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FORUM

Quantifying the impact of offshore wind farms on gannet populations: a strategic ringing project

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Given the conservation importance of Gannet populations in the British Isles, and concerns about possible adverse impacts of offshore wind farms on Gannets as a result of collision risk, we advocate the establishment of strategic monitoring studies at key colonies. Colour ringing adult Gannets to measure survival at colonies close to, and distant from offshore wind farms could indicate whether or not collision mortality has a detectable effect on adult survival. Colour ringing chicks could provide information on prospecting movements of immatures and colonies where birds recruit. Tracking studies of both adults and immatures would be highly desirable to complement improved monitoring of demography.

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Climate change caused by greenhouse gas emissions is considered to be one of the greatest current threats to seabird populations (Russell *et al* 2014, Sandvik *et al* 2014). However, reducing carbon emissions by generating electricity from wind energy offshore also represents a potential hazard to seabirds through risks of collision, displacement and barrier effects (Masden *et al* 2010, Searle *et al* 2014). Furness *et al* (2013) assessed that gulls (including Black-legged Kittiwake *Rissa tridactyla*), and Northern Gannet *Morus bassanus,* are the seabirds most vulnerable to collision mortality at offshore wind farms in UK waters, and recommended that monitoring and research should focus on quantifying adverse impacts on those populations. In 2004, Britain held 72% of the east Atlantic population and 54% of the world population of Northern Gannets (Wanless *et al* 2005), so the conservation importance of this species is particularly high. The Gannet is the focus of this forum, partly because of this high conservation importance, and partly because planning consent for several major offshore wind farms has just been granted in close proximity to major North Sea Gannet colonies. In particular, offshore wind farms off the Fife/Angus coast are close to the Bass Rock which has recently become the world's largest Gannet colony (Murray *et al* in press). Similar assessments of monitoring needs should consider Great Black-backed Gull *Larus marinus*, which like Gannet has a relatively high proportion of individuals flying at collision risk height, and other gull species.

Long term data on breeding success have been invaluable in understanding impacts of climate change and fisheries on seabird populations (e.g. Frederiksen *et al* 2004, 2013). Long term data on demography, based on ringing, have also provided insights into impacts of climate change, fisheries and predators on seabird populations (e.g. Oro & Furness 2002, Frederiksen *et al* 2004). The purpose of this Forum paper is to point out that, while we have exceptionally high quality data on Gannet breeding numbers (Wanless *et al* 2005), monitoring of key demographic data is less good, and there is a particularly urgent need to establish adequate monitoring of Gannet survival rate in relation to potential, but uncertain, adverse impacts of offshore wind farms.

Gannets may be at risk from fishery bycatch (BirdLife International 2009). However, the Gannet is considered less vulnerable than gulls to climate change impacts (Russell *et al* 2014), or to changes in fish stocks, because Gannets can take a wide range of fish from Lesser Sandeels *Ammodytes marinus* to adult Mackerel *Scomber scombrus*, and have the ability to travel large distances seeking food (Furness & Tasker 2000, Hamer *et al* 2007, Wakefield *et al* 2013). As a consequence, adverse impacts of offshore wind farms on Gannet populations would be likely to be more readily measured than with populations of seabirds already in decline due to climate change impacts and depleted prey fish stocks, where probably modest impacts of offshore wind farms may be hidden by much larger changes caused by climate and food stresses (Marine Scotland 2014). Breeding success of Gannets is monitored by the seabird monitoring programme coordinated by the Joint Nature Conservation Committee (JNCC). Gannet breeding success has tended to be high at all six regularly monitored colonies (Hermaness, Noss, Fair Isle, Ailsa Craig, Troup Head and Bempton) and in all years, so any large reduction in breeding success caused by collision mortality of breeding adults, displacement or barrier effects should be easy to detect. However, although the Bass Rock Gannet colony was intensively studied by Bryan Nelson in the 1960s (Nelson 1966), in recent decades breeding success of Gannets at the Bass Rock has not been routinely monitored, and would be a useful strategic addition to that programme. Furthermore, part of that colony is covered by CCTV cameras feeding images to the Seabird Centre in North Berwick so could potentially provide data on breeding success.

Offshore wind farm turbines will result in collision mortality of Gannets, but the numbers likely to be killed are difficult to predict with confidence. Gannets show high avoidance of offshore wind farms (Cook *et al* 2014). However, collision risk modelling based on precautionary assumptions suggests that numbers that may be killed could have measurable effects on breeding numbers of Gannets and adult survival rates of Gannets, particularly at colonies close to several large offshore wind farms (Marine Scotland 2014). Modelling of collision risk (WWT Consulting 2012, Marine Scotland 2014) suggests that the Gannet colonies most likely to display adverse effects are Bass Rock (part of Forth Islands Special Protection Area), and Bempton (part of Flamborough and Filey Coast pSPA), because most offshore wind farms in areas regularly frequented by Gannets are in UK North Sea waters from the Moray Firth to the English Channel. This suggests that monitoring of adult survival rates at those colonies, and at control colonies more distant from offshore wind farms, could provide clear evidence as to whether collision mortality did or did not cause a significant increase in the mortality rate of adult Gannets at colonies most likely to be affected.

Can survival rates of Gannets be measured accurately?

Only one study has measured survival rates of adult Gannets in the British Isles. Wanless *et al* (2006) used ring recovery data to estimate that adult Gannets have a mean annual survival of 92% and that about 30% of young survive to four years of age. Between 1959 and 2002, an average of 1,000 chicks and 33 adults were ringed each year in Britain and Ireland (mostly at Bass Rock, Ailsa Craig, Great Saltee, Hermaness, Scar Rocks, Fair Isle, Little Skellig and Bull Rock), providing a moderately robust estimate of adult survival. However, the small numbers ringed as adults limits analysis. The fact that in early years most ringing took place at the Bass Rock, whereas since 1990 hardly any birds have been ringed there, has also made it difficult to assess whether there are differences in survival between colonies or between decades. Wanless *et al* (2006) concluded 'more robust estimation [of survival rate] over the longer term would be achievable if more birds (especially adults) were ringed'. However, only 172 Gannets were ringed in Britain and Ireland in 2012 (Dadam *et al* 2013) and only 75 in 2013 (BTO online ringing reports), and this low level of effort compromises any attempt to monitor changes in Gannet survival from ring recovery data. So the first conclusion to reach is that there is an urgent need to increase ringing of Gannets if we are to obtain meaningful data on survival from ring recoveries.

It is remarkable that there have been no enduring studies of survival rates of Gannets by colour ringing breeding adults at colonies. Adult Gannets normally return to exactly the same nest site each year. At most accessible colonies adult Gannets can be caught at nest sites, before the egg has been laid. Adults attend nests from about February onwards. Even early in the season, adults at nest sites can be approached slowly without being disturbed, at least at colonies where they are used to seeing people, such as at the Bass Rock. However, there is a risk of gulls taking eggs or newly hatched chicks, or other Gannets stealing nest material from unattended nests, and so catching Gannets off nests containing an egg or small chick is not advisable. Catching adults when chicks are one-third to half grown may be optimal, as older chicks may be disturbed off the nest if their parent is caught. Birds attending nests can be caught with a pole and braided brass or nylon noose, and lifted off the nest with little disturbance to birds at neighbouring nests. Colour rings can be read on birds as they stand at, walk to, or depart from the nest, but can be difficult to see on incubating birds. Researchers deploying geolocation data loggers on breeding Gannets have found that a very high proportion of loggers can be recovered from adults the following breeding season (Kubetzki *et al* 2009, Fort *et al* 2012), so there is every reason to think that a high proportion of colour ringed adults could be resighted each year at colonies where some birds are accessible. Bass Rock, a key site close to proposed offshore wind farms, was especially suitable for such work as the Gannets there are used to seeing people visiting the colony, and large numbers could in the past be approached safely on the top of the island. Indeed, small numbers of breeding adults at the Bass Rock were colour ringed in the 1960s and their survival followed until the mid-1970s (Nelson 1978). However, numbers at the Bass Rock have increased so much in the last few years that access is now severely restricted by the dense presence of Gannet nests over almost all the top of the island. Nevertheless, about 100 breeding adults were recently colour ringed on the Bass Rock and provide a basis for future monitoring of survival rates. Smaller numbers have also been colour ringed at other colonies where logger deployments have taken place, including Grassholm, Ailsa Craig, Scar Rocks, and several Irish colonies. Although the Bempton colony is strategically important in the context of offshore wind farms, Gannets there are nesting on cliffs where climbing skills are required to access nests. Monitoring colour ringed adult Gannets at Bempton might be impractical. An alternative approach might be deployment of small transmitters attached to leg rings that could be programmed to signal that individuals were alive in subsequent seasons, though this would require technological innovation as such tags are not yet developed. Measurement of adult survival rates at Bass Rock, possibly in future at Bempton and Troup Head if suitable technology could be developed, and several other colonies should provide a test of the hypothesis that offshore wind farms reduce survival rates of adult Gannets at nearby colonies. In that regard, it would be preferable to be able to establish a longitudinal approach with survival of birds at the Bass Rock studied before and after construction of the wind farms as well as a cross-sectional approach comparing colonies. Wanless *et al* (2006) found no evidence of any difference in adult survival rates of Gannets at different colonies based on ring recovery data from 1959-2002. The Bempton colony is close to several large round three offshore wind farms that have been consented so are likely to be constructed soon and others currently in the planning process, while the Bass Rock colony is close to three large round three offshore wind farms that have been consented so are likely to be constructed soon. In contrast, Gannet colonies in the north and west of the British Isles are relatively distant from offshore wind farms and so birds from those sites are much less likely to be at risk of collision mortality. Power analysis would permit assessment of the numbers of birds that would need to be colour ringed at each colony in order to provide a reliable measure of the adverse impact of offshore wind farms on survival. Once a suitable sample of birds had been colour ringed, there would also be a need to add small numbers to the sample on a fairly regular basis since there is evidence for senescence in seabirds, with survival rate declining in the oldest fraction of the population (e.g. Ratcliffe *et al* 2002), so a comparison between samples should be based on groups of similar age structure. Furthermore, to obtain reliable results sufficient time would need to be invested in looking for marked birds, preferably every year and at each study colony.

Tracking movements of adults

While monitoring of adult survival rates is a high priority as a means of assessing whether offshore wind farms appear to be having adverse impacts on Gannet populations, tracking Gannet foraging flights from colonies near to offshore wind farms could provide insights into whether Gannets show strong avoidance behaviour, and therefore may be subject to barrier effects and displacement from foraging habitat, but be less at risk of collision mortality. Successful deployments on breeding Gannets include geolocator loggers (Kubetzki *et al* 2009, Fort *et al* 2012, Garthe *et al* 2012), satellite PTTs (Hamer et al 2000, Langston & Teuten 2012), GPS loggers and bird-borne cameras (Wakefield *et al* 2013, Votier *et al* 2013). These tracking studies demonstrate that Gannets are very suitable birds for deployment and recovery of devices. Furthermore, the tracking of breeding adults from several colonies has provided a very good understanding of the areas used by breeding adults both during and outside the breeding season (Fort *et al* 2012, Wakefield *et al* 2013). Thus while data for estimating trends in adult survival of Gannets are poor, the movement data and the colony count data are among the best for any seabird species in the world.

Flight height determines potential risk of collision, but the frequency distribution of flight heights of Gannets is not well known, and most data on flight height have been collected from wind farm development sites in the southern North Sea in areas where most Gannets are migrating rather than commuting to and from colonies (Johnson *et al* 2014). It is not known whether Gannets fly at different heights when breeding rather than migrating, or how much they alter flight height in the vicinity of offshore wind turbines, or in relation to weather or daylight conditions. It is possible to include an altimeter in a data logger which allows flight height to be measured to the nearest metre, whereas GPS loggers provide a measure of flight height that has an error of many metres. A strategic programme of deployment of devices on breeding Gannets would be highly desirable alongside monitoring of survival rates, to provide context to any measured variations in survival rate among colonies or over years.

In a recent editorial in British Birds, Newton (2014) questioned whether with all the new tracking technology available, old style ringing was still necessary for effective bird science and conservation. His emphatic answer was 'yes' and this forum article further endorses this view. However, Newton's (2014) take home message was that the usefulness of traditional ringing is hugely increased if it is used in combination with new technology. Given the current situation faced by North Sea Gannets this species would seem to be an ideal candidate for this approach.

Tracking movements of immatures

Although impacts on breeding adult Gannets are of particular concern, nearly half of the population consists of immature birds, not yet old enough to breed (Votier *et al* 2011). Immature Gannets probably behave very differently from adults (Votier *et al* 2011). Young immatures normally do not visit colonies during the summer, but remain at sea. Older immatures may visit many colonies before making a decision where to recruit (Votier *et al* 2011). Immature Gannets are likely to be exposed to very different risks from offshore wind farms compared to breeding adults. However, detailed data for this potentially crucial phase of life are almost completely lacking, and represent a major knowledge gap in terms of assessing impacts of offshore wind farms on Gannet populations. Whereas adults can be expected to return to their nest site so can potentially be recaptured to remove a data logger, immature birds would be very difficult, probably impossible, to recapture. Tracking immatures would be highly desirable to inform about risk. This would be possible using satellite technology, either platform transmitter terminals (PTTs) that transmit signals to satellites, or Global Positioning System (GPS) tags that transmit data to a base station (or the mobile phone network). Deployment of such devices is now becoming routine, but these tags are expensive (thousands of pounds per tag) so even in well funded research programmes, numbers that can be deployed tend to be small. Large scale marking of chicks with colony-specific colour rings could help map the ranges used by immatures and could complement more intensive studies deploying PTTs or GPS-GSM tags on immature Gannets.

Who should pay for such work?

Given the high percentage of the east Atlantic, indeed world population of Gannets breeding in the UK and the fact that major offshore developments are planned close to what has now become the world's largest gannetry (the Bass Rock; Murray *et al* in press), it seems obvious that developers should pay to provide reliable assessment of the adverse impacts of offshore wind farms on Gannet populations. Furthermore, there is a statutory requirement for developers to monitor environmental impacts when offshore wind farms are constructed, this duty being expressed as a planning consent condition set by the planning authority. However, existing offshore wind farm post-construction monitoring requirements have tended to focus on monitoring numbers of birds in the vicinity of constructed offshore wind farms and validation of collision risk estimates derived from pre-construction survey work. It would clearly be in the interests of offshore wind farm developers to quantify impacts on Gannet populations, since uncertainty about possible impacts might constrain future development. However, it would also be in the interest of conservation organisations to quantify impacts, and so some contribution to funding appropriate colour ringing and tracking studies might also reasonably come from conservation bodies.

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