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First-year Movements of Yellow-legged Gull (*Larus michahellis lusitanius*) from the Southeastern Bay of Biscay

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Abstract.—Information on when and where the Yellow-legged Gull (*Larus michahellis lusitanius*) population breeding in northern Iberia moves throughout the year is lacking. Here, distances and directions of gull movements during their first year of life were elucidated. Data on 2,776 sightings of 728 out of 2,421 gulls banded as chicks in the southeastern Bay of Biscay were analyzed. Overall, most (69.2%) gulls were found less than 50 km from their natal colonies and practically all gulls (95.9%) were found along the coast of northern Iberia, confirming the low mobility of this Yellow-legged Gull population. Distances at which gulls were found did not vary with time, suggesting that stable feeding resources exist across the area used by the population. *Received 29 January 2010, accepted 24 March 2010.*

Key words.—Breeding colonies, darvic rings, *Larus michahellis lusitanius*, northern Iberia, ringing, sighting data.

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The Yellow-legged Gull (*Larus michahellis*) is one of the most abundant large gulls in the southwestern Palaearctic, occurring in southern Europe, northern Africa and Macaronesia (Bermejo and Mouriño 2003; Olsen and Larsson 2004). More recently, Yellow-legged Gulls have colonized the Atlantic coast of France, some wetlands in central Europe and the English Channel (Geroudet 1984; Yésou 1991). Currently, two subspecies are recognized as breeding in Iberia (Olsen and Larsson 2004; Pons *et al.* 2004): *L. m. michahellis*, present on the Mediterranean basin, and *L. m. lusitanius*, on the Atlantic coast from the southeastern Bay of Biscay (Basque Country) to central Portugal (as far as southern Portugal according to Pons *et al.* 2004).

From a theoretical perspective, the seasonality and instability of feeding resources is one of the main causes promoting migration (Newton 2008). As these resources are thought to be abundant and stable along the coast of northern Iberia (Martínez-Abrain *et al.* 2002), Yellow-legged Gulls from the southeastern Bay of Biscay should be expected to be sedentary, therefore remaining in or close to natal colonies throughout the year. Previous studies have shown that *L. m. lusitanius* populations are more sedentary than L. m. michahellis populations (Munilla 1997; Martínez-Abrain *et al.* 2002). However, analyses of their movements, e.g. relative to patterns throughout the year, are scarce and based on small sample sizes (Munilla 1997; Pérez *et al.* 2006).

The generalized use of darvic rings has improved the efficacy of ringing projects (Rock 1999). Together with the development of an increasing network of birdwatchers in Iberia, the use of such rings now allows researchers to conduct more detailed analyses on movements of large gulls (Pérez *et al.* 2006). Indeed, this has resulted in 4 the detection of Yellow-legged gulls from northern Iberia in the Mediterranean Sea (Arizaga *et al.* 2009), suggesting that the distribution of northern Iberian Yellow-legged Gulls during the non-breeding season could be wider than previously thought. Detailed data on Yellow-legged Gull movements may also provide a useful knowledge base for better understanding gull population dynamics, thereby assisting in effective management policies.

Our aim was to describe the movements of first-year Yellow-legged Gulls from the southeastern Bay of Biscay, focusing on the distances travelled and the geographic distribution patterns throughout the year. As in other marine birds and large gulls, Yellow-legged Gull longest movements are performed by first-year individuals (Munilla 1997; Martínez-Abrain *et al.* 2002; Wernham *et al.* 2002). Thus, these movements can be used to assess the maximum range at which a given population could be able to disperse (Geroudet 1984).

METHODS

A total of 2,419 Yellow-legged Gull chicks, ca. 20 days old, were banded in seven breeding colonies in northern Iberia (Basque Country), during five consecutive years (2004-2008) (Table 1). The chicks were banded with both engraved colored PVC and metal rings. Each chick was banded with a unique engraved ring allowing it to be individually recognized. The codes used in this study were published in cr-birding (www.cr-birding.be). During the ringing process, our impact in the colonies was minimized by applying a thorough protocol designed to reduce the movement of chicks and time spent at each colony (Cantos 2000).

Sighting data on gulls observed alive outside the colonies were compiled from July 2004 to June 2009, mainly by birdwatchers. Recoveries of dead individuals (N = 19) were not considered in this analysis to avoid possible biases compared with sighting data. For each bird, only data relative to its first 12 months (from July to June of the next year) after being ringed were considered. Following Vincenty (1975), we calculated the ellipsoid (orthodrome) distance between the ringing and the sighting sites for each sighting. Compared with Euclidean distance, the orthodrome takes the curvature of the Earth into account, i.e. it is the shortest distance between two points considering that the surface of the Earth is not flat.

Analyses

When a bird is observed more than once, sightings cannot be considered independent. Thus, with the aim of avoiding potential pseudo-replication, we considered only the maximum distance at which each individual was sighted, either when all year-round data were pooled (N = 728), or per month (N = 1888). The proportion of gulls sighted only once varied seasonally (χ^2_{11} = 53.588, P < 0.001). In particular, this proportion tended to be higher during the months following the departure from the natal sites (Fig. 1). Thus, in order to avoid possible biases we considered in the analyses the number of times that each bird was observed (once/more than once).

We considered the maximum dispersal range of gulls during their first year of life. Maximum distances were not normally distributed (K-S test, P < 0.001; Fig. 2), and the variance of the raw data was very high (variance/mean: 197.77), indicating possible detached observations. Thus, distances were log-transformed and, although the distribution of the data was still not-normal (K-S test, P < 0.001), the variance was 6 reduced considerably (variance/mean: 0.19). With this lower variance, we used a Univariate Linear Model (ULM) on log-transformed maximum distance to test whether the distance at which gulls moved varied seasonally. The following two variables were included as factors into the ULM: month and type of individual depending on if it was seen only once or more than once.

We used circular statistics to analyze the spatial distribution of individuals. To test whether the data (sightings) were axially distributed (i.e. showed a bimodal distribution), we compared the length of the mean vector of all sightings (angles) with the length of the mean vector when all angles were multiplied by two. Data were axially distributed if the latter value was higher than the length of the mean vector of the nontransformed angles. We used a Watson-Williams F test to test inter-monthly variations of the mean direction at which the gulls were seen, and a Mardia-Watson-Wheeler test to assess inter-monthly variation in the spatial distribution of the gulls. An axial distribution is expected if gulls moved mainly along the coast of northern Iberia and west France. Other type of movements, e.g. to the south of Iberia, the Mediterranean coast in east Iberia or in-

Table 1. Number of banded Yellow-legged Gull chicks resighted/recovered during their first year of life. Colonies were located in the Basque Country, southeastern Bay of Biscay. The number of gulls sighted is the number of individuals sighted once or more after being banded; the percentage is the proportion of individuals sighted out of the total number of banded individuals.

Colony	Coordinates	Breeding years	No. gulls banded	No. gulls sighted	No. sightings
Ulia	43° 20'N 01° 57'W	2005-2008	838	301 (35.9%)	1040
Santa Clara	43° 19'N 01° 59'W	2005-2008	282	113 (40.1%)	586
Mollarri	43° 18'N 02° 09'W	2005-2008	33	16 (48.5%)	67
Guetaria	43° 18'N 02° 12'W	2006-2008	98	49 (50.0%)	296
Lekeitio	43° 22'N 02° 43'W	2004-2008	399	152 (38.1%)	538
Izaro	43° 25'N 02° 41'W	2004-2008	709	70 (9.9%)	194
Punta Lucero	43° 22'N 03° 06'W	2007-2008	62	27 (43.6%)	55

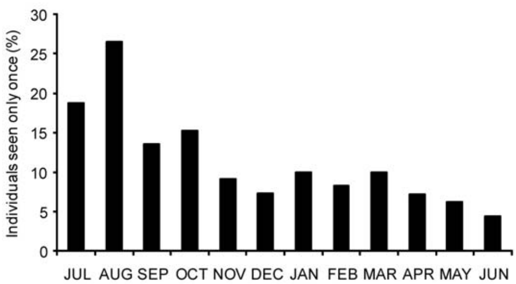

Figure 1. Seasonal distribution of individuals observed only once. Data were compiled during the first year of life (from July of the hatching year to June of the following year) of Yellow-legged Gulls banded as chicks in breeding colonies from the southeastern Bay of Biscay, northern Iberia.

land, would give rise to non-axial spatial distribution patterns. Neither the geographic distribution of sightings ($W = 0.844$, $P = 0.656$) nor the mean direction vector varied between individuals seen only once and individuals seen twice or more ($F = 0.002$, $P = 0.968$), so both groups were lumped to run the circular statistics.

SPSS 15.0 and Oriana 2.0 software were used for all statistical analyses. Statistical formulas were from Zar (1999).

RESULTS

From July 2004 to June 2009, 2,776 sightings of 728 individuals were collected. The proportion of individuals sighted per colony varied from 9.9% (Izaro) to 50.0% (Guetaria) (Table 1), with significant differences among colonies ($\chi^2_6 = 121.18$, $P < 0.001$). However, excluding Izaro, this proportion ranged from 35.9% to 50.0% without significant differences among colonies ($\chi^2_5 = 4.316$, $P = 0.505$).

Considering the maximum distance at which each individual was found, most gulls ($N = 504$; 69.2%) were detected less than 50 km from their colonies (Fig. 2) indicating that they did not leave the southeastern Bay of Biscay. Out of 728 individuals, only 30 (4.1%) were found along the coast of western Iberia up to central Portugal, and only two individuals were observed on the coast of eastern Iberia (Fig. 3). The farthest sightings in each direction were: to the north at 360 (± 5) km in Olonne (north-west France); to the south at 450 km in Quart de Poblet (near Valencia, east Spain); to the east at 440 km in Llagostera (north-east Spain); to the west at 680 km (also the farthest sighting) in Figueira da Foz (central Portugal).

The distances (log-transformed maximum distances) from natal site varied among months, but not between individuals seen only once or more than once (month: $F_{11,1887} = 2.546$, $P = 0.003$; number of sightings per individual: $F_{1,1887} = 18.280$, $P < 0.001$, interaction: $F_{11,1887} = 2.037$, $P = 0.022$; Levene test for the variance homoscedasticity: $P = 0.069$). The a *posteriori* analysis (Tukey-B test) did not reveal any significant seasonal difference for the fraction of gulls seen only once, but for gulls

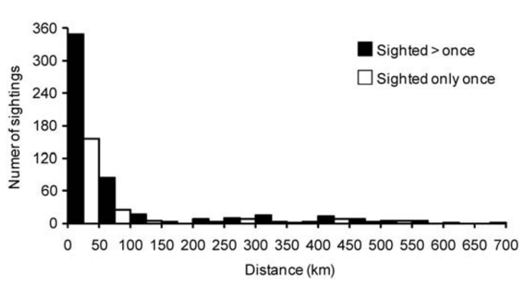

Figure 2. Histogram of the maximum distance at which each individual was sighted. Individuals sighted more than once: median (25-75 percentiles), 31.6 (20.6-69.5) km; range, 0.0-603.3 km; *N* = 514. Individuals sighted only once: median, 25.3 (14.8-62.1) km; range, 0.0-676.0 km; *N* = 214.

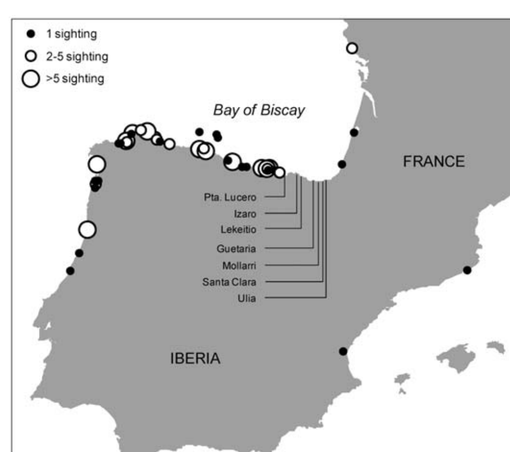

Figure 3. Location of Yellow-legged Gulls seen at more than 100 km from natal colonies located in the southeastern Bay of Biscay, northern Iberia. Each individual (maximum distance) has been considered only once (*N* = 116). Here, data on individuals sighted only once (*N* = 35) or more than once (*N* = 81) have been pooled.

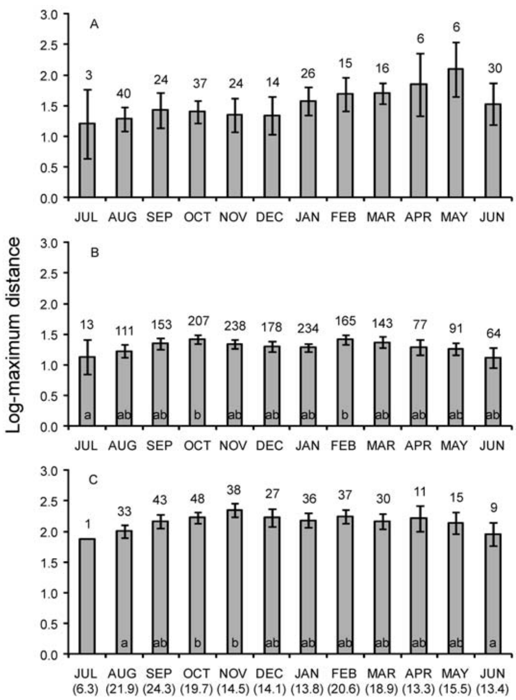

Figure 4. Distance (mean ± 95% confidence interval and sample size) of Yellow-legged Gulls throughout the first twelve months after fledging. A: Data for gulls seen only once; B: Data for gulls seen more than once; C: Data for all gulls that were seen at a distance > 50 km from the natal colony. Each individual was considered only once per month. When significant seasonal differences were detected (graphs B and C), a given letter groups months without significant differences between each other. Together with months, we show the proportion of gulls that moved > 50 km from the natal colony.

seen more than once (Fig. 4). An analysis of Fig. 4 reveals that such difference was because the mean distance at which gulls were seen reached two peaks in October and February that 8 significantly differed from the mean value in July. Since these results could be affected by those individuals that were never seen farther than 50 km, we repeated the analysis using only data from those gulls that were seen at distances > 50 km in at least one month. Again, we found significant seasonal differences (month: $F_{10,326} = 1.969$, $P = 0.036$; number of sightings per individual: $F_{1,326} = 3.759$, $P = 0.053$, interaction: $F_{10,326} = 0.789$, $P = 0.639$; Fig. 4).

Out of 728 individuals, 12 (1.7%) did not move from their natal areas and, therefore, they were removed from the data set used for circular analyses. The geographic distribution of the sightings did not fit a random distribution, but instead a bimodal one with the majority of gulls occurring along an east-west axis, i.e. along the coast of northern Iberia (Fig. 3; mean vector length: 0.380; mean vector length for the angles × 2: 0.794). After removing three gulls that were seen exactly to the north and south of their corresponding natal colonies, most sightings occurred to the west of the corresponding natal colonies ($N = 484$ versus 229; 67.9%; $\chi^2_1 = 91.199$, $P < 0.001$). The direction at which gulls were found did not vary seasonally ($F = 1.722$; $P = 0.063$), supporting the hypothesis that the axis along which the gulls were distributed did not vary with time. However, the geographic distribution of the sightings varied among months ($W = 109.028$, $P < 0.001$), indicating that there was variation in the proportion of sightings seen west or east to the corresponding origin colony (Fig. 5). Also, Fig. 5 shows that there was no clear trend in the temporal variation patterns of the proportion of gulls that moved east and west in relation to their natal sites.

DISCUSSION

The proportion of gulls sighted after being banded as chicks was similar for five out of six breeding colonies (mean = 36.0%) and low in one of the colonies (Izaro, 10.1%). Chicks from Izaro were banded at nearly 20 days old (as in the rest of the colonies) by the same ringers as in Lekeitio and Punta Lucero where, in contrast, the relative number of individuals seen after banding was significantly higher (Table 1; Izaro versus Lekeitio-Punta Lucero: $\chi^2_1 = 87.506$, P < 0.001). Thus, these differences among colonies cannot be explained by different rates of mortality associated with age of marking or with ring loss, but rather are probably due to the particular conditions on the island of Izaro, where the pre-fledgling mortality rate may have been higher.

Differences in dispersion among large gulls (even at the intra-specific level) have been commonly attributed to food availability and distribution during the winter

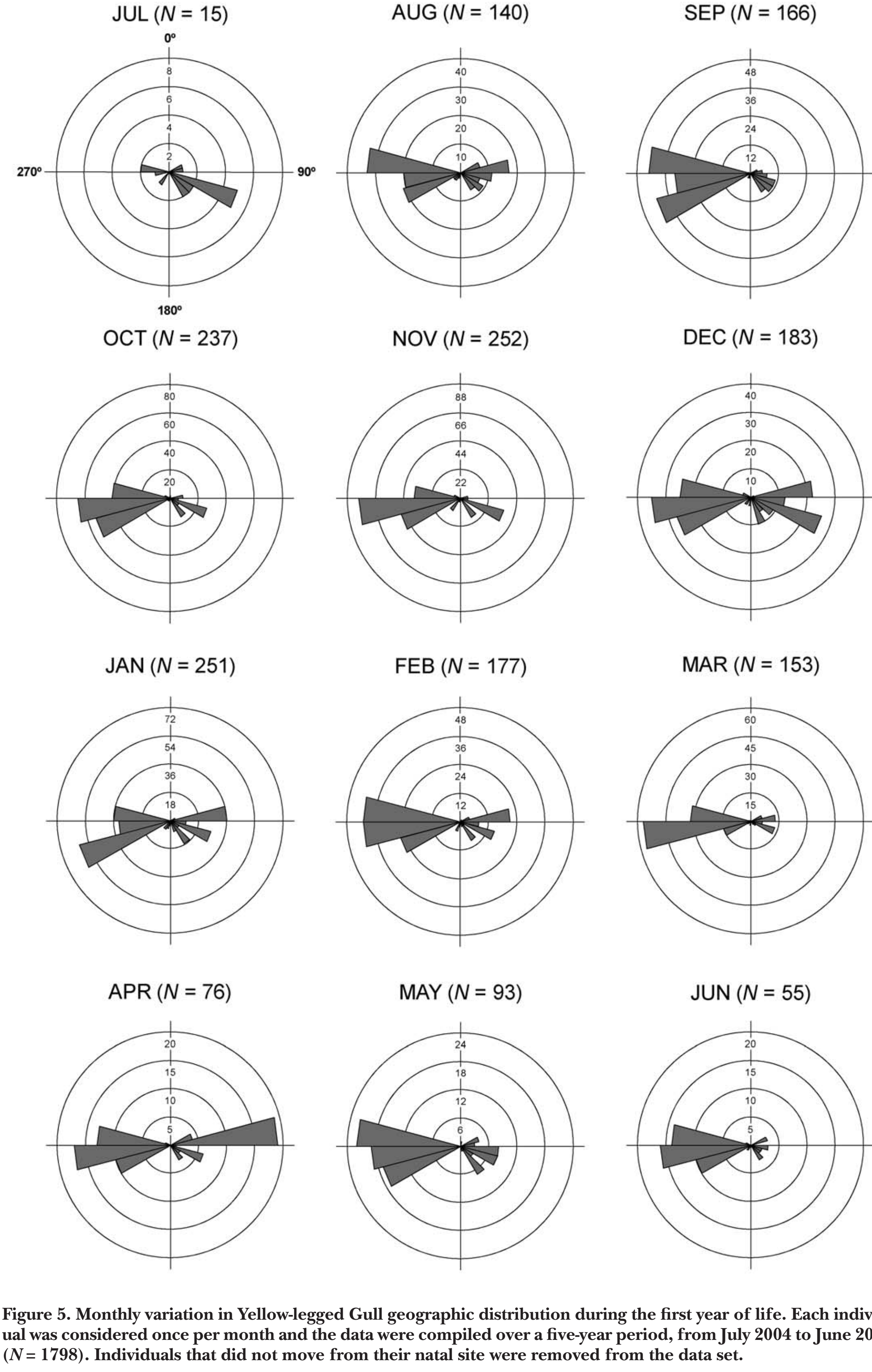

Figure 5. Monthly variation in Yellow-legged Gull geographic distribution during the first year of life. Each individual was considered once per month and the data were compiled over a five-year period, from July 2004 to June 2009 (N = 1798). Individuals that did not move from their natal site were removed from the data set.

(Southern 1980). Most sighting data were obtained less than 50 km from their origin natal colonies, supporting the view that gulls from the southeastern Bay of Biscay are resident (Munilla 1997). In contrast, their Mediterranean counterparts are migratory, especially immature birds that reach the Atlantic coasts of Iberia and France during late summer and autumn (Munilla 1997; Martínez-Abrain *et al.* 2002). Such differences in behavior may be caused by the availability of abundant and stable feeding sources yearround along the entire coast of the Bay of Biscay (Martínez-Abrain *et al.* 2002). Urban dumps are one of the main factors promoting sedentary behavior of large gulls (Kilpi and Saurola 1985). However, this does not seem to be a major cause explaining the sedentary behavior of gulls from the southeastern Bay of Biscay, since dumps are also abundant along the Mediterranean coast (Ramos *et al.* 2009). Thus, a higher amount of alternative feeding sources like fish or other marine prey in the Bay of Biscay during winter could explain these results.

With the exception of July, the distance at which gulls were seen from their natal sites did not vary throughout year. This contrasts with previous analyses for the Atlantic Yellow-legged Gull population (Munilla 1997), where the distance from the breeding colonies reached a maximum during the winter. Although annual or even geographic variation in movements cannot be ruled out, the higher sample size in our study suggests that the previously reported monthly variations could be statistical artefacts associated with a lower sample size. Whether dispersal behaviors may exist between the eastern and western gulls from the Bay of Biscay is a hypothesis which remains to be tested.

Most gulls were found to the west of their natal site, which seems to be a widespread phenomenon for the Yellow-legged Gull population in northern Iberia (Paterson 1997). Again, this suggests that better conditions prevail, particularly higher food supplies or better feeding places (Southern 1980), along the coast of northern Iberia than along the coast of southwestern France. A possible hypothesis explaining such westwards-biased distribution is a smaller human population in southwestern France than along the coast of northern Iberia. Consequently, there are fewer harbors and dumps offering gulls large food supplies in southwestern France. Alternatively, we cannot reject the possibility that, due to such low human density, there are fewer observers and, therefore, less surveying effort in southwestern France. A higher sighting effort in this zone could contribute to solving this methodological problem.

The proportion of gulls that moved west or east from their natal sites varied by month, but such variation seems to be caused more by methodological biases (variation 11 in sighting effort in different areas at different periods of the year) or seasonally random variations in the distribution of food available for gulls along the coast of the Bay of Biscay. Such seasonal variation highlights that gulls are efficient foragers, able to be where food resources are locally and/or temporally more abundant. In consequence, the development of management policies oriented to reduce the access of gulls to anthropogenic feeding sources at a local scale could be quite inefficient if such policies are not carried out at a larger geographic scale including the whole distribution range of given gull populations. Future studies dealing with more precise data on how food availability is distributed across the year may contribute to a better understanding of the seasonal geographic distribution patterns of Yellow-legged Gulls in the southeastern Bay of Biscay.

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