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DEVELOPING MARINE MAMMAL DYNAMIC ENERGY BUDGET MODELS AND THEIR POTENTIAL FOR INTEGRATION INTO THE IPCOD FRAMEWORK

BOTTLENOSED DOLPHIN

GREY SEALS

Introduction

Disturbance from marine activities can cause changes to marine mammal behaviour, physiology and health, which can have subsequent effects on an individual's vital rates, such as survival and reproduction. Dynamic Energy Budget (DEB) theory provides a framework that predicts the consequences of an individual's acquisition of environmental resources for energy demanding traits, such as growth and reproduction. DEB models can then be used to examine the potential effects of disturbance on an animal's energy intake and resulting reproductive success, and therefore could be used to explore disturbance during sensitive periods (i.e. those where significant disruptions to foraging might negatively impact an individual's breeding or survival).

The overall objective of this project was to explore how DEB frameworks can be used to model the link between disturbance and changes in population vital rates for five species of UK marine mammal: bottlenose dolphin, minke whale, harbour porpoise, harbour seal and grey seal.

Parameterising the Deb Model

A comprehensive literature review was conducted to obtain estimates for each of the parameters in the DEB model. This included well-documented parameters such as gestation period and maximum length, as well as other values that required subjective, expert judgement based on the literature, such as resource density and the effect of age on foraging ability. Suggested parameter values are provided for the five species in question, allowing future modelling work to incorporate these values.

A full harbour porpoise DEB model was then created, based on a previously published model which tracks the way in which individual female marine mammals assimilate energy over the

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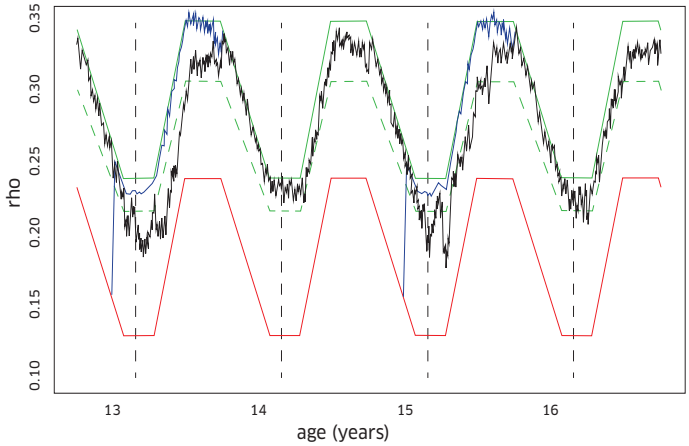
course of their lives from weaning to death, and how this energy is allocated to field metabolism, growth, foetal development, and lactation.

Where harbour porpoise values required subjective expert judgement or where a range of values are estimated in the literature, sensitivity testing was conducted to understand the most sensitive parameters in the harbour porpoise DEB model and to determine plausible ranges of these parameters. Sensitivity testing showed that varying the age at which the calf's foraging efficiency is 50% had marked effects on calf survival and consequential reproductive success of females..

Effects of disturbance

The report illustrates how the harbour porpoise DEB model can be used to investigate the potential effects of disturbance that causes a reduction in energy intake and subsequent effect on vital rates (survival and birth rate). This assumed that an individual's energy intake would be reduced by 25% on the day it was disturbed.

The model highlighted that nursing female harbour porpoise are particularly susceptible to disturbance between the time the calf is born until it is able to acquire at least some food independently (as shown in the figure; where the mother is predicted to be closest to starvation immediately following the birth of a calf). The results also showed that disturbance after the mother has begun to reduce milk provisioning and disturbance post-weaning are unlikely to markedly affect survival rates.



Use in IPCOD

Currently, the interim Population Consequences of Disturbance framework (iPCoD) uses links between disturbance and changes in vital rates (derived by expert elicitation – a method to generate robust distributions of expert opinion) to model population-level consequences. In the future, DEB models could be used to replace these links and be incorporated into the iPCoD code without major structural changes. However, the key limitation is that some of the DEB model parameters (that potentially have a large effect on susceptibility to disturbance) currently cannot be measured directly and appropriate values have to be chosen subjectively, meaning that some expert elicitation would still be required.

Further information

The project was funded by Scottish Government to address evidence gaps identified in the Scottish Marine Energy Research Programme (ScotMER).

Link to the full report here:
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