Project information

Keywords
Organochlorines, Climate, seabirds, adult survival
Project title
Effect of pollution on survival of a top predator: a case study integrating ecotoxicology climatology and demography (TOXICLIM).
Year
2015
Project leader
Kjell Einar Erikstad, NINA
Participants

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Flagship
Hazardous Substances
Funding Source

Flagship Hazarddous Substances

Own funding NINA

Summary of Results

Summary of results

Knowledge of long-term quantitative effect of chronic environmental contamination by persistent organic pollutants (POPs) at the population level is still an area with huge gaps. Many populations worldwide are strongly declining. A recent review of the status of, and threats to, all 346 species of seabirds, based on BirdLife International's data and assessments for the 2010 IUCN Red List show that overall seabirds are more threatened than other comparable groups of birds. In general seabirds are exposed to numerous well documented threats like overfishing, bycatch by commercial fisheries, climate change etc. Pollution is also stressed as an important threat, but to our knowledge any long-term effect of pollution on important life history traits are limited.

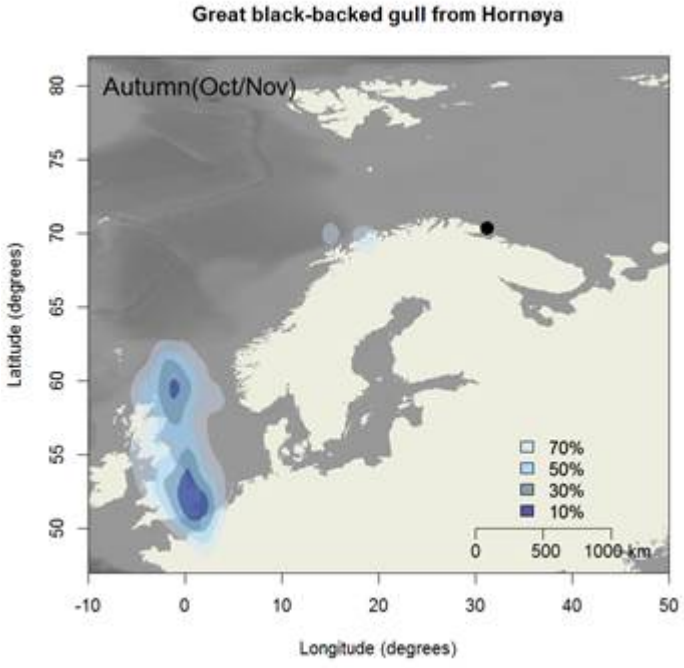
This project address one main scientific question that is at the cutting-edge discussion in ecotoxicology: How is the integration between climate and pollution affecting a seabird

population? We hypothesize that the negative effects of stressful climate conditions are expected to be more critical for individuals with high burdens of OCs.

We have achieved this by modelling the effect of pollution in tandem with state-of-the-art climate data, wintering areas of gulls in order to quantify and identify tele connectivity, which characterizes how seabirds are affected by both local and remotely-induced climate variability. The model species used is Great black-backed gull from Hornøya in northern Norway. Back to 2001 and 2002 a large number of birds was sampled for blood residues of OCs. Since 2001 birds have been re sighted every year in order to estimate their adult survival

Wintering areas of Black-backed gulls

The Great back-backed gulls at Hornøya shortly after the breeding season migrate to their wintering area in the North Sea and return back in early spring (Fig.1). Climate parameters were extracted from these areas in order to estimate the climate effect on adult survival.



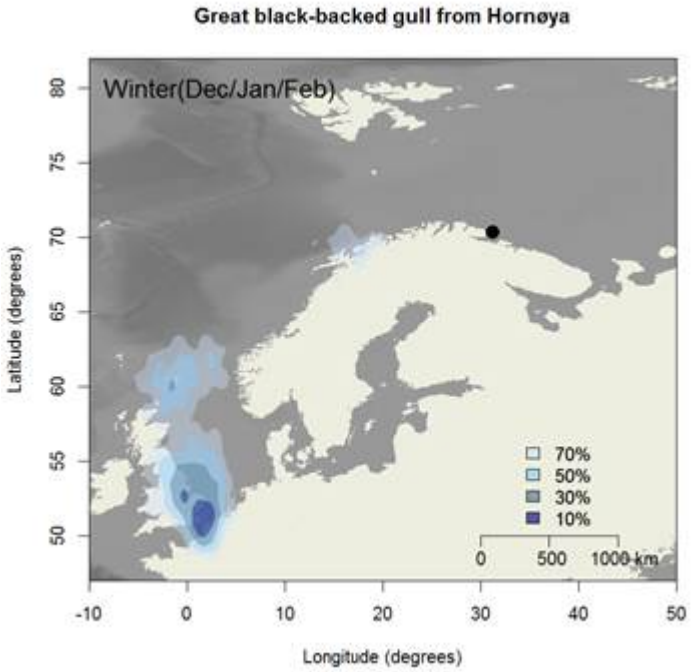
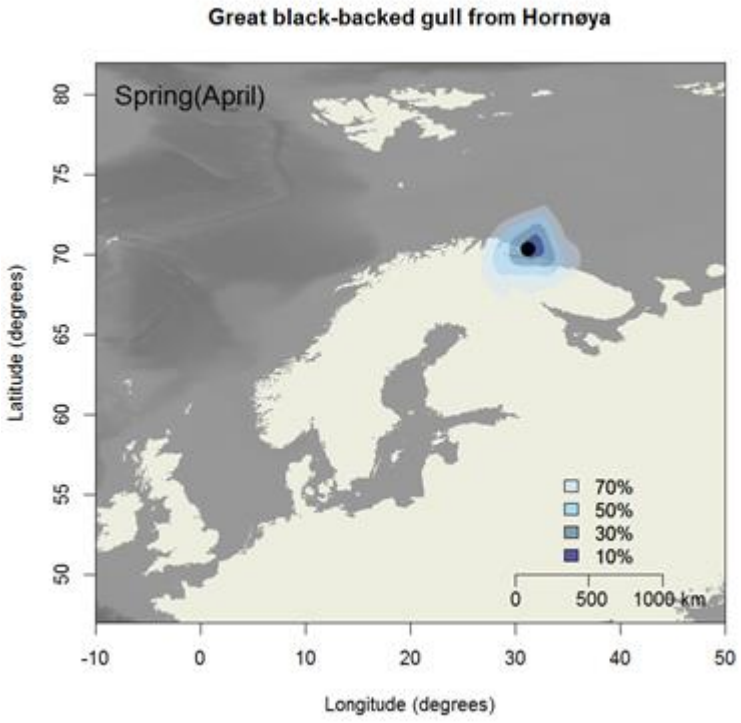
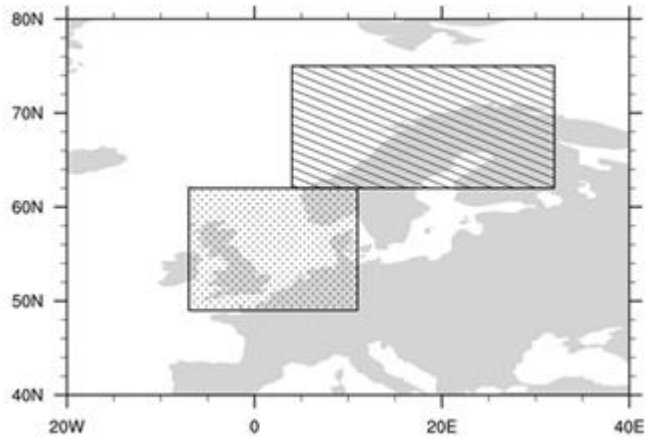


Fig.1. The year around migration and wintering areas of



Design for sampling climate variables

The six-hourly mean sea level pressure (MSLP) from the European Centre for Medium-Range Weather Forecasts (ECMWF) Re-Analysis Interim Project (“ERA-Interim”), are used for the climate analysis and climate covariate definition. ERA-Interim is a gridded model dataset at T255 (nominally 0.703125º, or around 79 km) horizontal resolution produced based on data assimilation of meteorological station data, satellite data, among others, which makes it a state-of-the-art climate dataset.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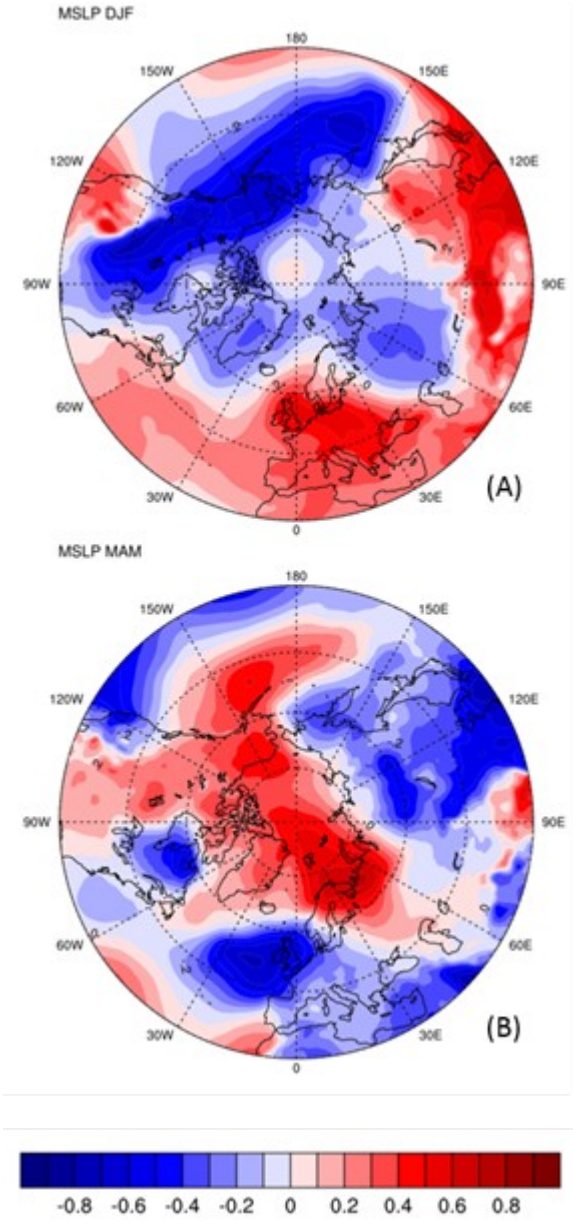


Fig.2. *Areas selected for extracting climate parameters (Left) based on migration routes and wintering areas of Great black-backed gulls (see also Fig.1) and MSLP (Right) aggregated into yearly averages for two main seasons and the correlation with yearly variation in adult survival of gulls over the year 2001 to 2015 :* ***(A)*** *boreal winter corresponding to December, January, and February (MSLP DJF); and* ***(B)*** *boreal spring corresponding to March, April, and May (MSLP MAM). The color shows the correlation coefficient between MSLP and adult survival.*

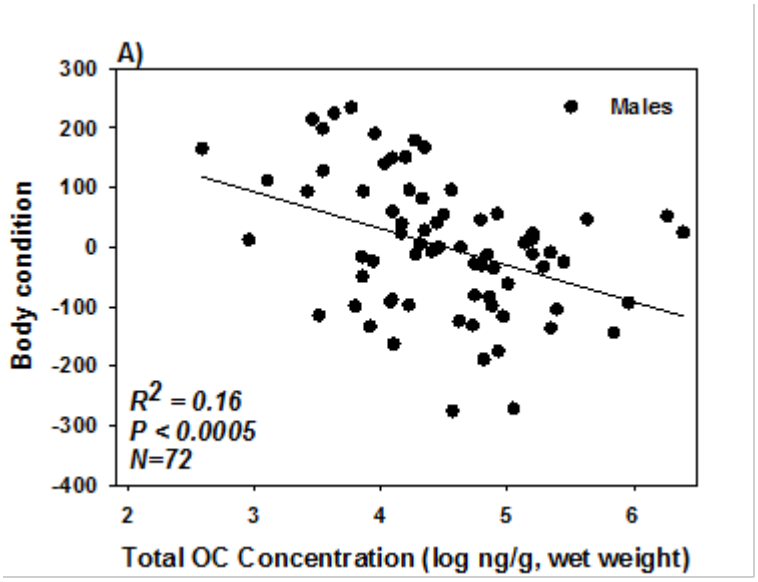
We have decided to select two main regions to construct climate covariate indices (See Fig.1). These regions reflect local changes in the atmosphere, which may affect the condition where the seabirds are located, thus creating favorable or unfavorable atmospheric states. Other regions could have been selected, for instance, where the correlation plots have highest correlation; however, here we want to test whether local

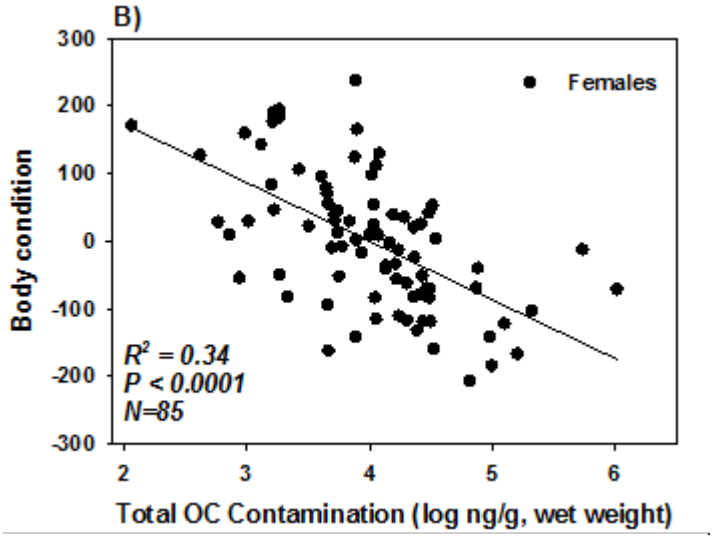
climate is related to where they choose to spend winter and spring.

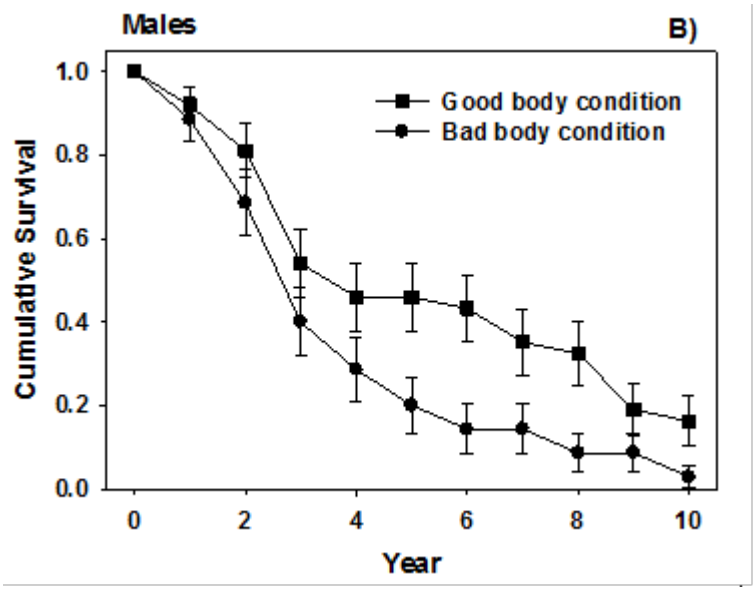
The correlation maps between MSLP and adult survival (Fig.3 right) show distinct features in DJF and MAM. In the Pacific basin, there is strong negative correlation throughout the basin and parts of North America, whereas in MAM, the correlations are positive and more concentrated closer to the Gulf of Alaska. In the Atlantic basin, there are strong correlations around the North Sea area in winter, whereas in spring, the correlation is negative in the North Sea and more shifted towards the tropical Atlantic sector. Also, the correlation is strong and positive over the Barents Sea region. None of these configurations resemble the North Atlantic Oscillation (hereafter "NAO"), as the patterns are not centralized over the characteristic zone of the NAO (See Mesquita et al., 2015 for details). Next, we combine MSLP DJF and MSLP MAM to create an index that tries to capture as much of the variance between these variables. The combination is made through the first principal component (PC1). Since these are two variables, the loadings are 1/sqrt(2) for each of them. **The Pearson correlation between PC1 and the adult survival is 0.72 (p value=0.013), and the variance explained is 65%.**

Pollution and the effect of adult survival

Overall there was a negative relationship between level of contamination of OC and the body condition of nesting birds (measured during late incubation) in 2001 and 2002 and this was evident both for males and females (Fig.3. A and B). Good and bad body condition is defined from a regression between body mass and body size. Residuals>0 is defined as good body condition and residuals


A)
Males
Body condition
$R^2 = 0.16$
$P < 0.0005$
$N=72$
Total OC Concentration (log ng/g, wet weight)


B)
Females
Body condition
$R^2 = 0.34$
$P < 0.0001$
$N=85$
Total OC Contamination (log ng/g, wet weight)


Males
B)
Good body condition
Bad body condition
Cumulative Survival
Year

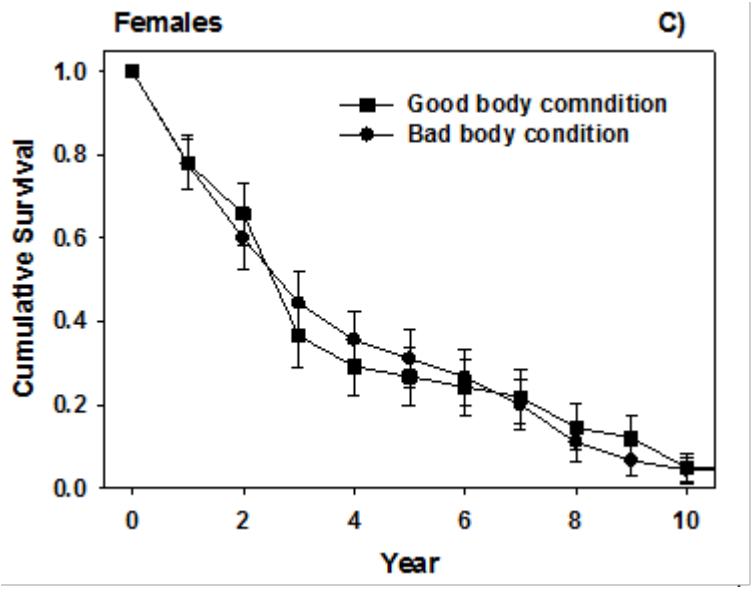


Fig 3. The relationship between body condition of male and female Great black-backed gulls and their total contamination of OCs (A and B). C and D shows survival estimates from a Cox Hazard model of males and females over time. The survival of males was higher among those in good body condition (Wald chic square =4.39, P= 0.03, Hazard ratio 1.68), but there was no such relationships among females (Wald chic square = 0.005., P=0.94).

Since level of contamination of OCs only was measured two years we used Kaplan Meyer plots and Cox Hazard models to estimate the effect of pollution on the adult survival of gulls over time (Fig. 3 C and D. Apparently males (and not females) with high levels of OCs and in poor body condition suffered a higher mortality over years than those with low levels of OCs and in a good body condition. The overall survival for birds in good body condition was during the first 10 year of the study 16% higher than among those in bad body condition (46% and 30% respectively).

To examine the influence of climate and pollution in tandem we estimated the differences in survival of males in the two groups over time and regressed that against the yearly variation in the climate index. Apparently the differences between the two groups followed the yearly variation in the climate index and explained as much as 53% of the differences (Fig. 4).

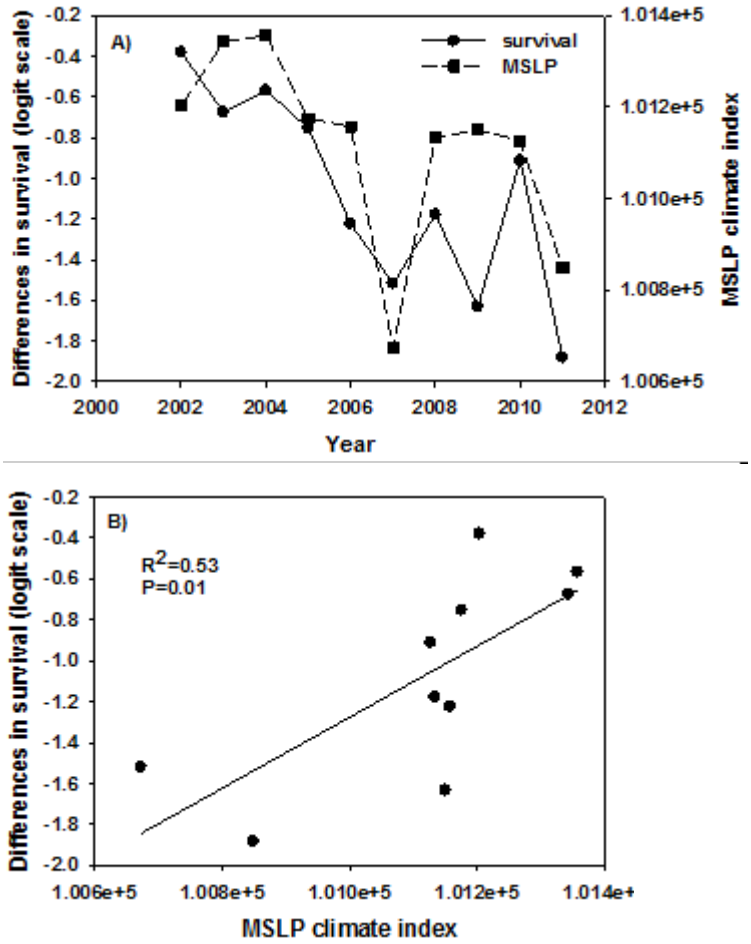


Fig.4. The differences in survival of males in good and bad body condition over time in relation to the climate index (A) and (B) the same data but the differences in survival are plotted against the climate index.

Overall this may suggest that climate and pollution in tandem are more critical for males than for females. There was no direct link between survival and pollution, but level of pollution did negatively affect the body condition which again affected their survival probabilities.

The project team is preparing a manuscript based on the findings which will be submitted by the end of the year;

Erikstad KE, Reiertsen TK, Mesquita MdS , Sandvik, H., Yoccos, N., Ballesteros, M. Bader J, Hodges K. (in prep.). Effect of pollution on survival of a top predator: a case study integrating ecotoxicology climatology and demography.

For the Management

The knowledge any effect of pollution on trends of seabird population are limited and such results are of great importance for management authorities. Many seabird populations worldwide are strongly declining. A recent review of the status of, and threats to, all 346 species of seabirds, based on BirdLife International's data and assessments for the 2010 IUCN Red List show that overall seabirds are more threatened than other comparable groups of birds.

Published Results/Planned Publications

Erikstad KE, Reiertsen TK, Mesquita MdS et al. (in prep.). Effect of pollution on survival of a top predator: a case study integrating ecotoxicology climatology and demography.

Communicated Results

This is a one year case study and so far there have been no communicated results and no master students have been involved. However already next year there will be ample opportunities for this. A particular outreach channel has been established in this respect, viz. a co-operation between NRK, SEAPOP and NINA, whose aim is to increase public focus and awareness of seabird populations and their status. NRK will during the breeding season 2016, broadcast live from the seabird colony Hornøya both online and on national TV during the best broadcasting time. The live broadcasting involves 15 cameras that will be put out in the colony, covering most species, and the public can follow individual nests/families throughout the breeding season. Some of this live broadcasting will also be sent over several days on NRK2 (according to the concept "slow TV"). Additionally, they will have half an hour live broadcasting with different reports and coverage from seabird work, once every week during the best broadcasting time, where different themes related to seabirds in general will be highlighted. Any results from studies about seabird's, climate and pollution will be of great interest in this respect. NRK has agreed that we can use such a seabird-project as a channel for communication (responsible producer in NRK is Nils Arne Sæbø; responsible organiser at NINA is Tone Kristin Reiertsen).

Interdisciplinary Cooperation

The project has two climatologists, who bring climate covariates through the use of state-of-the- art data sets; two ecologists who are well trained in survival and population modelling and an ecologist with high reputation in effect of pollution. This makes this project quite unique in that it considers an integrated view of the system, using information from the atmosphere, ocean, pollution and population modelling. Especially the cooperation with climatologist has given new insight to study the effect of climate in population ecology. This cooperation was stimulated by funding from the Fram Center (incentive finding and the Flaggship in Coastal Ecology). A recent publication by most the same project team on the use of climate models in population ecology has been given great attention both nationally and internationally;

Mesquita, M.d.S., Erikstad, K.E., Sandvik, H., Barrett, R.T., Reiertsen, T.K., Anker-Nilssen, T., Hodges, K.I., Bader, J. 2015. There is more to climate than the North Atlantic Oscillation: a new perspective from climate dynamics to explain the variability in population growth rates of a long-lived seabird. Frontiers in Ecology and Evolution http://dx.doi.org/10.3389/fevo.2015.00043

Budget in accordance to results

The funding from the Fram Centre and own funding by NINA has given us the posibillity to take this case from analyses to an international publication

Budget 2015

Budget per partner

Partner	Specification	Amount (in thousand kroner)
NINA	Salary	200
	Workshops	40
NTNU	Salary	120
Uni Research Climate and Bjerknes Centre	Salary	70
University of Reading	Salary	70
	TOTAL	500

In additon Tone Kristin Reiertsen (NINA) and Kjell Einar Erikstad have used 120 000 NOK each ("egenforskning" for this project

Could results from the project be subject for any commercial utilization

No

Conclusions

There is some important finding in the present study that needs to be considered in any future analyses on the effect of pollution and climate on populations.

- The contamination levels of OCs in the present study population is very low compared to other studied populations. Even though there was clear negative effects documented on the adult survival rate.
- Males and females responded differently on the level of contamination. It is therefore important to include the sex of adults in any analyses of adult survival.
- It is important to use long time series on adult survival to detect the effects. As shown here any effect of the pollution and climate was most evident late in life of the birds.