



# SEABIRD GROUP

## 10th International Conference

*Book of Abstracts*

**Brugge, Belgium**  
**27-30 March 2009**

VLIZ SPECIAL PUBLICATION 42  
COMMUNICATIONS OF THE RESEARCH  
INSTITUTE FOR NATURE AND FOREST  
INBO.M.2009.1.

Organized by:



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Misjel Decler

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## **PREFACE**

This publication contains the abstracts of the orals and posters presented at the 10<sup>th</sup> International Seabird Group anniversary meeting held in Bruges, Belgium, from 27-30 March 2009. The conference was co-organized by the Seabird Group, the Flanders Marine Institute (VLIZ) and the Research Institute for Nature and Forest (INBO).

The Seabird Group Conference strives to bring together an international group of people with a common interest for the study and the conservation of seabirds. The 10<sup>th</sup> meeting treated a broad spectrum of themes, ranging from breeding ecology, feeding ecology and energetics via conservational aspects to distribution, migration and population ecology of seabirds. The meeting was opened with a key note speech by Chris Perrins on the history of the Seabird Group. During the next two days, 32 selected speakers from 13 different countries presented their studies during oral sessions and more than 30 studies were presented during the poster-sessions.

I wish to thank all the authors of the submitted abstracts for their interest in the conference. I would like to thank all who helped in numerous ways before, during and after the conference, the conference secretariat, the scientific committee and the conference chairs for their valuable contributions. I gratefully acknowledge the generous sponsoring by the Seabird Group and the INBO. Special thanks go to the VLIZ for offering their facilities, for developing and hosting the conference website and to the staff of the INBO and VLIZ for offering their organizing talent. I am especially grateful to Ingrid Dobbelaere, Norman Ratcliffe and Jan Seys. Their dedicated and enthusiastic efforts made this symposium to a success.

Eric W.M. Stienen

Research Institute for Nature and Forest (INBO)

## TABLE OF CONTENTS

Preface.....	iii
<b>Albores-Barajas Yuri V., Cecilia Soldatini and Bruno Massa.</b> Breeding ecology of the Mediterranean subspecies of storm-petrel <i>Hydrobates pelagicus melitensis</i> .....	1
<b>Anderson Orea, Richard Phillips, Richard Shore, Rona McGill, Robbie MacDonald and Stuart Bearhop.</b> Diet, individual specialisation and breeding of Brown Skuas ( <i>Catharacta antarctica lonnbergi</i> ): an investigation using stable isotopes.....	2
<b>Anker-Nilssen Tycho and Tomas Aarvak.</b> Effects of white-tailed Eagles on the reproductive performance of Black-legged Kittiwakes, indications from a 26-year study in north Norway.....	3
<b>Arcos José Manuel, Juan Bécarea, Beneharo Rodríguez, Carlota Viada and Asunción Ruiz.</b> Seabird conservation through site-based protection at sea: the first marine IBA inventory in Spain.....	4
<b>Ashbrook Kate, Mike P. Harris, Sarah Wanless and Keith Hamer.</b> The neighbours from hell: adult-chick aggression in common guillemots .....	5
<b>Baccetti Nicola, Dario Capizzi and Paolo Sposimo.</b> Evolution of field techniques in ten years of rat management to protect Italian shearwater colonies .....	6
<b>Barlow Emily, Francis Daunt, Jane Reid, Stephen Cavers and Sarah Wanless.</b> The function of dispersal as a response to climate change in a long-lived seabird.....	7
<b>Bauch Christina, Simon Verhulst and Peter H. Becker.</b> Telomere length in Common Terns in relation to age, reproduction and survival .....	8
<b>Bicknell Anthony, Mairi Knight, David Bilton, Jim Reid and Stephen Votier</b> Assessing dispersal and meta-populations in Leach's storm-petrels ( <i>Oceanodroma leucorhoa</i> ) using forensic techniques.....	9
<b>Bonnaud Elsa, Karen Bourgeois, Eric Vidal, Jérôme Legrand and Matthieu Le Corre.</b> How can the Yelkouan shearwater survive feral cat predation? A meta-population structure as a solution? .....	10
<b>Bourgeois Karen, Justine Vorenger, Eric Vidal, Lucie Faulquier and Jérôme Legrand.</b> Diet and contamination of an endemic shearwater confined to the enclosed Mediterranean basin.....	11
<b>Braarup Cuykens Ann and Anders Mosbech.</b> Diet of thick-billed murre ( <i>Uria lomvia</i> ) during spring migration along the coast of Western Greenland .....	12
<b>Braasch Alexander, Hans-Otto Hoppen and Peter H. Becker.</b> Last laid, first served: an experimental approach to disentangle the effects of hatching asynchrony and testosterone in Common Tern chicks .....	13

<b>Cadiou Bernard, Christophe Barbraud, Armel Deniau, Matthieu Fortin, Jacques Nisser, François Quénot, Catherine Robert, François Siorat and Pierre Yésou.</b> Two consecutive years of breeding failure for European shags <i>Phalacrocorax aristotelis</i> in Brittany, France.....	14
<b>Cadiou Bernard, Yann Jacob and Gaëlle Quemmerais-Amice.</b> Intensive conservation actions for roseate terns <i>Sterna dougallii</i> in Brittany, France .....	15
<b>Chivers Lorraine, Chris Harrod, Kendrew Colhoun and Hansjoerg P. Kunc</b> Factors contributing to the decline in populations and reproductive success of seabirds on Rathlin Island, county Antrim, Northern Ireland.....	16
<b>Daunt Francis, Vsevolod Afanasyev, Aileen Adam, John P. Croxall and Sarah Wanless.</b> From cradle to early grave: juvenile mortality in European shags is related to poor foraging skills.....	17
<b>Dewar Meagan, J. Arnould and S. Smith.</b> Profiling the gastrointestinal microflora of little penguins ( <i>Eudyptula minor</i> ) .....	18
<b>Egevang Carsten, Iain Stenhouse and Richard R. Phillips.</b> Mapping Arctic Tern migration from Greenland to Antarctica and back.....	19
<b>Everaert Joris and Eric Stienen.</b> Impact of wind turbines on terns in Zeebrugge, Belgium.....	20
<b>Fijn Ruben, Karen Krijgsveld, Camiel Heunks, Martin Poot and Sjoerd Dirksen</b> Nocturnal and diurnal flight intensity and altitude of seabirds and migrants in and around an offshore windfarm in the Dutch North Sea .....	21
<b>Fort Jérôme, Warren P. Porter and David Grémillet.</b> Thermodynamic modelling predicts energetic bottleneck for seabirds wintering in the northwest Atlantic .....	22
<b>Frederiksen Morten, Kasper L. Johansen, David Boertmann, Mary S. Wisz and Anders Mosbech.</b> Spatial distribution of seabirds in spring in the marginal ice zone off West Greenland .....	23
<b>Gardarsson Arnthor, Gudmundur A. Gudmundsson, Kristjan Lilliendahl and Freydis Vigfusdottir.</b> Status of cliff-breeding seabirds in Iceland in 2005-2008 .....	24
<b>Grecian William James, Matthew J. Witt, Stuart Bearhop, Brendan J. Godley, Martin J. Atrill and Stephen Votier.</b> Using species-specific foraging ranges can determine how intrinsic and extrinsic factors shape colony dynamics .....	25
<b>Green Rebecca, Nancy Harrison, Claire Smith and Trevor Jones.</b> The relationship between dietary specialisation and productivity in great skuas, <i>Stecorarius skua</i> , on Handa Island.....	26
<b>Grémillet, David, Lorien Pichegru, Grégoire Kuntz, Anthony G. Woakes, Sarah Wilkinson, Robert J.M. Crawford and Peter G. Ryan.</b> A junk-food hypothesis for seabirds feeding on fishery waste .....	27
<b>Guse Nils, Stefan Garthe, François Bolduc, Jean-François Rail and William A. Montevecchi.</b> Distribution of seabirds in the Gulf of St Lawrence, Canada.....	28

<b>Hansen Erpur S.</b> Sandeel availability and Atlantic puffin recruitment, mortality, and harvest in the Westman Islands.....	29
<b>Hansen Erpur S. and Arnþór Garðarsson.</b> The Atlantic puffin population size of the Westman Islands, Iceland.....	30
<b>Hansen Erpur S., Broddi R. Hansen and Johann O. Hilmarrsson.</b> The Leach's storm-petrel population size of the Westman Islands, Iceland.....	31
<b>Heunks Camiel, Mardik Leopold, Martin Poot, Sander Lilipaly and Daniël Beuker</b> Trend, current status and ecology of Common Scoters <i>Melanitta nigra</i> in the Voordelta, the Netherlands .....	32
<b>Horn Michael H., Jeanette N. Hendricks and Tyler J. Flisik.</b> Pipefish rise in the west: recent dramatic increase in the diet of the Elegant Tern ( <i>Thalasseus elegans</i> ) nesting in southern California.....	34
<b>Karris Georgios, Stavros Xirouchakis, Kostas Grivas, Tasos Dimalexis, Stella Fraguedakis-Tsolis, Sinos Giokas and Spyros Sfenthourakis.</b> Preliminary results of monitoring the breeding performance of the Cory's shearwater on Strofades islands (Ionian Sea, western Greece).....	35
<b>Kotzerka Jana, Stefan Garthe and S.A. Hatch.</b> Night and day – contrasting foraging strategies of Black-legged Kittiwakes between pre-breeding and breeding stage.....	36
<b>Krijgsveld Karen, Ruben Fijn, Peter van Horsen, Jim de Fouw and Camiel Heunks.</b> Flight paths of seabirds and migrating birds in and around an offshore wind farm in the Dutch North Sea.....	37
<b>Le Bohec Céline, Michel Gauthier-Clerc, Joël M. Durant, David Beaune, Nils Chr. Stenseth, Roger Pradel, David Grémillet, Arnaud Béchet, Nicolas Chatelain and Yvon Le Maho.</b> How climate changes affect juvenile survival and recruitment in the King penguin.....	38
<b>Limmer Bente and Peter H. Becker.</b> Improvement of chick provisioning with parental experience in a seabird.....	39
<b>Ludwig Sonja C. and Peter H. Becker.</b> Within-season divorce in common terns – induced by predator disturbance?.....	40
<b>Ludynia Katrin, Rian Jones, Joan James, Kathleen Peard, Jean-Paul Roux and Les G. Underhill.</b> Close vicinity of foraging areas and breeding sites may explain positive population trends of endangered Bank Cormorants at Mercury Island, Namibia.....	41
<b>Ludynia Katrin, Jean-Paul Roux and Rian Jones.</b> Pelagic Goby, the main prey for seabirds in the northern Benguela: what we learn about fish and their role in the ecosystem from seabird diet.....	42
<b>Markones Nele, Stefan Garthe, Ommo Hüppop and Sven Adler.</b> Modelling seabird distribution patterns in the south-eastern North Sea using hydrographic data .....	43
<b>Markones Nele, Ommo Hüppop and Stefan Garthe.</b> Working hard, gaining less – The breeding season 2008 of kittiwakes at Helgoland, south-eastern North Sea .....	44

<b>McMahon Clive R. and Marc A. Hindell.</b> Royal penguin phenology: changes in the timing of egg-laying of a sub-Antarctic predator in response to a changing marine environment.....	45
<b>Medeiros Renata, Mark Bolton, William O.C. Symondson, Jaime A. Ramos, and Robert J. Thomas.</b> Small birds in a large ocean: how to study the diets of different storm petrels?.....	46
<b>Mitchell Ian, Ian Burfield and Matt Parsons.</b> Assessing the state of seabird communities in the NE Atlantic .....	47
<b>Monticelli David, Jaime Ramos and Jean-Louis Doucet.</b> Use of ringing data to unravel demographic strategies in tropical vs. temperate roseate terns .....	48
<b>Paiva Vitor H., Pedro Geraldes, Ivan Ramirez, Ana Meirinho, Stefan Garthe and Jaime Ramos.</b> Foraging along a marine productivity gradient: the plasticity of a pelagic seabird species, the Cory's shearwater.....	49
<b>Paiva Vitor H., Pedro Geraldes, Ivan Ramirez, Stefan Garthe and Jaime A. Ramos.</b> How Cory's shearwaters Area Restricted Search changes across a marine productivity gradient .....	50
<b>Paiva Vitor H., Tim Guilford, Jessica Meade, Pedro Geraldes, Jaime Ramos and Stefan Garthe.</b> Flight dynamics of a pelagic seabird foraging in a coastal environment: the Cory's shearwater case .....	51
<b>Perrins Christopher.</b> The history of the Seabird Group.....	52
<b>Pettex Emeline, Svein-Hakon Lorentsen, Robert T. Barrett, David Grémillet</b> Are Norwegian gannet populations constrained by their foraging environment? .....	53
<b>Poot Martin, Camiel Heunks, Hans Verdaat, Hein Prinsen, Pim Wolf, Mardik Leopold and Theo Boudewijn.</b> The shallow coastal zone in the SW-Netherlands as a concentration area for Red-throated divers <i>Gavia stellata</i> – variation in occurrence in relation to wind and tide .....	54
<b>Ratcliffe Norman, Steve Newton, Oscar Merne, Paul Morisson, Tom Cadwallender and Morten Frederiksen.</b> Population ecology of roseate terns <i>Sterna dougallii</i> in NW Europe .....	56
<b>Riechert Juliane, Olivier Chastel and Peter H. Becker.</b> Do prolactin and corticosterone plasma levels of breeding Common Terns influence their hatching success? .....	57
<b>Ross-Smith Viola and Peter Ferns.</b> Parental quality, reproductive performance and chick begging behaviour in lesser black-backed gulls .....	58
<b>Sabarros Philippe S., Sophie Bertrand, David Grémillet, Lorien Pichegru, Joël M. Durant, Nils Chr. Stenseth, Janet Coetzee, Nandipha M. Twatwa and Eric Machu.</b> Optimized foraging strategy for South African Cape gannets ( <i>Morus capensis</i> ) .....	59
<b>Stienen Eric W.M., Wouter Courtens and Marc Van de Walle.</b> Why Sandwich Terns <i>Sterna sandvicensis</i> work hard in the Netherlands and live leisurely in Belgium.....	60



<b>Thaxter Chris, Sarah Wanless, Mike P. Harris, Francis Daunt, Silvano Benvenuti, Yutaka Watanuki, David Grémillet, Simon Greenstreet and Keith Hamer.</b> Flexibility of foraging behaviour in two pursuit-diving seabirds: the importance of prey transport constraints .....	61
<b>van Franeker Jan Andries and the Save the North Sea Fulmar Study Group</b> Marine litter monitoring by seabirds .....	62
<b>van Horsen Peter and Martin Poot.</b> Large-scale mapping of seabird densities on the North Sea.....	63
<b>Vigfúsdóttir Freydís, Yann Kolbeinsson, Erpur S. Hansen and Jonas P. Jonasson.</b> Large-scale oceanic forces controlling the Atlantic puffin in S.-Iceland.....	64
<b>Votier Stephen, Stuart Bearhop, Matthew J. Witt, Richard Inger, David Thompson and Jason Newton.</b> Resource acquisition in a top marine predator: assessing the impact of fishery discards on foraging strategies of Northern Gannets ( <i>Morus bassanus</i> ) .....	65
<b>Wakefield Ewan, Richard Phillips, Jason Matthiopoulos, Javier Arata, Rosemary Gales, Nic Huin, Graham Robertson, Susan Waugh and Heinri Weimerskirch.</b> Breeding distribution of the black-browed albatross <i>Thalassarche melanophrys</i> – Global observation and prediction of the use of space by a wide-ranging, generalist marine predator.....	66
<b>Watson Maggie J.</b> Exploring the real cost of parasites: a meta-analysis of experimental studies.....	67
<b>Watson Maggie J.</b> Measuring the sometimes subtle effects of parasites and colonial seabirds .....	68

## **BREEDING ECOLOGY OF THE MEDITERRANEAN SUBSPECIES OF STORM PETREL *HYDROBATES PELAGICUS MELITENSIS***

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We followed the breeding season of storm-petrels (*Hydrobates pelagicus melitensis*) in Sicily during 2007 and 2008. The Mediterranean subspecies has been little studied, apart from the main colonies and population estimates. Our aim was to describe the reproductive biology and ecology of this subspecies. We estimated hatching and fledging success, as well as chick growth rate. We also studied the diet and foraging strategies of the species. In 2007 we found that breeding success in the inner part of the colony was higher than on the external part of the colony, despite adults having better body condition on the external part of the colony. In 2008 adults in the inner part of the colony had a better body condition compared to both the external part and the previous year, while adults on the external part had a similar body condition to that of the previous year, but also a lower breeding success than on the inner part of the colony. We suggest two options. First, adults in the inside arrive earlier and occupy the best places within the cave, leaving the outside for the lower condition individuals; the difference in body condition observed in 2007 may be due to weight loss as a result of incubation and long periods of fasting. Second, in 2008, individuals on the external part of the colony had as good body condition as the individuals on the inner part, but probably were less experienced and did not incubate for the whole period. Regarding chick growth we calibrated weight vs wing and observed that chicks reach a maximum weight of  $45.4 \pm 0.5$ g before starting to lose weight. The adults mean weight was  $28.5 \pm 0.45$ g.

It was known that storm-petrels feed on the surface, but we also observed that storm petrels dive for food down to 1.9m. Due to the absence of Euphausiids in the Mediterranean, the subspecies may have adapted to a different diet compared with the Atlantic subspecies; we observed that they eat and feed their chicks with crustaceans, and benthic fish species.

## **DIET, INDIVIDUAL SPECIALISATION AND BREEDING OF BROWN SKUAS (*CATHARACTA ANTARCTICA LONNBERGI*): AN INVESTIGATION USING STABLE ISOTOPES**

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The diet of brown skuas (*Catharacta antarctica lonnbergi*) on Bird Island, South Georgia was assessed using a combination of stable isotope analysis (SIA) and mixing model techniques. We found evidence that individual specialisation in diet of adult brown skuas was related to timing of breeding, which may reflect differences in intrinsic quality. Adults with more enriched <sup>13</sup>C values hatched chicks earlier than those with depleted <sup>13</sup>C values. Individuals with enriched <sup>13</sup>C fed predominantly on Antarctic fur seal (*Arctocephalus gazella*) carrion and placenta while those with lower ratios appeared to rely more on burrowing petrels (e.g. Antarctic prions *Pachyptila desolata*). Individual foraging differences clearly influenced timing of breeding and potentially the reproductive output of breeding pairs. We confirmed that the main components of the diet of brown skuas during incubation are, in decreasing order of importance, Antarctic fur seal placenta, burrowing petrels and fur seal muscle. In addition, we identified fur seal faeces in the diet during this stage, which had not been detected previously by traditional sampling methods. Finally we identified a correlation in  $\delta^{13}\text{C}$  values between pair members, attributable to the influence of courtship feeding of females by males, or assortative mating according to foraging preference or intrinsic quality.

## **EFFECTS OF WHITE-TAILED EAGLES ON THE REPRODUCTIVE PERFORMANCE OF BLACK-LEGGED KITTIWAKES; INDICATIONS FROM A 26-YEAR STUDY IN NORTH NORWAY**

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In the late 1990s, numbers of non-breeding White-tailed Eagles *Haliaeetus albicilla* that spend the summer in Røst, an offshore archipelago in northern Norway, increased drastically and have since remained high. Parallel data on eagle numbers (daily observations) and the population trends and breeding success (number of large chicks per nest) in three colonies of Black-legged Kittiwakes *Rissa tridactyla* were collected in 26 different years since 1979. Two of the colonies were on cliffs; the main colony, which decreased steadily from about 25,000 to 9,300 pairs during the study, and a small colony with highly variable breeding numbers (16-253 pairs). The third colony, however, which increased from 131 to 633 pairs over the period, is on buildings and never visited by eagles. Thus, the data sets enabled a direct estimation of to what extent the eagles affected kittiwake performance. As could be expected, breeding success in the building-nesting colony did not change significantly with the influx of eagles, but dropped markedly in two other colonies. While the main cliff-breeding colony and that on buildings had an equal breeding success (mean 0.79 fledglings per nest) in 13 years prior to the eagle boom, it was 42% lower on the main cliff than on the buildings (means 0.36 and 0.62 fledglings per nest, respectively) in the 11 following years. This is the first quantitative evidence of how the formerly threatened but now numerous White-tailed Eagle represents an additional stress to a newcomer on the Norwegian Red List, the Black-legged Kittiwake.

## **SEABIRD CONSERVATION THROUGH SITE-BASED PROTECTION AT SEA: THE FIRST MARINE IBA INVENTORY IN SPAIN**

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Seabirds face several serious threats at sea, which have been noticeably overlooked or unattended for long. With the increasing awareness of this gap, several initiatives are on the way to address seabird conservation at sea. Among them, and thanks to the increasing knowledge on seabird distribution patterns at sea, the protection of key areas is receiving increasing attention (Hyrenbach *et al.*, 2000). BirdLife International is now addressing this issue through extending its Important Bird Area (IBA) Programme to the marine environment (BirdLife International 2004). Two EC funded LIFE projects (2004-2009), in Spain (SEO/BirdLife) and Portugal (SPEA), have led this initiative, collecting data (surveys and tracking information) and developing the methodology to end up with their respective national inventories of marine IBAs. Both projects have succeeded on this initiative, and set a reference for future inventories of marine IBAs, with the support of BirdLife International. Here we present the results of the Spanish project, with a comprehensive and detailed marine IBA inventory which is expected to be the reference for the implementation of Special Protection Areas (SPAs) at sea within the framework of the Natura 2000 network.

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## **THE NEIGHBOURS FROM HELL: ADULT-CHICK AGGRESSION IN COMMON GUILLEMOTS**

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We report for the first time the adverse effect of conspecific aggression on chick survival during periods of poor food resources in a colonial breeder, the common guillemot (*Uria aalge*). During the poor conditions experienced in 2007, parents were forced to forage simultaneously, leaving many chicks unattended. Unexpectedly, these chicks were frequently attacked by conspecifics at neighbouring nest sites, often with fatal consequences. The combination of poor food supply and the changing social environment experienced by chicks resulted in the highest chick mortality recorded at this site since records began in 1983. Our work highlights this previously unsuspected trade-off between provisioning chicks and guarding them against attacks from neighbouring breeders, and that understanding how environmental conditions affect social dynamics is crucial to interpreting costs and benefits of colonial breeding.

## **EVOLUTION OF FIELD TECHNIQUES IN TEN YEARS OF RAT MANAGEMENT TO PROTECT ITALIAN SHEARWATER COLONIES**

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Several restoration projects have been planned and were carried out on the Italian islands during the last decade, in order to mitigate the detrimental impact of black rats *Rattus rattus* on the reproductive success of shearwaters. Early eradication projects (1999-2000) have been carried out on small islands (1 to 7,5ha), mainly selected according to their size, rather than to distance from mainland and expected benefit. Baits were placed inside bait stations, with a density of 6-10 per hectare. When islands were closer than 320m to land, rat recolonization attempts occurred within 2-5 years. A second wave of projects (2005-2006) aimed at eradicating rats from much larger and isolated islands (Zannone and Giannutri, respectively 103 and 240ha). In these projects a more precise calibration of bait station density and bait amount was allowed by specific studies on rat relative abundance in different habitat types. Bait stations were placed at an average density of 4 per hectare, and bait uptake was monitored at each replacement. Bait was applied on three different occasions, at intervals of 30 days; on both islands, a final supplementary baiting session was carried out on 50% and 25% of the area. Finally, Molara Island (350ha) was treated in October 2008 from the air. Rodenticide pellets of brodifacoum were spread from helicopters, along flight lines followed by GPS navigation system, on two sessions (10kg bait/ha for each distribution), with an interval of 20 days. Monitoring of the latter experiment is still in progress and the outcomes will be evaluated over the next months/years. The Zannone and Giannutri projects were apparently successful. In the 2009 breeding season, the productivity of c. 200 pairs of Cory's Shearwater *Calonectris diomedea* and c. 450 of Yelkouan Shearwater *Puffinus yelkouan* – previously close to nil – will be again on normal levels. The aerial technique, new for the Mediterranean context, appears to be suitable for lowering monetary costs of restoration projects and actually made the Molara operation possible.

## **THE FUNCTION OF DISPERSAL AS A RESPONSE TO CLIMATE CHANGE IN A LONG-LIVED SEABIRD**

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There is growing concern that climate change is causing marked changes in the number and distribution of many species. One of the clearest signs of climate change is a shift in species' distribution and this can occur either through extinction of local populations, or through the dispersal of individuals away from unfavourable conditions. Dispersal is therefore a potentially important mechanism whereby populations can adapt to climatic change. This study will be carried out on the European shag, *Phalacrocorax aristotelis*, a long-lived seabird that is declining in a region known to be experiencing rapid environmental change. The project aims to establish how dispersal within and between shag colonies along the north east coast of the British Isles varies in response to climatic variables. CEH possess a long-term, individual based study on the European shag on the Isle of May, Scotland. This contains data on breeding performance and provenance of more than 30,000 birds from over 30 years and as such is a valuable resource for assessing population change in this study. Through this, and the use of genetic techniques, the potential for individual dispersal to enable populations to adapt to environmental change will be ascertained, since dispersal away from unfavourable conditions during this time of climatic change may be crucial to species' persistence.



## **TELOMERE LENGTH IN COMMON TERNS IN RELATION TO AGE, REPRODUCTION AND SURVIVAL**

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Telomeres are complex nucleoprotein structures at the ends of eukaryotic chromosomes that protect chromosome integrity. In the absence of the enzyme telomerase, telomeres shorten with each cell division and shortening plays a key role in cellular senescence. However, telomere shortening is also influenced by DNA-damaging factors such as oxidative stress (von Zglinicki *et al.*, 2000). Telomere length shortens with age, but varies between individuals of the same age suggesting that individuals differ in their exposure or response to telomere-shortening stress factors (Hausmann *et al.*, 2003, Kotrschal *et al.* 2007). Thus telomere shortening can be interpreted as a proxy for damage accumulation and may predict e.g. mortality. We investigate telomere length in erythrocytes of common terns (*Sterna hirundo*) in relation to age, reproductive parameters and survival. The study is based on a long-term data set of sexed birds of known age, marked with transponders, which allow recording annual local survival and reproductive performance over the entire lifetime at the natal colony site (Becker *et al.*, 2001). We collected samples of about 150 individuals in two consecutive years. First results show that telomere length decreases with age and suggest a correlation with reproductive effort.

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## **ASSESSING DISPERSAL AND META-POPULATIONS IN LEACH'S STORM-PETRELS (*OCEANODROMA LEUCORHOA*) USING FORENSIC TECHNIQUES**

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Procellariiformes are long-lived and nest in a few densely aggregated places making them particularly vulnerable to the deleterious effects of global change, yet despite being one of the most threatened avian taxa in the world, we still know little about their dispersal behaviour. A large colony of 45,000 pairs of Leach's Storm-petrel (*Oceanodroma leucorhoa*) breeds on St Kilda, Scotland, representing 94% of the EU population, yet this population is under threat from large numbers of Great Skuas (*Stercorarius skua*) breeding on the same island. However, very large colonies of Leach's storm-petrel (>6 million birds) exist in Newfoundland and if birds are able to move between these locations, immigration to St Kilda may offset the effects of skua predation. Therefore dispersal may be critical for the long-term persistence of colonies of this species. Here we use a combination of molecular markers and stable isotopes to determine the extent of movement between Leach's Storm-petrel colonies in the North Atlantic. These data have important implications for understanding dispersal and meta-population dynamics of this species, as well as for implementing appropriate conservation strategies.

## **HOW CAN THE YELKOUAN SHEARWATER SURVIVE FERAL CAT PREDATION? A META-POPULATION STRUCTURE AS A SOLUTION?**

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The Yelkouan shearwater, *Puffinus yelkouan*, is an endangered Mediterranean endemic species of burrowing petrel threatened by feral cats. The life-history parameters of a small population of Yelkouan shearwaters on a Mediterranean island (Port-Cros) were studied in conjunction with the diet of feral cats, to examine the birds' vulnerability to introduced cats. Yelkouan shearwaters were the birds most frequently found in cat scats, with  $431 \pm 72$  birds killed per year, and predation was the highest during the pre-laying period. A demographic model was created using data for *P. yelkouan* and for closely related shearwater species. Without cat predation, only two of four survival rate scenarios led to a mean growth rate  $\lambda \geq 1$ . The model was constrained to have a stable population growth rate and used to predict predation scenarios compatible with the observed population stability because the population under study has remained stable at around 180 pairs for at least 20 years despite feral cat predation. The results of assuming that the population is closed were inconsistent with the estimated mortalities due to feral cats, while it was possible to reconcile the observed numbers of breeding pairs with the observed mortalities due to cats by assuming that Port-Cros Island is a sink sustained by immigration. This illustrates that small colonies may need to be sustained by larger ones to avoid being driven to extinction. Unfortunately, the absence of a large geographic scale ringing program makes the precise identification of the origin of the immigrants impossible in this case.

## **DIET AND CONTAMINATION OF AN ENDEMIC SHEARWATER CONFINED TO THE ENCLOSED MEDITERRANEAN BASIN**

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The Mediterranean Basin contains highly contaminated marine ecosystems. Because contaminants bioaccumulate throughout species' lifespan and biomagnify through the food chain, long-lived predators such as Procellariiformes are appropriate to monitor pollutants. However, little investigation has been made of contaminant levels in Mediterranean Procellariiformes. Here we analysed heavy metal (lead, cadmium, mercury, selenium) and pesticide contamination in the Mediterranean endemic Yelkouan shearwater *Puffinus yelkouan* compared to the Cory's shearwater *Calonectris diomedea*. As one of the main factors influencing contaminant levels in seabirds is diet, we also analysed the diet composition of the two species, revealing the predominance of fish prey in both shearwaters. Yelkouan shearwaters ate smaller preys and more frequently crustaceans while larger and potentially more contaminated mesopelagic and demersal preys tended to be more frequent in the Cory's shearwater diet. Lead, cadmium and selenium levels were higher in feathers of the Yelkouan shearwater, indicating that these heavy metal levels were not related to diet differences between the two species, but probably to different food foraging and moulting areas. The heavy metal levels we found probably have no adverse effect on these birds, but pesticide contamination of eggs could have caused some breeding failure.

## **DIET OF THICK-BILLED MURRE (*URIA LOMVIA*) DURING SPRING MIGRATION ALONG THE COAST OF WESTERN GREENLAND**

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During thick-billed murre (*Uria lomvia*) spring migration and staging in Disko Bay and south-eastern Baffin Bay (Western Greenland) 70 birds were sampled (2005 and 2006) for stomach analysis. The murre's esophagus and stomachs were removed, the content was conserved in 70° ethanol and before prey identification it was filtered with a 0.2µm mesh-sized net. The prey items were identified to the lowest taxonomic level possible and measured. The diet of the murre was mainly composed of four prey animals: polar cod (*Boreogadus saida*), capelin (*Mallotus villosus*), a mysid amphipod (*Parathemisto libellula*) and Arctic squid (*Gonatus fabricii*). Almost 20% of the stomachs were empty. Stomach contents weighed (mean ± standard deviation) on average 4.3±11.4g (slime and prey animals). Fish occurred in 46% of the stomachs containing prey or prey remains and crustaceans in 65%. The original size and weight of the prey animals were measured directly on the prey where possible or estimated based on measurements of prey remains. The size of two polar cods eaten was estimated from their otoliths and they were 144mm and 201mm long and weighed 19.6g and 55.6g respectively. The capelins (N=24) were estimated to be (mean ± standard deviation) 119±16mm long and to weigh 11.9±4.6g. The 124 *Parathemisto libellula* body lengths were either measured directly on entire animals or estimated from their telson (23±3mm) and their weights were estimated (103±26mg). The squid beaks (N=5) were the only sign of the ingestion of this prey kind but it was sufficient to estimate the original size and weight (120±29mm and 55.3±9.8g). Capelin and Arctic squid each represented around 40% of the estimated total wet weight of ingested prey animals, while the 124 amphipods only represented 2% of it. This study is the first diet study of thick-billed murre during spring in Western Greenland. When results were compared with 16 murre diet studies from other areas two main differences could be pointed out. The first is the absence of *Thysanoessa inermis* (Euphausiacea). The second difference is that the weight of the Arctic squid in this study was ten times higher than in a study made by Gaston (1985).

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## **LAST LAID, FIRST SERVED: AN EXPERIMENTAL APPROACH TO DISENTANGLE THE EFFECTS OF HATCHING ASYNCHRONY AND TESTOSTERONE IN COMMON TERN CHICKS**

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In many larid species asynchronous hatching establishes a distinct within-brood hierarchy accompanied with competitive asymmetries which are often detrimental to last-hatching chicks. A possible mechanism that is thought to mitigate the effects of hatching asynchrony is the differential allocation of resources across the laying sequence by the mother. In this context, the maternal deposition of androgens into the egg yolk increasing with laying sequence has received a lot of attention in recent research. In order to disentangle the effects of hatching asynchrony and the adaptive value of maternal androgen deposition we conducted a field experiment using the common tern (*Sterna hirundo*) as a model species as there is evidence for increasing concentrations of yolk androgens with egg-laying order (French *et al.*, 2001). We manipulated the natural hatching sequence within a brood, so that chicks from last laid eggs hatched first and vice versa. We hypothesized that chicks hatching first from last eggs should benefit from the combined advantages of hatching first and from an egg containing more androgens. We measured continuous chick growth and testosterone (T) levels in sibling broods at three successive post-natal developmental stages. Our preliminary results do not yet show a coherent picture but in general testosterone levels were low, and we did not find clear effects of egg position on plasma T levels and growth of the chicks.

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## **TWO CONSECUTIVE YEARS OF BREEDING FAILURE FOR EUROPEAN SHAGS *PHALACROCORAX ARISTOTELIS* IN BRITTANY, FRANCE**

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As part of the seabird monitoring programme in Brittany, several breeding colonies of shags are censused regularly. Additionally, data on breeding success are collected on some of these colonies located in different parts of the region. In 2006, productivity ranged from 0.7 to 1.9 chicks fledged per breeding pair. In 2007, breeding success was much lower, generally ranging from 0.1 to 0.6 chicks per pair. A decrease in breeding numbers was also reported in 2007, as well as delayed laying, high proportion of well built nests without subsequent egg-laying and significant failure at the egg or chick stages. Since similar results were recorded all around Brittany, this suggested a large-scale environmental effect. The potential causes remain unknown but food shortage is strongly suspected. The 2007 breeding season was also a poor year for some other seabird species in Brittany. In 2008, a major storm occurred in mid-March, washing out many nests of shags and leading to the disruption of breeding for early breeders. Afterwards, results differed between colonies, with locally low breeding numbers and high rate of breeding failure. Mean productivity ranged from 0.3 to 1.9 chicks per pair. Again, the poor breeding season should probably be linked to unfavourable environmental conditions.

## **INTENSIVE CONSERVATION ACTIONS FOR ROSEATE TERNS *STERNA DOUGALLII* IN BRITTANY, FRANCE**

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The whole French population of roseate tern is located in Brittany, and since the late 1980s the mixed tern colony of Dames Island held the large majority of the breeding birds. A crash in breeding numbers was recorded in Brittany in the 1960s-1970s, from around 500-600 pairs to only 30 pairs. Recreational activities and human disturbance, as well as gull-tern spatial competition and predation, were identified as factors which had detrimental effect on terns. Then, several tern reserves have been created. Gull control operations were conducted mainly in the 1980s and the 1990s. Daily wardening was set up from May to August around the main colonies since 1989. In recent years, predation by American minks and predation and disturbance by peregrine falcons on the terns of Dames Island became new major threats for roseate terns. To secure the breeding colonies for terns, conservation measures necessarily include the control of predators like mink, rat and gull, scaring attempt of the peregrine and wardening during the breeding season. Essential funding was obtained from a specific European Life-Nature programme 'Conservation of the roseate tern in Brittany 2006-2010'. In 2006, the colony was deserted by roseate terns but they fortunately came back in 2007, and 63-69 breeding pairs were recorded in Brittany. Unfortunately, despite trapping pressure, two attacks of minks occurred in 2008, and 36 adults of roseate terns were killed among the 57 breeding pairs.



## **FACTORS CONTRIBUTING TO THE DECLINE IN POPULATIONS AND REPRODUCTIVE SUCCESS OF SEABIRDS ON RATHLIN ISLAND, COUNTY ANTRIM, NORTHERN IRELAND**

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In recent decades, seabird colonies across the Northeast Atlantic, including the UK, have shown dramatic declines in numbers and productivity. Seabirds are useful indicators and their decline may point to problems in the wider marine environment. At Rathlin Island, Northern Ireland, whole colony surveys indicate that numbers of seabirds decreased between 1999 and 2007. Three monitoring plots of breeding seabirds have also been monitored by the RSPB on Rathlin since 1979. Data from these show that despite recent declines, guillemot *Uria aalge* and razorbill *Alca torda* numbers are still within previously recorded ranges but kittiwake *Rissa tridactyla* numbers are lower than those recorded previously. Moreover, complete breeding failures have been noted in a number of years since 2005. A detailed study on breeding guillemots, razorbills and kittiwakes was initiated in 2008. Guillemot breeding success was high in 2008 but razorbill breeding success was low because of predation by gulls. Kittiwake breeding success was higher than in recent years but still very low, depredation and starvation being the main causes of breeding failure. Low food availability, high predation rates and low reproductive success may explain declines in seabirds.

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## **FROM CRADLE TO EARLY GRAVE: JUVENILE MORTALITY IN EUROPEAN SHAGS IS RELATED TO POOR FORAGING SKILLS**

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In most seabirds, the majority of individuals die as juveniles in their first winter. A likely cause is inability to find sufficient food but, until now, no data exist on individual development of foraging in juvenile seabirds from fledging until death. We used miniaturised activity loggers to record daily foraging times of juvenile European shags *Phalacrocorax aristotelis*. Shag parents stopped feeding their chicks about one month after they fledged. From independence, juveniles compensated for poorer foraging abilities than adults by increasing the amount of time spent foraging (by over three hours/day on average), until constrained by shortening day length in early winter. Thereafter, juvenile foraging time tracked shortening day length up to the winter solstice, when foraging time of adults and juveniles converged and continued to track day length until early February. Patterns of juvenile mortality accorded with their foraging performance. Few juveniles in the population as a whole died up to mid-winter, when mortality increased to a peak in January-February, with juvenile mortality rates five times that of adults. In their last two weeks of life, juveniles showed a marked decline in foraging time consistent with individuals becoming moribund. The limitation placed on juvenile foraging time by day length in winter, followed by the coincident decline in foraging time among study juveniles and substantial mortality in the juvenile population, provides the first compelling evidence in seabirds that foraging proficiency of juveniles is a key determinant of survival.

## **PROFILING THE GASTROINTESTINAL MICROFLORA OF LITTLE PENGUINS (*EUDYPTULA MINOR*)**

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The focus of this project is to use molecular techniques to profile the microbial populations of the different regions of the gastrointestinal tract of little penguins. Samples from the mucosal and epithelial layers were collected during post mortem examination of three little penguin carcasses from the Phillip Island Nature Park. Profiles of the different regions of the gastrointestinal tract are obtained by using the molecular technique known as Polymerase Chain Reaction Denaturing Gradient Gel Electrophoresis or PCR-DGGE. These profiles show how the microbial populations differ in the different regions of the gastrointestinal tract.

## **MAPPING ARCTIC TERN MIGRATION FROM GREENLAND TO ANTARCTICA AND BACK**

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The deployment of archival geo-locator loggers, which record ambient light level and thereby allow the later calculation of geographical position, has proved to be a powerful tool when mapping long-distance seabird migrations. In recent years the mass of these loggers has decreased considerably and a new array of small seabirds are now possible study species.

The Arctic Tern (*Sterna paradisaea*) is known as the champion of long-distance migration, breeding as far north as the Arctic and wintering in Antarctic waters. In 2007, we equipped 50 Arctic Terns breeding in high-arctic Northeast Greenland with 1.4g geo-locators and, in 2008, we retrieved ten of these loggers.

This talk presents the first results of Arctic Tern migration routes and wintering areas from this study and the very first glimpse of a full year in the life of an Arctic Tern.

## IMPACT OF WIND TURBINES ON TERNS IN ZEEBRUGGE, BELGIUM

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We studied the impact of a wind farm (line of 25 small to medium sized turbines) on birds at the eastern port breakwater in Zeebrugge, with special attention to the nearby breeding colony of Common Tern *Sterna hirundo*, Sandwich Tern *Sterna sandvicensis* and Little Tern *Sternula albifrons*. With the data of found collision fatalities, and correction factors for available search area, search efficiency and scavenging, we calculated that during the breeding seasons in 2004-2007, respectively 168, 161, 177 and 133 terns collided with the wind turbines. The mean number of terns killed in 2004-2007 was  $6.7 \pm 0.7$  per turbine per year for the whole wind farm, and  $11.2 \pm 1.0$  per turbine per year for the line of 14 turbines on the sea-directed breakwater close to the breeding colony. The mean number of collision fatalities when including other species (mainly gulls) in 2004-2007 was  $20.5 \pm 1.6$  per turbine per year for the whole wind farm and  $33.1 \pm 4.2$  per turbine per year for 14 turbines on the sea-directed breakwater. The collision probability for Common Terns crossing the line of wind turbines in 2004 and 2005 amounted 0.110-0.118% for flights at rotor height and 0.007-0.030% for all flights. For Sandwich Tern this probability was 0.046-0.088% for flights at rotor height and 0.005-0.006% for all flights (Everaert and Stienen, 2007). Between 2005 and 2007, in total 64 Common Tern fatalities were collected and sexed, of which 64% were males. Uneven sex ratio among these birds was most pronounced during the period of incubation and early chick feeding (15 May–15 June), when 78% of the 28 mortalities were male (Stienen *et al.*, 2008). The breeding terns were almost not disturbed by the wind turbines, but the relative large number of tern fatalities in 2004-2007 was determined as a significant negative impact on the breeding colony in Zeebrugge [maximum additional mortality of 0.7% (Sandwich Tern), 2.0% (Little Tern) and 3.7% (Common Tern)]. We recommend that there should be precautionary avoidance of constructing wind turbines close to important breeding colonies, nor should artificial breeding sites be constructed near wind turbines, especially not within the frequent foraging flight paths.

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## **NOCTURNAL AND DIURNAL FLIGHT INTENSITY AND ALTITUDE OF SEABIRDS AND MIGRANTS IN AND AROUND AN OFFSHORE WINDFARM IN THE DUTCH NORTH SEA**

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Offshore wind farms may have several effects on local seabirds and migrants. The nocturnal passage of migrating land birds over the North Sea is reported frequently but numbers and flight altitudes are generally unknown. In 2006 the Offshore Wind farm Egmond aan Zee (OWEZ) consisting of 36 turbines has been built off the Dutch coast. Within this framework a Monitoring and Evaluation Program was conducted to study, amongst others, flight paths as well as flight altitudes and flux of local and migrating seabirds as well as non-marine migrating birds. This study is the first to measure fluxes and flight altitudes at sea (20km offshore) for both day and night up to 1.5km altitude.

Bird movements in and around the wind farm were registered automatically using a vertical radar system (Merlin, developed and installed by DeTect. Inc. Florida). This set-up enabled measurements of Mean Traffic Rates (MTR's or Flux) and flight altitudes of passing birds continuously during both day and night. Data were collected from spring 2007 until December 2008. Prior to construction of the wind farm similar research was carried out and results are compared to flight patterns recorded in this baseline study.

At sea high numbers of flying birds were seen at all altitudes, from sea level up to 1.5km. Migration at high altitudes included waders and thrushes. Movements seen during day at lower altitudes primarily included gulls as well as Cormorants, Gannets, Guillemots, Razorbills and Common Scoter. Seasonal and diurnal variations were recorded in both flux and flight altitudes. The peak MTR was found early in the night during autumn migration with up to 3,410 bird groups per km per hour. These numbers are as high as numbers recorded on land. Compared to the baseline study fluxes were relatively low in general and especially during spring migration. In summer flight activity was low and mostly reflected gulls. High altitude passage was mainly found during autumn migration. Results will be discussed in the light of the collision risks for birds with wind turbines at sea.

This study was commissioned by 'NoordzeeWind' (a joint venture of Dutch utility Nuon and Shell Wind Energy).

## **THERMODYNAMIC MODELLING PREDICTS ENERGETIC BOTTLENECK FOR SEABIRDS WINTERING IN THE NORTHWEST ATLANTIC**

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Studying the energetics of marine top predators such as seabirds is essential to understand processes underlying adult winter survival and its impact on population dynamics. Winter survival is assumed to be the single most important life-history parameter in long-lived species, but its actual drivers are still mysterious. Seabirds being usually offshore during the winter period, conventional metabolic studies are extremely challenging and new approaches are needed. We updated and used a new spatially- and temporally-explicit model based on the first principles of thermodynamics, Niche Mapper™, to predict energy expenditure and food requirements of the two main seabird species wintering in the northwest Atlantic: little auks *Alle alle* and Brünnich's guillemots *Uria lomvia*. For both species, our model predicts a sharp increase in energy expenditure between November and December, primarily driven by climatic factors such as air temperature and wind speed. These findings strongly suggest the existence of an energetic bottleneck for north Atlantic seabirds towards the end of the year, a challenging energetic phase which might explain recurrent events of winter mass-mortality, so called 'seabird winter wrecks'. Our study therefore emphasizes the relevance of this generic thermodynamic model to investigate the energy balance of wintering marine top-predators and its interplay with survival and population dynamics in the context of global change.

## **SPATIAL DISTRIBUTION OF SEABIRDS IN SPRING IN THE MARGINAL ICE ZONE OFF WEST GREENLAND**

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During the Arctic spring, the marginal ice zone is a very dynamic environment, where primary productivity is high and conditions change rapidly. Factors affecting the spatial distribution of seabirds before the start of the breeding season, when they are not confined to areas around breeding colonies, are not well understood. During spring 2006, detailed aerial and ship-based surveys of seabird abundance and distribution were conducted in the Disko Bay and SE Baffin Bay area in West Greenland. Simultaneous oceanographic sampling was conducted from the survey vessel.

Here, we use recently developed enhancements of distance sampling techniques to investigate how the spatial distribution of four common seabird species (northern fulmar, black-legged kittiwake, Brünnich's guillemot, black guillemot) was affected by static (depth, distance to colony) and dynamic (ice concentration, primary productivity, zooplankton biomass) environmental factors. We did not find any of these species to be positively associated with high ice concentrations, and associations with biological variables were rather weak. Instead, depth and distance to colony seemed more important for the distribution of these species. We speculate that the snapshot environmental data obtained during the survey (ice concentration and biomass at the lowest trophic levels) do not provide reliable proxies of food availability for pelagic seabirds at the relevant spatial scale.

We also estimated the total abundance of seabirds in the study area, based on conventional distance sampling. The study area (88,000km<sup>2</sup>) was used by approximately 89,000 northern fulmars, 77,000 black-legged kittiwakes, 430,000 Brünnich's guillemots and 21,000 black guillemots in April-May 2006. Understanding what determines the spatial distribution of these large populations is obviously important for assessing the impacts of ongoing oil exploration and future exploitation in the study area and elsewhere in W Greenland.



## STATUS OF CLIFF-BREEDING SEABIRDS IN ICELAND IN 2005-2008

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A complete survey of Icelandic cliff-breeding seabirds was conducted in 2005-2008, repeating a survey from 1983-1986 (Gardarsson 1995, 1996). The first survey yielded estimates (thousands of pairs) for Kittiwake *Rissa tridactyla* (630), Common Murre *Uria aalge* (990), Thick-billed Murre *U. lomvia* (580) and Razorbill *Alca torda* (380), and a partial estimate for Fulmar *Fulmarus glacialis*. Most murrees bred at Látrabjarg and Hornstrandir, NW-Iceland, most Razorbills at Látrabjarg, most Kittiwakes on cliffs of the Northwest and Northeast. By 2005-2008, Razorbill and Kittiwake levels were 82-84% of what they were in the 1980s, Fulmar and Common Murre 70% and Thick-billed Murre 56%. Numerical trends among species were unsynchronised, with each species showing considerable spatial variation. Fulmars declined except in central N-Iceland. Kittiwakes decreased widely but maintained numbers at Hornstrandir and increased at several small northern sites and two major southern sites. Common Murres declined to 50% in the Southwest and 80% at Látrabjarg and Hornstrandir but changed little in the North and East. Thick-billed Murres maintained numbers only at Látrabjarg and at Drangey, N-Iceland. Razorbills generally declined, but increased substantially at Grimsey, N-Iceland. The marked spatial variability in population changes of each species calls for intensified monitoring, designed to cover both spatial and temporal variation.

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## **USING SPECIES-SPECIFIC FORAGING RANGES CAN DETERMINE HOW INTRINSIC AND EXTRINSIC FACTORS SHAPE COLONY DYNAMICS**

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Despite over forty years of research since David Lack first investigated factors regulating colonial nesting seabirds, the topic remains hotly debated. Lack originally proposed that seabird colonies were regulated in a density dependent fashion and recent evidence supports this view, indicating that seabird colonies may be regulated by intra- as well as inter-specific competition for food. Nevertheless, no study has integrated both intra- and inter-specific competition simultaneously and more importantly has not corrected for the availability of resources. Previous studies have grouped foraging ability across species and projected foraging ranges using generic radii. Instead we estimate species-specific foraging ranges, and integrate them with data on the position and size of colonies around the coasts of the United Kingdom and Ireland. We use the resulting models of potential foraging effort to measure intra- and inter-specific comparisons of colony position, colony size and foraging range overlap. These models allow us to determine the degree to which both intra- and inter-specific competition may influence colony size and also highlight areas of high foraging effort. The results will be compared with data on remotely sensed marine characteristics, such as sea surface temperature, chlorophyll-a distribution and fisheries pressure, to elucidate the drivers of cross-species colony dynamics. These findings have implications for understanding the demography and conservation of colonial nesting seabirds.

## **THE RELATIONSHIP BETWEEN DIETARY SPECIALISATION AND PRODUCTIVITY IN GREAT SKUAS, *STECORARIUS SKUA*, ON HANDA ISLAND**

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Our study examines the diet of the great skua (*Stecorarius skua*) on Handa Island, Scotland, to investigate a possible relationship between diet type and productivity. Analysis of pellets since 2004 has shown that some individuals within this population have specialised diets, and that breeding pairs use proportionately more fish prey than bird, compared with non-breeding pairs. Fledging success varies, with a mean of 35.5% from 2003 to 2006. In 2008 we examined individual differences in the diet between breeding pairs and how this might influence their reproductive success. 20 pairs were monitored during the breeding season from June to August. Pellets were collected weekly from all territories and chicks measured approximately every 5 days. Data were also collected on egg lay date, clutch size, egg volume, hatching success and fledging success. In the context of our results we discuss the importance of the great skua population on Handa, as well as their impact on the local seabird population and their use of fish and fish discards.

## **A JUNK-FOOD HYPOTHESIS FOR SEABIRDS FEEDING ON FISHERY WASTE**

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Worldwide fisheries generate large volumes of fishery waste and it is often assumed that this additional food is beneficial to populations of marine top-predators. We challenge this concept via a detailed study of foraging Cape gannets *Morus capensis* and of their feeding environment in the Benguela upwelling zone. The natural prey of Cape gannets (pelagic fishes) is depleted and birds now feed extensively on fishery wastes. These are beneficial to non-breeding birds, which show reduced feeding effort and high survival. By contrast, breeding gannets double their diving effort in an attempt to provision their chicks predominantly with high-quality, live pelagic fishes. Owing to a scarcity of this resource, they fail and most chicks die. Our study supports the junk-food hypothesis for Cape gannets since it shows that non-breeding birds can survive when complementing their diet with fishery wastes, but that they struggle to reproduce if live prey is scarce. This is due to the negative impact of low-quality fishery wastes on the growth patterns of gannet chicks. Marine management policies should not assume that fishery waste is generally beneficial to scavenging seabirds and that an abundance of this artificial resource will automatically inflate their populations.

## **DISTRIBUTION OF SEABIRDS IN THE GULF OF ST. LAWRENCE, CANADA**

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Our study aims to describe and analyse current distribution patterns in parts of the Gulf of St. Lawrence which represents a hotspot for seabirds and marine mammals. The Gulf exposes a unique hydrography combining features of both an estuary and a small ocean. Based on ship-based seabird surveys carried out during the breeding seasons of 2007 and 2008, we present first results on the distribution of various seabird species as well as first results of the analysis on the influence of potentially important factors such as hydrography, prey abundance, distance to land, associations with marine mammals and human activity. Moreover, for Northern Gannets (*Sula bassana*), the study site offers the unique possibility to combine distribution data based on ship-based surveys with those derived from breeding birds of Bonaventure Island that were equipped with data loggers.

## **SANDEEL AVAILABILITY AND ATLANTIC PUFFIN RECRUITMENT, MORTALITY, AND HARVEST IN THE WESTMAN ISLANDS**

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About 20% of the Atlantic puffin (*Fratercula arctica*) world's population breeds in Vestmannaeyjar, about 1,300,000 burrows. Annual puffin harvest during the last decades in Vestmannaeyjar has been around 100,000 birds. The puffin's breeding success has been poor since 2005, attributed to a great reduction in the lesser sandeel (*Ammodytes marinus*) population. A newly started cooperative research project on the puffin-sandeel population dynamics is presented. Contemporary events evaluated are: (1) sandeel's annual population size, age composition, and mapping of the habitat distribution. (2) Puffin recruitment in relation to feeding frequency, and mortality by color ringing. The central goal of the project is the evaluation of the reciprocal effects of the sandeel and puffin population dynamics through time and climate change. This necessarily includes the effect of hunting on the puffin population. Two long-term data series are currently being analyzed and some preliminary results and aspects of analysis are presented: (1) Itemized annual puffin harvest in Vestmannaeyjar 1944-2007. This series contains information on sandeel population change, puffin recruitment rate and hunting pressure. (2) National puffin ringing data 1953-2008, of >60,000 birds ringed and 12,000 recoveries providing yearly- and age specific mortality rates. These data are further supplemented by two shorter data series: (1) annual number and season of fledglings since 1971, and (2) chick body mass at fledging since 1996, among other data. Combined these data provide considerable insight into puffin and sandeel long term population dynamics in relation to environmental changes.

## THE ATLANTIC PUFFIN POPULATION SIZE OF THE WESTMAN ISLANDS, ICELAND

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An estimate of the Atlantic puffin (*Fratercula arctica*) breeding population in the Westman Islands archipelago (Hansen, 1995) is presented. The preliminary estimate is  $\approx 1,300,000$  burrows (N). The estimate is calculated as  $N = A \times C_A \times D$ , where A is the two-dimensional surface area ( $m^2$ ) of the puffin colonies,  $C_A$  is area correction factor due to slope and landscape, and D is burrow density ( $burrows^{-1}.m^2$ ). Colonies were readily identifiable from aerial photographs (taken at either 1220m or 1830m HOSL, occasionally 610m). After digitizing, A was estimated in the program Microstation™.  $C_A$  is calculated as the ratio of A (2D) to the 3D surface area. Both variables were estimated in the sub-colony Stórhöfði, Heimaey, utilizing the program ArcView™. D was estimated in 9175 $m^2$  within puffin colonies: 64 randomly located 25 $m^2$  squares (1600 $m^2$ ) and in 9 transects (7575 $m^2$ ). Pending final analysis includes randomization- stratification methodology to reduce the variance of the population estimate.

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## THE LEACH'S STORM-PETREL POPULATION SIZE OF THE WESTMAN ISLANDS, ICELAND

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The breeding distribution of Leach's storm-petrel (*Oceanodroma leucorhoa*) and Atlantic puffin (*Fratercula arctica*) were mapped in Elliðaey Island (63°28'N, 20°22'W) in 1991, the largest European breeding colony of both species. Furthermore the breeding density of both species was measured in two transects covering an area of 4600m<sup>2</sup>. All puffin burrows were counted and Leach's petrel breeding density measured using the playback method (James and Robertson, 1985; Taoka *et al.*, 1989ab; Ratcliffe *et al.*, 1998) playing locally recorded male chatter and purr calls between 23:00-04:00 hours. In 164 equidistant (400 m<sup>2</sup>) plots the species breeding distributions were highly associated ( $\chi^2=64,256$ , d.f.=1,  $P<0,0001$ ). Out of 35 Leach's storm-petrel burrows, 20 (57%) were dug from within puffin burrows, a previously unreported case of commensalistic breeding association. A strong correlation was found between the breeding densities of the species ( $r\approx 0,6$ ), pending a final analysis. Using information on puffin breeding areas in the archipelago (see the poster of Hansen and Gardarsson in this conference), and the density correlation, the Leach's storm-petrel breeding population is estimated.

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## **TREND, CURRENT STATUS AND ECOLOGY OF COMMON SCOTERS *MELANITTA NIGRA* IN THE VOORDELTA, THE NETHERLANDS**

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Common Scoters winter in shallow coastal waters in the Baltic Sea, the North Sea and the Atlantic. Along the Dutch coast one of the main winter aggregations of Common Scoters used to be found in the southwest, in the Voordelta. In the late seventies and early eighties maximum numbers regularly exceeded 20,000 birds (> today's 1% of the total population). Just over the Belgium border another 10,000 birds wintered and all these birds may be seen as the same local population. Since then the numbers declined dramatically and maximum numbers have rarely exceeded 10,000 birds in the Voordelta and Belgium. The trends in other main aggregation areas along the Dutch coast show a comparable pattern with peak numbers in the seventies-nineties and a decline thereafter. Changes in the distribution and numbers of Common Scoters in this part of the wintering range are presumably driven by changes in total population size, local food availability and local levels of disturbance (fishery and recreation). Very low total numbers of scoters were present along the Dutch and Belgium coasts, with numbers dropping below 40,000 birds (while before 2004 numbers peaked above 120,000). In the last century the occurrence of large concentrations of suitable bivalve prey species was crucial for the maintenance of high winter concentrations of Common Scoters, but since the decrease and almost complete disappearance of the Cut Trough Shell *Spisula subtruncata*, which was the most important food source in the eighties and nineties in the Netherlands, the Voordelta is nowadays predominantly used by Common Scoters as a stop over area during spring migration with maximum numbers in April. Recently there are indications that Common Scoters have switched to feeding on Atlantic Jackknife Clams *Ensis directus*. This clam first appeared in the area in the nineteen eighties but only after 2,000 it showed a strong increase in abundance and huge concentrations of Atlantic Jackknife Clam formed in the Voordelta. In terms of biomass, there is more than enough *Ensis*-food in the Voordelta, but the awkward shape and size of this prey species may prevent successful feeding by Scoters. Further research will reveal whether Common Scoters can adapt and regain their former numbers in the area.

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## **PIPEFISH RISE IN THE WEST: RECENT DRAMATIC INCREASE IN THE DIET OF THE ELEGANT TERN (*THALASSEUS ELEGANS*) NESTING IN SOUTHERN CALIFORNIA**

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Elegant Terns are ocean foragers that during the breeding season feed mainly on lipid-rich northern anchovy (*Engraulis mordax*) and Pacific sardine (*Sardinops sagax*) in the Gulf of California and in Pacific coastal waters adjacent to southern California. In the early years of our research on tern foraging ecology that began in 1993, pipefish of 1-4 species formed a minor part (<5%) of the fish prey delivered by Elegant Terns to their chicks at nesting sites in the Los Angeles and San Diego areas. Since 2004, that proportion has increased markedly, reaching 56% in 2007 and 65% in 2008 at the Bolsa Chica Ecological Reserve, the major nesting site for Elegant Terns in southern California. By contrast, the proportions of northern anchovy declined from 76% in 1993 to 13% in 2007 and 20% in 2008. The recent surge of pipefish in the Elegant Tern diet has been characterized by a short (2–3 wk) pulse of high occurrence early in the chick-rearing period followed by a sharp decrease in numbers. Whether the abundance of pipefish coincides with peak prey deliveries by Elegant Terns because of the temporal pattern of pipefish life history or of local oceanographic conditions remains unknown but is of intense interest to us. We plan to raise Elegant Tern chicks in the laboratory on different proportions of anchovy and pipefish during the 2009 nesting season to help determine the potential impact of the apparently low-quality pipefish prey on energy allocation and postnatal growth in the chicks.

## **PRELIMINARY RESULTS OF MONITORING THE BREEDING PERFORMANCE OF THE CORY'S SHEARWATER ON STROFADES ISLANDS (IONIAN SEA, WESTERN GREECE)**

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A seabird survey was initiated in 2007 in the National Marine Park of Zakynthos in the Ionian Sea (western Greece). The study is part of a broader conservation project on the seabird populations of Greece aiming to assess their status, evaluate their breeding performance and investigate their foraging ecology. Here we report preliminary data on the population of the Cory's shearwater (*Calonectris diomedea diomedea*), in the Strofades island complex, which constitutes the most significant seabird species in this National Marine Park area. This long-lived and highly site-faithful species holds a substantial colony on Strofades islands, numbering 2,000-3,000 breeding pairs. In a sample of 103 nest sites that were being monitored during the last two breeding seasons (2007-2008), a hatching and fledging success of 83.5% and 84.9%, respectively, were found. Overall breeding success was 0.7 chicks per nesting pair per year, with most nest failures occurring during the incubation stage. Meanwhile 30% of hatchling losses were attributed to rat predation. Future research will focus on the assessment of the exact population size of the colony and its foraging activity in space and time.

## **NIGHT AND DAY – CONTRASTING FORAGING STRATEGIES OF BLACK-LEGGED KITTIWAKES BETWEEN PRE-BREEDING AND BREEDING STAGE**

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Black-legged Kittiwakes (*Rissa tridactyla*) are widely distributed in the northern hemisphere and the most abundant gull species in the world. They are already well studied in many respects, but more detailed knowledge about their foraging strategies and feeding areas is still needed.

During pre-breeding (April) and breeding (May-August) in 2008 we deployed miniaturised GPS-dataloggers to adult Black-legged Kittiwakes on Middleton Island in the Gulf of Alaska to investigate their foraging behaviour. In early pre-breeding stage (April), when returning from their wintering areas in central Pacific, kittiwakes perform almost exclusively nocturnal foraging flights (95%) in nearly always south-easterly direction of their colony to pelagic deep sea waters. Later during the breeding season they forage only over continental shelf areas not deeper than 200m, mainly during daytime. Nocturnal flights occur only in 24% of the trips. Nocturnal foraging trips during pre-breeding stage last longer than during breeding stage ( $p < 0.05$ ) and all overnight trips last significantly longer than foraging trips during daytime ( $p < 0.001$ ). Foraging trip duration was significantly longer ( $p < 0.001$ ) during the pre-breeding season (mean: 10.7h, range: 5.7-13.7h) than during the breeding season (mean: 4.5h, range: 1.4-15.7h) and kittiwakes travelled significantly farther from their colony site ( $p < 0.05$ ) in April (mean: 55km, range: 4-159km) than later from May-August (mean: 30km, range: 1.8-110km). There was no difference in total distance travelled per foraging trip in both breeding stages.

These different foraging strategies are also reflected in prey types found in pellets during both stages, which were sampled in previous years. The results show a high proportion of lanternfish (Myctophidae) or capelin and sand lance during the pre-breeding season and breeding season, respectively.

Our results show that Black-legged Kittiwakes perform very different foraging strategies during the different breeding stages. They alter their foraging behaviour with changing prey availability, preying on fish species which are probably easier available.

## **FLIGHT PATHS OF SEABIRDS AND MIGRATING BIRDS IN AND AROUND AN OFFSHORE WIND FARM IN THE DUTCH NORTH SEA**

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This study concerns ecological effects of an offshore wind farm on flying birds in the Dutch North Sea. It shows data on flight paths of birds in relation to this wind farm. Both visual and radar observations were carried out to provide information on the occurrence of birds in and around the wind farm, as well as on the deflection of flight paths.

Within the wind farm, visual observations were carried out one day per month, from spring 2007 until December 2008. These data provide information at species level. To observe flight paths during night time, and in order to collect data on flight paths continuously, irrespective of weather, an automated radar system was used (Merlin, provided and installed by DeTect Inc, Florida). Data thus collected provide information on birds in general in the area.

Flight paths of many different species were registered. Interspecific variation in reactions was considerable. However, intraspecific variation was low. Different groups or individuals of one species very much showed the same response to the wind farm. Reactions of the birds to the wind farm can be separated in four categories. Local birds either avoided the wind farm (e.g. Gannets) or did not avoid the wind farm (e.g. Cormorants that were attracted to the wind farm from the main land). Similarly, migrant birds either did (e.g. geese) or did not avoid the wind farm (e.g. terns, nocturnal thrushes). For each category, we will present and discuss examples of these flight paths.

Furthermore, we show results on flight paths that were recorded using radar. These flight paths were analysed to differentiate between flight directions within the wind farm, on the edges of the wind farm and further away from the wind farm. This provides information on the occurrence of deflection.

This study was commissioned by 'NoordzeeWind' (a joint venture of Dutch utility Nuon and Shell Wind Energy).

## HOW CLIMATE CHANGES AFFECT JUVENILE SURVIVAL AND RECRUITMENT IN THE KING PENGUIN

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Seabirds are sensitive indicators of the condition of marine ecosystems and, as such, might integrate and/or amplify the effects of climate forcing on lower levels in food chains. Furthermore, juvenile survival and recruitment are important determinants of fitness and population growth rates, but few studies have examined the effect of environmental stochasticity on these life history traits. In this present study, we investigate the post-fledging local survival and recapture probabilities, and the age-specific breeding proportions on recruitment in relation with environmental variability in the King penguin *Aptenodytes patagonicus* using capture-mark-recapture analysis and a long-term monitoring of seven cohorts of one-year-old individuals (electronically marking between 1998 and 2004). First results show that local survival from fledging to the following summer is lower than following survival probabilities. We suggest that lower quality individuals may disappear from cohorts during this first stressful event (*i.e.* the selection hypothesis), thus average survival increases the following years, *i.e.* with age. This might also be explained by an increase in *e.g.* foraging performance of all individuals as they gain experience over their early life (*i.e.* the constraint hypothesis). Moreover, post-fledging local survival probability after the first winter at sea differs among cohorts. The high variability might be attributed to the variation in environmental conditions that each cohort experienced during their first winter at sea, and/or during their first year of rearing on land. Individuals born during a year of harsh conditions (which impact on food availability) may have a low phenotypic quality, and consequently survive less well. Thus, the recruitment modelling will now allow us to assess the influence of environmental conditions (using several local and global environmental indices) encountered during early life (conditions at birth and growth, and/or during first foraging experience at sea), and at breeding on juvenile survival and probability of starting to breed at a given age.

## **IMPROVEMENT OF CHICK PROVISIONING WITH PARENTAL EXPERIENCE IN A SEABIRD**

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Age-related differences in the reproductive success of birds may be the result of experience-dependent changes in foraging and further parental skills. We tested this hypothesis in a long-lived seabird – the common tern *Sterna hirundo*. Transponder-marked birds were observed while feeding their young (1) as first-time-breeders (recruits) and (2) as experienced breeders in two consecutive years in a breeding colony at Port Wilhelmshaven, Lower Saxony, Germany. The influence of individual breeding experience on feeding rate, feeding success and food composition was investigated under consideration of potential year effects, using multivariate statistics. In addition, we compared the breeding success of experienced and inexperienced breeders. Feeding rate was not linked with experience, whereas experienced breeders had a higher feeding success than recruits. Both experienced breeders and recruits fed their young with the same prey species, but in recruits, the proportion of prey items with low energy content was higher. The latter was linked with a lower breeding success of recruits. Our study is, to our knowledge, the first one documenting an individual improvement of skills as reason for age-dependent improvement of reproductive success in birds after recruitment.

Keywords: Age differences; Chick growth; Diet spectrum; Experience; Feeding behaviour; Feeding efficiency; Recruits; *Sterna hirundo*.



## **WITHIN-SEASON DIVORCE IN COMMON TERNS – INDUCED BY PREDATOR DISTURBANCE?**

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In most seabird species divorce and mate change between breeding seasons occurs more or less frequently, but within-season mate change is rarely observed (Johnston and Ryder, 1987). In the Laridae, it was previously described just two times for probably widowed birds (Massey and Fancher, 1989; Ludwigs, 2005). Here, we report four cases of within-season mate change, following divorce in at least two cases, in renesting common terns *Sterna hirundo* during a year of heavy predation (2005) by a long-eared owl *Asio otus*. However, no intra-seasonal divorce was observed in two previous years with high predation pressure but much lower breeding density (1993 and 1998). Besides the obvious direct impact, nocturnal predators have also severe indirect effects, causing the death of young chicks by adults abandoning the colony at night-time (exposure to cold and wet weather) and lower hatching success by adults deserting their clutches (Wendeln and Becker, 1999). Accordingly, we found more deserted clutches, lower hatching success as well as more disappeared chicks in the affected year compared to other years. Predation also affected within-season nest-site fidelity: in years with high predation pressure 31.9% of renesting birds changed the subcolony for their replacement clutch, whereas in other years without predation it was only 12.3%.

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## **CLOSE VICINITY OF FORAGING AREAS AND BREEDING SITES MAY EXPLAIN POSITIVE POPULATION TRENDS OF ENDANGERED BANK CORMORANTS AT MERCURY ISLAND, NAMIBIA**

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The Bank Cormorant (*Phalacrocorax neglectus*), endemic to the Benguela Region, is declining throughout its range. In Namibia the population crashed between 1993 and 1998 and has not recovered.

Mercury Island is the only breeding site where the local breeding population has recovered from the crash. It represents today more than 80% of the Namibian subpopulation and more than 70% of the world's population, making Mercury Island the largest breeding site for this endangered species.

We studied the foraging behaviour of breeding Bank Cormorants from Mercury Island during the breeding season 2007-08 using data logger technology. Foraging areas were identified through MiniGPS devices attached to birds recording their locations at sea. Dive depth recorders allowed a detailed analysis of diving behaviour during foraging. Additionally, we investigated the diet of breeding Bank Cormorants from pellet analysis.

Areas frequently used for foraging by breeding cormorants were located within close vicinity to the island (maximum distance 5km). During the study period, all birds used almost identical areas, showing strong preferences for an area southwest of the island. Birds were mostly feeding at the sea bottom, diving to an average depth of 25m. The diet of Bank Cormorants at Mercury Island consisted almost entirely of Pelagic Goby (*Sufflogobius bibarbatus*). Size distribution of otoliths in the pellets confirm bottom diving by cormorants because demersal adult gobies are the main prey taken.

Increasing numbers of breeding pairs and good breeding success of Bank Cormorants at Mercury Island seem to be due, in part, to good prey availability in the vicinity of the island. Incorporating the identified feeding grounds into the Marine Protected Area (MPA) planned along the southern Namibian coast would be vital to ensure the future of this endangered species.

## **PELAGIC GOBY, THE MAIN PREY FOR SEABIRDS IN THE NORTHERN BENGUELA: WHAT WE LEARN ABOUT FISH AND THEIR ROLE IN THE ECOSYSTEM FROM SEABIRD DIET**

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The northern Benguela ecosystem is currently undergoing a regime shift due to a combination of overfishing and unfavourable environmental conditions. Changes in the food web show strong effects on top predators in the system; several seabird species show large population declines and are nowadays listed as 'Endangered'.

Their diet composition used to consist of mainly small pelagic fish species, such as anchovy and sardine which are nowadays almost absent from the system. Seabirds have to rely on other prey organisms and one of their main prey items is Pelagic Goby (*Sufflogobius bibarbatus*).

Limited information about the biology of this fish species exists because it is not commercially used and little studied so far. A combination of diet sampling and data logger work at several breeding sites along the Namibian coast is used in order to amplify this knowledge.

We demonstrate how seabird diet analyses can provide valuable information on spatial distribution and age class distribution of this species. Data logger work on the diving behaviour of penguins and cormorants feeding almost exclusively on Pelagic Goby provides information on vertical movements and age distributions of goby within the water column.

This information will lead to an improved understanding of the nature and scale of food web changes in the northern Benguela ecosystem and will be crucial for the evaluation of their effects on seabird populations.

## **MODELLING SEABIRD DISTRIBUTION PATTERNS IN THE SOUTH-EASTERN NORTH SEA USING HYDROGRAPHIC DATA**

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We analysed the influence of hydrographic parameters on seabird distribution in the south-eastern North Sea based on data of research cruises which combined hydrographic measurements with simultaneous seabird counts. We applied Generalized Additive Models to the data of one extensive research cruise to identify hydrographic parameters which had a significant influence on seabird distribution patterns. According to the models, the distribution of Northern Fulmar, Common Gull, Common Guillemot and Black-legged Kittiwake could be well explained by the selected hydrographic factors. Most important was the factor Secchi depth which indicates water transparency. We modelled seabird distribution patterns using the respective hydrographic parameters which had a significant influence on the distribution of the single species. We then compared modelled distribution patterns with the distribution patterns actually observed. In a next step, we predicted seabird distribution patterns for a second research cruise carried out at a similar time of year based on the model developed for the first research cruise and again compared modelled distribution patterns with the patterns actually observed.

## **WORKING HARD, GAINING LESS – THE BREEDING SEASON 2008 OF KITTIWAKES AT HELGOLAND, SOUTH-EASTERN NORTH SEA**

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Since 1990 the large colonies of the Black-legged Kittiwake *Rissa tridactyla* in the northern North Sea experienced substantial declines in breeding numbers of more than 50%. In contrast, the breeding numbers of kittiwakes at Helgoland in the south-eastern North Sea doubled during the same period and lately maintained relatively stable numbers of approximately 7,000 breeding pairs. A comprehensive evaluation of the situation of the kittiwake breeding colony at Helgoland however requires up-to-date information on breeding success. In June/July 2008, we carried out observations on different breeding parameters of kittiwakes in the breeding colony at Helgoland that enabled conclusions on breeding success. We observed low values of nest attendance and high foraging efforts of parents, low feeding frequencies and exceptionally low numbers of chicks. Diet analyses remarkably revealed the presence of terrestrial prey species and a higher percentage of marine invertebrates compared to results of previous diet studies at Helgoland. These results indicated unfavourable foraging conditions and a thus induced low breeding success of kittiwakes at Helgoland during 2008.

## **ROYAL PENGUIN PHENOLOGY: CHANGES IN THE TIMING OF EGG-LAYING OF A SUB-ANTARCTIC PREDATOR IN RESPONSE TO A CHANGING MARINE ENVIRONMENT**

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The earth's biota is experiencing fast and dramatic changes due to a rapidly changing climate. Early indications of climate induced changes in a system include changes in phenology; the sequence and timing of key events in a species annual cycle. There is convincing evidence from phenological changes of many bird species that there has been a general advancement of key events, such as the timing of egg-laying. However, interpreting these phenological shifts is not straightforward because they represent a paradox: changes in phenology can be seen as either positive where species are adapting to changing climatic conditions or negative where the changes negatively affect the biota.

Seabirds are especially sensitive indicators of changes in marine ecosystems because they integrate and/or amplify the effects of climate forcing on lower levels in food chains. Royal penguins are particularly well suited to such an investigation because they: are abundant, are a dominant consumer of Southern Ocean resources and they display highly synchronous breeding time tables. We studied laying dates of royal penguins in the 1960s and again in the 1990s to determine whether any such changes had occurred in the sub-Antarctic.

On average, 75 nests were monitored each year during the 6 years of the study in the 1960s, compared to 50 during the 1990s. The median laying dates in the 1960s ranged from 21 October to 25 October (overall median = 23 October), while those from the 1990s ranged from 19 October to 22 October (overall median = 20 October). This represents a three-day decrease in laying date over the 34 years of the study of 3.5 days ( $t_{7,8}=7.85$ ,  $p < 0.001$ ). The rate of change over the 34 years of the study was  $-0.108$  days.year<sup>-1</sup>. We found that median laying data was influenced by the Southern Oscillation Index (SOI) and thus providing evidence of the mechanism driving the change in laying date. There was positive relationship between SOI and median laying date. Laying date is later in years of high SOI which equates to lower productivity and this is in accordance with observations from the Antarctic continent where later laying dates were associated with lower sea ice, *i.e.* less food.

In order to assess the biological consequences of climate change it is not enough to only demonstrate phenological changes because disparate patterns can arise from the same proximate cause. Importantly, to predict the effects that a changing climate may have on the breeding time tables of animals requires not only a quantification of the links between the phenology shift and the magnitude of the climatic change but also an examination of the mechanisms driving the changes as shown above.

## **SMALL BIRDS IN A LARGE OCEAN: HOW TO STUDY THE DIETS OF DIFFERENT STORM PETRELS?**

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Understanding animals' foraging ecology is essential for the conservation of most species. With seabirds it is difficult to carry out dietary studies and these tend to be scarce. This is even harder if the study species is highly pelagic and very small, such as storm petrels. Thus, there is no standard satisfactory method to study their diet.

Molecular techniques have been recently developed to study the diet of predators by detecting prey DNA in their guts, regurgitations or faeces. These molecular techniques have not been extensively explored but are a very promising tool to improve the study of many trophic links, including in the marine habitats and the seabirds that dwell in them. The aim of this study is to develop a new method to study the diet of different species of storm petrels, contributing to two ongoing ecological case-studies of these species. Here we present the first results on the diet of storm petrels using a molecular technique based on the detection of prey DNA in the birds' faeces. In the long term we aim to contribute to the development of a feasible and reliable method to study the diet of breeding and non-breeding storm petrels, which will noticeably benefit the awareness on the future and conservation of these remarkable birds and will promote the applicability of similar techniques to other seabird species.

## ASSESSING THE STATE OF SEABIRD COMMUNITIES IN THE NE ATLANTIC

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Europe has a huge resource of marine ecosystems – while its land area covers 10 million km<sup>2</sup>, its seas cover almost five times as much. Europe's seas support 62 bird species (c. 12% of all Europe's birds), seven of these are on global IUCN Red List (c. 16% of all European GTBs) and 45% of the 62 have an Unfavourable Conservation Status (UCS) in Europe. While many European countries already monitor seabirds, there is as yet no initiative to bring together data from these countries and report on trends and other significant information at a pan-European level. We will present the results of a survey of the temporal and spatial extent of seabird monitoring in Europe, what information exists and how representative it is. We explore the feasibility of collating international seabird data from across Europe to help conserve and protect seabirds and marine biodiversity.

In 2008, seabird count data were collated from countries bordering the NE Atlantic to construct an indicator that will help marine managers to monitor the state of seabird communities and then act in response to any substantial changes. ICES<sup>1</sup> have recommended the indicator is adopted by the OSPAR Commission<sup>2</sup> as one of their Ecological Quality Objectives or EcoQOs. There are currently 11 EcoQOs in place that set targets for the state of elements within the marine ecosystem (e.g. fish, seals, seabirds). They aim to inform the management of human activities so that the marine ecosystem will continue to sustain the legitimate use of the sea.

The proposed EcoQO on seabird population trends as an index of seabird community health is as follows: *Changes in breeding seabird abundance should be within target levels for 75% of species monitored in any of the OSPAR regions or their sub-divisions.* Each year, an assessment will be made to determine if the EcoQO has been achieved; if it has not, appropriate action (*i.e.* further research or management) will be triggered.

We will describe the development of the proposed EcoQO and suggest it as a possible model for international seabird indicators elsewhere in Europe.

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<sup>1</sup> International Council for the Exploration of the Sea

<sup>2</sup> Responsible for upholding the OSPAR Convention for the Protection of the Marine Environment of the North-East Atlantic.



## **USE OF RINGING DATA TO UNRAVEL DEMOGRAPHIC STRATEGIES IN TROPICAL VS. TEMPERATE ROSEATE TERNS**

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Comparative studies of demographic parameters among seabird taxa have placed species on a slow-fast gradient expressing the trade-offs between fecundity (offspring productivity) and survival, where species with low fecundity but high rates of survival are considered 'slow'. Thus, life history theory predicts that the lower fecundity of tropical species – when compared to temperate ones – should be counterbalanced by relatively higher survival rates. This hypothesis, related to the lower productivity of tropical waters, has been rarely addressed between temperate and tropical populations of the same species. The roseate tern breeds both under temperate (e.g. Europe, North America) and tropical (e.g. Caribbean, Seychelles) systems, and thus offers the opportunity to test this prediction, although until recently there was a paucity of demographic information from tropical populations. In this communication, the results of a demographic study conducted between 1998-2007 on the tropical roseate tern population breeding on Aride Island (Seychelles) are presented. In particular, we estimated both reproductive parameters (including offspring productivity) and age-specific survival rates (from juveniles to adults). These estimates are further compared to published estimates available for temperate colonies, and discussed in relation to life history trade-offs between temperate vs. tropical roseate tern populations.

## **FORAGING ALONG A MARINE PRODUCTIVITY GRADIENT: THE PLASTICITY OF A PELAGIC SEABIRD SPECIES, THE CORY'S SHEARWATER**

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Foraging behaviour is largely constrained by the distribution, abundance, mobility and predictability of food resources and many animals show a certain degree of plasticity, *i.e.* a variation in behaviour in response to varying environments. We compared the behavioural foraging plasticity of a pelagic seabird species, Cory's Shearwater (*Calonectris diomedea*), during incubation and chick-rearing among seven different breeding areas of the North Atlantic (in the Azores, Madeira, Selvagens and Berlengas archipelagos) with contrasting ecological conditions, by deploying two types of data-loggers; the compass-Temperature log (from the family of the dead-reckoning devices) and Preci-Temperature Depth devices. Our measures (currencies) of foraging distribution and effort comprised: (1) diving rate, (2) midnight SST, (3) % of time travelling, (4) trip duration, (5) latitude of foraging areas, (6) longitude of foraging areas, (7) Dive depth, (8) dive duration and, (9) numbers of U-shape and V-shape dives/trip. Using these variables a principal component analysis separated the populations into two main groups, one with the Berlengas' population (foraging in the continental shelf) and the other, with populations from Azores, Madeira and Selvagens (foraging in pelagic oceanic areas). Trip duration and % of time travelling showed strong differences between study areas, presenting a clear dual foraging strategy for the species. Birds from Selvagens travelled longer distances for a longer time (82% of the trips were long trips (> 5 days of duration), whereas birds from Berlengas used mainly short trips (97%; < 4 days of duration) to forage along the Portuguese continental coast close to the colony. There was a positively significant correlation between the percentage of short foraging trips that birds performed in the different study areas and the concentration of chlorophyll-a in the waters surrounding the breeding places ( $r_s = 0.65$ ,  $P = 0.05$ ,  $N = 10$ ). Birds exploiting marine areas along the continental shelf used shallow depths and shorter dives (for both V and U-shape types) than birds feeding in oceanic waters. This meaning that birds adapted their modes of predation in order to cope with the diverse distribution of their prey items. The behavioural responses of birds was mainly dictated by the heterogeneity of their habitat that in time was driven by two productivity gradients present upon the north Atlantic. Firstly, productivity should increase from the subtropical warmer waters present close to Selvagens to northern colder waters on the north of the Azorean archipelago. Secondly, oceanic environments should be less profitable than coastal environments (upwelling areas), such as the Portuguese and African coastal environments.

## HOW CORY'S SHEARWATERS AREA RESTRICTED SEARCH CHANGES ACROSS A MARINE PRODUCTIVITY GRADIENT

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Foraging movements for central-place foragers such as Cory's shearwaters *Calonectris diomedea* during the breeding period may be divided into two different strategies: commuting and looping. A seabird commutes when he leaves the colony following a specific flight direction until it reaches a particular area of interest, decreasing its velocity and increasing its turning rate (using previous knowledge about the productivity of that area). Looping motion occurs when a bird forages not targeting a particular patch, behaving like it was searching for food on unknown areas. Moreover, Cory's shearwaters exhibited a dual foraging strategy, altering between short trips (ST, less than four days) and long trips (LT, more than five days). We tracked 54 birds, performing 78 foraging trips, in three different breeding areas of the North Atlantic, with contrasting ecological conditions: Corvo (Azores), Selvagens (Madeira) and Berlengas (Portuguese continental shelf). We used miniaturized and accurate GPS-loggers to understand the foraging strategy of different populations of Cory's shearwaters in terms of temporal and spatial dynamics of its foraging areas. We used First Passage Time analysis to obtain Areas of Restricted Search (ARS), and related those areas with remotely-sensed data on sea-surface temperature (SST), bathymetry and chlorophyll-*a* concentration (CHL-*a*). Almost all birds (95%) exhibited ARS behaviour. During LT, populations from Corvo and Selvagens used a search effort at mean values of  $97 \pm 6.5$  km and  $77 \pm 5.1$  km and another nested ARSs at  $28 \pm 3.2$  km and  $15 \pm 1.2$  km, respectively for Corvo and Selvagens. During ST, search effort of the three different populations was single scaled at  $8 \pm 0.9$  km;  $11 \pm 2.2$  km; and  $15 \pm 3.2$  km, respectively for Berlengas, Corvo and Selvagens. For birds breeding and foraging in a typical oceanic environment (Corvo), ARS plots were mostly associated with: seamounts (LT), a frontal area northwards Azores (LT), and bathymetry (ST). For adults breeding in the continental shelf (Berlengas) areas of restricted searches overlapped with both cold and shallow waters, and with high chlorophyll concentration (only ST performed). Lastly, Selvagens birds (an oceanic habitat with close access to NW African coast), presented ARS related with shallow waters and high chlorophyll concentration (for LT) and shallow waters (for ST). Our results demonstrate that Cory's shearwaters do have a scale dependent foraging behaviour when performing short and long trips, reflecting the hierarchical spatial distribution of different physical and biological variables, and most likely representing the spatial arrangement and Ideal Free Distribution of their prey.

## **FLIGHT DYNAMICS OF A PELAGIC SEABIRD FORAGING IN A COASTAL ENVIRONMENT: THE CORY'S SHEARWATER CASE**

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Inspecting how differently seabird species adapt their flight patterns in order to cope with the heterogeneity of their habitats and, determining whether birds planned to use the wind field or simply experience it, are two of the major topics influencing flight dynamic theories. Here, we present for the first time the three-dimensional flight dynamics of Cory's shearwaters *Calonectris diomedea* foraging in the upwelling region of the continental Portuguese coast. We reconstructed the two-dimensional movement of the birds with the deployment of recently miniaturized devices for telemetry; the global positioning systems loggers (GPS-loggers) that also store altitudinal movement of the birds. Cory's shearwater benefited from using the wind field in this continental shelf habitat. Prevalent winds were blowing from north-east and adults used those winds by adjusting their flight directions mainly towards north-west and south-west, meaning flying with cross (28.5%) and tail winds (31.4%), respectively, and avoiding head winds (7.9%;  $\chi^2_4 = 10.4$ ,  $P = 0.02$ ). During travelling phases flight speed was strongly influenced by the position of the bird with regard to the wind direction, as flight speed increased significantly with increasing Tail Wind Component values ( $TWC = 3.98X + 34.53$ ,  $r^2 = 0.29$ ,  $N = 27$ ,  $P = 0.04$ ). Cory's shearwater may also invest on shear soaring flying while exploiting the environment for food. Birds foraged mainly with side winds and ground speed used to forage was not constant during the foraging trip, it changed dynamically with altitude as a result of the ocean surface shear winds. Tail winds seemed to be more used for travelling speedy movements as they were concentrated at the beginning and at the end of the day. Cory's Shearwater concentrated their flying periods during the morning and afternoon, and the period around noon was used to rest on the sea-surface. Timing of higher flight velocity peaked in the morning and in the evening. At a larger scale the general heading taken from the colony seemed to be influenced by wind, but also by previous knowledge of productive zones (commuting behaviour). With such strategy, Cory's shearwaters presumably return to a (memorized) particular place in order to search and consume food, thereby spending less time in obtaining meals for themselves or their offspring.

## **THE HISTORY OF THE SEABIRD GROUP**

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The Seabird Group was founded in the UK in 1965 with the aim of increasing the communication between ornithologists interested in seabirds. The history of its progress and development since that date is reviewed.

Another of the aims was to produce a base-line for the seabirds by making a census of all the breeding sites in Britain and Ireland. This massive task was successfully completed and the results reported in a book published in 1974. Since then there have been two subsequent books reporting on the changes in numbers since that date. Methods of counting have become more sophisticated also and there are now more complex protocols for each species.

Seabird workers suffer from a disadvantage compared with most students of other birds. We see only what the birds are doing when they are at their nest and not when they are away from the colony. This means that we still do not know accurately where the birds from many colonies feed during the breeding season or spend the winter and our understanding of their feeding ecology is still poor. It also emphasises the international aspects of these birds. With this in mind suggestions are made for the ways forward for Seabird Groups in the future.

## **ARE NORWEGIAN GANNET POPULATIONS CONSTRAINED BY THEIR FORAGING ENVIRONMENT?**

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Environmental determinants of seabird population dynamics are complex, and even apparently healthy meta-populations such as that of the Northern Gannet, *Morus bassanus* show contrasting trends on a regional scale. This is the case for gannet colonies in the Barents and the Norwegian Seas, some of which show a rapid decline, while others are growing steadily.

We tested the hypothesis that current population trends are conditioned by food availability using foraging trip duration as a proxy of foraging effort (because of its significant relationship with foraging range in gannets). We compared the foraging effort of birds from the different colonies, contrasting them with similar data available for more dynamic colonies in France and the British Isles.

Results strongly suggest that gannets from Norwegian breeding sites benefit from good feeding conditions, and that other factors such as Sea Eagle *Haliaeetus albicilla* harassment and/or human disturbance are likely drivers of current gannet population trends along the Norwegian coast.

## **THE SHALLOW COASTAL ZONE IN THE SW-NETHERLANDS AS A CONCENTRATION AREA FOR RED-THROATED DIVERS *GAVIA STELLATA* – VARIATION IN OCCURRENCE IN RELATION TO WIND AND TIDE**

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The shallow coastal zone 'de Voordelta' in the SW-Netherlands is known for the occurrence of relatively large concentrations of Red-throated Divers. The area is intensively managed because of dikes and sluices for coastal defence. Soon after completion of the main dikes in around 1970, one of the bays (seaward of the Brouwersdam) that was formed in the process held relatively large concentrations of Red-throated Divers. These birds occur close to the coast and are readily observed from the dike. The bay is shallow, with some old natural gullies. It is partly protected from the sea by an emerged sand flat of several kilometres long at the seaward side. Since the early nineties long-term monitoring data have been gathered for this subregion. Peak numbers during all years (1991-2005) occurred in the second half of the winter and spring migration period (numbers in February-April on average 3-4 times higher than in the period November-January). In 2004/2005 and 2005/2006 data on diver numbers and distribution were collected for a larger area, including the nearshore and offshore areas from the dikes up to 10km offshore. Furthermore, detailed observations on behaviour and flights were made from the coast. Maximum numbers in the total area were between 1,100 and 1,500 birds. In the offshore area of the Voordelta the largest numbers were present in the first part of the winter (November-January). This might be related to the abundance of potential prey like small pelagic fish, although the information on diet choice of Red-throated Divers occurring in this region is still limited. In the coastal shallow areas the majority of the birds seem to be related to the gullies, so with the deeper waters, where they tend to occur later in the season, possibly because fishes move inshore for spawning. Indications were also found that turbidity and/or strong tidal currents during low tide played a role in the distribution pattern in the offshore area. During the aerial surveys which were mainly carried out during low tide, several times almost complete absences of birds were found in some of the offshore areas. During ship-based counts, carried out during different tidal phases, this was not the case. During low tide large fields of high turbidity occurs in these areas due to the erosion of the sand flats. At the same time, due to the tide, the areas become relatively shallow and the speed of the water current is high here, which also makes these areas unsuitable for efficient foraging. In addition to the tides, wind plays a role in the occurrence of Red-throated Divers. During situations with winds blowing from

land, the highest numbers were found in the sheltered shallow coastal areas. The lack of tailwind in this situation might stimulate migrant birds to stop over in the area.

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## **POPULATION ECOLOGY OF ROSEATE TERNS *STERNA DOUGALLII* IN NW EUROPE**

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Numbers of breeding Roseate Terns in NW Europe declined precipitously during the 1970s and staged a partial recovery since the early 1990s, but the reasons for this are poorly understood. We analysed capture-mark-resighting data from three main colonies (that host over 85% of the total breeding pairs in the metapopulation) to estimate age-specific survival, return and movement rates from 1989 to 2007 using multi-state models. We use these estimates, in conjunction with productivity estimates, to parameterise a retrospective population model that assesses the changes in demography that would be required to cause the observed population trends. Scenarios are based on observed changes in loss of a key breeding island and variation in effort-corrected sardine landings in the Ghanaian wintering grounds. We discuss the implications of our findings for future management of breeding habitat and Ghanaian fish stocks.

## **DO PROLACTIN AND CORTICOSTERONE PLASMA LEVELS OF BREEDING COMMON TERNS INFLUENCE THEIR HATCHING SUCCESS?**

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Egg loss due to predation or nest desertion is a main factor of breeding success in seabirds. Therefore a constant incubation and protection of the clutch seems to be necessary. Incubation behaviour is controlled by hormones, especially by prolactin and corticosterone and interspecific differences in these hormones and in reproductive performance are known. We studied whether baseline plasma levels of prolactin and corticosterone in breeding Common Terns (*Sterna hirundo*) are related to their hatching success. Therefore we took blood samples in the midst of individual incubation of 238 Common Terns in 2007 and related the hormone concentrations to their age and hatching success. The samples were taken via blood-sucking bugs (*Dipetalogaster maximus*), a non-invasive method without stress for the birds. The results showed no effect of the birds' age but clear positive influences of both high prolactin and corticosterone levels on the hatching success of the terns. Elevated prolactin levels may be associated with constant incubation (Chastel and Lormee, 2002) and may support the harmonization of mates in incubation shifts. However, slightly increased corticosterone baseline levels could (1) support antipredator behaviour (Kruuk *et al.*, 2004) in order to protect the clutch and (2) trigger the foraging activities (Angelier *et al.*, 2007) in coordination with incubation.

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## **PARENTAL QUALITY, REPRODUCTIVE PERFORMANCE AND CHICK BEGGING BEHAVIOUR IN LESSER BLACK-BACKED GULLS**

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A three year study was undertaken on the breeding biology of Lesser Black-backed Gulls (*Larus fuscus*) on Flat Holm Island, UK, which is home to a colony of approximately 12,000 individuals (including 4,000 breeding pairs). A 7,700m<sup>2</sup> area of this colony was visited daily from early April until late June of each year to examine nesting behaviour during the laying and hatching periods. Nest location, nest quality, nesting materials and surrounding vegetation were recorded, together with laying date and hatching date. Spatial analyses were undertaken using ArcGIS and R to explore the factors influencing nest distribution and hatching success. The timing of egg laying and egg size was also recorded, along with some aspects of chick morphology and begging behaviour. Compared to poor quality nests, laying commenced earlier in high quality nests located closer to cover. These nests were well spaced, with larger clutch and egg sizes, and had a higher hatching success. Despite this variation, no clear differences in the intensity of chick begging towards a standardized stimulus were observed.

## **OPTIMIZED FORAGING STRATEGY FOR SOUTH AFRICAN CAPE GANNETS (*MORUS CAPENSIS*)**

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Predator-prey relationships result from interactions occurring across different spatial and temporal scales. Predators have to develop a spatial foraging strategy for dealing with the multi-scale patterns of distribution of their prey. In the ocean, the distribution of fish (as prey) is generally patchy and unpredictable; this implies for seabirds (as predator) to have to adopt a strategy for searching patchy resource landscapes. In the highly productive upwelling area located off South Africa, Cape Gannets mainly prey upon sardine and anchovy. During the breeding period, adult birds perform daily foraging trips in order to provide frequent meals to their chick. For the years 2001-2007, we conjointly analysed about 300 foraging trips of Cape Gannet recorded with GPS, with the densities of sardine and anchovy that were recorded along acoustical transects; we investigated the relationship between the spatial behaviour of birds and the distribution of fish. We use the fractal dimension to describe on the one hand the degree of spatial exploration by birds, and on the other hand the degree of patchiness of fish aggregations. Here we show that the fractal dimension of the gannet movement and the fish distribution are correlated. This suggests that Cape Gannets have developed an optimal strategy for searching prey.

## **WHY SANDWICH TERNS *STERNA SANDVICENSIS* WORK HARD IN THE NETHERLANDS AND LIVE LEISURELY IN BELGIUM**

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Parent Sandwich Terns *Sterna sandvicensis* alternate brooding and foraging duties. While one parent is at sea foraging, the other parent attends the chick(s). During good foraging conditions this synchronised behaviour results in a constant presence of one of the adults at the colony site. If food consumption rate of the chick drops below critical levels, however, parents start to leave their chicks unattended at the nest. At Griend, an isle in the Wadden Sea hosting the largest Dutch colony, foraging effort of Sandwich Tern parents was strongly linked to diet composition of their chicks. In years with high proportions of sandeel in the chicks' diet, parents left their chicks unattended more often. The reason for this is that sandeel are relatively long, conspicuous fish that are more easily lost to kleptoparasitising Black-headed Gulls *Chroicocephalus ridibundus* patrolling the colony site. High proportions of sandeel in the chicks' diet resulted in a high incidence of robbing which in turn led to increased biparental foraging. By increasing the foraging effort parents were able to compensate for an imminent food shortage and counterbalance negative effects on chick growth and survival. Surprisingly, in Zeebrugge (Belgium) Sandwich Terns did not increase foraging effort when foraging conditions were poor. In some years chicks starved to death while parental attendance did not decrease. In such years, length frequency distribution of prey fish fed to the chicks showed anomalies suggesting that certain critical prey length were lacking from the chicks' diet. In Sandwich Terns increasing energy demands of growing chicks are met by adjusting prey size rather than increasing input rate to the colony. Therefore a continuous prey length spectrum is needed for proper growth of the chicks. When a certain prey length is missing, parents may not be able to compensate by bringing more small fish (energetically not feasible) whereas longer fish cannot be swallowed by the chicks. In poor years, prey fish of 5-8cm were missing from the prey spectrum. The presence of this prey size was crucial for the survival of Sandwich Tern chicks in Zeebrugge.

## **FLEXIBILITY OF FORAGING BEHAVIOUR IN TWO PURSUIT-DIVING SEABIRDS: THE IMPORTANCE OF PREY TRANSPORT CONSTRAINTS**

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Different species of central place foragers use a wide range of methods for transporting food, yet the importance of mode of prey transport for foraging behaviour has rarely been considered, especially in the context of responses to environmental change. Here, we use bird-borne devices and observations at the nest together with independent assessment of sandeel biomass and size in the same area that birds foraged, to examine flexibility in foraging behaviour and food provisioning of chicks for two species of seabird over eight breeding seasons: common guillemot (*Uria aalge*), which is an obligate single-prey loader and razorbill, which is a facultative multiple-prey loader (*Alca torda*). Guillemots had smaller core and total foraging areas than razorbills but travelled a greater vertical distance underwater. Thus the total volume of water sampled by each species was similar. In years of low sandeel biomass, guillemots made longer trips but delivered larger fish, mainly clupeids, whereas razorbills made shorter trips, returning with several small sandeels. Long trips by guillemots resulted in chicks being left unattended at the nest-site and hence vulnerable to attack, whereas razorbills were not left unattended even in the poorest years. This difference in parental non-attendance was most likely a main cause of lower breeding success of guillemots in years of low sandeel biomass. Razorbills have been considered more vulnerable than guillemots to adverse effects of low prey availability but this study suggests that as a consequence of being able to carry multiple prey, razorbills have previously unappreciated flexibility in foraging and food provisioning behaviour that single-prey loaders such as guillemots do not possess.

## **MARINE LITTER MONITORING BY SEABIRDS**

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Marine plastic litter is increasingly seen as a serious environmental problem not only affecting birds and mammals directly through entanglement and ingestion, but also as a potential carrier of concentrated chemical pollution which will be released after ingestion by an organism. Chemical concentrates on plastics will also occur at microscopically small particles, thus potentially affecting foodwebs down to filterfeeding organisms. As a consequence, an increasing number of policies aim at reductions in marine litter. Tools to monitor changes in the marine environment are needed. Monitoring marine litter through the abundance of plastics in stomach contents of beached Fulmars (*Fulmarus glacialis*) has been formalized as one of the Ecological Quality Objectives (EcoQO's) for the North Sea area by OSPAR. A provisional target for acceptable environmental quality has been set at the level that less than 10% of beached Fulmars has more than 0.1 g of plastic in the stomach. Currently, levels in the North Sea range between 40% to 60% of Fulmars having more than 0.1 g of plastic in the stomach. Shipping and fisheries are considered the main sources of plastics in the North Sea area and are thus the first target for new policies. The EcoQO approach may be adopted in the wider OSPAR area (northeast Atlantic), in the European Union through its Marine Strategy Directive, or in other parts of the world requiring pilot studies in different locations, sometimes using other seabird species.

## **LARGE-SCALE MAPPING OF SEABIRD DENSITIES ON THE NORTH SEA**

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Efficient and accurate mapping of seabird densities on the Dutch part of the North sea is done with regression kriging. The results are used for environmental impact assessment studies at sea and require high resolution, high quality bird density estimates. Due to the lack of ecological data like food availability proxy variables are used as explanatory variables. These are usually static (easy to obtain) variables like distance to coast, distance to colony, and depth. Here we show that the accuracy and explanatory power of the method is greatly enhanced if we include (derivatives of) sea surface temperature as explanatory variables in the analysis. Sea surface temperature is modeled, but also gradients of temperature change as proxy for fronts. Weekly mean sea surface temperature on a 4x4km grid are combined with the seabird measurements. The study shows that dynamic explanatory variables for the prediction of seabird distribution are better proxys than static variables.



## **LARGE-SCALE OCEANIC FORCES CONTROLLING THE ATLANTIC PUFFIN IN S.-ICELAND**

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Since 1875 Atlantic Puffins (*Fratercula arctica*) have been hunted in Iceland with a pole net, a technique where mainly nonbreeders (2-4yr) are caught, sparing breeding birds (>5yr). Breeding failure in the Vestmannaeyjar archipelago has been evident 2005-7, apparently due to food shortage and annual puffin harvest has also decreased. In this study, records from six islands were used, with the longest time series since 1943. Past decades oscillations in the catch records are evident. Inter-annual variation in puffin harvest is high and it is hypothesized that a local prevalence by nonbreeders is in direct relation to local food availability around the Islands. This is based on the observation that puffin harvest is highly correlated to fledglings' mean body mass. A correlation was found between the Sub-polar gyre index and puffin catch index 3-5 years later. Thus, indicating an effect of oceanographic dynamics on the reproductive output or the effect of winter survival in the western Atlantic which are later expressed in number of 2-4yr old puffins present near the natal colonies.

## **RESOURCE ACQUISITION IN A TOP MARINE PREDATOR: ASSESSING THE IMPACT OF FISHERY DISCARDS ON FORAGING STRATEGIES OF NORTHERN GANNETS (*MORUS BASSANUS*)**

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The huge quantities of waste produced by commercial fisheries worldwide attract large numbers of scavengers, including many thousands of seabirds. Although discards are widely assumed to be important to many seabird populations, much of the research comes from observations of seabirds at sea, where little is known about the reproductive status or origin of scavengers. Therefore, an important gap in our knowledge is to understand the way in which individual seabirds foraging from a central place respond to fisheries activity at-sea. Here we use data from the Vessel Monitoring System in the North East Atlantic to determine whether the foraging behaviour of individual breeding northern gannets (*Morus bassanus*) is influenced by fisheries activity. Moreover, by analysing stable isotope ratios in body tissues and fish prey we use recently developed iso-source models to accurately quantify the relative contribution of fish obtained in the form of discards and other 'natural' sources of marine prey. These results have important implications for understanding the strength of the link between fisheries and individual scavenging seabirds, which is of particular importance given likely changes in the availability of discards.

## **BREEDING DISTRIBUTION OF THE BLACK-BROWED ALBATROSS *THALASSARCHE MELANOPHRYS* – GLOBAL OBSERVATION AND PREDICTION OF THE USE OF SPACE BY A WIDE-RANGING, GENERALIST MARINE PREDATOR**

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For almost 20 years it has been possible to record the movements of pelagic seabirds using satellite-tracking. While this technique has provided a wealth of data on the behaviour and distribution of individuals, it has not hitherto led to robust, population-level predictions of spatial usage or to the prerequisite quantification of habitat preferences. This is a shortcoming, given that many seabirds, such as the albatrosses, currently face dire threats from bycatch. We used mixed effects Generalised Additive Models, black-browed albatross satellite tracks from nine Subantarctic colonies and remotely sensed oceanographic data, to address this shortcoming. We modelled spatial usage of breeding (and therefore central place constrained) albatrosses, as a function of accessibility (distance<sup>-1</sup>) and habitat preference. Although, like most pelagic seabirds, black-browed albatrosses are generalists, we show that across populations they have quantifiable habitat preferences, primarily for neritic and shelf slope waters. In addition, during incubation, they most prefer warm (~16°C) waters, which often lay to the north of their Subantarctic colonies. However, this species also has sufficient plasticity to exploit other habitats. Hence, birds from South Georgia also forage in the oceanic waters of the Brazil/Malvinas Confluence, an area characterised by very high mesoscale turbulence. During the post-brood stage, their lack of temperature preference means that birds from some populations travel further south, into Antarctic neritic and slope waters. During this stage, birds also tend to prefer areas >600km from neighbouring conspecific colonies, a behaviour that we hypothesise arises due to intraspecific competition, which is more intense than during incubation. Using our models and regional population data, we show that it is possible to predict the worldwide distribution and density of breeding black-browed albatrosses, an advance that we hope will lead to better conservation measures and to further insights into the ecology of seabirds.

## **EXPLORING THE REAL COST OF PARASITES: A META-ANALYSIS OF EXPERIMENTAL STUDIES**

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Knowledge of host-parasite interaction is important to the ecology and conservation of wild populations, yet determining the real impact of parasites on their free-ranging hosts has proven elusive. Captive and theoretical studies have quantified costs and identified life-history trade-offs, but integrating these parameters with field studies has proven elusive. Previous qualitative reviews of the costs of parasites to wild hosts have identified that there may be population costs as well as individual costs to wild hosts (Møller, 1997; Tompkins and Begon, 1999; Irvine, 2006). To date, no quantitative review of the cost of parasites has occurred. In an attempt to gain a better understanding of the cost of parasites, a meta-analysis was conducted on 42 datasets where effects of parasites on free-living hosts were determined by manipulating parasite load on the host. Both endo- and ectoparasites were examined and hosts included birds (n=35), mammals (n=6) and fish (n=1). Significant negative effects of parasites were found in the overall meta-analysis (effect size=0.41). A sub-group analysis found that only weight, body size (tarsus length) and number of young produced were significantly affected, while survival, overall breeding success, clutch size, hatching success and haematocrit were not affected. A comparison with other known drivers of population size equates this effect size with some effects of predation but not as high as resource availability. Given that most datasets in this meta-analysis were from passerines, it is imperative that future work concentrates on other groups of hosts in order to validate these findings. It is suggested that seabirds are prime candidates for such parasite perturbation experiments due to the large-sample sizes possible in colonial seabird species.

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## **MEASURING THE SOMETIMES SUBTLE EFFECTS OF PARASITES AND COLONIAL SEABIRDS**

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The parasites of birds are fairly well-documented, yet the cost of these parasites to the host has rarely been recorded except in extreme cases of mass host death. Experimental work removing parasites from hosts, mostly on passerines, has indicated sub-lethal effects may be common but not uniformly expressed across host species. A meta-analysis of the costs of parasites (ms submitted) to their hosts has highlighted the lack of experimental parasite work on non-passerine hosts. A pilot medicated study using silver gulls *Larus novaehollandiae* and crested terns *Thalasseus bergii* was undertaken during the 2008-2009 breeding season on Montague Island NSW and Phillip Island VIC, Australia. Rather than relying solely on traditional measures of the cost of parasites (morphometric responses, survival, reproductive success), novel measures incorporating ptilochronology (growth bands in feathers) and haematocrit as a proxy for metabolic rate were used. While it is expected that there will be significant negative effects of parasites, it is hoped that this method will elucidate the more subtle costs of parasites to the host as well as defining the quality of the host that the parasite chooses to parasitise (host quality hypothesis).