



## Short communication

# Adult and juvenile European seabirds at risk from marine plundering off West Africa

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## ABSTRACT

Foreign fisheries massively harvest waters off West Africa, plundering local marine economies and threatening African food security. Here we warn that these fisheries might affect both juvenile and adult European seabirds during their autumn migration and at their wintering grounds. Using miniaturised GPS, satellite transmitters and geolocators, we tracked the migratory movements of 64 adult and juvenile Northern gannets (*Morus bassanus*) and Scopoli's shearwaters (*Calonectris diomedea*) after their breeding season in the eastern Atlantic and the Mediterranean Sea, respectively. It was the first time ever that the movements of gannet fledglings were tracked with GPS accuracy. During winter (October to March) birds made extensive use of marine areas within the exclusive economic zones of Morocco, Western Sahara, Mauritania and Senegal. These juvenile and adult European seabirds are therefore dependent upon African marine resources and at risk from competition with fisheries, as well as intentional and incidental mortality by fishing gear. Those threats occur additionally to detrimental seabird–fishery interactions in Europe. There is an urgent need for improved marine conservation off West Africa, and our data demonstrating connectivity between specific European breeding colonies and African wintering areas are a major step towards stakeholder involvement.

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## 1. Introduction

Marine areas off West Africa currently experience the highest level of illegal, unreported and unregulated (IUU) fisheries in the world, which confiscate 40% of the total regional catch worth tens of millions US\$ per year (Agnew et al., 2009). African coastal states often do not have the necessary legislation to protect their marine resources (Agnew et al., 2009) and the fish stocks of Morocco, Western Sahara, Mauritania and Senegal are thereby being plundered, jeopardizing West African economies and food security (Kaczynski and Fluharty, 2002; Alder and Sumaila, 2004; Agnew et al., 2009; Ramos and Grémillet, 2013; Pauly et al., 2014). Chinese fisheries have recently been accused (Pauly et al., 2014), but 238 European fishing vessels also fished legally off Western Sahara between 2007 and 2011 on the basis of an agreement between the EU and Morocco that ignores the sovereignty of Western Sahara (<http://www.fishelsewhere.eu/>). Such short-sighted

'gold-rush' harvesting threatens regional fish stocks and food webs (Worm and Branch, 2012).

Abundant marine resources off West Africa also attract marine predators (Zeeberg et al., 2006), and the area is a wintering ground for numerous seabird species and a migratory corridor for others moving further into the South Atlantic (Wynn and Knefelkamp, 2004; Camphuysen and van der Meer, 2005; González-Solís et al., 2007). West Africa is well known as a wintering area for European seabirds through direct sightings and ring recoveries (e.g. Wanless, 2002). However, it is only recently that tracking technologies have allowed following the exact movements of individual seabirds between European breeding grounds and West Africa (González-Solís et al., 2007; Fort et al., 2012). Studies so far mainly focused on adult birds, which were the easiest to fit with electronic devices. However, new technologies now allow tracking juvenile birds on their very first migration (Weimerskirch et al., 2006). These advances are essential since they allow a more complete picture of population-level spatial ecology.

We tracked adult and juvenile Northern gannets *Morus bassanus* from a colony in the English Channel and Scopoli's shearwaters *Calonectris diomedea* from the Mediterranean during their

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migration from Europe to West Africa. We use this information to test the hypothesis that both juvenile and adult seabirds from specific European breeding sites move to West Africa in the autumn, where they are at threat from marine plundering.

## 2. Methods

### 2.1. Data collection

Field protocols for both species and study sites were validated with respect to ethics in animal experimentation by the French Direction des Services Vétérinaires (Permit N° 34-369). Three types of electronic tags were used, which all weighed less than 4% of birds' body masses, and complied with standards ensuring minimal device-related effects (Phillips et al., 2003). Impact studies on gannets and shearwaters during the breeding season found no measurable impact of tagging on bird performances (Grémillet et al., 2006; Authier et al., 2013). Northern gannets were equipped at their only breeding site in France (Sept-Iles Archipelago, Brittany). In June 2010, 37 adults were fitted with geolocators recording light levels (3.6 g; LAT2500, Lotek Inc, Canada) attached to leg rings. Birds were recaptured in June 2011, and tags downloaded. In early August 2012, Solar GPS-PTTs (30 g, 1% of bird body mass; NorthStar Inc, USA, programmed with a duty cycle of 8 h ON/48 h OFF) were attached to the tails of five soon-to-fledge juvenile gannets using tape, cable ties and superglue. Similarly, Scopoli's shearwaters, which are endemic to the Mediterranean (Sangster et al., 2012), were tracked from Riou and Frioul Islands off Marseille and Lavezzi Island in Corsica. Forty-three adults were fitted with geolocators (same as above) on Riou Island in July–August 2011. Another set of eleven adults and ten juveniles (fledglings of the year) were also tracked by solar Argos-PTT (9.5 g or 18 g,  $\leq 3\%$  bird body mass, Microwave Telemetry, USA, programmed with a duty cycle of 10 h ON/48 h OFF for 9.5 g-PTT and 12 h ON/24 h OFF for 18 g-PTT), which were taped to the back feathers of the birds in August or October 2011 (4 adults were equipped on Lavezzi Island, the remaining on Marseille Islands). Shearwater data have been partly published in Péron and Grémillet (2013), with no reference to the conservation context.

### 2.2. Data analysis

Geolocators recorded light levels which were used to estimate geographic locations using an onboard algorithm, following Wilson et al. (1992). Estimated positions were then filtered to eliminate outliers using a speed criterion as in Freitas et al. (2008). Filtered positions were mapped using kernel density distributions (Wood et al., 2000; smoothing factor: 1 decimal degree), using the 'adehabitatHR' package developed by Calenge (2006) in R Core Team (2013). GPS-PTT data had high (<100 m) accuracy and were therefore mapped as such. PTT tracks were discontinuous due to the on/off duty cycles of the tags, and tracks were therefore reconstructed using state-space modelling allowing hourly estimates of bird positions (Jonsen et al., 2007).

## 3. Results

Migratory movement data were collected for a total of 64 adult and juvenile Northern gannets and Scopoli's shearwaters: Twenty-four adult Northern gannets carrying geolocators were recaptured (from the 37 equipped), and estimated daily positions were gathered from 21 geolocators (3 loggers malfunctioned) across the entire inter-breeding period, from September 2010 to February 2011. Among tracked adult gannets, 62% remained in European

waters in winter, 14% entered the Mediterranean, and 24% went to off West Africa.

Four out of five GPS/PTT tags deployed on juvenile gannets functioned between August and November 2012, during the migratory phase of the birds. All tracked juvenile gannets went to West Africa. It was the first time ever that the movements of gannet fledglings were tracked, and their migration paths were followed with GPS accuracy. Thirty-four adult Scopoli's shearwaters carrying geolocators were recaptured (from the 43 equipped). The 27 tags which could be downloaded provided information about entire inter-breeding movements, between October 2011 and April 2012. All birds went/travelled through West Africa during this period, and 56% of individuals remained there all winter (of the remaining birds, 22% wintered in the Northern Benguela (Angola, Namibia), 15% in the Gulf of Guinea, and 7% in the middle Atlantic). All 21 PTTs deployed on juvenile and adult Scopoli's shearwaters functioned during the initial migratory phase (transmission lasted from one week to three months, from October to January), and 13 tagged birds were tracked from Europe to Africa during this period (6 juveniles and 7 adults).

All recorded spatial data concur to designate striking coastal habits of adult and juvenile birds during the initial migration phase (September to November) along the narrow continental shelf of West Africa (depth < 200 m), and extensive winter (October to March) use of waters within the Exclusive Economic Zones (EEZ) of Morocco, Western Sahara, Mauritania and Senegal (Fig. 1). GPS and PTT data are displayed as dots along the tracks, and geolocation data as contours of kernel density distributions.

Finer scale GPS movements of gannets showed highly coastal zig-zag movements typical of foraging between Agadir and Essaouira in Morocco (Fig. 2A) and Cap Blanc and Banc d'Arguin in Western Sahara and Mauritania. Scopoli's shearwaters movements were also very coastal but located further South in Senegal, with winter foraging grounds located off Saint-Louis in Senegal, and more generally between Dakar and Banc d'Arguin (Fig. 2B).

## 4. Discussion

Results from this biotelemetry study validate our hypothesis: Juvenile and adult Northern gannets and Scopoli's Shearwaters made extensive use of marine waters off West Africa during their autumn migration and wintering phase (Fig. 1). These findings have important conservation implications and point to the need for further investigations of fisheries impacts on the marine megafauna in this part of the world. Specifically, these impacts might take the form of competition for fish resources and/or of increased seabird incidental mortality.

### 4.1. Seabirds connect European and African marine ecosystems

West-African marine resources attract marine predators, including a suite of migratory seabirds (Wynn and Knefelkamp, 2004; Camphuysen and van der Meer, 2005). Previous at-sea observations which highlighted seabird abundance and richness off West Africa were nonetheless conducted on birds of unknown geographic origin. For example, a gannet seen in winter off Mauritania could have come from a breeding colony in Finmark, Brittany, or even Newfoundland (Fort et al., 2012; Fifield et al., 2014). In great contrast, we tracked of birds from specific European breeding colonies to show that West Africa is a key wintering area for two seabird species fully protected by European directives within their breeding habitats in the Eastern Atlantic and the Mediterranean Sea, respectively. Biotelemetry also allowed us to define the exact periods during which those areas are important for wintering European seabirds. Further, recent studies also stressed the

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