Project information

Project title

Drift of fish larvae, fish-stock interactions and their effects on seabird dynamics

Year

2013/2014

Project leader

Kjell Einar Erikstad, NINA

Participants

- Project leader; Kjell Einar Erikstad, NINA.
- Project participants; Frode Vikebø IMR, Tycho Anker Nilssen NINA, Robert T Barrett UiTø, Børge Moe (NINA), Leif Nøttestad IMR, Mette Mauritzen IMR, Hallvard Strøm NP, Sebastien Descamps NP, Per Fauchald (NINA), Tone Kristin Reiertsen NINA,Thierry Boulinier (CNRS, University of Montpellier, France), Aurore Ponchon (CNRS, University of Montpellier, France), Morten Frederiksen (Århus, University, Denmark), Hanno Sandvik (NTNU)

Flagship

Fjord and coast, Theme: Physical-biological coupling: Oceanography and habitat use by predators and their prey

Funding Source

Fram Centre, MFCA, NRC

Summary of Results

In agreement with the Flagship leaders, the scientific report covers all sources of funding (NRC, FRAM Centre and MFCA)

All the funding from the Fram Centre for 2013 was used to hire (part time) a competent post doc (Hanno Sandvik) at the new Center of excellence at NTNU in Trondheim (Centre for Biodiversity Dynamics (CBD), led by Bernt-Erik Sæther), who is skilled in stochastic population modeling and mark-recapture analyses of demographic time series. He has contributed to a number of papers and oral presentations (see publication list). Erikstad is also a partner in this Centre.

The funding from MFAC to IMR was used to develop further the fish larvae drift models and to organize the acoustic fish data from the ecosystem cruises in the Barents Sea for the period 1990 to 2010. These have been used in several papers (see publication list and highlights. Scientists from IMR have also participated on 3 workshops.

2013 was a very extensive field season. This involved monitoring population sizes and demographic traits and applying geolocation techniques and the following up of more than 500 loggers attached to 7 different species in 2012 spread in several colonies. This included GLS, GPS and time depth recorders (TDR) that has given us a large database on the winter distribution, feeding distribution around colonies and the diving depth of some of the species. This database will be used in the year to come to sort out the link between oceanographic conditions, prey distribution on both small and large scales and their effects on seabird populations.

Highlight 1:

Ponchon, A., Gremillet, D., Authier, M., Dahlsgaard-Christensen, S., Erikstad, K.E., Solis, J.G., Reiertsen, T.K., Tveraa, T., Boulinier, T. 2013. When things go wrong: dynamics of breeding failure in an Arctic seabird. Ecosphere (in press).

During breeding, long-lived species face important time and energy constraints that can lead to breeding failure when food becomes scarce. Despite the potential implications of intra-season dynamics in breeding failure for individual behavior, carry-over effects and dispersal decisions, little information is currently available on these dynamics at fine temporal scales. Here, we monitored the foraging behavior and the proportion of successful black-legged kittiwake pairs from nest construction to chick fledging in a colony of the southern Barents Sea, to relate foraging effort to the dynamics of breeding failure over an entire breeding season, and to infer the environmental conditions leading to this failure. Specifically, we tracked kittiwakes with GPS and satellite tags during incubation and early chick-rearing to document nest attendance, foraging range, time budgets and daily energy expenditures (DEE). We also monitored diet changes over time. We predicted that breeding failure would follow a non-linear trend characterized by a break point after which breeding success would drop abruptly and would be related to a substantial increase in foraging effort. Kittiwakes showed contrasting foraging patterns between incubation and chick-rearing: they extended their foraging range from 20 km during incubation to more than 450 km during chick-rearing **(Fig.1 and Fig.2)**and switched diet. They also increased their DEE and readjusted their time budgets by increasing time spent at sea. These changes corresponded to a break point in breeding dynamics beyond which the proportion of successful pairs abruptly dropped **(Fig.3**). At the end of the season, less than 10% of kittiwake pairs raised chicks in the monitored plots. This integrative study confirms that breeding failure is a non-linear process characterized by a threshold beyond which individuals face an energetic trade-off and cannot simultaneously sustain high reproductive and self-maintenance efforts. In this way, the occurrence of sudden environmental changes complicates our ability to predict population dynamics and poses conservation challenges.

Highlight 2:

Sandvik, H., Reiertsen, T.K., Erikstad, K.E., Anker-Nilssen, T., Barrett, R.T., Lorentsen, S.H., Systad, G.H. and Myksvoll, M. The decline of Norwegian kitiiwake populations: modeling the role of ocean warming. Climate Research (in revision).

Predicting the impact of human activities, including global climate change, on the biosphere has become one of the most important efforts in ecology. Ecosystems worldwide are changing rapidly as a consequence of anthropogenic impacts such as global warming (IPCC 2007), yet our understanding of the consequences of these changes on populations is limited. To be able to predict population trajectories, it is crucial to understand the mechanisms underlying variation of, and co-variation among, populations. Population fluctuations are determined by parameters such as intrinsic population growth rate and carrying capacity as well as by stochastic fluctuations in the environment .Furthermore, temporal variation in climate and other environmental variables may synchronize population fluctuations over large distances

The black-legged kittiwake (Rissa tridactyla) is a pelagic seabird whose population has recently declined in most parts of the North Atlantic, and which is red-listed in most bordering countries. In order to investigate possible causes for this decline, we analyzed the population dynamics of five kittiwake colonies along the Norwegian coast, ranging from 62° to 71° N, over the last 20–35 years (**Fig.1 and Fig.2)**. By quantifying the importance of sea surface temperatures (SST) in relevant areas of the North Atlantic, we tested the importance of climatic conditions throughout the populations' annual cycles. We found no synchrony among colonies; however, SSTs affected population dynamics, explaining up to 37% of the variation in annual population growth rate. While dynamics of the southerly colonies were mainly affected by winter conditions in the Grand Banks area, dynamics of the northernmost colonies were dominated by autumn conditions off Svalbard. The slopes were negative, indicating stronger population decline under warmer ocean conditions. Population dynamics were affected both via adult survival and offspring recruitment, as evidenced by the presence of unlagged effects as well as effects that are lagged by the age at recruitment. Finally, we performed population viability analyses taking into account the projected warming trends for the future. **(Fig.3).**The median time to extinction of the Norwegian colonies was 52–181 years without considering covariates; 45–94 years when considering the effects of SST but ignoring future warming; and 10–48 years when ocean warming, based on a "business as usual" scenario, was taken into account.

Highlight 3:

Barrett, R.T., Erikstad, K.E., Jenni-Eiermann , S., Lyngbo-Kristensen, D., Moum, T., Myksvoll, M., Reiertsen, T.K. and Sandvik, H. Stress hormones as proxies for short-term changes in food availability in a marine top-predator. Hormones and Behaviour (submitted).

Predicting the effects of climate variability on and through the different trophic levels is a major challenge, and one that increases in complexity as one climbs the food chain. Within the marine ecosystem, effects of climate on life history traits have been documented across many species and populations, including seabirds, often as a result of perturbations in food supply. One environmental factor that has proved difficult to measure independently is the seasonal changes in prey availability. In many studies, single annual proxies of prey abundance have been used to explain variability in seabird breeding performance, but much more important is the timing of the prey relative to the breeding season when energy demand is at a maximum.

It has proved extremely difficult to extrapolate the effects of within-season changes in prey abundance. Whereas reproductive parameters may not be a reliable measure of prey availability recent studies have shown that one practical alternative is to measure endocrinal changes. In particular levels of stress hormones (CORT) are known to correlate with food supply (and survival) over short and long intervals.

Until now, it has been impossible to relate seasonal changes in baseline CORT directly to independent short-term measures of food availability. Therefore the aim of this study was to relate short-term measures of physiological stress among common guillemots breeding in North Norway with concurrent and independent real-time measures of food availability within the foraging range of the population.

Through the unique resolution of an ocean drift model providing a daily proxy of larval numbers within the foraging range of adults, this study was able, for the first time, to document very short-term effects of food availability on seabird breeding performance.

The drift model (**Fig.1**) revealed a considerable seasonal variation in the numbers of cod larvae in the guillemot foraging area around Hornøya (**Fig.2**) to which baseline CORT levels responded, as predicted, through a decrease with increasing numbers of prey in two of the three years of the study (**Fig.3**).

Although numbers and overall biomass of larvae from the northern spawning grounds were much higher than those from the south every year, especially in 2009 and 2011 (**Fig. 2**), there was very little variation in the former during the season, thus excluding them as a factor explaining the short-term variations in CORT. One can also infer from their response to the two sources of larvae that guillemots prefer cod larvae from the southern spawning grounds, despite their lower number. This is likely due to the greater size and hence higher nutritive value of the southern larvae that, when arriving at Hornøya, have drifted northwards for a longer time and in warmer water (hence enhancing their growth) than their northern counterparts.

Highlights 1:

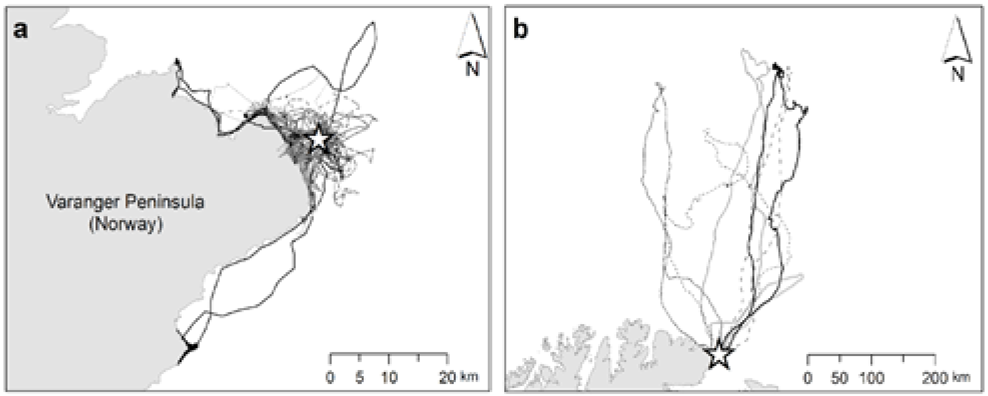

Fig.1.Foraging trips recorded with GPS loggers from kittiwake breeders nesting on Hornøya (white star) during (a) Incubation (*n*= 8 individuals) (b) Early chick-rearing.

Fig.2 Maximum distance from the nesting colony of Hornøya recorded from three failed kittiwake breeders (black, light grey and dark grey) tracked with PTTs (satellite transmitters) over the breeding season. The points correspond to locations recorded for 10h every 48h.

Fig.3. Proportion of successful kittiwake pairs over the breeding season 2011 in three colony sectors on Hornøya, Southern Barents Sea. Points represent raw data whereas solid and dashed lines represent data modeled with a beta-regression.

Highlights 2:

Fig.1. Map of Norway showing all registered breeding colonies of black-legged kittiwakes. The five study colonies are highlighted (orange). The size of the circles indicates the number of apparently occupied nests in 2005.

Highlights 3:

Fig. 1. The study area including the most important current features, the Norwegian Atlantic Current (NAC) and the Norwegian Coastal Current (NCC), cod spawning areas numbered from north to south and the common guillemot colony at Hornøya (red star) centred in the approximate foraging area of chick-feeding adults (black box).

Fig. 3. Baseline CORT levels in adult common guillemots breeding at Hornøya, NE Norway in relation to abundance of cod larvae from southern spawning grounds (regression line and 95% confidence intervals) within the guillemots' foraging area. The plot correct for variation between the sexes and within the season (early vs. late), such the axes are standardised to a mean of zero. Note that the scales of the x-axes differ between years. Ticks indicate the distribution of the variables.

Fig. 2. Modeled numbers of cod larvae from southern (4-11) and northern (1-3) spawning areas within the approximate foraging area of adult common guillemots breeding on Hornøya, NE Norway in relation to egg-laying and hatching dates in 2009, 2010 and 2011. (See Fig. 1 for spawning areas and foraging range). (Frequency = no. of eggs laid or hatched d-1).

For the Management

Knowledge about the fluctuations of fish populations and the population trends among seabirds has high priority among government authorities. In 2013 the Environment Ministry appoint an expert group of seabird and fishery ecologists

to review management strategies based on the new knowledge. It was organized a 2 day workshop in Tromsø and the work from this workshop will be reported in December 2013. Mainly scientists from the larva drift project were appointed for this expert group.

The oil companies have shown interest, especially to the extensive use of logging technology to get detailed data on both the spatial and temporal variation in seabird distribution outside the breeding season. For 2014 they (Norsk Ole og Gass) have risen funding's for the use of our database on the spatial winter distribution of Common guillemots from different breeding colonies. The idea is to develop methods to estimate the effect of any oil spill in a given area on the population dynamics at the colony level. This method will later be implemented to improve the MIRA -model.

Published Results/Planned Publications

Publications 2013 (Project participants in bold)

Barrett, R.T. and Erikstad, K.E. 2013. Environmental variability and body condition in departing Common Guillemot chicks. MARINE BIOLOGY : 160: 1239-1248 DOI: 10.1007/s00227-013-2175-y

Bustnes, J.O., **Anker-Nilssen, T., Erikstad, K.E.,** Lorentsen, S.H and Systad,G.H. 2013. Changes in the Norwegian breeding population of European shag correlate with forage fish and climate. Marine Ecology Progress Series Vol. 489: 235–244.

Castano PR, **Vikebø FB**, Sundby S .A model approach to identify the spawning grounds and describing the early life history of North-East Arctic haddock (Melanogrammus aeglefinus). ICES JMS (in revision).

Erikstad K.E., Reiertsen T.K., Barrett R.T., Vikebø F. and Sandvik H. 2013 Seabird and fish interactions: the fall and rise of a Common Guillemot population. Marine Ecology Progress Series.Vol 475:267-276, doi:10.3354/meps10084

Hanssen, S.A.and **Erikstad, K.E.** 2013.The long- term consequences of egg predation. Behaviour Ecology: 24 **:**564-569 DOI**:** 10.1093/beheco/ars198

Kristiansen T, Vollset KW, Sundby S **and Vikebø FB.** Behavior determines vertical distribution of first feeding larval cod. ICES JMS (accepted) .

Langangen Ø., Stige LC, Yaragina N**, Vikebø FB,** Bogstad B and Gusdal Y (2013) Egg mortality of Northeast Arctic cod (Gadhus morhua) and haddock (Melangogrammus aeglefinus). ICES JMS (accepted).

Lien V, **Vikebø FB,** Skagseth Ø **(2013)** A mechanism for atmospheric control of oceanic heat transport to the Arctic. Nature Communications, doi:10.1038/ncomms2505**.**

Lyngbo-Kristensen, D., **Erikstad, K.E., Reiertsen, T.K.,**Moum. T., **Barrett, R.T. and** Jenni-Eiermann, S. 2013. Are female offspring from a single-egg seabird more costly to raise? Behavioral Ecology doi:10.1093/beheco/ars144 **.**

Myksvoll, M.S., Erikstad, K.E., Barrett, R.T., Sandvik, H., and Vikebø, F. 2013, Climate-driven ichthyoplankton drift modell predicts growth of predator young, PLoS ONE 8(11): e79225. doi:10.1371/journal.pone.0079225

Myksvoll, M.S., Sandvik, A.D., Asplin, L., and Sundby, S. 2013, Effects of river regulations on fjord dynamics and retention of coastal cod eggs, ICES Journal of Marine Science, doi: 10.1093/icesjms/fst113

Myksvoll, M.S., Jung, K.-M., Albretsen, J., and Sundby, S. 2013, Modelling dispersal of eggs and quantifying conncectivity among Norwegian coastal cod subpopulations, *ICES Journal of Marine Science*, doi: 10.1093/icesjms/fst022

Ottersen G, Bogstad B, Yaragina N, Stige LC, **Vikebø FB,** Padmini D A review of early life history dynamics of Barents Sea cod (Gadus morhua). ICES JMS (accepted).

Ponchon, A., Gremillet, D., Authier, M., Dahlsgaard-Christensen, S., **Erikstad, K.E**., Solis, J.G., **Reiertsen, T.K**., Tveraa, T., **Boulinier, T**. 2013. When things go wrong: dynamics of breeding failure in an Arctic seabird. Ecosphere (in press)

Reiertsen, TK, Erikstad, KE., **Moe, B, Barrett, RT., Mauritsen, M, Ponchon, A., Boulinier,T. Frederiksen, M, Anker-Nilssen, T**., Johns, D and Yoccoz, N. Prey density in non-breeding areas affects adult survival of Black-Legged Kittiwakes Rissa Tridactyla from the southern Barents Sea. (Marine Ecology Progress series (in press)

Sandvik, H., Reiertsen, T.K., Erikstad, K.E., Anker-Nilssen, T., Barrett, R.T., Lorentsen, S.H., Systad, G.H. and **Myksvoll, M.** The decline of Norwegian kitiiwake populations: modeling the role of ocean warming. Climate Research (in revision).

Two candidates (females) which are partners in the project have finished their PhD.

Reiertsen, T.K. 2013. Seabirds , Climate and Prey. A population study of two seabird species. PhD thesis University of Tromsø, May 2013.

Ponchon, A. 2013. Individual behaviors and population response to environmental changes". PhD thesis CNRS, University of

Montpellier, France, November 2013.

Submitted

Barrett, R.T., Erikstad, K.E., Jenni-Eiermann , S., Lyngbo-Kristensen, D., Moum, T., **Myksvoll, M., Reiertsen, T.K. and Sandvik, H.** Stress hormones as proxies for short-term changes in food availability in a marine top-predator. Hormones and Behaviour (submitted).

Langangen Ø, Stige LC, Yaragina NA, Ottersen G, **Vikebø FB** and Stenseth NC (To be submitted) Spatial variations in mortality in pelagic early life stages of a marine fish (Gadus morhua). Ecology.

Lorentsen, S,H., **Anker-Nilssen, T., Erikstad, K.E.** and Røv, N. European shag clutch size and breeding phenology are more related to forage fish availability than to climate. Marine Ecology Progress series (submitted).

Ponchon, A., Reiertsein, T.K., Choquet ,R., **Erikstad K.E.,** McCoy , T.D., Tornos, J., Tveraa, T., and **Boulinier, T**. Capturer-recapture surveys: does the spatial scale of sampling design matter? Methods in Ecology and Evolution (submitted).

Reiertsen, T.K., Barrett, R.T. and Erikstad, K.E. Kittiwakes on the cliff edge: a demographic analysis of a steeply declining arctic kittiwake population. Avian Concervation (submitted).

Presentations

Anker-Nilssen, T. Noen utfordringer for miljørisikoanalyser olje/sjøfugl. Workshop om Sjøfugl og Olje, Statoil og Norsk Olje og Gass, Tromsø.

Myksvoll, M.S., Erikstad, K.E., Barrett, R.T., Sandvik, H. and Vikebø, F. 2013. Modellering av klimavariasjoner og larvedrift nær en sjøfuglkoloni, Havet og Kysten forskninsseminar Forskningsrådet, Trondheim.

Myksvoll, M.S. 2013. Strømmende data – forskningsressurs for skolen. Lærerkonferanse – Livet i fjæra 12.november, Akvariet i Bergen.

Myksvoll, M.S., Johnsen, I.A., Falkenhaug, T., Asplin, L., Dahl, E., Sundby, S., Nedreaas, K., Bjelland, O. and Kvamme, B.O. 2013, Fjorder i endring – klimaeffekter på miljø og økologi, Klimaforum 22.oktober, Bergen kommune og Bergens næringsråd.

Myksvoll, M.S., Falkenhaug, T., Asplin, L., Dahl, E., Sundby, S., Nedreaas, K., Bjelland, O. and Kvamme, B.O. 2013, Klimaendringer i kyst- og fjordstrøk – effekter på kystnært fiske og havbruk, Arbeidsseminar om klimatilpasning Hordaland Fylkeskommune, 16.september

Myksvoll, M.S., Erikstad, K.E., Barrett, R.T., Sandvik, H., and Vikebø, F. 2013, Lomvi og torskelarver (Common Guillemots and cod larvae), SEAPOP seminar 2013, Trondheim, 10.-11.april

Reiertsen, T.K., Erikstad, K.E. m.fl. 2013. Hvordan beregne effekter på bestandsnivå hos sjøfugl. Workshop om Sjøfugl og Olje, Statoil og Norsk Olje og Gass, Tromsø.

Reiertsen, T.K. 2013. Climate and evolutionary change in seabirds. 4th SEAPOP Seminar, Trondheim.

Reiertsen, T.K. 2013. Factors affecting kittiwake adult survival. 4th SEAPOP Seminar, Trondheim.

Sandvik H, Reiertsen TK, Erikstad KE, Anker-Nilssen T, Barrett RT, Lorentsen S-H, Systad GH & Myksvoll MS (2013) The role of ocean warming in the decline of kittiwakes in Norway. 43rd Annual Meeting of the Ecological Society of Germany, Austria and Switzerland (Potsdam), talk.

Sandvik, H., Reiertsen, T.K., Erikstad, K.E., Anker-Nilssen, T.K.,

Barrett, R.T. Lorentsen, S.H., Systad, G.H. and Myksvoll, M.S. 2013. Klimaets betydning for bestandsendringer hos krykkje. SEAPOP-seminaret (Trondheim), foredrag.

Communicated Results

There have been 3 workshops during 2013 covering all aspects of the project. There has also been great interest from the media especially related to the steep declines in some seabird species in the Barents Sea area. Several Scientists has participated at seminars and Conferences.

There has been produced two videos from the field work in two of the main seabird colonies Hornøya and Røst which can be seen at

YouTube

http://youtu.be/tPG3ECg7OHg

http://youtu.be/peP0o9Xk4uI

Interdisciplinary Cooperation

The project is inter-disciplinary and brings together the disciplines of oceanography, fishery biology climate, ecology and population modeling. This is a challenge but has so far been a very constructive approach which has given us new insight to marine ecological processes. This cooperation has also so far given a number articles in referee journals over the years.

Budget in accordance to results

The funding from the Fram Center has been important in several ways. The funding from 2011 made it possible to write the interdisciplinary application to the NFR. The funding for 2012 and 2013 has made it possible to hire a post doc with skills in population modeling to work closely with a post doc in oceanographic modeling at IMR. The funding from FKD has also made it possible for the fishery people at IMR to work closely with rest of the project team with the use of acoustic data from their cruises.

Could results from the project be subject for any commercial utilization

No

Conclusions

a) The project has so far given an important contribution to the understanding of oceanographic processes and how these may influence both prey distribution and seabird dynamics. The challenge for the next years is to further develop statistical methods and use population modeling in order to separate such effects both on a small and large scale. By using the large database on seabird dynamics, fish prey distribution and important demographic traits in seabirds this will give a novel understanding of marine processes.

b) We have not developed any new methods but uses recent geolocation techniques in order to follow the spatial movement’s seabirds both in the areas around the colony during the breeding season and in their wintering areas.