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Sanderlings *Calidris alba* in Portugal: directed counts reveal a much larger population than previously thought

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Sanderlings *Calidris alba* nest in the high Arctic and migrate to winter in coastal areas at a wide range of latitudes where they are regularly counted as part of the International Waterbird Census (IWC). However, given their broad range of habitats (which includes beaches and small lagoons, for example), counting Sanderlings in the large wetlands typically targeted by the IWC may provide an incomplete assessment of their population. To better survey the Sanderling wintering population in Portugal, we monitored the coast of Portugal with Projeto Arenaria, a citizen science project that counts Sanderlings and other waders on open rocky and sandy shores, since the winter of 2009–2010. Further, in the winters of 2015–2016 and 2021–2022, we carried out a 'National Directed Count of Sanderlings' (NDCS) in estuarine and lagoon areas. These differ from the typical IWC counts by being carried out at mid-tide (not high tide) and by making an extra effort to cover marginal habitats away from the main wader roosting sites. Summing results from Projeto Arenaria and NDCS yielded 5,544 Sanderlings in the 2015–2016 winter and 6,439 in 2021–2022, approximately trebling the estimates of the IWC counts in the same period. Trend analysis based on annual counts in selected coastal areas with sandy and rocky shores (from Projeto Arenaria), from the winter of 2009–2010 to 2022–2023, indicated a stable Sanderling population, consistent with the East Atlantic Flyway IWC estimates for the most recent years.

Keywords

monitoring

non-estuarine

East Atlantic

Flyway

INTRODUCTION

Sanderlings *Calidris alba* in the East Atlantic Flyway nest exclusively in the high Arctic tundra but in winter are spread widely over diverse habitats (estuaries, lagoons, open seashores; Connors *et al.* 1981, Lourenço *et al.* 2013) over a large area, from Northern Europe to southern Africa (Delany *et al.* 2009, Reneerkens *et al.* 2009). Hence, monitoring Sanderlings can provide insights into environmental changes in a broad region. Sanderlings, with their varied migratory strategies, are also a useful species to study how global changes affect long-distance bird migration (Reneerkens *et al.* 2020).

Given the relative inaccessibility of their breeding grounds, information on Sanderling numbers and population trends is mostly obtained in their winter quarters, through the International Waterbird Census (IWC) conducted along the entire East Atlantic Flyway (e.g., van Roomen *et al.* 2022). However, Sanderlings present challenges when it comes to monitoring numbers as part of the IWC, as the survey primarily covers the larger wetlands while several wader species such as Sanderlings winter on non-estuarine habitat (Burton *et al.* 2008) and often do not aggregate with other waders at high-tide roosts in major wetlands. While an increasing number of non-estuarine sites are included in the IWC, to estimate long-term population trends and assessment of the total population size, it is important that non-estuarine wetlands are monitored as an integral part of the IWC across the entire flyway (Rehfisch *et al.* 2008). On the other hand, the high winter-site fidelity of Sanderlings (Lourenço *et al.* 2016) and their tendency to occur in small flocks may allow more accurate counts and provide reliable estimates of population trends, based on monitoring of representative wintering areas.

More generally, the frequent lack of concordance of waterbird population trends derived from the IWC winter counts compared to breeding bird surveys, suggests that there are limitations to current IWC counts or breeding bird surveys (van Turnhout *et al.* 2022). Therefore, complementary approaches should be developed.

From the 1970s to the 2000s, the monitoring of waders in Portugal primarily involved counts conducted in major wetlands, as part of the IWC (e.g. Rufino 1980, 1990, Costa & Rufino 1997). IWC January counts in years with complete coverage of major wetlands (2005, 2006, 2007, 2010, 2015, 2018, 2019) yielded a total of approximately 1,000–2,000 Sanderlings (ICNF pers. comm.). In 2009–2010, the first national census of the open Portuguese coast (beaches and rocky shores) through a Citizen Science project (Projeto Arenaria) showed the presence of *ca*. 3,000 additional Sanderlings during winter (Lecoq *et al.* 2013), greatly increasing the estimated size of the national wintering population. Indeed, based on our experience before this project, counts in major wetlands often failed to adequately cover suitable Sanderling habitat (including sites within those major wetlands). We felt that increased directed efforts might further change the overall assessment of the population.

This paper (1) presents updated estimates of the Sanderling wintering population in Portugal obtained through directed censuses (in two different winters) that complement the IWC, and (2) assesses population trends based on ongoing monitoring of coastal areas through Projeto Arenaria.

METHODS

Projeto Arenaria

Projeto Arenaria started in 2009–2010 with the aim of counting waders and other birds on the rocky and sandy open shores of Portugal. Within the framework of Projeto Arenaria, the Portuguese mainland coast is divided into 198, 5 × 5 km UTM (Universal Transverse Mercator) squares that are assigned to volunteers to count around (within three hours of) low tide. Counts take place in December or January, with a few counts to fill gaps in February; for more details of the methods see Lecoq *et al.* (2013), Lourenço *et al.* (2013), Meirinho *et al.* (2014). Counts attempting full coverage of the coast were carried out in the winter of 2009–2010, 2015–2016 and 2021–2022. In the other years, a fixed subset of 49 randomly chosen squares was defined as priority for annual monitoring. During all counts, observers were asked to record the habitat where Sanderlings were observed.

In the winter of 2015–2016, 10 UTM squares were not surveyed. However, this likely had minimal impact on the overall Sanderling estimate, as these 10 squares combined held only 17 Sanderlings during the 2009–2011 coastal winter survey. In the winter of 2021–2022, we repeated the effort of 2015–2016.

IWC counts

International Waterbird Counts have been conducted annually in Portugal since the 1970s, carried out in mid-winter by the Instituto da Conservação da Natureza e das Florestas (ICNF) staff and collaborators. Major wetlands are visited by land or boat. Waders are mostly counted when gathered at their high tide roosts (Costa & Rufino 1997, Hearn *et al.* 2018).

National Directed Census of Sanderlings (NDCS)

In the winters of 2015–2016 and 2021–2022, we complemented the IWC national counts using the network of volunteers of Projeto Arenaria. Besides the normal Projeto Arenaria counts described above, we surveyed wetlands at mid-tide (IWC counts occur at high tide), covering as much as possible of the large estuaries and coastal lagoons and, as far as possible, visiting all the areas with sandy beaches and sandflats (which are not always covered by IWC counts). Volunteers were also asked to target small

estuaries and small coastal lagoons that usually harbour very small numbers of waterbirds. Mid-tide surveys could not be carried out for Ria Formosa so, for that area, we used the results from high-tide IWC counts.

In the Azores and Madeira archipelagos, most of the coast is composed of rather inaccessible steep and rocky cliffs. Counts were carried out in 2015–2016 and 2021–2022 covering virtually all suitable Sanderling habitat, which is very restricted in these archipelagos.

Analyses

To investigate the population trend for wintering Sanderlings in Portuguese non-estuarine areas covered by Projeto Arenaria, between 2009–2010 and 2022–2023, we used TRIM (Trends and Indices for Monitoring Data), a standardized tool used to analyse time-series counts that allows the inclusion of missing counts (Pannekoek & van Strien 2004). This method is frequently used for the estimation of trends in abundance of breeding birds (Kamp *et al.* 2021), but also wintering waders and waterfowl (Kasahara & Koyama 2010, Belo *et al.* 2023) and other fauna, such as butterflies (e.g., Wepprich *et al.* 2019). TRIM takes overdispersion and serial correlation of count data into account and enables the calculation of yearly indices and standard errors and the estimation of trends using a log-linear Poisson regression model for counts (Pannekoek & van Strien 2004). For the trend analysis using Projeto Arenaria data, squares that included only a short section of coast were merged with the contiguous square, giving a total of 156 squares. The 14 winters of Projeto Arenaria's coastal surveys considered in the analysis included three winters with near-complete censuses (2009–2010 – 150 squares monitored, 96%; 2015–2016 – 137 squares monitored, 88%; 2021–2022 – 147 squares monitored, 94%). For the remaining winters, counts were made in an average of 34% of the 156 squares (range 41–73 squares monitored). Trend analysis was performed in the R environment (R Core Team 2023) using the rtrim package (Boogart *et al.* 2020). The maps were produced using QGIS 3.30.2 (QGIS Development Team 2023).

RESULTS

Total numbers and main wintering areas

We recorded 5,544 Sanderlings (Projeto Arenaria + NDCS counts) in the mainland of Portugal in the 2015–2016 census and 6,479 individuals in 2021–2022. In 2015–2016, of the total of individuals counted, 2,893 (52%) were on shores open to the ocean covered by the core Projeto Arenaria survey and 2,651 (48%) were in estuarine and coastal lagoon habitats covered by the NDCS. Very similar percentages were recorded for 2021–2022, with 3,363 (52%) Sanderlings on open shores and 3,116 (48%) on estuaries or coastal lagoons (Fig. 1). Considering a few small lagoons and estuaries, and the percentage of larger areas that were not surveyed, we estimate that no more than a few hundred birds might have been missed. Counts at the four main wintering sites in coastal wetlands in Portugal, as obtained by IWC and NDCS, are presented

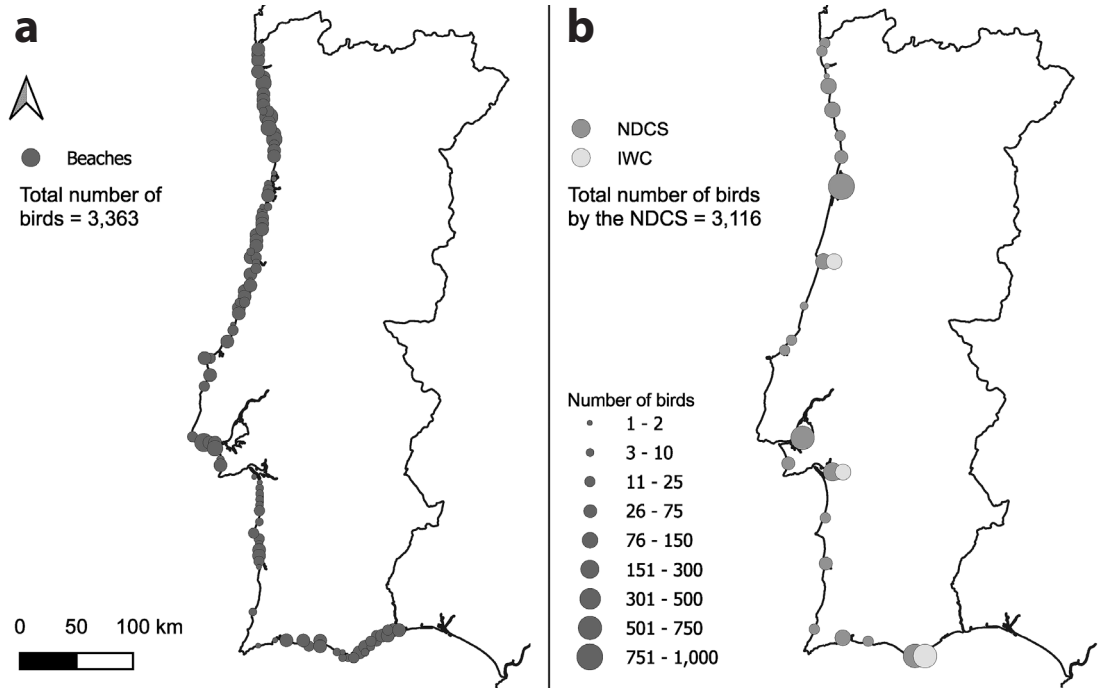

Fig. 1. Map of Portugal showing the numbers of Sanderlings recorded in the 2021–2022 winter census: **(a)** on the shore in Projeto Arenaria and **(b)** in estuaries and coastal lagoons during mid-tide and high-tide counts (NDCS - National Directed Census of Sanderlings, IWC – International Waterbird Census).

Table 1. Sanderling counts at the four major wetlands in Portugal. The table shows high-tide counts carried out within the IWC framework and mid-tide counts carried out as part of the National Directed Census of Sanderlings (NDCS). An '-' indicates that there were no counts.

	Ria de Aveiro		Tejo estuary		Sado estuary		Ria Formosa	
	IWC	NDCS	IWC	NDCS	IWC	NDCS	IWC	NDCS
Jan 2016	307	568	413	588	155	407	498	-
Jan 2022	-	988	0	663	100	170	674	-

in Table 1. Sanderlings are rare in the insular regions of Madeira and the Azores, with only five individuals observed in Madeira and 45 counted in the Azores in 2015–2016, and one individual in Madeira and 150 in the Azores in 2021–2022.

In the 2015–2016 counts of Projeto Arenaria, 510 (18%) of the Sanderlings were observed on rocky shores, 2,342 (81%) on sandy beaches, and only 41 (1%) in other habitats (e.g., piers, pools). The corresponding values for 2021–2022 were 1,216 (36%) on rocky shores, 1,854 (55%) on sandy beaches and 293 (9%) in other habitats. It should be noted that the use of rocky habitats is not sporadic or limited to roosting, as large numbers of Sanderlings were seen feeding in such habitats in some squares, mostly on rock ledges.

Population trends

Projeto Arenaria counts conducted in the same squares over the past 14 years revealed a stable Sanderling winter population (0.999 ± 0.008; Multiplicative Slope ± SE) along the open beaches of the Portuguese mainland (Fig. 2). Sanderlings were recorded in 83% of the monitored squares (n = 156) while there were 51% missing counts. The model accounted for both overdispersion ($\sigma = 22.9$) and serial correlation ($\rho = 0.02$).

DISCUSSION

The sum of counts from Projeto Arenaria and from NDCS suggest a wintering population of *ca*. 6,000 Sanderlings in Portugal; contrasting with the numbers reported to the IWC in the past decade, which have averaged less than 2,000 birds (ICNF pers. comm.). The discrepancy in numbers is due not only to the inclusion of additional counts of beaches and rocky shores (which account for about half of the wintering Portuguese population) but also due to the omission of some major Portuguese wetlands in most years.

It is also worth noting that the NDCS carried out at mid-tide and covering most of the suitable habitats in major estuaries and lagoons of the Portuguese coast, often yielded larger numbers of Sanderlings compared to IWC high-tide counts (Table 1). High-tide counts typically focus on major roosting sites of waders and other waterbirds, while Sanderlings often roost in small flocks along beaches and may even keep foraging during periods around high tide within the surf zone of sandy shores (Connors *et al.* 1981, Grond *et al.* 2015). This behaviour is likely a major contributing factor to the notably higher numbers obtained in extensive mid-tide counts. However, it is important to note that in many wetlands (such as in Ria Formosa), counting waders at mid-tide may not be feasible, as the area is too large and many sectors are relatively inaccessible. Therefore, even for Sanderlings, high tide counts of roosts may remain the best available option in those areas.

Our findings cannot be directly generalized to other countries or regions, but they do suggest that Sanderling populations may be considerably underestimated by IWC counts (see also Burton *et al.* 2008). Further investigations are required to determine if more comprehensive counts conducted in different locations will support the idea that Sanderling numbers at the flyway level are higher than commonly assumed (Wetlands International 2021).

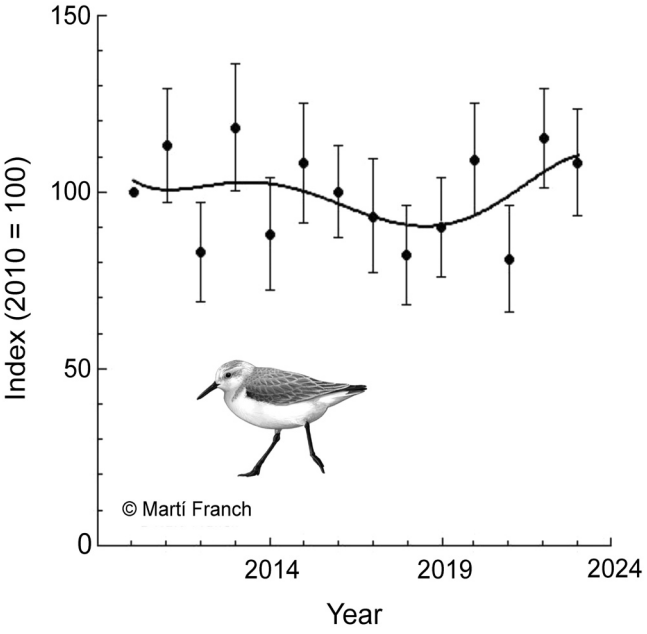

Fig. 2. Trend and indices (± SE) for the winter population of Sanderlings in Portugal over fourteen years (2010–2023) based on the Projeto Arenaria counts along open shorelines.

Sanderlings in the East Atlantic Flyway experienced a population increase, as assessed by the IWC, in the late 20th century and early 21st century. However, recent data suggest a stabilization in numbers (van Roomen *et al.* 2022). Our annual monitoring of selected squares on the marine shores of Portugal (Projeto Arenaria) from 2010 to 2023 also suggests a stable Sanderling population. Counts based on the continuation of more thorough census programs which better target Sanderling will be needed to determine whether this population is indeed stable, or starting to decline, in common with several other high Arctic wader species (Meltofte 2013, van Roomen *et al.* 2022).

Despite their wide range of habitats, Sanderlings are not unique in presenting challenges related to accurate population counting (e.g. Burton *et al.* 2008, Nagy *et al.* 2022). Such challenges likely also affect monitoring results for other wader populations, particularly in countries like Portugal and other countries to the south in this flyway, where the number of people involved in counts is limited and coverage of wetlands varies (Nagy *et al.* 2022). This variability may cause problems in interpreting wader population trends. To better assess waterbird population trends in a world undergoing rapid and profound changes, it is essential to establish highly repeatable counting methodologies (Nagy *et al.* 2022). Projects like Projeto Arenaria may help us move towards this goal. An assessment of the repeatability of wader counts would be valuable and could further complement and aid in the interpretation of the broader IWC results.

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