

EUROPEAN SEABIRDS

PROCEEDINGS OF THE SEABIRD GROUP CONFERENCE

held at

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27-29 March 1992

Seabird Group

c/o The Lodge, Sandy, Bedfordshire, England

Editor:

Mark L Tasker

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Editorial

The fourth International Seabird Group conference was held in the University of Glasgow's Kelvinside Conference Centre from 27-29 March 1992 in association with the University's Department of Zoology. The general theme was on European Seabirds; this title was meant to reflect the number of contributions on seabird research worldwide being carried out by European workers. The theme was not exclusive of other research on seabirds however. As in previous conferences, abstracts of all papers presented are printed as the proceedings. This volume is comprised of 40 of these abstracts and in addition includes seven papers not presented. Reasons for this non-presentation range from incineration of data by arsonists and an inability to travel from Russia. Abstracts have not been refereed, and anyone particularly interested in their contents are encouraged to contact individual authors directly. Two workshops, one on European Beached Bird surveys and the other on evaluating the threats to the seabirds of the North Sea, accompanied the conference. Their results are not reported here, but will be the subject of separate reports.

The conference was, as usual, enlivened by a number of informal activities. The Seabird Group is very grateful for the large number of contributions, both financial and material, to the successful running of both the formal and informal aspects of the conference. Major contributors are acknowledged on the title page.

Which factors can explain the variation in adult body condition decrease during the chick rearing period in common *Uria aalge* and Brunnich's *U. lomvia* guillemots

Magne Asheim and Rob Barrett

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The main factor influencing adult body condition during the chick rearing period is their activity budget. Time budgets were not recorded in this study, instead chick growth was used as a parameter reflecting adult activity. This accounted for chick diet and time of breeding.

A stepwise multiple regression, including time of breeding, chick growth and the cost of adult flight (using Pennycuik's 1989 formula) explained slightly more than 60% of the variation in adult body condition decrease. However, the most important factor was their cost of flight and we tested its significance by estimating the amount of daily flight time needed to achieve the average weight loss. These estimates were unreasonably high - and we therefore suggest that these birds reduce weight by decreasing their food intake as well. We therefore argue that breeding adults are adapted to an optimal working capacity, and we suggest that more work be done on this capacity.

Shetland sandeels - modelling the effects of the fishery

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The breeding failures of Shetland seabirds in recent years have been caused by food shortage. The main prey of the affected seabirds is the sandeel *Ammodytes marinus*. Since 1974, sandeels have been fished in Shetland. The population model used to estimate sandeel stocks is virtual population analysis. This model assumes that natural mortality of sandeels is constant and known. I will describe why these assumptions are unrealistic. However, even if the assumptions were completely true, the published results of the VPA vary so much from year to year that they do not form a sound basis for rational management of the sandeel stock. RSPB has argued that knowledge of the state of the sandeel stocks is so poor that a precautionary approach to the fishery is needed.

Are puffins really petrels?

Rob Barrett

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and

Geir Gabrielsen and Per Fauchald, Norwegian Institute for Nature Research, c/o Tromsø Museum, University of Tromsø, N-9000 Tromsø, Norway.

Compared to other auks, Atlantic puffins *Fratercula arctica* and other members of the *Fraterculinae* have unusually long incubation periods, at about 45 days. What are the mechanisms behind this? Do the incubating birds enter a mild torpor as suggested for petrels (Brooke, M.L. 1990 *The Manx shearwater* Poyser, London)? In 1991, series of field measurements of egg temperatures and adult body temperatures during incubation, resting metabolic rates of adult Atlantic puffins caught while incubating, and weight changes of adults during incubation were made on Hornøya, North Norway. Preliminary analyses suggest that incubating puffins have a lower body temperature and metabolism, and hence lower egg temperatures than non-incubating adults.

Do radio transmitters influence body mass and feeding performance in common terns?

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During our studies of common tern foraging using radiotelemetry in the Wadden Sea, we investigated whether the radio transmitters influenced body condition, foraging success and flight duration. The data collected by the method of automatic recording body mass and nest relief of the radio-tagged adults during incubation, revealed only slight differences between tagged and untagged mates.

Seabirds as monitors of environmental chemicals in the Wadden Sea

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From 1987 to 1990 seabird eggs were used to monitor environmental chemicals on the German North Sea coast. The fish-eating terns were contaminated most among 11 coastal bird species. The significant microgeographic patterns (9-14 sampling sites along the coast) indicate the different input of various chemicals by the rivers Elbe, Weser and Ems into the North Sea. Highest residues were found in eggs from the Elbe estuary and the inner German Bight. An investigation of temporal trends from 1981 to 1990 revealed that concentrations of several contaminants increased (mercury, PCBs, lindane, DDT). To complement the European monitoring programs by a top predator, I propose to use eggs of seabirds as monitors of chemicals. In addition monitoring of seabirds' reproductive biology should be performed as an early warning system to indicate negative effects of chemical pollution.

Feeding territories in the great skua *Catharacta skua*

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Great skuas feed mainly on fish around the Shetland Islands, but also parasitise and feed on other seabirds. Until recently, great skuas were not known to defend feeding territories. The foraging behaviour of great skuas at seabird colonies was investigated in relation to their breeding sites on Hermaness between 1986 and 1989.

Time budget analysis showed that some pairs were holding feeding territories. On such territories, which were defended against conspecifics, great skuas took most of their food, and spend much of their foraging time. A distinct segregation was found between the diets of coastal and inland breeders on Hermaness, as shown by the contents of pellets. Coastal pairs depended mainly on other seabirds. Such territorial behaviour appears relatively widespread among great skua pairs that breed along the coast of a colony such as Hermaness. These are however a relatively small part of the total breeding population.

There are therefore two contrasting feeding strategies in great skuas. Pairs that defend a feeding territory may get benefit in food provisioning for their chick as well as an increased ability to defend the chick against predation, but defence of such a territory may cost more energy. Such behaviour may restrict the number of great skua pairs foraging on seabird colonies and by extension limit the number of seabirds, such as puffins killed by skuas in any one breeding season. This would apply in particular when food availability is low at sea.

Sperm competition and testis size in auks

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A positive association between testis size and intense sperm competition has been noted across a wide range of animals, including birds, mammals and frogs. We compared testis size among the members of the *Alcidae* to determine whether a similar pattern was evident in this group of birds. Testis length varied more than three fold over the species examined but most of this variation was attributed to differences in body mass. Colonial species had larger testes than solitary-nesting Marbled Murrelet *Brachyramphus marmoratus*, a pattern that would be expected if the risk of sperm competition increases with the degree of coloniality. Testis length in the least auklet *Aethia pusilla* was more than 50% larger than its body size and proportionately larger than any other alcid. We suggest that the unusual size of the testes in this species may be a consequence of its relatively low rate of mate fidelity compared to other aluids.

Ecosystem modelling: the birds of the North Sea

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This paper describes an ecosystem modelling project and discusses seabirds and other top predators in that context. The project is titled European Regional Seas Ecosystem Model (ERSEM) and involves biologists and modellers at nine EC universities and institutions. The overall aim is to produce a simulation model of the marine ecosystem, to gain insights into carbon and nutrient dynamics at almost all levels of the system. The model is applied to the North Sea at present but may be used for other European shelf seas in a subsequent phase of the project. The North Sea is considered as a number of boxes, within which biological and chemical processes are modelled. Fluxes of material between boxes are determined by a water transport model. The modelling approach is highly aggregated; fish, for example, are represented as three age-structured functional groups, 'pelagic', 'demersal' and 'sandeel'.

At present, the model considers top predators as a sink, rather than as dynamic components of the system. Carbon flows to seabirds, seals and commercial fishing have been estimated using established methods; these estimates will be applied to the model and will be varied in order to determine top-down effects on the rest of the system. The rate of removal due to commercial fishing, on a whole North Sea scale, is likely to be an order of magnitude greater than that due to seabirds. The effect that the commercial catch has on the model as a whole will be of particular interest therefore. Various further developments of the model are envisaged, for example the dynamic representation of seabirds and greater spatial resolution over coastal areas. With these developments the model will offer insights into the population dynamics of North Sea seabirds.

Prebreeding prospecting and recruitment in the kittiwake *Rissa tridactyla*

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The kittiwake, as with other seabirds, has a prebreeding prospecting period between the first return to the breeding grounds and first breeding. The behaviour of these prebreeders was studied in 1990 and 1991 at the Cap Sizun kittiwake colonies (Brittany, France). Some of these birds, called squatters, occupy nests of the current year either with unattended chicks (squatting on chicks) or empty (squatting on nests). This occurs after the fall in attendance of the breeders in the middle of the rearing period. Other birds, which land only on non-breeding sites, are called mere prospectors. These three categories clearly differ behaviourally. They reflect progressive stages in the ontogenetical social process of recruitment. Squatters on chicks are the oldest prebreeding birds and are implicated in this process more than squatters on nests and the latter more than mere prospectors. Prospecting can be interpreted as a behavioural mechanism which allows the assessment of the environmental quality of different breeding places prior to recruitment.

Summer distribution of seabirds and marine mammals in the Greenland Sea, 1985-1990

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Offshore ship-based surveys between Iceland, Jan Mayen and Svalbard were conducted, June-August 1985-1990. Seabirds and marine mammals were counted in this area in late June 1985-1988 using a 300m wide band transect on one side, ahead of the ship. During transect counts, a 180° scan ahead of the ship was usually maintained simultaneously, while this scan was the only way of counting when Svalbard was circumnavigated in July/early August 1988-1990.

Fulmars are abundant and widespread in the Greenland Sea, but with highest concentrations near colonies. A 'low density' area is found far offshore between Jan Mayen and Svalbard, while a more detailed analysis would show feeding concentrations at the Svalbard shelf edge. LL-phase fulmars were dominant around Iceland and Jan Mayen, while relatively more coloured specimens were seen along the East Greenland ice edge. A sudden change in the proportion coloured, from less than 5% to over 90%, occurred in the 'low density' area between Jan Mayen and Svalbard. This pattern was very similar between years. Great skua sightings in the Greenland Sea indicate a regular contact of the Icelandic skuas with the recently established Jan Mayen population. Within the Svalbard archipelago, great skuas were commonly seen, particularly in the pack ice zone. Brunnich's guillemots, little auks, puffins and black guillemots were the commonest auks, of which highest densities were encountered near colonies.

Five seal species were seen, often associated with pack ice or large icefields. Between Jan Mayen and Svalbard, in very deep, ice-free waters, harp seals were the only seal seen, often porpoising at the bow of the ship. Of some ten species of cetaceans observed, minke (mainly inshore) and bottlenose whale (deep water) were two of the commoner whales.

Do puffins spend the summer in the Mediterranean?

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Puffins are regular winter visitors to the Mediterranean, where they seem to occupy a deep-water area to the southwest, between the Balearic Islands and North Africa. Smaller numbers spread out from this area after the main wintering season, and occur further north during late spring and the summer. Such behaviour is unique to this species and contrasts with that of razorbills, gannets and great skuas, all of which abandon the Mediterranean during the summer months.

An ecological analysis of the situation reveals that razorbills, gannets and great skuas live on continental shelf waters during the winter months, in a habitat not unlike the North Atlantic waters they occupy during the breeding season. However, because of the unique oceanography of the Mediterranean, that habitat virtually disappears during the summer months, forcing even the non-breeding birds out into the Atlantic again.

The puffin's habitat is farther out to sea, with most being found on oceanic waters beyond the continental shelf. That habitat persists, although perhaps impoverished, during the summer months, when it also occupied by Cory's shearwaters and British storm petrels. In such conditions, a number of non-breeding puffins might survive the summer months without having to leave the Mediterranean.

Seabird regulation - the fallacy

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No abstract received.

Mink and common terns in western Scotland

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The objectives of this work are to measure the breeding success of common terns *Sterna hirundo* on the west Scottish coast over a number of years and to identify factors influencing it. The study area extends from Mallaig to Machrihanish (about 180 km linear, 1000 km of mainland coast). In 1991, as in previous years, most chicks that fledged were produced at a few offshore colonies (>1 km from mainland). Inshore colonies (<1km from mainland), although more numerous, produced many fewer chicks per pair. This pattern is believed to be due mainly to a higher level of predation at inshore colonies than at offshore colonies by wild North American mink *Mustela vison* living along the mainland coast. This hypothesis was investigated in 1991 by identifying reasons for failure at inshore and offshore colonies.

In 1991 there were nine inshore colonies at which the chicks reached the point of hatching or beyond. They held 406 pairs of common tern. Six colonies failed completely because of mammalian predation. Four (213 pairs) failed because of mink, one (65 pairs) because of mink and/or otter *Lutra lutra*, and one (26 pairs) because of otter. At the other three colonies (102 pairs), 65 chicks fledged despite otter predation at one colony. Thus the majority (52-68%) of pairs at inshore colonies lost all their chicks to mink. The total productivity of the nine inshore colonies was 65 fledged chicks or 0.16 chicks per pair.

The number of offshore colonies in the study area varies between one and five depending on the year. In 1991 there were two at which chicks reached the point of hatching or beyond. They held 641 pairs and, despite mink and otter predation at one large colony of 620 pairs, fledged 325 +/- 105 chicks or 0.51 +/- 0.16 chicks per pair. Thus in 1991 offshore colonies produced about three times as many chicks per pair as did inshore colonies.

That tern colony size is also a significant factor affecting the outcome of attack by mink is suggested by the following preliminary information from three seasons 1989-1991. These are based on thirteen incidents of known mink attack which were accompanied by satisfactory quantitative details. These details are scarce and difficult to obtain as evidence is usually removed within hours by scavengers and tides. In eleven incidents, no clutches or chicks survived. These all involved colonies of <100 pairs and <100 clutches or large chicks. In two incidents, significant numbers (>100) chicks survived. These occurred in 1989 and 1991 and involved the same large colony of 600-800 pairs at which several hundred large chicks were available on each occasion. About 100 large chicks were killed in each of the two incidents. One possible explanation is that the mink simply tired after killing this number.

In 1987-1991, every year there were one to five large (100-800 pairs each) offshore colonies of common tern in the study area. In 1969 the largest colony recorded in this area held 99 pairs. In 1987-1991 most pairs bred offshore; in 1969 most pairs bred inshore. Many former inshore sites are now deserted; those that remain suffer from heavy mink predation every year, as illustrated above. The increase and spread of wild mink in the last 20-30 years thus appears to have caused terns to move offshore and to combine into fewer larger colonies. These large colonies are not out of range of mink, but the above findings suggest that their progeny are less susceptible to annihilation by mink.

The breeding and feeding biology of the lesser black-backed gull in southwest Ireland

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In recent years the number of breeding lesser black-backed gulls *Larus fuscus graellsii* has increased in Ireland coinciding with a sustained decline in the numbers of great black-backed gulls *L. marinus* and herring gulls *L. argentatus*. The migratory behaviour of the adult lesser black-backed gull has also altered with large numbers now overwintering in Ireland compared with the occasional individual that did so in the past.

In the 1991 season on Cape Clear Island, SW. Ireland, 322 pairs of lesser black-backed gull bred. The clutch size was high (average for the island 2.83 eggs/nest), as was the hatching success (average percentage for the island 80.4%). Three egg clutches had the highest percentage of hatching. Clutches started immediately after the main peak of laying had the highest percentage hatching and highest average number of chicks per nest.

Fledging success was difficult to quantify, all estimates are therefore minima. Although the Pointabullaun colony appeared to fledge more chicks, the lower success recorded at Foillycahill may be partly explained by the dense vegetation present there which inhibited recapture of the chicks. It is interesting to note that when Foillycahill was sectioned the area with the densest vegetation cover had the lowest percentage fledging and the area with the highest percentage fledging had open bare rock. Fledging information is therefore inconclusive but appears to have been up to 1.33 chicks per nest. This figure is based on a mark/recapture estimate at five weeks from peak hatching date. At Pointabullaun there was a positive relationship between the number of chicks that fledged and the size of the nest. This was not found at Foillycahill.

An estimated 55 pairs of herring gulls, one order of magnitude less than a decade ago, bred on the island in 1991. Clutch size was high (average for the island 2.9/nest). Although the percentage hatching was high (average for the island 71.2%) it was lower than the corresponding figure for lesser black-backed gulls. Average herring gull fledging success was up to 1/nest.

The diet of the lesser black-backed gull consisted mainly of earthworms, beetles (mainly *Carabidae*), fish (mainly *Gadidae*) and a large amount of vegetation. The herring gull diet although similar, contained more mussels, limpets and rubbish.

The effect of age and experience on egg-size and hatching success in wandering albatrosses

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We investigated the influence on egg-size and hatching success of maternal age and experience and individual and year effects on wandering albatrosses of known age (7 - 30 years) and experience (1 - 8 breeding attempts) over a ten-year period. Older and more experienced birds laid larger eggs. After allowing for year and controlling for experience, significant age effects remained. However age accounted for only 6% of the overall egg-size variation. Egg-size varied significantly between years and has increased over the last decade. Individuals laid eggs of consistent sizes; 55% of the random variation in egg-weight was due to such effects. Egg and hatchling weight were very closely linked; larger eggs also had higher hatching success. The latter was influenced significantly by age and experience but neither remained significant after controlling for the other. Year effects were also detectable.

That there are significant effects of age, experience, year and individual on egg-weight (and hatching success) is probably typical of seabirds generally, though with different balances between factors depending on species and situation. Our findings suggest that age was a more important influence than breeding experience does not support recent suggestions that hatching success is mainly influenced by experience and that experience will have a greater effect on reproductive success in long-lived species with high mate fidelity. However, wandering albatrosses may have acquired much relevant experience before even starting to breed and are not necessarily typical of other seabirds in this respect.

Ectoparasites and demography in the kittiwake *Rissa tridactyla*

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Theoretical potential for parasites to regulate host population growth has been demonstrated in mathematical models, but empirical data are rare. As colonial species, seabirds are epidemiologically particularly exposed. In this study we investigate the relationship between ectoparasite density and demographic status of kittiwake colonies.

Data collected in Britain on 1975 birds in 32 colonies whose demographic status (decreasing, or increasing) and age were known. The age of the chicks was estimated from their wing length. The only species of tick found on the birds was *Ixodes uriae*, a common ectoparasite on seabirds. Because of its biology, this tick was more linked to the substratum on which the birds live than to the host itself and processes of infection in new colonies are poorly understood. Our data suggest that this occurs when newly fledged infected juveniles visit other breeding areas. Tick prevalence and average load increased with time since first establishment of the colony. This effect tended to level off after about 30 years. Colonies on buildings did not have ticks. Both young colonies and those on buildings are excluded from the following analyses. Tick density was not distributed normally. This showed that tick occurrence on birds is influenced by the colony demographic status (n=21), the age of the chicks and the number of chicks per nest. One confounding effect might have been the wide geographic scale (hence in very different ecological context) that the data were collected over. However, this effect seems unlikely to have been operating as colonies of each demographic status were checked in each of the areas visited. Consequently, we conclude that ectoparasites play an important part in kittiwake demography.

Further data were collected in the Cap Sizun (Brittany, France) kittiwake colonies between 1980 and 1991. About 6000 chicks belonging to about 180 samples/year were caught and checked for parasites. For each sample/year, the location, number of nests, breeding success per nest and density of ticks per nest were found. Preliminary analyses confirm the role of ticks in population regulation. More detailed

analyses of the data will allow a finer insight of the interaction between this ectoparasite and kittiwake populations. The above results highlight the important role of pathogens in population regulation of colonial seabirds.

Feeding biology of puffins on Skomer Island, Wales

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This is part of a comparative study into the differences in the population of puffins on Skomer between the 1970s and 1990s. The same prey species are being taken, but in the past the relative proportions have changed from 85% sandeels *Ammodytes tobianus* and 15% sprat *Sprattus sprattus* early in the season to 84% sprat later. In the past two years, this ratio has remained at 85% sandeels throughout. In both 1990 and 1991, sprat size has increased with date through the season, while sandeel size has remained unchanged.

The frequency of feeds to the chicks has declined from an average of 5.9 -6.5 feeds/day in the 1970s to 3.5 in 1990 and 4.3 in 1991. As load weight has remained unchanged, the chicks would seem to be receiving substantially less food than in the past. This is borne out by calculations of the energy intake of the chicks, which also shows a decline. However, chick growth rates in 1991 were similar to those in the 1970s, although peak weight in 1990 was significantly lower.

The shortest feeding trips allow the birds to be fishing at a maximum of 25 km from the colony, and studies with capillary depth gauges indicate that they are diving to around 23m.

Roosting behaviour and winter dispersion in black-headed gulls

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The function of the roost is approached by searching for acting mechanisms, rather than by the more usual method of testing theoretical *a priori* hypotheses. Roosts of black-headed gulls *Larus ridibundus* were studied in central Belgium in order to investigate night-time behaviour and patterns of bird dispersion. Evidence that suggests that roosts act as "redistribution centres" are presented. (1) Roosts are not centrally placed relative to the feeding sites; the different roosts are hierarchically organised in a "roost network". (2) The differential use of connected roost sites is consistent in place and time during the first part of the winter, birds 'try' systematically different distribution between roosts. During the rest of the winter, this distribution remains stable despite a very variable number of birds being present. (3) Shape of the roosting groups is linked with departure direction. (4) Birds do not sleep at night; night-time group movements are complex and might be involved in the dispersal system.

Feeding site fidelity and weekend adjustment in black-headed gulls *Larus ridibundus*: a test of the information centre hypothesis

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Mock, Lamey and Thompson (1988, *Ornis Scand.* 19: 231-248) identified seven components of the information centre hypothesis proposed by Ward and Zahavi (1973, *Ibis* 115: 517-534). The first one is that successful feeding birds are faithful to the site where they have been successful. This assumption

was tested by colour marking 700 black-headed gulls on a rubbish tip in central Belgium. The results indicated a high degree of infidelity among the birds, despite the fact that they were successful. The adjustment of the gulls to the weekend closure of the dump (they did not visit it at the weekend) is considered in the light of the information centre hypothesis. The information-transfer mechanism as proposed by Ward and Zahavi does not account for such adaptation, but the results are not inconsistent with the general idea of an information centre. Three kinds of redistribution between feeding sites are proposed.

Modelling of seabirds foraging behaviour and energetics

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The use of models is important in the study of interactions between predators and prey. It is generally accepted that one of the most important factors which affect seabirds' breeding performance is food availability. For seabirds, the availability of food is highly variable and patchy in time and space. The mechanisms of a dynamic and discrete model which simulates prey distribution and abundance and the optimal foraging for several seabird species during the breeding season is presented. The main question addressed is how the distribution and abundance of prey affect the activity and energy budget of seabirds.

Diet of fulmarine petrels in the Windmill Islands, Wilkes Land, Antarctica

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The diet of four Antarctic species of fulmarine petrels (*Fulmarus glacialisoides*, *Thalassoica antarctica*, *Daption capense*, *Pagodroma nivea*) was investigated by means of the water-off-loading technique. Warm water pumped into the bird's stomach forces it to regurgitate its complete stomach contents. Adverse effects of this technique on the well-being or breeding performance of these birds were found to be negligible.

The bulk (about 80% by weight) of fulmarine petrel food during the breeding season proved to be fish, almost exclusively *Pleuragramma antarcticum* of 10 to 20 cm in length. Most of the remainder of the diet was small sized krill *Euphausia superba*. The Cape petrel had about 37% krill in its diet, the otherspecies much less.

These results are for 1986/87, but preliminary results of work conducted in 1990/91 are very similar. These studies, and comparable ones in other continental regions, suggest that fish is a more important intermediate level in Antarctic marine food chains than has often been assumed.

Foraging of common terns in the Wadden Sea: a study by radiotelemetry.

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In 1989 we studied the foraging behaviour of Common Terns breeding on Oldeog using the method of radiotelemetry. We could track about 360 foraging flights of 12 adults. The mean foraging radius of the completely documented trips was 6.3 km. One flight covered at mean a distance of 40 km and lasted 115

minutes. The tide strongly influenced the choice of specific foraging areas. Tidal flats were preferably visited during ebb-tide, whereas areas with a greater water depth were more frequently used during flood. The duration of flights to distinct areas differed significantly.

Energetic investments by adult breeding seabirds.

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The doubly-labelled water technique was used to study the daily energy expenditure of adults and chicks of five different seabird species breeding on Svalbard and in northern Norway. The energy requirements of chicks was compared with measurements of parental energy requirements. The proportion of energy delivered to the chick by the parent increased with the number of chicks raised. In some species the parental investment was less than 15% and seems to be linked to the species' foraging behaviour.

Colony attendance and intracolony philopatry in immature and recruiting guillemots

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Immature guillemots returning to the Isle of May did so at progressively earlier dates from age 2 to 4-5, but the mean date of departure did not vary between cohorts. Many 2 and 3 year olds began the season attending club sites on sea rocks, but there was a significant tendency to move up into the colony later in the season. Birds which recruited arrived earlier that season and the previous season than same-aged birds that did not. In the colony, immatures of all ages were highly sedentary but tended to be even more so at older ages. Intracolony natal philopatry was very strong. 67% of immatures predominantly attended their natal subcolonies; 57% of birds recruiting did so into their natal subcolony. No subcolony exceeded 5% of the total adult population.

Survival rates and immigration in immature guillemots

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Large numbers of guillemots were ringed as pulli on the Isle of May from 1983; some of these began to visit the colony from the age of two. Birds do not normally attempt to breed until they are 5-6 years old. Return rates varied widely between cohorts and were consistent between years. This difference appeared to be due to differential survival. Return rates at ages 3 and 4 were significantly negatively correlated with the number of hours of gale force winds in July-September of the natal year. During this period fledglings are at sea and dependent on their male parent.

Fifty-one individuals ringed as pulli at other colonies were identified on the Isle of May in 1991. There was no evidence that any of these birds bred. Most of the colonies where extensive ringing occurs were represented. 33 (65%) originated in north and north-east Scotland, but birds from the Northern Isles and west coast as far south as Skomer were observed. Most were three or four years old and seen only once

- significantly less often than native birds of the same age. Distribution within the colony was similar to native birds. Modelling suggests that non-native birds are a very substantial proportion of the total population of immatures. If generally true, this will affect models of population structure and dynamics in this species.

Responses of skuas to reduced food supply: a test of life history predictions

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An integrated approach to the use of seabirds as indicators of marine food supplies was proposed by Cairns (1987 *Biological Oceanography* 5: 261-271), based upon predicted relationships between food availability and seabird population and behaviour parameters. This model was able to account for apparent contradictions in previous studies relating seabirds to their prey base, but has not since been tested with novel data. We test the ability of the model to describe changes in the breeding ecology of great skuas *Catharacta skua* in Shetland over a 19-year period with pronounced changes in prey availability. As predicted by the model, colony attendance, chick growth and breeding success were all lower in years of poor food supply. However, chick growth changes were slight and difficult to measure. Contrary to Cairn's model and to life history theory, adult survivorship was markedly affected by prey availability during the breeding season. This could not be explained by events outside the breeding season, since survival at another colony with good food supply showed no decline over the same period. The implications of these findings for the use of seabirds as monitors of marine food supplies are discussed.

Variability of feeding frequency and meal size in Cory's shearwater *Calonectris diomedea*

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Male and female petrels feed their chicks independently and at long intervals, so that the nutritional state of the chick at one feeding conveys little information about its needs at the end of the succeeding foraging trip. This has led to the suggestion (Ricklefs 1990 *Colonial Waterbirds* 13: 1-6) that adult petrels have an intrinsic rhythm and do not regulate feeding by responding to the needs of their chicks. We investigated variation in meal size and feeding frequency of Cory's shearwater in relation to chick age and body condition, by weighing chicks at four-hour intervals throughout the night. Overall, 79% of chicks were fed each night on average, and intervals between feeds varied from one night (80.5%) and four nights (0.8%). Individual meals were estimated by two methods to weigh 65g and 74g on average. The proportion of each meal retained by chicks over 24 hrs was not related to chick age, but increased with decreasing body condition, in terms of mass corrected for body size. Meal size and feeding frequency were not related to chick age or body condition. The implications of these findings for Ricklef's hypothesis are discussed.

Sandeels and herring in the diet of the shag

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Little is known of seasonal differences in the diet of any British seabird population due to the problems of obtaining, regular food samples. Shags *Phalacrocorax aristotelis* which breed on the Isle of May roost at the colony throughout the year. I collected ca. 1,600 pellets over a three year period, most contained otoliths from sandeels *Ammodytidae*. This talk describes seasonal and annual changes on the diet. Timing of breeding success of Isle of May shags are closely correlated with abundance of young herring *Clupea harengus* (Aebischer 1986; *J. Anim. Ecol.* 55: 613-629) and the links between the diet and breeding are discussed.

Breeding investment and adult survival in puffin *Fratercula arctica* and kittiwake *Rissa tridactyla*

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The purpose of these studies is to evaluate the relationship between parental investment and adult survival in puffins and kittiwakes. The study is carried out at Hornoya in northern Norway where all seabird species have a high breeding success. To evaluate the relationship between parental investment (= weight loss during breeding season) and adult survival we manipulated clutch size (kittiwake) and the length of the feeding period (puffin), and recorded the rate of colour-ringed breeding birds the following season.

Allometric growth and early fledging in skuas, an adaptation to ground predation? - a comparison of the brown skua of Deception Island and the long-tailed skua of Greenland

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The skuas *Stercorariidae* have a bipolar distribution with the genus *Stercorarius* in the Arctic and the genus *Catharacta* around the Antarctic and in the North Atlantic. Chicks of the long-tailed skua *Stercorarius longicaudus* are exposed to ground predation while those of the brown skua *Catharacta skua lonnbergi* are not. Ground predation puts a premium on early mobility and thus a relatively early development of legs and wings in the long-tailed skua can be expected.

Comparison of allometric growth in the long-tailed skua in Greenland and the brown skua on South Georgia and Deception Island indicate that at fledging, body weight and measurements of appendages in brown skua have 12-14% higher values than in the long-tailed skua, approaching adult brown skua values.

Legs and wings in the long-tailed skua do not grow faster than in the brown skua, but the long-tailed skua seems to fledge at a less full-grown and earlier stage than in the brown skua, which has relatively longer appendages and greater energy reserves at fledging. This could indicate a relatively early development of the ability to escape from ground predation in the long-tailed skua.

The influence of changes in sandeel availability on breeding seabirds

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Sandeels are the main food supply of the majority of seabirds breeding in the Shetland area, where in recent years, low abundance of these fish has given rise to very low breeding success of several seabird species. In contrast, in 1992 sandeel abundance in Shetland increased by over two orders of magnitude (see abstract by Wright *et al.*, this volume). In this paper, we present results from an observational and radio tracking study of the effects of this large change in food abundance on a surface feeding species, the kittiwake *Rissa tridactyla* in comparison with the common guillemot *Uria aalge*, a pursuit diver.

In the year of low food availability (1990) kittiwakes at the study colony fledged no young, whereas in 1991 breeding success averaged almost one young per pair. The overall breeding success of guillemots did not change significantly between years (averaging 0.59 per laying pair in 1990 and 0.7 in 1991). When food supply was low, kittiwakes foraged much further from the colony, made much longer foraging trips during both incubation and chick rearing, fed their young at a low rate and left them unattended at the nest from an early age. As a result of this increased effort, the adults themselves were apparently in poorer condition in the low food situation.

Guillemots fed further from the colony in the poor food year (but in both years foraging distance averaged less than 10 km), trips away from the nest were longer during chick rearing, feeding rate lower and the chicks grew less well. At sea, dive duration did not change, but the mean number of dives per diving bout was three times greater and the foraging trips three times longer. While young were brooded continually in both years, non foraging birds spent much longer off duty at the colony in the good food year. These differences resulted in radical differences in the energy expended during a foraging trip at sea, and in the overall daily time budgets in the two years.

The difference in the effect of the changes in sandeel abundance on the two species may relate to differences between the two species in foraging specialisation, and the nature and pattern of time constraints when breeding.

A study of live guillemot *Uria aalge* and razorbill *Alca torda* strandings, victims of oil pollution, on the South Devon coast

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The stranding of live seabirds, victims of chronic oil pollution, occurs annually along the coastline of the south-west peninsula during winter months. This study is an attempt to determine, over the period 1981 - 1991, the areas along the South Devon coast which appear to attract the greatest number of these seabird victims.

Data was extracted from RSPCA records (covering the area from the River Exe estuary to Plymouth) and entered into a computer data base. It was immediately evident that only auk species would provide any significant information as these species accounted for 970 of the 1310 victims over the decade. The results are graphically displayed for each year, together with a histogram showing monthly variations; it is evident that extensive variations exist.

The study has provided some historical base line data. Other variable factors have to be considered, such as tidal flow, prevailing currents, wind (direction and strength), coastline terrain and public use and accessibility. These factors will be collected and collated in a future on-going study, which we hope will produce some interesting and useful indications of oil contaminated seabird strandings.

Twenty-five years of winter beached bird surveys in northern France

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Late winter beached bird surveys have been carried out in northern France (2 counties - Picardie & Nord-Pas-de-Calais and 3 departments - Somme, Nord & Pas-de-Calais) since 1967. In the beginning, surveys were irregular and the length of beach surveyed rather low. From 1974 onwards, almost 100% of beaches were censused each year (in late February), at least in Nord-Pas-de-Calais. The total beach length covered each year is about 175 km. by 30-40 volunteers.

A grand total of 26385 birds of 130 different species have been counted. The average number of beached birds found per year varies between 210 and 9400 (mean=1055, SE=1828). The density varies between 1 and 52 birds per kilometre. There is considerable interannual variation in the numbers of beached birds censused. These variations are related to: 1) actual mortality rate (winter weather, amount of oil at sea, hunting etc.) and 2) surveying conditions (carcasses silted up by sand in strong winds, scavenging pressure etc.). It is likely that the most important factors causing variation are winter weather, oil at sea and surveying conditions.

Excluding passerines, the ten most abundant species found are: guillemot (16.8% of grand total), kittiwake (6.7%), razorbill (6.5%), black-headed gull (5.4%), common gull (4.2%), herring gull (4.1%), great black-backed gull (2.4%), great crested grebe (2.2%), oystercatcher (1.6%) and common scoter (1.3%).

The cause of death was not known for over half of the corpses. 36.4% of all birds found were oiled and 10.2% were killed by hunters. Cold spells also causes winter mortality, but this cause of death is not easily diagnosed in the field.

Seabird life history traits

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Seabirds have attracted the attention of biologists partly because of their extreme life histories. Pelagic species exhibit low reproductive rates - attempting to rear only one chick per year, slow development, delayed maturity and high annual adult survival rates. Although low reproductive output and slow growth suggest severe energy limitation during the breeding season, many species respond to experimentally elevated food demand by increased food provisioning. It was suggested that the single-chick brood minimises reproductive stress during years of low food availability, when chick solicitation determines parental effort, and thereby minimises adult stress-related mortality in an unpredictably variable environment. A computer model was used to demonstrate the possibility that fat accumulation by nestling petrels maximised the probability of chick survival when parents are faced by day-to-day stochastic variability in foraging success. Slow development, both of the embryo and the chick, was related to the absence of sibling competition within broods, permitting factors favouring slow growth to prevail: reduced energy and nutrient demands of chicks and perhaps increased potential longevity associated with longer incubation. Pelagic seabirds offer excellent model systems for exploring the implications of sibling competition and parent-offspring conflict in an environment that only marginally sustains reproduction.

"A tale of two terns"; population and productivity in little terns *Sterna albifrons* and Sandwich terns *S. sandvicensis* in Britain.

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Little and Sandwich terns are two of the 79 bird species regularly breeding in Britain singled out for special conservation attention (Red Data Birds in Britain, Batten *et al.* 1990) Both breed in Britain in internationally important numbers. They are legally protected through inclusion on Annex 1 of the EC Birds Directive.

Several previous population estimates have summed available records and regarded these as minimum estimates (Lloyd *et al.* 1975, Thomas 1982, Thomas *et al.* 1989). The aims of this talk are to present a more complete assessment of population trends since 1969 and the first analysis of national trends in productivity of both little and Sandwich terns in Britain. In addition the relationship between colony size and productivity will be examined and differences between the two species discussed.

The great skua *Catharacta skua* is becoming a regular breeding bird in Norway and on Svalbard

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The great skua first established themselves as breeding birds in Norway and Svalbard in the 1970s. In 1990, about 20 pairs nested in western Norway, 10-15 pairs in north Norway, SW of the North Cape, 25-30 pairs on Bear Island and 30-50 pairs along the western and northwestern coasts of Spitzbergen. Isolated pairs nested in SE Svalbard and on the Kola peninsula. Several Shetland birds have been recovered and a bird hatched in Finnmark was recently found nesting in the Murmansk area.

Factors influencing food load sizes of shags

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Weights of food loads brought back to broods by 26 shags *Phalacrocorax aristotelis* were determined using the water-offloading procedure. Loads consisted almost entirely of lesser sandeels *Ammodytes marinus*. Load weight was extremely variable ranging from 8 to 208 g with a mean of 106 g. Data on foraging behaviour, collected concurrently, indicated that shags brought back heavier loads when they were feeding farther away from the colony and brood biomass was larger.

Foraging strategy in the wandering albatross

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During the last three years, foraging by wandering albatrosses was studied from the Crozet Islands using satellite telemetry. This revealed that wandering albatrosses use two different foraging strategies - systematic foraging over great distances in the pelagic waters and foraging over specific zones closer to the colony. These strategies are used alternately during the breeding season, and each differs between the sexes. Using new smaller satellite transmitters, and recently developed temperature loggers, it is now possible to investigate foraging effort and foraging success, to discover exactly when birds feed. The long-debated question of whether wandering albatrosses feed at night or by day can now be resolved.

Does being a plump puffin pay? - relationships between adult body mass and breeding performance in the Atlantic puffin *Fratercula arctica*

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Relationships between the condition (in terms of body mass) at the onset of, and during, chick rearing and breeding performance in terms of provisioning rates, length of the rearing period and chick condition at fledging were examined in the Atlantic puffin.

Chick condition at fledging was positively related to parental condition at the onset of rearing and to the total mass loss of the pair during rearing. Pairs with high mass loss rates also provisioned at higher rates. However, the length of the rearing period was dictated by weather conditions during rearing rather than by parental condition.

Possible evidence for parental mass loss being adaptive, to reduce flight costs, rather than a result of 'breeding stress', is discussed.

Aspects of the foraging ecology of penguins

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Recent technological improvements have made it possible to develop miniature logging units which can be deployed on free-living seabirds to monitor aspects of bird foraging activity at sea. During the 1991/92 austral summer a dead reckoning unit, recording travel speed, dive depth and travel direction was deployed on African *Spheniscus demersus*, Adelle *Pygoscelis adeliae*, Gentoo *P. papua* and chinstrap *P. antarctica* penguins. Subsequent to recovery of the units, the foraging tracks of the birds (in three dimensions) could be calculated by using vectors. During foraging at sea, birds also carried an ingested stomach temperature sensor. Drops in stomach temperature indicated when, and how much prey was caught. Consideration of the results of the stomach temperature sensor in conjunction with the dead reckoner enabled determination of where the birds caught their prey.

What determines sandeel availability to seabirds?

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The factors determining sandeel availability to seabirds were examined in two years of markedly different breeding success at Shetland. Investigations of sandeel abundance and age composition during June and July in 1990 and 1991 indicated that the abundance and distribution of sandeels differed significantly between the two years, as a result of markedly higher larval survival in 1991. However, sandeel distribution, rather than simply low year-class strength, possibly had a more profound effect on availability in 1990, since appreciable numbers of 0-group sandeels were not evident in Shetland waters until after the chick-rearing period. In 1991, 0-group sandeels were abundant and widespread throughout the period of chick rearing.

Dietary information for kittiwakes suggested that the availability of suitably sized sandeels for surface feeding seabirds may have differed between years, since only small (30-40 mm TL) planktonic larvae were found in regurgitates in 1990. The size range of sandeels sampled by trawl in both years was large (35-120 mm TL) however, and historical information on the size of 0-group sandeels in June and July suggest that such a wide size range is typical. Consequently, in years of high abundance seabirds may be selective in the size of prey brought back to chicks.

The accessibility of sandeels to avian predators was considered in relation to emergence behaviour and vertical movements. Based on comparative catch data from dredge and trawl hauls, 1-group and older sandeels appeared to spend an increasing amount of their time in the sediment from late June. Direct video observations on sandeel occurrence in the water column in late July supported this view. Consequently, the accessibility of older age-classes to surface feeding seabirds and possibly to diving seabirds may decline during the chick-rearing period. Observations on sandeel vertical migration indicated that shoals tended to be aggregated away from the surface and that surface shoals were relatively small. Repeated surveys at one site indicated that the occurrence of shoals in surface waters was associated with the vertical distribution of their prey. These observations highlighted the considerable differences in accessibility between surface feeding and diving seabirds.

Papers not presented

Auk wrecks in the southern North Sea, 1981-1991: oil pollution or food shortage?

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Since winter 1980/81, mass strandings of guillemots and razorbills have been reported during beached bird surveys in the southern North Sea (Belgium, the Netherlands, Germany). A high proportion of the birds were slightly oil contaminated, but starvation was the proximate cause of death in most cases. Age, sex and origin (biometrics and ringing recoveries) of the birds were studied, indicating that most guillemots were immature males from Scottish (east and west coast) colonies, while most razorbills were adults from the Irish Sea and Irish colonies. It appeared that an increase in wintering numbers was responsible for the sudden increase in numbers washing ashore, possibly in response to changing fish stocks. Beached bird surveys are usually conducted in order to assess the effect of marine oil pollution on seabirds. This paper will discuss how valuable beached bird surveys can be in monitoring 'wintering success' of seabirds.

Attendance patterns of young thick-billed murre *Uria lomvia* cohorts at Coats Island, Northwest Territories.

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Since 1984 the Canadian Wildlife Service has ringed approximately 2000 thick-billed murre chicks annually at the west colony on Coats Island, N.W.T., Canada. All were banded on the right leg with a year-specific colour ring.

Data derived from periodic counts of all right legs visible from fixed observation points give an indication of the attendance of different age classes. Counts were done simultaneously from up to four vantage points and were repeated many times within several breeding seasons. Both banded and unbanded right tarsi were recorded. The resulting data indicated age specific use of different colony areas, and the pattern of colony attendance by different age classes over the course of the season.

One-year-olds have never been recorded at the colony. Two-year-old birds arrived mid way through the incubation period, whereas older cohorts were present throughout the breeding season. The number of three-year-olds present on the colony was consistently larger than that of two-year-olds suggesting that not all two-year-olds visited the colony.

Most banded birds were resighted within the area where chick banding was carried out. Birds showed greater philopatry and increasing site attachment with age. Within the banding area, there was no significant difference in the proportions of two-year-olds and three-year-olds seen at different levels on the cliff, although there was a tendency for two-year-old birds to occupy ledges on the upper portion of the colony. Four, five and six-year-olds, were found in significantly higher numbers on ledges in the centre of the colony than those at the top or bottom of the cliff.

Breeding biology of the spectacled guillemot *Cephus carbo*

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This study was carried out on Talan Island (northern part of the Okhotsk Sea) during 1987 and 1988. Spectacled guillemot pairs use individual feeding territories during the pre-laying period. Spectacled guillemots have a clutch of two eggs, the mass and size of which are considerably bigger than those of two other *Cepphus* guillemots. Perhaps because of this, spectacled guillemots have a longer period between laying of the first and second eggs (7 days on average). Incubation lasts about 27 days and hatching takes less than one day. Growth and development of the chicks are very similar to those of the black guillemot *Cepphus grylle*. Nestlings spend about 35 days in the nest.

In 1987 and 1988, both chicks survived to leave the nest. This has not been recorded previously. The most important prey species fed to spectacled guillemot chicks were benthic fish, *Cottidae* (44% by number) and *Pholis pictus* (27% by number). The composition of food carried to the chicks was very constant, probably because the spectacled guillemots had individual feeding territories during the chick-rearing period. Breeding density of spectacled guillemots on Talan Island seems to be limited by feeding condition in spring. Only those pairs that established feeding territories in spring started to breed.

Feeding ecology of the horned puffin *Fratercula corniculata* and tufted puffin *Lunda cirrhata* nestlings at Talan Island (northern part of the Okhotsk Sea) in 1987-1989

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A simultaneous comparison showed a significant difference in species composition of the food of tufted puffin and horned puffin chicks. Tufted puffin chicks were fed predominantly sandlance *Ammodytes hexapterus* (42-47% by weight) in 1987 and 1988, whereas horned puffin chicks were fed Pacific herring *Clupea harengus* (54% by weight) in 1987 and sandlance (79% by weight) in 1988. The overlap index of food quantity between the two puffin species was 83% and 80% in 1987 and 1988 respectively. Prey length and weight differed significantly between puffin species for herring and pollack *Theragra chalcogramma* in 1987 and for sandlance, herring, pollack and capelin *Mallotus vilosus* in population characteristics of fish schools used by birds.

There was no evidence of a correlation between food intake and the age of chicks in either of the two species. Our results suggested no marked age-related changes in feeding rates, meal weight and daily intake in both species. Horned puffins tended to feed their chicks more frequently than tufted puffins, possibly because horned puffins forage within 10 km of the colony, while tufted puffins feed also outside the zone.

Study of colonial seabirds study in the northeast USSR

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This vast area covers about 1.2 million km². and is washed by four seas of the Arctic and Pacific oceans. The coastal and lowland habitats along the north-east shoreline of the USSR are occupied by some 14 million seabirds of 29 species. Their populations are concentrated in more than 700 colonies.

The seabird investigations in the north-east are carried out in two main ways:

1. By mapping seabird colonies in the region. These are held in a database state seabird colony information.
2. The long-term monitoring of seabird communities at field stations. These investigations include breeding success, feeding strategies and the role of seabirds as an indicator of the marine ecosystems health.

Methods of estimating the size of the auklet population on the Okhotsk Sea coast.

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It is very hard to determine the mass of species of small alcids nesting in the rocky slopes. A census of crested and least auklets was conducted on the northern part of the Okhotsk Sea where millions of colonies of these birds are located.

The authors used various methods to estimate the numbers of auklets:(1) counting flying birds above colonies and returning from feeding areas; (2) censusing birds on selected plots including colour banded individuals; (3) Counting nests within sample areas.

The results show that total estimates of auklet numbers based on surface counts is usually 2.5 - 8.5 times less than the total numbers at the colonies.

Diving behaviour of shags *Phalacrocorax aristotelis* in relation to habitat and prey

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The diving behaviour of shags was studied using radio telemetry during three breeding seasons on the Isle of May, Scotland. Most dives lasted 41-90 sec; recovery times between dives were more variable but the majority lasted 11-80 sec. Birds dived in water ranging from 7-50m deep but most dives were in 26-35m of water.

The main determinant of dive duration was water depth at the diving location. Recovery time was influenced by dive duration, water depth and number of dives in a sequence. On average Shags feeding chicks needed to catch 1-2 fish per dive in 1987 and 1988 but in 1989 when birds were feeding on much smaller prey the average prey capture rate rose to 10 fish per dive.