Shag marine SPA identification: Data collection, collation and analysis

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Contents

1. Introduction

In 1979 the European Commission adopted the Birds Directive which, amongst other conservation measures, requires Member States to classify Special Protection Areas (SPAs) for birds listed on Annex I to the Directive and for regularly occurring migratory species. The European shag (*Phalacrocorax aristotelis*, hereafter referred to as 'shag') is a regularly occurring migratory species.

Shag distributions have mainly been investigated via two survey and analysis schemes: the European Seabirds At Sea (ESAS) program during winter and breeding seasons, and the inshore wintering waterbird assessment, covering distinct areas during the winter season only. At present, there are 13 colony SPAs in place to protect shags during the breeding season. Of these, 11 are in Scotland and two are in England. As shags tend not to range far from the coast during the breeding season, there have been concerns that some breeding season aggregations may not be adequately identified by the ESAS program (which has limited coverage close to the coastline). JNCC therefore investigated how well shag aggregations have been covered across their UK range and how potential gaps could be filled. One of the UK's largest shag breeding colonies (at the Isle of May, Scotland) was thought to have important foraging areas associated with the colony which were not identified in the ESAS analysis. A recent report by the Centre for Ecology & Hydrology (hereafter referred to as 'CEH report') provided a novel evidence source on shag distributions around the Isle of May. This document describes the methodology used within the CEH report.

2. Data collection

Shag distributional data was collected from breeding birds during the chick rearing periods over the course of 13 years (1987 to 2010). Four different methods were used:

- Dead-reckoning using Very High Frequency (VHF) telemetry (in most years between 1987 and 1998).
- Triangulation using VHF telemetry (2001).
- Dead reckoning using compass loggers (2002).
- GPS loggers (2003, 2006, 2008, 2009, 2010).

All of these methods required the birds to be equipped with signal transmitting (VHF) or data logging (Compass or GPS loggers) devices. The deployment period was usually very short and did not exceed two days in most cases. Details of the data collection process are listed in Box 1.

Box 1: Devices to collect shag distribution data

For VHF telemetry birds were fitted with a VHF radio signal emitter and the receiver aerial was placed at the highest point of the island. From the strength and consistency of the signal received, it was possible to determine a precise time-activity budget, namely whether the bird was flying, on the water surface or diving. Following the dead-reckoning method, locations of foraging birds were estimated by using the bearing of the bird leaving the colony, the flight time to the foraging site, and the average flight speed (as published in the literature). Alternatively, foraging locations were determined via triangulation, following the direction and strength of the signal from an additional position on the island and marking the intersection of the two bearings.

Using compass loggers, the bearing of the birds movement was recorded by the device in one-second intervals and the subsequent foraging trip was described by a series of joined vectors (short sections of flight between each one-second interval). The length of each vector was again determined by the birds average flight speed. The method allowed distinction between different activities such as flying or diving.

GPS loggers record latitude and longitude of the bird location directly. This technology has been rapidly advancing over recent decades but devices only became small and light enough for use on shags approximately10 years ago. Flight speed can be calculated via distance and time covered between two locations. Foraging locations were estimated using flight speeds.

3. Identification of foraging areas

Foraging aggregations around the colony were mapped for each year of the study and density maps were produced using Kernel Density Estimation, which model the spatial distribution using the observed data. Resulting maps were produced at a resolution of 400m x 400m grid cell size, showing density contours at a series of percentage levels. For example a 50% density contour captures 50% of the shag foraging area, a 99% contour captures 99% of the shags foraging area.

It was tested whether sufficient data had been collected to adequately represent the population's foraging range by identifying the point where additional data are unlikely to increase the foraging range size. In the Isle of May example approximately 8 years were required to reliably identify and describe 90% of the long-term population foraging range, so it was concluded that 13 years data is more than adequate.

4. Consistency of use

To examine the consistency with which the identified foraging areas were used over time, the study period was split into three different time periods (1987 to 1992, 1994 to 2003 and 2006 to 2010). Kernel densities were calculated for each of these periods and areas where either 50% or 90% density contours of the different periods overlapped were identified, showing which core areas were consistently used over time.

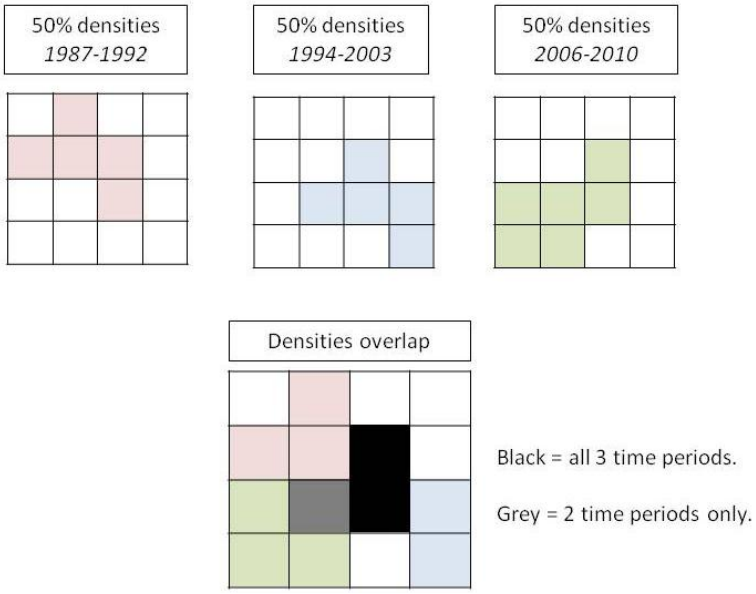

Figure 1: Simplified illustration of overlap in shag foraging areas across 3 time periods.

5. Boundary delineation

Shag densities (from the Kernel Density Estimation maps) from the combined distributional data across the entire study period (1987 to 2010) were plotted at percentage increments against the increase in the proportion of the total area used for foraging. This shows how the total area used increases with the total percentage of the foraging area captured. Using a method called maximum curvature a point can be identified where disproportionately large areas would have to be included within a boundary to accommodate any substantial increase in foraging shag density.

This density contour includes the three core areas which were consistently used over time.

In addition to shag areas identified by the inshore wintering waterbird or ESAS analyses, the area identified as described in this document, around the Isle of May, is included within the final Scottish suite of possible marine SPAs which are being considered.