An unprecedented Western Palearctic concentration of Wilson's Storm-petrels *Oceanites oceanicus* at an oceanic upwelling front offshore Mauritania

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Abstract
An opportunistic boat-based survey to the Mauritania upwelling zone in July 2005 discovered an unprecedented concentration of Wilson's Storm-petrels *Oceanites oceanicus*. Flocks of up to 600 birds were concentrated along the boundary between warm surface waters and cooler upwelled waters. These flocks formed an aggregation of at least 5,000 birds, which is an unprecedented total for this species in Western Palearctic waters.

Introduction

The Mauritania upwelling zone lies just within the Western Palearctic boundary and is an important feeding area for both resident and migratory seabirds (e.g. Wynn & Knefelkamp 2004; Camphuysen & van der Meer 2005). Upwelling in this region is driven by northeast-flowing Trade Winds pushing surface waters offshore. These surface waters are replaced by cold, deep, upwelled waters, which are rich in nutrients and able to support elevated levels of primary productivity. This in turn supports concentrations of higher trophic levels, including fish and seabirds (Wynn & Knefelkamp 2004).

Previous pelagic trips to the region in winter and spring have revealed important concentrations of species such as Cory's Shearwater *Calonectris diomedea*, Northern Gannet *Morus bassanus*, Pomarine Skua *Stercorarius pomarinus*, Long-tailed Skua *Stercorarius longicaudus*, Sabine's Gull *Xema sabini*, Black Tern *Chlidonias niger* and Common Tern *Sterna hirundo* (Brown 1979; Leopold 1993; Burton & Camphuysen 2003; Camphuysen 2003; Wynn & Knefelkamp 2004; Camphuysen & van der Meer 2005).

From 4–26 July 2005, a research expedition to the Mauritanian continental shelf and upper slope (Figure 1) enabled the seabird assemblage in mid summer to be assessed for the first time. The purpose of this short article is to document an unprecedented Western Palearctic concentration of Wilson's Storm-petrels *Oceanites oceanicus* recorded in the Mauritania upwelling zone between 15 and 17 July 2005, and to briefly discuss the controls on their spatial distribution.

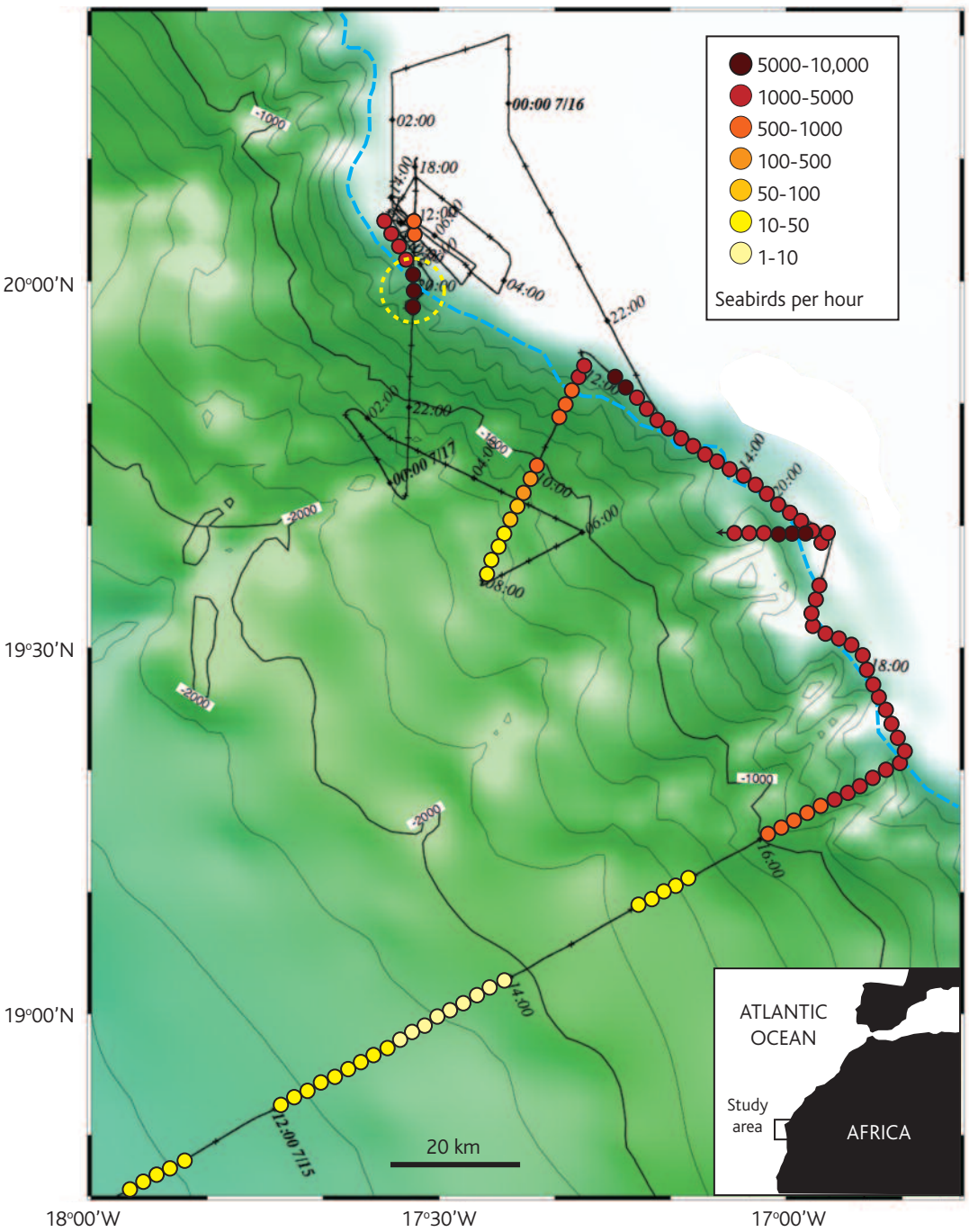

Figure 1. Map showing the abundance of seabirds (in birds per hour) off Mauritania in the period 15–17 July 2005. The thin black line is the vessel track with 2-hourly markers. Bathymetric contours are at 200 m spacing. The dashed blue line shows the shelf edge at a depth of c. 120 m, delimiting shelf (white) and slope waters (green). The yellow dashed circle shows the location of the profile in Figure 4. Inset map (bottom right) shows the general location of study area.

Data collection

The data presented here were collected during the research expedition *RV Meteor* M65/2, which departed from Dakar, Senegal, on 4 July 2005 and finished in Las Palmas, Gran Canaria, on 26 July 2005. The expedition was mostly concerned with geological and geophysical studies of the northwest African continental margin (see Krastel *et al*. 2006), but recorded continuous measurements of sea surface temperature (SST) and water depth (WD). There were opportunities for a single observer (RBW) to record all wildlife observations during geophysical surveys, including seabirds, cetaceans and migrant land birds and insects. As these observations were opportunistic it was not possible to employ a rigorous fixed methodology to quantify absolute seabird abundance, so any totals obtained should be taken as estimates.

During 15–17 July 2005, observations were made in the vicinity of the Mauritania Shelf about 50–150 km west of Cape Timiris between 19º00'N 16º50'W and 20º10'N 17º40'W (Figure 1). In this area a simple recording unit of 'seabirds per hour' was used when the ship was undertaking geophysical surveys (at a speed of about 5.0 knots), so that the influence of SST and WD on seabird density could be investigated. Observations were undertaken with 10x binoculars during continuous 180º scans in front of the vessel. Photos were taken sporadically in order to more accurately count flock sizes in large seabird aggregations.

Results

Ship data for SST and WD reveal that the strongest temperature gradient occurred at the continental shelf edge, separating warm, deep, offshore waters (> 24ºC) from cooler upwelled waters over the shelf and upper continental slope (< 22ºC). The narrow 'mixing zone' at the shelf edge was about 10–25 km wide and was characterised by SST of 22–24ºC (Figure 2). In deep water areas (> 1,000 m WD) on the middle and lower slope, seabird density was consistently low (< 10 birds per hour; Figure 1). On the upper slope seabird densities progressively increased as water depth decreased, peaking at > 5,000–10,000 birds per hour on the shelf edge at c. 100 m WD. The latter area was characterised by a high density of commercial fishing vessels, mostly pelagic pair-trawlers in pursuit of Horse Mackerel *Trachurus trachurus*, European Pilchard *Sardina pilchardus*, and Round Sardinella *Sardinella auritus*.

The commonest seabird species in the shelf-edge 'mixing zone' was Wilson's Storm-petrel, but several thousand Black Terns (roughly 80–90% first-summer birds) and hundreds of Cape Verde Shearwaters *Calonectris edwardsii*, Royal Terns *Sterna maxima* and Common Terns were also recorded. With the exception of the storm-petrels, most birds were seen directly associating with fishing vessels or moving between vessels, as previously noted by Camphuysen & van der Meer (2005).

The largest numbers of Wilson's Storm-petrels were observed in calm weather on 16 July 2005 at approximately 20º00'N 17º30'W. An estimated 5,000–10,000 individuals were counted immediately upslope of the shelf edge at c. 100 m WD. The birds formed huge flocks sitting on the water aligned with the shelf edge, one

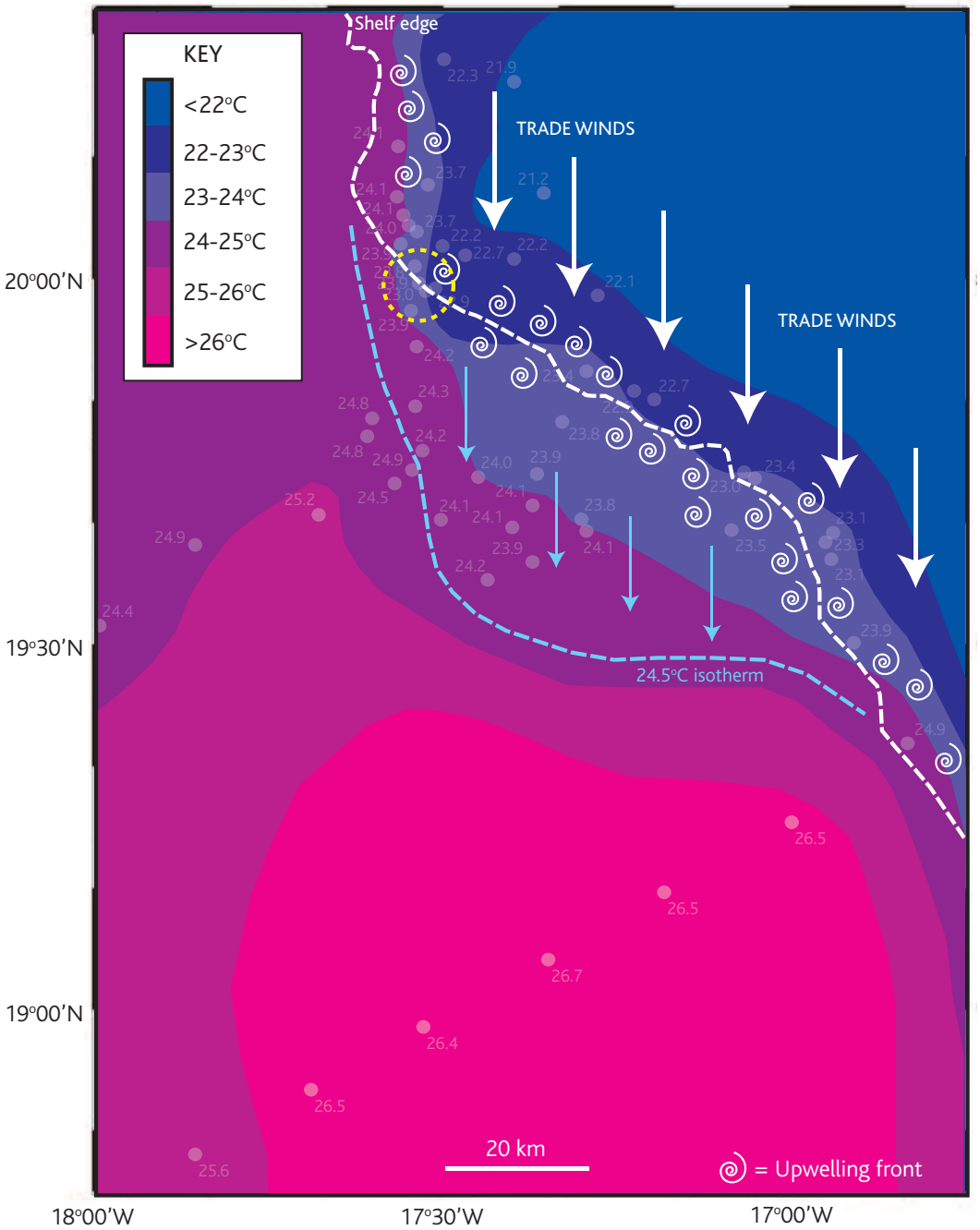

Figure 2. SST map across the Mauritania upwelling zone during the period 15–17 July 2005. *In situ* vessel-derived SST measurements (°C) are in pale grey. Interpolated isotherms (at 1°C intervals) are represented by coloured shading. The white dashed line shows the location of the shelf edge. The blue dashed line illustrates how the 24.5°C isotherm is pushed southwards, away from the shelf edge, by the northerly Trade Winds, with warm surface waters being replaced by cooler upwelled waters (< 22–23°C). The yellow dashed circle shows the location of the profile in Figure 4.

Figure 3. Flock of Wilson's Storm-petrels *Oceanites oceanicus* at the shelf edge in the Mauritania upwelling zone, 16 July 2005. At least 600 birds are present in this flock. © Russell Wynn.

of the flocks containing at least 600 birds (Figure 3). The vessel crossed the shelf edge twice between 0830–0930 h, and on both occasions the highest density of flocks was noted to occur at the interface between cool upwelled waters and warmer surface waters, represented by a temperature change of 1ºC over a distance of ca. 5 km (Figure 4). The following day (17 July 2005) another shelf crossing was undertaken at approximately 19º52'N 17º17'W in windier conditions (Figure 1). This crossing also produced high numbers of Wilson's Storm-petrels (100–500 per hour) and several thousand Black Terns.

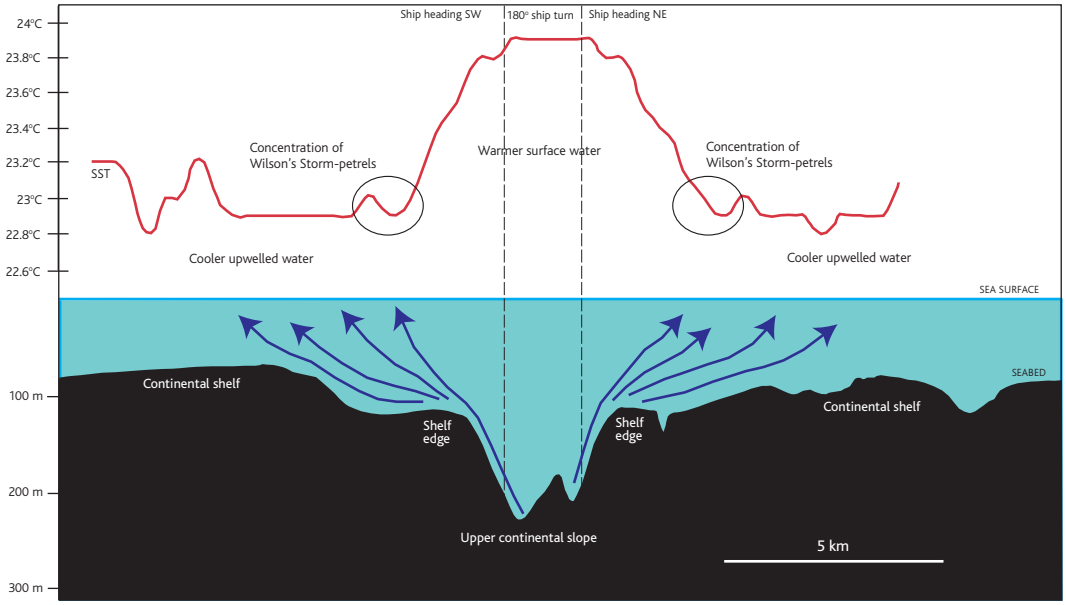

Figure 4. Cross-sectional profile of water depth and SST in the Mauritania upwelling zone, recorded during a repeat transect across the shelf edge in calm weather on 16 July 2005 (see Figures 1 and 2 for approximate location). Note the ship turned 180º halfway through the illustrated profile and returned on a parallel line, generating a 'mirror image'. The lower panel shows the seabed profile (black area below the seafloor) and the abrupt break-of-slope at the shelf edge. The blue arrows show the interpreted flow of cooler upwelled waters. The upper panel shows the vessel-derived SST profile; note the contrast between cooler (< 23ºC) upwelled waters on the shelf compared to warmer surface waters over the upper slope.

Figure 5. Wilson's Storm-petrel *Oceanites oceanicus* in the Mauritania upwelling zone, 15 July 2005. © Russell Wynn.

Discussion

Previous studies (Wynn & Knefelkamp 2004; Camphuysen & van der Meer 2005) have suggested that elevated primary productivity, high densities of shoaling pelagic fish, and associated commercial fishing activities are the primary controls on high seabird densities occurring in the Mauritania upwelling zone. The results presented here provide further evidence of the importance of the narrow mixing zone at the shelf edge to species such as Wilson's Storm-petrel and Black Tern, both of which probably number hundreds of thousands in this area in mid summer. Although most of the seabird species observed in July 2005 were associated with commercial fishing vessels spread across a broad area, the highest numbers of Wilson's Storm-petrels were encountered along the narrow upwelling front in an area where SST and WD change rapidly. Convergent processes at the upwelling front are likely to concentrate zooplankton and small prey fish in this zone. It is likely that wind-driven mixing will reduce the strength of this front at the sea surface, which may be why lower densities of storm-petrels were recorded in windier conditions when crossing this boundary.

Wynn & Knefelkamp (2004) recorded a total of 500–1,000 Wilson's Storm Petrels over several days in the Mauritania upwelling zone during April–May 2003, and on 6 May 2011 a total of 230 Wilson's Storm-petrels were observed from *MV Plancius* as it moved north along the upper Mauritania slope between 19º43'N and 20º59'N at 200–1,000 m WD (Brereton 2011). Further south, day counts of several hundred birds have been made during pelagic trips off Senegal in spring, e.g. 615 on 25 April 1992 (Marr & Porter 1992). An overview of the species' occurrence in European waters (Halley & Noeske 2007) documented counts of up to 300 off west Iberia in summer, with smaller numbers around Macaronesia and extending north to southwest UK and Ireland. However, the large numbers of Wilson's Storm-petrels recorded off Mauritania during this study are unprecedented in a Western Palearctic context, and indicate that mid summer is probably the peak period for the species in the region.

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