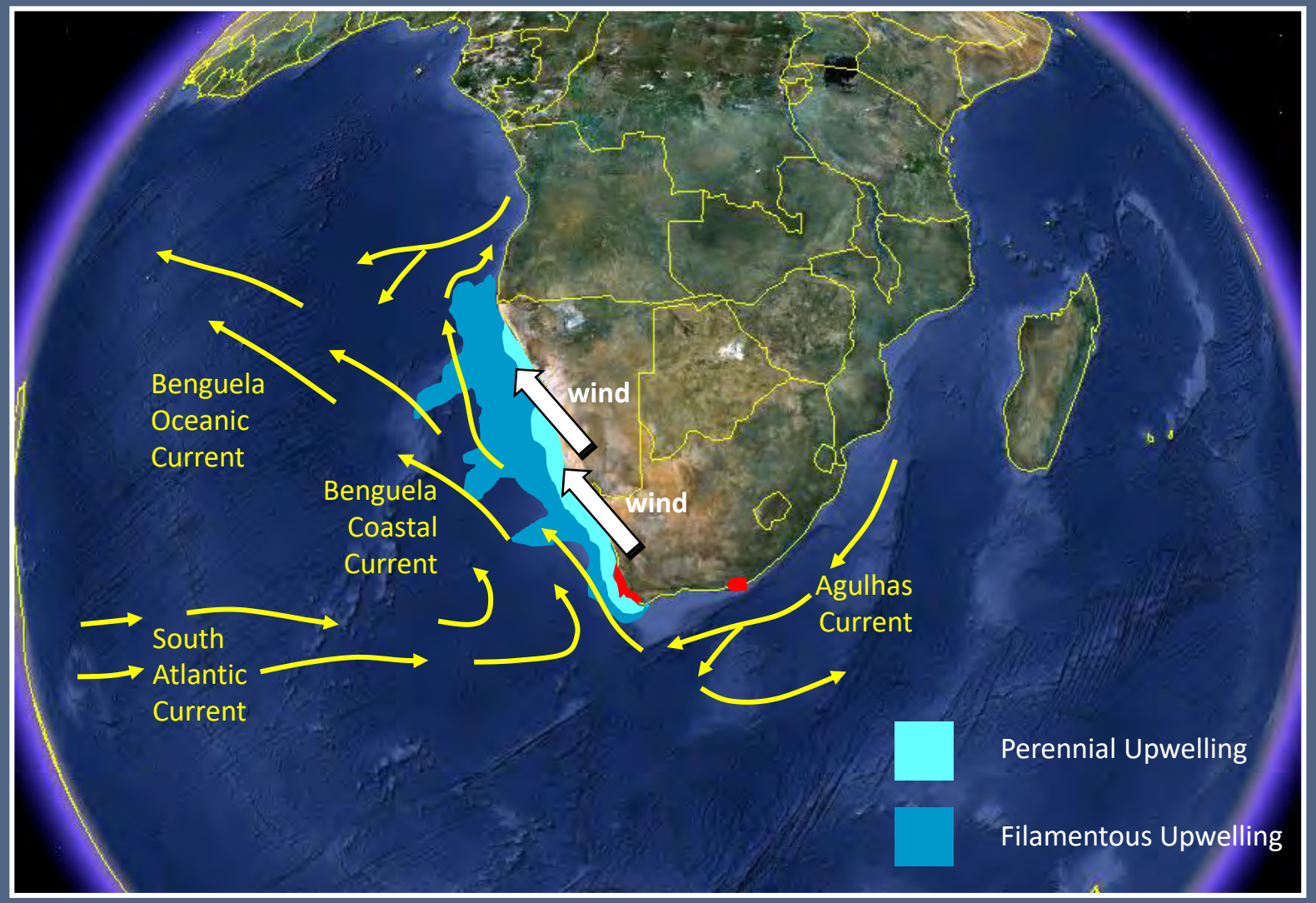

Cape anchovy
Engraulis encrasicolus

Sardine
Sardinops sagax

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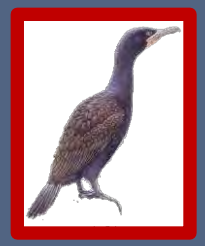

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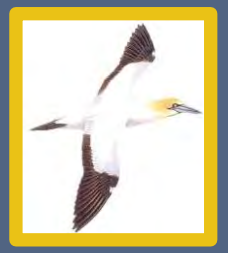

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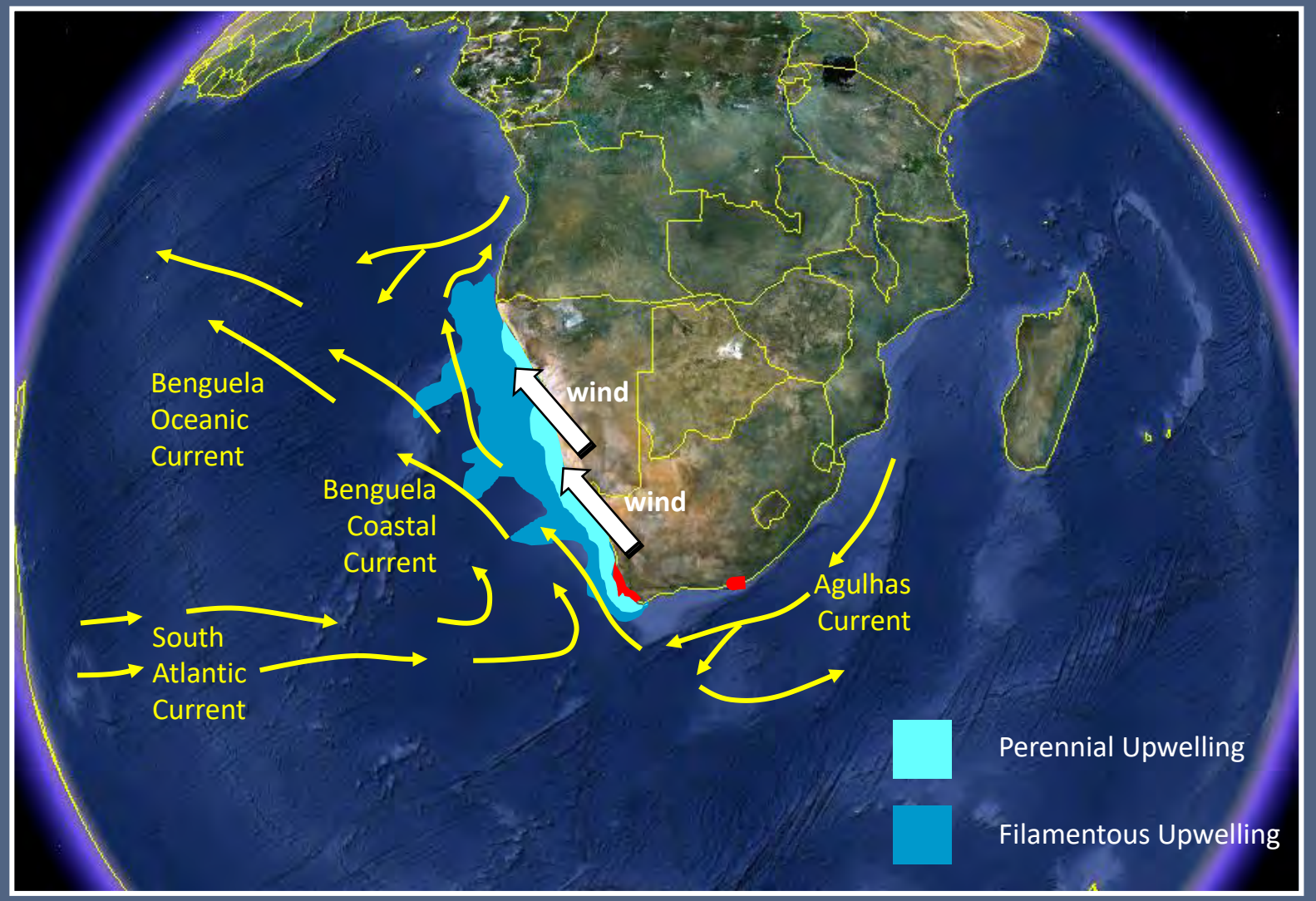

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Phalacrocorax neglectus

West coast rock lobster
Sardinops sagax

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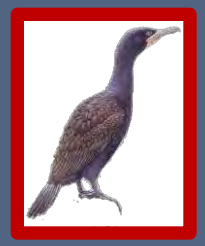

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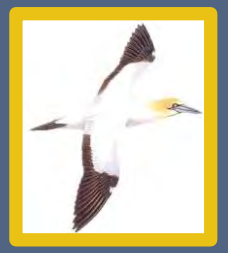

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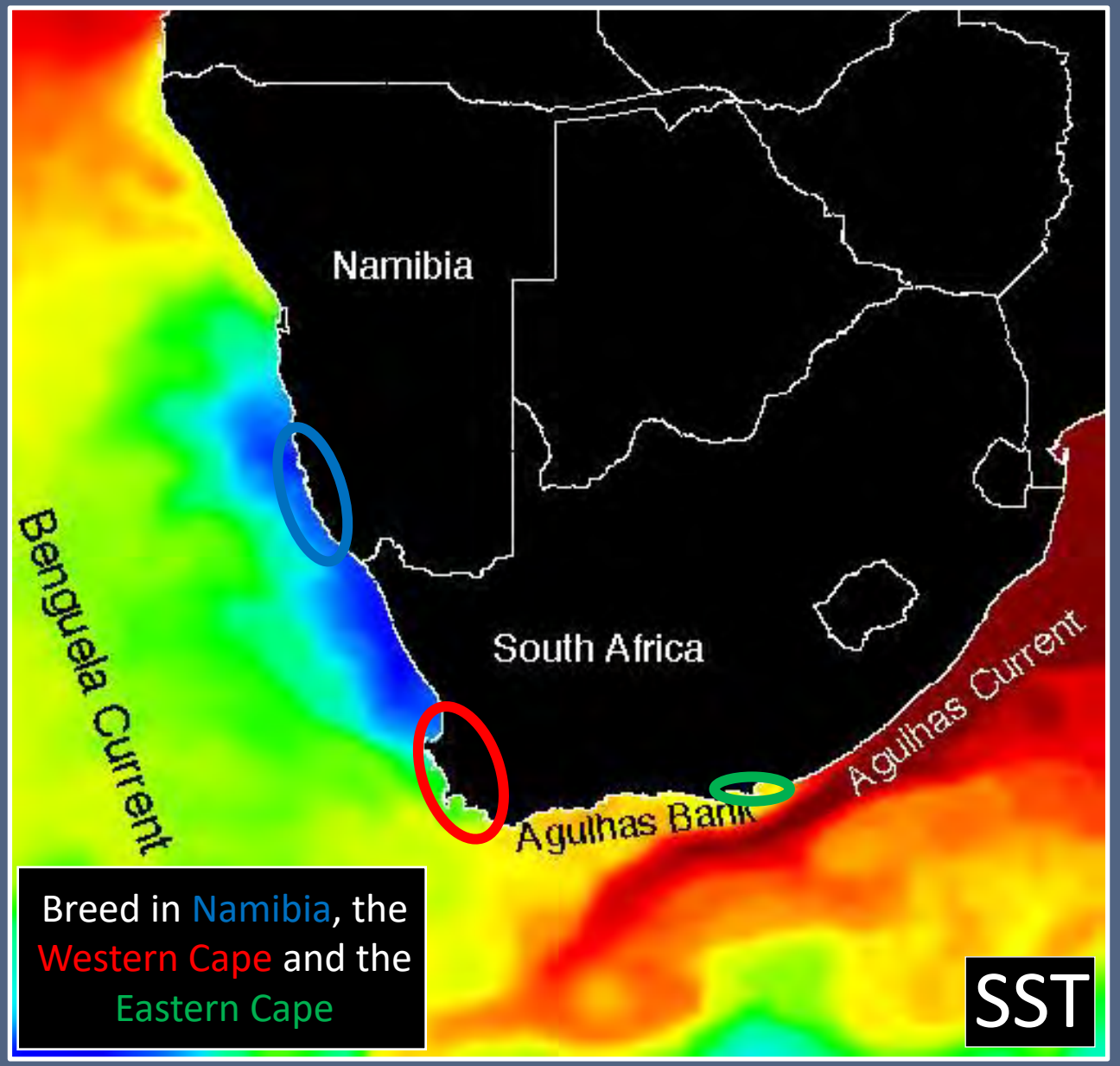

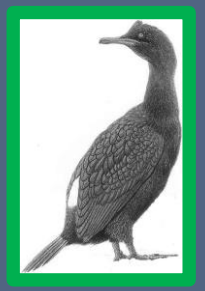

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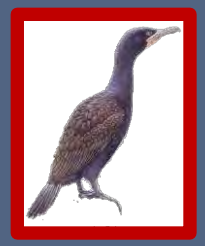

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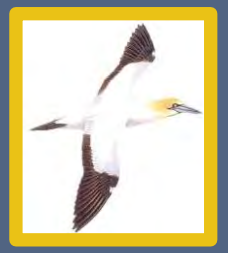

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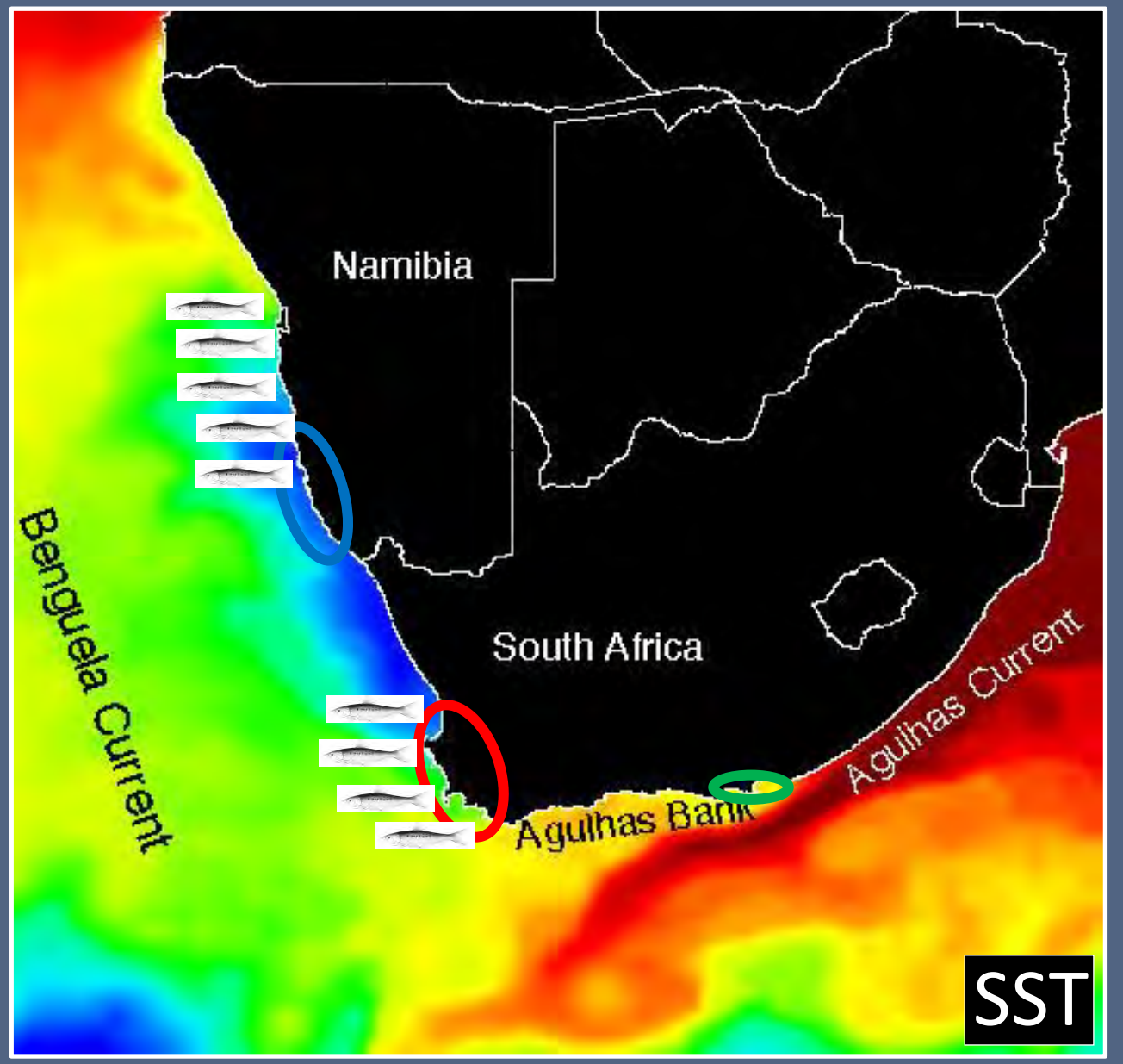

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Rapid environmental change in the Benguela

Drivers

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↑ Upwelling mean and variability (1980s/1990s)

↑ SST in northern Benguela & Agulhas Current (since 1980s)

↓ summer SST on south-west coast (since 1980s)

Periods of O_2 depletion (1950s, 1990s/2000s)

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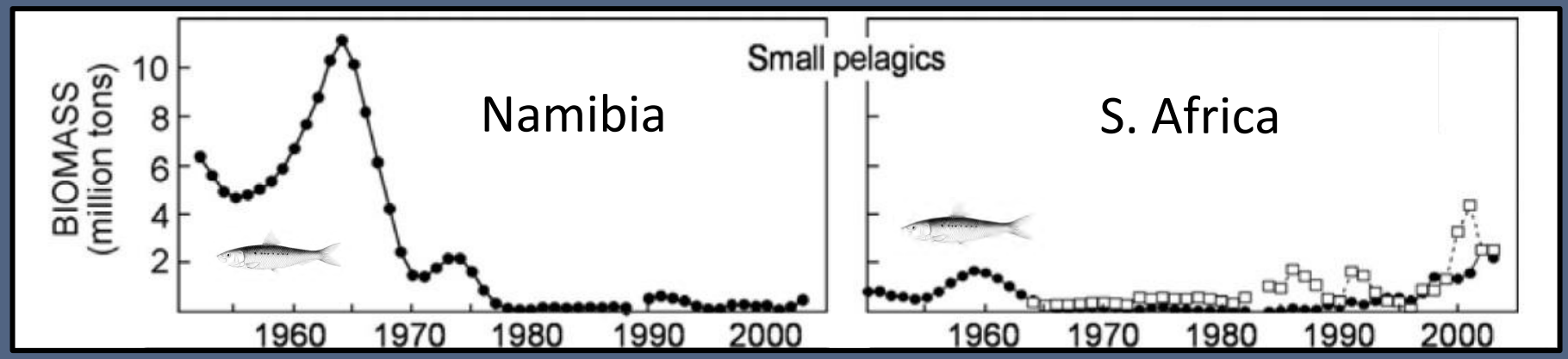

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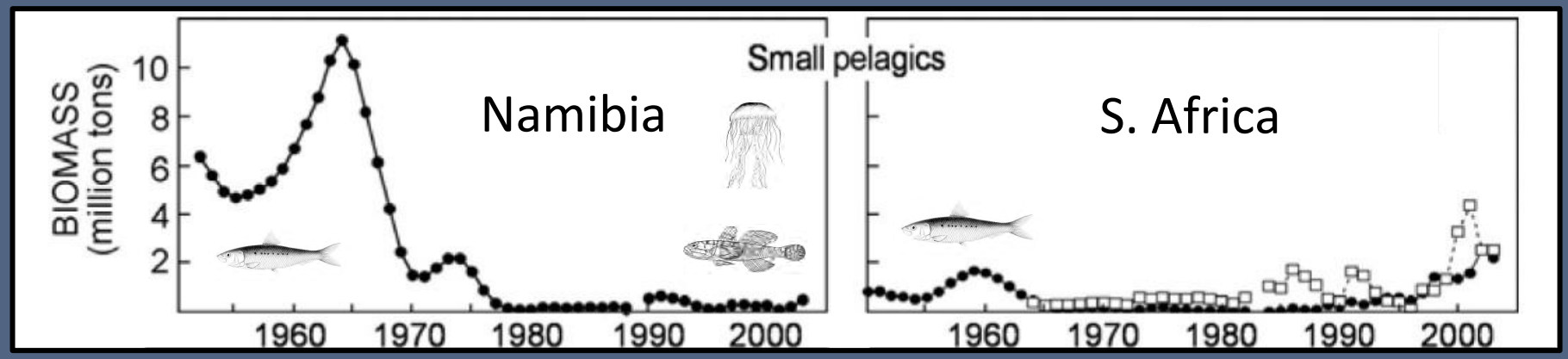

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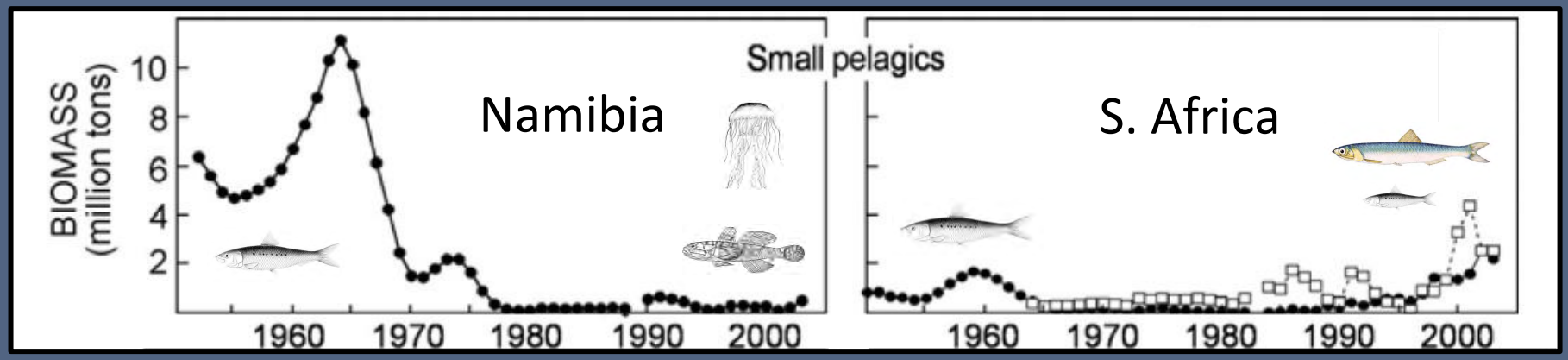

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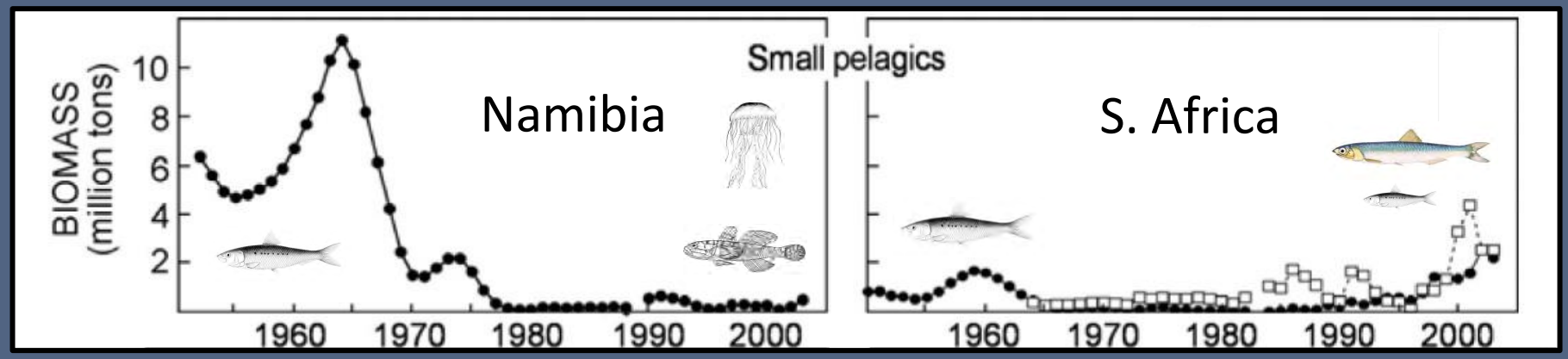

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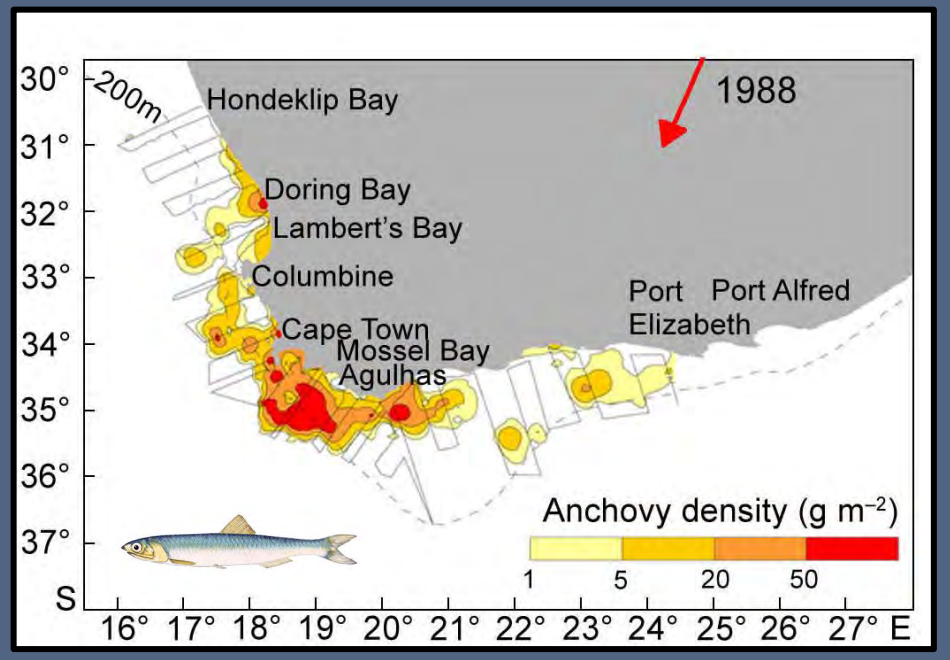

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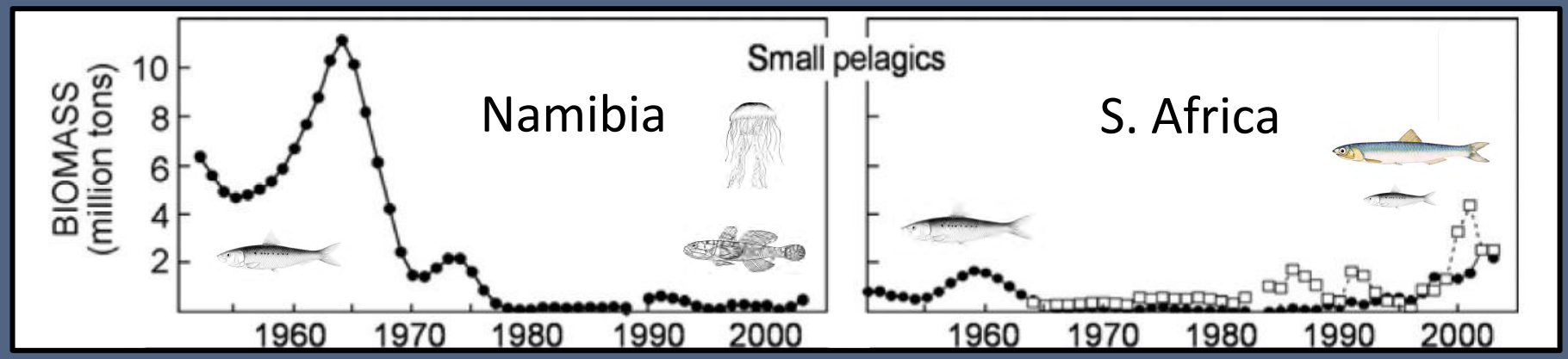

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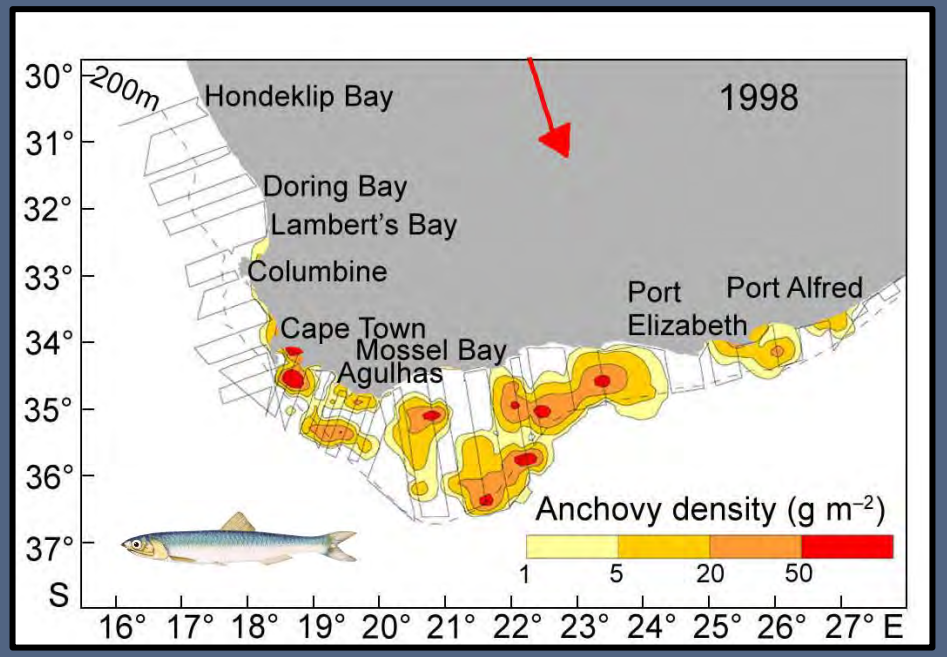

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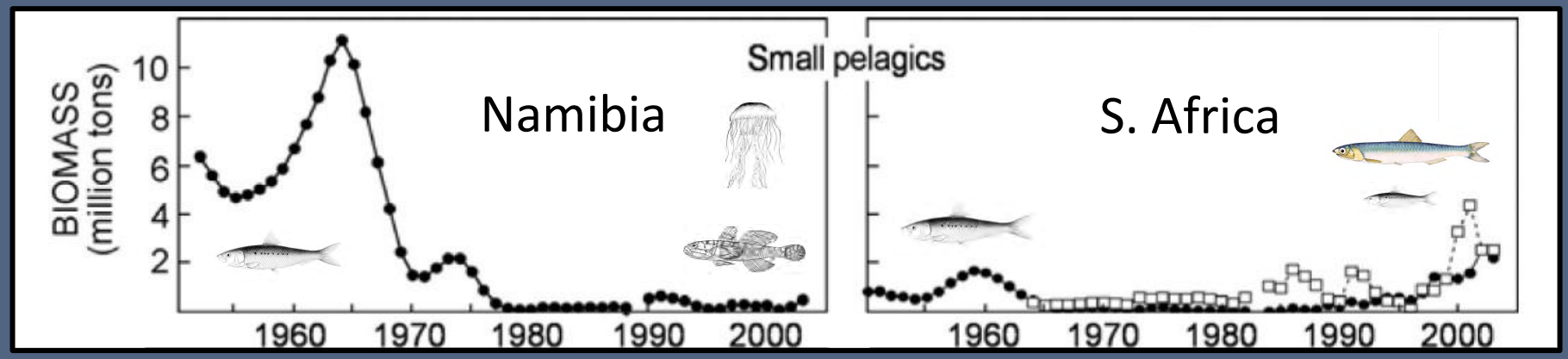

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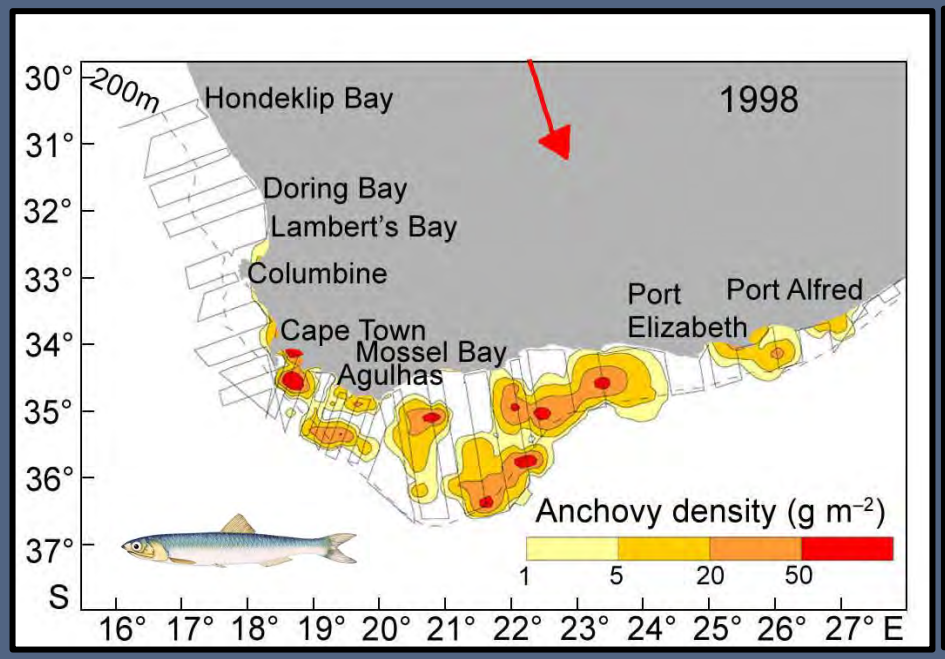

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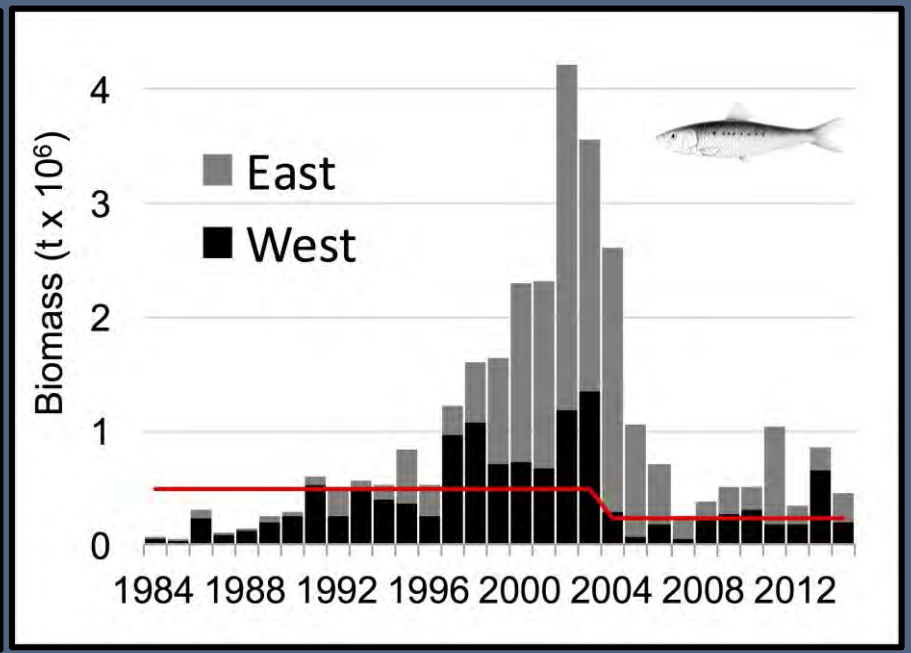

Updated from Coetzee et al. 2008, ICES J. Mar. Sci. 65: 1676–1688

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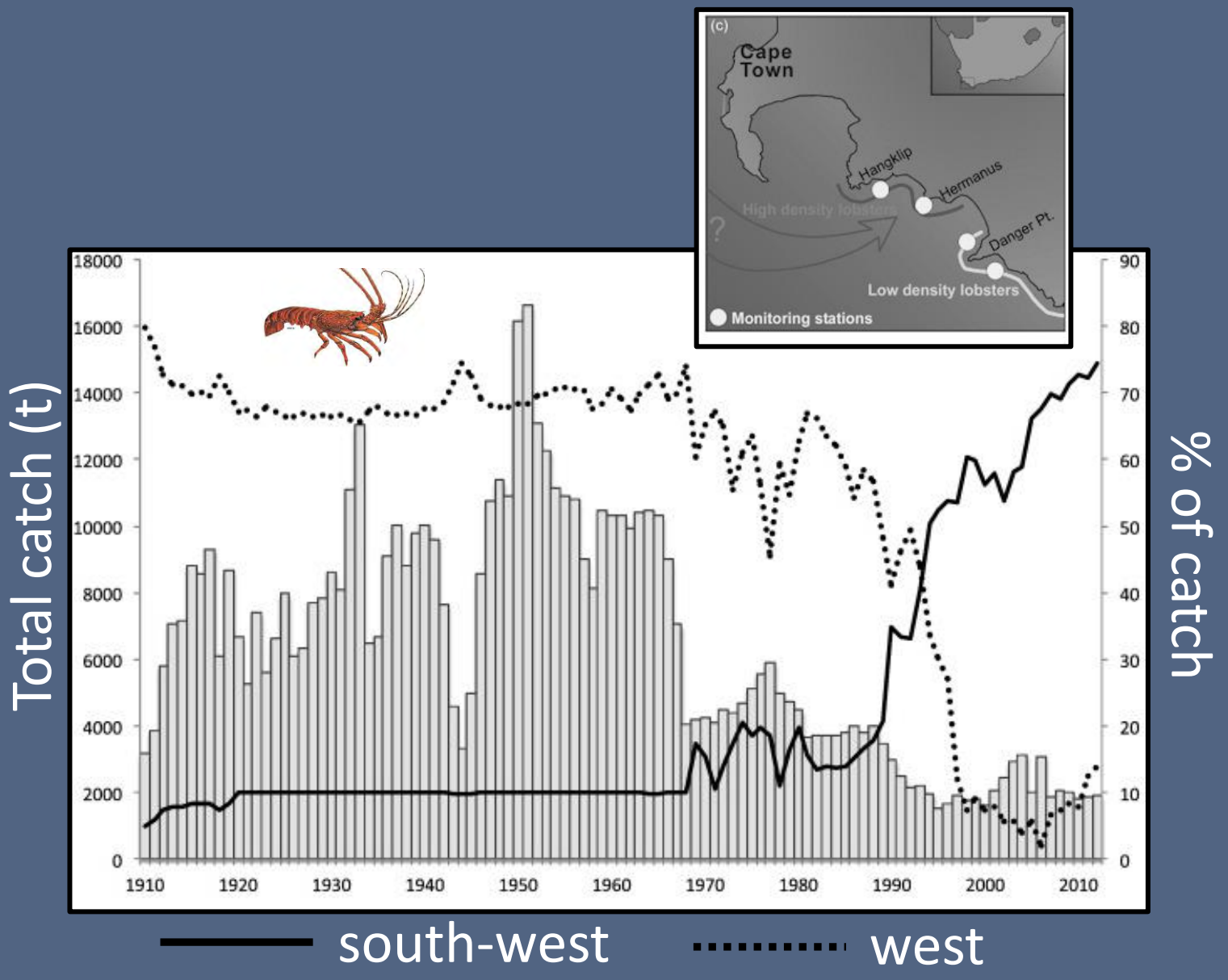

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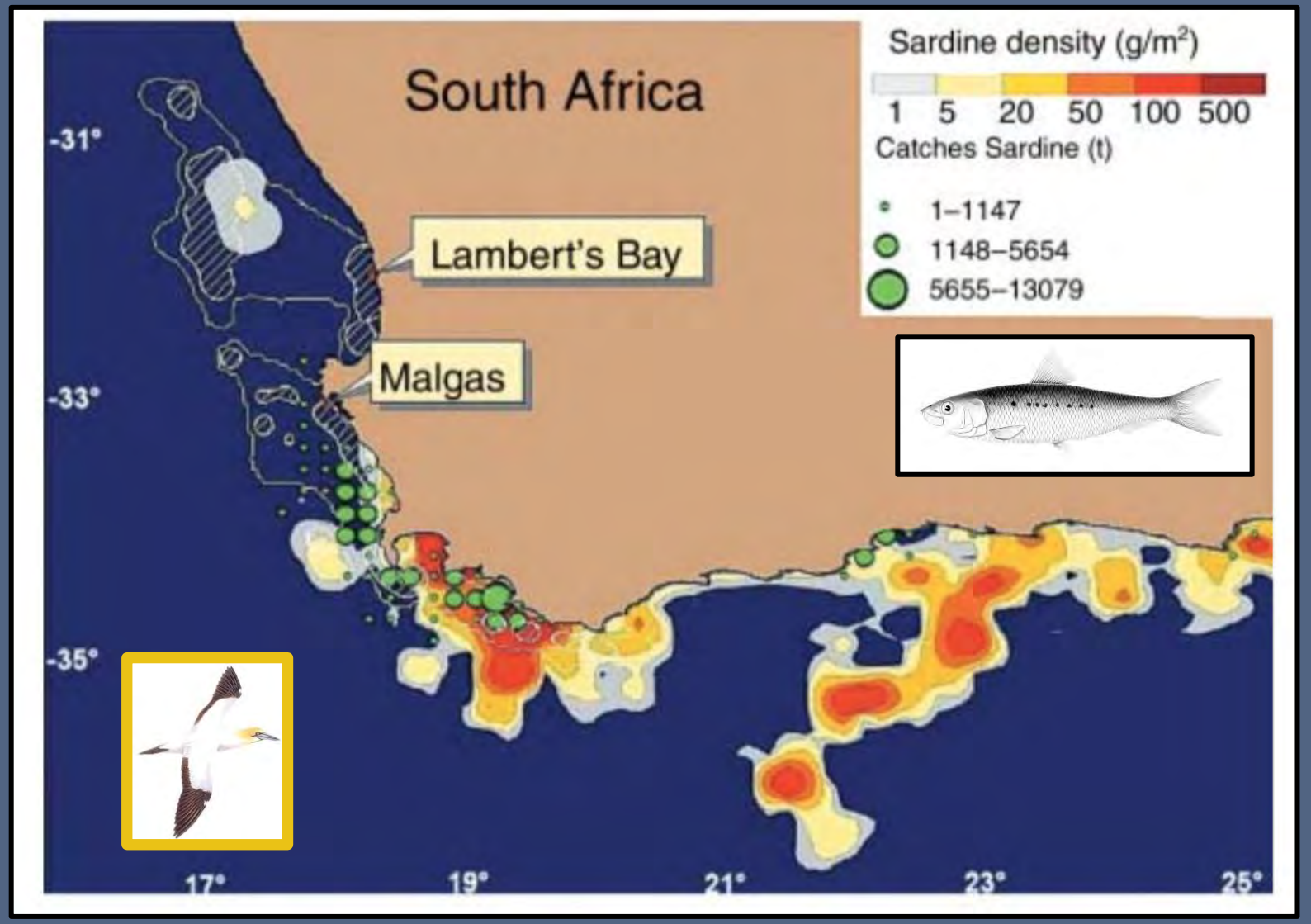
Seabird responses

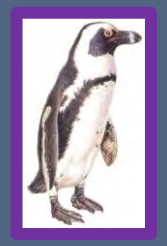
- Spatial mismatch



Grémillet et al. 2008, J. Appl. Ecol. 45: 610–621.

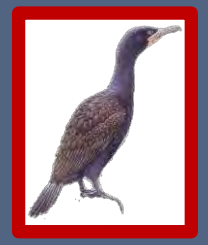
Seabird responses

- Population declines



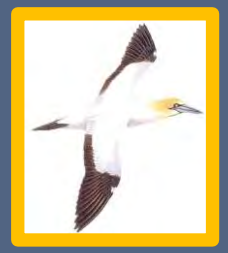
African penguin
Spheniscus demersus

~ 60% since 2001



Cape cormorant
Phalacrocorax capensis

~ 64% since 1978



Cape gannet
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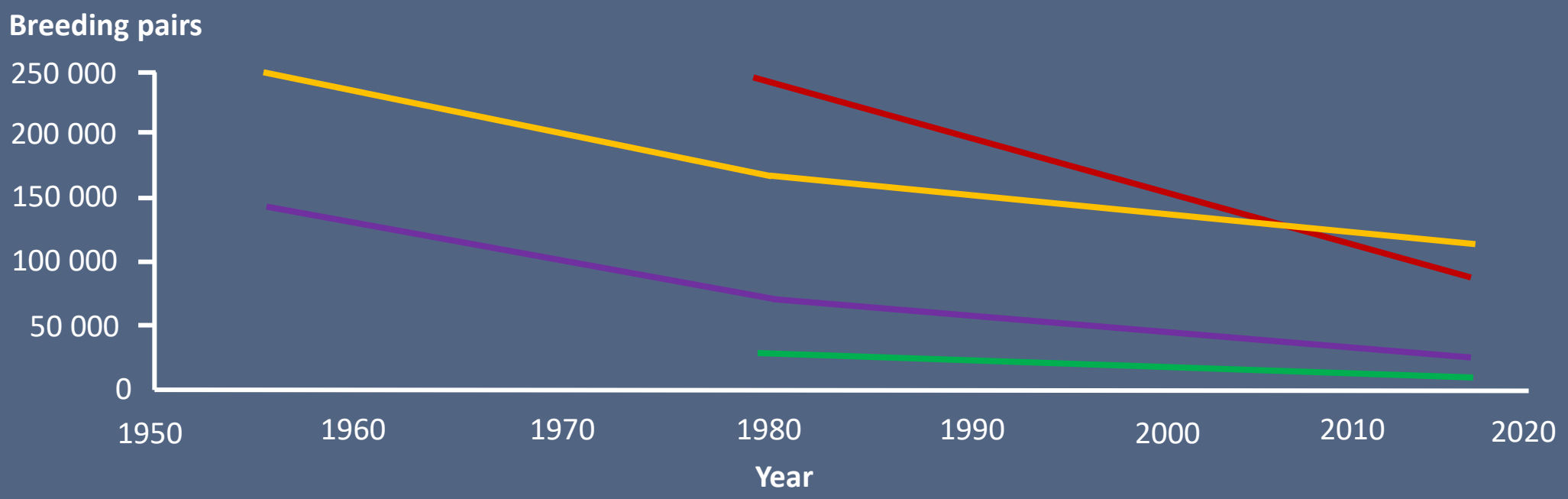
~ 52% since 1956

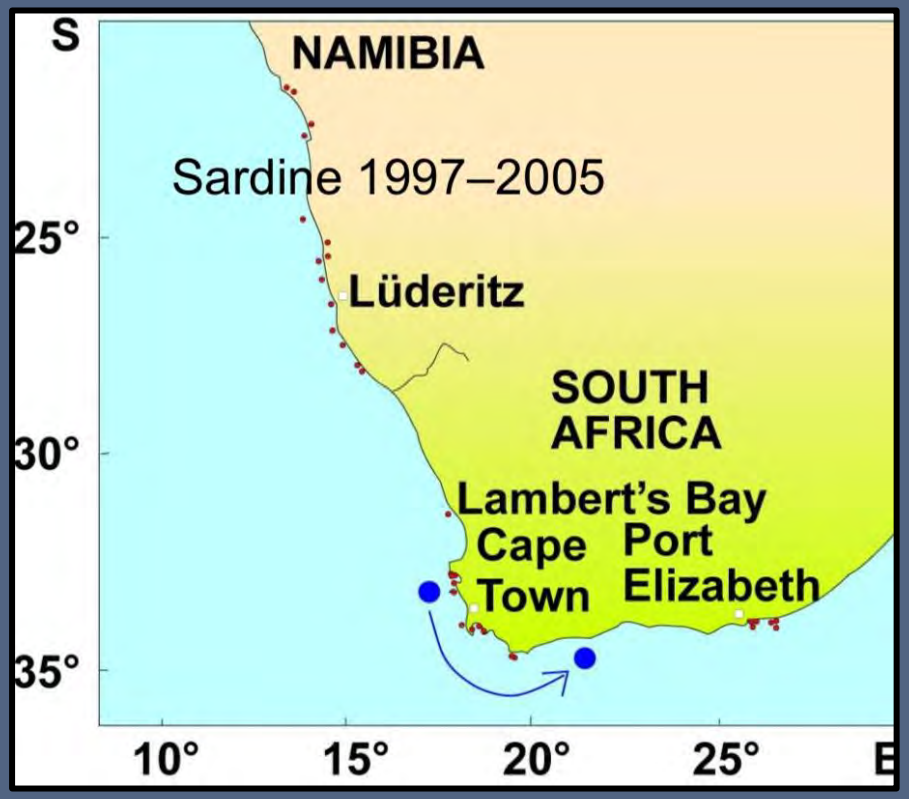
Bank cormorant
Phalacrocorax neglectus

~ 53% since 1978

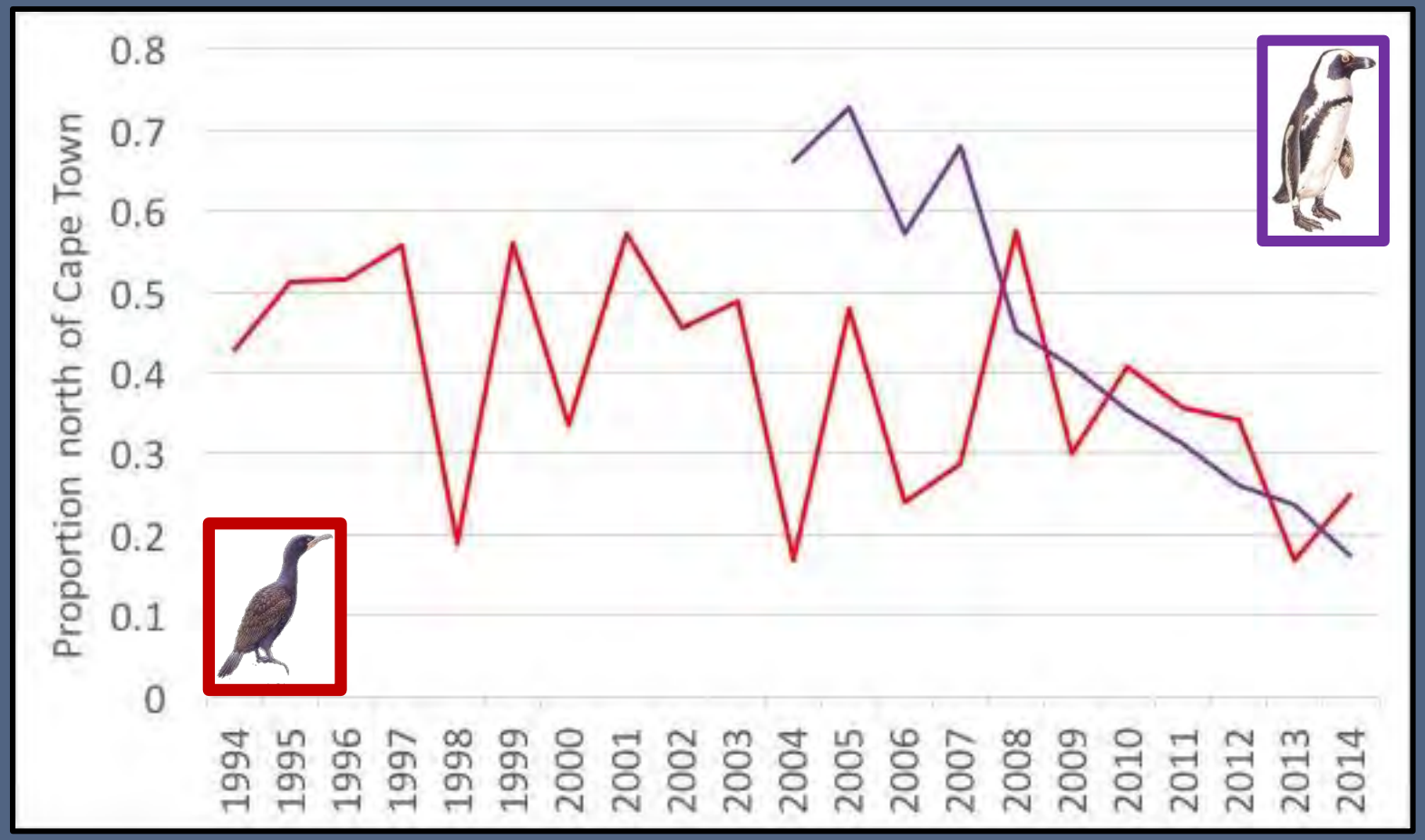


Seabird responses

- Eastward shifts
- Regionally different population dynamics?



Eastward displacement



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- Diet – scavenging from snoek hand-lines (Crawford et al. 2016)
- Phenology? (anecdotally)

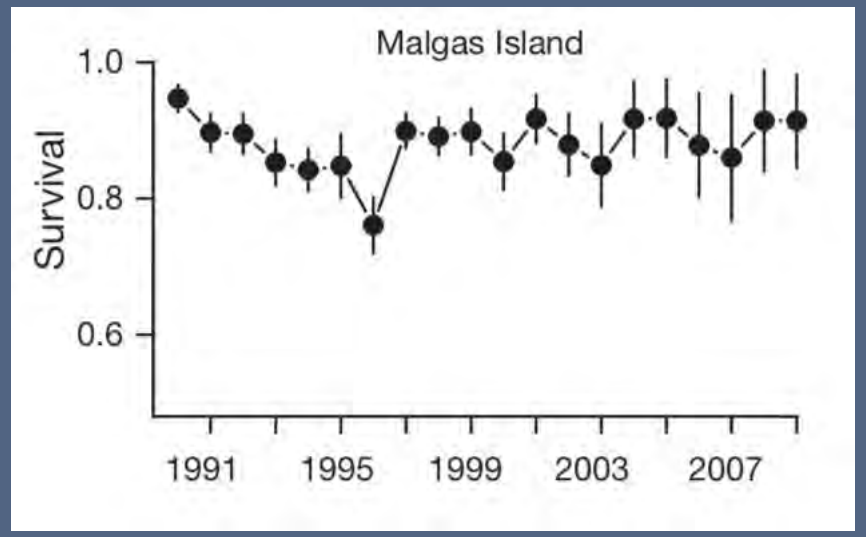
Cape Gannets

- Fecundity – declines in chick growth rates (Cohen et al. 2014)

Cape Gannets

- Fecundity – declines in chick growth rates (Cohen et al. 2014)
- Survival – maintained high survival (Distiller et al. 2012)

Distiller et al. 2012, Mar. Ecol. Prog. Ser. 461: 245–255.



West

Cape Gannets

- Fecundity – declines in chick growth rates (Cohen et al. 2014)
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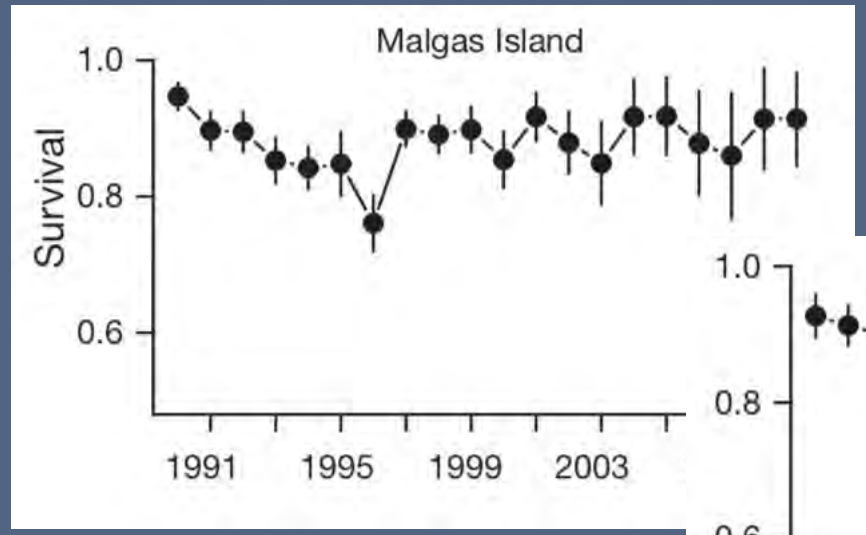
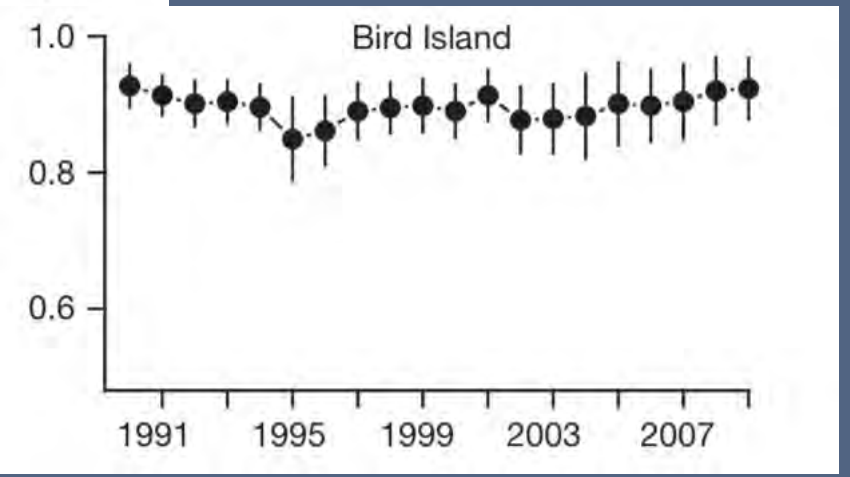
Distiller et al. 2012, Mar. Ecol. Prog. Ser. 461: 245–255.



West

East



Cape Gannets

- Fecundity – declines in chick growth rates (Cohen et al. 2014)
- Survival – maintained high survival (Distiller et al. 2012)
- Recruitment? – changes in adult and chick condition (Grémillet et al. 2016)

Cape Gannets

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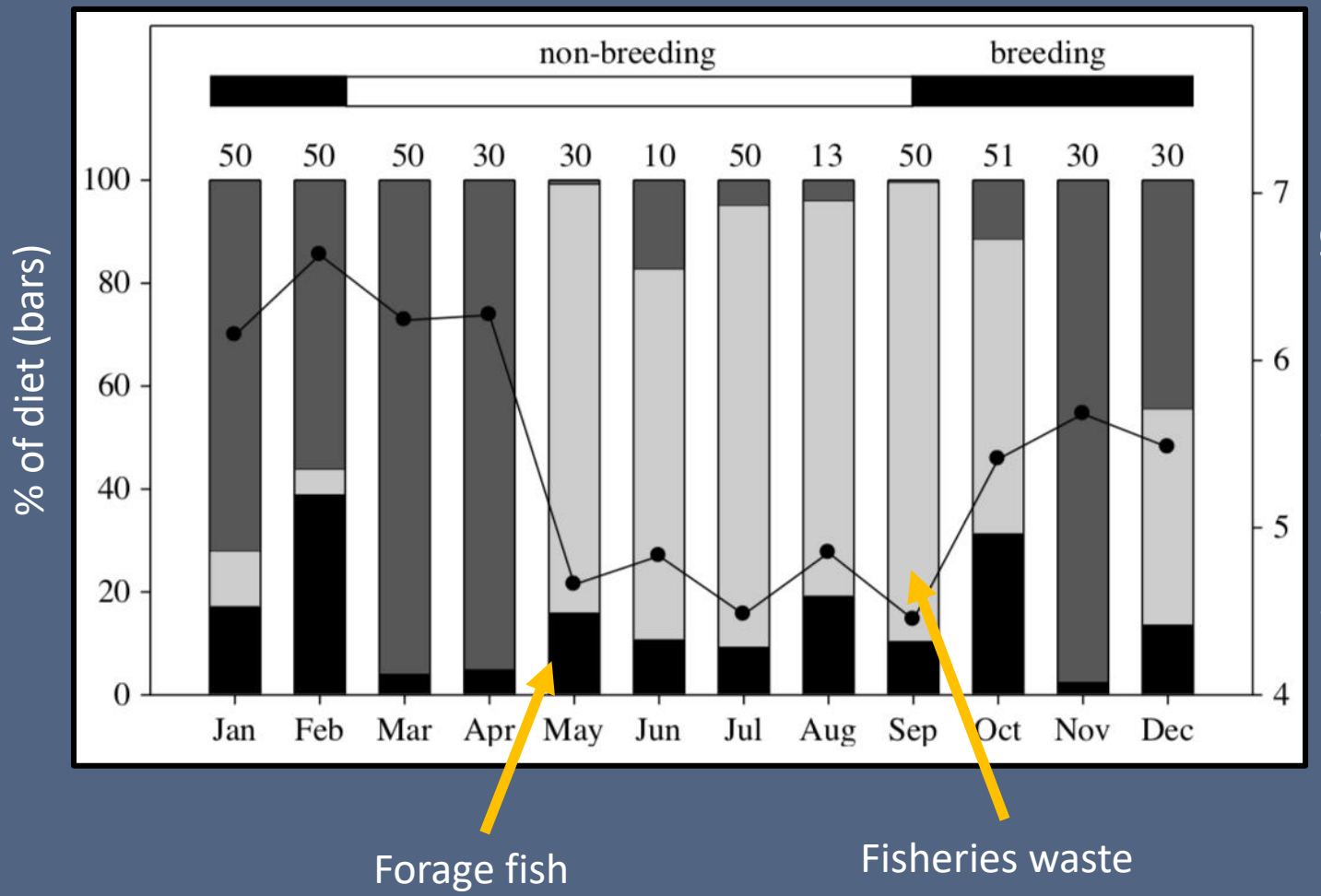
- Diet – greater reliance on discards (Grémillet et al. 2008, 2016)

Cape Gannets



- Diet – greater reliance on discards

Grémillet et al. 2008, Proc. R. Soc. B 275: 1149–1156.

Cape Gannets

- Fecundity – declines in chick growth rates (Cohen et al. 2014)
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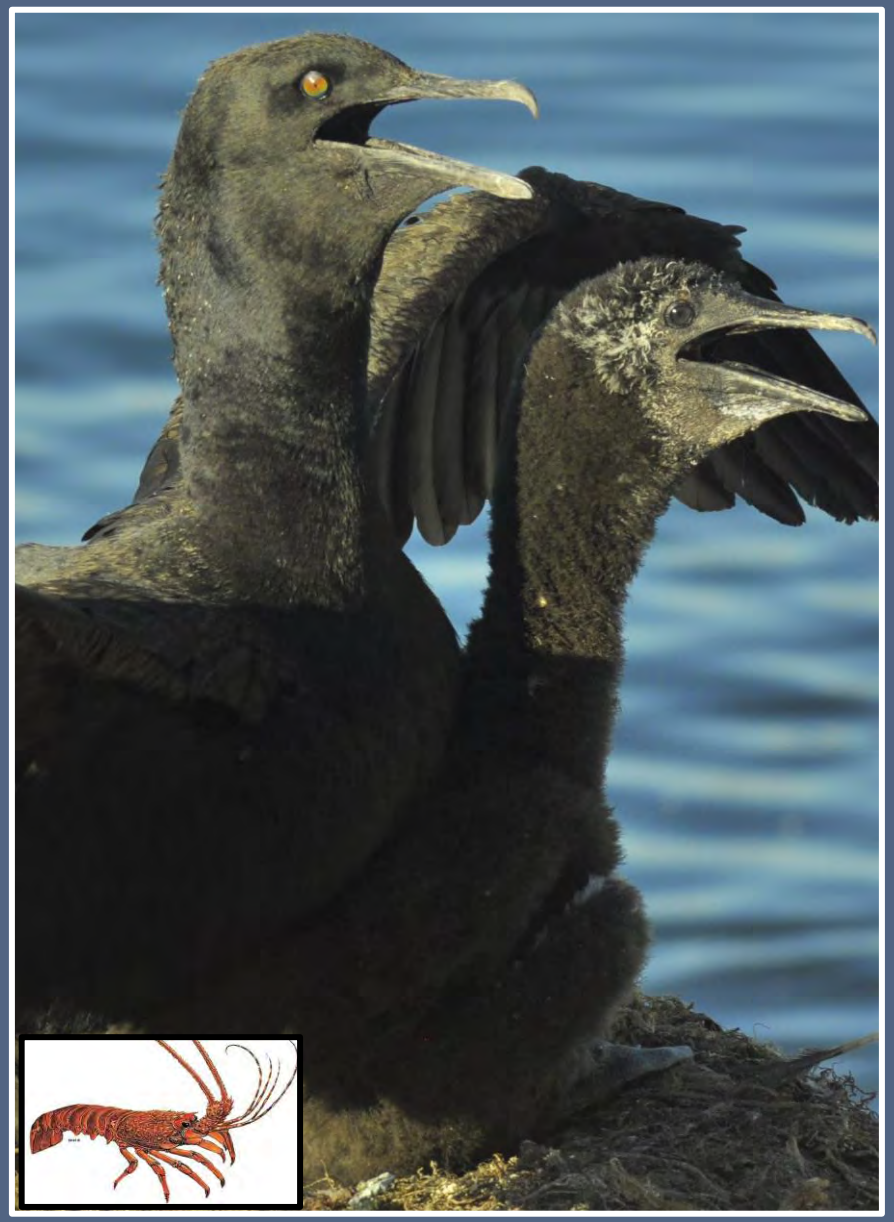
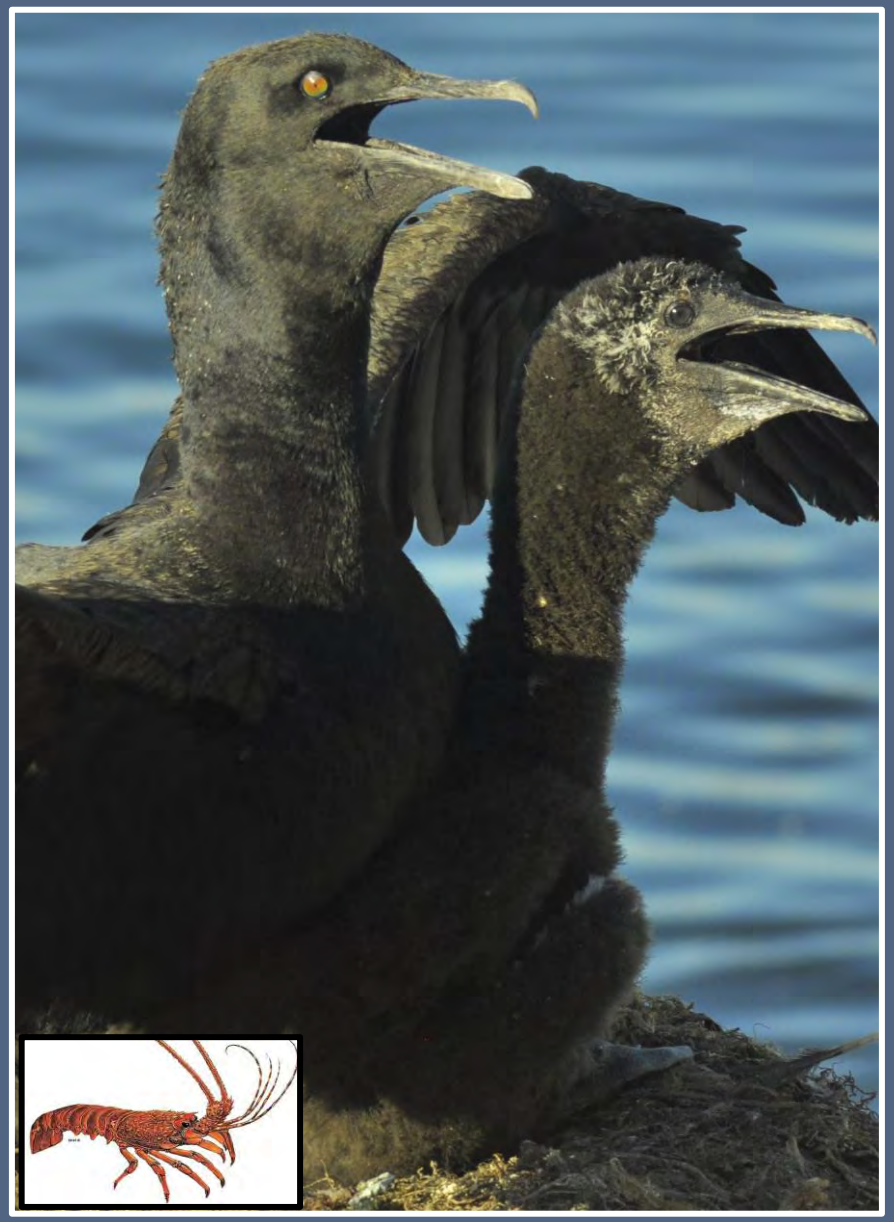
- Phenology?

Bank Cormorants



- Poorly studied

Bank Cormorants



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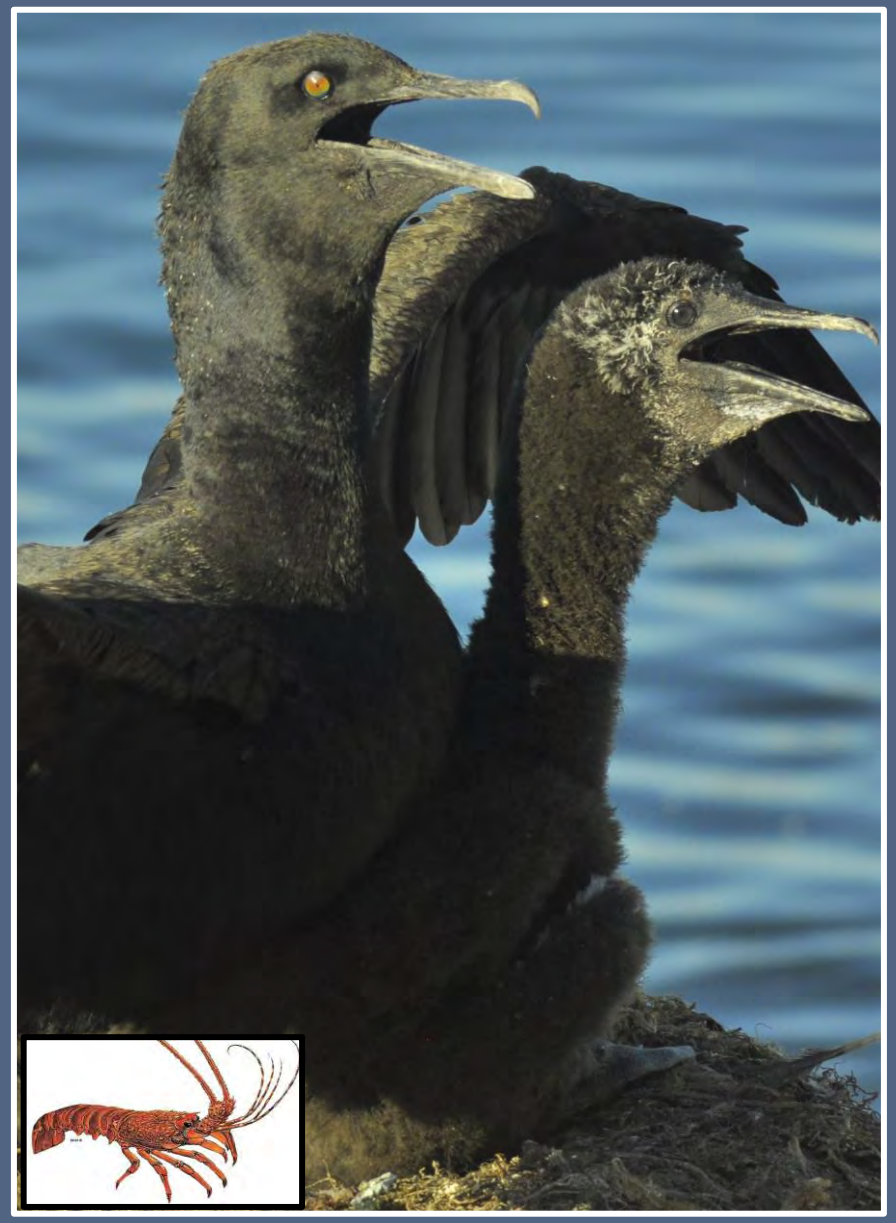
- Fecundity? – impacted by heat and storms (Sherley et al. 2012)

Bank Cormorants



- Poorly studied
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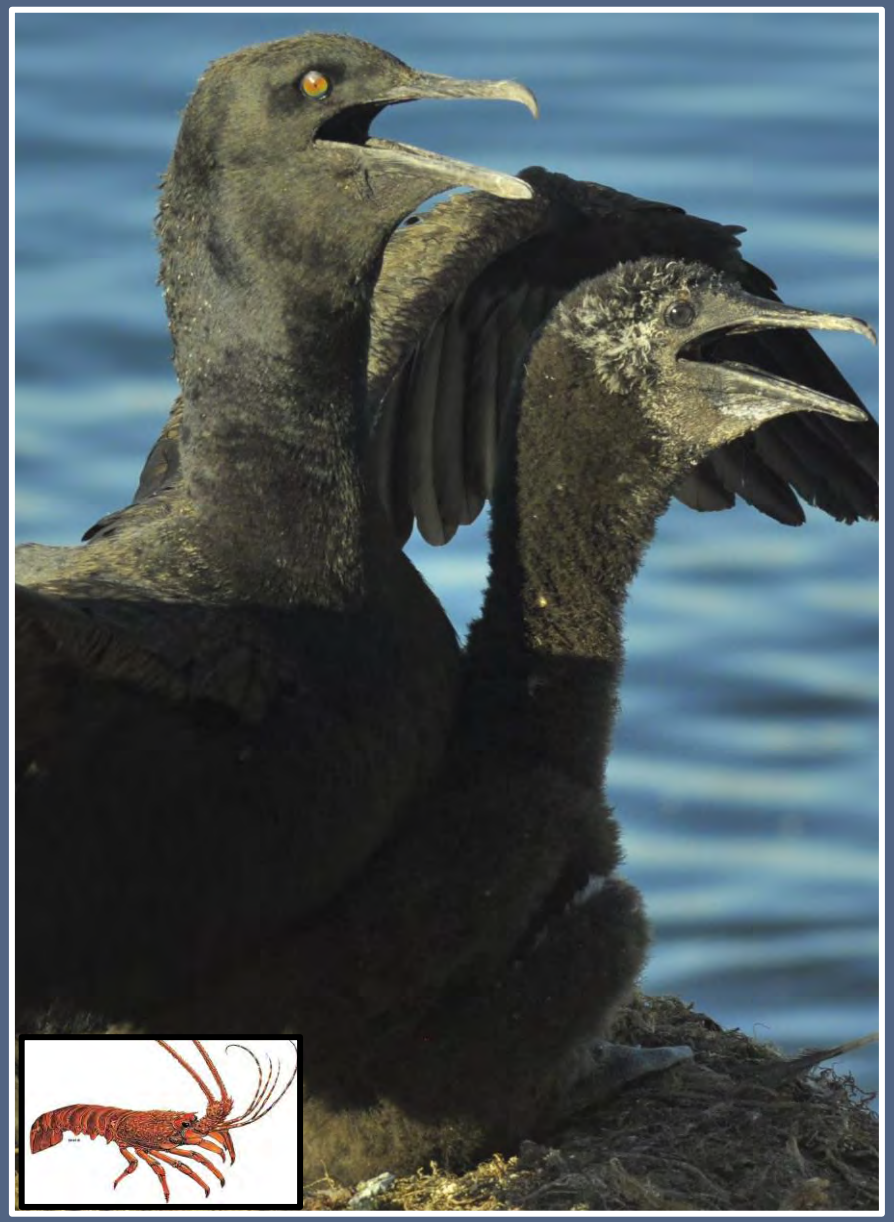
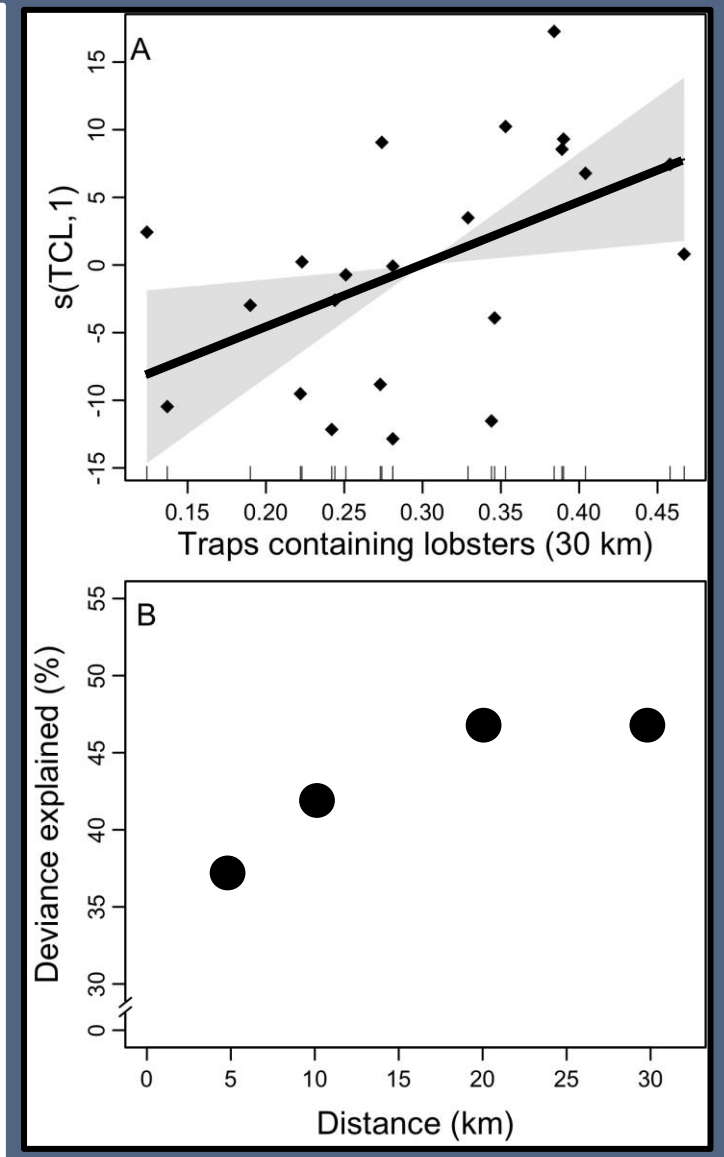
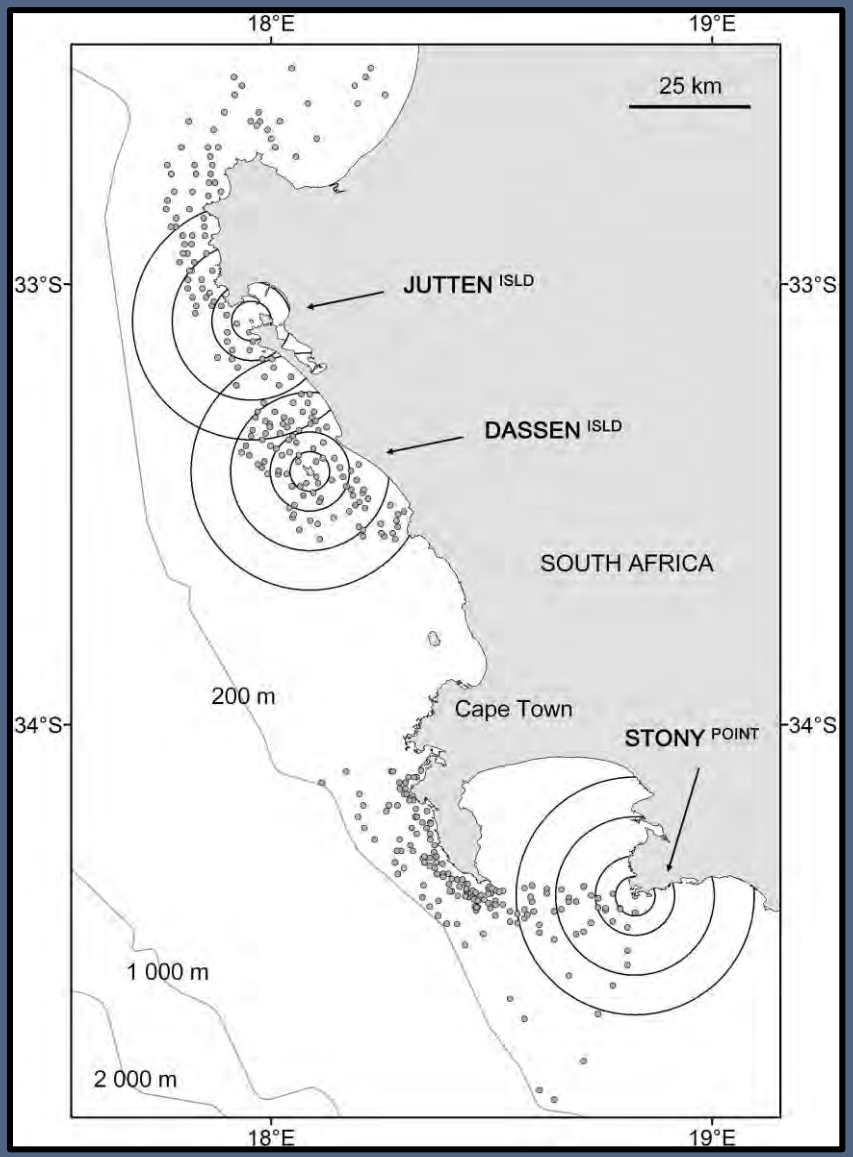
- Survival and Recruitment? – population change linked to local lobster availability (Sherley et al. 2017)

Bank Cormorants

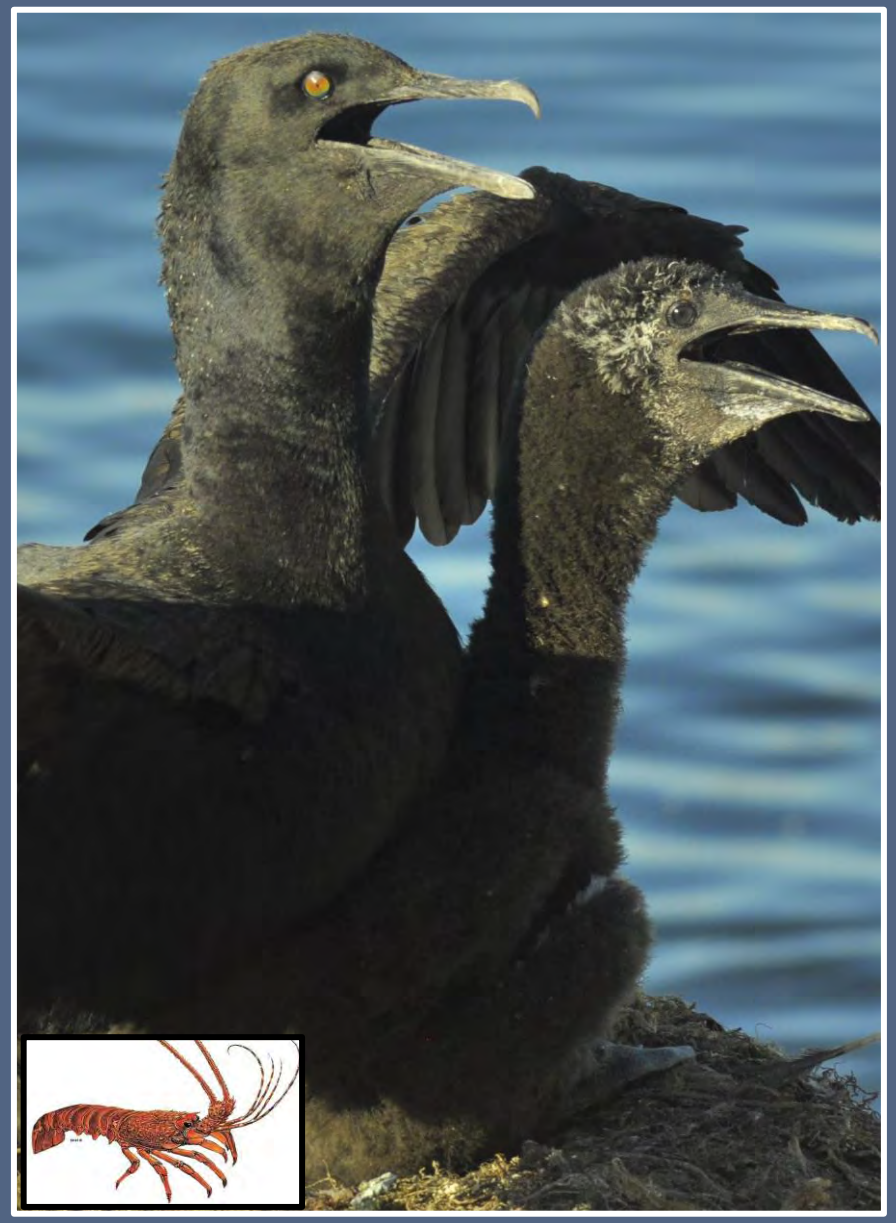






Sherley et al. 2017, Conserv. Biol. 31: 1312–1321.

Bank Cormorants



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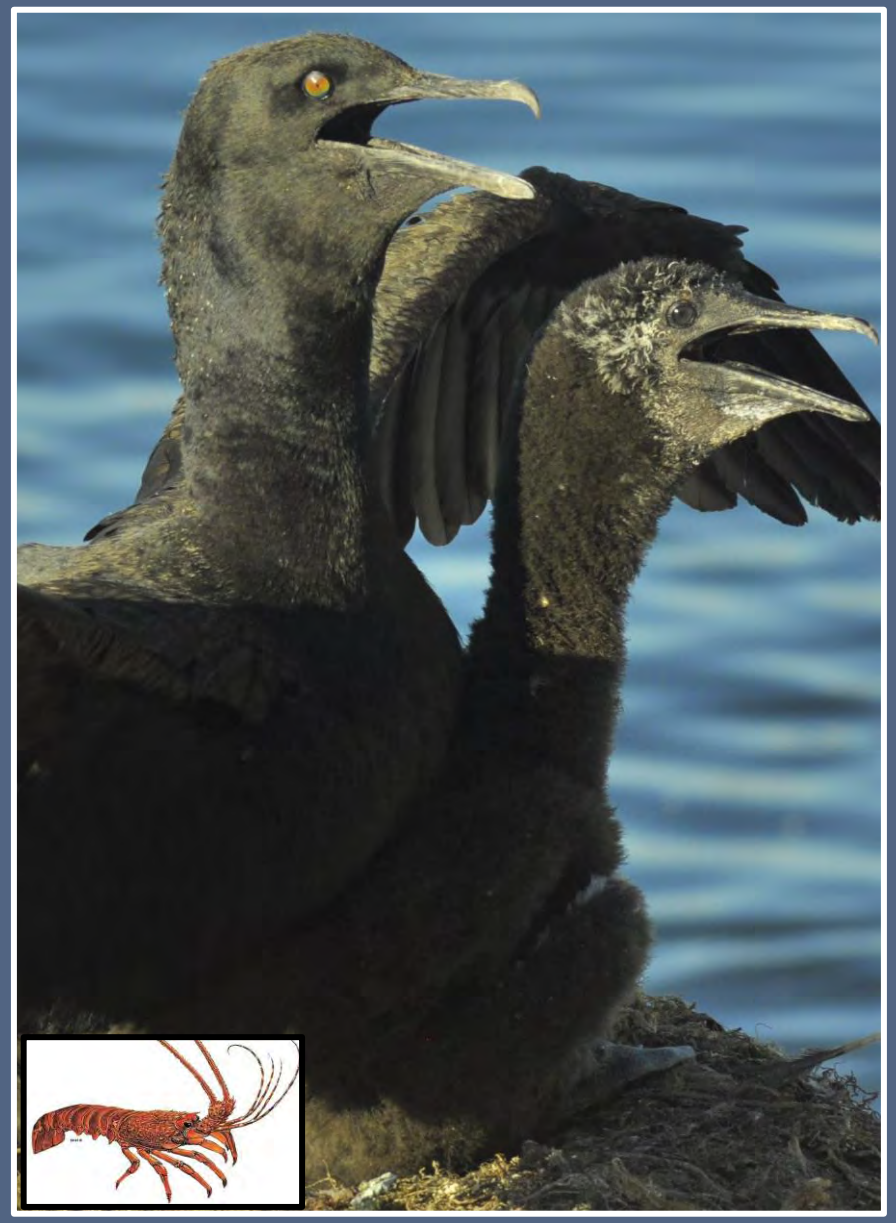

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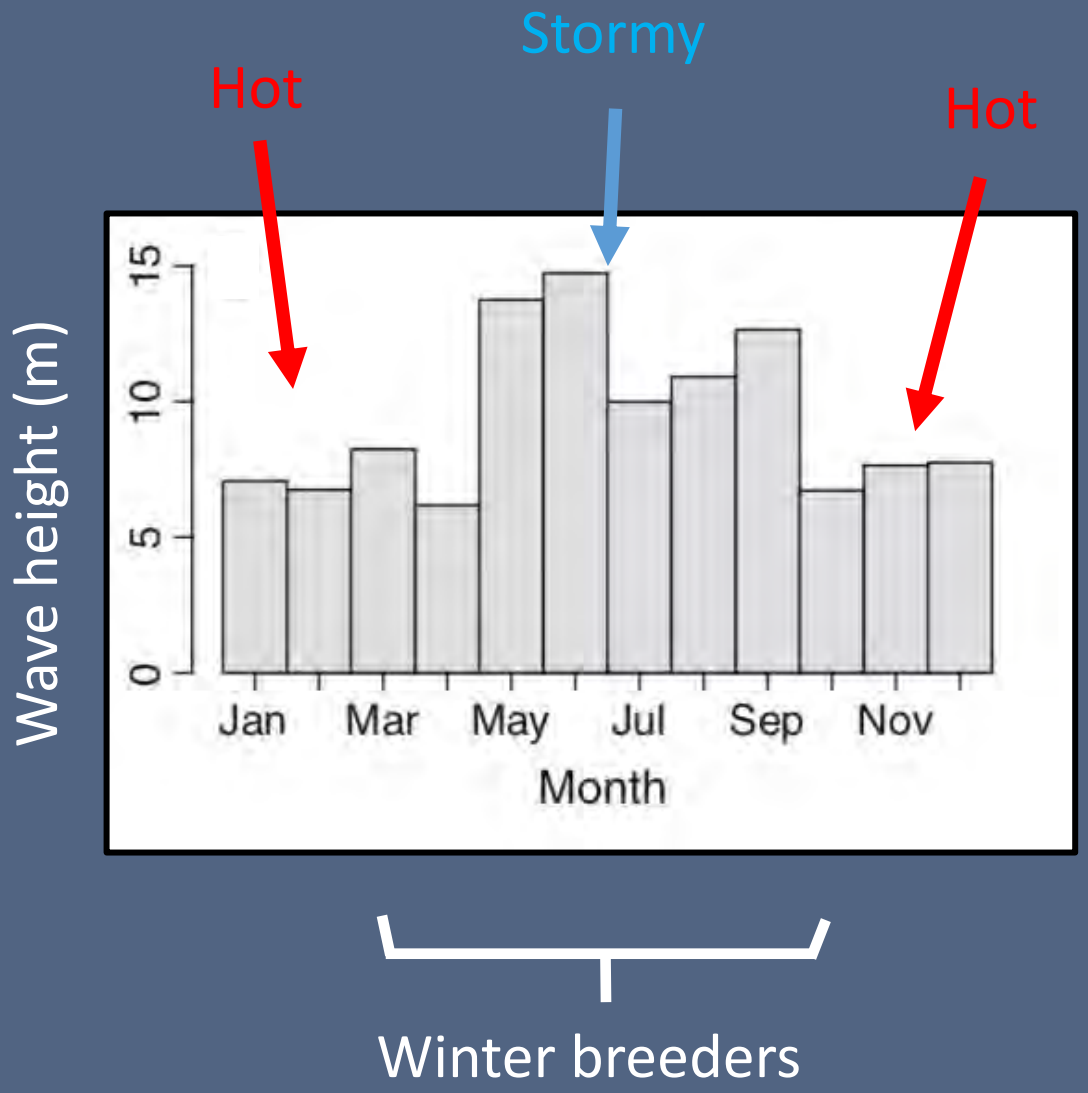
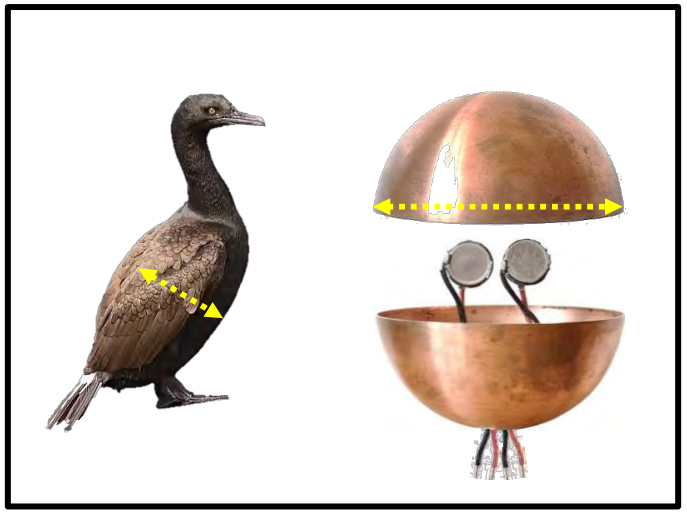
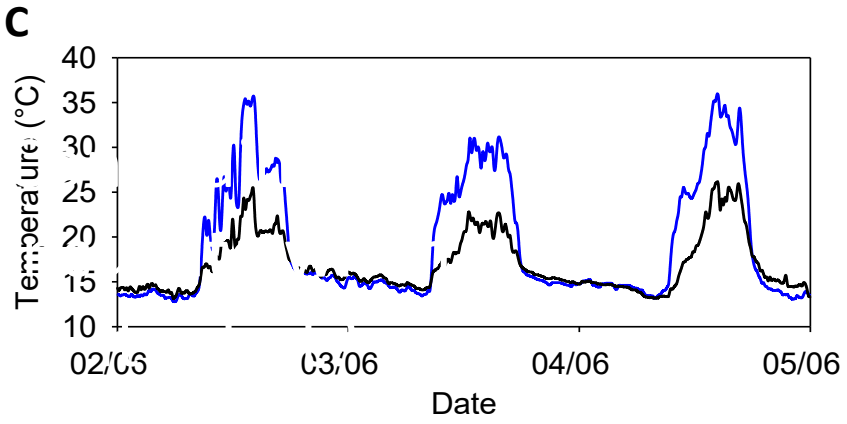
- Diet – switch to goby in Namibia (Ludynia et al. 2010)
- Phenology? – May get squeezed by direct effects

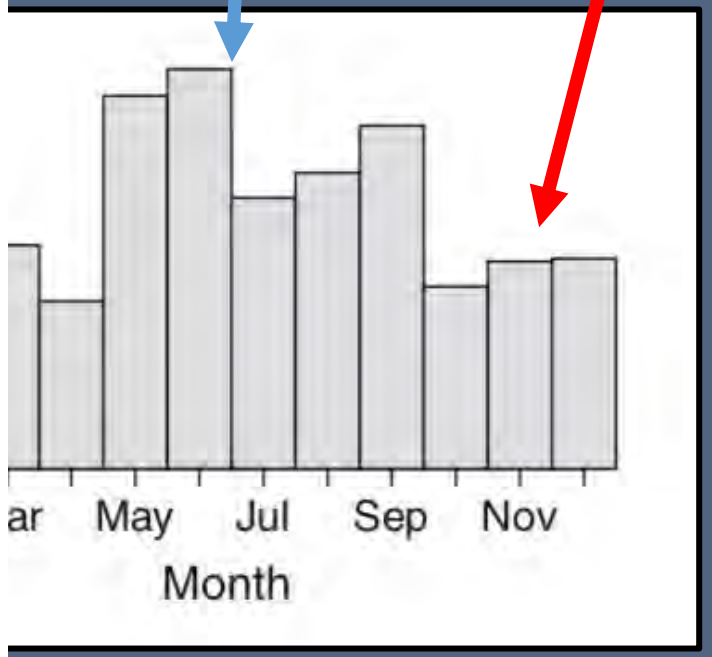
Bank Cormorants



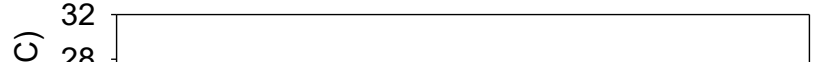
Sherley et al. 2012, J. Ornithol. 153: 441-445; Cook et al. In prep.



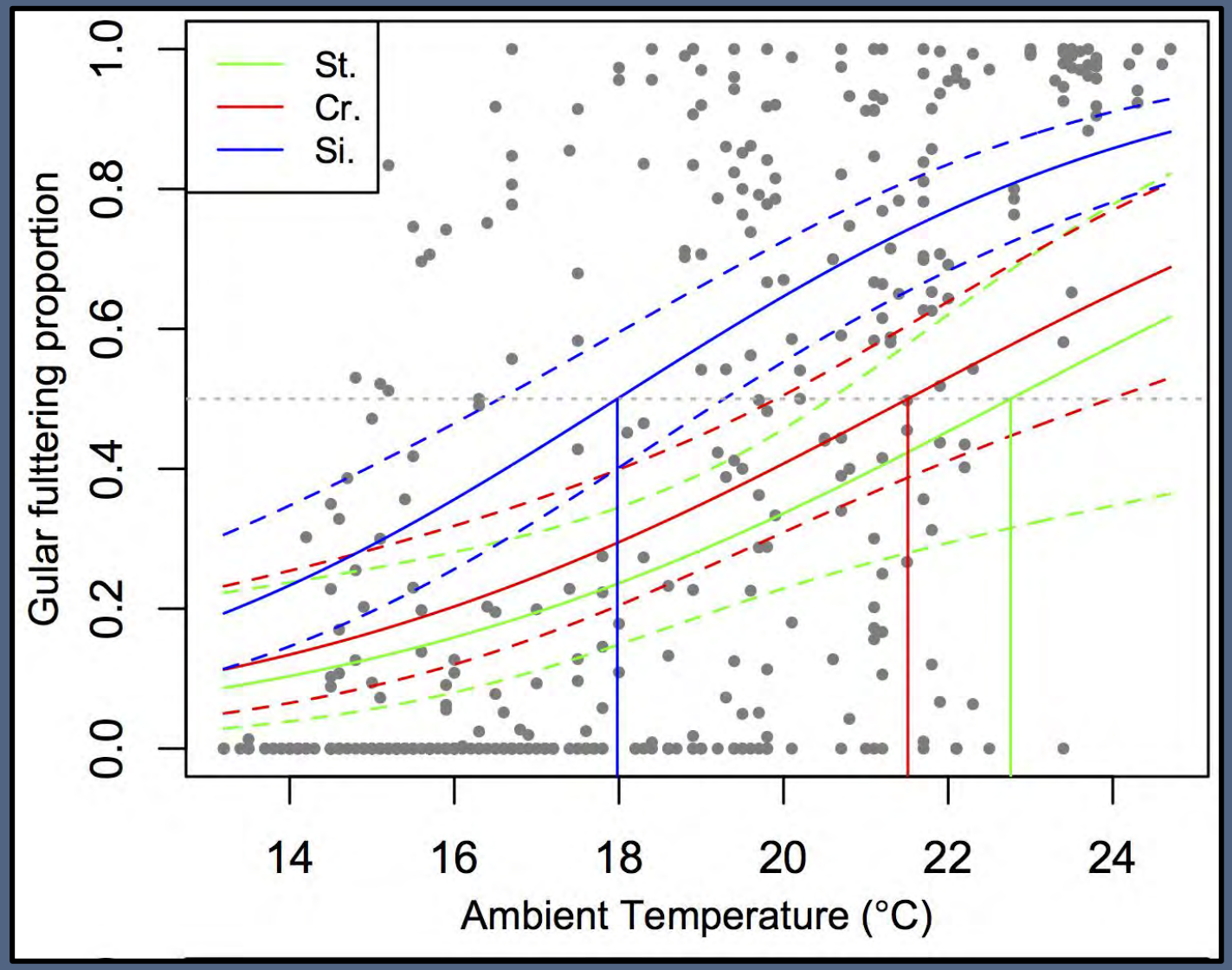


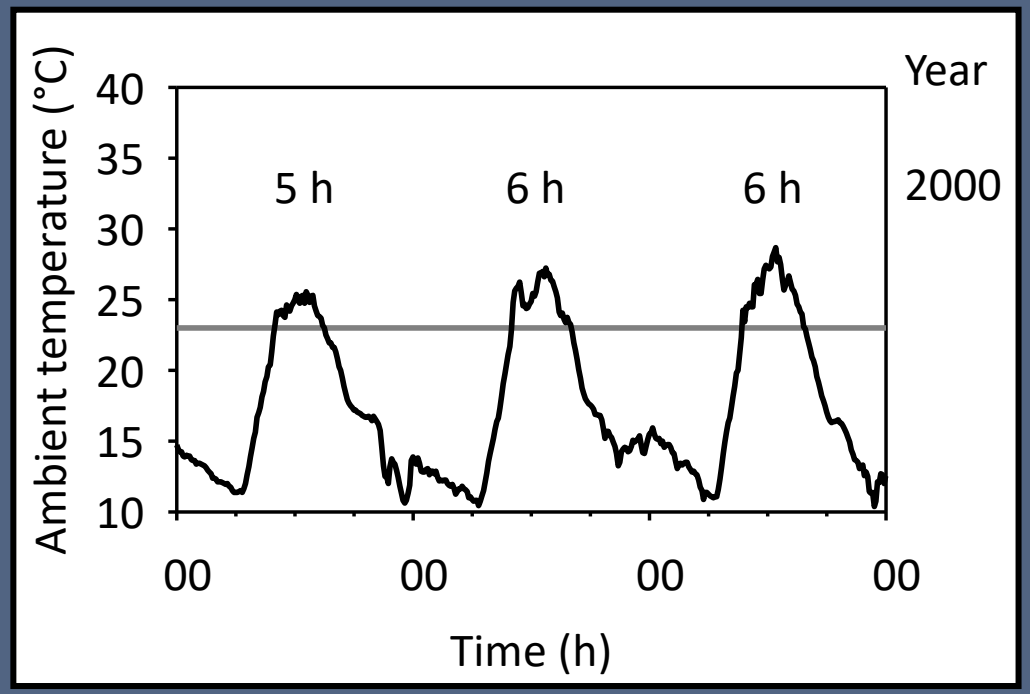


Winter breeders



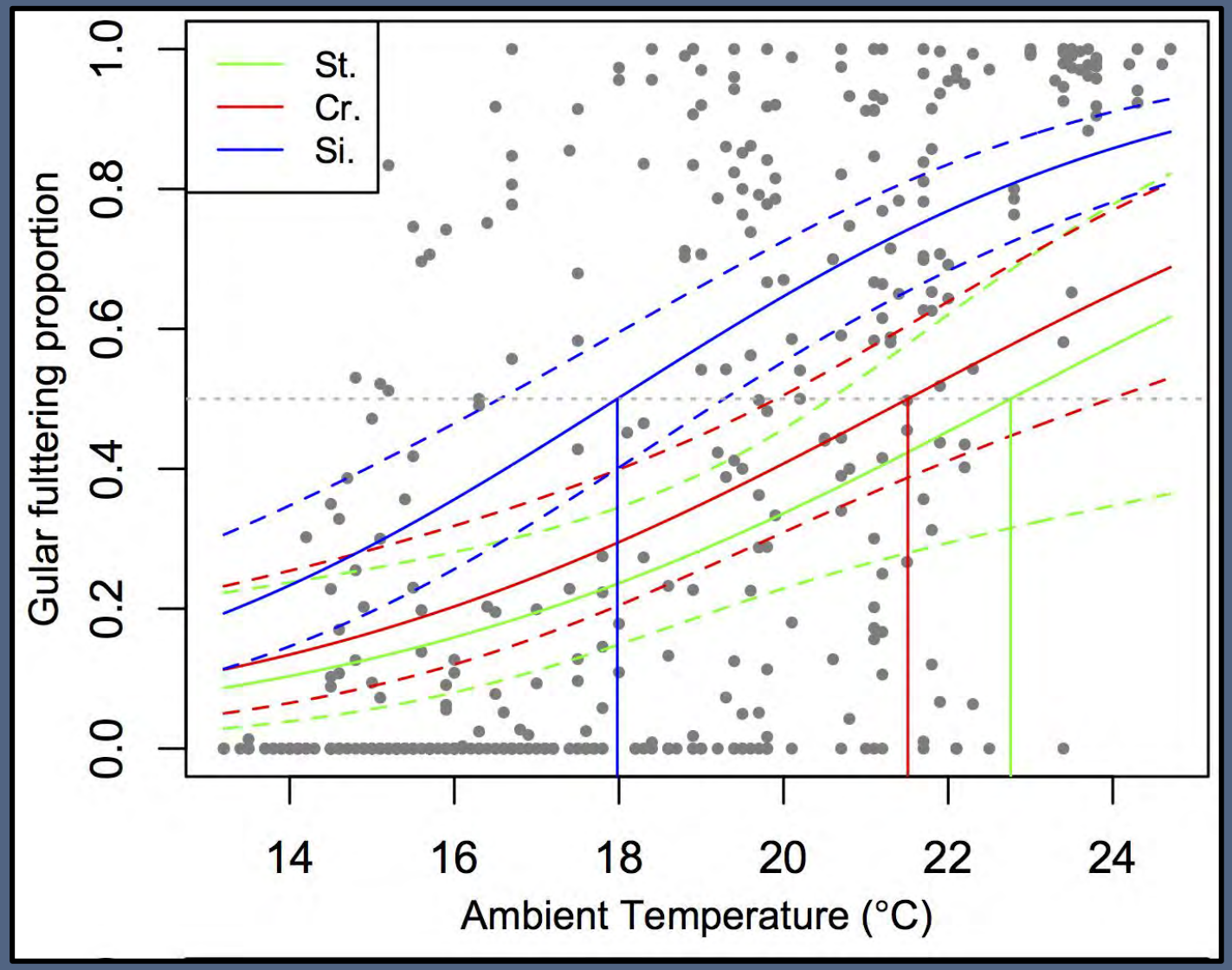
Bank Cormorants

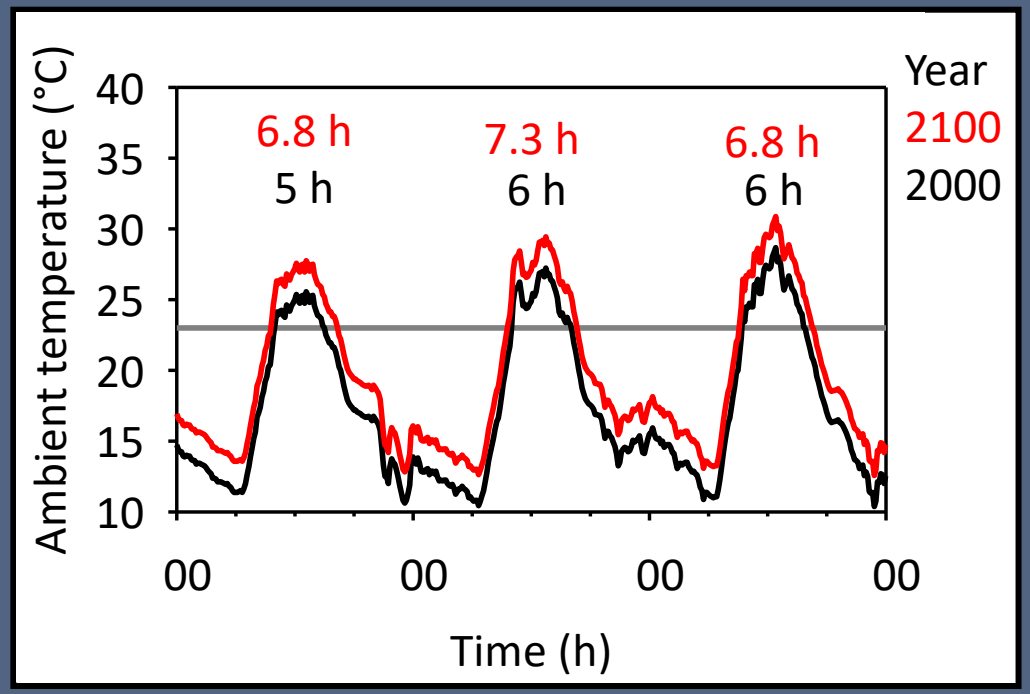




Cook et al. In prep.

Bank Cormorants



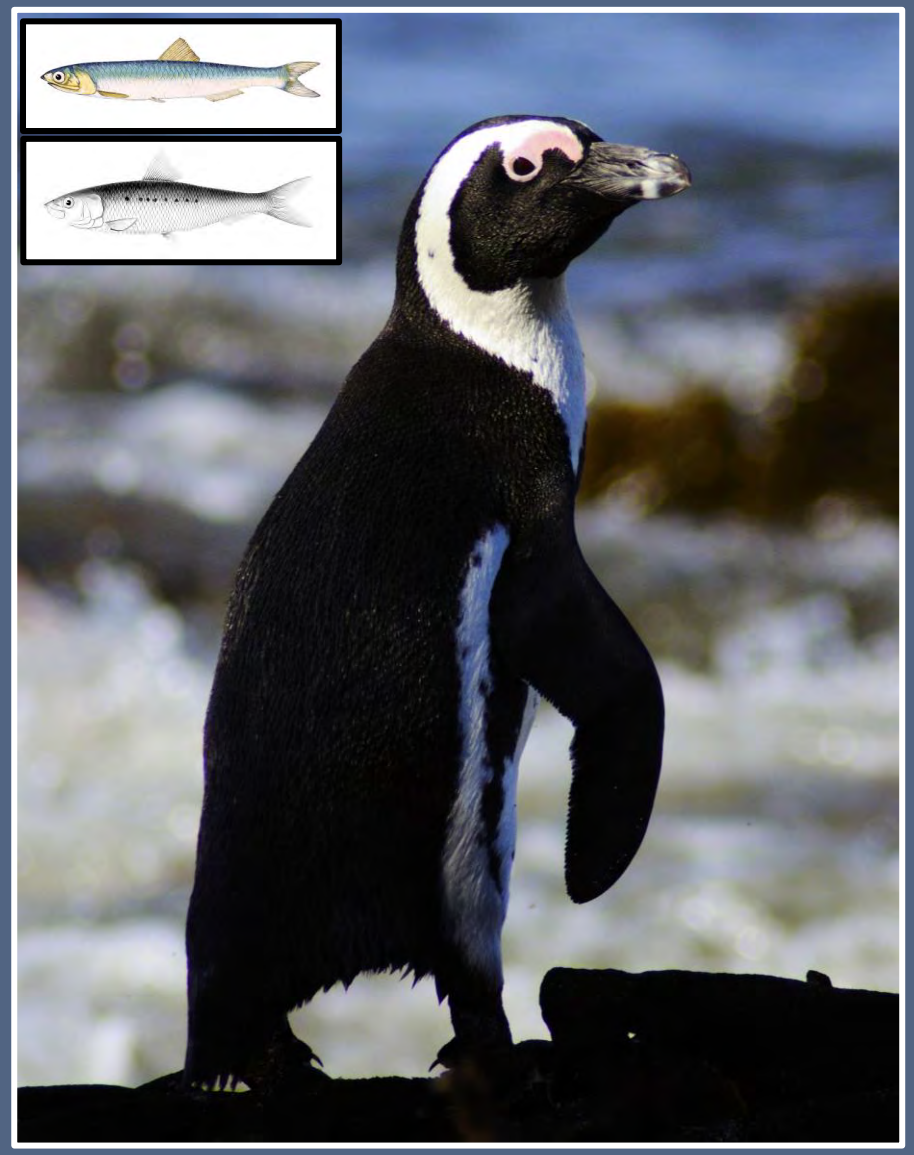


Daily time thermoregulating increases by **23%**.

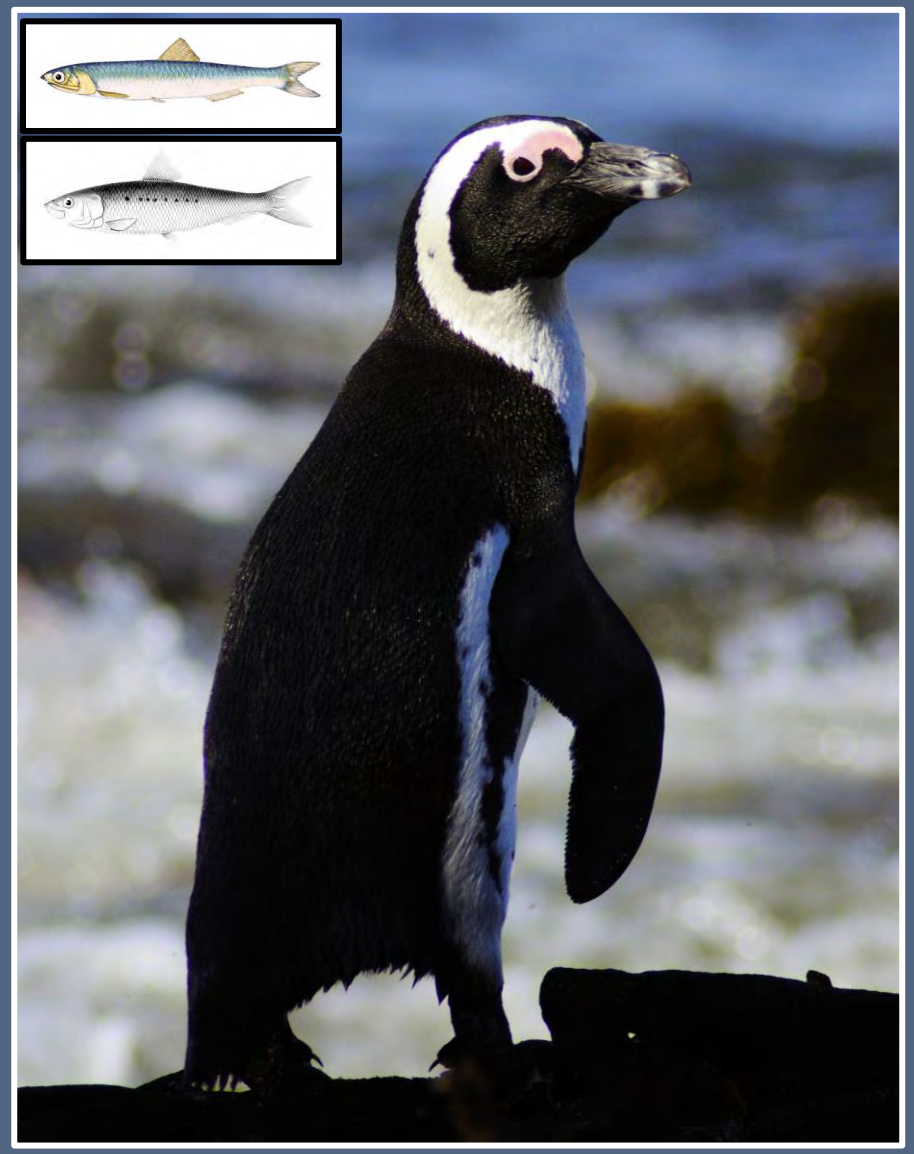
Daily water loss increases by up to **10%**.

Cook et al. In prep.

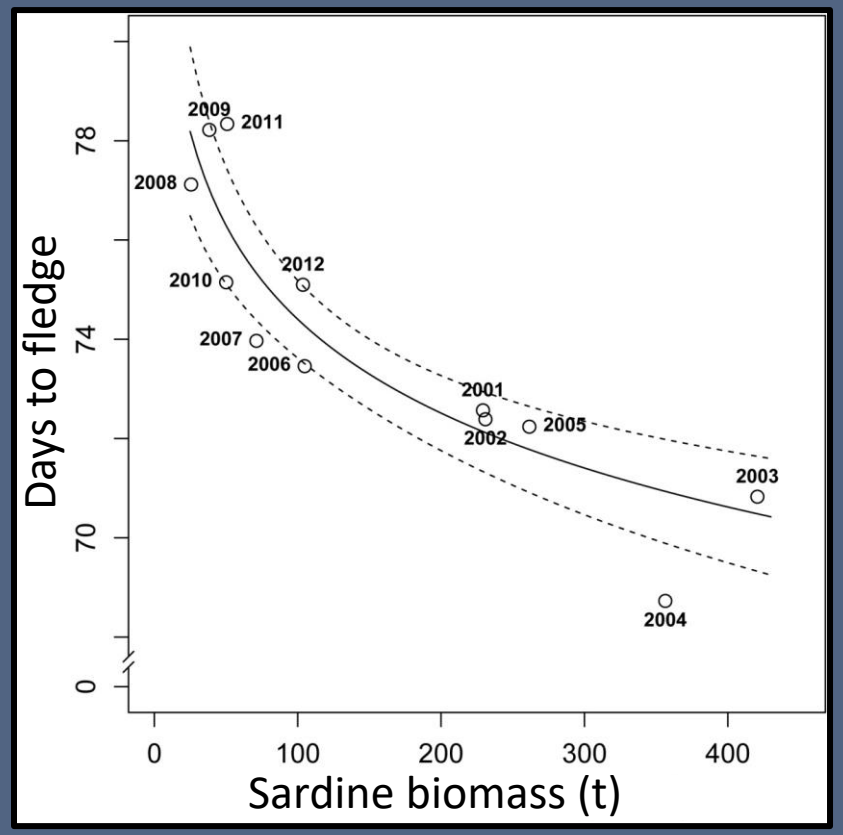
African penguins



African penguins

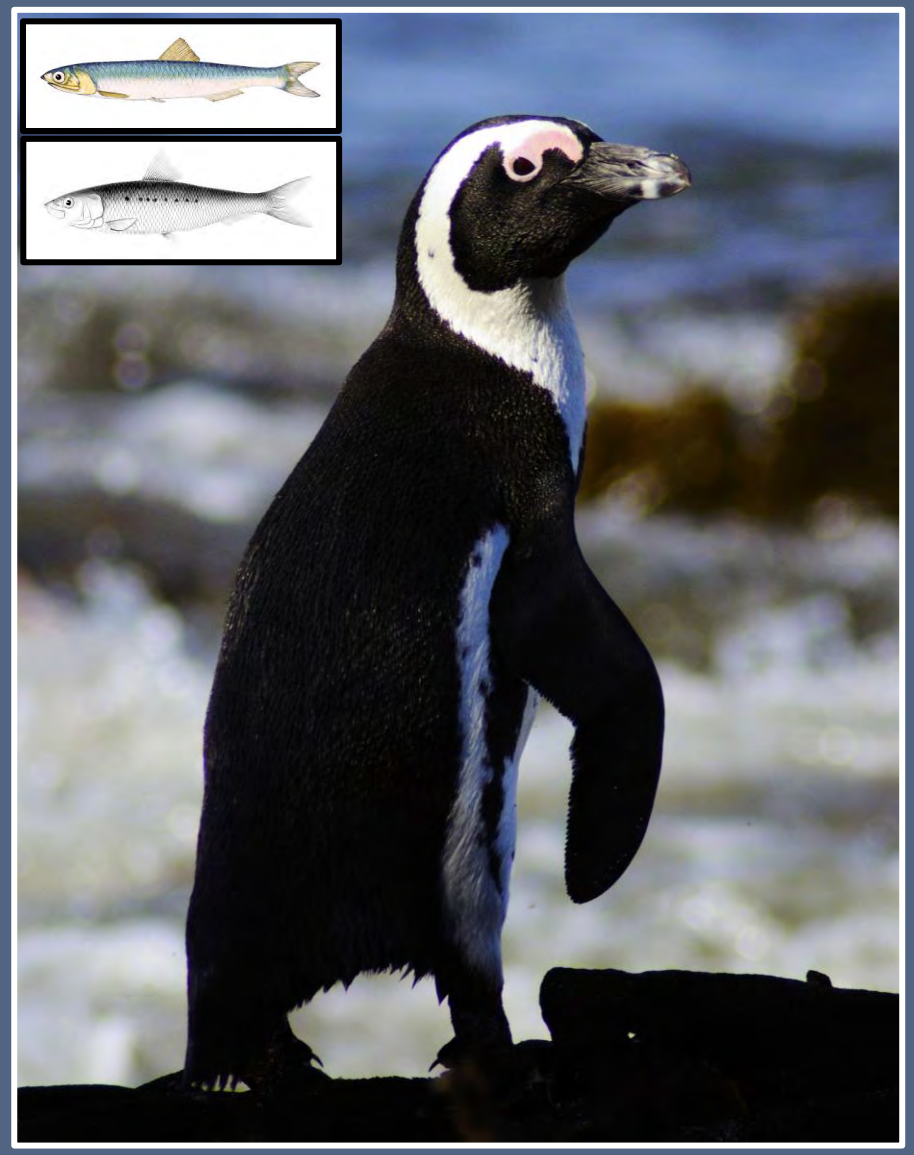


- Fecundity – breeding success maintained. But, declines in chick growth rates (Sherley et al. 2013)



Sherley et al. 2013, Mar. Ecol. Prog. Ser. 473: 291–301.

African penguins



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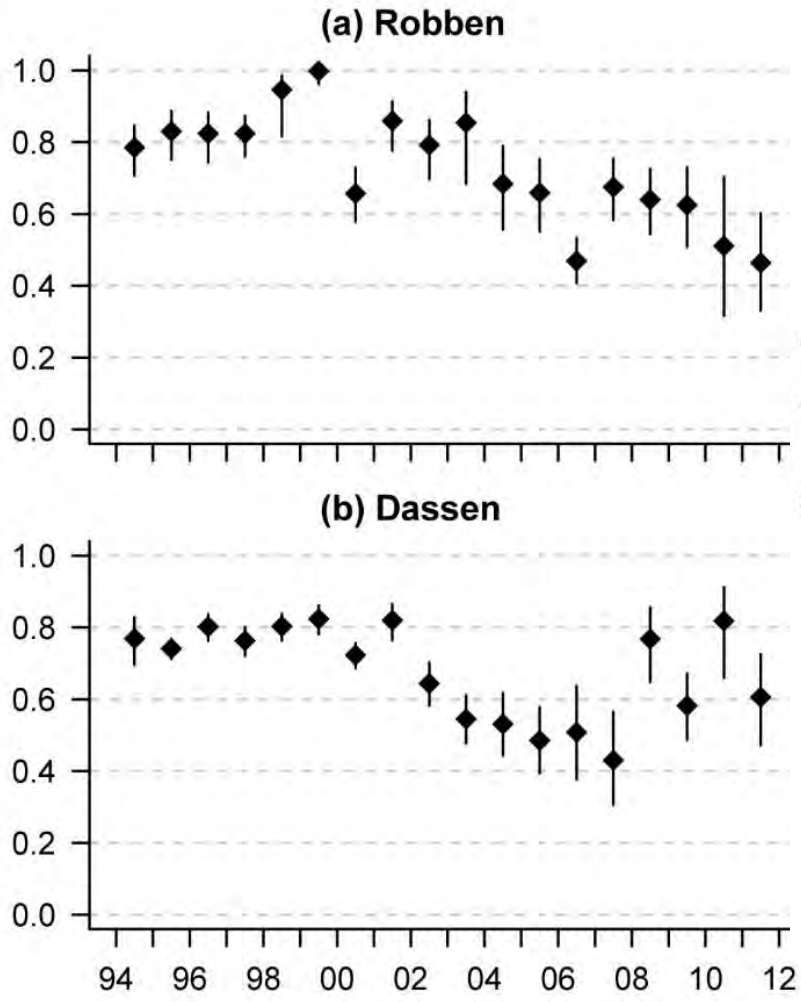
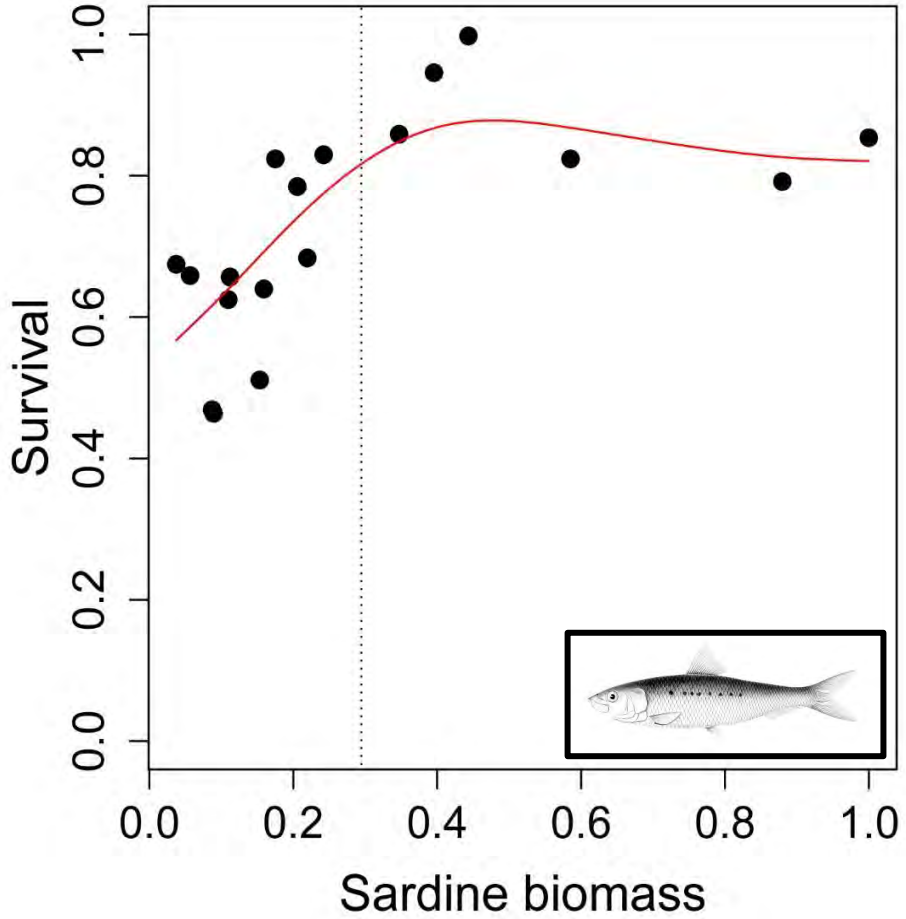
African penguins

Harding 2013, MSc thesis, UCT



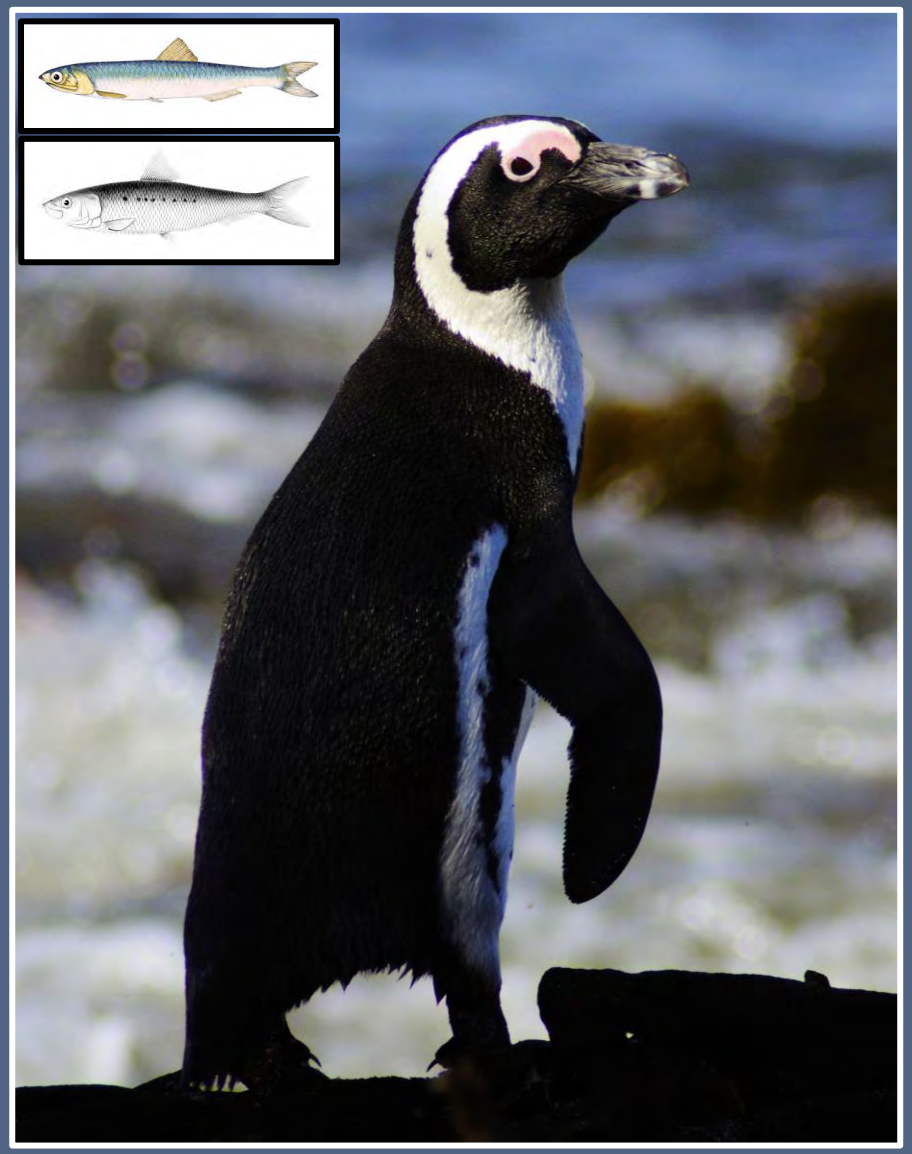


Sherley et al. 2014, Ibis 156: 716–728; Weller et al. 2016, Ecol. Model. 327: 44-56.

Adult survival: 0.81 from 1994-2001 and 0.61 from 2002-2012

Sardine biomass west of Cape Agulhas

African penguins



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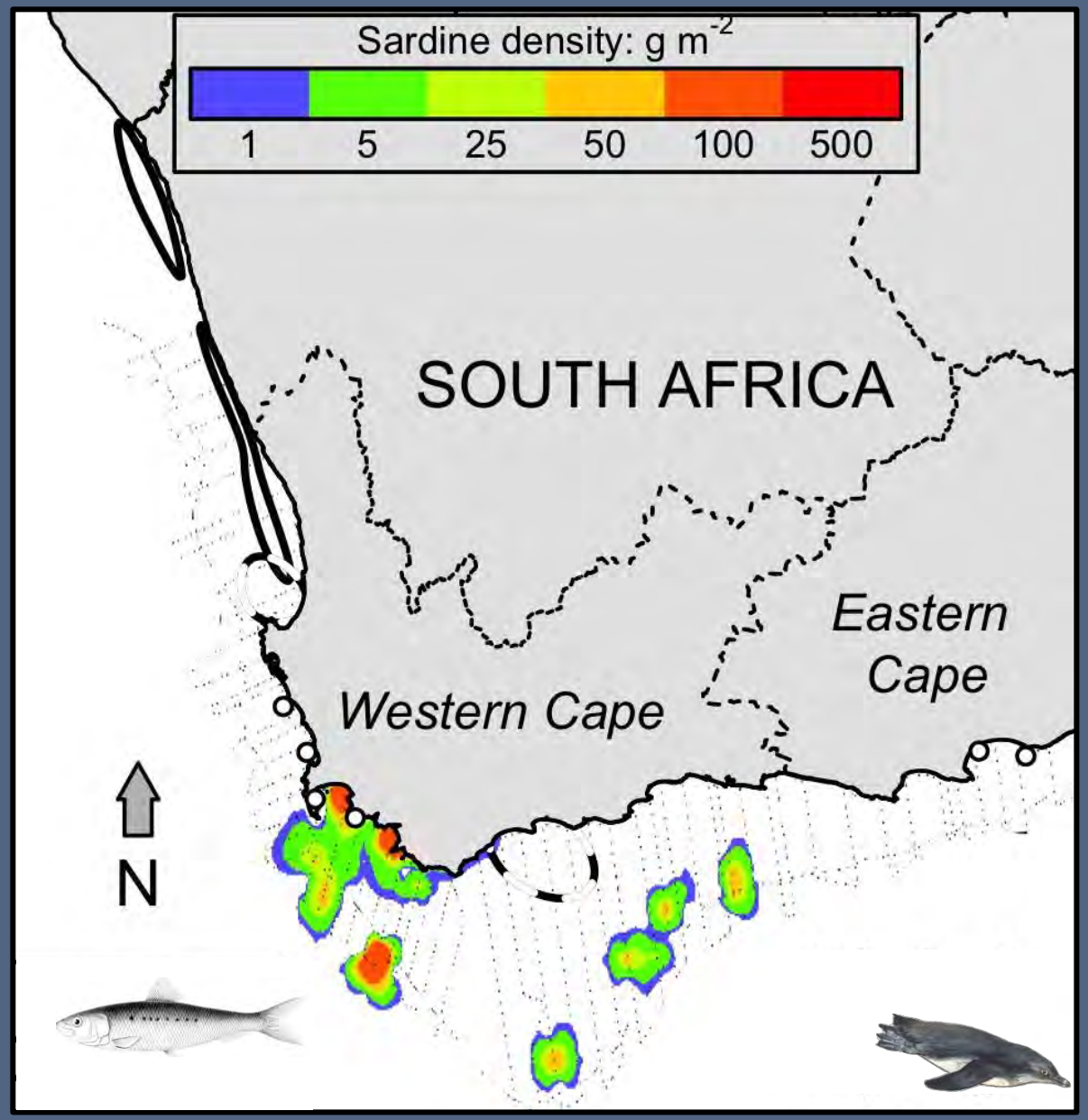
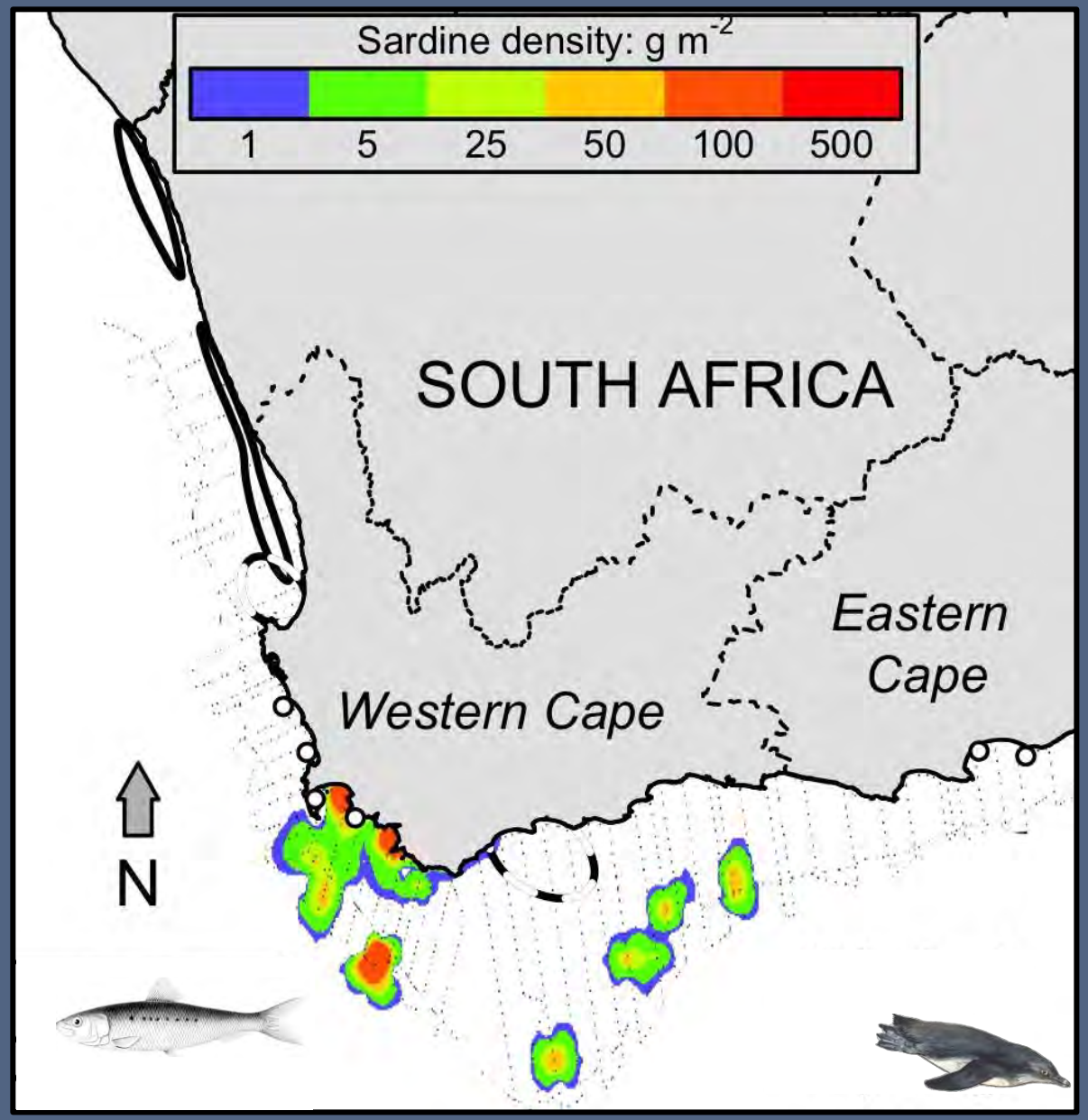
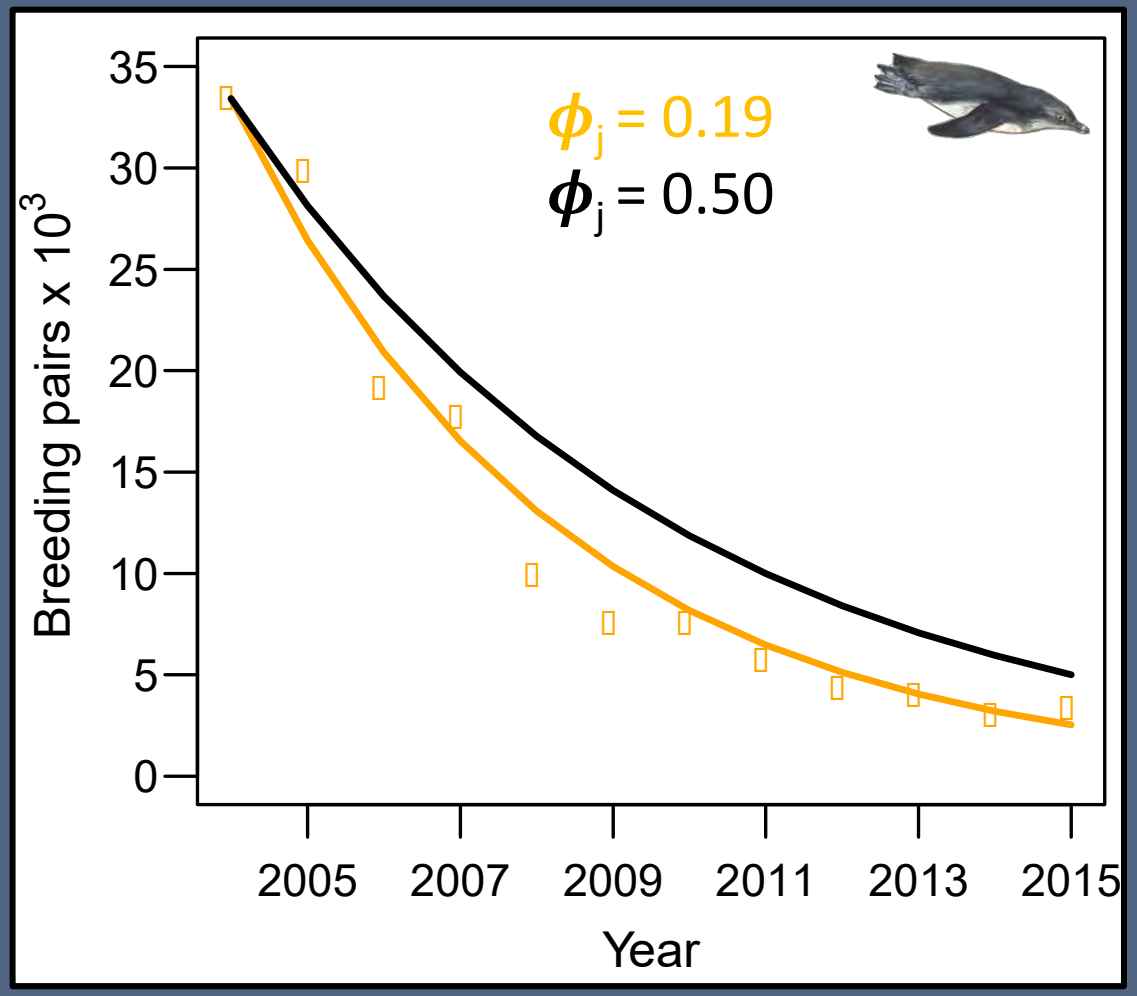
African penguins



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

African penguins

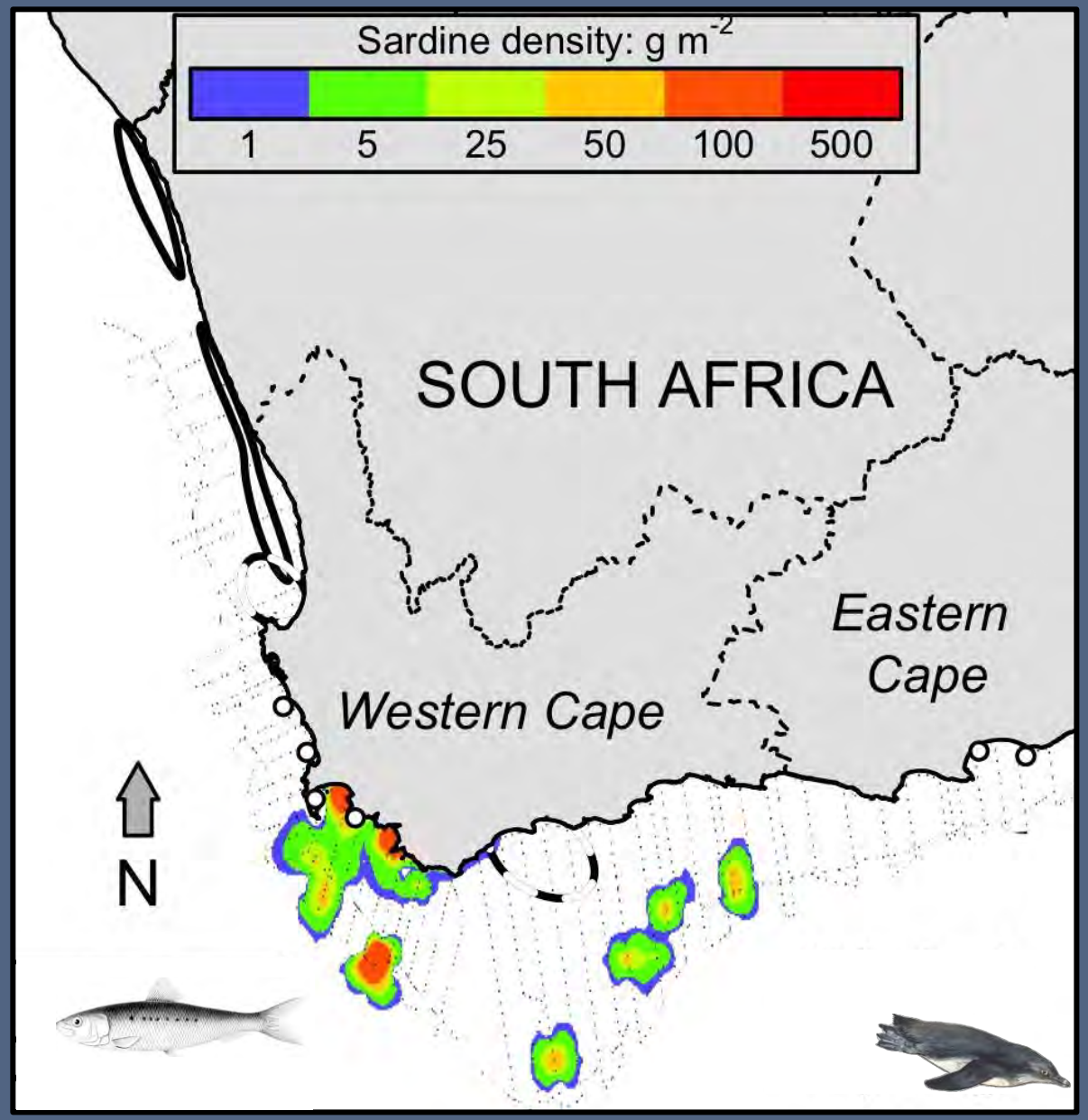


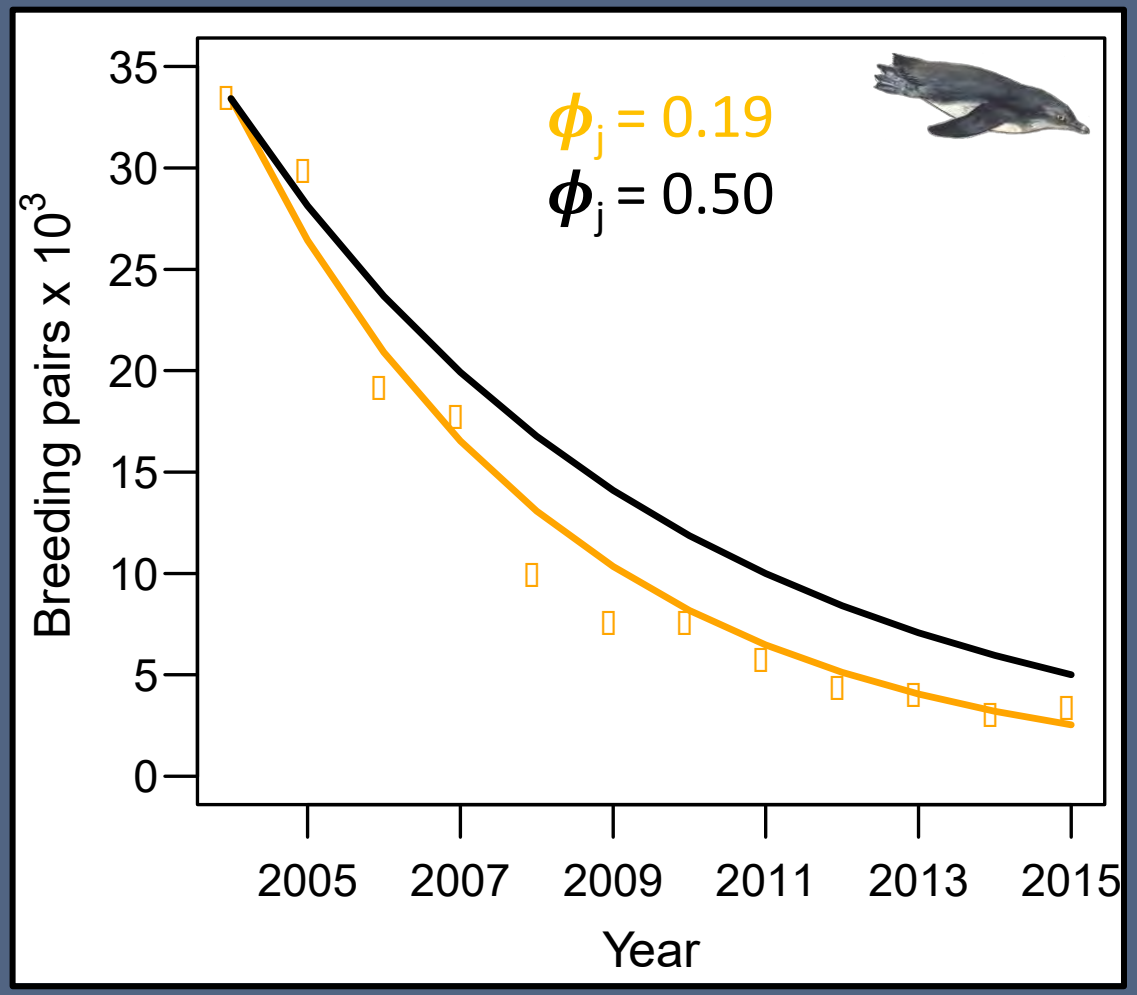


Points = observed; Lines = modelled

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

African penguins



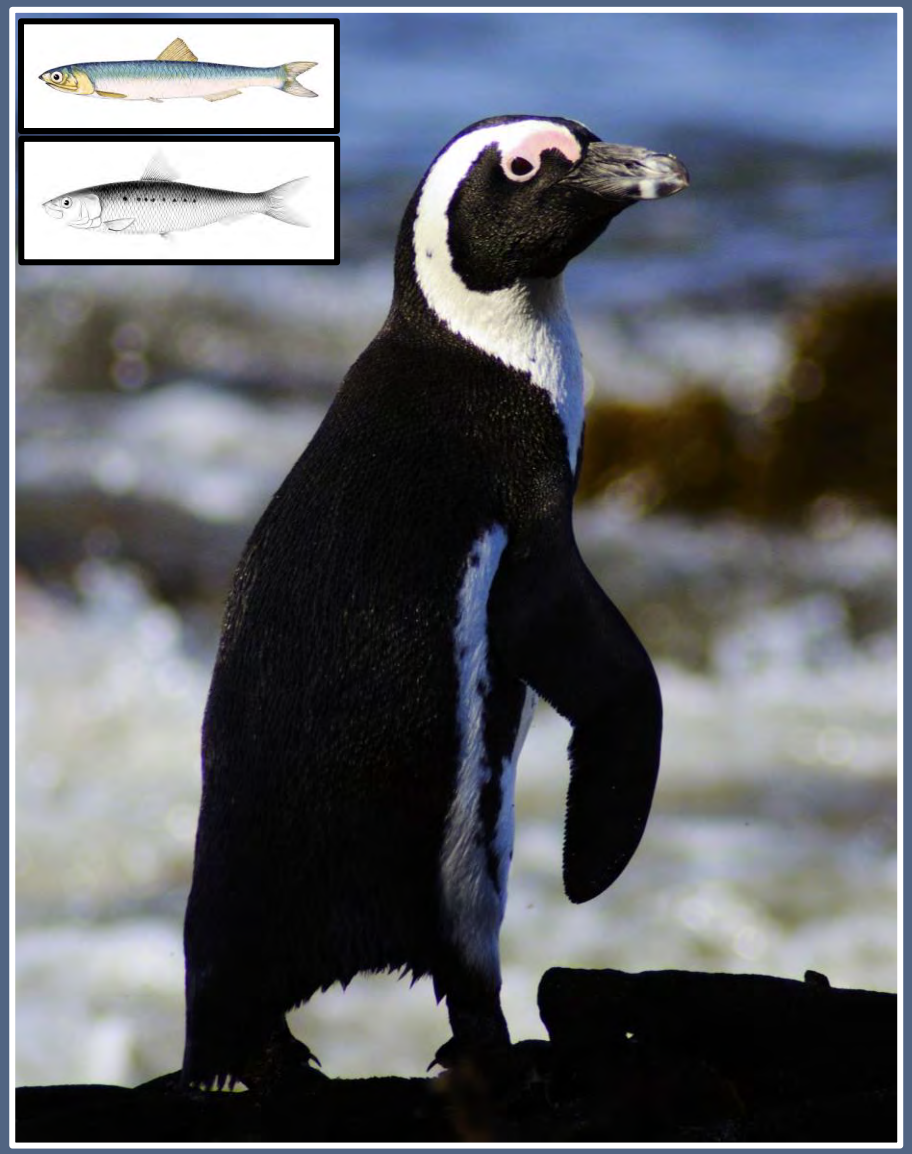


Points = observed; Lines = modelled

~98% higher

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

African penguins



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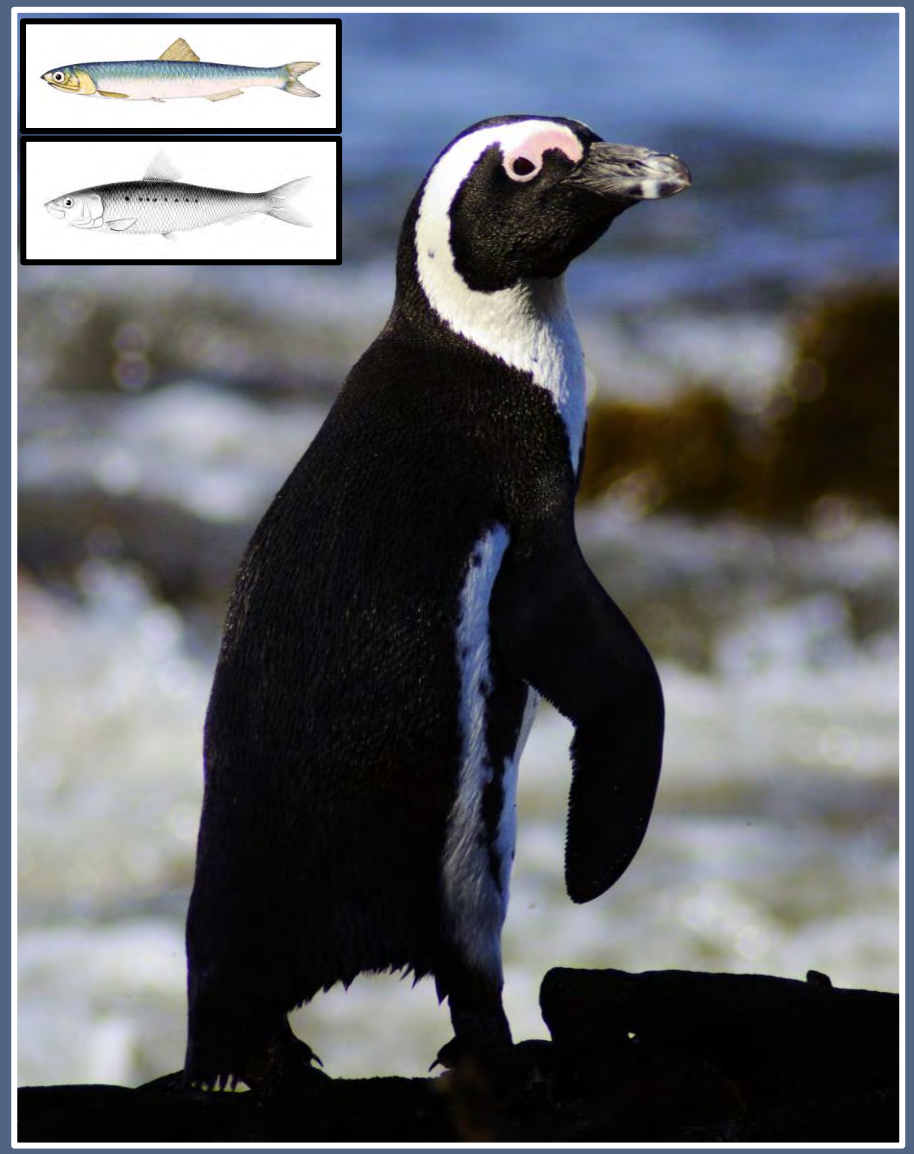
African penguins



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- Phenology?

Conclusions

- Both direct and indirect effects

  Fecundity

  Survival

  Recruitment

  Diet

  Phenology(?)

  - Future work will need to incorporate direct and indirect effects

Conclusions

- Non-adaptive responses

  Latitudinal shifts: impossible in southern Africa!

  Shifts in phenology: compatibility with food availability or weather?

Conclusions

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  Latitudinal shifts: impossible in southern Africa!

  Shifts in phenology: compatibility with food availability or weather?

- Adaptive responses

  Decrease in body size and in plumage insulation: compatibility with foraging?

Conclusions

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- Local or global extinction?

Acknowledgments: Thanks to SANCCOB, DAFF, DEA, SAN Parks, Robben Island Museum, Overstrand Municipality, CapeNature, Leiden Conservation Foundation, San Diego Zoo, PICES and numerous other funders.

Co-authors: Fitsum Abadi, Res Altwegg, Barbara Barham, Peter Barham, Philna Botha, Alan Clark, Janet Coetzee, Timothee Cook, Andy Cockcroft, Rob Crawford, Bruce M. Dyer, Astrid Jarre, Jessica Kemper, Katrin Ludynia, Tarron Lamont, Azwianewi B. Makhado, Nola Parsons, Jean-Paul Roux, Peter Ryan, Kylie L. Scales, Lynne Shannon, Les G. Underhill, Leshia Upfold, Stephen C. Votier, Lauren Waller and Florian Weller.