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Diet and foraging range of Slender-billed Gulls *Chroicocephalus genei* breeding in the Saloum Delta, Senegal

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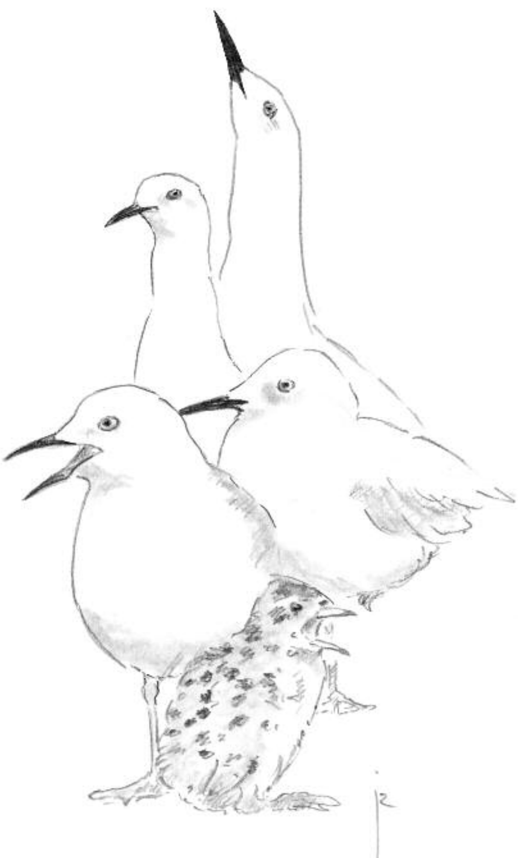

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West African Slender-billed Gulls *Chroicocephalus genei* are considered vulnerable due to a very restricted breeding range. However, little information on their ecology is available to support conservation action. We describe diet and foraging range of Slender-billed Gulls breeding in the Saloum Delta National Park in Senegal. Diet was analysed on the basis of fish otoliths in excretion (mixture of pellets and faeces) collected near nests at the end of the incubation period between 2000 and 2015. Gulls mainly consumed fish of the families Cichlidae (25–93%), Clupeidae (0–54%) and Mugilidae (0–34%). The log-ratio proportion of Mugilidae increased significantly between 2000 and 2015, but there was no significant trend for other prey taxa. In 2014, UvA-BiTS GPS-trackers were fitted to three Slender-billed Gulls to study movement and foraging range. During daytime, these gulls spent 27% of their time incubating the eggs, 10% elsewhere in the colony and 63% outside the colony on foraging trips. Foraging trips lasted on average 18 ± 9.5 (±SD) hours. Total distance covered was on average 96 ± 39 km with a maximum distance to the colony of 37 ± 13 km. There were marked and consistent individual differences in the flight paths of the gulls. In two birds, foraging mainly took place in mangrove-bordered lagoons, salt pans, creeks, rivers and a complex of abandoned rice fields. The third bird almost exclusively explored the Atlantic coast near a fishing village in The Gambia. The home range and the foraging area of the three birds together measured 2400 and 1800 km^2, respectively. The diet components found near the nests of the three birds could only partly be related to their foraging areas.

Key words: otoliths, diet, marine fish, GPS tracking, time budgets, habitat use, West Africa

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Knowledge of a species' diet and foraging habitat is crucial for understanding its general ecology. Slender-billed Gulls *Chroicocephalus genei* mainly occur in the Mediterranean and Black Sea region, in West, Southwest and South Asia, and in West Africa (Del Hoyo *et al.* 1996). The world population is estimated at c. 100,000 pairs and the species is categorized as 'Least Concern' (Birdlife International 2017). However, the West African breeding population is relatively small, comprising some 7500 breeding pairs (Wetlands International 2006). Part of the Mediterranean population migrates to West Africa in winter, as has been shown by Spanish colour-ringed individuals (B. Piot pers. comm.). However, so far there are no indications that birds from both populations mix during the breeding season. At present, more than 98% of the West African population breeds at three sites: the Saloum Delta and the Estuary of the Senegal River in Senegal, and the Banc d'Arguin in Mauritania. These sites are formally protected, but breeding colonies are subject to occasional egg-poaching, may severely suffer from natural predation events, and suitable breeding habitat tends to disappear as a result of coastal erosion. Furthermore, there is the threat of intensive industrial (Jacobs 2017) and artisanal (Beatley & Edwards 2018) overfishing with as of yet unknown effects on the species' feeding opportunities. For this reason, the Slender-billed Gull was included in a monitoring program started in 1998 focusing on population size, breeding parameters and diet of West African ground nesting colonial breeding birds (Veen *et al.* 2018). Here, we describe the diet of Slender-billed Gulls of the breeding population in the Saloum Delta in Senegal using eight years of data. In addition, we depicted the foraging range of three breeding birds in 2014 based on detailed GPS-tracking data.

METHODS

Study site

This study was carried out in the Parc National du Delta du Saloum (73,000 ha, 13°37'N, 16°37'W) situated at the Atlantic coast of Senegal, just north of the Gambian border. The park comprises the deltas of the seasonal rivers Saloum, Diombos and Bandiala, and consists of numerous mangrove-bordered waterways, over 200 islands and islets, lagoons, salt pans and tidal flats. Three islands, Ile aux Oiseaux, Ansoukala and Jakonsa, are important breeding sites for ground-nesting colonial breeding birds, including the Slender-billed Gull. The National Park is a Ramsar Site and managed by the Direction des Parcs Nationaux du Sénégal. For more information see Keijl *et al.* (2000) and Veen *et al.* (2006). In 2011 it was designated as an UNESCO World Heritage Site (UNESCO 2011).

Study species

Slender-billed Gulls were found breeding in the study area between 1998 and 2015. The number of breeding pairs varied between 4864 and 9184, which represents more than 50% of the West African population (Veen *et al.* 2003, 2012a).

Until 2010, nearly all gulls nested on Ile aux Oiseaux but in 2011 large numbers moved to Ansoukala, which was followed by another move to Jakonsa. The changes of breeding sites were probably caused by intense predation of eggs and chicks by Sacred Ibises *Threskiornis aethiopicus* on Ile aux Oiseaux and flooding of nests and drowning of chicks on Ansoukala. In 2015, 316 pairs bred on Ile aux Oiseaux, zero on Ansoukala and 7211 on Jakonsa (Veen *et al.* 2015).

In the Saloum Delta, Slender-billed Gulls breed in sub-colonies of a few up to more than 200 nests. Nests are placed on higher parts of the beach, usually on small dunes sparsely covered with *Ipomoea pes-caprae* or *Sesuvium portulacastrum*. Egg-laying is highly synchronized starting at the beginning of April and extending to the beginning of June (Veen *et al.* 2003). Foraging usually takes place far away from the colony, but occasionally birds were seen feeding within a few kilometres from their nests along the coast or in creeks and on tidal flats between Ile aux Oiseaux and the mainland. Group size of foraging birds varied between single birds and tens of individuals, the latter often behind fishing vessels or above shallow creeks on tidal flats where fish was trapped during low tide. Prey is caught by surface dipping, surface seizing or surface plunging. Several Slender-billed Gulls preyed upon the eggs of Royal Terns *Thalasseus maximus* or were actively involved in stealing fish when Royal Terns tried to feed their chicks.

Diet analysis

Slender-billed Gulls produce pellets and defecate while sitting on the nest. Throughout the incubation period a growing crust of a mixture of pellets and faeces (further called excretion) is formed on the nest rim and around the nest. In most years, intact pellets could not be collected separately from this mix, because they were (almost) absent. We therefore concentrated our diet study on the excretion assuming that this would include prey in pellets and faeces in a representative way.

In eight years, excretion was collected in one sampling session, around 10–15 nests in an advanced stage of incubation. In case of the GPS-tagged birds, excretion was collected shortly after they had abandoned their nests, which also took place in the egg phase. As a consequence, our results represent the diet of adult breeding birds. All material collected in a particular year was treated as one mixed sample, except for the three nests of our GPS-tagged birds in 2014 which we analysed separately.

Samples were kept in plastic bags, labelled and stored under dry conditions. They were then transferred to 15×25-cm bags of plankton netting with a mesh size of 0.3 mm (Scrynel PA 300/47) and soaked for 24 h in hot water (c. 60°C) with washing powder. Samples were subsequently put in a washing machine to be washed at 70°C (pre-wash and main washing program with washing powder, no use of centrifuge). Washed samples were dried and spread out on a contrasting black background after which prey remains were selected. With the exception of two parts of a crab, we only found fish remains. We therefore decided to concentrate prey identification on fish otoliths, which were identified using a binocular microscope (Novex 4.5–65×). All samples were searched twice to make sure that all otoliths had been found.

Each fish has three pairs of otoliths: the *sagittae*, *utriculi* and *lagaenae*. We only considered *sagittae* as these otoliths are most appropriate in showing species specific characteristics, except for the family of the Ariidae for which *utriculi* were considered.

The total number of fish in a sample can be reconstructed by counting paired and single otoliths. For 10–15 nests it was practically impossible to pair otoliths from samples spanning weeks of deposition. For this reason, we decided to simply present the total number of otoliths found in the results section.

GPS-tracking data

To study foraging range and movements of Slender-billed Gulls, 7.5-g solar-powered UvA-BiTS GPS-trackers (Bouten *et al.* 2013) were attached to three incubating individuals between 28 April and 5 May 2014. Birds were caught on the nest using a wire-netting cage (50×50×20 cm) kept open by a small stick, which was connected by a rope to a hide. The birds entered the cage and settled on their eggs within 10 minutes. Once a bird was quietly incubating its eggs, it was caught and removed from the cage. When handling the birds, the eggs were covered with vegetation to avoid predation. The trackers were attached to the back using a Teflon ribbon harness (Kenward 1987) and standard biometric measurements were taken. The birds were marked with metal and colour rings and with a yellow dot on the back, wing or neck using picric acid to follow tagged individuals visually within the colony. Picric acid was used because it is clearly visible for a long period of time. The whole handling procedure lasted 15–20 minutes. The three birds all returned to their nests within 15 min after release. The sex of the three birds was unknown.

The UvA-BiTS tracking system is a flexible GPS tracking system using two-way interaction to remotely upload settings and download data from small solar-powered trackers via an antenna system (Bouten *et al.*

In the Saloum Delta, Slender-billed Gulls typically breed in sub-colonies of up to a hundred nests, which are usually surrounded by breeding Grey-headed Gulls *Chroicocephalus cirrocephalus* (photo Jan Veen, Ansoukala Island, Saloum Delta, 20 May 2012).

Slender-billed Gull with datalogger on back (photo Hanneke Dallmeijer, Il aux Oiseaux, Saloum Delta, 4 May 2014).

2013). Antennas were placed close to the breeding colony to allow downloading while the birds were on their nests. Along with positional data, GPS-trackers measured instantaneous speed (v_i: speed of a bird when a GPS measurement, referred to as a 'fix', is taken). Trajectory speed (v_t) was calculated using time and distance between consecutive positions. Distance between positions was calculated using function distMeeus from R package geosphere v. 1.5–5 (Hijmans 2015). An area of 300 m around the nest was used to separate time spent inside and outside the colony and to designate the beginning and end of a trip. Assuming that the gulls would be less active in foraging during the night (Del Hoyo *et al.* 1996), the trackers were programmed to collect one fix/h for the period 20:00–6:00. During daytime, one fix/10 min was collected within the colony and one fix/4 min outside the colony. We calculated (1) time spent incubating (<25 m from nest, accounting for measurement error), (2) time within colony but not on nest (25–300 m from nest), and time spent outside the colony (>300 m from nest).

Most trips lasted many hours and covered long distances. However, there were also trips of short duration (maximum distance from nest 300–790 m). Since foraging rarely occurred at this distance, such trips were excluded from the trip analysis. Activities during foraging trips outside the colony were determined as follows: (1) resting (v_i < 0.4 m/s), foraging (v_i between 0.4 and 8 m/s), and flying (v_i > 8 m/s). For each trip, the maximum distance to the nest, total distance covered and trip duration were calculated. Fixes classified as 'foraging' were attributed to different habitat types (ocean, coast and beaches, lagoons and mangroves, rice fields, rivers, tidal flats, and inland) by inspecting each individual foraging point in Google Earth. Home range size was calculated by plotting all GPS-positions on a grid with 5×5-km squares and counting the number of grid squares that contained fixes. Foraging area was calculated in the same way, using only fixes classified as 'foraging' (see above).

Statistical analysis

Diet data were statistically analysed focussing on (1) the change in diet over time and (2) the diet of the three GPS-tracked individuals (in relation to their foraging habitat).

To analyse the yearly changes in diet, we looked at the changes in the proportions of a given fish family of the total diet. A problem with proportional data is that it is sum-constrained and hence the proportions are not independent. This can be accounted for by a log-ratio transformation for statistical analyses (e.g. Aitchison 1986, Kucera & Malmgren 1998, Veen *et al.* 2012a). After the log-ratio transformation, we used linear regressions with the transformed proportion of a given fish family as response variable. We had no a-priori hypothesis about the nature of the relationship and we analysed whether including year as an explanatory variable could explain significantly more variance in diet compared to a model including the intercept only. Allowing for a non-linear fit by including year^2 as explanatory variable did not qualitatively change the results (results not shown). Only fish families that made up 5% or more of the diet were analysed independently, the rest was concatenated in a 'rest' group. Model fit was assessed using an *F*-test (Fisher 1918 and implemented as described in Crawley 2007) and only the output of this test is provided as the log-ratio transformed parameter estimates are not informative nor are we aware of a way to back-transform them. Given the limited amount of data collected, the lack of hypotheses regarding temporal patterns of diet and data gaps between years, this analysis should be seen as exploratory instead of an exhaustive analysis.

For the diet of GPS-tracked birds, we used a Pearson's χ^2-test for independence to test for differences in diet among them. Different prey families were combined as many families were recorded only occasionally. If the assumptions of the Pearson's χ^2-test were not met (no more than 20% of the values must have expected value less than 5 and no expected values less than 1), a Fisher's exact test was used.

RESULTS

Diet composition

We identified 20 fish families, 31 genera and 32 species in eight samples with 4469 otoliths. For five genera or families, otoliths could not be identified to the species level. We conclude that at least 37 species were present in our material. All diet data collected during eight years of observation are given in Table S1.

A comparison of samples collected in different years is hampered by the various taxonomic levels of prey distinguished. We have therefore chosen to compare prey at the family level, which allows us to include all data. The diet of Slender-billed Gulls in the Saloum Delta, almost exclusively consisted of Cichlidae (25.3–93.1%), Clupeidae (0–54.6%) and Mugilidae (0–34%, Table 1). Occasionally, the families of Gerreidae and Haemiramphidae exceeded the 5% level (Table 1).

When looking at the diet of all years combined, only three fish families exceeded the 5% threshold (Cichlidae, Clupeidae, Mugilidae). The other families were combined into the rest group. The log-ratio proportion of Mugilidae increased significantly during the observation period ($F_{6,7} = 6.525$, $P = 0.043$). There was no significant trend through time in the proportion of Cichlidae ($F_{6,7} = 1.168$, $P = 0.321$), Clupeidae ($F_{6,7} = 0.188$, $P = 0.680$) nor the rest group ($F_{6,7} = 1.639$, $P = 0.248$).

Diet of GPS-tracked birds

Our diet data set from nests of GPS-tracked birds contained many fish families that occurred in very low frequencies in the bird's diet and in order to adhere to the assumptions of the Pearson's χ^2-test we had to lump most families together and ended up with three groups: the Cichlidae, Gerreidae and a 'rest' group containing

Table 1. Proportional occurrence of fish families (percentage of number of otoliths) in excretion of Slender-billed Gulls breeding in the Saloum Delta, Senegal. Only families comprising >5% of the total number of otoliths in at least one sample have been included. Other families were lumped together. Proportions > 5% are in bold.

		Number of otoliths (%)							
Family	**Year:**	2000	2001	2003	2011	2012	2013	2014	2015
Cichlids (Cichlidae)		**93.1**	**77.0**	**47.8**	**88.8**	**31.6**	**25.3**	**62.9**	**59.3**
Clupeids (Clupeidae)		1.1	**14.3**	**22.2**	**9.2**	**54.6**	**40.0**	**5.6**	**5.0**
Mojarras (Gerreidae)		1.8	0.4	**5.0**	0.2	1.2	**13.2**	4.8	0.0
Halfbeaks (Haemiramphidae)		2.3	1.1	**7.2**	0.0	4.1	1.6	3.6	0.0
Mullets (Mugilidae)		1.0	2.8	**8.3**	1.3	**6.5**	**15.8**	**17.0**	**34.0**
Other families		0.7	4.4	**9.5**	0.5	2.0	4.1	**6.1**	1.7
Number of otoliths		1273	1407	180	445	339	190	394	241

Table 2. Proportional occurrence of fish families (percentage of number of otoliths) in excretion collected around the nests of three GPS-tracked Slender-billed Gulls (and their mates) in 2014. Only families comprising >5% of the total number of otoliths in at least one of the samples have been included. Other families were lumped together. Proportions > 5% are in bold.

		Number of otoliths (%)		
Family	**Bird ID:**	2070	2074	2068
Cichlidae		**75.0**	**85.7**	**75.4**
Gerreidae		2.3	0.0	**15.8**
Sparidae		**6.8**	0.0	0.0
Other families		**15.9**	**14.3**	8.8
Number of otoliths		44	105	171

all other families that occurred in the dataset. Note that this rest group is different from the one in the previous analysis.

Cichlidae dominated in excretion collected from the nests of all GPS-tracked birds, which includes the excretion of their mates (Table 2). The diet of the nests differed significantly from each other (Pearson's $\chi^2_4 = 27.796$, $P < 0.001$). The nest of bird 2068, with a substantial higher number of Gerreidae, significantly differed from that of bird 2070 (Pearson's $\chi^2_2 = 10.772$, $P = 0.005$) and 2074 (Pearson's $\chi^2_2 = 19.264$, $P < 0.001$). Bird 2070 and 2074 did not differ significantly (Fisher's exact test, $P = 0.104$)

Tracking data

The three tagged birds were from the same colony and caught and handled in the early morning during the incubation period (Table 3). All birds deserted their clutch between c. 12 and 18 days after tagging. Since Slender-billed Gulls breed highly synchronized and none of the nests in the colony area had hatched when

Table 3. Overview of tracking data of three Slender-billed Gulls in a breeding colony in the Saloum Delta, Senegal, in 2014.

Bird ID	Body mass (g)	Date and time of deployment	Days tracked	Number of fixes	fate of nest
2068	365	28 April (9:23)	17 (29/4–13/5)	2634	empty 14 May
2070	315	28 April (9:56)	18 (29/4–14/5)	2822	empty 14 May
2074	288	5 May (9:43)	12 (5/5–16/5)	1852	empty 15 May

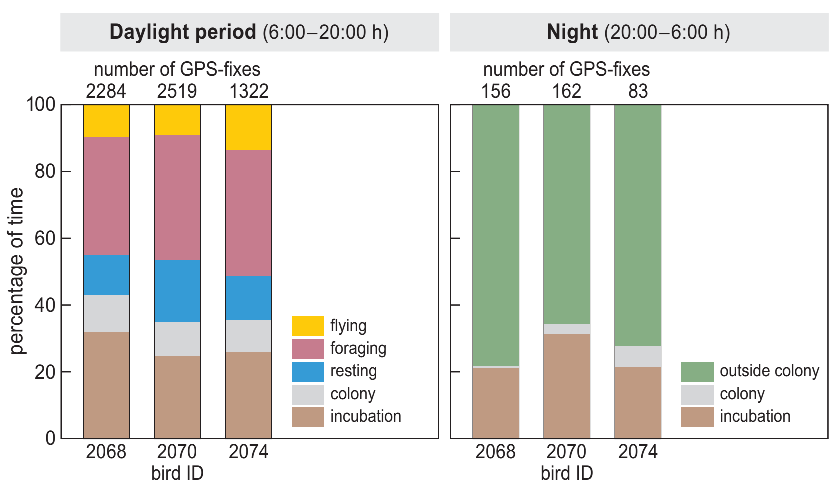

Figure 1. Time budgets of three GPS-tracked Slender-billed Gulls breeding on Ile aux Oiseaux in 2014 for the daylight period and for the night. Resting, foraging and flying refer to activities outside the colony area. No activities have been attributed to the presence of the birds outside the colony during the night. Numbers below the bars refer to the tracking device number of the individual birds, whereas numbers above the bars refer to the number of GPS-fixes.

the tracked birds left their nests, we conclude that nest abandonment occurred in the egg-stage. The nests were not checked on a daily basis to avoid disturbance and as a consequence, the exact time and date of the disappearance of the eggs is unknown. Egg-predation by Sacred Ibises was the most likely cause of egg loss, as this species heavily preyed upon the eggs of Slender-billed Gulls, destroying more than 80% of the 974 clutches of the 2014 breeding population.

Time budgets

The GPS-tracked Slender-billed Gulls spent slightly more time incubating during the day than at night (27.4% vs. 25.0%, all birds; Figure 1). Time spent elsewhere in the colony was shorter at night than during the day (3.4% vs. 10.2%, all birds). All three birds spent less than 30% of their time at the nest. Since we have no indications that Slender-billed Gulls leave their nest unguarded, partners must have taken an unequal share in incubation duties. Outside the colony during the day, birds spent most time foraging (37.1%), but also resting (14.5%) and in flight (10.8%; Figure 1).

Movements and habitat use

The tracked individuals combined covered a total area of 2400 km^2 during the two weeks of tracking, whereas foraging fixes were recorded in an 1800 km^2 area (Figure 2B and C). Notably, the individual birds used different areas during foraging trips (Figure 2A, D–F). Bird 2068 flew west and north, bird 2070 crossed the estuary of the Gambia River after which it followed the Gambian coast, and bird 2074 flew southeast crossing

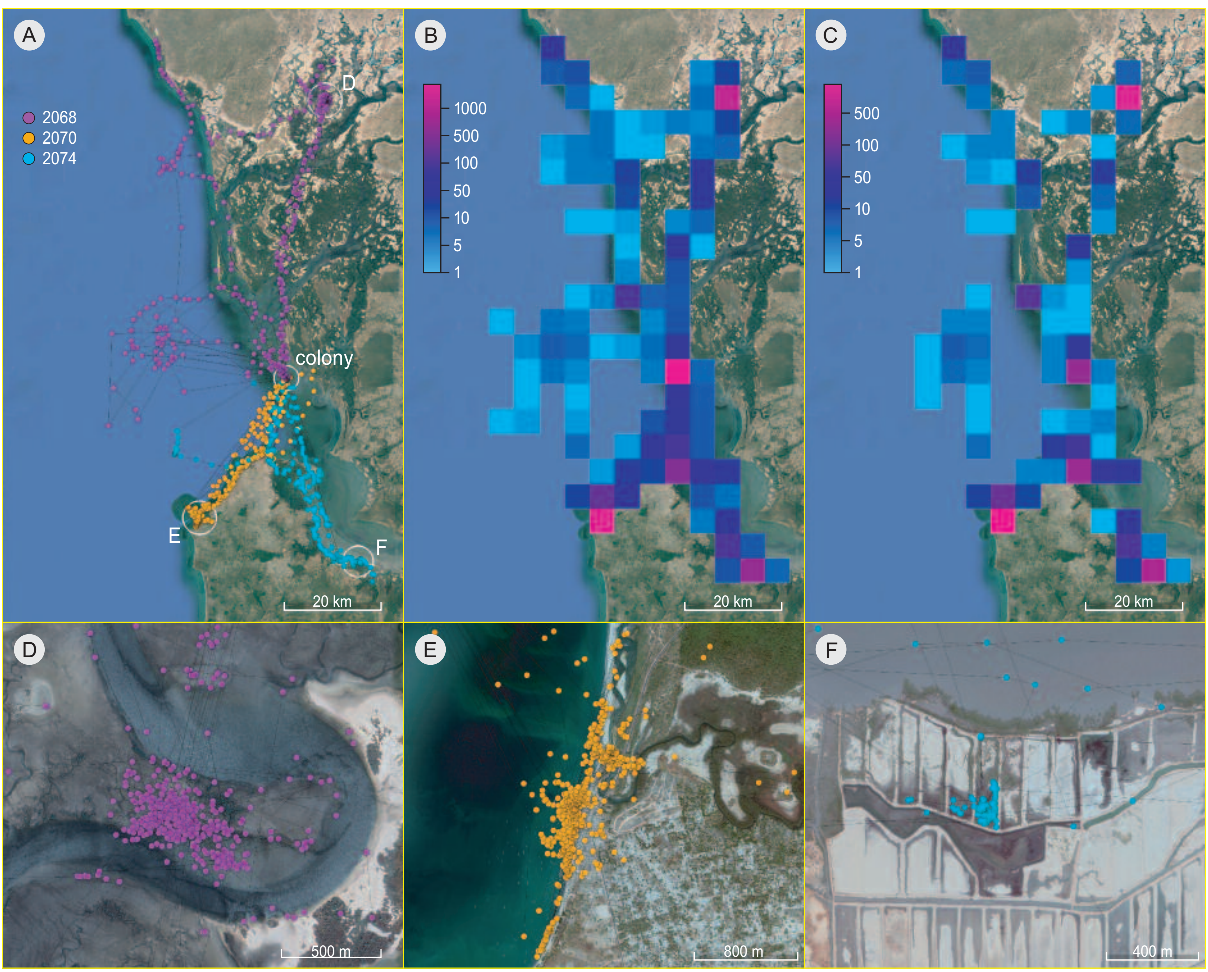

Figure 2. (A) Flight paths of three incubating Slender-billed Gulls from the breeding colony on Ile aux Oiseaux in 2014 with each dot representing a GPS-fix and each unique colour representing a different individual bird. (B) Home range and (C) foraging area for all three birds combined are summarised in 5×5-km squares. Note that the frequency of GPS-fixes is represented on a log-10 scale. The foraging hotspots for bird 2068, 2070 and 2074 are presented in panel D–F, respectively.

the estuary of the Gambia River and following its southern border upstream. Two of the birds used the same area on all consecutive days. Bird 2068 however changed from a variable flight direction during the first 7 days (ocean and coast) to an inland destination during the following 10 days.

Foraging movements covered a variety of different habitats (Figure 3). The gulls mainly used coastal lagoons and mangrove-bordered streams and rivers (2068), the coastal area around the fishing village of Tanji (2070), and a complex of abandoned rice fields and the Gambia River (2074). To a lesser extent foraging fixes were situated on tidal flats, especially east of the breeding island Ile aux Oiseaux, on the ocean (more than 1 km from the coast), and on islands (Figure 3).

At night and away from the colony, bird 2068 spent 71% of its time on the Atlantic Ocean at a distance of more than 10 km from the coast. Bird 2070 spent 93% of its time on the Bijol Islands, situated 2.2 km west of Tanji fishing village, the latter being its favourite foraging site during the day. Bird 2074 spent 31% of its time on the Gambia River and 54% in abandoned rice fields, which also were favourite daytime foraging areas. Night fixes usually were close to each other with very low speeds, suggesting that the birds were resting.

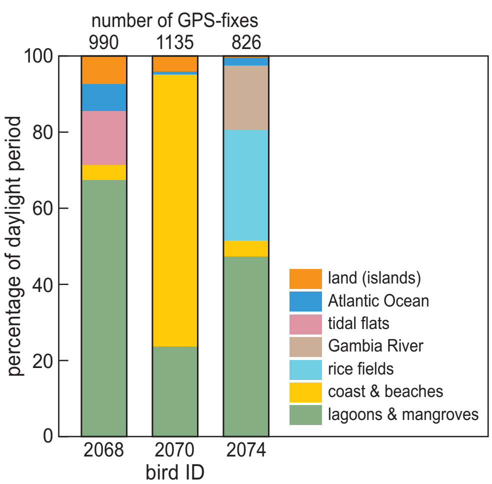

Figure 3. Foraging habitats of three GPS-tracked Slender-billed Gulls breeding in the Saloum Delta, Senegal, in 2014. Data are based on fixes of GPS-trackers obtained during the daylight period (6:00–20:00). Number of fixes are given on top of bars.

Foraging trips

Maximum trip distance from the colony (all birds) was on average 37 ± 13 km (±SD, range: 17–74). Birds covered on average 96 ± 39 km per trip (range: 41–214) and trips lasted on average 18 ± 10 h (range: 7–38). Foraging trips were highly variable between the individuals (Table 4). There was great variation in the maximum trip distance for bird 6068 and 2074, but not for bird 2070, which flew to exactly the same feeding site each day.

DISCUSSION

Accuracy of the diet analysis method

Diet studies based on an analysis of pellets and faeces have been criticised as being inaccurate (e.g. Johnstone *et al.* 1990, Barrett. *et al.* 2007). It has been stressed that soft-bodied prey tend to be under-represented or even absent. Moreover, in case of otoliths or other hard parts of prey this method might lead to an underestimation of small and thin specimens, which may break, erode or even disappear in the acid gastric environment of the bird's gastro-intestinal tract. The results presented in this study are based on the presence of fish otoliths, which were selected against a black background, from washed samples. Considering the various methodological pitfalls of the method used, the following should be noted: (1) it has been shown that the washing procedure used has no impact on the number and quality of the otoliths in the samples (Leopold *et al.* 2015); (2) a trial in which prey were selected against a black and a white background showed better results for the black background; against a white background no additional prey were found (Veen unpubl.); (3) our method is suitable for finding small prey remains such

Table 4. Foraging trip characteristics for three GPS-tracked Slender-billed Gulls in a breeding colony in the Saloum Delta, Senegal, in 2014.

Bird ID	number of trips	Maximum distance (km)		Total distance (km)		Total time (min)	
		mean ± SD	range	mean ± SD	range	mean ± SD	range
2068	12	43.26 ± 17.68	25.04–3.98	116.95 ± 50.63	65.92–214.22	1083.70 ± 522.08	629.59–2106.93
2070	11	34.79 ± 0.36	34.37–35.32	82.34 ± 10.25	62.82–96.41	1253.19 ± 625.32	496.17–2289.85
2074	8	32.19 ± 10.61	17.47–44.86	82.37 ± 33.28	41.37–134.97	941.20 ± 586.53	399.22–2295.22

as shrimp mandibles, as has been shown in a study on the diet of Eurasian Spoonbills *Platalea leucorodia* at the Banc d'Arguin, Mauritania (Veen *et al.* 2012b). No such small prey were detected in the Slender-billed Gull's excretion; (4) we did not make use of other hard parts of prey such as bones, scales and spines for identifying prey, because no reference collection for such prey remains was available; (5) we extracted and identified all otoliths with a width of 0.3 mm or more, present in our material after being washed in bags with a mesh size of 0.3 mm. We always searched our samples twice to minimise the probability that otoliths were overlooked. Furthermore, most otoliths were in rather good condition, not being strongly eroded.

We conclude that an underestimation of otoliths of certain species, because they were dissolved before being excreted, seems unlikely but cannot be excluded. It is also unlikely that the Slender-billed Gulls took large numbers of prey such as shrimp, which can easily be identified by their mandibles. However, we cannot exclude the possibility that the birds consumed soft-bodied prey like worms and insects as reported by Fasola *et al.* (1989), Del Hoyo *et al.* (1996) and Cama *et al.* (2012) for Slender-billed Gulls in other breeding colonies.

Diet composition

Slender-billed Gulls are reported to have a varied diet, eating fish, insects, marine invertebrates and occasionally vegetable matter, with fish and invertebrates being most commonly taken (Fasola *et al.* 1989, Del Hoyo *et al.* 1996, Cama *et al.* 2012). Habib (2017) mentions small fish, especially Cichlidae, and worms for a colony in northern Egypt. Despite intensive search, we only found fish remains in excretion of the Slender-billed Gulls breeding in the Saloum Delta, but soft-bodied prey may have escaped attention because of the method chosen (see above). Most fish belonged to the Cichlidae, Clupeidae and Mugilidae families. The proportional occurrence of the dominant fish families varied between years but only proportions of Mugilidae increased significantly between 2000 and 2015. Depending mainly on fish seems to be typical for Slender-billed Gulls breeding in West Africa as it has also been found for birds breeding in Parc National de la Langue de Barbarie (estuary of the Senegal River, Senegal) and the Banc d'Arguin, Mauritania (Veen *et al.* 2003, 2006). However, prey species composition may differ markedly between sites (Veen *et al.* 2003, 2004). This suggests that West African Slender-billed Gulls are opportunistic feeders, concentrating on fish and taking what is available in the colony's vicinity.

Time budgets

All three tracked birds spent less than 30% of their time at the nest where they presumably were incubating the eggs. In the Saloum Delta, Slender-billed Gulls never leave their clutch unattended (pers. obs.). Partner birds, therefore, must have been at the nest for more than 70% of their time. The unequal share of duties at the nest might be explained in different ways. Firstly, in many bird species males and females take an unequal share in incubation duties. In a variety of larid species females have been shown to take a greater share in incubation than males (e.g. Western Gull *Larus occidentalis*, Pierotti 1981; Great Black-backed Gull *Larus marinus*, Butler & Janes-Butler 1983, Common Tern *Sterna hirundo*, Wiggins & Morris 1987, Fasola & Saino 1995). Such differences appear to vary between years and colonies in relation to environmental conditions. However, a female share of 70% seems exceptional and has only been observed for Western Gull (Pierotti 1981). Assuming that also in Slender-billed Gulls, females take a greater share in incubation duties, this suggests that our GPS-tracked birds were all males. Unfortunately, we were not able to determine sexes of the birds. Secondly, we cannot exclude the possibility that stress involved in catching the birds on the nest may have led to a decrease in their willingness to incubate the eggs, although the quick return of the birds to their nests after capture does not appear to corroborate this hypothesis. Lastly, the presence of the GPS-trackers may have negatively influenced the ability of the birds to catch food resulting in an increase of the time spent in the foraging areas.

Habitat-diet relationships

The gulls showed marked and consistent individual differences in the areas explored for foraging, which is in agreement with observations on a variety of seabird species (Samantha *et al.* 2014, Wakefield *et al.* 2015) including gulls (Camphuysen *et al.* 2015, Masello *et al.* 2013, Tyson *et al.* 2015). Lagoons, salt pans, small streams and abandoned rice fields, nearly always bordered by mangroves, were highly favoured by bird 2068 and 2074, whereas bird 2070 predominantly explored the Atlantic coast. In all years of observation three fish families were extremely numerous in the diet samples: Cichlidae, Clupeidae and Mugilidae. Cichlids are extremely abundant in the lagoons, streams and mangrove areas of the Saloum Delta (pers. obs.). Juvenile stages of the most common clupeids in the diet (*Sardinella aurita* and *S. maderenses*) have a marine coastal distribution (A. Corten pers. comm.). Several species of mugilids occurring in the area all live in

Breeding Slender-billed Gulls showing threat displays (photo Jan Veen, Saloum Delta, 20 May 2012).

marine coastal waters, some in brackish and fresh water, whereas a number of species are especially common in hypersaline lagoons and salt pans (Froese & Pauly 2018). An analysis of excretion collected near the nests of the GPS-tracked birds in all cases showed a predominance of cichlids (>75%). This coincides with the favourite foraging area of 2068 and 2074, but not with the preference of 2070 to forage in coastal oceanic waters. However, it should be stressed that excretion collected near the nests covers the whole incubation period, which is about twice the duration of our GPS logging period. Moreover, excretion collected near a nest originates from both partners, which may use different foraging areas.

Foraging trips

Foraging trips greatly varied in maximum distance from the nest, total distance covered and duration. In a number of cases the duration of trips made by bird 2070 and 2074 were very long, with a maximum duration of 38 hours. Such trips were carried out towards the end of the observation period. All nests were most likely preyed upon by Sacred Ibises, but the exact date of predation is unknown. We therefore cannot exclude the possibility that these long duration trips were carried out when the clutch had already been destroyed. Sacred Ibises traditionally breed in the mangroves on the island in a colony of c. 50 pairs, but predation on the eggs of gulls and terns appeared to be a new phenomenon.

The three tracked birds covered a total area of 2400 km^2 during the two weeks of tracking, whereas foraging fixes were recorded in a 1800 km^2 area. There was large variation in the areas exploited by the individual birds. As a consequence, the total foraging areas used by the 2014 breeding population in the Saloum Delta, which consisted of c. 17,000 individuals on three islands, was presumably much larger.

Slender-billed Gulls may catch their food in different ways. Fish is usually caught by surface dipping, surface seizing or surface plunging while flying around (Cramp & Simmons 1993). However, prey may also be obtained while swimming or walking, although this can be expected to be rare when fish is caught. The lack of detailed observations on the behaviour of these gulls made it difficult to split our data into flying, foraging and resting. In particular, the last two categories were difficult to distinguish from each other. In most cases, fixes assigned to flying were connected by a straight line between colony and foraging area or between different foraging areas. Foraging fixes and resting fixes, however, were often scattered within the same areas, suggesting that the gulls alternate foraging and resting periods and rest within their foraging areas. The frequency of fixes taken at night was too low (1/h) to distinguish between activities. However, in most cases the clustering of fixes at the same spot suggested that the birds were resting.

Fisheries, food availability and protection

This study was initiated at the end of the 1990s in reaction to an alarming increase of fishery activities in the West African region stimulated by government subsidies to foreign fleets (Rashid Sumaila *et al.* 2016). Global fish exploitation rates were found to be unsustainable and Pauly *et al.* (1998) warned that continuation of the trend would lead to widespread population collapse. To study the possible impact of over-fishing on fish-eating birds, a monitoring program was set up including the Slender-billed Gull. Between 1998 and 2015, breeding parameters (breeding population size, clutch size, egg dimensions and chick condition) and diet composition were measured. We did not find consistent between-year changes in the breeding parameters mentioned, nor did we find clear correlations between breeding parameters and diet components that might point at food availability problems (own unpubl. data). Stocks of small pelagic fish off Senegal, The Gambia and Mauritania are either heavily exploited (Sardine *Sardina pilchardus*), fully exploited (Chub Mackerel *Scomber colias*, Anchovy *Engraulis encrasicolus*) or over-exploited (Horse Mackerels *Trachurus trachurus* and *T. trecae*, Sardinellas *Sardinella aurita* and *S. maderensis* and Bonga Shad *Ethmalosa fimbriata*; FAO 2018). Data presented by Belhabib *et al.* (2013) and Pauly & Zeller (2015) also show persistently decreasing trends for captures of pelagic species. Between 1998 and 2014, decreasing captures of *Brachydeuterus auritus* (80%), and Mugilidae (67%, probably mainly *Mugil ceplhalus*) are mentioned. Several among the above-mentioned fish species occur in the diet of the Slender-billed Gull in the Saloum Delta. No data are available on the development of stocks of cichlid species which made up between 25.3% and 93.1% of the diet of the Slender-billed Gulls in our study (Table 1). Cichlids are not mentioned in the recent Red List of Marine Bony Fishes of the Eastern Central Atlantic (IUCN 2017). In Senegalese waters, cichlids are almost exclusively targeted by artisanal fishermen and almost predominantly large specimen are taken. Slender-billed Gulls tend to concentrate on very small one-year class fish. Over-fishing of older age classes does not necessarily lead to a decrease of the availability of the youngest stages. In contrast, taking away older fish may lead to an increase of the number of recruits until the level of 'recruitment over-fishing' is reached (Gulland 1983), which will inevitably lead to a collapse of the stock. So far, we have no indications that West African Slender-billed Gulls suffer acutely from over-fishing effects. This does not mean such effects are not present as they could be masked by other sources of variation or only appear once a threshold is reached. During our study period egg-poaching, flooding of nests and predation were the most important mortality factors during the breeding period (Veen *et al.* 2015). Since the West African breeding population of the Slender-billed Gull is small and possibly isolated from other populations, special attention for effective protection of colony sites is needed.

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REFERENCES

Aitchison J. 1986. The statistical analysis of compositional data. Chapman and Hall, London.

Barrett R.T., Camphuysen C.J., Anker-Nilssen T., Chardine J.W., Furness R.W., Garthe S., Hüppop O., Leopold M.F., Montevecchi W.A. & Veit R.R. 2007. Diet studies of seabirds: a review and recommendations. ICES J. Mar. Sc. 64: 1675–1691.

Beatley M. & Edwards S. 2018. Overfished: In Senegal, empty nets lead to hunger and violence. GlobalPost Investigations. https://gpinvestigations.pri.org/overfished-in-senegal-empty-nets-lead-to-hunger-and-violence-e3b5d0c9a686

Belhabib D., Koutob V., Gueye N., Mbaye L., Mathews C, Lam V. & Pauly D. 2013 Lots of boats and fewer fishes: A preliminary catch reconstruction for Senegal, 1950–2010. Fisheries Centre, University of British Columbia, Working Paper Series 2013–3.

Birdlife International 2017. Species factsheet *Larus genei*. www.birdlife.org

Bouten W., Baaij E., Shamoun-Baranes J. & Camphuysen C.J. 2003. A flexible GPS tracking system for studying bird behaviour at multiple scales. J. Ornithol. 154: 571–580.

Butler R.G. & Janes-Butler S. 1983. Sexual differences in the behaviour of adult Great Black-backed Gulls (*Larus marinus*) during the pre and post-hatch periods. Auk 100: 63–75.

Cama A., Abellana R., Christel I., Ferrer X. & Vieites D.R. 2012. Moving to the sea: a challenge for an inshore species, the slender-billed gull. Mar. Ecol. Prog. Ser. 463: 285–295.

Camphuysen C.J., Shamoun-Baranes J., Van Loon E.E. & Bouten W. 2015. Sexually distinct foraging strategies in an omnivorous seabird. Mar. Biol. 162: 1417–1428.

Cramp S. & Simmons K.E.L. (eds) 1993. Handbook of the birds of Europe, the Middle East and North Africa. The birds of the Western Palearctic. Oxford Univ. Press, Oxford.

Crawley M.J. 2007. The R book. Wiley, Chichester.

Del Hoyo J., Elliott A. & Sargatal J. (eds) 1996. Handbook of the birds of the world. Vol.3. Hoatzin to Auks. Lynx Editions, Barcelona.

FAO 2018. Report of the FAO working group on the assessment of small pelagic fish off northwest Africa. Nouadhibou, Mauritania, 22–27 May 2017. FAO Fisheries and Aquaculture Report FIAF/R1221 (Bi).

Fasola M. & Saino N. 1995. Sex-biased parental-care allocation in three tern species (Laridae, Aves). Can. J. Zool. 73: 1461–1465.

Fasola M., Bogliani G., Saino N. & Canova L. 1989. Foraging feeding and time activity niches of eight species of breeding seabirds in the coastal wetlands of the Adriatic Sea. Boll. Zool. 56: 61–72.

Fisher R.A. 1918. The correlation between relatives on the supposition of Mendelian inheritance Trans. R. Soc. Edinburgh 52: 399–433.

Froese R. & Pauly D. (eds) 2018. FishBase. www.fishbase.org

Gulland J.A. 1983. Fish stock assessment: a manual of basic methods. Wiley, Chichester.

Habib M.I. 2017. Slender-billed Gulls *Larus genei* breeding at El Nasser Salinas, northern Egypt, June 2017. Sandgrouse 40: 28–35.

Hijmans R.J. 2015. Geosphere: spherical trigonometry. R package version 1.5-5. https://CRAN.R-project.org/package=geosphere

IUCN 2017. Red List of Marine Bony Fishes of the Eastern Central Atlantic. IUCN, Gland, Switzerland.

Jacobs A. 2017. China's appetite pushes fisheries to the brink. New York Times: 30 April 2017.

Johnstone I.G., Harris M.P. Wanless S. & Graves J.A. 1990. The usefulness of pellets for assessing the diet of adult shags *Phalacrocorax aristotelis*. Bird Study 37: 5–11.

Keijl G.O., Brenninkmeijer A., Schepers F.J., Brasseur R.E., Ndiaye S., Stienen E.W.M. & Veen J. 2000. Oiseaux nicheurs sur les cotes du Parc National du Sine Saloum, Senegal, 998. WIWO-report 68, IBN-report 99/6. Zeist, The Netherlands.

Kenward R. 1987. Wildlife radio tagging. Equipment, field techniques and data analysis. Academic Press, London.

Kucera M. & Malmgren B.A. 1998. Logratio transformation of compositional data – a resolution of the constant sum constraint. Mar. Micropaleont. 34: 117–120.

Leopold M.F., Begeman L., Hesze E., van der Hiele J., Hiemstra S., Keijl G., Meesters E., Mielke L., Verheyen D. & Gröne A. 2015. Porpoises: from predators to prey. J. Sea Res. 97: 14–23.

Masello J.F., Wileski M., Voigt C.C. & Quillfeldt P. 2013. Distribution patterns predict individual specialization in the diet of Dolphin Gulls. PLoS ONE 8(7): e67714.

Pauly D. & Zeller D. (eds) 2015. Sea Around Us concepts, design and data. www.seaaroundus.org (accessed 28-10-2018)

Pauly D., Christensen V., Dalsgaard J., Froese R. & Torres Jr F. 1998. Fishing down marine food webs. Science 270: 860–863.

Pierotti R. 1981. Male and female parental roles in the Western Gull under different environmental conditions. Auk 98: 532–549.

Rashid Sumaila U., Lam V., Le Manach F., Swartz W. & Pauly D. 2016 Global fisheries subsidies: An updated estimate. Marine Policy 69: 189–193.

Samantha C.P., Bearhop S., Grémillet D., Lescroël A., Grecian W.J., Bodey T.W., Hamer K.C., Wakefield E., Le Nuz M. & Votier S.C. 2014. Individual differences in searching behavior and spatial foraging consistency in a central place marine predator. Oikos 123: 33–40.

Tyson C., Shamoun-Baranes J., Van Loon E.E., Camphuysen C.J. & Hintzen N.T. 2015. Individual specialization on fishery discards by lesser black-backed gulls (*Larus fuscus*). ICES J. Mar. Sc. 76: 1882–1891.

UNESCO 2011. Delta du Saloum. World Heritage List. https://whc.unesco.org/en/list/1359

Veen J., Peeters J., Leopold M.F., Van Damme C.J.G. & Veen T. 2003. Les oiseaux piscivores comme indicateurs de la qualité de l'environnement marin: suivi des effets de la pêche littorale en Afrique de l'Ouest. Alterra report 666, Wageningen, The Netherlands.

Veen J., Dallmeijer H.J. & Diop M.S. 2004. Le suivi de la biodiversité des poissons lelong du littoral de l'Afrique de l'Ouest, utilisant les oiseaux marins comme indicateurs. Report Wetlands International, Dakar/VEDA Consultancy, The Netherlands.

Veen J., Dallmeijer H.J. & Diagana C. 2006. Monitoring colonial nesting birds along the West African Seaboard. Report, Wetlands International/VEDA consultancy.

Veen J., Mullié W.C.M. & Sylla C.M. 2012a. Testing research methods to study food and feeding behaviour of Royal Tern *Thalasseus maximus*, Caspian Tern *Sterna caspia* and Slender-billed Gull *Larus genei* with special reference to the use of satellite tracking devices. Report, VEDA consultancy/FIBA.

Veen J., Overdijk O. & Veen T. 2012b. The diet of the endemic subspecies of the Eurasian Spoonbill *Platalea leucorodia balsaci*, breeding at the Banc d'Arguin, Mauritania. Ardea 100: 123–130.

Veen J., Mullié W.C.M., Dallmeijer H.J., Folmer E., Diouf E., Gomis N. & Samb M. 2015. Studying colony breeding terns and gulls in the Saloum Delta National Park, Senegal, 2015. Report, VEDA consultancy/Birdlife International.

Veen J., Dallmeijer H.J. & Veen T. 2018. Selecting piscivorous bird species for monitoring environmental change in the Banc d'Arguin, Mauritania. Ardea 106: 5–18.

Wakefield E.D., Cleasby I.R., Bearhop S., Bodey T.W., Davies R.D., Miller P.I., Newton J., Votier S.C. & Hamer K.C. 2015. Long-term individual foraging site fidelity – why some gannets don't change their spots. Ecology 96: 3058–3074.

Wetlands International 2006. Waterbird Population Estimates – Fourth Edition. Wetlands International, Wageningen, The Netherlands.

Wiggins D.A. & Morris R.D. 1987. Parental care of the Common Tern *Sterna hirundo*. Ibis 129: 533–540.

SAMENVATTING

In West Afrika bevindt zich een broedpopulatie Dunbekmeeuwen *Chroicocephalus genei* van ca. 7500 paren. Meer dan 90% van deze meeuwen broedt in drie gebieden, waar ze bedreigd worden door menselijke verstoring, predatie, erosie van broedplaatsen en overbevissing. Dit artikel beschrijft de resultaten van onderzoek naar de voedselsamenstelling en de voedselgebieden van een broedpopulatie in Senegal, dat tussen 1998 en 2015 werd uitgevoerd. De voedselsamenstelling werd bepaald door het analyseren van een mengsel van poep en braaksels dat rond de nesten werd verzameld. In deze monsters werden uitsluitend resten van vissen gevonden, die op basis van otolieten gedetermineerd werden. Het bleek dat de broedende meeuwen tijdens de eifase hoofdzakelijk vissen aten van de families van de cichliden (Cichlidae 25–93%), haringachtigen (Clupeidae 0–54%) en harderachtigen (Mugilidae 0–34%). Het percentage harderachtigen nam significant toe in de periode 2000–2015. Met behulp van dataloggers werden in 2014 de dagelijkse activiteiten van drie broedende vogels bestudeerd. Overdag broedden deze vogels gemiddeld 27% van hun tijd, terwijl 10% elders in de kolonie werd doorgebracht en 63% tijdens foerageervluchten buiten de kolonie. Er waren opvallende individuele verschillen in de gebieden die de vogels tijdens hun foerageervluchten bezochten. Twee vogels foerageerden in lagunes, zoutpannen, kreken, rivieren en rijstvelden. De derde vogel concentreerde zich op een kustgebied vlak bij een vissersplaatsje in Gambia. De *home range* en het foerageergebied van de drie vogels tezamen was respectievelijk 2400 en 1800 km^2. In de discussie wordt ingegaan op de nauwkeurigheid van de methode om voedsel te bepalen op basis van otolieten in braakballen en poep. De West Afrikaanse dunbekmeeuwen lijken vrijwel uitsluitend vissen te eten, terwijl in kolonies in het Middellandse Zeegebied ook insecten en wormen als prooi genoemd worden. De geringe deelname aan het broeden van de loggervogels (27%) is opmerkelijk. Mogelijke verklaringen zijn: (1) de sekse van de gezenderde vogels (bij meeuwen broeden mannen vaak minder dan vrouwen), (2) stress als gevolg van het vangen en (3) effecten van het dragen van een datalogger op foerageer-efficiëntie. Er zijn geen aanwijzingen voor voedselgebrek bij de Dunbekmeeuwen als gevolg van visserijinspanningen. In dit verband dient benadrukt te worden, dat relevante gegevens over de populatiegrootte van de belangrijkste prooivissen schaars zijn. Wij pleiten voor een betere bescherming van de broedkolonies.

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SUPPLEMENTARY MATERIAL

Table S1. Diet composition of Slender-billed Gulls breeding in the Delta du Saloum, Senegal, based on otoliths in excretion (mixture of pellets and faeces collected near nests) in eight years of observation.

			Excrements							
Family	**Species**	**Year:**	2000	2001	2003	2011	2012	2013	2014	2015
Atherinidae	*Atherina* sp.							1		
Ariidae	*Arius* sp.									
Batrachoididae	*Halobatrachus didactylus*			1						
Citharidae	*Citharichthys stampflii*				2			1	1	
Carangidae	Carangidae				1					
	Selene dorsalis								2	
Cichlidae	Cichlidae		1184		86	395	107	48	248	143
	Chromidotilapia guntheri			23						
	Hemichromis fasciatis			16						
	Tilapia guineensis		1	230						
	Saratherodon melanotheron			815						
Citharidae	*Citharus linguatula*			1						
Clupeidae	Clupeidae		14	13	40	38	185	67		12
	Ethmalosa fimbriata			4		1		9		
	Sardinella sp.					2			22	
	Sardinella aurita			67						
	Sardinella maderensis			117						
Engraulidae	*Engraulis encrasicolus*			7						
Gerreidae	*Eucinostomus melanopterus*		21	5	9	1	3	22	14	
	Gerres nigri		2				1	3	5	
Gobiidae	Gobiidae		1			1				
Haemulidae	Haemulidae		1							
	Brachydeuterus auritus		4	1			1		1	1
	Pomadasys incisus			6				1	1	
	Parakuhlia macrophthalmus									
Haemiramphidae	Haemiramphidae		29	16	13		14		14	
	Haemiramphus brasiliensis							3		
Mugilidae	Mugilidae		13	34	15	6	22	18	67	82
	Liza sp.									
	Liza grandisquamis									
	Liza dumerili									
	Liza falcipinnis			6						
	Mugil sp.									
	Mugil bananensis									
	Mugil cephalus							12		
Polynemidae	*Galeoides decadactylus*		1	3	5				4	
	Pentanemus quinquarius			1						
Pristigasteridae	*Ilisha africana*		2	5			1	5	15	
Sciaenidae	Sciaenidae				1					
	Pseudotolithus elongatus						1			
Soleidae	Soleidae				1		4			2
	Solea senegalensis					1				
	Synaptura lusitanica			1						
	Microchirus sp.				7					
Sparidae	Sparidae			23						1
	Dentex sp.									
	Dentex maroccanus			4						
	Diplodus vulgaris			4						
	Pagellus bellottii			2						
Trachinidae	Trachinidae			2						
Total number otoliths			1273	1407	180	445	339	190	394	241