

## Could whales have maintained a high abundance of krill?

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### ABSTRACT

**Question:** Several million large whales were killed between 1900 and 1970. All these whales preyed on krill (*Euphausia superba*). Why has krill population abundance declined after the elimination of their primary predator?

**Hypothesis:** Krill have changed their behaviour due to the absence of whales and this change in behaviour has resulted in a decrease in krill abundance.

**Methods:** I reproduced a computer model of krill life history. I then extended the model as an individual-based model to show the effects of habitat choice on individual lifetime reproductive success and abundance.

**Conclusions:** In the context of our current understanding of krill physiology, predator-invoked behaviour may lead to increased population abundance and, without the predator, natural selection may favour behaviour that would lead to lower abundance. This reverses the predictions of mass balance ecosystem models.

*Keywords:* computer model, IBM, regime change.

### INTRODUCTION

Krill abundance in the Southern Ocean either did or did not increase dramatically as a result of the removal of 2 million whales within 100 years (Clapham and Baker, 2001). A large surplus of krill had been predicted (Mackintosh, 1973; Laws, 1977; Smetacek and Nicol, 2005). Other predictions included a large increase in other predators of krill; for instance, a yearly increase of 300 million penguins was hypothesized (Sladen cited in Ozawa and Sato, 1967). If, however, the abundance of krill did not increase dramatically and neither did any of its other predators, this would represent a paradox.

The first challenge is to ascertain if there is a paradox to be addressed. The case cannot be proved either way as sufficiently accurate data are not available. Nevertheless, evidence strongly justifies the assumption of a paradox. Based on the average whale's diet, before 1900 whales ate 175–190 million tonnes of krill a year, and by 1987 whales ate less than

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