

Using the information from the exert and figures below, answer the following questions:

The effects of climate forcing on primary and secondary production of the short austral food webs may be integrated at higher levels<sup>101</sup>, and thus amplified in top-level predators such as seabirds. This has led to a strong interest in studying Antarctic and sub-Antarctic top predators (especially penguins, which are major consumers of the Southern Ocean ecosystem) as sensitive indicators of environmental changes<sup>102</sup>. To understand how variability in marine resources affects their demography over the timescale of years, simultaneous investigations of variation in breeding success and survival are necessary and require long-term individual monitoring at the population scale.



Most of our present knowledge on the population dynamics of penguins is based on large flipper-banding schemes. The key advantage is that bands can be identified from a distance, avoiding recapture stress for the birds.

King Penguins from a breeding colony on Possession Island, (46°25'S, 51°35'E, Crozet archipelago) were monitored from 1998-2008 using automatic identification (RFID chips). One hundred birds were randomly sampled in their breeding area and 50 of them were fitted with a metal flipper band.

(exerts and figures from Le Maho Y, Saux C et al, Jan 2011, Reliability of flipper-banded penguins as indicators of climate change. Nature (269) 203-4.)

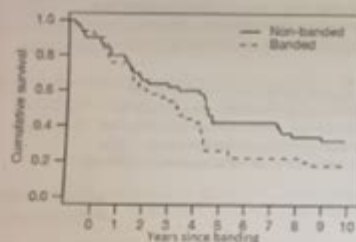


Figure 1 Survival of banded and non-banded king penguins during the 10-year study period. (Cox proportional hazard model,  $p=0.04$ )

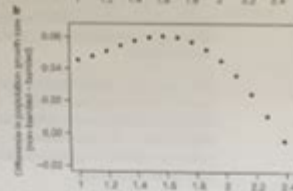
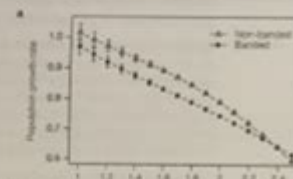


Figure 2 | Simulated population growth rates of banded and non-banded penguins as functions of SST. a, Growth rates of both populations across SST at the marginal ice zone (MEZ). Error bars, s.e.m. b, Difference between the two growth rates. A quadratic relation well approximated the difference (Growth rate =  $0.27 \pm 0.01 \text{ SST} - 0.06 \pm 0.005 \text{ SST}^2$ ,  $P < 0.001$  for both and SST<sup>2</sup>).

- 10a. Describe what does Figure 1 shows?
- 10b. Summarize what Figure 2 shows. Were the results of the study statistically significant?
- 10c. What does Yvon Le Maho's study tell you about the use of bands to mark penguins?
- 10d. Describe how these findings could affect the results of mark-recapture studies that used banding?

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