The Effects of Sandeel Availability, Puffin Harvest and Climate Change on the Vestmannaeyjar Atlantic Puffin Population

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Introduction

The breeding success of the Atlantic puffin *Fratercula arctica* in Vestmannaeyjar was poor in 2005-7, due to a great reduction in the lesser sandeel *Ammodytes marinus* population. Sandeels are the single most important food source by the majority of Icelandic seabird species. Puffin has been harvested in Iceland for centuries and the mean annual puffin harvest in Vestmannaeyjar is about 100.000 birds.

We present here an outline of our newly started cooperative research project and provide some preliminary results on puffin-sandeel population dynamics. The project's central aims are to investigate:

(1) The effect of sandeel availability on puffin reproduction.

(2) The effect of puffin hunting on the population.

(3) The effect of climate on the sandeel and puffin populations (see Vigfúsdóttir *et al*. 2008).

Puffin Population Dynamics

POPULATION SIZE

We estimate the Vestmannaeyjar population to be 1.300.000 pairs, or ~20% of the world's Atlantic puffin population.

RECRUITMENT

- **Proportion of population breeding is measured annually.**
- **Breeding success monitored in 200 burrows annually.**
- **Analysis of puffin fledgling data 1991-2007.** Fledgling number, body mass, fledging time (see Figs. 1. and 2.).
- **Analysis of puffin harvest data 1945-2007.** Figs. 2. & 3.

MORTALITY

- **Capture-Mark-Recapture study.** 3000 puffins will be color-ringed/yr for 3 years. Investigation of population size, breeders mortality rate, survival, recruitment, and basic assumptions for interpreting the analysis of the national ringing data.
- **Analysis of national ringing data 1953-2007.** Investigation of annual and age specific mortality rates of >60.000 ringed birds and >12.000 recoveries mainly of non-breeders (age bias due to the pole netting hunting method) .

PUFFIN HARVEST

Long term time-series of annual puffin harvest has recently been compiled (Fig. 3.). The data appears to contain information on recruitment rate of both sandeel and puffin populations in addition to harvest pressure (Figs. 1-3). A large climate effect is evident (Vigfúsdóttir *et al.* 2008).

FORAGING ECOLOGY

- **Feeding frequency**. Automated 24 hr continuous monitoring of chick's feeding frequency throughout the breeding season provides the link between sandeel availability and recruitment.
- **Diet composition and energy density**. Food will be collected from breeding birds, both at sea and in the colonies.

CLIMATE EFFECTS

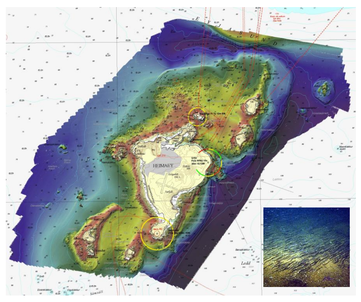
Preliminary results are presented in Vigfúsdóttir *et al.* (2008).

Sandeel Availability

POPULATION DYNAMICS. Density, age composition, size, mass, and energy density are measured annually.

HABITAT MAPPING. >500 km^2 of sandeel habitat around Vestmannaeyjar will be mapped during summer 2008.

TANK EXPERIMENTS. *E.g.* activity patterns in relation to day length.



Results

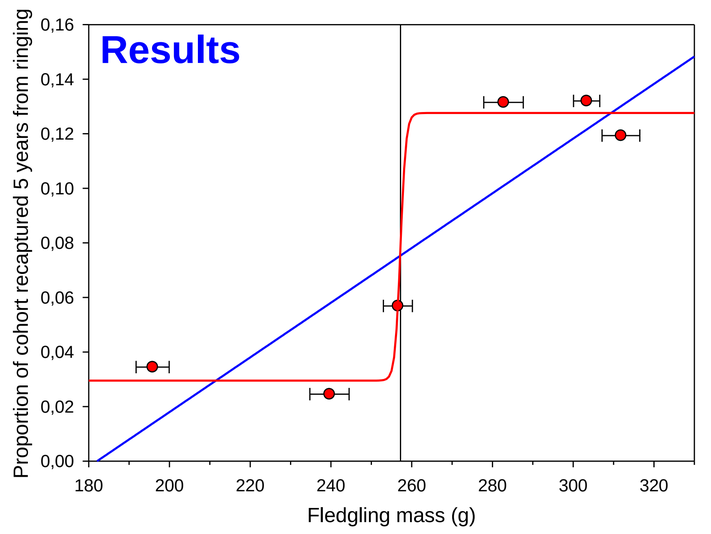


Fig. 1. The relationship between puffin fledgling's body mass (g, S.E.) and the proportion of puffin cohorts recaptured within 5 years of ringing (survival). Body mass explains 76% (R^2) of the variability in fledgling's survival in a linear regression (shown in blue, $F_{1,5} = 12.675$, $P<0.0236$). The possibility of a survival-body mass threshold (vertical black line at 257 g), below which survival is lowered, and above which survival is enhanced, is demonstrated by a Sigmoid curve shown in red. In the Sigmoid model fledgling body mass explains 99% (R^2) of the variability in fledgling's survival (nonlinear regression, $F_{3,5} = 54.062$, $P<0.0182$). New data will clarify the exact shape of the curve, but the relationship is strong and of great biological significance.

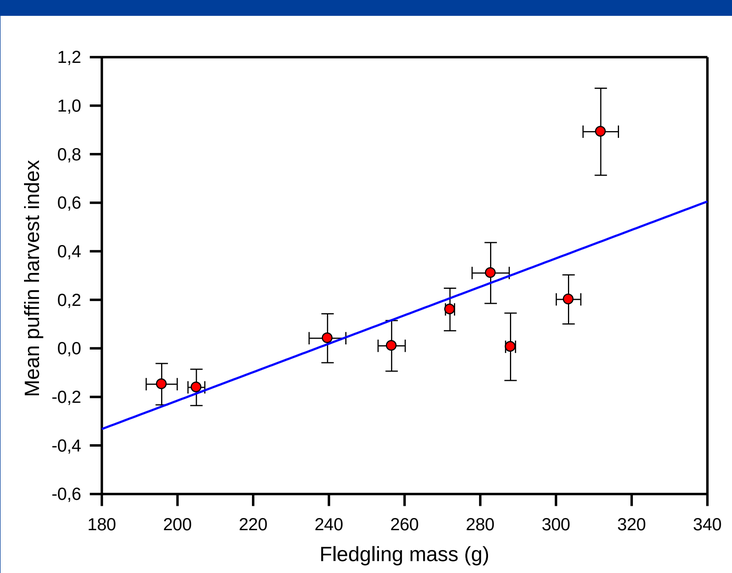


Fig. 2. Puffin fledgling body mass (g, ±S.E.) and the mean puffin harvest index (±S.E.) are highly correlated $r_p = 0.75$ ($P<0.05$, $v = 7$), supporting the hypothesis that both variables are dependent on sandeel availability (see also Fig. 3.). Fledgling body mass "explains" 57% (R^2) of the variability in mean harvest index ($F_{1,8} = 9.269$, $P<0.0187$) in a linear regression analysis.

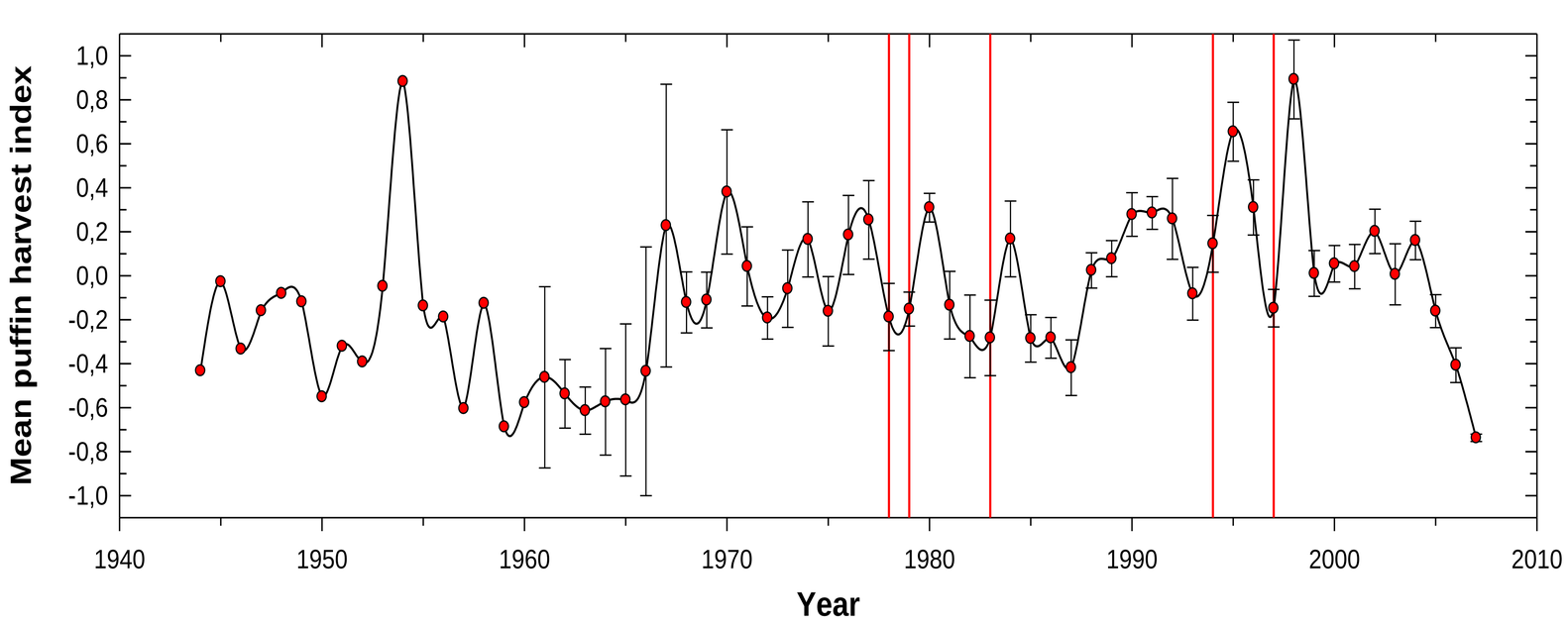


Fig. 3. The mean puffin harvest index 1944-2007 (S.E.). The index is an yearly average of standardized harvest number in seven hunting clubs in Vestmannaeyjar (the number included increases with time, n≥5, ≥1967). The annual harvest number for each club is standardized by dividing by each club's average harvest from the beginning of records. The vertical red lines show years of widespread chick mortality reported in the newspaper Morgunblaðið. These data further support the hypothesis that the puffin harvest is dependent on local sandeel availability, as is chick survival (see also Fig. 1.) and so does the association between the two. Given this observations, the graph illustrates both sandeel´s and puffin's relative recruitment histories.

References

Freydís Vigfúsdóttir *et al.* (2008). Large-scale oceanic forces controlling a top predator in a marine ecosystem? Poster V91 in the Natural Science Symposium 14.-15 mars 2008, Askja Reykjavik.

Acknowledgements

Bjargveiðifélög Vestmannaeyja generously provided the puffin harvest data. The project is gratefully funded by the Icelandic Research Council. Gísli Óskarsson kindly provided the fledglings mass data. Icelandic Coast Guard, Hydrographic department for permission to use the bathygraph of Vestmannaeyjar.