the Seabird Group

11th International Conference

2-4 Sep 2011, University of Plymouth

Conference Handbook and Book of Abstracts

The University of Plymouth

Marine Biology & Ecology Research Centre

Marine Institute University of Plymouth

RSPB

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Welcome Message from Dr Stephen Votier

This publication contains abstracts of the oral and poster presentations from the 11th International Seabird Group Conference held at the University of Plymouth, UK during 2nd-4th September 2011. The conference was co-organised by the Seabird Group and the Marine Biology & Ecology Research Centre, University of Plymouth. The Seabird Group Conference strives to bring together an international group of people with a shared interest in the study and conservation of seabirds.

At a time of unprecedented change in the marine environment, seabird populations are under severe threat. Therefore, it is all the more important that like-minded individuals are able to come together to discuss issues relating to seabirds and to help safeguard their future. The level of interest in this topic was typified by the >950 delegates who attended the first World Seabird Conference in Victoria, BC, Canada during September 2010. The 11th meeting of The Seabird Group meeting covers a range of themes including behaviour and monitoring, foraging, as well as impacts of environmental change. There are also three special themed sessions coordinated by guest editors on particularly topical issues: marine renewables and seabirds (Dr Rowena Langston); individual specialisations in seabirds (Professor Stuart Bearhop); and seabird migration (Dr Francis Daunt).

The meeting will be opened with a key note talk by Professor Bob Furness (University of Glasgow) entitled “Seabird responses to environmental change: insights from 30 years of PhD supervision”. We are delighted to be able to hear about Bob’s long and illustrious career; among his legacies is the supervision of 55 PhD students, many of whom are seabird biologists. Bob retired in July 2011 and we include a short biography on page 6 of this publication.

During the next two days we will hear 40 oral presentations with speakers from 13 countries and also and have the chance to study >35 posters. We received many more applications for oral presentations than there were spaces available – this made life difficult for the scientific committee but suggests that seabird research is in a healthy condition. The scientific committee and I would like thank all of the authors of the submitted abstracts for their interest in the conference and for submitting work of a very high standard.

I would like to thank the scientific committee, organising committee, executive committee and the conference chairs for all their help in putting together the conference and conference programme. I am also grateful to the sponsorship contributions from the RSPB and the University of Plymouth Marine Institute, particularly given the current financial climate. I would also like to thank all of those people who helped with the planning of the conference (Linda Wilson, Eric Steinen, Kerry Leonard, Freydís Vigfúsdóttir and Sam Patrick) with particular thanks to Jen Brogan and Leon Thompson.

Dr Stephen Votier
Marine Biology & Ecology Research Centre
Seabird Group 11th International Organising Committee

Seabird Group 11th International Conference Organising Committee

Organising Committee

Norman Ratcliffe (BAS, Cambridge, UK)
Stephen Votier (University of Plymouth, Plymouth, UK)
Linda Wilson (JNCC, Aberdeen, UK)

Scientific Committee

Stuart Bearhop (University of Exeter, Falmouth, UK)
Francis Daunt (Centre for Ecology & Hydrology, Penicuik, UK)
Rowena Langston (RSPB, Bedfordshire, UK)
Norman Ratcliffe (Chairman, Seabird Group, BAS, Cambridge, UK)
Stephen Votier (University of Plymouth, Plymouth, UK)
Sarah Wanless (Centre for Ecology & Hydrology, Penicuik, UK)

Executive Committee

Norman Ratcliffe (Chairman, Seabird Group, BAS, Cambridge, UK)
Linda Wilson (JNCC, Aberdeen, UK)
Martin Heubeck (SOTEAG, Aberdeen, UK)
Chris Thaxter (BTO, UK)
Kerry Leonard (Bangor, Northern Ireland)
Andy Webb (JNCC, Aberdeen, UK)
Mark Newell (CEH, Penicuik, UK)

The Seabird Group

c/o BTO – The Nunnery
Thetford – Norfolk IP24 2PU
www.seabirdgroup.org.uk

Marine Biology & Ecology Research Centre

University of Plymouth - Plymouth PL4 8AA
http://www.plymouth.ac.uk/research/mberc

Sponsors

It is a pleasure to acknowledge the support for our conference and sponsorship from the following organisations. The Seabird Group 11th International Conference organising committee would like to take the opportunity to thank all of the sponsors for their support and generosity.

The RSPB speaks out for birds and wildlife, tackling the problems that threaten our environment and promoting the conservation of wild birds and their habitats. We are a charity supported by over one million members, based in coastal and rural areas as well as towns and cities.

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The RSPB's work covers a wide range of issues including planning, climate change, energy, water, agriculture and marine issues. We have practical experience of managing land and coast for conservation, farming forestry and other enterprises. We undertake scientific and economic research to underpin our land management, policy analysis and advocacy.

We also work with Birdlife International partners across the world to carry out crucial conservation projects and policy advocacy on a global stage. To find out more, please visit our website www.rspb.org.uk

The Marine Institute at the University of Plymouth represents a large pool of world-leading experts whose breadth of marine knowledge and expertise is second to none, enabling us to understand the relationship between the way we live, the seas that surround us and the development of sustainable policy solutions. Our network of professionals is consulted globally and contributes towards practical solutions. We are integrating our multidisciplinary expertise in marine research, education and innovation to train new scientists, policy-makers, technicians and business managers of the future.

For further information, please visit www.plymouth.ac.uk/marine

Keynote Speaker Biography

Professor Bob Furness

"Seabird responses to environmental change: insights from 30 years of PhD Supervision"

Bob decided to become an ornithologist under the inspirational influence of Peter Mawby, who took him to ring seabirds in Shetland. Bob has been returning to Shetland ever since, mostly to Foula. He trained at Durham University, and then took up a postdoc at Aberdeen University, from where he moved to Glasgow University, retiring in July 2011 and taking up a part-time post as Principal Ornithologist with MacArthur Green Ltd.

During this time Bob has supervised an extraordinary 55 PhD students, many of who have gone to have successful academic careers and some of which are long-term supporters of the Seabird Group. He has published on topics as diverse as sex determination in sea turtles, goosander moult migration, use of garden bird feeders by siskins, subspecies of eiders, stable isotopes and fatty acids as markers of diet, mercury pollution, birds as monitors of environmental change, deer eating live seabirds, but mostly on seabird-fishery interactions.

Bob is a Fellow of the Royal Society of Edinburgh, a member of BTO Council, a member of SNH Scientific Advisory Committee, and has chaired ICES Working Groups and a panel advising the Danish government on monitoring environmental impacts of marine wind farms. Unlike most people he actually likes Great Skuas.

Academic Programme at a Glance

Friday 2nd September – Roland Levinsky Building, University of Plymouth		
1600 – 1800	Registration and mounting of posters	
1800 – 1900	Plenary Session	Professor Bob Furness (University of Glasgow): "Seabird responses to environmental change: insights from 30 years of PhD supervision"
19.00 – 1920	Seabird Annual General Meeting	
1900 – 2200	University of Plymouth Marine Institute funded Reception & Poster Session	
Saturday 3rd September– Roland Levinsky Building, University of Plymouth		
0800 – 0920	Late registration and welcome coffee	
Session 1	**Marine Renewables and Seabirds**	**Chair: Dr Rowena Langstone (RSPB, UK)**
0900 - 0920	Gannets and offshore wind farms – towards a tracking-based approach to the assessment of impacts	Keith Hamer (University of Leeds, UK)
0920 – 0940	Flight patterns of seabirds in an offshore wind farm in the Netherlands	Ruben Fijn (Bureau Waardenburg, Netherlands)
0940 - 1000	Seabird-windfarm interactions are revealed through GPS telemetry	Chris Thaxter (British Trust for Ornithology, UK)
1000 - 1020	Assessing the potential effects of marine renewable energy developments on black guillemots	Elizabeth Masden (Environmental Research Institute, UK)
1020 - 1040	Pre-construction monitoring of birds using Rhode Island's offshore waters	Peter Paton (University of Rhode Island, USA)
1040 - 1120	Refreshment break and posters	

Session 2	**Behavior and Monitoring**	**Chair: Professor Tim Guilford (University of Oxford, UK)**
1120 - 1140	Identifying dispersal behaviour in Leach's storm-petrel *Oceanodroma leucorhoa* across the North Atlantic using traditional and Bayesian stable isotope analysis	Anthony Bicknell (University of Plymouth, UK)
1140 - 1200	The role of parasites in family conflict dynamics in the European shag	Hanna Granroth-Wilding (University of Edinburgh, UK)
1200 - 1220	Extraordinary long persistence of maternal antibodies in a long lived seabird: implications from albatross conservation to comparative immunology	Thierry Boulinier (CEFE-CNRS, France)
1220 - 1240	Combining tracking and transect data to identify important foraging areas for terns	Linda Wilson (JNCC, UK)
1240 - 1300	Intensive monitoring provides new insights into key flyways and foraging areas of the Balearic Shearwater in UK and French waters	Russell Wynn (National Oceanography Centre, UK)
1300 - 1400	Lunch and posters	
Session 3	**Individual Specialization in Seabirds**	**Chair: Professor Stuart Bearhop (University of Exeter, UK)**
1400 - 1420	Using isotopic tools to help evaluate the causes and consequences of individual dietary specialisation	Seth Newsome (University of Wyoming, USA)
1420 - 1440	Individual specialization in foraging behaviour in a wide-ranging marine predator	Thomas Bodey (University of Exeter, UK)
1440 - 1500	Specialization in foraging behaviour by thick-billed murres leads to dietary specialization	Kyle Elliot (University of Manitoba, Canada)
1500 - 1520	Long term individual migration tracking of the Manx shearwater *Puffinus puffinus*	Holly Kirk (University of Oxford, UK)
1520 - 1540	Migratory navigation in the Atlantic Puffin *Fratercula arctica*	Tim Guilford (University of Oxford, UK)
1540 - 1620	Refreshment break & posters	

Session 4	**Foraging**	**Chair: Dr Richard Phillips (British Antarctic Survey, UK)**
1620 - 1640	Foraging behaviour within foraging trips for chick rearing common guillemot recorded with combined deployment of GPS and time-depth recorders.	Tom Evans (Lund University, Sweden)
1640 - 1700	Some like it hot and stratified: Influence of hydrographic features on seabird distribution in the German Bight in summer	Franziska Guepner (Research and Technology Centre, University of Kiel, Germany)
1700 - 1720	Foraging behaviour of rockhopper penguins during different years and breeding stages at New Island, Falkland Islands	Katrin Ludynia (Max-Planck Institute for Ornithology, Germany & University of Cape Town, South Africa)
1720 - 1740	Time-activity budgets and reproductive success in the black-legged kittiwake	Lorraine Chivers (Queen's University Belfast, Northern Ireland)
1740 - 1800	Frequent locations of oceanic fronts as an indicator of seabird foraging habitat	Peter Ian Miller (Plymouth Marine Laboratory, UK)
1915 - 0000	Banquet at the National Marine Aquarium	
Sunday 4th September– Roland Levinsky Building, University of Plymouth		
0800 – 0900	Information desk and welcome coffee	
Session 5	**Seabird Migration**	**Chair: Dr Francis Daunt (Centre for Ecology and Hydrology, UK)**
0900 - 0920	Where do kittiwakes winter in the Atlantic? Simultaneous tracking of breeders from 18 colonies.	Morten Frederiksen (Aarhus University, Denmark)
0920 - 0940	Dispersal patterns of fledglings and implications for the development of individual migration strategies in wandering albatrosses	Richard Phillips (British Antarctic Survey, UK)
0940 - 1000	Survival strategy of little auks facing the challenges of a North Atlantic winter	Jérôme Fort (CEFE-CNRS, France)
1000 - 1020	Understanding migration strategies of Lesser Black-backed Gulls with GPS telemetry	Viola Ross-Smith (British Trust for Ornithology, UK)
1020 - 1040	Persistent organic pollutant levels in a top marine predator in relation to wintering area and diet	Eliza H K Leat (University of Glasgow, UK)
1040 - 1120	Refreshment break & posters	

Session 6	**Seabird Migration II**	**Chair: Dr Francis Daunt (Centre for Ecology & Hydrology, UK)**
1120 - 1140	Meta-population evidence of oriented chain-migration in Northern gannets	David Grémillet (CEFE-CNRS, France)
1140 - 1200	Consistent wintering behaviour and carry-over effects in a marine predator	James Grecian (University of Plymouth, UK)
1200 - 1220	Can we trace the migration of Atlantic seabirds using stable isotopes?	T Militão (University of Barcelona, Spain)
1220 - 1240	Machine learning approaches to understanding migration and foraging behaviour	Robin Freeman (University of Oxford, UK)
1240 - 1300	A newly described seabird diversity hotspot in the deep Northwest Atlantic identified using individual movement data	Ewan Wakefield (University of Leeds, UK)
1300 - 1400	Lunch & Posters	
Session 7	**Impacts of Environmental Change I**	**Chair: Dr Morten Frederiksen (Aarhus University, Denmark)**
1400 - 1420	Multi-trait ageing and differential impact of environmental variations in an extremely long-lived bird	Deborah Pardo (CEBC-CNRS, France)
1420 - 1440	Annual survival in rockhopper penguins and the influence of sea surface temperatures.	Nina Dehnhard (Max Planck Institute for Ornithology, Germany)
1440 - 1500	Climate, fish stocks and fisheries and their effect on the long term population trends in the Black-Legged Kittiwake	Tone Reiertsen (Tromsoe University Museum, Norway)
1500 - 1520	Size matters: Density-dependent responses to environmental change	Rachel Davies (University of Leeds, UK)
1520 - 1540	Arctic Terns in Iceland: causes and consequences of declines in productivity	Freydis Vigfusdottir (University of East Anglia, UK)
1540 - 1620	Refreshment break & posters	

Session 8	**Impacts of Environmental Change II**	**Chair: Dr David Grémillet (CEFE-CNRS, France)**
1620 - 1640	Seabirds as bio-indicators of coastal ecosystem recovery following the Prestige oil spill	Rocio Moreno (University of Barcelona, Spain)
1640 - 1700	Modelling the climate change effect on apex predators in the Celtic Sea using a multi-trophic level approach	Valentina Lauria (University of Plymouth, UK)
1700 - 1720	Informed dispersal and seabird population response to environmental change: how telemetry can help	Aurore Ponchon (CEFE-CNRS, France)
1720 - 1740	Long term effectiveness of MPAs: insights from a 16 year data set on summer foraging distributions of European shags	Maria Bogdanova (Centre for Ecology & Hydrology, UK)
1740 - 1800	Long-term decrease in egg size shared by contrasting populations of Atlantic Puffins *Fratercula arctica* in North Norway	Robert Barrett (Tromsoe University Museum, Norway)
1800	Conference close	

List of Posters

Banks AN & Clough SC	New technology for age-old questions
Bosman DS, Stienen, EWM & Lens L	Migratory diversification in a closely-related species pair in relation to other life-history traits
Cadiou BC, Pouline PP & Dugué LD	Occurrence of marine debris in European shag's nests as indicator of marine pollution
Cama A & Arcos JM	Incidence and causes of seabird mortality in Atlantic Spanish coasts: a new beached bird programme within FAME Project
Cook ASCP, Parsons M, Mitchell I & Robinson RA	Reconciling policy with ecological requirements in biodiversity monitoring
Cook ASCP, Wright LJ & Burton NHK	Flight heights and avoidance rates of seabirds in relation to offshore wind farms
Cooke F, Cook ASCP, Barker S, Andrews J, Wright LJ & Burton NHK	Standardised sea-watching measures the influence of environmental variables and season on bird abundance
Cowen HC, Oppel SO, Hervias SH, Oliveira NO, Geraldes PG, van Heezik YvH & Brooke MB	How to measure cat activity in shearwater colonies to explain variation in Cory's shearwater nest survival?
Edwards EWJ & Thompson PM	GPS tracking of breeding northern fulmars (*Fulmarus glacialis*) – differences in distribution between Scottish colonies?
Evans TJ, Baaij E, Shamoun-Baranes J, Hentati J, Bouten W & Åkesson S	Foraging movements of breeding lesser black-backed gulls (*Larus fuscus fuscus*) at an island colony in the Baltic Sea using high frequency GPS data
Frandsen MSF & Mosbech AM	Composition of chick meals and foraging behaviour of little auks (*Alle alle*) from large breeding colonies in High Arctic Northwest Greenland
Garcia-Tarrason MG, Bécares JB, Arcos JA, Bateman SB, Jover LJ & Sanpera CS	Linking feeding ecology and habitat use in an endangered seabird: Stable Isotopes and GPS data in Audouin's gull
Guilford TC, Wynn R, McMinn M, Rodriguez A, Jones AR, Maurice LD & Suberg L	Migratory movements of the critically endangered Balearic Shearwater revealed by geolocator tracking

Harris S, Quintana S & Raya Rey A	Individual consistencies in search behaviour of breeding Imperial Cormorants (*Phalacrocorax atriceps*) at Punta León, Argentina
Hawkins BF, Daunt F, Monaghan P, Newell M, Wanless S & Dawson A	Nutritional stress and breeding failure in the black-legged kittiwake: a hormonal pathway?
Huffeldt NH, Linnebjerg JL, Falk KF, Frederiksen MF & Merkel FM	No apparent effect of sex on Brünnich's guillemots' (*Uria lomvia*) time-budgets during incubating and chick rearing despite segregated attendance patterns at Kippaku, Northwest Greenland
Inger R, Christen N & Bearhop S	Quantifying the potential avian impacts of the world's first commercial tidal current turbine: SeaGen
Linnebjerg JL & Frederiksen MF	Wintering areas of three sympatric breeding alcids
Merkel FM, Huffeldt NH & Johansen KJ	Estimating breeding success by remote time-lapse photography and GIS-based analyses in a cliff-nesting seabird
Morgan EM	Interactions between puffins and Larus gulls on Burhou, Channel Islands: A review of the last five years of management
Newell MA, Harris MP, Wanless S & Daunt F	Validation of chick diet and provisioning rate of common guillemots using videos
Nicoll MAC, Jones CG, Ratcliffe N, Tatayah V & Norris KJ	The non-breeding season migration of the Round Island petrel
Oppel S, Raine AF, Borg JJ, Raine H, Bonnaud E, Bourgeois K & Breton AR	Low adult survival probabilities threaten the Yelkouan shearwater *Puffinus yelkouan*
Perrins C	Factors affecting weight and survival of fledgling Manx shearwaters *Puffinus puffinus*
Peter HU, Kopp M, Phillips RA & Hahn S	South polar skuas from a single breeding population overwinter in different oceans
Quinn LQ, Cabot DC, Meharg AM, Phillips RP & Thompson PT	Inter and intra-colony differences in wintering foraging area use by northern fulmars

Ramirez F, García-Tarrasón M, Rami L, Genovart M, Sanpera C & Jover L	Nutritional constraints on egg size: the role of calcium in the intra-clutch pattern of egg size variation
Reyes JM, Phillips RA & González-Solís J	Activity patterns of pelagic seabirds during the nonbreeding period
Soanes L, Dodd S, Arnould J & Green J	How do we accurately estimate the foraging areas of seabirds?
van Noordwijk HJ & Quillfeldt P	Is fledging success determined by differences in maternal egg investment?
Vera E, García-Tarrasón M, Blasco M, Genovart M, Jover L & Sanpera C	Enrichment of short telomeres with aging in Audouin's gull (*Larus audouinii*)
Wade HM	Spatial use of the marine environment by breeding great skuas *Stercorarius skua* and potential effects of marine renewable energy developments
Waggitt JJ, Briffa M, Grecian WJ, Newton J, Patrick SC & Votier SC	Do seabird breeding colonies function as information centres - as study with northern gannets *Morus bassanus*?
Wright LJ, Cook ASCP, Thaxter CB, Moran NJ, Musgrove AJ, Cook F, Barker S, Andrews J & Burton NHK	The value of sea-watching in monitoring seabirds
Wright LJ, Ross-Smith VH, Cook ASCP & Burton NHK	Strategic Ornithological Support Services for the Offshore Wind Industry

Plymouth, Devon

Welcome to Plymouth

Plymouth Hoe

The largest city in Devon, Plymouth overlooks one of the world's greatest and most beautiful natural harbours, Plymouth Sound. Plymouth's past and present is connected with the sea and its shores have seen the departure of some of history's greatest adventurers including the sailing the sailing of the Mayflower and founding of the New World, Sir Francis Drake's defeat of the Spanish Armada, and Captain Cooks search round unmapped territories.

An open plateau, Plymouth Hoe is an excellent spot for a picnic or spotting ships in Plymouth Sound. Historically renowned for Sir Francis Drake's patronage and a game of bowls, Plymouth Hoe is also home to some favorite tourist attractions including Smeaton's Tower, a lighthouse and work of engineering genius.

Situated in Sutton Harbour, the Barbican has a charming ambience resplendent with old architecture and a historic site in its own right. It was from here Captain Cook's adventures started and thousands of convicts were shipped off to Australia. The Pilgrim Father's spent their last night here in 1620 in Island House, before setting sail on their North American Quest. You can visit the Mayflower Steps or the Plymouth Mayflower for more info on Plymouth's nautical heritage, take a rest in the charming Elizabethan Garden or visit the Elizabethan House. Studded with cafés, restaurants and bars, the Barbican also vibrates at night. Just across from the barbican is one of Plymouth's premier attractions, the National Marine Aquarium, the largest and most spectacular of its kind in Britain.

The Barbican

The Barbican

Lido, Plymouth Hoe

Plymouth City Centre is a modern, pedestrianized area with a wide range of shops, cafes, restaurants and is also home to one of the UK's BBC Big Screens which has become a focal point for the city's open air entertainment since it was installed in 2008.

Drake Circus is Plymouth's very own covered shopping centre. Opened in October 2006 it is home to a wide range of well-known high street and independent stores and restaurants. It has eight major stores plus over 48 shops, cafes and restaurants. It is full of modern facilities for shoppers, including 1,270 car parking spaces, lavatories, lifts and disabled access.

Drake Circus Shopping Centre

Plymouth City Centre

Plymouth Map

with key attractions and distances

All distances are timed in minutes walking the shortest and most direct route from the Piazza. All times are approximate depending on individual speed of walking. The times are shown like this example: 1 7

1 Independent Quarter

2 The Piazza

3 Royal Parade

4 Millbay

5 The Sound

6 The Hoe

7 Mayflower Steps

8 Plymouth Gin

9 Al Fresco dining

10 Historic Barbican

11 Modern Barbican

12 Drake Circus

13 Cornwall Street

14 City Museum and Art Gallery

15 Roland Levinsky Building

Conference Banquet – National Marine Aquarium
Saturday 3rd September, 2011

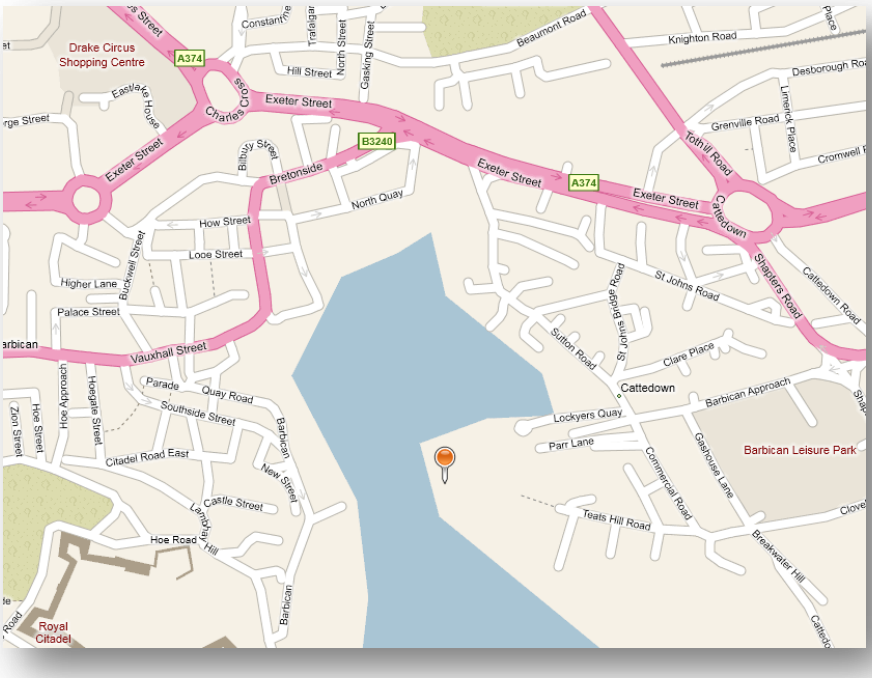
Schedule:
19.15 - Arrival and collect glass of wine
19.30 - Private tour of aquarium
20.15 - Sit down in restaurant inc wine
22.30 - Meal end, move to Horizons bar area
00.12 - Last orders at bar
01.00 - Aquarium closes

All tickets to be booked in advance

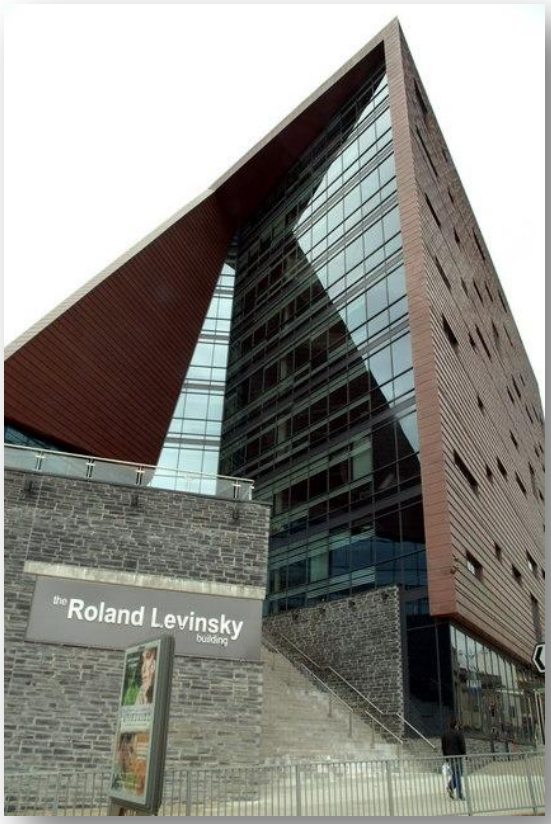
The Conference Banquet on Saturday 3rd September is taking place in Britain's most up-to-date aquarium, the National Marine Aquarium, with many spectacular underwater displays and wide-screen viewing windows, giving you an amazing close-up of the fish.

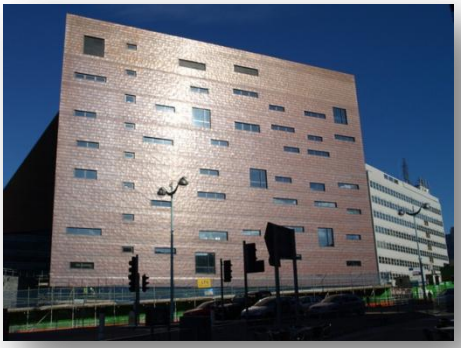
The National Marine Aquarium is located in the Coxside area of Plymouth. Follow the brown and white fish signs, which can be found on all entry roads into the city.

The recommended route is the A38 to Marsh Mills (Sainsbury's) then along the A374 Embankment Road. The route for the Aquarium and Barbican Car Park (main parking for the Aquarium) is signposted from here. **If you have SAT NAV the postcode is: PL4 0DX.** The Barbican car park is pay and display and there are no change facilities.



Conference Venue
Roland Levinsky Building, University of Plymouth



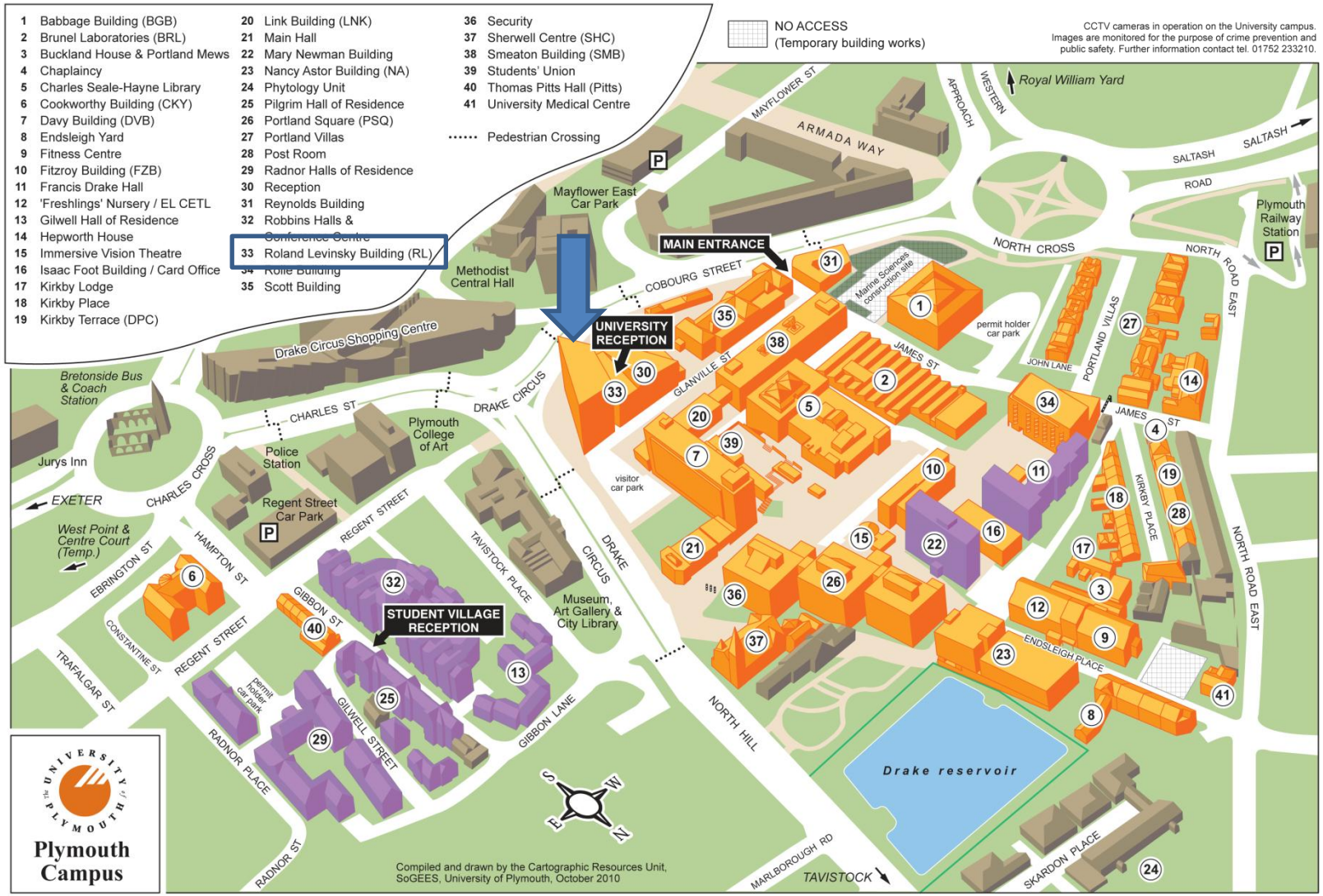


This award winning iconic building houses the Faculty of Arts and Peninsula Arts. It is complete with lecture theatres, a public art gallery and a theatre for performances.

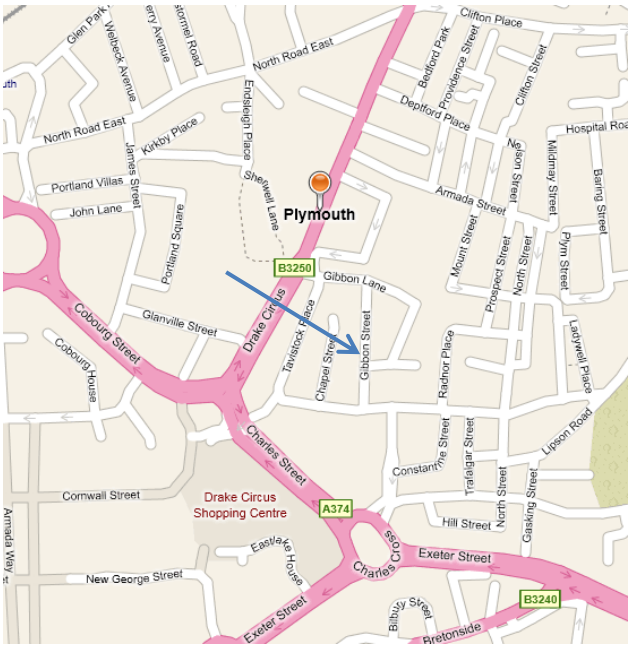
Completed in September 2007, this building was designed by Henning Larsen, famous for their work on the Royal Danish Opera House in Copenhagen, and as its facilities are open for use by the public, benefits the city of Plymouth and the South West region as a whole.

Also housed in this building is the main university reception providing a friendly, professional information and signposting service.

University of Plymouth Campus Map

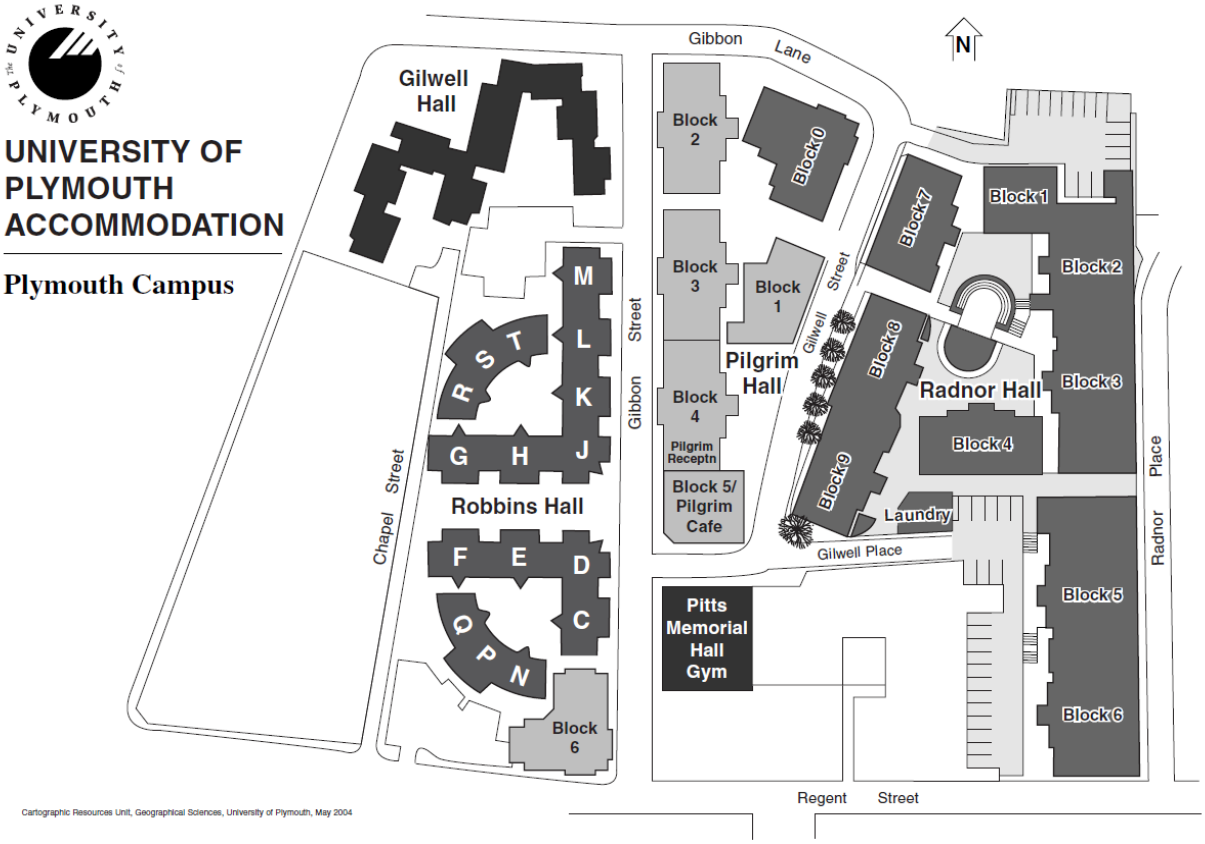


Accommodation at the University of Plymouth



Student Village Reception is located on Gibbon Street, Plymouth, and is open daily from 0800-2200, check-in is from 1400. Please check-out by 1000 on the day of departure.

If your arrival is outside of these times, please notify Reception on 01752 582984. Outside of Reception opening hours, you will need to contact our Security office on 01752 588400.



www.plymouth.ac.uk/summeraccommodation

Seabird Group 11th International Conference
2-4 September, University of Plymouth

Book of Abstracts

Oral Presentations

Long-term Decrease in Egg Size Shared by Contrasting Populations of Atlantic Puffins *Fratercula arctica* in North Norway

Barrett, RB.[1] and Anker-Nilssen, TAN.[2]
[1]Univerity of Tromsø
[2]Norw. Inst. for Nature Research
e-mail: rob.barrett@uit.no; Tycho.Anker.Nilssen@nina.no

Optimal parental fitness is compromised by investment in reproduction and entails a trade-off between the production of a maximum number of independent offspring in any one season and the parents' self-maintenance and subsequent chances of future survival. Besides adjustments in brooding and feeding effort, offspring production in birds can be regulated through changes in clutch size or, for species that lay only a single egg, egg size.

Proximate factors determining egg size are largely unknown although food quality and availability during the egg-formation period is considered important. Results of studies addressing the effects of climate change on egg size are equivocal with two studies showing a decrease and two an increase with increasing spring temperatures. This anomaly may be partly explained by some populations being unable to adjust for changes in the phenology of the nesting environment resulting in a mismatch between food availability and breeding dates.

On this background, we address the last 30 years' trend in egg size of the Atlantic Puffin *Fratercula arctica* breeding on two colonies in North Norway with very different population histories: the relatively small colony on Hornøya, where breeding numbers doubled over the period to ca. 10 000 pairs in 2010, and the huge colony at Røst, where the population decreased by 73%, from 1.4 million pairs to

At these two colonies, Puffin egg volume declined by 0.13% and 0.10% p.a. respectively. Exploratory analyses have ruled out a corresponding decrease in adult body size or any change in laying date as the cause of these declines. Nor was there any evidence of changes in adult age structure of either population in the same time period. There were, however, significant negative correlations between egg volume and pre-breeding SSTs at Hornøya and Røst. Why egg volume should change with SST is discussed in the context of energetic constraints and prey stocks, but the results suggest it may be a response to climate change, most likely mediated through pre-laying food quantity and/or quality.

Identifying Dispersal Behaviour in Leach's Storm-petrel *Oceanodroma leucorhoa* across the North Atlantic using Traditional and Bayesian Stable Isotope Analysis

Bicknell, A.[1], Knight, M.[1], Bilton, D.[1], Reid, J.[2] and Votier, SC.[1]
[1]University of Plymouth
[2]JNCC
e-mail: anthony.bicknell@plymouth.ac.uk; mairi.knight@plymouth.ac.uk; david.bilton@plymouth.ac.uk; jim.reid@jncc.gov.uk ; stephen.votier@plymouth.ac.uk

Procellariformes 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. The successful dispersal of individuals between breeding colonies has implications for population dynamics, genetics and conservation of colonies under threat. It is therefore important to understand any behaviour, or part of the annual cycle, that may influence dispersal. For species where it is currently unsuitable or impractical to use direct tracking devices to monitor their movement, alternative indirect methods of identifying movement and behavior that may promote dispersal between breeding colonies must be adopted. Using carbon and nitrogen stable isotope values from breeding, non-breeding and wrecked Leach's storm-petrels, and zooplankton from the Continues Plankton Recorder, in Canada and Europe we conducted traditional and Bayesian stable isotope analyses to identify two behaviours of non-breeding and breeding birds that potentially promote dispersal between largely spaced colonies in the North Atlantic and have led to the genetic similarity of these colonies.

Individual Specialization in Foraging Behaviour in a Wide-Ranging Marine Predator

Bodey, TW.[1], Patrick, SC.[2], Votier, SC.[2], Gremillet, D.[3], Wakefield, ED.[4], Hamer, KC.[4] and Bearhop, S.[1]

[1]University of Exeter

[2]University of Plymouth

[3]CEFE-CNRS

[4]University of Leeds

e-mail: t.w.bodey@exeter.ac.uk; samantha.patrick@plymouth.ac.uk; stephen.votier@plymouth.ac.uk; david.gremillet@cefe.crns.fr; e.d.wakefield@leeds.ac.uk; k.c.hamer@leeds.ac.uk; s.bearhop@exeter.ac.uk

It is becoming increasingly apparent that treating all animals in a population as ecological equivalents, particularly in studies of resource use, can mask individual level effects that have important implications for our understanding of demographic, ecological and evolutionary processes. Indeed, individual specialization appears to be a widespread phenomenon, and given its potential impact it remains surprisingly under-investigated. However, the generation and persistence of such specializations is likely to be strongly influenced by a number of factors, particularly interactions with conspecifics. Such effects should be especially apparent among centrally placed foragers such as breeding seabirds. Here we use a combination of remote tracking technologies and stable isotope techniques to examine the degree of specialization in the foraging behaviours and diets of individual Northern Gannets *Morus bassanus* from colonies of varying size. We found individual birds showed repeatable behaviours, but that consistent differences between individuals also existed, emphasising the role of individual divergence and the presence of more specialised individuals, a feature that would be masked through examining population level variation. Such individualistic responses to resources and environmental variation suggest a potential mechanism by which specializations can be maintained over large spatial scales.

Long Term Effectiveness of MPAs: Insights from a 16 Year Data Set on Summer Foraging Distributions of European Shags

Bogdanova, MI.[1], Wanless, S.[1], Harris, MP.[1], Takahashi, A.[2], Sato, K.[3], Watanuki, Y.[4] and Daunt, F.[1]

[1]Centre for Ecology and Hydrology

[2]National Institute of Polar Research, Tokyo

[3]Ocean Research Institute, University of Tokyo

[4]Hokkaido University

e-mail: marib@ceh.ac.uk; swanl@ceh.ac.uk; mph@ceh.ac.uk; atak@nipr.ac.jp; katsu@ori.u-tokyo.ac.jp; ywata@fish.hokudai.ac.jp; frada@ceh.ac.uk

The marine environment has experienced dramatic change in recent decades as a result of human activities and climate warming. Numbers of many seabird species have declined over the same period. A primary tool for safeguarding seabird populations in the breeding season is the designation of important habitats as Marine Protected Areas (MPAs). However, the identification of MPAs is complex, since population distributions may vary across seasons or years in relation to environmental conditions and mechanisms such as density dependence and intrinsic within-individual effects. Of particular concern is that MPAs that are designated based on a narrow range of past or current conditions may not be effective in the long term in a system experiencing major changes. It is therefore crucial to quantify the extrinsic and intrinsic determinants of foraging distribution and designate marine areas that are important over a broad range of conditions. However, this is rarely possible because of the shortage of long-term data on foraging distributions. In this study, we present the longest and most comprehensive data set on summer foraging distributions of a single seabird population available in the Northern Hemisphere. 290 European shags breeding on the Isle of May were deployed with locational loggers in 16 breeding seasons from 1987 to 2010. Over this 23 year period, the population has experienced significant environmental change and shown a ten-fold range in population size and five-fold range in annual breeding success. Despite this substantial variation, we recorded strikingly consistent foraging distributions, enabling us to identify marine habitats that have been important in a range of conditions over a long time period. These results have profound implications for the designation of MPAs that remain effective in the long term in the face of climate change.

Extraordinary Long Persistence of Maternal Antibodies in a Long Lived Seabird: Implications from Albatross Conservation to Comparative Immunology

Boulinier, T.[1], Garnier, R.[1], Ramos, R.[2], Staszewski, V.[3], Militão, T.[2], Lobato, E.[1] and González-Solís, J.[2]

[1]CEFE-CNRS Montpellier

[2]Universitat de Barcelona

[3]University of Edinburgh

e-mail: Thierry.Boulinier@cefe.cnrs.fr; Romain.Garnier@cefe.cnrs.fr; ramos@ub.edu; vincent.staszewski@ed.ac.uk; tnetomilitao@ub.edu; Elisa.Lobato@cefe.cnrs.fr; jgsolis@ub.edu

Seabirds are especially good models for studying the responses of populations to environmental changes, notably in food availability. But their extreme life histories may also be associated with some extraordinary physiological characteristics, such as particularities of their immune system. The evolution of different paces of life has been suggested as a major force constraining physiological mechanisms such as immunity. In some long lived oviparous species, a prolonged persistence of maternal antibodies in offspring could thus be expected in order to protect them over their especially long growth period. Using an intergenerational vaccination design, we explored the temporal persistence of maternal antibodies in offspring of the Cory's shearwater (*Calonectris diomedea*) and found, as expected, that specific maternal antibodies can persist more than 40 days in the plasma of nestlings, with an estimated half-life of 25 days post hatching. This temporal persistence is much longer than previously known for any bird species, notably for quails (*Coturnix coturnix*) and black-legged kittiwakes (*Rissa tridactyla*), for which we have comparative data. We also show that maternal antibodies in the considered procellariiform species are functional as late as 20 days of age and that the impact of such effects on population viability could be dramatic, notably if vaccination was used for the conservation of populations threatened by infectious diseases affecting nestlings. These results have broad implications, from comparative immunology to evolutionary eco-epidemiology and conservation biology.

Time-activity Budgets and Reproductive Success in the Black-Legged Kittiwake

Chivers, LSC.[1], Lundy, ML.[1], Houghton, JDR.[2] and Reid, NR.[1]
[1]Quercus, Queen's University, Belfast
[2]Queen's University, Belfast
e-mail: lchivers02@qub.ac.uk; m.lundy@qub.ac.uk; j.houghton@qub.ac.uk; neil.reid@qub.ac.uk

Seabirds are central placed foragers during the breeding season and, as marine food resources are highly patchy, flexibility in their diet and foraging behaviour may be particularly important in maintaining energy delivery rates to the nest. Kittiwakes are small, surface-feeding seabirds that particularly sensitive to changes in food availability as they have a limited ability to switch diet or vary their activity budgets. Rathlin Island, Northern Ireland, is a Special Protection Area for its large seabird assemblages; however, the black-legged kittiwake *Rissa tridactyla* has recently suffered low breeding success and, in some years, complete breeding failure at the site consistent with other colonies throughout the British Isles. This is the first study to use GPS and temperature-depth data-loggers jointly to demonstrate the relationship of between-year foraging variability and reproductive success in kittiwakes. In a year of poor breeding success, chicks starved and food delivery rates were low because foraging trips were longer in duration as birds travelled further than in a year of average breeding success. Nevertheless, kittiwakes spent the same amount of time attempting to catch prey and resting on the water and thus any increases in foraging trip duration was a consequence of increased flying time commuting to feeding grounds further from the colony. Consequently, we infer that the patchiness of marine resources may be highly variable not just in space but also in time. Variation in the availability of suitable kittiwake forage, relative to the location of a colony, is sufficient to influence reproductive fitness between years.

Size Matters: Density-Dependent Responses to Environmental Change

Davies, RD.[1], Wanless, S.[2], Lewis, S.[3] and Hamer, KC.[1]
[1]University of Leeds
[2]Centre for Ecology & Hydrology
[3]University of Edinburgh
e-mail: bgy5rdd@leeds.ac.uk; swanl@ceh.ac.uk; Sue.Lewis@ed.ac.uk; k.c.hamer@leeds.ac.uk

Intra-specific competition for food resources affects both foraging behaviour and population growth rates in many species. The productivity of marine ecosystems has been strongly affected by recent climate change, and these effects have been propagated up the food chain to higher predators, yet the role of density-dependence in shaping predators' responses to climate change has been largely overlooked. Here we examine trip durations, nest attendance patterns and colony growth rates of chick-rearing northern gannets at 10 colonies of varying size in the UK and Ireland in two years (2000 and 2009) with contrasting prey availability. Density-dependence was much stronger under poorer conditions, indicating that larger populations are more vulnerable to adverse impacts of environmental change. Our analysis also revealed a greater apparent effect of competition from neighbouring colonies under poorer conditions. We discuss the implications of these results within the context of impacts of environmental change on populations of different sizes and conservation status.

Annual Survival in Rockhopper Penguins and the Influence of Sea Surface Temperatures

Dehnhard, ND.[1], Poisbleau, MP.[2], Demongin, LD.[3], Ludynia, KL.[4] and Quillfeldt, PQ.[1]

[1]Max Planck Institute for Ornithology
[2]Max Planck Institute for Ornithology and University of Antwerp
[3]Max Planck Institute for Ornithology and University of Antwerp
[4]Max Planck Institute for Ornithology and Animal Demography Unit
e-mail: dehnhard@orn.mpg.de; Maud.Poisbleau@ua.ac.be; laurentdemongin@gmail.com; ludynia@ftz-west.uni-kiel.de; quillfel@orn.mpg.de

Southern rockhopper penguins (*Eudyptes chrysocome chrysocome*) are listed as vulnerable by the IUCN after a dramatic population decline during the 20th century. Knowledge about annual survival rates is essential to understand the species' demography and the mechanisms behind the population decline. Since the breeding season 2006/07, we have marked a total of 526 adults and 215 chicks in our study colony on New Island/Falkland Islands with PIT-tags and recorded presence/absence throughout the following four breeding seasons. Our dataset allowed us to compare survival rates of different age groups and between males and females under different oceanographic conditions. Mortality mainly occurred in the non-breeding season, and was higher in females compared to males (average annual survival was 90.7% for adult females and 93.1% for adult males). In the first three year-intervals, survival rates of adults as well as chicks and immatures were higher than any reported for crested penguins so far (maximum annual adult survival was 94.8% for females and 96.2% for males). This reflects generally good food availability during the study period and also gives hope for a slow recovery of population numbers. However, mortality was significantly higher in the last year, which was characterised by very low sea surface temperatures (SST). We found a quadratic relationship between average SST anomaly and survival rates, indicating a narrow optimum range for penguin survival. Together with previously observed population declines, the present data suggest rockhopper penguins to be highly sensitive to changes in sea surface temperatures and the underlying food-web, a worrying perspective in times of global climate change.

Specialization in Foraging Behaviour by Thick-Billed Murres Leads to Dietary Specialization

Elliot, KH.[1], Woo, KJ.[2], Provencher, J.[3], Ropert-Coudert, Y.[4] and Gaston, AJ.[2]

[1]University of Manitoba
[2]Environment Canada
[3]Carleton University
[4]CNRS
e-mail: haliaeetus@gmail.com; kerrywoo@gmail.com; jennipro@uvic.ca; docyaounde@gmail.com; tony.gaston@ec.gc.ca

Seabirds are often characterized by groups of sympatric species that differ in diet. For example, thick-billed murres and common murres coexist, and when they do they differ in diet (common murres have thinner bills and are more piscivorous). Perhaps these assemblages have resulted from sympatric speciation through individual specialization. To examine the role of individual specialization in an Arctic seabird, we monitored diet for 19 years, foraging behaviour (accelerometers, GPS loggers or time-depth recorders) for 10 years and stable isotope signatures for 5 years at a thick-billed murre colony in northern Canada. Diet was highly specialized, with many individuals showing significant levels of specialization that persisted across years. Although males specialized on “risk-averse” prey and females on “risk-prone” prey, the majority of the specialization occurred at the level of the individual. Similarly, there was little evidence for a trajectory in specialization within individuals; foraging behaviour and diet did not change with age. Birds capturing particular prey items used particular stereotyped foraging behaviours, and those behaviours were maintained across time. We concluded that dietary specialization occurred through certain individuals returning to the same locations and foraging in a similar way across time. Nonetheless, specialization was not correlated with morphology (intestine length, bill depth, hematocrit) or fitness (reproductive success, survival). We concluded that although specialization was an important component of foraging ecology at our study site, there was no clear evidence that it played a role in sympatric speciation.

Foraging Behaviour within Foraging Trips for Chick Rearing Common Guillemot Recorded with Combined Deployment of GPS and Time-depth Recorders

Evans, TJ.[1], Olof, O.[2] and Susanne, S.[1]
[1]Lund University
[2]Stockholm University
e-mail: tom.evans@biol.lu.se; olof.olsson@stockholmresilience.su.se; Susanne.Akesson@biol.lu.se

We studied the foraging behaviour of chick rearing common guillemot (*Uria aalge*) breeding at Stora Karlsö, an intermediate sized colony located in the Baltic Sea. To investigate activity within foraging trips we used a combined deployment of GPS and time-depth recorders, together providing high resolution activity data with major behaviour types (e.g. flight and diving) distinguishable. Foraging trips typically consisted of a short outward flight followed by a period sitting on the sea surface, 'splashdown' (0.39 ± 0.48 h), after which several (5.3 ± 3.8) diving bouts would occur, which were interspersed with short flights and periods of water surface activity; after the final diving bout guillemots typically returned directly to the colony. Foraging was concentrated in the evening and morning, at these times diving frequency was high and dive depths shallower than midday or midnight. There appeared to be a bimodal foraging strategy with longer nocturnal trips departing in the evening and returning in the morning, and shorter daytime foraging trips. Flight ground-speeds are apparently affected by wind with outward flights (20.0 ± 2.8 ms-1) aided by tailwinds and inward flights (15.1 ± 2.5 ms-1) into headwinds. Foraging area use may be affected by wind, as during our study most outward flights are to the North West which followed the wind direction; this could reflect a strategy to reduce crosswind drift, reducing orientation complexity.

Flight Patterns of Seabirds in an Offshore Wind Farm in the Netherlands

Fijn, RC., Krijgsveld, KL., Heunks, C., Japink, M. and Dirksen, S.
Bureau Waardenburg
e-mail: r.c.fijn@buwa.nl; k.l.krijgsveld@buwa.nl; c.heunks@buwa.nl; m.japink@buwa.nl; s.dirksen@buwa.nl

The increasing demand for renewable energy implies that seabirds are facing increasing numbers of offshore wind turbines in their habitat. Offshore wind farms may affect seabirds by causing collisions, barrier effects, or disturbance. In the Dutch North Sea, flight patterns of seabirds were studied within the framework of a three-year effect-study, following a two-year baseline study.

Fieldwork was carried out between 2007 and 2010 in the Dutch Offshore Wind Farm Egmond aan Zee (OWEZ). Fluxes, flight altitudes and deflection of flight paths of local and migrating seabirds as well as migrating landbirds, were studied with both visual as well as continuous radar observations. Flight paths, being flight directions and routes through the wind farm area, were studied to assess the occurrence of deflection. Fluxes and flight altitudes were studied to quantify the number of birds at risk from collision with the turbines. Visual observations provided information at species level. Horizontal and vertical radar were equipped with Merlin (DeTect Inc.) to allow automated data recording and processing. These radars provided continuous data on flight paths, including data during nighttime and adverse weather.

Flight paths of seabirds and other species were registered visually. Interspecific variation in reactions was considerable, while intraspecific variation was low. Reactions of the birds to the wind farm could be separated in four categories. Local seabirds either did avoid the wind farm (e.g. gannets) or did not (e.g. cormorants attracted to the wind farm from the main land). Similarly, migrant seabirds either did (e.g. scoters) or did not avoid the wind farm (e.g. terns).

Seasonal and diurnal variations in bird activity were recorded in both flux and flight altitudes from sea level up to 1.5 km. Movements during the day at lower altitudes primarily included seabirds like marine ducks, gulls, cormorants and alcids. High altitude passages were mainly nocturnal migratory landbirds including waders and thrushes.

This study was commissioned by ‘Noordzeewind’ (a joint venture of Nuon and Shell Wind Energy).

Survival Strategy of Little Auks facing the Challenges of a North Atlantic Winter

Fort, J.[1], Beaugrand, G.[2], Grémillet, D.[3] and Phillips, RA.[4]
[1]National Environmental Research Institute, Denmark
[2]Laboratoire d'Océanologie et de Géosciences, France
[3]Centre d'Ecologie Fonctionnelle et Evolutive, France
[4]British Antarctic Survey
e-mail: fort.jerome@gmail.com; gregory.beaugrand@univ-lille1.fr; david.gremillet@cefe.cnrs.fr; raphil@bas.ac.uk

With an estimated global population of 80 million individuals, little auks (*Alle alle*) are among the world's most numerous seabirds and a major component in pelagic food webs. These 150g birds feed on zooplankton, and winter offshore in some of the most inhospitable areas of the subarctic and arctic regions of the North Atlantic. How such a small, warm-blooded creature can survive the extreme cold, high winds and reduced food availability associated with a northern winter has long been a mystery. Using a multidisciplinary approach, we show how little auks ensure their winter survival by adopting specific migratory strategies allowing a balance between food intake and heat loss. Miniature electronic loggers deployed on little auks breeding in Greenland indicate a migration of >2000 km to winter in a restricted area off Newfoundland. Synoptic data available from the Continuous Plankton Recorder (CPR), indicate that this region harbours some of the highest densities of the copepod *Calanus finmarchicus* found in the North Atlantic during winter. Examination of large-scale climatic and oceanographic data suggests that little auks favour patches of high copepod abundance in areas where the air temperature ranges from 0°C to 5°C. These results greatly advance our understanding of animal responses to extreme environmental constraints, and highlight that information on habitat preference is key to identifying critical areas for marine conservation.

Where do Kittiwakes Winter in the Atlantic? Simultaneous Tracking of Breeders from 18 Colonies

Frederiksen, M.
Aarhus University
e-mail: mfr@dmu.dk

An understanding of the non-breeding distribution and ecology of migratory species is necessary for successful conservation. Many seabirds spend the non-breeding season far from land, and information on their distribution from ring recoveries and at-sea surveys is very limited. The black-legged kittiwake *Rissa tridactyla* is a widespread and numerous seabird in the North Atlantic and Pacific, but breeding populations throughout the Atlantic range have declined recently. To help understand the reasons for the decline, we tracked breeding adults from 18 colonies throughout the Atlantic range over the non-breeding season using light-based geolocation. Geolocation data loggers were deployed on breeding kittiwakes in 2008 and 2009, and retrieved in 2009 and 2010. Data from 236 loggers were processed and plotted using GIS. Size and composition of wintering populations were estimated using information on breeding population size. Most tracked birds spent the winter in the West Atlantic, between Newfoundland and the Mid-Atlantic Ridge, including in offshore deep-water areas. Some birds (mainly local breeders) also wintered in the North Sea and west of the British Isles. There was a large overlap in winter distributions of birds from different colonies, with closer colonies showing larger overlap. We estimated that 80% of the 4.5 million adult kittiwakes in the Atlantic wintered west of the mid-Atlantic Ridge, with only birds from Ireland and western Britain staying mainly on the European side. The high degree of mixing in winter of kittiwakes breeding in various parts of the Atlantic range implies that the overall population is very sensitive to potentially deteriorating environmental conditions in the west Atlantic, e.g. due to lack of food or pollution.

Machine Learning Approaches to Understanding Migration and Foraging Behaviour

Freeman, R.[1], Dean, B.[2], Kirk, H.[3] and Guilford, T.[3]
[1]Computational Ecology and Environmental Science, Microsoft Research
[2]ABRG, University of Oxofrd
[3]ABRG, University of Oxford
e-mail: icytos@gmail.com; ben.dean@zoo.ox.ac.uk; holly.kirk@zoo.ox.ac.uk; tim.guilford@zoo.ox.ac.uk

As technological innovation has reduced the size and cost of various telemetry and biologging devices, the number of species and individuals being tracked during migration and foraging has grown significantly. The wealth of data this present can be hard to interpret using traditional analysis, but lends itself well to the application of machine learning and pattern recognition techniques.

Here we present a variety of approaches to the investigation of at-sea behaviour in migratory seabirds using machine learning. We examine the objective identification of behavioural states during foraging behaviour, and explore the combination of unsupervised and supervised classification to identify marine stopovers during migratory journeys. We then present recent work on combining these approaches in multiple data series to gain a more detailed understanding of wintering distributions, migration and foraging behaviour. We discuss how these methods can be used to approach large datasets, and can reveal novel understanding of underlying behaviour, and finally how they may also allow researchers to reduce the negative impacts of larger devices.

The Role of Parasites in Family Conflict Dynamics in the European Shag

Granroth-Wilding, HMV.[1], Burthe, SJ.[2], Daunt, FHJ.[2] and Cunningham, EJA.[1]

[1]University of Edinburgh

[2]Centre for Ecology and Hydrology

e-mail: hanna.granroth-wilding@ed.ac.uk; sburthe@ceh.ac.uk; frada@ceh.ac.uk; e.cunningham@ed.ac.uk

Infection by parasites is commonplace and costly, with direct impacts on host fitness. Despite the potency of parasite infection as an ecological and evolutionary force, this aspect of seabird ecology has been largely overlooked. In terrestrial species, parasite burdens have been shown to affect pre- and post-mating reproductive success. One mechanism by which these effects may play out is the influence of parasites on conflict dynamics within the brood. The allocation of resources between siblings varies between brood members and is crucial to growth and recruitment. By changing their ability to compete for food, parasite burden in chicks could fundamentally alter whole brood success.

European shags *Phalacrocorax aristotelis* provide an ideal model by which to address this question. The modal brood size of three gives rise to intricate but tractable within-brood interactions, and chicks are constantly exposed to gastrointestinal parasites through their food. This system also demonstrates individual variability in responses to infection as shag chicks of different rank and sex differ systematically in growth rate and survival. Moreover, previous work on shags has established that these parasites are integral to chick-rearing. We examined the interplay between infestation and brood dynamics by experimentally reducing the worm burden of broods of shag chicks on the Isle of May, south-east Scotland. Entire broods were dosed with ivermectin or sham-treated in early chick-rearing, and each individual's subsequent survival and growth rate were monitored. Being an exceptionally productive season, parasite treatment had no direct effect on survival. However, the effects of parasite treatment on growth rate varied strongly with rank and to a lesser degree with sex. Detailed behavioural observations using video cameras suggest that these patterns may be mediated by begging behaviour. Preliminary analysis indicates that stronger chicks beg at a higher rate, indicating that begging may be a signal not of need but condition. A comparison with dosing experiments from previous years suggests that the relationship shows very strong year effects. The impact of gastrointestinal parasites demonstrated here highlights the need for a deeper understanding of their role in seabird systems at large.

Consistent Wintering Behaviour and Carry-over Effects in a Marine Predator

Grecian, WJ.[1], Bearhop, S.[2], Attrill, MJ.[1], Godley, BJ.[2], Grémillet, D.[3], Le Nuz, ML.[4], Lescroël, A.[5], Newton, J.[6], Patrick, SC.[1], Phillips, RA.[7] and Votier, SC.[1]

[1]University of Plymouth, UK
[2]University of Exeter
[3]Centre d'Ecologie Fonctionnelle et Evolutive, Montpellier, France
[4]Ligue pour la Protection des Oiseaux, France
[5]Université de Rennes, France
[6]Natural Environment Research Council Life Sciences Mass Spectrometry Facility, East Kilbride, UK
[7]British Antarctic Survey, Cambridge, UK
e-mail: james.grecian@plymouth.ac.uk; S.Bearhop@exeter.ac.uk; M.Attrill@plymouth.ac.uk; B.J.Godley@exeter.ac.uk; David.GREMILLET@cefe.cnrs.fr; resnat7iles@lpo.fr; amelie.lescroel@univ-rennes1.fr; Jason.Newton@glasgow.ac.uk; samantha.patrick@plymouth.ac.uk; raphil@bas.ac.uk; stephen.votier@plymouth.ac.uk

Individual fidelity to particular wintering locations is potentially widespread among migratory animals, yet is relatively poorly understood. Locating the optimum habitat during the non-breeding period is crucial for an individual to replenish resources lost during the previous breeding attempt, and therefore should be under strong selection. Indeed there is increasing evidence to suggest that the consequences of wintering habitat selection may carry-over to impact individuals in subsequent seasons. For marine vertebrates, while resources show high spatio-temporal variability at small scales, they occur within regions that are consistently productive at large-scales. Individual consistency in migratory strategy may allow individuals to return repeatedly to known foraging grounds. Furthermore, the development of persistent individual foraging specialisations may reduce competition during the wintering period. We combine two approaches to study the wintering behaviour of a migratory marine predator, the Northern gannet *Morus bassanus*: the use of geolocation sensors (GLS) to track individuals over multiple seasons, and the analysis of stable isotope ratios in consumer tissues to provide information on dietary preferences during the wintering period. This approach allows us to spatially resolve dietary information, and so compare foraging strategies both between and within wintering locations. We describe the migration strategies of gannets from two breeding colonies in the north-west Atlantic, and demonstrate that (1) individuals are consistent in both the location and size of wintering ranges across consecutive

seasons, (2) the isotopic values of feathers grown in consecutive winters are highly repeatable, (3) there are within-wintering location and between-individual isotopic differences that (4) reflect individually consistent strategies. Moreover (5), these strategies affect both the timing of arrival at the breeding colonies and body condition, which may have fitness consequences. We conclude that gannets adopt individual migratory and foraging specialisations that persist over multiple years, potentially allowing individuals to repeatedly target heterogeneously distributed resources during winter. These strategies interact with seasonal conditions and so have consequences for individual condition and phenology in the subsequent breeding season. These patterns may arise to reduce competition for resources such as food and space during the non-breeding period, or be the result of heritable migratory traits.

Some Like it Hot and Stratified: Influence of Hydrographic Features on Seabird Distribution in the German Bight in Summer

Guepner, F.[1], Markones, N.[1], Riethmueller, R.[2] and Garthe, S.[1]
[1]Research and Technology Centre, University of Kiel
[2]Helmholtz-Zentrum Geesthacht
e-mail: guepner@ftz-west.uni-kiel.de; markones@ftz-west.uni-kiel.de; rolf.riethmueller@hzg.de; garthe@ftz-west.uni-kiel.de

Increasing anthropogenic use of the North Sea and its resources requires a thorough understanding of factors and processes driving distribution patterns of seabirds at sea as an essential basis for future conservation and management measures.

Large and small scale hydrographic structures, such as water masses, fronts, stratification phenomena are known to influence the distribution of seabirds either directly or indirectly through food availability. In the German Bight, previous studies on the link between hydrography and the distribution of seabirds were carried out based on limited spatial and temporal resolution of oceanographic data only. The present study concentrates on the habitat choice of seabirds at sea in the German Bight based on high-resolution hydrographic data in order to reveal the environmental characteristics that cause and drive distribution patterns. The connecting link between hydrographic features and seabird distribution will be shown in more detail using the example of the common guillemot (*Uria aalge*).

To compare seabird distribution to hydrographic features, we carried out ship-based seabird counts simultaneously along with hydrographic measurements. Oceanographic data were collected by a towed undulating vehicle system. This system, known as `Scanfish', is able to measure hydrographic parameters continuously with a high spatial and temporal resolution throughout most of the water column. For this presentation, we analysed bird and hydrographic data collected during two summer cruises in 2009 and 2010 carried out in the framework of the COSYNA project of the Helmholtz-Zentrum Geesthacht.

Preliminary data analysis revealed a strong correlation between the distribution of common guillemots and water temperature. Highest aggregations of guillemots were found in offshore areas with a strong thermal stratification. A high proportion of birds encountered consisted of chick-leading adults, some of which were observed to forage actively. We assume that stratified water bodies are of great importance for guillemots as foraging areas during the sensitive chick-rearing period.

Migratory Navigation in the Atlantic Puffin, *Fratercula arctica*

Guilford, TC.[1], Freeman, R.[2], Boyle, D.[3], Dean, B.[1], Fayet, A.[1], Kirk, H.[1], Phillips, RA.[4] and Perrins, CM.[5]

[1]University of Oxford

[2]Microsoft Research Cambridge

[3]Edward Grey Institute of Field Ornithology, University of Oxford

[4]British Antarctic Survey

[5]dward Grey Institute of Field Ornithology, University of Oxford

e-mail: tim.guilford@zoo.ox.ac.uk; icytos@gmail.com; daveboyle44@hotmail.com; ben.dean@zoo.ox.ac.uk; annette.fayet@gmail.com; holly.kirk@zoo.ox.ac.uk; raphil@bas.ac.uk; chris.perrins@zoo.ox.ac.uk

Navigational control of avian migration is understood, largely from the study of terrestrial birds, to depend on either genetically or culturally inherited information. By tracking the individual migrations of Atlantic Puffins, *Fratercula arctica*, we describe migratory behaviour in a pelagic seabird that is apparently incompatible with this view.

Until recently the overwintering behaviour of the Puffin remained poorly understood largely because of a paucity of ringing recoveries. Using miniature archival light loggers (geolocators) we tracked birds breeding at Skomer Island, Wales, UK, many over two successive years. Puffins do not migrate to a single overwintering area, but follow a dispersive pattern of movements changing through the non-breeding period, showing great variability in travel distances and directions. Despite this within population variability, individuals show remarkable consistency in their own migratory routes among years. This combination of complex population dispersion and individual route fidelity cannot easily be accounted for in terms genetic inheritance of compass instructions, or cultural inheritance of traditional routes. We propose an alternative hypothesis, suggesting that a mechanism of individual exploration and acquired navigational memory may provide the dominant control over Puffin migration, and potentially other pelagic seabirds, despite the apparently featureless nature of the ocean over which they travel.

Gannets and Offshore Wind Farms – Towards a Tracking-Based Approach to the Assessment of Impacts

Hamer, KC.[1], Langston, RHW.[2] and Wakefield, ED.[1]
[1]University of Leeds
[2]RSPB
e-mail: K.C.Hamer@leeds.ac.uk; rowena.langston@rspb.org.uk; E.D.Wakefield@leeds.ac.uk

In the face of climate change due to anthropogenic greenhouse gas emissions, the European Union has required that its member states meet 15% of their energy needs from renewable sources by 2020. In response, the planning and construction of offshore renewable projects has burgeoned. Most ambitious of all are UK proposals, which, if fully realised, will see an order-of-magnitude increase in the number of wind turbines operating in British waters. The impact these developments will have on the internationally import populations of UK seabirds remains to be seen but evidence from onshore wind farms shows that, for some species, disturbance and mortality due to direct collisions could be significant. These must be weighed against beneficial effects, principally the mitigation of climate change. To-date, impact assessments for proposed wind farms in UK waters have relied heavily on analysis of aerial and boat-based survey data. While this approach gives a synoptic view of the entire seabird assemblage within a proposed development area, it suffers from a number of limitations, i.e. the provenance, sex and breeding status of birds observed at sea are usually undetermined; behavioural information is limited; and movement data, crucially including flight height, are recorded subjectively. We suggest that seabird telemetry can be used in a complementary way to correct these shortcomings.

The northern gannet *Morus bassanus* is a large, wide-ranging, aerial seabird. These traits, together with the fact that 55% of its population breeds around the British Isles, mean the potential for adverse, population level, effects from wind farms need to be assessed. Here, we present detailed tracking data for gannets breeding at two colonies bordering the North Sea (Bass Rock and Bempton Cliffs); including high-resolution three-dimensional foraging tracks, and discuss how such data can be used to assess the potential impacts of wind farm developments on seabirds from these colonies and beyond.

Long Term Individual Migration Tracking of the Manx Shearwater *Puffinus puffinus*

Kirk, L.[1], Dean[1], Freeman[2] and Guilford, C.[1]
[1]University of Oxford
[2]Microsoft Research, Cambridge
e-mail: holly.kirk@zoo.ox.ac.uk

The last few years have seen an extraordinary growth in the study of animal migration, accelerated by the miniaturisation of individual tracking technology. These techniques have been particularly valuable in studying pelagic seabird species renowned for their elusive and far-ranging migratory behaviour. Previous work using geolocators (small archival light loggers; British Antarctic Survey) has confirmed that Manx shearwaters (*Puffinus puffinus*) conduct a trans-equatorial, trans-Atlantic migration to overwintering areas on the Argentinean Patagonian shelf after breeding in Wales. This journey covers some 10000 km, returning via the Caribbean, possibly stopping over to refuel in the North Atlantic on the way. Since 2006 we have been following the migration of the Manx shearwater using geolocators. We report data from repeated migration trips of over twenty individuals breeding on Skomer Island (Wales), some covering four consecutive years. We explore variation in migratory routes, migratory phenology, and overwintering destinations between individuals and within individuals across multiple years. In particular we focus on individual spatial and temporal fidelity, and apparent southwards progression in the core overwintering area, mid-ocean stop-over behaviour during return migration, and an apparent period of reverse migration prior to breeding.

Modeling the Climate Change Effect on Apex Predators in the Celtic Sea using a Multi-trophic Level Approach

Lauria, V.[1], Attrill, M.[1], Edwards, M.[2], Brown, AF.[3] and Votier, SC.[1]
[1]University of Plymouth
[2]Sir Alister Hardy Foundation for Ocean Science
[3]Natural England
e-mail: valentina.lauria@plymouth.ac.uk; M.Attrill@plymouth.ac.uk; maed@sahfos.ac.uk; andrew.brown@english-nature.org.uk; stephen.votier@plymouth.ac.uk

Marine ecosystems are exposed to pressures exerted by climate change and fisheries. Determining the impacts of these stressors remains a major goal for both population biologists and applied ecologists. Over the last 20 years, changes in abiotic factors in the North-east Atlantic have been linked to changes in the diversity and abundance of plankton communities. Climate also has profound effects on the demography and population dynamics of marine apex predators such as seabirds. It is important to understand how bottom-up effects will influence higher trophic level populations such as fish and apex predators. This is, however, difficult due to the complexity of the structure and functioning of marine ecosystems. Research is needed to understand the mechanisms that link different trophic levels and to quantify the effects of these anthropogenic disturbances on populations of predators.

The aim of this study is to investigate the effect of climate change on the pelagic food web in the Celtic Sea. We examined the bottom-up forcing through four trophic levels from plankton to apex predators using long-term datasets. Each trophic level was tested for climatic effects (changes in food availability, sea surface temperature and North Atlantic Oscillation). For seabirds, two demographic parameters were used: breeding success and population growth rate, to test if populations were also regulated by intrinsic factors (such as population density).

Our results indicate that the Celtic Sea food web shows a weak signal of climate forcing. Seabird populations are influenced from direct and indirect effects of climate change and intrinsic factors, however their responses vary according to the species. Analysis of long-term data appears to be essential in understanding ecosystem structure and response to changes. The research reported here highlights the potential use of prediction tools for decision support within marine biodiversity conservation.

Persistent Organic Pollutant Levels in a Top Marine Predator in Relation to Wintering Area and Diet

Leat, EHK.[1], Furness, RW.[1], Borga, K.[2], Bustnes, JO.[3] and Magnusdottir, E.[4]

[1]University of Glasgow
[2]NIVA, Oslo, Norway
[3]NINA, Tromso, Norway
[4]University of Iceland
e-mail: e.leat.1@research.gla.ac.uk; Bob.Furness@glasgow.ac.uk; katrine.borga@niva.no; jan.o.bustnes@nina.no ; elm3@hi.is

Top marine predators, including seabirds, are regularly sampled to monitor levels of persistent organic pollutants (POPs) in the marine environment. Despite restrictions on use and production of many POPs, and declines in some legacy POPs in the environment, concern remains about levels of these chemicals in marine biota and their potential toxicity. Many species of seabird are migratory, however there is a lack of studies investigating the possible contribution of time spent in their wintering area to their POP burdens as sampled during the breeding season. Advances in technology now mean it is possible to link the POP levels of individual birds to their wintering area, recorded using geolocators. The great skua (*Stercorarius skua*) was chosen as study species as it is a top predator with high levels of POPs (Leat et al. 2011 Environ. Pollut. 159:1222-1228), and has breeding populations that contain individuals which winter in geographically diverse locations. Of 10 loggers recovered from the Icelandic population 5 birds wintered in North America in the Grand Banks area, 4 wintered in the eastern Atlantic and one crossed the Atlantic from North America to Iberia during the winter. Great skuas from Bear Island show similar patterns whereas those from Shetland all winter of southern Europe and NW Africa. Differences in regulation of POP use between North America and Europe give rise to differences in POP levels recorded in the western and eastern Atlantic which may be reflected in the great skua. Another aspect of variation which is known to effect POP levels in biota is diet. Lipophilic POPs tend to bioaccumulate. Little is known about the diet of great skuas in their wintering areas, therefore δ13C and δ15N stable isotopes were measured in the 8th primary feather of birds sampled to evaluate any potential relationships between diet and POP levels. This paper will present POP levels in great skuas in relation to their differing migrations, wintering areas, and diet.

Foraging Behaviour of Rockhopper Penguins during Different Years and Breeding Stages at New Island, Falkland Islands

Ludynia, K.[1], Quillfeldt, P.[2], Dehnhard, N.[2], van Noordwijk, HJ.[2] and Masello, JF.[2]

[1]Vogelwarte Radolfzell, Max-Planck Institute for Ornithology & ADU, University of Cape Town

[2]Vogelwarte Radolfzell, Max-Planck Institute for Ornithology

e-mail: kludynia@gmail.com; petra.quillfeldt@gmx.de; dehnhard@orn.mpg.de; riekvn@gmail.com; masello@orn.mpg.de

During the past decades, the population of the southern rockhopper penguin (*Eudyptes chrysocome chrysocome*) on the Falkland Islands has decreased stepwise to less then 20 % of its original size in the 1930s. These changes in numbers are believed to be related to altered environmental conditions and food availability. During the incubation period, birds are known to spend longer periods away from the colony, thus being able to reach more distant and possibly more productive areas at sea. During guard and crèche stages, penguins are limited to foraging areas closer to the colony, having to return more frequently to feed their chicks. We studied the foraging behaviour of rockhopper penguins using GPS data loggers during three breeding seasons between 2008/09 and 2010/11 at New Island, Falkland Islands. Our aim was to identify differences in foraging behaviour between breeding stages and years and relate these to oceanographic and feeding conditions. Differences in foraging behaviour during the incubation period may also be related to different energetic needs in males and females during the subsequent breeding stages. Male penguins travelled large distances foraging over the Patagonian shelf during the incubation periods in both years studied (300-400 km away from the colony), while females presented shorter foraging trips, staying closer to the island. Males presumably forage in more productive waters further away from the colony to be able to fast again during the chick guard stage. Females continued to forage in close vicinity to the island during the guard stages of all three years studied (average distance to the colony of 30 km for 1-day trips), mostly presenting daily returns to the colony. The foraging effort was lower during crèche when both partners were involved in chick provisioning. Rockhopper penguins at other breeding sites in the South Atlantic have been found to stay at sea for longer periods, presumably due to unfavourable environmental conditions. Relatively short foraging trips as well as the lack of major inter-annual differences indicate favourable feeding conditions for rockhopper penguins at New Island during the three consecutive breeding seasons studied.

Assessing the Potential Effects of Marine Renewable Energy Developments on Black Guillemots

Masden, EA., Wade, H. and Jackson, A.
Environmental Research Institute
e-mail: elizabeth.masden@thurso.uhi.ac.uk; helen.wade@thurso.uhi.ac.uk; angus.jackson@thurso.uhi.ac.uk

As governments pledge to combat climate change, renewable energy developments are becoming common features of terrestrial and marine environments. The Pentland Firth in the north of Scotland is no exception, with sites recently leased for wave and tidal renewable energy developments. The Pentland Firth provides habitats for breeding seabirds, and although wave and tidal energy are perceived as 'green', international legislation requires that seabirds are not negatively impacted by the developments. As yet, many of the environmental effects of marine renewable energy devices are unknown. For diving seabirds, the main concerns are likely to be displacement from habitat and collision with devices. One species known to forage in high flow environments and dive to depths at which tidal turbines are proposed to be deployed is the black guillemot *Cepphus grylle*. There is limited ecological information available for this species. At two leasing sites (the Inner Sound and the Ness of Duncansby), tidal energy devices to be deployed have exposed turbine blades, but there is minimal information on the vertical distribution and swimming behaviour of black guillemots within the water column i.e. dive profiles. Consequently, at present it is impossible to estimate (with confidence) collision risk posed to marine birds by tidal devices. Similarly, little is known of the small scale distribution of individuals in areas of proposed developments. Therefore it is impossible to assess with any certainty the potential disturbance and displacement impacts of tidal devices on black guillemots.

We present preliminary results from the first year of study (summer 2011) into the horizontal and vertical movements of black guillemots around the island of Stroma and the Inner Sound of the Pentland Firth using temperature depth recorders (TDRs) and GPS loggers. The results of this project will provide information on the potential impact of tidal energy devices on black guillemots. More generally, the results will provide ecological information on the spatial and temporal variation in habitat use by black guillemots. This information will aid marine planning and more specifically, the development of marine protected areas.

Can we trace the Migration of Atlantic Seabirds using Stable Isotopes?

Militão, T.[1], Kolbeinsson, Y.[2], Ryan, P.[3], Boulinier, T.[4], Becker, PH.[5], Phillips, RS.[6] and González-Solís , J.[1]

[1]Universitat de Barcelona

[2]Natturustofa Nordausturlands Hafnarstett

[3]University of Cape Town

[4]Centre d'Ecologie Fonctionnelle et Evolutive, Montpellier

[5]Institut fuer Vogelforschung

[6]- British Antarctic Survey

e-mail: tnetomilitao@ub.edu

Tracking devices, such as geolocators, are revealing many new aspects of the migratory dynamics of seabirds but it is expensive to use them in large numbers, and unfeasible to deploy on very small species. In these occasions intrinsic markers, such as the analysis of stable isotope ratios of feathers, can be a useful alternative to trace migratory movements. In contrast with the terrestrial environment we still have insufficient baseline knowledge for linking isotopic signatures of different feathers to movements amongst distinct water masses. In this study we linked the carbon and nitrogen signatures of feathers from tracked birds to specific water masses in the Atlantic Ocean. We analyzed the isotopic signatures of feathers in three Procelllariiforme species: the great (*Puffinus gravis* from Gough Island), the Manx (*P. Puffinus* from Iceland) and the Cory's (*Calonectris diomedea borealis* from Canary Islands) shearwaters and 2 Charadriiforme species: Black-legged Kittiwake (*Rissa tridactyla*, from Norway) and Common Tern (*Sterna hirundo*, from Germany). These species breed in different archipelagos but share several feeding grounds throughout the Atlantic (e.g. the Arctic Atlantic or the Patagonian shelf) in different periods of their annual cycle. Stable isotope signatures in different feathers corresponded well with the areas in which we inferred that they were grown. Thus, stable isotope analysis of feathers is a powerful tool to trace the migratory movements of seabirds in the Atlantic.

Frequent Locations of Oceanic Fronts as an Indicator of Seabird Foraging Habitat

Miller, PI.
Plymouth Marine Laboratory
e-mail: pim@pml.ac.uk

We have studied the distribution of oceanic fronts observed by satellite as a proxy for enhanced pelagic biodiversity. These maps can then be applied to assist in the designation of Marine Protected Areas (MPAs) and site selection for marine renewable energy installations (MREIs). It is already known that frequent front zones are associated with higher abundance and diversity of phytoplankton, zooplankton, certain pelagic fish and megafauna such as cetaceans and basking sharks. We are now seeking to use fronts to help understand the foraging hotspots of seabirds, from tagging and sightings datasets. A 10-year time-series (30,000 satellite images) was processed and aggregated to generate a front climatology of the UK continental shelf, indicating the regions where strong fronts are most frequently observed during each season. A UK government (Defra) project has used these results to advise the selection of potential MPAs.

The excellent spatial and temporal coverage of satellite data suggest important applications for the marine renewable industry. The site selection procedure for potential MREIs could exploit frontal indicators as a cost-effective initial risk assessment of impacts to seabird migration. This research is based on the composite front map approach, which is to combine the location, strength and persistence of all fronts observed over several days into a single map, improving interpretation of dynamic mesoscale structures (Miller, 2009). These techniques are robust and applicable to any geographic area.

Miller, P.I. (2009) Composite front maps for improved visibility of dynamic sea-surface features on cloudy SeaWiFS and AVHRR data. Journal of Marine Systems, 78(3), 327-336. doi:10.1016/j.jmarsys.2008.11.019

Seabirds as Bioindicators of Coastal Ecosystem Recovery Following the Prestige Oil Spill

Moreno, R.[1], Jover, L.[1], Diez, C.[2] and Sanpera, C.[1]
[1]Universitat de Barcelona
[2]Universidade de Vigo
e-mail: rocio@rociomoreno.com; lluis_jover@ub.edu; karminha13@gmail.com; csanpera@ub.edu

In November 2002 and just three years after the Erika spill, the tanker Prestige was wrecked off the Atlantic north-west coast of Spain (Galicia), releasing approximately 60.000 tonnes of oil products, which dispersed from Northern Portugal to France and contaminated key marine ecosystems such as the Parque Nacional de las Islas Atlánticas. Here we used the two main species breeding in the National Park, the European shag (*Phalacrocorax aristotelis*) and the yellow-legged gull (*Larus michahellis*), to gain insights into long-term alterations in food web dynamics and to investigate the persistence of oil pollution in the affected coastal ecosystem. In order to achieve that, we analyzed stable isotopes (δ13C, δ15N and δ34S) and heavy metal concentrations (Hg, Cu, Pb, Zn, Cr, V and Ni) in chick feathers sampled at three affected colonies during seven post-spill years (from 2003 to 2009), and compared it with pre-spill values (spring/summer 2002) obtained from feathers of juvenile shag corpses collected at the time of the incident. Although most short-term studies published until today indicate a strong initial impact during the first year after the spill with recovery by 2004, δ15N and Hg, Pb and Cu concentrations of yellow-legged gulls and European shags indicate changes in the food web structure and chronic oil pollution in the affected area for at least three years, and provides the strongest evidence to date on the lasting impact of the Prestige incident in the Galician marine ecosystem.

Multi-trait Ageing and Differential Impact of Environmental Variations in an Extremely Long-lived Bird

Pardo, D., Barbraud, C. and Weimerskirch, H.
Centre d'Etudes Biologiques de Chizé
e-mail: pardo@cebc.cnrs.fr; babraud@cebc.cnrs.fr; henriw@cebc.cnrs.fr

A main goal in ecology is to predict the ecological consequences of global changes. Inter-individual variability observed within populations complicates the understanding of their dynamics and can lead to false predictions. Currently, a growing number of studies are highlighting the effects of ageing in wild populations. In the context of increased rates of extinction of species and global changes, it seems paramount to consider how individuals differentially respond to environmental variations according to their age.

Black-browed albatrosses are long-lived and have been studied intensively in the French Southern territories since 1969, the oldest individual being 35. First, we investigated how age affects 7 demographic, morphometric and life history traits within both the maturation and the senescence phases. Second we looked for differential impacts according to age of an array of environmental covariates including climate and fisheries in both breeding and wintering zones.

Age effects: All survival and reproductive parameters increased at younger ages, except chick body condition and structural size, suggesting that younger parents had already acquired good foraging capacities. Failure during incubation was the main cause of the poor breeding success of young breeders. There was evidence for reproductive and actuarial senescence at advanced ages, well after the mean age at first reproduction. A drop in chick body condition at fledging strongly suggests decreased foraging capacities of old individuals.

Environmental effects according to age: Survival and breeding success were strongly positively linked to sea surface temperature in summer. Longline effort in winter improved breeding success and chick body condition the following year, probably because of the food offered by discards. Finally, breeding success was affected negatively by longline effort in summer. Age classes were affected differently: older birds had greater responses to environmental covariates than younger ones, which in turn were more affected than middle-aged individuals.

We discuss these findings in the light of environmental canalization, where survival is predicted to be strongly canalised, especially in the most important part of the population: middle-aged individuals.

Pre-construction Monitoring of Birds using Rhode Island's Offshore Waters

Paton, WC., Winiarski, L. and McWilliams, R.
University of Rhode Island
e-mail: ppaton@mail.uri.edu; withakri@gmail.com; srmcwilliams@mail.uri.edu

There currently are no offshore wind farms in the United States, but two wind facilities (5-6 wind turbines [30 MW] and up to 200 wind turbines [1000 MW]) are planned for Rhode Island. The Rhode Island Ocean Special Area Management Plan (RI OSAMP) is an adaptive management plan that will define use zones for Rhode Island and Block Island Sounds through a standardized research and planning process. These zones are intended to protect wildlife, commercial and recreational uses, while providing for future activities, such as renewable energy development. To quantify spatial and temporal distribution, abundance and flight ecology of birds using this study area, we conducted a combination of land-based seawatches, ship-based line-transect surveys, aerial line-transect surveys and land-based radar surveys from 2009 to the present. Land-based sea watches allowed us to assess spatial variation, the relative abundance of birds, flight ecology (both flight altitude and direction), and to model the phenology of common species using nearshore waters. Ship-based and aerial surveys allowed us to develop density surface models of the spatial and temporal distribution of common avian species across the 3,800 km2 study area using Program Distance. Our results documented considerable seasonal and spatial variation in avian abundance and we are presently conducting aerial line-transect surveys across the study area to further capture this temporal and spatial variability. All biological data, including our avian data, collected as part of the OSAMP will be included in an Ecological Value Model (EVM) that will rank biological importance on a fine spatial scale across the study area to help guide regulators and developers. Our presentation will focus on those survey and analytical methodologies of interest to seabird biologists and explore how these types of avian data can be used in the context of future marine spatial planning.

Meta-population Evidence of Oriented Chain-migration in Northern Gannets

Pettex, E.[1], Fort, J.[2], Tremblay, Y.[3], Lorentsen, SH.[4], Garthe, S.[5], Votier, S.[6], Pons, JB.[1], Siorat, F.[7], Furness, RW.[8], Grecian, J.[6], Montevecchi, WA.[9] and Grémillet, D.[1]

[1]Centre d'Ecologie Fonctionnelle et Evolutive
[2]National Environmental Research Institute
[3]Centre de Recherche Halieutique Méditerranéenne et Tropicale
[4]Norwegian Institute for Nature Research
[5]Research and Technology Centre
[6]University of Plymouth, [7]Station LPO de l'Ile Grande
[8]University of Glasgow
[9]Memorial University of Newfoundland
e-mail: emeline.pettex@univ-lr.fr; fort.jerome@gmail.com; yann.tremblay@ird.fr; svein.h.lorentsen@nina.no; garthe@ftz-west.uni-kiel.de; stephen.votier@plymouth.ac.uk; seise.dir@gmail.com; francois.siorat@bretagne-environnement.org; bob.Furness@glasgow.ac.uk; james.grecian@plymouth.ac.uk; mont@mun.ca; david.gremillet@cefe.cnrs.fr

Oriented migrations have been identified in a large number of terrestrial bird species. Conversely, seabird post-breeding movements are generally regarded as dispersive. New biotelemetry technologies allow researchers to challenge this assumption, yet recent work mainly focuses on single seabird populations. Here we used miniaturized geolocators to reveal inter-breeding movements and winter distribution of northern gannets (*Morus bassanus*) at a meta-population scale. We focused on five major breeding colonies distributed along a latitudinal gradient of ca. 2500 km, including the southern- and the northernmost European breeding sites. Our data collected for 86 individuals show that European gannets mainly winter off Western Europe and West Africa, two of the most productive areas of the North Atlantic. Breeding and wintering grounds are connected by a major gannet flyway running along the coasts of Western Europe and Africa, from Shetland to Senegal. Crucially, maximum winter range was similar across colonies (3500 km) despite their wide latitudinal range. This strongly suggests chain-migration, and is opposed to the general opinion that large pelagic birds such as gannets enjoy unlimited range outside of the breeding season. Our study therefore demonstrates oriented migration in gannets, and highlights the benefit of meta-population approaches of seabird movements. It is essential to include such processes in marine management plans, especially in the design of adaptive pelagic protected areas due to improve the conservation of marine biodiversity.

Dispersal Patterns of Fledglings and Implications for the Development of Individual Migration Strategies in Wandering Albatrosses

Phillips, RA.[1], Freeman, MP.[1], Chisham, G.[1], Freeman, R.[2] and Croxall, JP.[3]
[1]British Antarctic Survey
[2]Microsoft Research
[3]Birdlife International
e-mail: raphil@bas.ac.uk; mpf@bas.ac.uk; gchi@bas.ac.uk; a-robfr@microsoft.com; John.croxall@birdlife.org

Seabirds are very long-lived, and some species spend >10 years at sea acquiring the experience, flight, foraging and navigational skills that are necessary for successful breeding. During this time, juvenile survival rates are typically much lower than adults, but whether this reflects selection against those that disperse to poorer quality habitats, have poor foraging proficiency or flight skills at the outset, or learn or mature too slowly, is unknown. We deployed combined geolocator-immersion loggers in 2000 and satellite-transmitters in 2009 on fledgling wandering albatrosses from Bird Island, South Georgia. Just fewer than half the birds fitted with loggers were seen back at the colony 4-6 years later, and 17 of the devices recovered provided 24 to 769 days of data (mean ~ 12 months). Satellite-transmitters provided higher resolution data for 11 fledglings for 21-334 days. Fledglings tracked in 2000 dispersed widely in the Southern Ocean, and had a distribution similar to that of nonbreeding adults. By comparison, birds tracked in 2009 did not travel nearly as far within an equivalent time period post-fledging. Unlike nonbreeders, fledglings showed no consistent sexual segregation in latitude. Dispersal patterns of fledglings showed a striking degree of individual variability, but by comparison with most studies of nonbreeding adult seabirds, there was little evidence of regional site fidelity between years. By two months post-fledging, satellite-tracked fledglings flew as fast, on average, as adults, suggesting that high flight proficiency develops relatively quickly. Analysis of the distribution of flight times based on immersion data suggested that individual variation in activity patterns of fledglings (or at least, those that survive) is as large as the variation between fledglings and nonbreeding adults, and between adult males and females. These results will be discussed in the context of the development and heritability of individual migration strategies in albatrosses and other seabirds.

Informed Dispersal and Seabird Population Response to Environmental Change: How Telemetry can help

Ponchon, AP.[1], Grémillet, DG.[2], Doligez, BD.[3], Gonzales-Solis, JGS.[4], Tveraa, TT.[5], Chambert, TC.[6] and Boulinier, TB.[1]
[1]CEFE-CNRS UMR 5175
[2]CEFE-CNRS UMR5175
[3]University of Lyon 1
[4]University of Barcelona
[5]Norwegian Institute for Nature Research
[6]Montana State University
e-mail: aurore.ponchon@cefe.cnrs.fr; david.gremillet@cefe.cnrs.fr; blandine.doligez@univ-lyon1.fr; jgsolis@ub.edu; Torkild.Tveraa@nina.no ; thierry.chambert@gmail.com; thierry.boulinier@cefe.cnrs.fr

In a context of large scale environmental changes, movements related to dispersal of individuals among populations are important to consider, notably because of their potential consequences on the spatial distribution of species range, but also on the dynamics of colonisations/extinctions within a metapopulation framework. In a variable and heterogeneous environment, numerous species have developed behavioural adaptive strategies to choose suitable habitat patches before dispersing, relying on environmental and social cues. In particular, some seabirds are known to use social cues based on conspecifics reproductive success to assess the local quality of potential breeding patches by displaying prospecting behaviours, i.e. by visiting breeding patches without breeding there. However, little is known about the role that such behaviour could play at larger scales and the consequences they could have on the adaptive strategies of dispersal in response to environmental changes. Here, we outline the use of available biotelemetry tools to explore behavioural strategies followed by individuals during breeding habitat selection, notably when visiting potential breeding habitat at a hierarchy of spatial scales. To illustrate the potential offered by such approaches, we present the results of a study combining GPS and satellite tracking with an experimental approach based on the manipulation of individual breeding success to explore the behavioural response of individuals in terms of prospecting strategies but also of foraging strategies at a hierarchy of spatial scales in a colonial seabird species, the Black-legged kittiwake (*Rissa tridactyla*).

Climate, Fish Stocks and Fisheries and their effect on the Long Term Population Trends in the Black-Legged Kittiwake

Reiertsen, TKR.[1], Barrett, RTB.[2] and Erikstad, KEE.[3]
[1]Tromsoe University Museum; Tromsoe, Norway
[2]Tromsoe University Museum, Tromsoe, Norway
[3]Norwegian Institute of Nature Research, Tromsoe, Norway
e-mail: tone.reiertsen@uit.no; rob.barrett@uit.no; kjell.e.erikstad@nina.no

Over the last two decades, many seabird populations have declined greatly along the coast of Norway and some colonies have either become extinct or are on the verge of extinction. One major concern is an increase in SST and increased fluctuations in important prey fish stocks. In general, seabirds feed on small pelagic fish stocks and/or young age classes of larger predatory fish. For the Barents Sea area there is good evidence that climatic fluctuations, commercial fisheries and interactions between fish species and the environment may cause pronounced spatial and temporal variation in prey fish abundance. In the present study we have analysed the yearly population fluctuations and the variance in demographic traits in the black-legged kittiwake in a colony in the southern part of the Barents Sea (Hornøya). We analyse the effect of small and large scale variation in SST as well as the yearly variation in important prey fish stocks and their interaction with the fisheries. The kittiwake population strongly declined from ca 20 000 breeding pairs in 1980 to ca 10 000 pairs in 2010. Over the same time period there was a negative trend in breeding success which closely correlated with an increase in the SST in the Barents Sea. There is also evidence that capelin *Mallotus villosus* and herring *Clupea harengus* fisheries have contributed to a reduced breeding success. Adult survival declined over time and correlated positively with the variation in the total capelin stock. Matrix population models showed that both reduced recruitment and fluctuations in adult survival contributed to the downward population trend. We will demonstrate that further warming of the sea and the strong fluctuations in important prey species as well as the interaction with fisheries may be a serious threat to this population.

Understanding Migration Strategies of Lesser Black-backed Gulls with GPS Telemetry

Ross-Smith, VH.[1], Thaxter, CB.[1], Clark, NA.[1], Conway, GJ.[1], Rehfisch, MM.[1], Bouten, W.[2] and Burton, NK.[1]

[1]British Trust for Ornithology

[2]University of Amsterdam

e-mail: viola.ross-smith@bto.org; chris.thaxter@bto.org; nigel.clark@bto.org; greg.conway@bto.org; mark.rehfisch@bto.org; w.bouten@uva.nl; niall.burton@bto.org

Although information on the annual movements of Lesser Black-backed Gulls has long been available through ringing studies, the details of their migratory behaviour is less well understood. We therefore attached GPS tags (recording over an annual cycle) to 11 breeding adults in 2010 and 14 in 2011 at Orford Ness, UK. We sought to (1) quantify migration routes, timings and flight heights, (2) assess intraspecific differences in migratory behaviour, and (3) investigate birds' destinations and habitat use when not breeding or migrating.

Preliminary investigations of birds tagged in 2010 revealed considerable variation in the timing of migration, with birds dispersing from the colony between 17/07/10 and 24/08/10, and leaving the UK between 25/07/10 and 27/11/10. All gulls reached their overwintering grounds in Morocco between 09/08/10 and 04/12/10, while one individual visited Mauritania. At 18.31±12.66 days, outward migration routes were longer and more varied in duration than return journeys (12.62±2.32 days). Some birds selected fast and relatively direct routes to their wintering grounds (minimum 2.05 days), crossing the Bay of Biscay between Brittany and Galicia, before following the Iberian coast southwards and flying from Cape St Vincent to Casablanca. Other birds travelled south in stages, hugging the coast (maximum outward migration, 36.52 days). Birds spent approximately five months at their wintering grounds (149.52±59.59 days), during which time beaches, landfill sites, reservoirs, ports and flood plains were frequented. Nights were often spent on roof-tops or resting just offshore. Some birds returned to Orford Ness along routes similar to their outward journeys, although two birds selected a different path and migrated across central Spain. Birds arrived at the breeding colony between 20/03/11 and 12/04/11.

These data highlight the value of using GPS data to assess migration routes. Inclusion of further data from birds marked in 2011 will enable the use of habitat association modelling and assessment of movements in relation to weather patterns. This study will provide a holistic understanding of migratory behaviour in this species.

Arctic Terns in Iceland: Causes and Consequences of Declines in Productivity

Vigfusdottir, F.[1], Gunnarsson, TG.[2] and Gill, JA.[3]
[1]University of East Anglia, Snaefellsnes Research Centre, Icelandic Institute of Natural History
[2]South Iceland Research Centre - University of Iceland
[3]University of East Anglia
e-mail: freydisv@hi.is; tomas@hi.is; j.gill@uea.ac.uk

Iceland is home to internationally important populations of many seabirds, and the productive waters of the Atlantic and Arctic oceans that surround Iceland provide the resources to fuel their productivity. However, recent breeding failures among many seabird populations are suggesting rapid and severe changes in prey resources in Icelandic coastal waters.

Around 20-30% of the world's Arctic terns breed in Iceland, in colonies ranging from tens to tens of thousands of pairs. In recent years, there has been growing evidence of declining productivity but the cause of these declines is not known. Since 2008, we have explored potential causes and consequences of changes in Arctic Tern productivity by quantifying 1) the scale and synchrony of chick mortality among colonies, 2) regional and local-scale variation in diet and prey delivery and 3) links between provisioning rates, chick growth, chick mortality and conspecific kleptoparatism.

Persistent food shortage throughout the season was indicated by low provisioning rates, low growth rates of chicks and high chick mortality throughout the breeding season. However, geographic variation in growth rates and diet suggested between-colony differences in the availability of differing prey types, with inshore colonies typically experiencing greater success than colonies with more exposed feeding grounds. In addition, large colonies experienced higher levels of breeding failure and higher rates of conspecific kleptoparatism, indicating potential density-dependent influences on breeding success. These findings suggest that widespread resource limitation is driving declines in Arctic Tern productivity, and that the huge colonies which are reliant on marine resources may be experiencing the most severe impacts. Given the importance of Iceland as breeding area for this species, these findings are alarming and stress the need to understand changes in the availability of marine prey resources in Icelandic waters.

A Newly Described Seabird Diversity Hotspot in the Deep Northwest Atlantic Identified using Individual Movement Data

Wakefield, ED.
University of Leeds
e-mail: e.d.wakefield@leeds.ac.uk

Pelagic seabirds are one of the planet's most widely distributed and far-ranging groups of animals but also one of its most endangered. Recent declines in numbers have largely been attributed to fisheries bycatch but seabird populations are also sensitive to climatic variability, suggesting that they may be impacted by future climate change. In order to understand these threats and to design bycatch mitigation measures such as pelagic Marine Protected Areas (MPAs) it is necessary to determine the distribution of seabirds at sea. Ship-based surveys have provided reasonable coverage within many national Exclusive Economic Zones and large-scale studies have been carried out in parts of the Southern Ocean and North Pacific. However, surprisingly little is known about the drivers of seabird diversity and distribution in the high seas of the North Atlantic. We therefore used individual movement data from 16 species to quantify the mesoscale diversity and relative abundance of seabirds in the North Atlantic's oceanic waters. All tracked birds were adults, representing 30 populations of North Atlantic breeders and southern hemisphere migrants. Tracking data, mainly recorded during the inter-breeding period using light-based geolocators, reveal a hitherto undescribed seabird hotspot in deep (>3000 m) waters between the Grand Banks and the Mid-Atlantic Ridge (MIR), south of the Charlie Gibbs Fracture Zone (CGFZ). The hotspot, which is approximately 1000,000 km^2 in extent and lies entirely in international waters, was used by 15 of the tracked species during one or more key life history stage (i.e. breeding, wintering or staging). Despite considerable variability between species, populations and individuals, the hotspot persisted throughout the year, its location coinciding with the sub-Polar Frontal zone. Here the North Atlantic Current diverges due to the topographical constraint of the MIR and CGFZ causing intense mesoscale turbulence. We hypothesise that these conditions give rise to persistently high, spatiotemporally predictable prey abundance. In addition to seabirds, the hotspot is used by other wide-ranging megafuana, including turtles, cetaceans and bluefin tuna. The latter are targeted by a burgeoning longline fishery. Given the threat this poses and the hotspot's high diversity, we suggest it should be made an MPA.

Combining Tracking and Transect Data to Identify Important Foraging Areas for Terns

Wilson, LJ., Black, J., Allen, S. and Kober, K.
JNCC
e-mail: linda.wilson@jncc.gov.uk; julie.black@jncc.gov.uk; sophy.allen@jncc.gov.uk; kerstin.kober@jncc.gov.uk

To date, most studies on the at-sea distributions of seabirds have been based exclusively on data collected using either transect surveys or, more recently, tracking methods (e.g. radio-telemetry, GPS loggers, satellite transmitters). While the former provides information at the population level, the latter provides information at the individual level. Although it is acknowledged that both types of data are complimentary, they have only rarely been used in an integrated manner and this has been largely limited to longer-range foragers such as shearwaters. The Joint Nature Conservation Committee is currently undertaking survey and analysis to identify important marine areas around the UK for terns Sterna spp. during the breeding season which may be suitable for designation as Special Protection Areas. Both transect and visual-tracking data have been collected concurrently, or in some cases across different years, within the same area and for several study colonies. This paper will outline the analytical and interpretational issues of each type of data and present how we propose to use both datasets to help address these in an integrated way. This will be done in the context of how tracking and transect datasets for relatively short-range foragers such as terns can be used to inform the identification of protected areas.

Intensive Monitoring Provides New Insights into Key Flyways and Foraging Areas of the Balearic Shearwater in UK and French Waters

Wynn, B.[1], Jones, R.[1], Suberg[1], Collins[1], Thébault[2], Yésou[3] and Brereton, M.[4]

[1]National Oceanography Centre
[2]GEOCA
[3]ONCFS
[4]Marinelife
e-mail: rbw1@noc.ac.uk; alice.jones@noc.soton.ac.uk; lavinia.suberg@noc.soton.ac.uk; philip.collins@noc.soton.ac.uk; laurent.thebault243@orange.fr; pierre.yesou@oncfs.gouv.fr; tom.brereton@biscay-dolphin.org.uk

Recent studies have revealed that the core post-breeding distribution of Balearic Shearwaters in northeast Atlantic waters has shifted northwards in the last two decades. As a consequence, internationally important numbers of this Critically Endangered seabird can now be encountered off southwest UK and northwest France during summer and autumn. In order to assess the numbers of birds involved and identify their favoured flyways and foraging areas, a five-year monitoring programme for Balearic Shearwater started in January 2007 as part of the SeaWatch SW project.

Over 4500 records have been collated from UK and Ireland since 1 Jan 2007. Boat-based monitoring off southern England by Marinelife has provided additional data from offshore. Balearic Shearwaters are now seen throughout the year in UK waters, although the largest numbers occur from July to September. About 70% of records are from southwest England. Foraging hotspots have been identified, although most aggregations are of

Effort-based visual monitoring has also been undertaken at the southwest tip of the UK mainland. In the period 2007-10 almost 4000 hours of observations were made from this strategic watchpoint between 15 July-15 Oct. This unique dataset has shown that Balearic Shearwaters are seen passing offshore almost every day, with a peak day count of 268 on 18 Sept 2010. Large movements only occur for one or two days and are not generally associated with large numbers of wind-driven seabirds; they are therefore interpreted to be foraging movements involving birds from northwest France.

Finally, increased collaboration between UK and French ornithologists is providing new information on the species' occurrence off northwest France. In 2010, up to 5700 birds were recorded simultaneously off northern Brittany, equating to about 25% of the World population. Foraging aggregations have been observed in nutrient-rich coastal waters from Bay of Morlaix to Bay of Mont-Saint-Michel. It is thought that these birds are dominantly non-breeders, and further collaborative work is planned to better understand their at-sea distribution and foraging ecology in this region.

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Book of Abstracts

Poster Presentations

New Technology for Age-old Questions

Banks, A N. and Clough, S C.
APEM Ltd
e-mail: a.banks@apemltd.co.uk; s.clough@apemltd.co.uk

The offshore renewable energy industry has grown rapidly over the last decade and advances in digital and optical technology have been exploited for use in offshore surveys of seabirds, particularly in relation to wind energy and wave / tidal power. Historically, seabird surveys have relied upon observer-based visual transect methods. As technology has evolved, drawbacks from visual methods have been overcome by new digital methods, and we here discuss application of these methods to aerial seabird surveys in marine areas. These techniques have been applied successfully to generate population estimates and describe distribution for several offshore wind farm sites in the UK. Obtaining accurate and precise estimates of bird abundance is crucial to determining and measuring effects of offshore wind farm construction, whilst exact geo-referenced locations of birds can inform decisions on spatial planning. Such data lend themselves to spatial modelling, which allows smoothed density surfaces to be produced. Furthermore, new innovations allow increasingly large amounts of supplementary data to be collected; for example, flight height of birds can be estimated in a repeatable and testable way. New technology can therefore answer essential questions about the impact of offshore development on seabirds; with further advances in technology, we anticipate methods continually improving, both in terms of image quality and realistic survey coverage. New innovations will further help to meet the task of surveying seabirds in challenging environments and provide answers to impact questions posed by large-scale renewable energy expansion.

Migratory Diversification in a Closely-related Species Pair in Relation to Other Life-history Traits

Bosman, D.S.[1], Stienen, E.W.M.[2] and Lens, L.[1]
[1]Ghent University
[2]Research Institute of Nature and Forest
e-mail: Davy.Bosman@ugent.be; Eric.Stienen@inbo.be; Luc.Lens@ugent.be

Migration is a widespread phenomenon that transcends taxonomic boundaries, albeit associated with extensive behavioral and life-history variation among species. A vast amount of past and present research has illustrated the adaptive role of migration in response to seasonal and spatial variations in environmental conditions, but only recently in relation to other life-history traits. Studies on differential migration, defined as 'the situation in which migration in some distinguishable classes (ages, sexes, races) differs with respect to distance, timing or both', in particular, have revealed how migratory behavior may trade-off with other costly activities in the annual cycle of species. Life history trade-offs, which are a key assumption underlying optimality models of life history evolution, play a prominent role in the interpretation of life history variation within populations. As a result, various properties of migratory behavior, such as migration distance, timing of departure or arrival, or habitat use outside the breeding season, have been predicted to differ between ages and sexes, possibly caused by different life-history decisions when allocating critical resources to other annual routines such as breeding. Comparison of life-history traits between closely-related species is considered a strong approach for studying the nature of trade-offs underlying life-history variation between and within species. Following this approach, we studied age- and sex-related variation in migratory behavior of Herring gulls (*Larus argentatus*) and Lesser black-backed gulls (*Larus fuscus*), two phylogenetic and ecological closely-related species that occur in sympatry in NW Europe. Despite the fact that both species breed in mixed colonies, show a comparable degree of sexual size dimorphism, mature after 3-7 years with four age classes recognizable on plumage features, and are equally long-lived, they differ in their annual migration pattern along the western coastline of continental Europe.

Occurrence of Marine Debris in European Shag's Nests as Indicator of Marine Pollution

Cadiou, BC.[1], Pouline, PP.[2] and Dugué, LD.[2]
[1]Bretagne Vivante - SEPNB
[2]Parc naturel marin d'Iroise
e-mail: bernard.cadiou@bretagne-vivante.org; patrick.pouline@aires-marines.fr; patrick.pouline@aires-marines.fr

European shags *Phalacrocorax aristotelis*, as many other seabird species, frequently use marine debris (synthetic ropes, fishing nets, etc.) as nesting materials. A simple method, based on visual investigation, was developed to assess occurrence and abundance of marine debris in shag's nests during annual census of breeding pairs. Data were recorded in 2010 and 2011 in different colonies located in the Iroise Marine Natural Park, western Brittany, France. Results pointed out high variability between colonies, with only a few percent of nests containing debris in some colonies or only a few percent of nests without debris in other colonies. A few cases of entangled birds have been reported. Samples of debris were also collected after fledging of young and classified into different categories according to the OSPAR classification of marine litter, in order to identify their origin (fishery activities, domestic use, etc.). This indicator of marine debris in shag's nests was included in the management plan of the Iroise Marine Natural Park, and could be used to monitor marine pollution as well as to monitor potential effects of awareness campaign to reduce plastic pollution in the marine environment. Such campaign could be carried out at the scale of the Iroise Marine Natural Park for some sources of debris identified, especially those arising from local fisheries. Further developments would also investigate marine currents in the study area, which could explain the location of higher densities of floating debris in the vicinity of some breeding colonies.

Incidence and Causes of Seabird Mortality in Atlantic Spanish Coasts: A New Beached Bird Programme within FAME Project

Cama, A. and Arcos, JM.
SEO/Birdlife
e-mail: albert_camatorrell@yahoo.es; jmarcos@seo.org

Beached birds surveys have been extensively used to monitor seabird mortality incidence and distribution, as well as to ascertain causes of such mortality. In Spain this survey method has been used to conduct the ICAO (Beached Bird Coastal Inspection) since the 1980's, an annual survey that aims to cover as much Spanish coast line as possible. Despite the valuable information provided by this programme, there are a few weaknesses worth to be noted: (1) the survey takes place only once a year; (2) it is conducted by volunteers, and the effort largely varies between years for this cause; (3) many corpses are just noted without ascertaining the cause of the death; and (4) original data are dispersed and very difficult to compile. Thus, to complement the information supplied by the former program, a new beached bird programme began in May 2011 in the Spanish Iberian Atlantic and Cantabria coasts, within the frame of the InterReg Project FAME project (www.fameproject.eu). The programme aims to assess reference mortality levels and the main seabird causes of death to detect site and species specific and global seabird threats. The project consists in monthly beach surveys in 15 representative areas that include ca. 10 km. of sandy shoreline each. The novel objective of determining the main causes of death is achieved by on-field necropsias and with the collaboration of wildlife recovery centres. The preliminary results of the first surveys will be presented.

Reconciling Policy with Ecological Requirements in Biodiversity Monitoring

Cook, ASCP.[1], Parsons, M.[2], Mitchell, I.[2] and Robinson, RA.[1]
[1]British Trust for Ornithology
[2]JNCC
e-mail: aonghais.cook@bto.org; matt.parsons@jncc.gov; ian.mitchell@jncc.gov.uk; rob.robinson@bto.org

The UK and Ireland are home to a number of internationally important populations of breeding seabirds. There is a statutory requirement to monitor these populations as a part of national biodiversity strategies and Article 4 of the EU's Directive on the Conservation of Wild Birds (EC/79/409). Consequently, for the past 21 years individual colonies have been monitored as part of the Seabird Monitoring Programme, with additional data contributed by periodic whole population censuses.

Currently population trends for breeding seabirds are produced at a variety of scales, covering the UK and Ireland as a whole, their constituent countries and a number of regional monitoring schemes. However, there is concern that these regions reflect policy requirements rather than ecological relevance, particularly for mobile species. The foundations for these monitoring schemes are considered and evaluated in relation to the results from an analysis of regional variation in seabird population trends. This analysis sought to identify a series of ecologically coherent regions in which trends in abundance and breeding success varied in a consistent fashion. The number of ecologically coherent regions identified varied from two in the Northern gannet and common guillemot to seven in the great cormorant. Trends imputed for ecologically coherent regions more closely matched those observed between whole population censuses and were more consistent than those identified for more policy-driven monitoring regions. By accounting for ecology in the design of monitoring regions population variation in mobile species can be more accurately represented, leading to the design of more realistic monitoring regions.

Flight Heights and Avoidance Rates of Seabirds in Relation to Offshore Wind Farms

Cook, ASCP., Wright, LJ. and Burton, NHK.
British Trust for Ornithology
e-mail: aonghais.cook@bto.org; lucy.wright@bto.org; niall.burton@bto.org

One of the potential impacts on birds from offshore wind farms in the mortality associated with collisions with turbine blades. Whilst there have been considerable advances in the development of statistical techniques to estimate potential collision related mortality, there are still significant gaps in knowledge surrounding flight heights and avoidance rates of seabirds in relation to offshore wind farms.

An extensive literature review was undertaken to investigate flight heights and avoidance rates of seabirds in relation to offshore wind farms. The proportion of birds recorded flying at heights which placed them at risk of collision varied by species, with gulls being particularly susceptible to collisions. Whilst the proportion of some species, such as gulls and terns, flying at collision risk height was highly variable between sites, for other species, such as divers and auks, there was relatively little variability.

Studies of avian interactions with wind farms have tended to focus on collision and mortality rates rather than actual avoidance rates. Whilst these provide a surrogate for avoidance rates, they do not necessarily reflect true avoidance rates as not all birds which fail to take avoidance action will collide with turbine blades.

Avoidance behaviour varies in response to distance from turbines, and it is important to distinguish between macro-avoidance of the whole wind farm (i.e. effectively displacement) and micro avoidance of individual birds within a wind farm. However, studies of avoidance have varied in their approaches, in particular, in the distances at which avoidance is measured and thus the avoidance rates reported are not strictly comparable.

There is an urgent need for further research into the flight heights and avoidance rates of seabirds in relation to offshore wind farms. Ideally, this would include direct measurements of these variables through the tagging of individual birds and the monitoring of movements at a broader scale through the use of technologies such as radar.

Standardised Sea-watching Measures the Influence of Environmental Variables and Season on Bird Abundance

Cooke, F.[1], Cook, ASCP.[2], Barker, S.[1], Andrews, J.[1], Wright, LJ.[2] and Burton, NHK.[2]

[1]Norfolk Ornithologists' Association

[2]British Trust for Ornithology

e-mail: f.cooke1@btinternet.com; aonghais.cook@bto.org; jedandrews@shrike4.freeserve.co.uk; jedandrews@shrike4.freeserve.co.uk; lucy.wright@bto.org; niall.burton@bto.org

Sea-watching represents an under-used and potentially valuable resource for exploring patterns of seabird occurrence around the UK coast and as a tool for monitoring species using the marine environment. One of the most comprehensive UK sea-watching datasets has been collected from the Norfolk Ornithologists' Association's (NOA) Holme Bird Observatory through standardised observations undertaken since May 2005. We present the preliminary outputs of a collaborative project between NOA and BTO investigating this dataset. We explore the outputs that standardised sea-watching data at bird observatories can provide on a site-level in a format that is readily accessible to amateur and professional ornithologists alike. Analyses summarise seasonal and annual variation in numbers of key species recorded at Holme Bird Observatory throughout the year. Species recorded at Holme include those that winter in the area, those that breed in the area and passage migrants whose numbers peak in spring and autumn. The most commonly recorded species were seabirds including Herring Gull, Gannet and Sandwich Tern. However, significant numbers of other species were also recorded including Dark-bellied Brent Goose, Wigeon, Common Scoter and Red-throated Diver. Statistical modelling analyses are used investigate how the numbers of a subset of four commonly recorded species – Gannet, Red-throated Diver, Kittiwake and Sandwich Tern – varied in relation to environmental factors, as collected on the standardised recording forms by observers. These species were selected as they were felt to be representative of different ecological groups occurring around Holme Bird Observatory. Species abundances were most strongly influenced by seasonality, but also by wind speed and direction. Trends in abundance across years are also presented. These preliminary analyses have shown that modelling can be used to investigate the factors causing variability in the numbers of seabirds observed at Holme Bird Observatory, and have demonstrated the value of standardised sea-watching in understanding the factors that affect birds' use of the marine environment.

How to Measure Cat Activity in Shearwater Colonies to Explain Variation in Cory's Shearwater nest Survival?

Cowen, HC.[1], Oppel, SO.[2], Hervias, SH.[3], Oliveira, NO.[3], Geraldes, PG.[3], van Heezik, YvH.[4] and Brooke, MB.[1]

[1]University of Cambridge

[2]RSPB, [3]SPEA

[4]University of Otago

e-mail: honor@thecowens.co.uk; steffen.oppel@rspb.org.uk; sandra.hervias@spea.pt; nuno.oliveira@spea.pt; pedro.geraldes@spea.pt; yolanda.vanheezik@otago.ac.nz; m.brooke@zoo.cam.ac.uk

Shearwaters are vulnerable to predation by introduced mammals during the breeding season. In particular, feral cats (*Felis catus*) can prey on chicks, and nest survival may be lower in areas with higher cat activity or density. However, there is no standard method for measuring cat activity around shearwater colonies. We evaluated the explanatory power of five different measures of cat activity on Cory's shearwater (*Calonectris diomedea borealis*) nest survival on Corvo Island, Azores. In 2010, we deployed 24 infrared camera traps and conducted scat transect surveys around six Cory's shearwater colonies in which we monitored the fate of 154 nests during the breeding season. Based on camera trap and scat survey data we derived the following indices of cat activity for each colony: the number of individual cats, number of cats/ camera trap day, scats / day and transect, and two estimates of cat density obtained from spatially explicit capture-recapture models and from the daily movement rates of cats. We then evaluated the support for each of these cat measurements in models describing the weekly nest survival of Cory's shearwaters. Cory's shearwater nest survival was 0.459 (95% CI, 0.159 to 0.680). Weekly nest survival varied during the season, with generally high weekly survival rates during early incubation and the weeks before fledging, but low weekly survival rates around hatching. There was limited support for any of the cat measures. The simple cats/trap day index explained as much variation as more labour intensive methods. Scat transect counts explained the least variation in Cory's nest survival. All our cat measurements provided one estimate per colony over the whole season and may therefore have been suboptimal for explaining temporal fluctuations in nest survival. As nest survival varied strongly throughout the season, we recommend cat activity indices that can provide data at a weekly temporal resolution to explain the fluctuation in predation events. Cameras fixed in specific places over the breeding season, providing a simple index of cat number per day, may be more useful for explaining nest survival than estimates of cat density that require long sampling intervals and therefore cannot track temporal fluctuations.

GPS Tracking of Breeding Northern Fulmars (*Fulmarus glacialis*) – Differences in Distribution between Scottish Colonies?

Edwards, EWJ. and Thompson, PM.
University of Aberdeen
e-mail: e.edwards@abdn.ac.uk; lighthouse@abdn.ac.uk

The northern fulmar is one of the most abundant seabirds in the North Atlantic. Having undergone a well-documented population expansion over the last 200 years, fulmars breed ubiquitously on coasts from north of the Arctic Circle to Spain. They are wide-ranging marine predators and scavengers, and one common theory put forward to explain the expansion is that they have benefitted from the provision of an energetically cheap and easily available food source in the form of discards from the whaling and fishing industries. In recent years, some fulmar populations have been in decline, which may be attributable to changes in environment or fishing practices. Recent technological advances have enabled tracking of seabirds in greater numbers and on smaller budgets than previously possible. Previous dietary studies have shown variation in use of fisheries discards between breeding colonies, but this has not previously been linked to heterogeneity in foraging areas. Fulmars were tracked using GPS loggers during early chick-rearing at breeding sites in Orkney (2010 and 2011) and on St Kilda (2011) to assess the degree of overlap of foraging range for birds from two oceanographically distinct Scottish colonies whilst constrained by breeding. I present some early results and analysis from my first field season.

Foraging Movements of Breeding Lesser Black-backed Gulls (*Larus fuscus fuscus*) at an Island Colony in the Baltic Sea using High Frequency GPS Data

Evans, TJ.[1], Baaji, EW.[2], Shamoun-Baranes, J.[2], Hentati, J.[3], Bouten, W.[2] and Åkesson, S.[1]

[1]Lund University

[2]University of Amsterdam

[3]University of Stockholm

e-mail: tom.evans@biol.lu.se; E.W.Baaij@uva.nl; shamoun@uva.nl; jonasdelawarensis@hotmail.com; wbouten@science.uva.nl; Susanne.Akesson@biol.lu.se

The eastern race of the lesser black-backed gull (*Larus fuscus fuscus*), is listed as near threatened in Sweden, having undergone a steep population decline in recent decades. This contrasts with stable or increasing populations in the other European races (*L. f. intermedius* and *L. f. graellsii*). This study uses a solar powered remote download GPS device to study the movement ecology of a population during the breeding period at Stora Karlsö Island, a Baltic Sea colony. High frequency position data (< 10 s) allows very detailed information on foraging behaviour to be gained, indicating places of area restricted search (ARS) behaviour in addition to larger scale activity, such as geographical distribution of foraging effort. Here we present some of the initial results from the 2011 field season. Including individual foraging strategies (pelagic vs. arable); changes in foraging area use through the breeding season; and individual field use of arable land.

Composition of Chick Meals and Foraging Behaviour of Little Auks (*Alle alle*) from Large Breeding Colonies in High Arctic Northwest Greenland

Frandsen, MSF.[1] and Mosbech, AM.[2]
[1]Department of Artic Environment, NERI, University of Aarhus and University of Copenhagen
[2]Department of Artic Environment, NERI, University of Aarhus
e-mail: mmsf@dmu.dk; amo@dmu.dk

Only few little auk studies have focused on the largest breeding population in the high arctic northwest Greenland where 80 % of the little auks are estimated to breed. This study reports on the chick diet composition from one of the main colonies, the Paakitsoq colony, located on the southeaster margin of the North Water Polynya. Results revealed the highest proportion of the large high arctic copepod *Calanus hyperboreus* reported for any little auk colony. Species diversity in the chick meals was low which could reflect a high availability of few preferred prey species. However, individual chick meals were generally low in number of prey items and total energy content compared with published results from other colonies. This surprising result may be explained by the late sampling time corresponding to the chick mass-recession period where chicks are feed less. This interpretation is supported by TDR data showing that birds only showed moderate diving effort. The composition of chick meals reflects the availability of prey items. Prey item distribution is closely linked with water temperatures which strongly affect the foraging pattern of the little auks. Results of the foraging strategy analysed in this study revealed a bimodal distribution of trip duration. Long trips lasted between 9.6 and 17.4 h while short trips lasted between 0.7 and 6.6 h. The total flight duration differed between the two trips types. Birds on a long foraging trip spent significant more time flying than birds on short foraging trips. Flight duration corresponded to a maximum foraging range of 120.4 km (mean long trips = 69 km; mean short trips = 26.5 km). Water temperature was equal for dives performed on long and short trips which might suggest that the general foraging strategy did not differ between the trip types. These results are compared with studies of little auk foraging behaviour from colonies in eastern Greenland and Svalbard where the birds have different oceanographic conditions.

Linking Feeding Ecology and Habitat use in an Endangered Seabird: Stable Isotopes and GPS Data in Audouin's Gull

Garcia-Tarrason, MG.[1], Bécares, JB.[2], Arcos, JA.[2], Bateman, SB.[1], Jover, LJ.[1] and Sanpera, CS.[1]

[1]University of Barcelona

[2]SEO/BirdLife

e-mail: m.garcia@ub.edu; jbecares@seo.org; jmarcos@seo.org; sbateman.posse@gmail.com; lluis_jover@ub.edu; csanpera@ub.edu

Audouin's gull (*Larus audouinii*) is an endemic breeding seabird to the Mediterranean region, which is catalogued as Near Threatened at global level by the International Union for the Conservation of Nature (IUCN). The bulk of the population breeds in Spain (>90%), with about 2/3 concentrated in the Ebro Delta (10,000-15,000 pairs). The relevance of this colony for the conservation of the species is therefore crucial, and conservation measures there must be based on solid knowledge to be effective. Several studies have been carried out on this regard, mostly based on breeding performance, but still little is known about the detailed distribution patterns and their link with the feeding ecology of the species. To this aim, we tagged 60 adult birds with GPS loggers during 10-15 days, coinciding with the incubation period in 2011. Blood samples (1 ml) were taken after retrieval of the GPS, to carry out the Stable Isotopes Analysis (SIA). GPS data revealed a wide habitat use by Audouin's Gull in the Ebro Delta, ranging from exclusively marine individuals to ricefield specialists, all the way up to intermediate situations. Some individuals went as far as 200 km from the colony and stayed more than two days outside. Individuals expending the most of the time at sea showed the highest $\delta^{13}C$ values and the lowest $\delta^{15}N$ ones. On the other hand, ricefield specialists presented the lowest $\delta^{13}C$ values and the highest $\delta^{15}N$ ones. These elevated N values in the ricefields are presumably due to eutrophication of the system and not to a longer trophic chain. The combination of SIA and GPS data provides a great potential for the comprehension of the foraging ecology of the species on an individual basis, and will strongly contribute to design conservation measures for the species.

Migratory Movements of the Critically Endangered Balearic Shearwater Revealed by Geolocator Tracking

Guilford, TC.[1], Wynn, R.[2], McMinn, M.[3], Rodriguez, A.[3], Jones, AR.[2], Maurice, LD.[4] and Suberg, L.[2]

[1]University of Oxford

[2]National Oceanographic Centre, Southampton

[3]Skua Gabinet d'Estudis Ambientals SLP, Palma

[4]British Geological Survey

e-mail: tim.guilford@zoo.ox.ac.uk; rbw1@noc.ac.uk; miguel.mcminn@skuaslp.info; ana.rodriguez@skuaslp.info; alice.jones@noc.soton.ac.uk; loma@bgs.ac.uk; lavinia.suberg@noc.soton.ac.uk

The Balearic Shearwater *Puffinus mauritanicus* is a small (500g) Procellariform endemic to the Mediterranean's Balearic Islands, and is currently regarded as critically endangered because of its small and declining breeding population. At-sea movements of this species are poorly understood, but changes in the patterns of sightings in recent years suggest that migratory movements may be undergoing significant change. Using miniature on-board archival light-logging devices (geolocators), we investigated the long-distance movements of birds breeding at the largest known colony of shearwaters on Mallorca. Geolocators were deployed on 34 birds (17 nesting pairs) in April 2010, and data recovered from 29 devices in March 2011 were used to reconstruct the migratory movements of birds outside the breeding season. Here we present the first data describing individual migratory movements and phenology of birds as they leave their Mediterranean breeding grounds to spend the late summer at sites concentrated off the Atlantic coasts of Iberia and France, before returning to the Mediterranean in late autumn. Some implications for population migratory dynamics, and issues of at-sea conservation, will be discussed. Details of pre-breeding season visits to the colony are also revealed. The impacts of such telemetry studies on tagged birds will also be evaluated.

Individual Consistencis in Search Behavior of Breeding Imperial Cormorants (*Phalacrocorax atriceps*) at Punta León, Argentina

Harris S.[1], Quintana F[1]. & Raya Rey A[2].
[1]Centro Nacional Patagónico, CONICET
[2]Centro Austral de Investigaciones Cientíicas, CONICET
e-mail: harrissabrin@cenpat.edu.ar; quintana@cenpat.edu.ar; arayarey@speedy.com.ar

The few studies to date indicate that foraging behaviour on successive trips taken by individual seabirds is more consistent than would be expected if they represented random samples from a given population. Individual consistencies could result from prey specialization or limited variation in the surrounding environment over short temporal scales, as well as the forager's sex, age, life history and current physiological and behavioural restrictions. Behavioural consistency has been linked to time elapsed between events, being stronger at shorter time intervals. During the 2009 breeding season at the Punta León colony (64° 29.75 W;43° 04.6 S), twenty-two breeding Imperial Cormorants (*Phalacrocorax atriceps*) (twelve females and ten males) were equipped with mini GPS loggers to record their position (at 1 Hz) during two foraging trips on consecutive days. Thirteen of these individuals (seven females and six males) were fitted with loggers during a second period, twelve days later, again for two consecutive foraging trips. Several parameters were extracted from the foraging trips to evaluate individual consistency. On consecutive days, there was a high degree of similarity in the trips of individual females in terms of the maximum distances from the colony and shore, sinuosity, and area covered relative to the maximum distance reached. In contrast, although individual males showed similar trip durations on consecutive days, in general they tended to increase the maximum distance reached from the colony and the shore as well as the percentage of time flying on the second day. In addition, females tended to be more consistent than males in most foraging trip parameters during the second series of deployments. However, considerable behavioural variability between individuals was detected for both sexes. An increase in food demand by the growing offspring, as well as changes in the environment as the season progresses, may have different impacts on females compared with males, potentially exerting greater pressure on females to optimize their behaviour or providing them with less flexibility than males in terms of foraging opportunities.

Nutritional Stress and Breeding Failure in the Black-Legged Kittiwake: A Hormonal Pathway?

Hawkins, BF.[1], Daunt, F.[1], Monaghan, P.[2], Newell, M.[1], Wanless, S.[1] and Dawson, A.[1]

[1]Centre for Ecology and Hydrology

[2]University of Glasgow

e-mail: betwki@ceh.ac.uk; frada@ceh.ac.uk; p.monaghan@gla.ac.uk; manew@ceh.ac.uk; swal@ceh.ac.uk; asda@ceh.ac.uk

In order to understand recent declines in North Sea populations of black-legged kittiwakes (*Rissa tridactyla*), within-individual physiological responses to environmental change must be considered. Kittiwake body mass and breeding activity has been recorded on the Isle of May, Scotland for over 20 years. These data have allowed exploration of the relationships linking fisheries and oceanographic factors to productivity and life history decisions. Breeding success has varied over this period between 0.02 and 1.38 chicks fledged per nest and there is a positive relationship across years between average body mass and breeding success. In 2010, a detailed study was undertaken to assess the links between nutritional stress and subsequent breeding failure. Nest were monitored daily and breeding adults were caught during incubation and chick rearing in order to measure body condition and take blood samples for hormone analysis. We examined whether changes in a stress hormone (corticosterone) and a hormone linked to parental behaviour (prolactin) related to body condition and timing of breeding failure. This question is of fundamental importance to our understanding of climate effects on seabirds. Changes in these two hormones are likely to underpin the resolution of the trade-off between reproduction and survival, and how individuals vary in their responses to the currently challenging conditions during breeding in the North Sea.

No Apparent Effect of Sex on Brünnich's Guillemots' (*Uria lomvia*) Time-Budgets during Incubating and Chick Rearing Despite Segregated Attendance Patterns at Kippaku, Northwest Greenland

Huffeldt, NH.[1], Linnebjerg, JL.[2], Falk, KF.[2], Frederiksen, MF.[2] and Merkel, FM.[3]

[1]Dept. of Arctic Environment, NERI, Aarhus University and University of Copenhagen
[2]Dept. of Arctic Environment, NERI, Aarhus University
[3]Dept. of Arctic Environment, NERI, Aarhus University and Greenland Institute of Natural Resources
e-mail: nph@dmu.dk; ckj430@alumni.ku.dk; jafl@dmu.dk; knudfalk@hotmail.com; mfr@dmu.dk; fme@dmu.dk

Time-budgets of male and female Brünnich's Guillemots (*Uria lomvia*) from Kippaku, Northwest Greenland were compared throughout the 2010 breeding season using direct observations and time-depth recorders. Time-budgets are considered as one of the most useful parameters for seabird monitoring to detecting, and understanding environmental change. Uria sp. have recently been shown to have differences in aspects of their time-budgets between males and females, and between incubation and chick rearing. Therefore, understanding time-budgets between males and females throughout the breeding season is important in understanding how a colony may responds to environmental change, and to illuminate if sexes differ in their allocation of time to certain behaviours. The results were tested using linear mixed effect models. Diurnal attendance differed between the sexes, with males incubating/brooding primarily during day hours, while females were there during the "night" hours. Females and males differed in attending their mate at the colony. Otherwise, we found no overall sex effects for the Kippaku colony, but proportion of trips spent foraging and resting on the water were found to be different for the sexes when chick age was accounted for. The sexes provisioned their chick equally per day. However, there were significant differences in time-budgets between incubation and chick rearing stages when sex was not considered. For this colony it appears that males and females use similar effort during the breeding season, but change how they spend their time between incubation and chick rearing.

Quantifying the Potential Avian Impacts of the World's First Commercial Tidal Current Turbine: SeaGen

Inger, R., Christen, N. & Bearhop, S.
Centre for Ecology and Conservation, University of Exeter
e-mail: richinger@gmail.com; nadja_ch@hotmail.com; s.bearhop@exeter.ac.uk

It is clear that there must be a paradigm shift in energy production from fossil fuels to alternative energy sources to mitigate the effects of anthropogenically induced climate change. The marine environment is a virtually untapped source of energy and marine renewables are likely to provide a substantial component of these novel energy sources.

Marine renewable energy installations can broadly be categorised as those exploiting the power of the wind, waves and the tides. Tidal current stream turbines harness the power of the latter, and the world's first commercially viable device is currently installed in the mouth of the UK's largest sea lough, Strangford in Northern Ireland. While much of the concerns of the potential environmental impacts of SeaGen have concentrated on the effect on marine mammals, there exists the possibility that such devices may also impact on local avian populations, particularly diving species.

Initial monitoring of the SeaGen site before and after installation of the device revealed a slight displacement effect on some species, although this is thought to be biologically insignificant. While single devices are unlikely to detrimentally affect avian populations, arrays of such devices, which are planned for the future, have the potential to produce additive effects, which might prove to have significant impacts. In this study we aim to identify the more subtle displacement effect and behavioural changes that SeaGen may be having on local avian populations and use these data to extrapolate the effects to arrays of devices.

Wintering Areas of Three Sympatric Breeding Alcids

Linnebjerg, JL. and Frederiksen, MF.
Aarhus University
e-mail: jafl@dmu.dk; mfr@dmu.dk

The archipelago Kitsissut Avalliit off south Greenland holds an unusually high diversity of breeding seabirds, including five sympatric breeding alcids. Limited ringing recovery data suggest that Brünnich's guillemots move north to winter off the western coast of Greenland as well as off Newfoundland; and common guillemots winter off west Greenland. We used geolocators to identify the migration routes and wintering areas of adult breeding Brünnich's guillemots, common guillemots and razorbills from 2009-2011. Most birds were followed for two years, and preliminary results from the first winter show large variation between species. As expected, Brünnich's guillemots migrated north after the breeding season where they stayed until the return to the breeding area in early April. Common guillemots had two distinct migration routes. One wintering area was just off the coast of south-west Greenland, while the other route brought the birds to east Greenland. Razorbills migrated to Newfoundland, where some individuals stayed for the entire non-breeding period, some stayed for a while before continuing to Nova Scotia, while others flew straight to Nova Scotia, before heading back to south Greenland. We compare the full migration schedules over two years of known-sex birds of all three species.

Estimating Breeding Success by Remote Time-lapse Photography and GIS-based Analyses in a Cliff-nesting Seabird

Merkel, FM.[1], Huffeldt, NH.[2] and Johansen, KJ.[1]
[1]University of Aarhus
[2]University of Copenhagen
e-mail: fme@dmu.dk; nph@dmu.dk; kalj@dmu.dk

Breeding success is an important reproductive measurement in most seabird monitoring programs. It is a valuable predictor of future population development and is sometimes used in adaptive management to adjust harvest levels. At the same time, it is useful as an indicator for environmental change. The measurement is widely used, easily compared between years and locations and there is a long tradition for measuring breeding success. In practice, however, breeding success is one of the most work-intensive measurements to collect as it requires several observation periods over the breeding season. As seabirds often nest in remote logistically challenging locations that usually imply expensive use of man-hours and solid funding.

In this study we propose an alternative "no-fieldwork-required" method to estimate breeding success using remote time-lapse photography and GIS-based analyses. With this method a single visit every second or third year is adequate in the collection of annual data covering the entire breeding season. In this case study of Brünnich's Guillemots (*Uria lomvia*) in West Greenland, we used photos taken once an hour from the 30th of June until the 30th of July 2010 (n = 730) and in the same period we made direct observations to be able to verify the method. For each photo, all birds within the study plot were identified and recorded in a GIS. On the basis of spatial analyses of these data, the breeding sites in the plot were identified. Subsequently, breeding success at the individual sites was evaluated from analyses of continuity in attendance. Preliminary results indicate that this is a promising method to estimate breeding success, potentially applicable to other species of gregarious birds. The method serves multiple purposes as it automatically generates data on bird numbers and colony attendance in addition to information on breeding success.

Interactions between Puffins and Larus gulls on Burhou, Channel Islands: A Review of the Last Five Years of Management.

Morgan, EM.
Alderney Wildlife Trust
e-mail: ecologist@alderneywildlife.org

One of the most southerly breeding colonies of Atlantic Puffin (*Fratercula arctica*) in the East Atlantic is located on Burhou (Alderney, Channel Islands). Puffin numbers in this area declined severely from around 1970-1980, probably due to the effects of oil spills and human disturbance. Since the 1980s Puffin numbers on the island remained relatively stable. The number of Larus Gulls (especially Lesser-Black Backed Gulls (*Larus fuscus*)) nesting on the island over this period, however, has increased dramatically. Due to concerns that an increasing gull population could be limiting the chance of Puffin population recovery, a management strategy was set up in 2007 to try and facilitate an increase in the number of breeding Puffins on Burhou. This strategy involved some habitat management work (namely bracken control) and the setting up of 'gull exclusion zones' within approximately 50m of the main puffin colonies. Within these zones gulls were discouraged from nesting and any nesting attempts were removed.

Five years on we review the successes and limitations of this management strategy. Preliminary findings are indicative of a small rise in apparently occupied Puffin burrows (AOB). In 2005-2007 an average of around 120 pairs of Puffin bred on the island, by 2010 this figure had risen to around 150 pairs. Though this increase is not significant ($r=0.7$, $p=0.19$) there appears to have been a shift in the distribution and density of AOBs on the Island. Fewer puffins appear to be nesting in the East and West ends of the Island and there has been an increase in numbers using the more central colonies where management efforts have been more heavily focused.

Validation of Chick Diet and Provisioning Rate of Common Guillemots Using Videos

Newell, MA., Harris, MP., Wanless, S. and Daunt, F.
CEH
e-mail: manew@ceh.ac.uk; mph@ceh.ac.uk; swanl@ceh.ac.uk; frada@ceh.ac.uk

Chick diet and provisioning rate in bill-loading seabirds is typically recorded from direct observations of breeding birds returning to the colony with prey. However, validation is important to quantify any error or bias associated with this method. In this study, we carried out a dawn to dusk observation watch of 99 pairs of common guillemot *Uria aalge* breeding on the Isle of May on 22nd June 2009, and simultaneous video recording of a subset of the study group (n = 36 pairs). For each arrival of a bird returning to provision the chick, we recorded the time, the nest site identity and prey species and size. Whilst the video recording was not of sufficient quality to identify prey species or size, it was able to validate the provisioning rate and nest site identity. Thus, we ascertained the percentage of arrivals that were missed by observers and of nest sites that were correctly identified. Validation of provisioning rate is important in parameterising consumption models, and accurate nest site identification enables appropriate testing of important potential determinants of diet and provisioning rate such as nest site characteristics, past success rate and chick age.

The Non-breeding Season Migration of the Round Island Petrel

Nicoll, MAC.[1], Jones, CG.[2], Ratcliffe, N.[3], Tatayah, V.[4] and Norris, KJ.[1]
[1]University of Reading
[2]Durrell Wildlife Conservation Trust
[3]British Antarctic Survey
[4]Mauritian Wildlife Foundation
e-mail: m.a.c.nicoll@reading.ac.uk; carlgjones@btinternet.com; notc@bas.ac.uk; vtatayah@mauritian-wildlife.org; k.norris@reading.ac.uk

The Round Island petrel is a medium sized petrel that breeds on Round Island, Mauritius, in the Western Indian Ocean. The population breeding on Round Island is actually a species complex, consisting of one Atlantic species, two species from the South Pacific, and inter-specific hybrids and therefore consists of individuals with a range of genetic and hence geographic origins dictated by its evolutionary history. As one component of a wider programme of research we are interested in understanding if an individual's origin affects at sea distribution patterns, particularly in the non-breeding season. Therefore, from November 2009 - February 2010 we deployed 135 MK15 British Antarctic Survey (BAS) geolocators on adult petrels on Round Island and here we report the recorded migration routes. Between October 2010 and February 2011, 75 of these geolocators were recovered and we were able to obtain data from 63 of the tags using the relevant BAS software, whilst the remaining 12 failed during deployment. For each petrel the over-winter migration period was established by examining the activity (time on/off water in a 24 hour period) and light transition data to determine the appropriate start/end dates and the most probable track was estimated using the analytical package 'tripEstimation' in R 2.11.1. Tagged petrels left Round Island between 28/11/2009 and 29/08/2010 and were at sea for on average 192 days (+/- 40days, range 130-323 days) before returning between 20/05/2010 and 21/01/2011 having covered on average 27307 km (+/- 6709km, range 12804-43615 km). The tracks from the 63 petrels covered the majority of the Indian Ocean north of 40oS (excluding the Bay of Bengal and the south-western section of the Somali basin), the Arabian Sea and the Gulf of Oman. Preliminary mapping of the data revealed extensive between-individual variation, but 'population-level' concentrations of activity in and around the Arabian basin, the Mascarene basin/ridge, the southern end of the mid-Indian basin and the Cocos (Keeling) Islands. We suggest that the majority of tracked petrels are targeting productive ocean areas and that their use of these areas may coincide with seasonal phytoplankton blooms and favourable wind conditions.

Low Adult Survival Probabilities Threaten the Yelkouan Shearwater *Puffinus yelkouan*

Oppel, S.[1], Raine, AF.[2], Borg, JJ.[3], Raine, H.[2], Bonnaud, E.[4], Bourgeois, K.[5] and Breton, AR.[6]

[1]RSPB

[2]BirdLife Malta

[3]Heritage Malta

[4]IPNA-CSIC

[5]Université Paul-Cézanne

[6]Colorado State University

e-mail: steffen.oppel@rspb.org.uk; mkazuni@yahoo.co.uk; diomedea@onvol.net; helenleach2002@yahoo.co.uk; ebonnaud@ipna.csic.es; karen.bourgeois@univ-cezanne.fr; insightdd@gmail.com

Many seabird species are experiencing population declines, with key factors being high adult mortality caused by fishery by-catch and predation by introduced predators on nesting islands. In the Mediterranean, both of these pressures are intensive and widespread. We studied the adult survival of an endemic Mediterranean seabird, the Yelkouan shearwater (*Puffinus yelkouan*), between 1969-1994 and 2007-2010 in Malta and between 2004-2010 in France using mark-recapture methods. Mean annual survival probabilities for breeding adults were below 0.9 for all colonies and periods. Between 1969-1994, annual survival for adults of unknown breeding status was on average 0.74 (95% confidence interval: 0.69-0.80) in Malta, possibly as a result of various human disturbances (including illegal shooting), light pollution and fisheries by-catch. Over the period 2004-2010, we found strong support for variation in adult survival probabilities between breeders and non-breeders, and islands with and without introduced predators in France. Survival probabilities for non-breeders (0.95, 0.81-1.0) appeared to be higher than for breeders (0.82, 0.70-0.94), but were imprecise partly due to low recapture probabilities. In Malta, we found evidence for heterogeneity in survival probabilities between two unknown groups (probably breeders and non-breeders), and seasonal variation in survival probability. Birds were more likely to survive the period including the peak breeding season than an equally long period during which they roam widely at sea. Although annual adult survival probability was still low (0.85, 0.58-1.0), colony protection measures appear to have reduced mortality at nesting cliffs. Our estimates of adult survival probabilities over the past four decades are consistent with overall population declines. Threats to Yelkouan shearwaters require immediate management actions to avoid ongoing population declines in the western Mediterranean.

Factors Affecting Weight and Survival of Fledgling Manx Shearwaters *Puffinus puffinus*

Perrins, CM.
University of Oxford
e-mail: chris.perrins@zoo.ox.ac.uk

Fledgling Manx Shearwaters come to the surface in late August and through September. They are present on the surface for a few dark nights before departure. The first fledglings come to the surface around the 20th August and most have departed by 10th September, though in some recent years fledging seem to have been a bit later than this. They leave on their own, their parents having already left.

Manx Shearwaters were studied intensively on Skokholm Island during the decade 1964-74. During that time more than 70,000 fledglings were ringed. Of these more than 11,000 were encountered again, mostly on the island, but others elsewhere (recoveries in the calendar year of hatching were excluded). In addition, in the three years 1965-67 more than 11,000 fledglings were weighed. Recaptures on Skokholm ceased when the island ceased to be a Bird Observatory. Recoveries from elsewhere continued for some years and although a few of the birds are probably still alive, recoveries elsewhere have now ceased because the rings became worn and fell off.

There is a steady decline in fledging weight through the season. This analysis shows that both date of fledging and weight of the young birds affect their chance of future survival.

Further, there is evidence that fledging weight has declined with time and the birds fledging today are lighter than they were in the 1960s. This may have implications for the future health of these large colonies.

South Polar Skuas from a Single Breeding Population Overwinter in Different Oceans

Peter, HU.[1], Kopp, M.[1], Phillips, RA.[2] and Hahn, S.[3]
[1]Jena University, Polar & Bird Ecology Group
[2]British Antarctic Survey, Natural Environment Research Council, Cambridge
[3]Swiss Ornithological Institute,Sempach
e-mail: bpe@uni-jena.de; koppi2000@gmx.de

Seabirds in seasonal environments are often long-distance migrants and, for many species and populations, ranges throughout the non-breeding period are unknown. As conditions during the non-breeding season often affect subsequent performance, the choice of migration strategy can have major implications for timing of breeding and success and, ultimately, population dynamics.

We equipped adult Skuas with geolocators (MK5 and MK9; British Antarctic Survey, Cambridge) during four breeding seasons (2006-2009) at King George Island in the Maritime Antarctic (62°12'S, 58°58'W). Sixty-five individuals were recaptured at the same breeding site during consecutive seasons until 2011, resulting in 85 annual tracks, in some cases three consecutive years for one bird. Overall, 72% of individuals migrated to the Atlantic, and 28% to the Pacific Ocean. Individuals choose the same ocean in consecutive non-breeding seasons. Ninety-two percent of Skuas overwintered in the northern hemisphere, in three regions in the Atlantic and two in the Pacific. Despite migrating to different oceans, birds showed a similar figure-of-eight flight pattern, and equivalent residency periods in the main wintering areas. In addition, 87% of the migrants used stopped-over at terminal staging sites off South America shortly before return to the breeding site.

The remarkable diversity of migration patterns recorded in this study suggests that nonbreeding Skuas experience a wide range of environmental conditions, as oceanography and climatic oscillations differ fundamentally between the north Pacific and Atlantic. This suggests a degree of flexibility in terms of habitat requirements, which might buffer this species from possible adverse of future climate change or other anthropogenic threats in wintering grounds. Nevertheless, as conditions experienced during one stage of the annual cycle can have repercussions, the adoption of a particular migration strategy may affect body condition on return to the colony, laying date, breeding success or survival. If so, as environmental conditions change over time, certain strategies will offer a selective advantage. Assuming, as seems likely, the migration pattern is heritable, this has implications for population dynamics and genetic structure in the future.

Inter and Intra-colony Differences in Wintering Foraging Area Use by Northern Fulmars

Quinn, LQ.[1], Cabot, DC.[2], Meharg, AM.[1], Phillips, RP.[3] and Thompson, PT.[1]
[1]University of Aberdeen
[2]Little Saltee
[3]British Antarctic Survey
e-mail: lucy.r.quinn@abdn.ac.uk; david@cabotandco.com; a.meharg@abdn.ac.uk; raphil@bas.ac.uk; lighthouse@abdn.ac.uk

Light-based geolocators are revolutionising our understanding of seabird foraging and habitat use over the non-breeding period. Increased information of this time period will be an important part of understanding a species' overall dynamics. Northern fulmars, though still numerous in the UK, are nevertheless experiencing declines in several UK and Irish colonies. Investigating differences in wintering foraging areas both within and between colonies and characterizing an individual's wintering area will potentially aid in understanding differences in breeding success and population dynamics of the fulmar. We employed GLS loggers to track northern fulmars at both a Scottish (Eynhallow, 2006-2011) and Irish (Little Saltee, 2010-2011) colony. Locations obtained from geolocator data demonstrate individual, sex, pair and inter-annual differences in the extent to which birds use wintering foraging areas in the North Atlantic. Consistency in wintering foraging area use is shown and inter-colony comparisons will also be discussed. Work in identifying an individual's wintering habitat may help explain why the northern fulmar in the North Sea is currently experiencing such declines.

Nutritional Constraints on Egg Size: The Role of Calcium in the Intra-clutch Pattern of Egg Size Variation

Ramirez, F.[1], García-Tarrasón, M.[1], Rami, L.[2], Genovart, M.[3], Sanpera, C.[1] and Jover, L.[1]
[1]UB
[2]UAB
[3]IMEDEA-CSIC
e-mail: ramirez@ub.edu; m.garcia@ub.edu; laura_rami@hotmail.com; xell@imedea.uib-csic.es; csanpera@ub.edu; lluis_jover@ub.edu

Mechanisms of resource acquisition and allocation to egg formation are crucial for the comprehension of avian reproductive strategies. However, little is known about how egg formation in wild birds might be constrained by the availability of specific nutrients such as calcium (Ca). We investigated the relationship between plasma levels of Ca (mg/dL) in incubating Audouins' Gulls (*Larus audouinii*) and egg size (total egg weight, g). Female plasma levels of Ca were adjusted by the number of days elapsed between clutch completion and the capture of individuals (i.e. days of incubation) to account for observed negative trend of Ca values throughout incubation (slope 95% CI = -0.24, -0.07). Subsequently, we investigated the relationship between adjusted plasma levels of Ca and the size of particular eggs within the laying sequence (first-, second, and third/last-laid eggs). Adjusted Ca levels were positively related to the size of third-laid eggs (slope 95% CI = 1.06, 4.12), whereas no significant relationships were observed for the first- and second-laid eggs. Accordingly, the intra-clutch pattern of egg size (commonly based on the relatively smaller size of last-laid eggs) varied according to female plasma levels of Ca with a less pronounced intra-clutch profile for females with higher Ca levels. Results suggest that the availability of Ca for breeding females may play a fundamental role in determining the relative size of the last-laid egg and, therefore, to the intra-clutch pattern of egg size variation.

Activity Patterns of Pelagic Seabirds during the Nonbreeding Period

Reyes, JM.[1], Phillips, RA.[2] and González-Solís , J.[1]
[1]Universitat de Barcelona
[2]British Antarctic Survey
e-mail: josemanuel.delosreyes@ub.edu

At-sea activity budgets of pelagic seabirds remain largely unknown, especially during the non-breeding period. Recently, the development of combined geolocator-immersion loggers has made it possible not only to determine location but also the proportion of time spent flying and resting, as well as the frequency of takeoffs and landings over the entire annual cycle. This information is critical not just for reconstructing general activity budgets, including during long-distance migration, but for a better understanding of the role that foraging mode plays in determining the ecological niche. The main aim of this study was to compare the activity budget of shearwaters and petrels during the non-breeding period. We deployed geolocators on Cory's (*Calonectris diomedea borealis*), Scopoli's (*C.d. diomedea*), Cape Verde (*C. edwardsii*), Cape Verde little (*Puffinus boydi*), Macaronesian (*P. baroli*), great (*P. gravis*) and Manx (*P. puffinus*) shearwaters, and on Bulwer's petrels (*Bulweria bulwerii*). We recorded a broad spectrum of activity budgets, ranging from mainly diurnal to mainly nocturnal species, revealing a temporal axis of trophic segregation among northeast Atlantic seabird species. Activity during long-distance migration in some species was also clearly influenced by the moon.

How do we Accurately Estimate the Foraging areas of Seabirds?

Soanes, L.[1], Dodd, S.[2], Arnould, J.[3] and Green, J.[1]
[1]University of Liverpool
[2]RSPB
[3]University of Deakin
e-mail: louise.soanes@liv.ac.uk; stephen.dodd@rspb.org.uk; john.arnould@deakin.edu.au; jonathan.green@liv.ac.uk

Seabirds breeding on Puffin Island, Anglesey were tracked during the breeding season using IgotU GPS loggers to determine their foraging areas. GPS loggers were deployed for two to six days which recorded 2-15 foraging tracks per individual. Two seabird species were tracked, a coastal benthic feeder – the European shag *Phalacrocorax aristotelis* and an offshore surface feeder- the Black-legged kittiwake *Rissa tridactyla*. The R package Adehabitat was used to perform kernel density analysis for each species using cumulative trips per individual and cumulative numbers of individuals, our aim was to determine the minimum number of foraging trips or individuals that could accurately estimate an individual's or population's foraging area. This work will aid the planning stages of future spatial analysis studies which are often limited by time and financial resources. It will also have implications for studies determining inter-individual specialisation and the use of tracking data to define important foraging areas.

Seabird-windfarm Interactions are revealed through GPS Telemetry

Thaxter, CB.[1], Ross-Smith, VH.[1], Clark, NA.[1], Conway, GJ.[1], Bouten, W.[2] and Burton, NHK.[1]

[1]British Trust for Ornithology

[2]University of Amsterdam

e-mail: chris.thaxter@bto.org; viola.ross-smith@bto.org; nigel.clark@bto.org; greg.conway@bto.org; w.bouten@uva.nl; niall.burton@bto.org

The UK Government has a commitment to obtain 15% of the country's electricity from renewable sources by 2020. Thus many wind farms are currently under construction, and several more are proposed. Wind farms may impact bird populations directly, through displacement, presenting barriers to movement and collision mortality, as well as indirectly through changes to habitat or prey. We report on preliminary investigations into the foraging behaviour of Lesser Black-backed Gulls and Great Skuas, that are features of UK Special Protection Areas (SPAs) to understand (1) their connectivity with consented and proposed wind farm development zones, (2) the extent of use of such zones, and (3) flight altitudes that could inform collision risk modelling. In summer 2010, GPS tags were fitted to 11 Lesser Black-backed Gulls at Orford Ness, part of the Alde-Ore Estuary SPA, and four Great Skuas on the Foula SPA in Shetland. For Lesser Black-backed Gulls, 70 out of 352 foraging trips contained a marine component (maximum foraging range, 159 km). However, some birds never foraged offshore, while others spent more than half their time at sea. For those foraging offshore, considerable temporal and spatial overlap was recorded with Round 1 and 2 wind farms currently under construction, as well as with proposed Extensions and Round 3 development sites (maximum 95% kernel density estimate per bird = 49%). Great Skuas had a maximum foraging range of 219 km (88 marine foraging trips), but no overlaps with wind farms were recorded, as there are none within the vicinity of the colony. However, Great Skuas may interact with wind farms outside the breeding season on their migrations (a subject of further investigation). Preliminary assessment of precision and accuracy of altitude measurements revealed that both species often flew at altitudes where they might be vulnerable to disturbance by wind turbines. These initial analyses show the value of GPS data in assessing connectivity and potential interactions between SPA features and offshore wind farms. Further data are currently being collected, including assessment of migration routes, which will provide a much clearer understanding of seabird-windfarm interactions.

Is Fledging Success Determined by Differences in Maternal Egg Investment?

van Noordwijk, HJ. and Quillfeldt, P.
Max Planck Institute for Ornithology, Vogelwarte Radolfzell, Germany
e-mail: riekvn@gmail.com; quillfeldt@orn.mpg.de

Seabirds often live in fluctuating environments where food availability during a season can be unpredictable as well as large fluctuations between breeding seasons occur. Within such a system we investigated if we could explain differences in reproductive output between breeding seasons by differences in maternal investment under different environmental conditions. Females might alter their offspring's phenotype, independent of genes, by the amount they invest in egg size, egg composition of yolk and albumen in nutrient content, but also in the hormone content, and even by laying earlier or later in the season. All these factors can have long lasting effects on the growth and behaviour of their offspring and on its survival in the short and long term.

We collected data in three consecutive breeding seasons 2006/07, 2007/08 and 2008/09 on Imperial Shags (*Phalacrocorax albiventer atriceps*) on the Falkland Islands. As an indicator for the environment we used sea surface temperature (SST) data. The SST was significantly lower during egg laying in the year that stable isotope analyses of eggshells revealed that females had foraged on a higher trophic level during laying. This year also had earlier laying dates. Egg mass was not significantly higher in this year, but interestingly, eggs hatched heavier chicks. Suggesting the egg composition was different. The fledging success in this year was also significantly higher with 1.9 nestlings per nest than in the other breeding seasons with 1.3 and 1.4 nestlings per nest. But, although the year with the higher fledging success had earlier laying dates and higher hatching masses, individual variation of these factors had no direct influence on fledging. We therefore argue that laying date and the relation between egg mass and hatching mass are indicators of environmental quality but not themselves determining fledging success.

Enrichment of Short Telomores with Ageing in Audouin's Gull (*Larus audouinii*)

Vera, E.[1], García-Tarrasón, M.[2], Blasco, M.[1], Genovart, M.[3], Jover, L.[2] and Sanpera , C.[2]
[1]CNIO
[2]UB
[3]IMEDEA-CSIC
e-mail: evera@cnio.es; m.garcia@ub.edu; mblasco@cnio.es; xell@imedea.uib-csic.es; lluis_jover@ub.edu; csanpera@ub.edu

Telomer are short tandem repeated sequences of DNA that cap eukaryotic chromosomes and function in stabilizing chromosome end integrity. Telomere shortening has been included among the intrinsic factors involved in the rate of aging in several species of birds and mammals. Up to now, the main assay to determine TL (telomere length) in avian studies in the wild has been the TRF (Telomere Restriction Fragment) carried on nucleated erythrocites. However, TRF can only report an average value of telomere length for the whole cell sample and includes also subtelomeric sequenceswhich vary in length.

In the present study we analysed TL dynamics in Audouin's gulls of known age and sex. We used the High throughput Q-Fish method (HTQ-FISH) on PBMC (PerIpherical Blood Mononucleated Cells) which provides a quantification of individual telomere spots within the nuclei. We discuss the relationship between age and several location measures of individual telomere length distribution. As short telomeres are the direct responsible for telomere dysfunction we were particularly interested in relate aging to the percentage of short telomeres as a more sensible measure of telomere variation. Gender differences at several age classes on both, TL and the percentage of short telomeres are also assessed.

Spatial Use of the Marine Environment by Breeding Great Skuas *Stercorarius skua* and Potential Effects of Marine Renewable Energy Developments

Wade, HM.
Environmental Research Institute - University of the Highlands and Islands
e-mail: helen.wade@thurso.uhi.ac.uk

The marine renewable energy industry is growing rapidly in Scotland, with areas of the Pentland Firth and Orkney waters proposed to become 'the Saudi Arabia of renewable energy'. Commercialization of wave energy converters could result in large areas of the ocean being used as wave farms, with numerous devices occupying the sea surface. It is largely unknown how seabirds focus their foraging efforts in the marine environment and which areas are key for foraging activity. Evidence from the offshore wind energy industry suggests that seabirds may be affected by marine renewable energy developments (MREDs) through disturbance and displacement from areas of the marine environment. Should MRED sites overlap with key foraging locations there are potential implications for seabird populations.

The Pentland Firth and Orkney waters are important areas for breeding great skuas, many of which nest in Special Protection Areas (SPAs). Several of these SPAs are located in the vicinity of sites leased for development of marine renewable energy. As approximately 60% of the global great skua population breeds in Orkney and Shetland it is essential that this population is not negatively impacted by MREDs. In addition, great skuas are known for their prey switching ability, which may have wider implications for other seabird populations should MREDs displace great skuas from foraging areas and alter their behaviour. At present, our knowledge of great skua foraging activity and how great skuas utilise the marine environment is limited.

Using biologging technology, this project aims to identify foraging locations and establish how great skuas utilise the marine environment. Ten solar-powered data loggers will be deployed on breeding great skuas from a colony on Hoy, Orkney. High resolution GPS data will provide information on the distances that great skuas travel to forage during the breeding season and locations of foraging activity. Tri-axial accelerometer data will provide an insight into the fine-scale foraging and prey-search behaviour of breeding great skuas. Information about foraging locations could inform marine spatial planning and recommendations for locating marine development sites that minimise associated seabird population impacts.

Do Seabird Breeding Colonies Function as Information Centres - A Study with Northern Gannets *Morus bassanus*?

Waggitt, JJ.[1], Briffa, M.[1], Grecian, WJ.[1], Newton, J.[2], Patrick, SC.[1] and Votier, SC.[1]

[1]University of Plymouth

[2]Natural Environment Research Council (NERC) Life Sciences Mass Spectrometry Facility

e-mail: james.waggitt@hotmail.co.uk; mark.briffa@plymouth.ac.uk; james.grecian@plymouth.ac.uk; jason.newton@glasgow.ac.uk; samantha.patrick@plymouth.ac.uk; stephen.votier@plymouth.ac.uk

An estimated 96% of seabird species form dense and highly aggregated breeding colonies. It is widely assumed that their colonies function as 'information centres' where information on the whereabouts of prey patches is exchanged among colony members, although robust empirical tests of this are scarce. This presumably reflects previous difficulties when tracking seabirds between their terrestrial nest sites and pelagic foraging grounds. Here we employ a number of techniques to overcome these difficulties. Using a combination of miniaturised GPS loggers, stable isotope analysis of blood plasma and conventional in-situ observations, we examine whether a large colony of northern gannets *Morus bassanus* functions as an information centre. To do this, we test the hypothesis that knowledge of prey patches are exchanged among neighbours - leading to neighbours having similar foraging tactics. However, our studies revealed: (1) neighbours tended to disperse widely over the first few minutes of their foraging trips, (2) there was no evidence of following behaviour, (3) most neighbours commuted towards different prey patches, (4) most neighbours encountered different prey patches and (5) most neighbours exploited different isotopic niches over the preceding 4-5 days. In short, our results provide very weak support for the hypothesis that knowledge of a prey patch is exchanged among neighbours. Instead we propose that because of resource dynamics and interference competition, individual or low density foraging may be adaptive for this species.

The Value of Sea-watching in Monitoring Seabirds

Wright, LJ.[1], Cook, ASCP.[1], Thaxter, CB.[1], Moran, NJ.[1], Musgrove, AJ.[1], Cook, F.[2], Barker, S.[2], Andrews, J.[2] and Burton, NHK.[1]

[1]British Trust for Ornithology

[2]Norfolk Ornithologists' Association

e-mail: lucy.wright@bto.org; aonghais.cook@bto.org; chris.thaxter@bto.org; nick.moran@bto.org; andy.musgrove@bto.org; f.cooke1@btinternet.com; jedandrews@shrike4.freeserve.co.uk; jedandrews@shrike4.freeserve.co.uk; niall.burton@bto.org

The United Kingdom is of international importance for its colonies of breeding seabirds, and the majority of populations at these sites are well monitored and protected. However, sea-watching, which is carried out at many coastal locations around the UK and nearby countries, has the potential to provide considerable information on the distribution and movements of seabirds away from their colonies throughout the year.

One of the most comprehensive UK sea-watching datasets has been collected from the Norfolk Ornithologists' Association's (NOA) Holme Bird Observatory through standardised observations undertaken since May 2005. We present the preliminary outputs of a collaborative project exploring the potential of sea-watching data, using NOA's Holme Bird Observatory dataset as a case study. Analyses are used to develop preliminary annual indices of species abundance, taking into account a range of environmental factors that caused observed bird numbers to vary.

Annual abundance indices at Holme provided a good match to observed regional population trends derived from national surveys such as the Seabird Monitoring Programme and Wetland Bird Survey. Models considering environmental factors typically matched population trends derived from national surveys more accurately than those which did not, indicating the value of correcting for these variables.

These findings demonstrate the potential value of sea-watching as a wider monitoring tool. They are discussed in light of the conclusions of a successful workshop that brought together representatives of bird observatories and other sea-watchers from around the UK and Republic of Ireland, statutory nature conservation bodies and academics to review the potential for setting up a national sea-watching monitoring scheme.

Strategic Ornithological Support Services for the Offshore Wind Industry

Wright, LJ., Ross-Smith, VH., Cook, ASCP. and Burton, NHK.
British Trust for Ornithology
e-mail: lucy.wright@bto.org; viola.ross-smith@bto.org; aonghais.cook@bto.org; niall.burton@bto.org

Renewable energy generation is widely recognised as a critical component of the effort to minimise the effects of climate change. The UK government is committed to reducing greenhouse gas emissions by 80% by 2050, and producing 15% of UK energy from renewable sources by 2020, including an estimated 25 GW of offshore renewable wind energy. The scale of offshore wind farm development currently proposed around the UK is unprecedented and raises a number of challenges. One of the key issues is the potential impact of wind farms on bird populations. Offshore wind farms may affect birds through displacement of individuals, direct mortality due to collisions, indirect changes to habitat or prey abundance and barrier effects for migrating birds or those making regular movements (for example, between breeding colonies and foraging sites). However, a number of uncertainties exist in assessing the likely magnitude of these effects, for example in relation to the distribution of many bird species with respect to development zones, and the extent to which their behaviour may place them at risk during construction and operation. These uncertainties create potential for consenting delays and may prevent regulatory authorities from granting consents.

In this light The Crown Estate and British Trust for Ornithology are collaborating with representatives from the offshore wind industry, as well as regulators and advisory bodies, to provide independent strategic ornithological support services to the wind farm industry. The group aims to identify and develop key pieces of research to address strategic ornithological issues in relation to offshore wind farm development, to improve our understanding of the impacts of offshore wind farms on birds and thus reduce the consenting risk posed by the current uncertainties in this field. The outcomes of initial projects, and the current priorities of the group, are summarised here.

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We pride ourselves on the reliability and durability of our tracking equipment and the exceptional performance delivered. We combine state of the art technology with animal-focused design to produce the most effective and yet energy efficient products on the market.

"Thanks to you and your team for the great job you did on the adult kiwi transmitters, they are all perfect dimensions and really well packaged"

Department of Conservation, NZ


Blue Duck

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Extensive Avian Product Range

Technology vs. animal weight
Quick reference

GPS

How they work: GPS receivers attached to a study species receive signals transmitted from a constellation of orbiting GPS satellites to accurately calculate its position on the earth through trilatteration. The accuracy of GPS receivers today is within several metres. Data recovery requires retrieval of the device.

Attachments options: Glue on, harness and tail mount

Range: **Micro GPS:** Small, lightweight datalogger starting at just 23 g with rechargeable batteries for multiple deployments

Argos

How they work: Argos transmitters or Platform Transmitter Terminals (PTT) attached to a study species transmit at programmed intervals to the Argos satellite network. Consecutive transmissions received by an Argos satellite are used to calculate the animal's location on earth. The locations are available to the end user in near real time with accuracies between 250 m to 1.5 km. Sirtrack KiwiSat Argos transmitters offer a wide range of dependable tracking solutions.

Attachments options: Glue on, harness

Range: **KiwiSat 202:** These efficient 0.5 W transmitters, starting at 32 g are predominantly used on penguins and include temperature sensors and salt water switches to save power when submerged.

KiwiSat 303: These avian 0.5 W transmitters, starting at 21 g, are predominantly used on flying birds and include activity/mortality and temperature sensing.

VHF

How they work: VHF transmitters attached to a study species emit a pulsed radio signal allowing a researcher to physically locate and observe the animal by homing into the signal using a receiver and directional antenna. Sirtrack VHF transmitters are easy to use, reliable and versatile providing exceptional value.

Attachments options: Glue on, harness, implant, leg band, necklace, tail mount

Range: **Lite TX:** Small, light weight transmitter from 0.9 to 7 g for small wildlife as light as 20 g body weight with up to seven months life.

Core TX: Life, range and power output significantly higher than above and micro controlled for smart functionality including duty cycling and mortality, from 7 to 25 g.

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Electronic tag applications

Case study

1

2

3

4

1 Little penguins are the first diving bird to be tagged using the G5.

2 Plaice are just one fish species standing to benefit from the introduction of the new tags.

3 G5 tags have revealed new insights into mink behaviour.

4 G6A tags have been used to investigate loggerhead turtle activity patterns.

CTL
Cefas Technology Limited

Diving birds

One of the first applications for the tags was studying little penguin behaviour in Australia. Large tags have the effect of introducing underwater drag, which can affect the behaviour of tagged diving birds. As the drag effect is cumulative, so the behavioural effects may be increased over time, and accuracy of results diminished. The small size of the G5 tag means reduced drag, and therefore genuine behavioural data are collected.

Data were collected during the day-long diving trips that the penguins undertook. Depth and temperature information was recorded every second during the penguins' dives, and graphs of the results produced once the tags were retrieved. The G5 also recently demonstrated its reliability and robustness when it was used in studying little auk diving behaviour in the Arctic Ocean.

Fish behaviour

Studies of North Sea plaice have largely been restricted to tagging mature female fish, which are larger than males and juveniles and can carry older generations of DST. However, the small size and low weight of the G5 enables it to be used successfully to tag male and immature female plaice. Previous studies demonstrated that North Sea plaice have a relatively elaborate population structure. Using the G5, population structures are already being seen that have not been predicted in spite of 100 years of conventional tagging data. Scientists are also using the tags to investigate the differences in female and male plaice behaviour.

Diving mammals

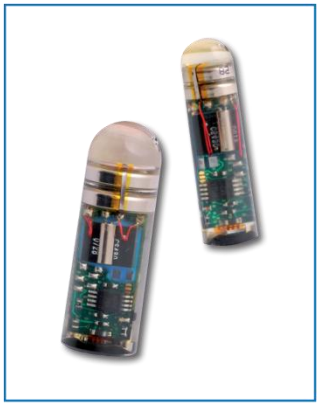
Scientists have used the G5 to investigate diving behaviour in free-living American mink in lowland rivers. The size and the weight of the G5 allows tags to be attached directly to radio-collars. Because mink are nocturnal, elusive and only active for a few hours per day, it is generally impossible to directly observe their behaviour, and radiotracking does not show exactly what an individual is doing. Most previous studies of mink diving behaviour have been limited to laboratory studies. Several hundred dives have been recorded using the G5, already revealing new insights into mink behaviour.

Accelerometer studies

Investigating at-sea activity patterns of free ranging sea turtles remains difficult. Direct in-water observations and the use of animal-borne video have allowed the collection of information on activity patterns for only short periods of time (i.e. a maximum of 24 hours). The recent development of a tri-axial accelerometer however provides new means to assimilate detailed activity-budgets over relatively long periods of time for free-ranging individuals.

G6a were deployed on female loggerhead turtles to investigate their activity patterns during their nesting season in Greece. Depth, temperature and accelerometry data were collected for 6 weeks and revealed interesting activity patterns that were never described before.

www.cefastechnology.co.uk



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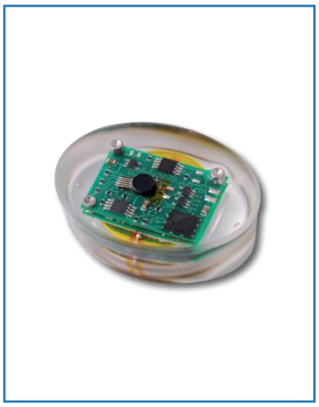

6

5 Cefas G5 / G5 Long Life
6 Cefas G6A

About us

The Centre for Environment, Fisheries and Aquaculture (Cefas) is a multidisciplinary scientific research and consultancy centre. We provide a comprehensive range of services in fisheries management, environmental monitoring and assessment, and aquaculture to a large number of clients worldwide. We have more than 500 staff based in two laboratories, our own ocean-going research vessel and over 100 years of fisheries experience. We have a long and successful track record in delivering high-quality services to clients in a confidential and impartial manner. (www.cefas.co.uk)

Cefas Technology Limited (CTL) is a wholly owned subsidiary of Cefas specialising in the application of Cefas technology to specific customer needs in a cost-effective and focussed manner. CTL systems and services are developed by teams that are experienced in fisheries, environmental management and aquaculture, and in working closely with clients to ensure that their needs are fully met. (www.cefastechnology.co.uk)

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With our unique facilities and our breadth of expertise in environmental and fisheries management, we can rapidly put together a multidisciplinary team of experienced specialists, fully supported by our comprehensive in-house resources. Our existing customers are drawn from a broad spectrum with wide-ranging interests.

Clients include:

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- the World Bank
- Food and Agriculture Organisation of the United Nations (FAO)
- oil, water, chemical, pharmaceutical, agro-chemical, aggregate and marine industries
- non-governmental and environmental organisations
- regulators and enforcement agencies
- local authorities and other public bodies

We also work successfully in partnership with other organisations, operate in international consortia and have joint ventures commercialising our intellectual property.

Contact us

Matthew Eagle
Cefas Technology Limited,
Cefas Lowestoft, Pakefield Road,
Lowestoft, Suffolk NR33 0HT, UK

Tel +44 (0) 1502 524308
or +44 (0) 1502 562244
Fax +44 (0) 1502 524569
Email matthew.eagle@cefastechnology.co.uk

www.cefastechnology.co.uk

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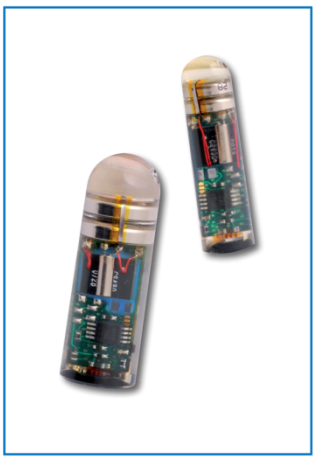
Cefas G5
Data Storage Tag

Product leaflet



G5 / G5 Long Life

- **pressure and temperature sensors**
- **small and lightweight (weighs 1g in water)**
- **up to 2MB memory**
- **optional dive logging**
- **logging rates up to 10Hz**
- **optional float**
- **up to 2 years' battery life**

Overview

Our Cefas Data Storage Tags (DST) are a result of over 20 years of DST development and expertise at Cefas. The tags have been developed by our in-house Technology team in close conjunction with the Fisheries Scientists. With this combination of technical expertise and scientific experience the tags are designed to meet the needs of scientists involved with behavioural research.

The tags are market-leading products offering considerable advantages over other tags, both in capability and price. We provide complete customer support from technical sales advice through to application and data interpretation.

Cefas G5

Launched in 2005, the Cefas G5 is much smaller and lighter than previous generations of DST, yet has a much larger memory capacity. The weight reduction helps to ensure that tagged fish, birds or animals behave as naturally as possible. This means that tagging studies can be carried out on a wider range of species, opening up new fields of research. The tag is capable of taking up to two million readings from its pressure or temperature sensors over the life of the battery, allowing it to log data at a greater resolution than other tags.

DST users want greater programming flexibility, so key features of the G5 are its independent pressure and temperature settings. Repeat Logging allows users to configure short bursts of data logging over an extended period of time.

If your research involves studying diving birds and mammals, you will be interested in our Dive Switch and Fast Logging Rate option. The Dive Switch allows the Fast Logging Rate to be activated when the animal enters the water so that dive profiles can be measured.

- Fast Logging at rates down to 0.1 seconds
- Fast Logging Rate activated by entry into water
- deactivated by removal from water / return to surface
- operates in fresh water and seawater.

Robustness and reliability of the Cefas tag technology comes as standard. Please see overleaf for a full technical specification.

Contact us

Matthew Eagle
Cefas Technology Limited,
Cefas Lowestoft, Pakefield Road,
Lowestoft, Suffolk NR33 0HT, UK

Tel +44 (0) 1502 524308
or +44 (0) 1502 562244
Fax +44 (0) 1502 524569
Email matthew.eagle@cefastechnology.co.uk

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Key features

25 January 2011

Specification	Cefas G5 Standard 1MB / 2MB	Cefas G5 Long Life 1MB / 2MB
Diameter	8mm	11.5mm
Length	31mm	35.5mm
Weight in Air	2.7g	5.7g
Weight in Seawater	1.3g	2.25g
Depth Sensors[1]	100, 200, 500, 1000, 2000m	
Absolute Max Depth	3000 m	
Operating Temperature	–2°C to 40°C	
Absolute Temp Range	–10°C to 60°C	
Maximum number of readings at 8 bit resolution	1.036M / 2.031M	
Battery Life[2]	10 months	24 months
Multiple 30 day memory fill (typical)	3	10
Rate of logging	Up to 1 hour at 1 second resolution Up to 18 hours at 1 minute resolution	
Optional Dive Logging / Water Switch	10Hz; 5Hz; 4Hz; 2Hz	

Additional specifications

Physical parameters	
Casing	Acrylic / Urethane
Real time clock	
Temperature Compensated	Yes 2°C to 34°C, User settable
Memory	
Type Flash	1MB / 2MB
Time series data points	
at 8 bit resolution	1.036M / 2.031M
at 10 bit resolution	832k / 1.625M
at 12 bit resolution	693k / 1.354M
Delayed Start of Logging	Yes
Data retention	10 years
Summary Log	Daily record of max / min parameters
Communications rate	115.2k baud
Other	
Battery Chemistry	Silver
Communication	Direct Contact
Depth sensing	
Accuracy[3]	±1% Full Scale at 12 bit ADC
Resolution	100m sensor Better than 4cm 200m sensor Better than 8cm 500m sensor Better than 15cm 1000m sensor Better than 30cm 2000m sensor Better than 60cm
Temperature Compensated[3]	Yes, 2°C to 34°C
Maximum depth before pressure sensor failure	1.5 X Full Scale
Temperature Sensing	
Accuracy	±0.1°C at 12 bit ADC Range[3] 2°C to 34°C
Resolution	0.03125°C
Response Time[4]	28 seconds
Required Peripherals	
Reader	Connected via serial port or USB serial adaptor
Data Output	CSV format (MS Excel etc.)
Software	G5 Host – Windows OS

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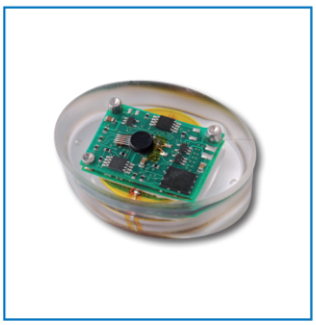
1 Optional depth sensing ranges available. **2** Under normal operating conditions and a single 1MB memory fill. Multiple deployments may significantly affect the tag life. **3** Accuracy degrades outside this range. **4** Typical time to reach 66% of step from 5 to 30 degrees.

Specifications mentioned in this publication are subject to change without notice. This publication supersedes and replaces all information previously supplied.

Cefas G6
Data Storage Tag

Product leaflet



G6 / G6 Long Life

- **pressure and temperature sensors**
- **up to 40MB memory**
- **logging rates up to 30Hz**
- **dive logging**
- **up to 10 years' battery life**

Overview

Our Cefas Data Storage Tags (DST) are a result of over 20 years of DST development and expertise at Cefas. The tags have been developed by our in-house Applied Technology team in close conjunction with the Fisheries Scientists. With this combination of technical expertise and scientific experience the tags are designed to meet the needs of scientists involved with behavioural research.

The tags are market-leading products offering considerable advantages over other tags, both in capability and price. We provide complete customer support from technical sales advice through to application and data interpretation.

Cefas G6

The Cefas G6 is based upon the tried and tested Cefas G5, logging pressure and temperature, but it offers the additional benefits of a longer life and much larger memory capacity. The tag is capable of taking up to 40 million readings from its pressure or temperature sensors over the life of the battery.

DST users want greater programming flexibility, so key features of the G6 are its independent pressure and temperature settings. Repeat Logging allows users to configure short bursts of data logging over an extended period of time.

If your research involves studying diving birds and mammals, you will be interested in our Dive Switch and Fast Logging Rate. The dive switch allows the Fast Logging Rate to be activated when the animal enters the water so that dive profiles can be measured.

- Fast Logging at rates at up to 30Hz
- Fast Logging Rate activated by entry into water
- deactivated by removal from water / return to surface
- operates in fresh water and seawater.

Robustness and reliability of the Cefas tag technology comes as standard. Please see overleaf for a full technical specification.

Contact us

Matthew Eagle
Cefas Technology Limited,
Cefas Lowestoft, Pakefield Road,
Lowestoft, Suffolk NR33 0HT, UK

Tel +44 (0) 1502 524308
or +44 (0) 1502 562244
Fax +44 (0) 1502 524569
Email matthew.eagle@cefastechnology.co.uk

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Cefas Technology Limited

www.cefastechnology.co.uk

Key features

25 January 2011

	Cefas G6 16MB	Cefas G6 40MB
Length x Width x Height (max)	40mm x 28mm x 15mm	
Weight in Air	7.3g	
Weight in Seawater	2.3g	
Depth Sensors[1]	100, 200, 500, 1000, 2000m	
Absolute Max Depth	3000m	
Operating Temperature	–10°C to 60°C	
Absolute Temp Range	–30°C to 60°C	
Maximum number of readings at 8 bit resolution	16.711M	41.88M
Battery Life[2]	5 years	
Multiple 15 day memory fill	8	4
Rate of logging	Up to 1 hour at 1 second resolution Up to 18 hours at 1 minute resolution	
Dive Logging / Water Switch	10Hz; 5Hz; 4Hz; 2Hz	

Additional specifications

Physical parameters		
Casing	Epoxy resin / Urethane	
Real time clock		
Temperature Compensated	Yes 2°C to 34°C, User settable	
Memory		
Type Flash	16 MB	40 MB
Time series data points		
at 8 bit resolution	16.711M	41.88M
at 10 bit resolution	13.369M	33.504M
at 12 bit resolution	11.141M	27.92M
Delayed Start of Logging	yes	
Data retention	20 years	
Summary Log	Daily record of max / min parameters	
Communications rate	115.2k baud	
Other		
Battery Chemistry	Lithium Manganese Dioxide	
Communication	Direct Contact	
Depth sensing		
Accuracy	±1% Full Scale at 12 bit ADC	
Resolution	100m sensor Better than 4cm 200m sensor Better than 8cm 500m sensor Better than 15cm 1000m sensor Better than 30cm 2000m sensor Better than 60cm	
Temperature Compensated[3]	Yes, 2°C to 34°C	
Maximum depth before pressure sensor failure	1.5 X Full Scale	
Temperature Sensing		
Accuracy	±0.1°C at 12 bit ADC Range[3] 2°C to 34°C	
Resolution	0.03125°C	
Response Time[4]	15 seconds / 60 seconds	
Required Peripherals		
Reader	Connected via serial port or USB serial adaptor	
Data Output	CSV format (MS Excel etc.)	
Software	G5 Host – Windows OS	

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Cefas Technology Limited

1 Optional depth sensing ranges available **2** Under normal operating conditions and single memory fill. Multiple deployments may significantly affect the tag life. **3** Accuracy degrades outside this range. **4** Typical time to reach 66% / 90% of step from 5 to 30 degrees.

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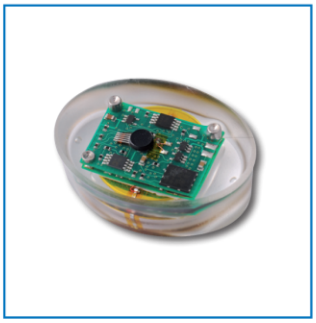
Cefas G6A Accelerometer Data Storage Tag

Product leaflet



G6A / G6A Long Life

- **pressure and temperature sensors**
- **3 axis accelerometer ±2g or ±8g**
- **up to 40MB memory**
- **logging rates up to 30Hz**
- **optional dive logging**
- **10+ years' battery life**

Overview

Our Cefas Data Storage Tags (DST) are a result of over 20 years of DST development and expertise at Cefas. The tags have been developed by our in-house Technology team in close conjunction with the Fisheries Scientists. With this combination of technical expertise and scientific experience the tags are designed to meet the needs of scientists involved with behavioural research.

The tags are market-leading products offering considerable advantages over other tags, both in capability and price. We provide complete customer support from technical sales advice through to application and data interpretation.

Cefas G6A

The Cefas G6A is a new product that includes a 3 axis accelerometer (±2g or ±8g) in addition to the usual pressure and temperature sensors. This tag also has a larger battery to support the logging of data at up to 30Hz, which offers a combination of longer life and larger memory capacity. The tag is capable of taking up to 40 million readings from its sensors over the life of the battery.

DST users want greater programming flexibility, so a key feature of the G6A is its independent sensor settings. Repeat Logging allows users to configure short bursts of data logging over an extended period of time.

If your research involves studying diving birds and mammals, you will be interested in our Dive Switch and Fast Logging Rate. The dive switch allows the Fast Logging Rate to be activated when the animal enters the water so that dive profiles can be measured.

- Fast Logging at rates up to 30Hz
- Fast Logging Rate activated by entry into water
- deactivated by removal from water / return to surface
- operates in fresh water and seawater.

Robustness and reliability of the Cefas tag technology comes as standard. Please see overleaf for a full technical specification.

Contact us

Matthew Eagle
Cefas Technology Limited,
Cefas Lowestoft, Pakefield Road,
Lowestoft, Suffolk NR33 0HT, UK

Tel +44 (0) 1502 524308
or +44 (0) 1502 562244
Fax +44 (0) 1502 524569
Email matthew.eagle@cefastechnology.co.uk

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Cefas Technology Limited

www.cefastechnology.co.uk

Key features

25 January 2011

	Cefas G6A 16MB	Cefas G6A 40MB
Max Dimensions - Length x Width x Height	40mm x 28mm x 15mm	
Weight in Air	7.3g	
Weight in Seawater	2.3g	
Depth Sensors[1]	100, 200, 500, 1000, 2000m	
Absolute Max Depth	3000m	
Operating Temperature	–20°C to 60°C	
Absolute Temp Range	–30°C to 60°C	
Maximum number of readings at 8 bit resolution	16.711M	41.88M
Battery Life[2]	10+ years	
Multiple 15 day memory fill (typical)	7	3
Rate of logging	Up to 1 hour at 1 second resolution, Up to 18 hours at 1 minute resolution	
Accelerometer range	±2g or ±8g	
Accelerometer resolution	18mg or 72mg	
Dive Logging / Water Switch	30Hz; 25Hz; 20Hz; 15Hz; 10Hz; 5Hz; 4Hz; 2Hz	
Accelerometer rate	30Hz; 25Hz; 20Hz; 15Hz; 10Hz; 5Hz; 4Hz; 2Hz	

Additional specifications

Physical parameters		
Casing	Epoxy Resin / Urethane	
Real time clock		
Temperature Compensated	Yes, 2°C to 34°C	
Memory		
Type Flash	16MB	40MB
Time series data points[5]		
at 8 bit resolution	16.711M	41.88M
at 10 bit resolution	13.369M	33.504M
at 12 bit resolution	11.141M	27.92M
Delayed Start of Logging	Yes	
Data retention	20 years	
Summary Log	Daily record of max / min parameters	
Communications rate	115.2k baud	
Other		
Battery Chemistry	Lithium Manganese Dioxide	
Communication	Direct Contact	
Depth sensing		
Accuracy	±1% Full Scale at 12 bit ADC	
Resolution	100m sensor Better than 4cm, 200m sensor Better than 8cm, 500m sensor Better than 15cm, 1000m sensor Better than 30cm, 2000m sensor Better than 60cm	
Temperature Compensated[3]	Yes, 2°C to 34°C	
Maximum depth before pressure sensor failure	1.5 X Full Scale	
Temperature Sensing		
Accuracy	±0.1°C at 12 bit ADC Range[3] 2°C to 34°C	
Resolution	0.03125°C	
Response Time[4]	15 seconds / 60 seconds	
Required Peripherals		
Reader	Connected via serial port or USB serial adaptor	
Data Output	CSV format (MS Excel etc.)	
Software	G5 Host – Windows OS	

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Cefas Technology Limited

1 Optional depth sensing ranges available. **2** Under normal operating conditions and single memory fill. Multiple deployments may significantly affect the tag life. **3** Accuracy degrades outside this range. **4** Typical time to reach 66% / 90% of step from 5 to 30 degrees. **5** Accelerometer channel can only be logged at 8bit resolution. Giving ~129 hours at 30Hz with all 3 channels.

Specifications mentioned in this publication are subject to change without notice. This publication supersedes and replaces all information previously supplied.

Cefas GPS-A
GPS and Accelerometer Data Storage Tag

Product leaflet

- **pressure and temperature sensors**
- **3 axis accelerometer +/-2g or +/-8g**
- **GPS locator**
- **40MB memory**

Overview

Our Cefas Data Storage Tags (DST) are a result of over 20 years of DST development and expertise at Cefas. The tags have been developed by our in-house technology team in close conjunction with the Fisheries Scientists. With this combination of technical expertise and scientific experience the tags are designed to meet the needs of scientists involved with behavioural research.

The tags are market-leading products offering considerable advantages over other tags, both in capability and price. Coupled with this design know-how is a competitive pricing structure and customer support from technical sales to application support.

Cefas GPS-A

The Cefas GPS-A is a new product that includes a GPS locator with a 3 axis accelerometer (±2g or ±8g), in addition to the usual pressure and temperature sensors. This tag also has a larger battery to support the GPS unit and the logging of data at up to 30Hz, which offers a combination of longer life and larger memory capacity. The tag is capable of taking up to 40million readings from its sensors over the life of the battery.

DST users want greater programming flexibility, so a key feature of the Cefas GPS-A is its independent sensor settings. Repeat Logging allows users to configure short bursts of data logging over an extended period of time.

If your research involves studying diving birds and mammals, you will be interested in our Dive Switch and Fast Logging Rate feature of these tags. The dive switch allows the fast logging rate to be activated when the animal enters the water so that dive profiles can be measured.

- Up to 700 GPS fixes
- Option to log multiple GPS fixes each day
- Fast Logging at rates up to 30Hz
- Fast Logging Rate activated by entry into water
- Deactivated by removal from water / return to surface
- Operates in fresh water and seawater.

Robustness and reliability of the Cefas tag technology comes as standard. Please see overleaf for a full technical specification

Contact us

Matthew Eagle
Cefas Technology Limited,
Cefas Lowestoft, Pakefield Road,
Lowestoft, Suffolk NR33 0HT, UK

Tel +44 (0) 1502 524308
or +44 (0) 1502 562244
Fax +44 (0) 1502 524569
Email matthew.eagle@cefastechnology.co.uk

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Cefas Technology Limited

www.cefastechnology.co.uk

Key features

25 January 2011

	Cefas GPS-A 40MB
Max Dimensions - Length x Diameter	80mm x 20mm
Weight in Air	40g
Weight in Seawater	17g
Depth Sensors	100m
Absolute Max Depth	100m
Operating Temperature	–20°C to 60°C
Absolute Temp Range	–30°C to 60°C
Maximum number of readings at 8 bit resolution	41.88M
Battery Life	700 GPS Fixes and 1 Memory fill (battery replaceable)
Maximum Number of GPS readings	700
Rate of logging	Up to 1 hour at 1 second resolution, Up to 18 hours at 1 minute resolution
Accelerometer range	±2g or ±8g
Accelerometer resolution	18mg or 72mg
Dive Logging / Water Switch	30Hz; 25Hz; 20Hz; 15Hz; 10Hz; 5Hz; 4Hz; 2Hz
Accelerometer rate	30Hz; 25Hz; 20Hz; 15Hz; 10Hz; 5Hz; 4Hz; 2Hz

Additional specifications

Physical parameters	
Casing	Acrylic / Urethane
Real time clock	
Temperature Compensated	Yes, 2°C to 34°C
Memory	
Type Flash	40MB
Time series data points[3]	
at 8 bit resolution	41.88M
at 10 bit resolution	33.504M
at 12 bit resolution	27.92M
Delayed Start of Logging	Yes
Data retention	20 years
Summary Log	Daily record of max / min parameters
Communications rate	115.2k baud
Other	
Battery Chemistry	Lithium manganese Dioxide
Communication	Direct Contact
Depth sensing	
Accuracy	±1% Full Scale at 12 bit ADC
Resolution	Better than 4cm
Temperature Compensated[1]	Yes, 2°C to 34°C
Maximum depth before pressure sensor failure	1.5 X Full Scale
Temperature Sensing	
Accuracy	±0.1°C at 12 bit ADC Range[3] 2°C to 34°C
Resolution	0.03125°C
Response Time[2]	15 seconds / 60 seconds
Required Peripherals	
Reader	Connected via serial port or USB serial adaptor
Data Output	CSV format (MS Excel etc.)
Software	G5 Host – Windows OS

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Cefas Technology Limited

1 Accuracy degrades outside this range. **2** Typical time to reach 66% / 90% of step from 5 to 30 degrees. **3** Accelerometer channel can only be logged at 8bit resolution. Giving ~129 hours at 30Hz with all 3 channels.

Specifications mentioned in this publication are subject to change without notice. This publication supersedes and replaces all information previously supplied.

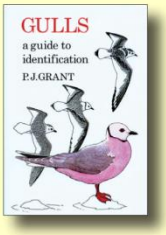
Books for Birders
Summer 2011

"NHBS have become the world's foremost supplier of natural history and environmental books."

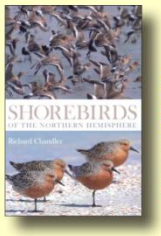
John Burton, CEO, The World Land Trust

Seabird Highlights

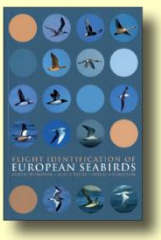
Shorebird Ecology, Conservation, and Management
Mark A Colwell
Hbk | 2010
£41.95 | #186516



Gulls: A Guide to Identification
Peter Grant
Hbk P-O-D | 2010
£50.00 | #188135



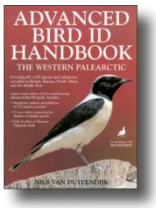
Shorebirds of the Northern Hemisphere
Richard Chandler
Pbk | 2009
£29.99 | #174969



Flight Identification of European Seabirds
Anders Blomdahl, Bertil Breife and Niklas Holmstrom
Pbk | 2007
£29.99 | #166387

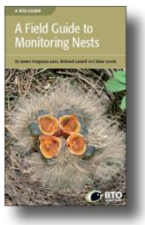
Pbk | 2010
£4.99
#188091

State of the World's Waterbirds 2010
Edited by Simon Delany, Szabolcs Nagy and Nick Davidson



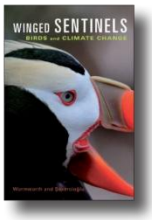
Advanced Bird ID Handbook: The Western Palearctic
Nils Van Duivendijk
Reference companion for the original Advanced Bird ID Guide with larger and more widely spaced text, and more than 100 additional pages.It has been updated with additions and amendments to 570 species accounts, all recent taxonomic changes and new species in the region.

Pbk | 2011
£24.99 | #191190



A Field Guide to Monitoring Nests
James Ferguson-Lees, Richard Castell and Dave Leech
Written and illustrated by experts, this richly illustrated guide contains a wealth of information for 146 British and Irish species, together with introductory sections on nest-monitoring techniques, nest identification, legislation, the BTO Nest Record Scheme and nest-finding skills.

Pbk | 2011
£24.99 | #189706

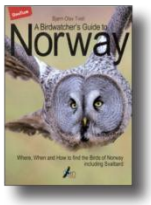


Winged Sentinels: Birds and Climate Change
Janice Wormworth and Cagan H Sekercioglu
Birds' responses provide early warning signs of the impact of climate change. "Winged Sentinels" uses colourful examples to show how particular groups of birds face heightened threats from climate change, and to explore how we can help birds adapt in a warming world.

Pbk | 2011
£24.99 | #191348

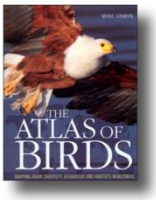
Feathers: The Evolution of a Natural Miracle
Thor Hanson
Informed by Hanson's own field experiences from Africa to Antarctica, "Feathers" deftly traces a history of evolution, fluff, flight, fancy, and function. A captivating and beautifully-written exploration of the human fascination with feathers, this book transports readers from mythical associations with the divine to the height of modern-day science and technology.

Hbk | 2011
£18.99 | #187625



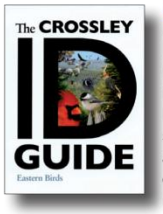
A Birdwatcher's Guide to Norway: Where, When and How to find the Birds of Norway including Svalbard
Bjorn Olav Tveit
For the first time ever, here is a guide to the birdwatching sites of Norway, including the arctic archipelago of Svalbard (Spitsbergen). More than 350 sites are covered with detailed maps and descriptions on what to see, when to go and how to get there on your own.

Pbk | 2011
£44.99 | #191143



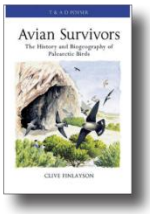
The Atlas of Birds: Mapping Avian Diversity, Behaviour and Habitats Worldwide
Mike Unwin
Stunning full-colour maps reveal where birds are found and explain the many factors behind their distribution, while numerous photographs and illustrations showcase the most fascinating and colourful aspects of bird behaviour. Conservation concerns are highlighted throughout.

Pbk | 2011
£16.99 | #187634



The Crossley ID Guide: Eastern Birds
Richard Crossley
Unlike other guides, with individual photographs or illustrations, this book features large, lifelike scenes for each species. These 680 scenes are each composed of 12-20 color images showing the bird in a wide range of views, and angles, in various plumages and behaviours - including flight - and in the habitat in which they live.

Pbk | 2011
£24.95 | #186611



Avian Survivors: The Biogeography of Palearctic Birds
Clive Finlayson
How will birds react to a world of global warming? These are the key issues to be explored in this book, with particular reference to Western Palearctic birds. Climate changes that have affected the region in the last two million years will be explored. A major part of the book will be devoted to the distribution of Western Palearctic birds in relation to bioclimate.

Hbk | 2011
£50.00 | #186679

Your credit card will be charged on the day the book is dispatched to you. Please note that prices are subject to minor fluctuations due to publisher's price changes and those in $ and € are approximate.

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NHBS Newsletter

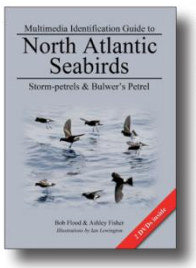
Seabird Group Conference 2011

The reed beds at the River Otter Nature Reserve; an SSSI and one of our favourite places in Devon

NEW!

Multimedia Guide to North American Seabirds:

Storm-petrels & Bulwer's Petrel



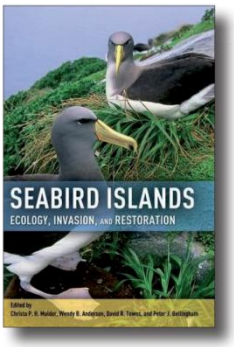
Hbk with 2 DVD
2011 | **£39.99**
#192841

Bob Flood, Ashley Fisher

This identification guide on the storm-petrels of the North Atlantic is the culmination of many years of at-sea observations by the authors. It is the first in what is planned to be a four-part series on regular and vagrant bird species of the North Atlantic. The book is accompanied by 2 DVDs with over 120 minutes of both at-sea footage and, for some species, in-hand and at-colony footage. The DVDs follow the contents of the book, allowing cross-referencing, and form an excellent preparation for a seawatch or a pelagic trip.

NEW!

Seabird Islands: Ecology, Invasion, and Restoration

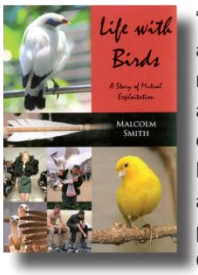


Edited by Christa P H Mulder, Wendy B Anderson, David R Towns and Peter Bellingham

Provides the first large-scale cross-system compilation, comparison, and synthesis of the ecology of seabird island systems. Offering a new conceptual framework into which to fit the impacts of seabirds on island ecology, this is an essential resource for academics and resource managers alike.

Hbk | September 2011 | **£50.00** | #191786

Life with Birds - an interview with author Malcolm Smith



"I think I've always noticed bird/human interactions wherever I've been – though probably more subconsciously until I began to think about compiling and organizing them into chapters for the book. It's been part of a life-long interest in birds combined with a training as a biologist, though with very limited time to pursue these interests personally when I was Chief Scientist at the Countryside Council for Wales..."

Read the full interview on our website.
Follow the 'blog' tab and search for "life with birds".

About NHBS

"I would like to say how pleased I was with your service both from the point of ordering to delivery and you kept me informed by email of the progress. Many thanks, your customer service is certainly something to be proud of."

Yvonne Lilley, Birmingham, UK

"Discovering nature starts with reading and that discovery can be made at NHBS. Planet Earth has a twin sister with NHBS, I call her Planet Book. Here I found every subject I was looking for represented. NHBS has enriched my life with knowledge for many years now and I hope that they will continue to do so as long as I live."

Gerard van Leusden, Utrecht, The Netherlands

Read more customer testimonials, leave your feedback and find out more at www.nhbs.com/about.

Forthcoming: September 2011

The Royal Entomological Society Book of British Insects

Peter C. Barnard

#191947

£34.99
~~£39.95~~
(Offer ends 31/12/2011)

Pre-order now at www.nhbs.com

"Hampshire Ecological Services Ltd use NHBS to supply bat boxes as part of our specialist bat mitigation work. We welcome the range and price of boxes available and have been delighted with the speedy service compared to other suppliers."

John Poland,
Hampshire Ecological Services

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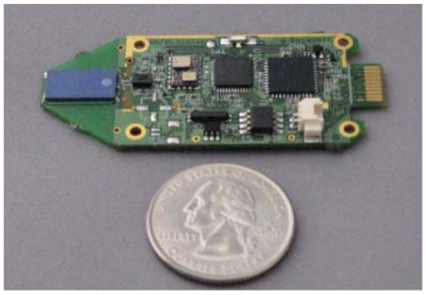
Everything for wildlife, science & environment

www.nhbs.com

TrackTag®

The NAVSYS TrackTag® uses NAVSYS-proprietary technology to dramatically reduce acquisition time for GPS data acquisition. This has a major effect on battery size and lifetime, permitting extremely small package archival GPS tags to be built for applications such as bird and animal tracking, military and homeland security applications.

- Captures GPS data for download when tag is retrieved.
- Extremely long duration (>2 years)
- Proven performance under tree canopy.
- Different package and GPS antenna options for different scenarios.
- Position record interval programmable from seconds to months.
- Typical capacity 128,000 positions (other options available)
- Unpackaged weight as low as 13 grams including 1 year battery and GPS antenna
- Optional salt-water switch wakeup.
- Optional external analog and digital input connector for addition data logging.



TrackTag Board

TrackTag Technology Overview

TrackTag has been designed for extremely low-power, long-duration standalone position recording of assets, and is suited for applications including certain animal tracking and surveillance markets. It has been designed to overcome the limitations of standard GPS receivers, which cannot be run on small batteries for long periods of time. A conventional GPS receiver, if woken up every hour will (optimistically) need powered for at least 6 seconds to compute a navigation fix. By contrast, TrackTag needs to be powered up for less than 60 milliseconds to acquire enough data for a GPS fix. This power saving is achieved by the use of the NAVSYS patented TIDGET process, whereby the raw GPS data is acquired unprocessed, and the time-consuming and power-hungry GPS signal processing is deferred until the data is retrieved from the TrackTag. Each TrackTag is programmed to wake up at a user-definable interval (seconds to hours) to take a position fix. At the time of each position fix, an auxiliary data set comprising temperature, battery voltage and system status is also automatically logged.

TrackTag can be provided unpackaged for the customer to package or with a variety of housing options:

- Large mammal collar (highest GPS sensitivity), self-contained unit (include batteries for 2 year deployment) for attachment to a customer-provided collar.
- Diving bird housing (waterproof to 5 meters depth) lightweight housing.
- Diving animal housing (pressure proof to 2000ft water depth)

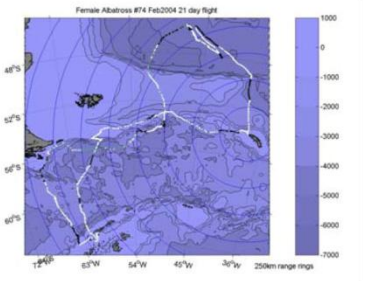
TrackTag has had successful deployments on:

- Penguin, seal, turtle
- Albatross, arctic skua
- Tapir, jaguar, puma

Large mammal TrackTag Enclosure

The these pictures show results from successful TrackTag field trials in the South Atlantic (on albatrosses, although the tags used were sufficiently small and light to be on much smaller species), and under rain-forest tree canopy in South America (50% of all TrackTag fixes computed a solution, while with conventional GPS technology collars our customer.

Tracking Results under Amazonian Tree Canopy



Albatross Track in South Atlantic

NAVSYS Corporation 14960 Woodcarver Road, Colorado Springs, Colorado 80921
phone 719-481-4877 *fax* 719-481-4908 *Web site* www.navsys.com
NAVSYS Ltd, Springwood House, Linburn Rd, Kirknewton, W Lothian, EH27 8DY UK Phone: +44 131 333 4773

DST bird

LIGHT INTENSITY

TEMPERATURE

New geolocator for bird tracking studies

ADVANTAGES AT A GLANCE

- Data Storage Tag measuring light levels and temperature
- User programs the start date & time and sampling interval
- Supplied with a set of communication box and SeaStar software
- Memory capacity total 52,000 measurements
- Option for choosing different sampling interval for light and temperature
- Very small size 17 mm x 7 mm x 7 mm
- Weight only 1.5 g
- Battery life ~18 months
- Data can be easily imported into other softwares for further analysing

Star-Oddi is a leading edge manufacturer of equipment for ocean and freshwater research, specializing in the design of scientific equipment based on microelectronics and sensors. High emphasis is put on developing equipment that can be used to protect, restore and manage the aquatic environments through ecosystem-based management.

DATA STORAGE TAGS (DSTs)

Data Storage Tags have been manufactured and developed by Star-Oddi since 1993. DST is a miniature underwater data logger available with different sensors for such variables as temperature, pressure, conductivity, tilt, magnetic field strength and acoustic signals. The DSTs are used worldwide in research projects, including fish tagging and aquatic environmental monitoring

DST BIRD

DST bird is a tiny geolocator intended for migration studies of birds. The data logger measures and records light level and temperature.
All measured data is stored in the logger's internal memory. When the logger is retrieved after the measuring period, recorded data is uploaded in the supporting SeaStar software where it can be viewed and analyzed in graphic and tabular form. Each measurement is displayed with its date and time. The same logger can be reused as long as the battery lasts.
The very small and lightweight tag opens up new possibilities for bird scientists to tag smaller birds that little migration information exist on. With large amount of temperature and light datapoints from tags, the scientist is able to analyse bird migration route with approximate geolocation (latitude and longitude) at given dates and times by comparing data from tags to existing weather data collected by authorities.

DST BIRD TECHNICAL SPECIFICATIONS

Sensors	Temperature and light
Size (length x diameter x height)	17 mm x 7 mm x 7 mm
Weight in air	1.5 g
Temperature range	-2 to +30°C (30.2°F to 86°F)*
Light range	10-400 Lux
Memory	52000 measurements in total**
Memory type	Non volatile EEPROM
Resolution temperature	0.1°C
Accuracy temperature	Better than +/- 0.5 °C
Response time temperature	Time constant (63%) reached within 18 sec.
Resolution light	2 lux
Accuracy light	+/-25 lux
Response time light	Immediate
Sampling interval	In second(s), minute(s), or hour(s)
Number of sampling intervals	1 to 7 intervals within the measurement period***
Minimum sampling interval	1 second
First recording	User defined in the software
Communication	Wireless through communication box
Battery lifetime	18 months****
Data retention	25 years
Housing material	Epoxy
Attachment hole	2 mm
Depth survival	150 m

*Extension to 45°C available.
**Divided between temperature and light.
***It's possible to shift between different intervals within the measurement period, for example having different intervals between night and daytime or during specific months.
****For sampling interval of 10 minutes or greater and within the range -1°C to +40°C.

SEASTAR

SeaStar (for Windows©) is the graphic supporting software for all Star-Oddi loggers. The user sets the start time, start date and sampling interval in SeaStar before starting the recorder. Sampling interval can be set in second(s), minute(s) and/or hour(s).
With default programming light and temperature are recorded at the same time. Optionally, it is possible to define different sampling intervals for the parameters (primary and secondary parameters/ parameter pairs with different sampling frequency). With this option memory partitioning can be customized according to individual preferences.

DSTs can also be programmed with up to 7 different sampling intervals. These intervals can then be defined in a preferred order within a measurement sequence. Number of measurements is defined for each interval. The measurement sequence is repeated until the memory is full or the logger retrieved. Programming several sampling intervals in a sequence can be useful when more/ fewer measurements are needed at certain time periods.

After retrieving the DST, recorded data is uploaded in SeaStar, where the results can be analyzed in graphic and tabular form along with date and time. The logger can be reprogrammed and reused as long as the battery lasts. Data can be retrieved even after the logger's battery is empty. Data can be imported into more advanced software packages for geolocation analysis.

COMMUNICATION BOX

The Communication Box works as an interface for data transfer between the DSTs and a PC. Communication between a DST and the Communication Box is wireless. The Communication Box is connected to a PC using either a USB or RS-232C 9 pin serial cable. When a logger is connected to a PC the logger is powered through the Communication Box and is not using its internal battery.

STAR ODDI

Logging Life Science

Vatnagardar 14 104 Reykjavik Iceland
Tel: +354 533 6060 Fax: +354 533 6069
star-oddi@star-oddi.com
www.star-oddi.com

Ecotone Telemetry

ORNITHOLOGY WITH PASSION AND EXPERIENCE

ECOTONE

Catalogue valid from may 2011

GPS-GSM TELEMETRY LOGGERS

ECOTONE 'DUCK' EP-10 SOLAR

Modular system for birds, marine mammals, turtles, small terrestrial mammals
Can be attached as a backpack, glue-on or custom-designed collar

ELECTRONIC MODULE

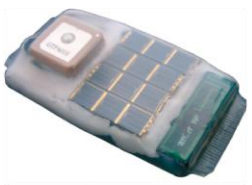
- Designed by Ecotone engineers and scientists to meet requirements of long-term wildlife telemetry.
- GPS module using SiRF III architecture and custom-designed omnidirectional super-sensitive antenna provide rapid acquisition of precise GPS positions, even in adverse conditions such as dense vegetation or deep valleys.
- Extremely effective solar charger does not require direct sunlight.
- High-quality components and advanced technology used throughout.
- Temperature sensor built into the housing. Temperature is written into each fix with GPS position.
- All GPS positions as well as readings from temperature and optional sensors are stored in non-volatile memory.
- GSM-GPRS module consumes very little power. Sensitive GSM antenna allows data to be transmitted even from locations where mobile phones do not detect the network.

BASIC FEATURES

- The electronic module, batteries and antenna are fitted in a strong waterproof housing.
- Module dimensions start at 35 x 55 x 15 mm.
- Packs from 25g, but weights depend on battery size and optional accessories.
- All GPS data are transmitted by GSM network. When the network is unavailable data are stored and sent in next sessions.
- Even a few hours of exposure to sunlight will allow a solar charger to supply enough power to work for some days with no sun.
- System can automatically adjust sampling rate to available power resources.

OPTIONS, SENSORS AND ACCESSORIES

- VHF telemetry with activity and mortality sensors;
- mortality sensor integrated with GSM system;
- solar charger modules can be added for faster sampling rates or use in extremely poor light;
- custom-designed housings and user-
- specific features available.



ECOTONE 'DUCK' EP-10 SOLAR

Control panel and data format

All basic functions are available from password-protected control panel at www.ecotone.pl. GPS positions, temperature, battery state, GSM signal strength and much more can be monitored in real time. Data can be viewed with Google Map and Google Earth, and can be downloaded in .klm and .csv format. GPS positions can be forwarded on request to user's cellphone.

DUCK SOLAR	
Unit weight [g]	< 30
Number of GPS positions including GSM transmition	> 700*
Estimated battery life with no solar for sampling rate of 1 GPS fix/hour [months]	> 1*

* NOT LIMITED WITH SOLAR CHARGER

ECOTONE GPS-GSM TELEMETRY COLLARS

BISON EP-10 5xD
Large animals such as bison, buffalo, elk, big antelope, rhino, elephant
WOLF EP-10 2xD
Big and medium animals such as deer, antelope, jaguar, wolf
FOX EP-10 1xC and 2xC
Medium animals weighing more than 7kg such as small antelope, medium cats, monkeys

BASIC FEATURES

- The electronic module, batteries and GSM and GPS antennas are sealed in a strong waterproof housing. No wires in the belt, which facilitates adjustment of collar diameter and helps to prevent damage.
- VHF telemetry with built-in activity and mortality sensors. Strong signal helps relocate animal in forested areas from up to 6km and 15-20km in open areas.
- All GPS data are transmitted by GSM network. Fixes are stored when the network is unavailable and are sent in next sessions

Collar version	BISON 5xD	WOLF 2xD	WOLF 1xD	FOX 1xC
Minimum collar weight [g]	2200	570	460	220
Typical belt width [mm]	75	40	40	30
Number of GPS positions including GSM transmission	44000	1800	9000	4300

ECOTONE EP-3.3 miniature GPS logger

Automatic radio transmission feature eliminates need to recapture tagged animals Almost unlimited battery life with solar charger. Modular system allows user vast range of options. Can be designed as a glue-on unit, backpack, collar, ...

MAIN FEATURES:

- Ultra small and light - 1.3 g without battery & potting
- Dimensions: only 15 x 20 x 3mm;
- Extremely effective optional solar charger;
- Migration detecting - optional
- Battery state controled
- Radio bidirectional link:

- data download and control of GPS;
- range up to 1000m in open areas;
- automatic transfer of collected data;
- GPS switched off within range of base station;

- Diving sensor - optional
- User-replaceable batteries

Smallest recommended sets:	
NO SOLAR	
• EP-3.3 LP, 30mAh bat., light potting (LP) for non-aquatic animals ~ 90 GPS fixes in 15-60 min intervals	3,1 g
• EP-3.3 DV SP, 60mAh bat., diving sensor and strong potting (SP) ~ 250 GPS fixes in 15-60 min intervals	3,9 g
• EP-3.3 DV SP, 200mAh bat., diving sensor and strong potting (SP) ~ 1000 GPS fixes in 15-60 min intervals or 1500 in 1-3min. intervals	7,9 g
• EP-3.3 DV SP, 450mAh bat., diving sensor and strong potting (SP) ~ 2200 GPS fixes in 15-60 min intervals or ~3000 in 1-3min. intervals	11,0 g
SOLAR	
• EP-3.3 DV SC SP, 30mAh bat., diving sensor solar charger No battery live limits, automatic voltage control, interval from 4 GPS fix/hour	from 5,5 g

office@ecotone.pl
tel (+48) 58 552 33 73
fax (+48) 58 552 15 35
www.ecotone.pl