

Spatio temporal distribution of waterfowl wintering in Camargue, Southern France

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Situated in Southern France, Camargue is a 150,000 ha wetland of major importance in Europe for wintering Anatidae species and coots. We took advantage of standardized aerial surveys conducted monthly from September to March since 1964 to model the spatio-temporal distribution of Greylag Goose (*Anser anser*), Common Coot (*Fulica atra*) and nine species of ducks, during daytime in Camargue. To take into account potential influence of three successive observers over the last 50 years, we considered longitudinal data from terrestrial surveys that were conducted on the same

species over the last 25 years in four nature reserves. In the end, our model offers a straightforward dynamic picture of the distribution of each species at two time scales: over the winter and over years. In addition, we tested for a common response of species with similar trophic status. Results will be discussed in the context of land-use changes that have profoundly transformed the Camargue over the last decades such as changes in proportions of area covered by ricefields, saltpans, nature reserves and hunting estates.

Estimating wintering populations of waterbirds by aerial high-resolution imaging

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Estimates of avian populations and their dynamics are highly dependent on the accuracy of the applied census technique and the design of spatial coverage. Most estimates of the wintering populations of waterbirds (and seabirds) have been derived from surveys using observers positioned on the shore, on ships or in low-flying airplanes. Visual aerial surveys have typically been flown beneath 80 m altitude to allow observers to identify the birds. However, at low altitude, there is a significant risk of birds being disturbed and either missed or miscounted. Furthermore, census data collected by visual techniques need to be corrected for distance-related observation bias. Latest developments in digital aerial imaging allow a less invasive census of waterbirds, thereby solving the problem of distance-dependent detectability. From orthogonal high-resolution digital images, it is possible to map locations of individuals and estimate bird population sizes with a high degree of precision. For example, from high resolution digital still aerial surveys it was estimated that 14,161 Red-

throated Divers (*Gavia stellata*) were present in the Outer Thames Estuary, which represents the highest number ever reported for a single site in northwest Europe. It is possible that earlier visual surveys had underestimated the numbers of divers present in this Special Protected Area (SPA). Applying state-of-the-art spatial models (i. e. the Complex Region Spatial Smoother creSS method) to these data suggest that habitat features and anthropogenic factors, such as boat traffic, significantly influence the distribution of divers. These results have major implications for the future design and implementation of surveys for assessing populations of wintering waterbirds in Europe. We discuss the minimum technical and methodological requirements for carrying out digital aerial surveys and develop a conceptual framework based on empirical trials for the calibration of observational and camera-based survey techniques, in order to evaluate the backlog of existing population estimates.