

# COMPOSITION OF THE SEABIRD COMMUNITY OFF FRENCH GUIANA

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## ABSTRACT

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We provide information on the seabirds occurring year-round in waters of the French Guiana Exclusive Economic Zone, based on data obtained from three boat-based campaigns: a campaign by the Groupe d'Étude et de Protection des Oiseaux de Guyane was conducted for four days every two months from July 2011 to June 2012; a campaign by Cohabys was performed for five days per month from January to May 2018; and a campaign by Ocean Science & Logistic consisted of four 10-day surveys conducted in June, July, September, and October 2018. Overall, 30 seabird species within 1 110 groups of birds were sighted along 6 686 km of surveys conducted during favorable weather conditions (Beaufort < 5). Seabirds of the family Laridae were the most frequently observed, followed by those of the family Procellariidae. In waters over the continental slope, the most frequently observed species were Sooty Tern *Onychoprion fuscatus*; Brown Noddy *Anous stolidus*; Wilson's *Oceanites oceanicus* and Leach's *Hydrobates leucorhous* Storm Petrels; Great *Ardenna gravis*, Manx *Puffinus puffinus*, and Audubon's *Puffinus lherminieri* Shearwaters; and Masked Booby *Sula dactylatra*. In waters over the shelf, the most common species were Common Tern *Sterna hirundo*, Laughing Gull *Leucophaeus atricilla*, and Royal Tern *Thalasseus maximus*. In the coastal area, the most common species were Laughing Gull, Royal Tern, and Cayenne Tern *T. acuflavidus eurygnathus*. The Magnificent Frigatebird *Fregata magnificens* was sighted in all habitats. Monthly presence/absence and associations of species were also analyzed. Our results underline the high species diversity of seabirds within the waters of French Guiana as well as the diverse uses of available habitats. Indeed, the region is not only a major nesting area, but also a major foraging area for wintering, summering, and migrating species. We recommend strengthening seabird conservation measures and, in particular, increasing the extent of Marine Protected Areas.

**Key words:** South America, conservation, diversity, zonation, boat-based campaigns

## INTRODUCTION

French Guiana is a tropical French overseas territory situated along the northern coast of South America. Its Exclusive Economic Zone (EEZ; 04–09°N, 049–054°W) spans 132 000 km<sup>2</sup> and extends 200 nautical miles (370 km) into the Atlantic Ocean. It includes a wide continental shelf, a continental slope, and an abyssal plain, where depths approach 4 500 m (Guiral & Le Guen 2012). French Guiana, Suriname, Guyana, southern Venezuela, and northern Brazil (Amapá state) are referred to as the Guianas. Compared to other tropical regions, the waters of the Guianas are characterized by relatively high but seasonal productivity owing to river discharge, in particular from the Amazon River (Longhurst 2007).

These areas are not free from human impacts. Bycatch in fishing nets was found to be a major concern for the Guiana dolphin *Sotalia guianensis* and sea turtles (IUCN France *et al.* 2017). Local releases of contaminants from land mining in coastal waters are also an issue, especially for top predators, and high mercury concentrations have been found in several nesting seabird species (Sebastiano *et al.* 2017). The development of the oil industry in the Guianas has also

been identified as a threat in IUCN documents (IUCN France *et al.* 2017). The poor results of exploratory drilling off French Guiana in 2018 and the passing of French legislation in 2017 that prohibits new exploratory permits in French territories put an end to oil development in French Guiana's EEZ. However, these activities are still numerous in neighbouring countries and may impact the regional marine environment. According to the recent regional IUCN Red List assessment, three marine mammal species, two sea turtle species, and 10 seabird species are classified as Threatened in French Guiana (IUCN France *et al.* 2017). This work also highlighted the limited information available on seabirds in the territory, as 19 of the 38 seabird species evaluated were classified as Data Deficient.

Most of the current available data on seabirds in the French Guiana EEZ has been collected by a local ornithological association, Groupe d'Étude et de Protection des Oiseaux de Guyane (GÉPOG). Their work has shown that the Île du Grand Connétable Nature Reserve, a small island located 18 km off the southeastern coast, is a major nesting site for seabirds, including: Laughing Gull *Leucophaeus atricilla*, Brown Noddy *Anous stolidus*, Royal Tern *Thalasseus maximus*, Cayenne Tern *T. acuflavidus eurygnathus*<sup>1</sup>, Magnificent

<sup>1</sup> While Cayenne Tern is not included in the IOC World Bird List (12.1), the name is used in the Guianas to differentiate it from Cabot's Tern *Thalasseus acuflavidus acuflavidus*, which may also be sighted in the region (Lee & Mackin 2012).

Frigatebird *Fregata magnificens* (hereafter frigatebird), and the Sooty Tern *Onychoprion fuscatus* (Dujardin & Tostain 1990). About 50% of the Royal Tern's Caribbean population, 20% of the Laughing Gull's Caribbean population, and 33% of the Cayenne Tern's global population nest in this reserve. All these species have been classified in the regional IUCN Red List: the Sooty Tern is classified as Critically Endangered; the frigatebird as Endangered; and the Brown Noddy, Laughing Gull, Royal Tern, and Cayenne Tern are classified as Vulnerable (IUCN France *et al.* 2017).

Other information contributes to what was known of seabird occurrence in the study area prior to our work. The first dedicated program to assess the megafauna off French Guiana was an aerial survey in October–November 2008, which was repeated in 2017 (REMMA program; Mannonci *et al.* 2013, Laran *et al.* 2019). During this survey, seabirds from seven seabird families were identified. Laridae was the most abundant, particularly Sooty Terns, followed by frigatebirds. These campaigns were useful for monitoring and providing information on community composition at the family level, but because planes were used, species identification was limited. In addition, the two surveys were conducted in October–November and thus did not account for seasonal variation. In October–November 2017, Martinez *et al.* (2019) opportunistically collected bird sightings during an oceanographic survey in waters of the upper continental slope (200–2000 m depth). Eight families and 12 species were identified. The most frequently sighted taxa were: Laridae, with mainly Common Tern *Sterna hirundo*; Stercorariidae, dominated by Pomarine Jaeger *Stercorarius pomarinus*; Procellariidae with mainly Cory's Shearwater *Calonectris borealis*; and frigatebirds. This opportunistic boat-based study, though limited to a restricted area and period, significantly improved knowledge on seabird diversity in the French Guiana EEZ.

Between 2012 and 2018, different non-governmental organizations conducted three boat-based visual and acoustic campaigns dedicated to cetaceans and seabirds in the French Guiana EEZ. They used the same vessel and followed comparable sampling protocols. The first was a naturalist survey conducted in 2011–2012 by GEPOG. The second was part of an exploratory drilling impact assessment by Cohabys in early 2018. The third was a scientific survey undertaken in 2018 during the dry and rainy seasons by a local association, Ocean Science & Logistic (OSL). We combined and analyzed the data sets of these boat-based campaigns to assess year-round seabird use throughout the French Guiana EEZ, including species richness, distribution, phenology, and associations.

## MATERIAL AND METHODS

### Study area

French Guiana waters are profoundly influenced by the turbid freshwater discharge from the Amazon River (Hu *et al.* 2004), an influence that usually reaches a maximum in May–June and a minimum in November (Lentz 1995). The river plume is carried northwest by the North Brazil Current and its extension, the Guiana Current. These currents curl offshore, in a pattern known as a retroflection, from June through December (Hu *et al.* 2004). Consequently, biological productivity varies seasonally; it is at its highest and extends the furthest offshore during late spring and early summer (May–August; Hu *et al.* 2004). Wind and wave patterns in the area are dominated by northeastern trade winds. The EEZ can be divided into four habitats: coastal, continental shelf, continental

slope, and oceanic (Fig. 1). The coastal area, defined here as 0–20 m in depth, extends 20–30 km offshore. The waters have high turbidity and low salinity, and the productivity is low due to low levels of available irradiance (Froidefond 2012, Ternon & Guiral 2012). The continental shelf is 100 km wide and slopes smoothly to a depth of 100 m. The combination of riverine nutrient inputs and decreased turbidity creates a productive zone (Smith & Demaster 1996), which extends more or less seaward and can reach the slope when conditions are favorable (i.e., high river discharge plus retroflection). The continental slope may be divided into the upper slope (100–1500 m depth) and the lower slope (1500–3500 m depth). The western side is called the Demerara Plateau; it is wider than the eastern side and has a gentler slope. The slope area is notched by submarine canyons that favor transport of nutrients to deep waters. In addition, hard substrates such as rocky outcrops and a carbonate system have been recently discovered at depths of 100–200 m; these substrates support a highly diversified and dense macrobenthic community (Moura *et al.* 2016). The oceanic area reaches depths of more than 4500 m and is characterized by blue, oligotrophic waters.

### Boat-based campaign protocols

Data were collected during three independent boat-based campaigns, which were conducted on an 18-m sailing catamaran. Both sails and engine were used, depending on the weather, to maintain the vessel's speed between 5 and 6 knots (~9–11 km/h). The GEPOG campaign was conducted between July 2011 and June 2012, and it consisted of six surveys that were each four days long, conducted every two months. Transects were not pre-designed. The campaign covered all the habitat types, from coastal to oceanic, but the effort was concentrated in the center of the EEZ (Fig. 1). A visual effort was performed from sunrise to sunset (06h00 to 18h00) in sea conditions up to Beaufort 6. At all times, at least two experienced observers were on duty and rotations were performed every one to four hours. The mean daily Beaufort sea state was recorded at the end of the day. When an individual or a group of birds was detected, the following data were recorded: species identification to the lowest possible taxonomic level (from Gill *et al.* 2021), group size, and geographic position.

The Cohabys campaign consisted of five monthly surveys, each lasting five days, from January to May 2018. The OSL campaign was conducted in 2018 and consisted of four surveys, each lasting 10 days; two took place during the rainy season (June and July) and the other two were during the dry season (September and October). The Cohabys and OSL campaigns focused on the continental slope, but an opportunistic effort was made on the coastal area and the continental shelf, from the departure harbor to the survey area (Fig. 1). Cohabys surveys consisted of transects that were pre-designed to study the central slope area (Fig. 1). OSL surveys consisted of transects that were pre-designed to sample the whole slope area. Cohabys and OSL surveys followed the same standard Marine Mammal Observer protocol (Pelagis Observatory, La Rochelle University, France; e.g., Authier *et al.* 2017): the crew consisted of three trained observers. At all times, two observers were positioned on the highest part of the vessel roof, and each concentrated their search effort on the forward watch (relative to the centerline of the vessel, 270° to 0° for the port observer and 0° to 90° for the starboard observer) with naked eyes; binoculars were used only to identify sighted individuals. Rotations were organized every hour, so that each observer could rest for one hour after every two-hour shift. The visual effort was performed from sunrise to sunset, in sea conditions up to Beaufort 6. Beaufort sea state, glare severity, and cloud coverage were recorded

at each rotation and whenever any of these parameters changed. Sighting data collected included bird species identification to the lowest possible taxonomic level (according to Gill *et al.* 2021), age (immature/adult), group size, geographic position, observation angle, and distance from the boat.

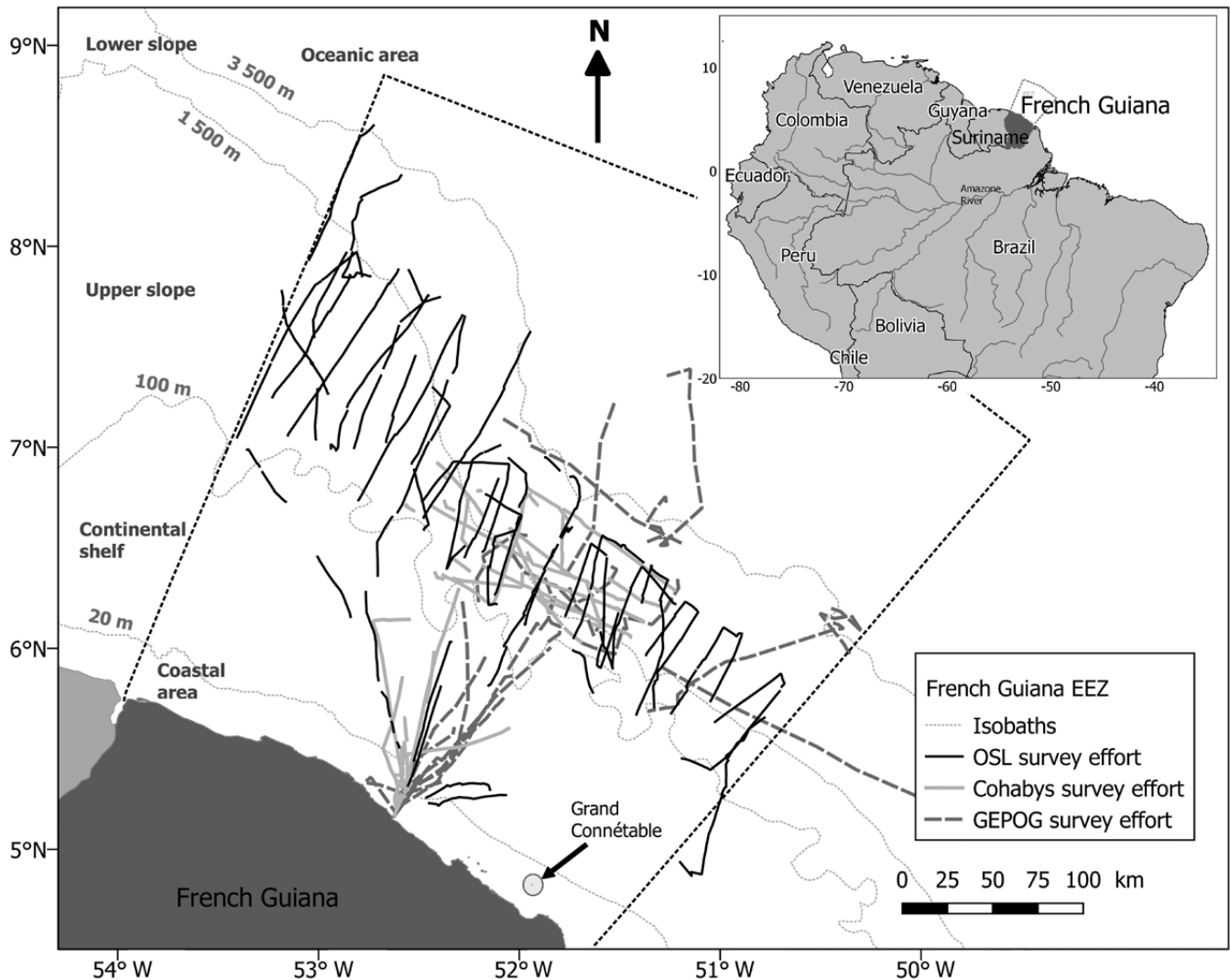
### Data analyses

While sightings were collected in conditions up to Beaufort 6, only data collected during favorable sea conditions (Beaufort < 5) were considered for the analysis. In order to analyze the community composition, we summed the number of sightings for each taxon and each campaign. We then calculated the sighting frequency for groups and individuals, as

$$\frac{n_{si}}{N}$$

where  $n_{si}$  is the number of groups/individuals sighted for species  $i$  and  $N$  is the total number of bird groups or individuals sighted.

Since the protocols were not identical between the GEPOG, Cohabys, and OSL campaigns, these numbers were computed separately for each. The distribution, monthly presence, and associations of the most frequently sighted species were then analyzed. First, for the most frequently observed species, habitat-specific encounter rates were calculated as the number of individuals sighted per 100 km of effort in the considered habitat and for the considered campaign. Habitats were defined as described above. When < 20 individuals were recorded for a species during a campaign, the habitat-specific sighting rate was not computed. Similarly, when effort was < 100 km for a campaign in a particular habitat, the sighting rates were not computed for that habitat. Second, the monthly presence of seabirds in French Guiana was described. For this qualitative description, all visual records from all campaigns were combined, including those made during non-favorable weather conditions (i.e., up to Beaufort 6). Third, species associations were studied from OSL data, as this information was systematically recorded during only this campaign. From these data, when > 10 sightings had been collected for a species, we computed the sighting frequencies for



**Fig. 1.** Characteristics of the French Guiana Exclusive Economic Zone (extent, bathymetry, habitats, and protected areas). The overlaid track lines show the spatial distribution of the visual effort performed during the GEPOG (black dashes; 1961 km), Cohabys (grey dashes; 1491 km), and OSL (black lines; 3234 km) campaigns in favorable weather conditions (Beaufort < 5).

single individuals, monospecific groups, and multispecific groups for that species as

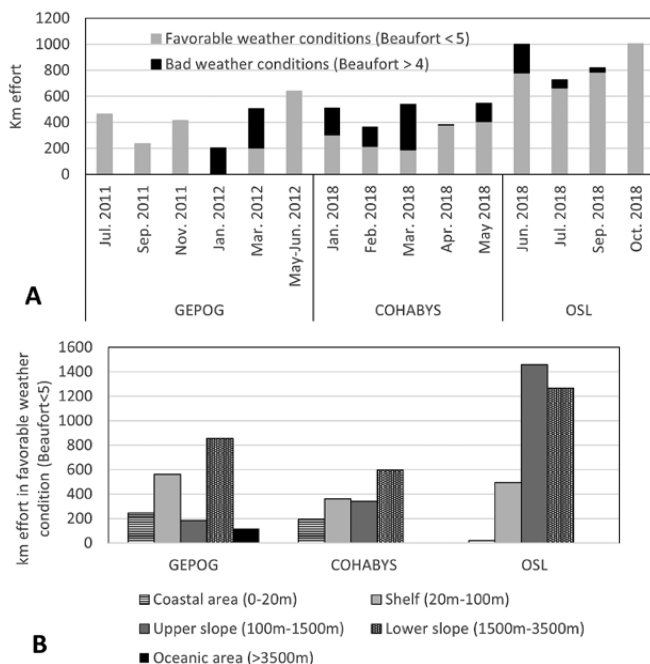
$$\frac{n_{gi}}{N}$$

where  $n_{gi}$  is the number of single, monospecific, or multispecific groups sighted for species  $i$  and  $N$  is the total number of groups sighted for species  $i$ .

## RESULTS

### Campaign efforts

A total of 6686 km were surveyed under favorable weather conditions during the GEPOG, Cohabys, and OSL campaigns (Fig. 2A). Of this, the GEPOG campaign accomplished 1961 km of effort: 44% (855 km; Fig. 2B) was conducted over the lower slope, 29% (559 km) was over the shelf, and 13% (245 km) was in the coastal area; effort was limited (< 10% each) over the upper slope and the oceanic area. The Cohabys campaign completed 1491 km of the total effort: 40% (596 km; Fig. 2B) was conducted over the lower slope, 24% (360 km) was over the shelf, 23% (340 km) was over the upper slope, and 13% (195 km) was in the coastal area; effort was limited in the oceanic area. The OSL study covered 3234 km of effort: 45% (1456 km) was conducted over the upper slope, 39% (1266 km) was over the lower slope, and 15% (493 km) was over the shelf; effort was limited in the coastal and oceanic areas. Overall, bad weather conditions led to no usable effort in January and little in February (Fig. 2A). In addition, because of the survey designs, no effort was performed in August and December, and the effort conducted in the oceanic area was limited.



**Fig. 2.** Visual effort performed during GEPOG, Cohabys, and OSL campaigns. Effort is detailed by (A) survey and (B) habitat. For panel (B), only effort that was performed when weather conditions were considered favorable for bird visual surveys (Beaufort < 5) is shown.

A total of 1110 groups of birds were sighted in favorable weather conditions, including 362 groups and 1013 individuals for the GEPOG survey, 181 groups and 611 individuals for the Cohabys survey, and 567 groups and 5228 individuals for the OSL survey (Table 1). Mean encounter rates per 100 km of effort per campaign were as follows:  $20.0 \pm 5.5$  groups and  $61.0 \pm 37.0$  individuals for GEPOG;  $12.8 \pm 2.7$  groups and  $31.7 \pm 14.3$  individuals for Cohabys, and  $18.2 \pm 3.1$  groups and  $158.4 \pm 58.7$  individuals for OSL.

### Community composition

Our cumulative number of identified taxa increased rapidly to 27 species during the GEPOG campaign (Fig. 3), then continued to increase slowly to 33 species during Cohabys campaign, and finally increased rapidly again to reach a plateau of 43 species during OSL surveys (October 2018). Of the 43 species identified, 30 were seabirds (Table 1): 13 Laridae, six Procellariidae, three Stercorariidae, two Oceanitidae, two Hydrobatidae, two Sulidae, one Phaethontidae, and one Fregatidae. The Laridae family was the most frequently sighted. Larids made up 44% of sighted groups and 65% of recorded individuals during the GEPOG campaign, 47% of the groups and 80% of the individuals during the Cohabys campaign, and 50% of the groups and 83% of the individuals during the OSL campaign. The Procellariidae family was the second-most frequently observed (Table 1). Procellariids accounted for 14% of the groups and 9% of the individuals recorded during the GEPOG campaign, 13% of sighted groups and 5% of recorded individuals during the Cohabys campaign; and 27% of the groups and 12% of the individuals during the OSL study.

In terms of species, the most frequently observed larid species were (Table 1) the Sooty Tern (up to 31% of the groups and 78% of the individuals) and the Common Tern (up to 11% of the groups and 28% of the individuals). Other abundant species in this family were: Brown Noddy (up to 4% of the groups), Laughing Gull (up to 6% of the groups), Royal Tern (up to 7% of the groups), and Cayenne Tern (up to 6% of the groups). Among Procellariidae, the species most often sighted were Great Shearwater *Ardena gravis* (up to 14% of the groups), Manx Shearwater *Puffinus puffinus* (up to 6% of the groups), and Audubon's Shearwater *Puffinus lherminieri* (up to 4% of the groups). Among Oceanitidae, the species most frequently sighted was Wilson's Storm Petrel *Oceanites oceanicus* (up to 7% of the groups), and the most frequently observed hydrobatid was Leach's Storm Petrel *Hydrobates leucorhous* (up to 9% of the groups). Two other species were often encountered: Magnificent Frigatebird (up to 7% of the groups) and Masked Booby *Sula dactylatra* (up to 6% of the groups). Several seabird species were observed only once, even when including data recorded during bad weather conditions: Black-legged Kittiwake *Rissa tridactyla*, Great Black-backed Gull *Larus marinus*, Cabot's Tern *Thalasseus acutiflavus acutiflavus*, Bridled Tern *Onychoprion anaethetus*, Black-bellied Storm Petrel *Fregatta tropica*, and Sooty Shearwater *Ardena grisea* (Appendix 1, available on the website).

### Species distribution

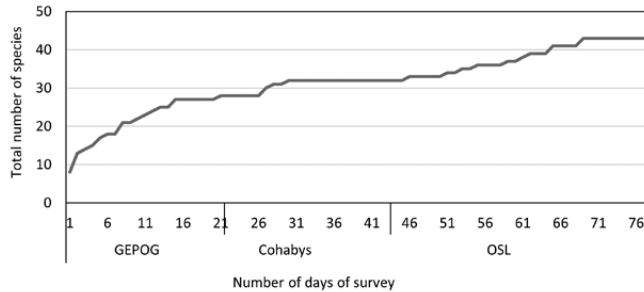
Among the Laridae, the Sooty Tern showed the most pelagic distribution, with higher encounter rates on the lower slope during the OSL and Cohabys campaigns (155 and 44 individuals sighted/100 km, respectively; Figs. 4, 5) and in the oceanic area during the GEPOG campaign (the only campaign that performed consistent effort in this habitat; 85 individuals

**TABLE 1**  
**List of identified bird families and seabird species, number and frequency of sightings**  
**in favorable weather conditions (Beaufort < 5), for groups and individuals**

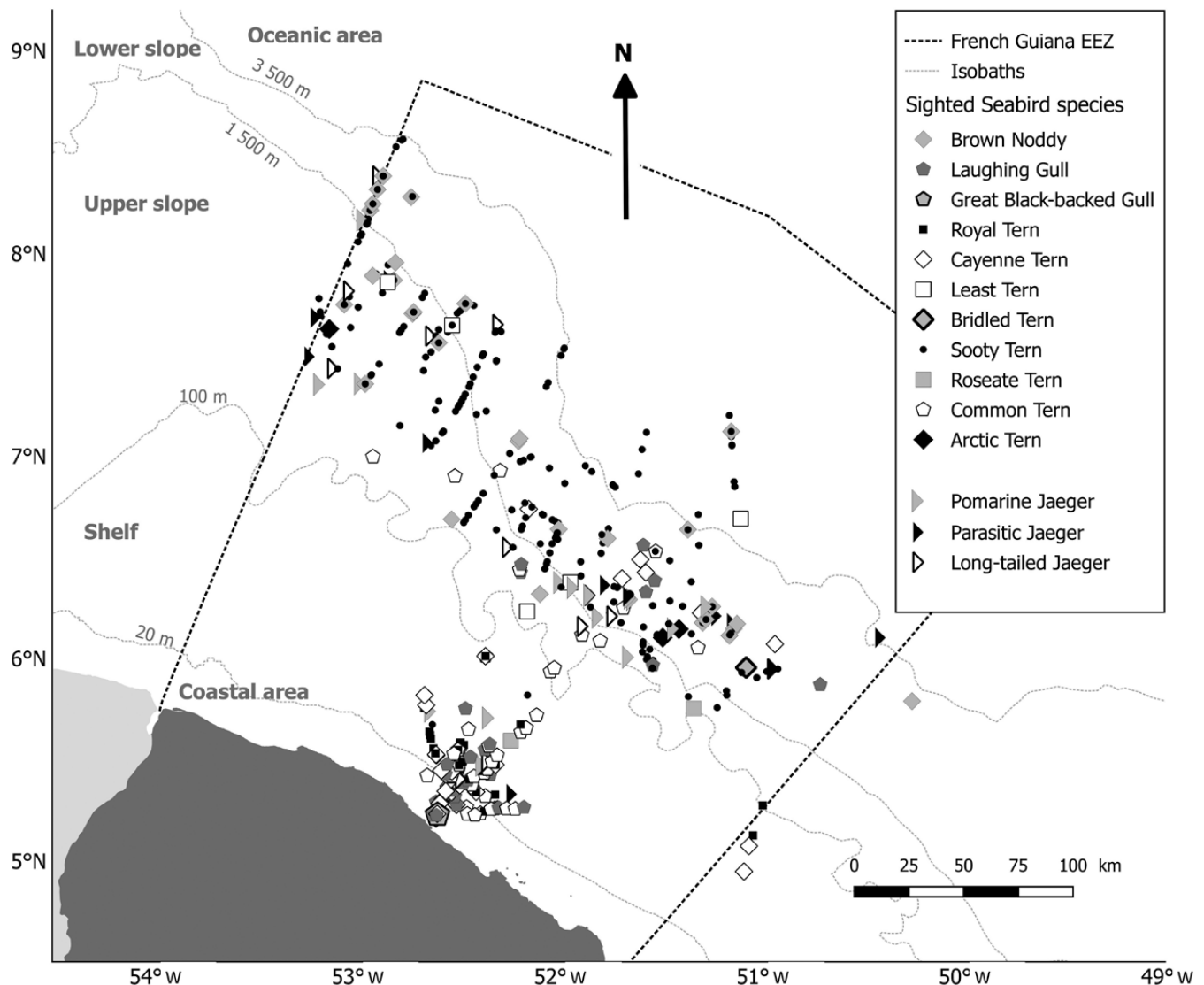
Family name		Number of group (individual) sightings			% of group (individual) sightings		
Common name	Scientific name	GEPOG	COHABYS	OSL	GEPOG	COHABYS	OSL
	Charadriidae			5 (5)			1 (<1)
	Scolopacidae	18 (66)		24 (70)	5 (7)		4 (1)
	Laridae	158 (661)	85 (486)	285 (4360)	44 (65)	47 (80)	50 (83)
Brown Noddy	<i>Anous stolidus</i>	7 (15)	3 (5)	21 (95)	2 (1)	2 (1)	4 (2)
Black-legged Kittiwake	<i>Rissa tridactyla</i>	One sighting with Beaufort > 4					
Laughing Gull	<i>Leucophaeus atricilla</i>	23 (50)	5 (8)	5 (5)	6 (5)	3 (1)	1 (<1)
Great Black-backed Gull	<i>Larus marinus</i>		1 (5)			1 (1)	
Royal Tern	<i>Thalasseus maximus</i>	24 (44)	2 (3)	21 (32)	7 (4)	1 (<1)	4 (1)
Cayenne Tern	<i>T. acutifluidus eurygnathus</i>	21 (48)	6 (27)	19 (31)	6 (5)	3 (4)	3 (1)
Cabot's Tern	<i>T. acutifluidus acutifluidus</i>	1 (1)			<1 (<1)		
Least Tern	<i>Sternula antillarum</i>	2 (7)		3 (5)	1 (1)		1 (<1)
Bridled Tern	<i>Onychoprion anaethetus</i>			1 (1)			<1 (<1)
Sooty Tern	<i>Onychoprion fuscatus</i>	28 (189)	18 (274)	173 (4062)	8 (19)	10 (45)	31 (78)
Roseate Tern	<i>Sterna dougallii</i>	1 (1)		2 (3)	<1 (<1)		<1 (<1)
Common Tern	<i>Sterna hirundo</i>	39 (283)	2 (26)	23 (72)	11 (28)	1 (4)	4 (1)
Arctic Tern	<i>Sterna paradisaea</i>	2 (3)		1 (1)	1 (<1)		<1 (<1)
Unidentified terns	<i>Sterna spp.</i>	10 (20)	48 (138)	15 (52)	3 (2)	27 (23)	3 (1)
Unidentified Laridae				1 (1)			<1 (<1)
	Stercorariidae	26 (29)	9 (9)	20 (25)	7 (3)	5 (1)	4 (<1)
Pomarine Jaeger	<i>Stercorarius pomarinus</i>	8 (9)	5 (5)	3 (3)	2 (1)	3 (1)	1 (<1)
Parasitic Jaeger	<i>Stercorarius parasiticus</i>	2 (2)	2 (2)	7 (10)	1 (<1)	1 (<1)	1 (<1)
Long-tailed Jaeger	<i>Stercorarius longicaudus</i>	7 (9)		6 (7)	2 (1)		1 (<1)
Unidentified Stercorariidae		9 (9)	2 (2)	4 (5)	2 (1)	1 (<1)	1 (<1)
	Phaethontidae	5 (5)	5 (9)	5 (5)	1 (<1)	3 (1)	1 (<1)
Red-billed Tropicbird	<i>Phaethon aethereus</i>	4 (4)	5 (9)	5 (5)	1 (<1)	3 (1)	1 (<1)
Unidentified Phaethontidae		1 (1)			<1 (<1)		
	Oceanitidae	26 (34)	0 (0)	10 (11)	7 (3)	0 (0)	2 (1)
Wilson's Storm Petrel	<i>Oceanites oceanicus</i>	26 (34)		9 (10)	7 (3)		2 (<1)
Black-bellied Storm Petrel	<i>Fregata tropica</i>			1 (1)			<1 (<1)
	Hydrobatidae	34 (50)	8 (10)	33 (60)	9 (5)	4 (2)	5 (1)
Leach's Storm Petrel	<i>Hydrobates leucorhous</i>	34 (50)	6 (6)	31 (58)	9 (5)	3 (1)	5 (1)
Band-rumped Storm Petrel	<i>Hydrobates castro</i>		2 (4)	2 (2)		1 (1)	<1 (<1)
Unidentified Oceanitidae / Hydrobatidae		20 (28)	22 (24)	7 (7)	6 (3)	12 (4)	1 (<1)
	Procellariidae	49 (87)	24 (32)	153 (651)	14 (9)	13 (5)	27 (12)
Cory's Shearwater	<i>Calonectris borealis</i>	3 (6)	8 (10)	9 (9)	1 (1)	4 (2)	2 (<1)
Sooty Shearwater	<i>Ardenna grisea</i>			1 (1)			<1 (<1)
Great Shearwater	<i>Ardenna gravis</i>	10 (17)		77 (541)	3 (2)		14 (10)
Manx Shearwater	<i>Puffinus puffinus</i>	11 (24)	1 (1)	33 (39)	3 (2)	1 (<1)	6 (1)
Audubon's Shearwater	<i>Puffinus lherminieri</i>	3 (4)		20 (34)	1 (<1)		4 (1)
Bulwer's Petrel	<i>Bulweria bulwerii</i>			4 (4)			1 (<1)
Unidentified Procellariidae		22 (36)	15 (21)	9 (23)	6 (4)	8 (3)	2 (<1)
	Fregatidae	22 (39)	12 (17)	12 (14)	6 (4)	7 (3)	2 (<1)
Magnificent Frigatebird	<i>Fregata magnificens</i>	22 (39)	12 (17)	12 (14)	6 (4)	7 (3)	2 (<1)
	Sulidae		12 (12)	4 (4)		7 (2)	1 (<1)
Masked Booby	<i>Sula dactylatra</i>		10 (10)	4 (4)		6 (2)	1 (<1)
Red-footed Booby	<i>Sula sula</i>		2 (2)			1 (<1)	
	Hirundinidae	2 (2)		5 (8)	1 (<1)		1 (<1)
	Unidentified birds		4 (12)			2 (2)	
TOTAL		362 (1013)	181 (611)	567 (5228)	100 (100)	100 (100)	100 (100)

sighted/100 km). Some larid species were sighted only on the slope area (Figs. 4, 5): Brown Noddy, Least Tern *Sternula antillarum*, Bridled Tern, and Arctic Tern *Sterna paradisaea*. The Common Tern was predominantly observed on the shelf (Figs. 4, 5). Laughing Gull, Royal Tern, Black-legged Kittiwake, Great Black-backed Gull, Cabot's Tern, and Roseate Tern *Sterna*

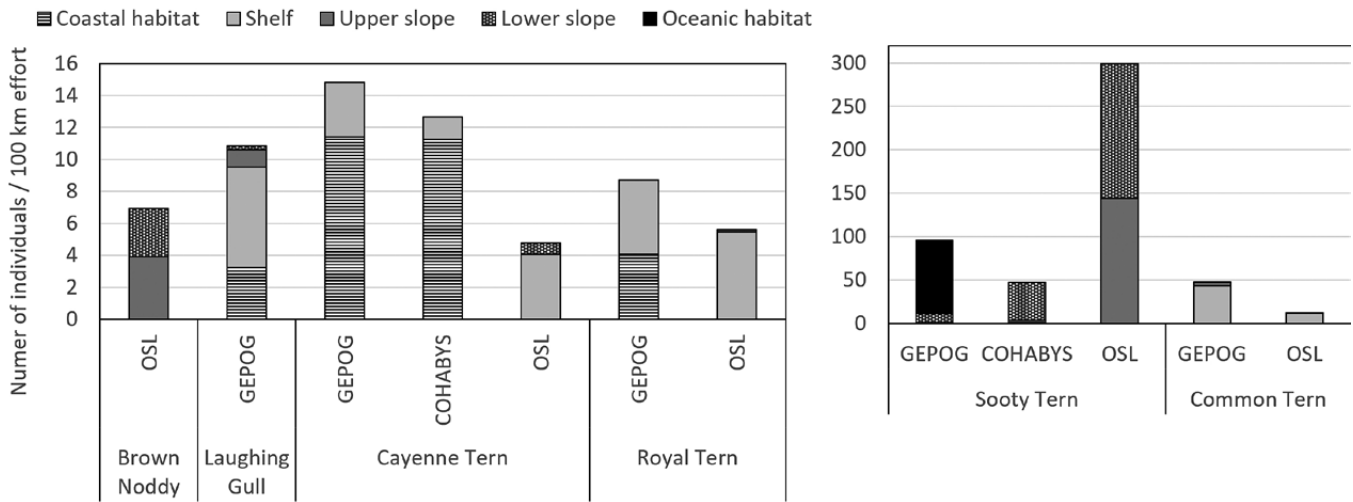
*dougallii* were sighted mainly in the coastal and shelf areas (Fig. 4). Finally, the Cayenne Tern showed higher encounter rates in the coastal habitat (11 individuals/100 km during the GEPOG and Cohabys campaigns; Fig. 5). Jaegers were sighted mainly on the slope area (Fig. 4). Red-billed Tropicbirds *Phaethon aethereus* were observed from the shelf to the oceanic area (Fig. 6). Oceanitidae were sighted in the slope and oceanic areas, and Hydrobatidae were observed in all habitats except for the coastal area (Figs. 6, 7). The two most observed species, Wilson's and Leach's Storm Petrels, showed higher encounter rates on the upper slope habitat compared with the other habitats (Fig. 7). Most procellariid sightings were on the slope ( $n = 215$ ); six were recorded on the shelf, five were in the oceanic area, and none occurred along the coast (Fig. 6). Among the most frequent species, Great Shearwater seemed to be distributed mainly on the upper slope (28 individuals/100 km), Manx Shearwater showed a higher encounter rate in the oceanic area during the GEPOG campaign (four individuals/100 km; Fig. 7), and Audubon's Shearwater showed a similar encounter rate on the upper and lower slope (Fig. 7). The Magnificent Frigatebird was sighted in all habitats (Figs. 6, 7), and boobies were observed primarily on the slope (Fig. 6).



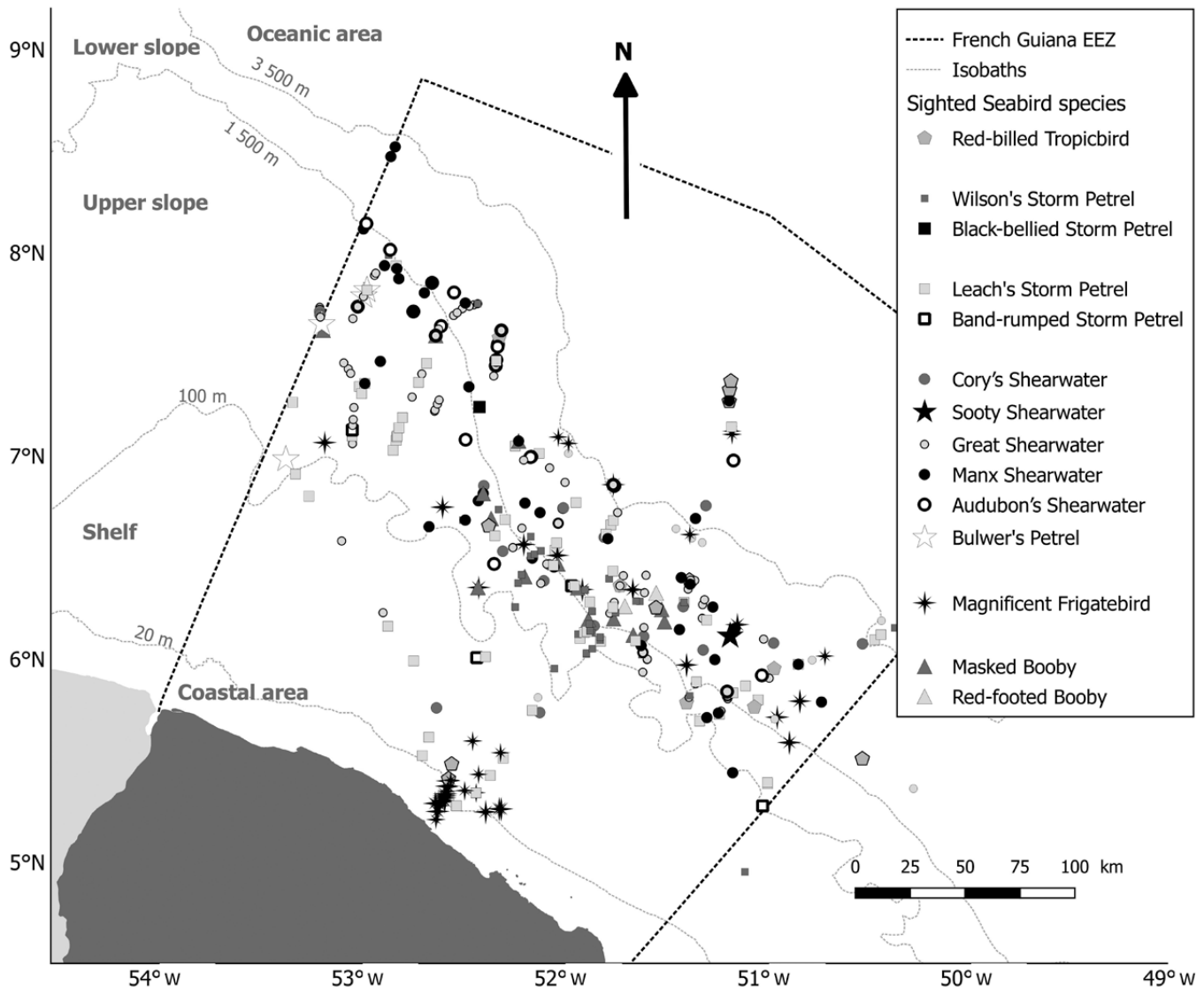
**Fig. 3.** Cumulative number of species identified for all campaigns in favorable weather conditions (Beaufort < 5).



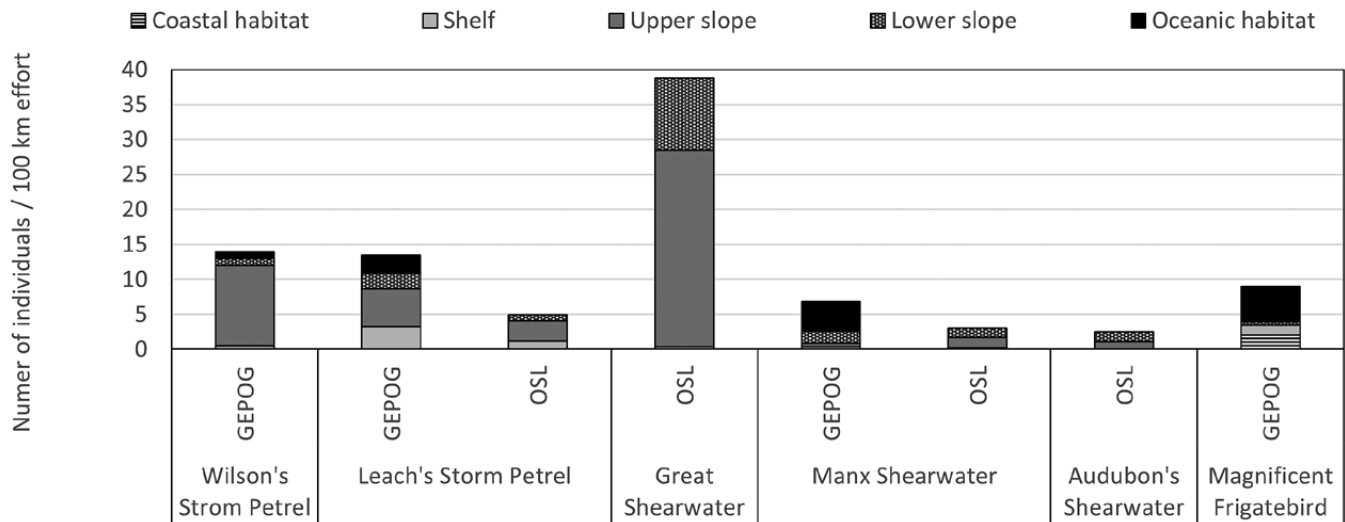
**Fig. 4.** Laridae and Stercorariidae sightings collected in the French Guiana Exclusive Economic Zone during our three campaigns in favorable weather conditions (Beaufort < 5).



**Fig. 5.** Encounter rates of most frequently sighted Laridae species, expressed as the number of individuals sighted per 100 km effort, in each habitat, in favorable weather conditions. The Cohabys campaign was limited to the coastal, shelf, and slope habitats, while the OSL campaign was limited to the shelf and slope habitats. When < 20 individuals were recorded for a species during a campaign, the habitat-specific sighting rates were not computed.



**Fig. 6.** Sightings of Phaetontidae, Oceanitidae, Hydrobatidae, Procellariidae, Fregatidae, and Sulidae collected in the French Guiana Exclusive Economic Zone during our three campaigns in favorable weather conditions (Beaufort < 5).



**Fig. 7.** Encounter rates of most frequently sighted Oceanitidae, Hydrobatidae, Procellariidae, and Frigateidae species, expressed as the number of individuals sighted per 100 km effort, in each habitat, in favorable weather conditions.

### Species monthly presence

Species from most of the families seemed to be observable in the study area year-round, except for oceanitids, which were sighted only in June–October; and phaethontids, which were observed only in March–July, apart from one sighting in November of an individual that could not be identified to the species level (Table 2). As for the most frequently sighted larid species, Cayenne and Sooty terns were sighted year-round (or almost). The other species were regularly sighted during only part of the year: March–September for Laughing Gull; and May–June to November–January for Brown Noddy, Royal Tern, and Common Tern. The most common oceanitid, the Wilson's Storm Petrel, occurred in June–October. The most frequently sighted hydrobatid, the Leach's Storm Petrel, was observed in June–March. Among the common Procellariidae, Great Shearwater was sighted in March–July; Manx Shearwater was sighted in March and then in June through January; and Audubon's Shearwater was sighted in March, June, July, and October. Magnificent Frigatebird was sighted year-round. Masked Booby was sighted regularly in February through July, plus two sightings in October. Immature birds were sighted frequently in only a few species: Long-tailed Jaeger *Stercorarius longicaudus*, Parasitic Jaeger *Stercorarius parasiticus*, Pomarine Jaeger, Sooty Tern, Common Tern, and Masked Booby.

### Frequently sighted species associations

Brown Noddy was observed most of the time in multispecies flocks (10 of the 21 sightings). They were always in association with Sooty Tern and were sometimes associated with additional species, in particular shearwaters ( $n = 5$ ). Royal, Cayenne, and Common terns were most frequently sighted as single individuals (62%, 58%, and 65% of sightings, respectively; Table 3); they were never observed in multispecies flocks. Sooty Tern was encountered primarily in monospecific groups (45% of sightings; Table 3) but when observed in multispecies groups (21% of sightings), they were most often associated with Brown Noddy ( $n = 10$ ), Great Shearwater ( $n = 20$ ), and/or Manx Shearwaters ( $n = 7$ ). Leach's Storm Petrel was seen

most often as single individuals, then in monospecific flocks, and rarely in multispecies groups (58%, 39%, and 3% of the sightings, respectively). Great, Manx, and Audubon's Shearwaters were most frequently observed as single individuals (57%, 76%, and 50% of sightings, respectively) and then in multispecies flocks (30%, 24%, and 35% of sightings, respectively). The Manx Shearwater was never encountered in a monospecific group. The species most often encountered in association with shearwaters was the Sooty Tern. The Magnificent Frigatebird was predominantly sighted as single individuals (83% of sightings). As fewer than 10 sightings were recorded during the OSL campaign for Laughing Gull, Wilson's Storm Petrel, and Masked Booby, the data were not processed to analyze associations for these species.

## DISCUSSION

### Study contribution and limits

This study provided new information on the seabird species occurring year-round in the entire French Guiana EEZ by combining data obtained from three boat-based campaigns. Overall, a total of 6686 km were visually surveyed under favorable weather conditions (Beaufort < 5) and 1110 groups of birds were sighted. In total, 43 bird species were identified, among which were 30 seabird species belonging to eight families. Laridae was the family most frequently observed, followed by Procellariidae. On the slope area, the most frequently observed species was the Sooty Tern (up to 31% of the groups and 78% of the individuals). Other common species on the slope were Brown Noddy, Wilson's Storm Petrel, Leach's Storm Petrel, Great Shearwater, Manx Shearwater, Audubon's Shearwater, and Masked Booby. On the shelf, the most common species were Common Tern (up to 11% of the groups and 28% of the individuals), Laughing Gull, and Royal Tern. In the coastal area, the most common species were Laughing Gull, Royal Tern, and Cayenne Tern. The last most abundant species, the Magnificent Frigatebird, was not confined to any particular habitat. For all of the abovementioned species, we determined the period when they were sighted in the French Guiana EEZ, as well as their associations with other species.



**TABLE 2**  
**Monthly presence of species detected during the GEPOG, COHABYS, and OSL campaigns under all weather conditions (up to Beaufort 6)<sup>a</sup>**

Common name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	
<b>Laridae</b>	S	S	S	S	S	S	S	No effort	S	S	S	No effort	
Brown Noddy			S			S	S		S	S			
Black-legged Kittiwake			S										
Laughing Gull	S		S	S	S	S	S		S (Im)				
Great Black-backed Gull			S										
Royal Tern	S		S		S	S	S		S	S			
Cayenne Tern	S		S	S	S	S	S		S	S (Im)			
Cabot's Tern											S		
Least Tern							S			S	S (Im)		S
Bridled Tern						S							
Sooty Tern	S	S	S (Im)	S	S	S (Im)	S (Im)			S (Im)	S (Im)		S
Roseate Tern						S				S	S (Im)		
Common Tern	S		S			S (Im)	S			S (Im)	S (Im)		S
Arctic Tern											S		S
<b>Stercorariidae</b>	S		S	S	S	S	S			S	S		S
Pomarine Jaeger	S (Im)		S	S	S					S	S		S (Im)
Parasitic Jaeger			S (Im)		S	S	S (Im)			S	S		
Long-tailed Jaeger			S			S (Im)	S				S (Im)		S (Im)
<b>Phaethontidae</b>			S	S	S	S	S						S
Red-billed Tropicbird			S	S	S	S	S						
<b>Oceanitidae</b>						S	S			S	S		
Wilson's Storm Petrel						S	S			S	S		
Black-bellied Storm Petrel						S							
<b>Hydrobatidae</b>	S	S	S			S	S			S	S		S
Leach's Storm Petrel	S	S	S			S	S			S	S		S
Band-rumped Storm Petrel	S	S	S			S	S						
<b>Procellariidae</b>	S	S	S	S	S	S	S		S	S	S		
Cory's Shearwater	S		S	S	S	S	S		S				
Sooty Shearwater									S				
Great Shearwater			S		S (Im)	S	S						
Manx Shearwater	S		S			S	S		S	S	S		
Audubon's Shearwater			S			S	S			S			
Bulwer's Petrel						S	S						
<b>Fregatidae</b>													
Magnificent Frigatebird	S	S	S	S	S	S	S		S (Im)	S	S		
<b>Sulidae</b>		S	S	S	S	S	S			S	S		
Masked Booby		S	S	S (Im)	S (Im)	S	S (Im)			S (Im)			
Red-footed Booby		S		S (Im)									

<sup>a</sup> S = sighted at least once; Im = immature birds sighted at least once

The main limitations of our analysis related to small sample sizes and to the heterogeneity of effort between seasons and habitats. Small sample sizes resulted in part from (1) the use of a small vessel that reduced the observer detection distance, (2) the limited overall effort, and (3) the fact that we could not aggregate the data over the three campaigns, as the GEPOG campaign protocol was not standard. There was a reduced effort in January and February because of bad weather; due to the design of the campaigns, there was no effort in August and December

and limited effort in oceanic area. In addition, the seasonal variability of effort differed among habitats and vice versa. Consequently, robust quantitative analyses, such as comparisons of the community species richness and composition between seasons and between habitats, could not be computed. In addition, we may have missed or underestimated the presence of some species, in particular offshore species that are present only during short periods that were poorly sampled, if they were sampled at all.

**TABLE 3**  
**The most frequently observed species associations for seabirds in French Guiana's**  
**Exclusive Economic Zone in favorable weather conditions (Beaufort < 5)<sup>a</sup>**

	Brown Noddy	Royal Tern	Cayenne Tern	Sooty Tern	Common Tern	Leach's Storm Petrel	Great Shearwater	Manx Shearwater	Audubon's Shearwater	Magnificent Frigatebird
<b>Number (frequency) of sightings for:</b>										
All sightings	21	21	19	173	23	31	77	33	20	12
Single individuals	7 (33%)	13 (62%)	11 (58%)	59 (34%)	15 (65%)	18 (58%)	44 (57%)	25 (76%)	10 (50%)	10 (83%)
Monospecific groups	4 (19%)	8 (38%)	8 (42%)	78 (45%)	8 (35%)	12 (39%)	10 (13%)	0	3 (15%)	1 (8%)
Multispecific groups	10 (48%)	0	0	36 (21%)	0	1 (3%)	23 (30%)	8 (24%)	7 (35%)	1 (8%)
<b>Number of sightings in association with:</b>										
Brown Noddy	4	0	0	10	0	1	1	3	1	0
Royal Tern	0	8	0	0	0	0	0	0	0	0
Cayenne Tern	0	0	8	0	0	0	0	0	0	0
Sooty Tern	10	0	0	78	0	1	20	7	4	1
Common Tern	0	0	0	0	8	0	0	0	0	0
Leach's Storm Petrel	1	0	0	1	0	12	0	1	0	0
Great Shearwater	1	0	0	20	0	0	10	3	6	1
Manx Shearwater	3	0	0	7	0	1	3	0	1	0
Audubon's Shearwater	1	0	0	4	0	0	6	1	3	1
Magnificent Frigatebird	0	0	0	1	0	0	1	0	1	1

<sup>a</sup> Only species that were sighted more than 10 times during the OSL campaign were included in this analysis.

### Seabird community composition

#### Taxonomic diversity

In total, 30 seabird species were identified: 13 Laridae, six Procellariidae, three Stercorariidae, two Oceanitidae, two Hydrobatidae, two Sulidae, one Phaethontidae, and one Fregatidae. As the cumulative number of taxa seems to have reached a plateau (Fig. 3), it is possible that all the species that may regularly be found in the area have been identified. The French Guiana Bird Certification Committee (Comité d'Homologation de Guyane, CHG) maintains the list of bird species identified in French Guiana, based on opportunistic data and dedicated seabird studies since 2005. In 2010, prior to our results, 37 seabird species from 10 families had been identified: 20 Laridae, five Stercorariidae, four Procellariidae, two Oceanitidae, one Diomedidae, one Phaethontidae, one Fregatidae, one Sulidae, one Phalacrocoracidae, and one Pelecanidae (CHG 2010). The most recent CHG report (CHG 2020), which includes the results presented here, listed 53 seabird species from 11 families. Such results indicate the importance of our effort. The high number of species listed by the CHG (2020) also shows that 14% of the worldwide seabird species (368 species, Gill *et al.* 2021) and all seabird families, apart from Alcidae and Spheniscidae, can be found in the French Guiana EEZ, which underscores the high avifaunal value of the territory.

#### Most common taxa

During the aerial surveys conducted throughout the expanse of the French Guiana EEZ, in October–November 2008, Laridae was the most frequently sighted bird family (89% of individuals). In October and November 2017, Martinez *et al.* (2019) opportunistically collected bird sightings during an oceanographic survey of the upper continental slope. The most frequently sighted families were Laridae (42% of individuals) and Fregatidae (30% of individuals). In waters off northern Brazil (Amapá and Pará States), the bird assemblage was recorded near the mouth of the Amazon River through two boat surveys conducted between March and May 2015, from depths of 10–3100 m (Daudt *et al.* 2019). There, too, the most frequently recorded seabird family was Laridae (64% of individuals). Hence, whatever the habitat, Laridae has been the most frequently sighted seabird family reported in studies conducted in northern Brazil and French Guiana, including ours. In Suriname, marine mammal observers opportunistically collected bird sightings during several oil exploration surveys. On the lower slope (1200–3300 m depth) in May–July 2012, shearwaters were the most frequently encountered seabirds, accounting for 78% of all birds recorded (de Boer *et al.* 2014). In the upper slope area (100–2000 m depth) in May–September 2015, Willems *et al.* (2017) most often sighted members of the Laridae and Procellariidae families.

Finally, on the shelf (40–60 m depth) in June–September 2013, the individuals Willems *et al.* (2017) recorded most frequently were in the Fregatidae and Laridae families. Hence, the abundance of Laridae seems to be less pronounced in Suriname. This difference could be due to the presence of larid breeding colonies in French Guiana and northern Brazil. Indeed, the Île du Grand Connétable Nature Reserve in French Guiana constitutes a major nesting site for several larid species (Dujardin & Tostain 1990). Similarly, in Brazil, Large-billed Tern *Phaetusa simplex* is known to breed along the coast of Pará and Amapá states, and Laughing Gull breeds in the neighbouring state of Maranhão (Carlos 2009).

Regarding larid species in the slope area, most studies—including ours—showed that Sooty Tern was one of the most abundant species (Mannocci *et al.* 2013; Willems *et al.* 2017, Daudt *et al.* 2019; Appendix 2, available on the website). Regarding Procellariidae, all campaigns conducted in the region confirmed the abundance of Great, Audubon's, and Manx Shearwaters in the slope area. Contrary to our study, Cory's Shearwater has been identified as one of the most abundant species in several campaigns (i.e., de Boer *et al.* 2014, Willems *et al.* 2017, Martinez *et al.* 2019). The other species we most frequently identified in the slope area (Wilson's and Leach's Storm Petrels, Masked Booby) were also identified as such in at least two of the previous campaigns (de Boer *et al.* 2014, Willems *et al.* 2017, Daudt *et al.* 2019). Other species were also frequently recorded in some of the previous studies, including Pomarine Jaeger, Red-billed Tropicbird, and Brown Booby *Sula leucogaster*. Although these species have never been recorded as abundant in French Guiana, they have all been sighted before in the territory (CHG 2020). On the shelf, Laughing Gull, Common Tern, and Magnificent Frigatebird were the most frequently sighted species in Suriname, Brazil, and our study. The Royal Tern was recorded as an abundant taxon in only our study and in northern Brazil (Daudt *et al.* 2019). The fact that French Guiana holds an important breeding population for this species may explain this result (Dujardin & Tostain 1990).

Hence, the community taxonomic composition is quite similar in all studies conducted from the Amazon River mouth to Suriname. We believe most of the observed differences are due to local environmental factors, and, in particular, the presence of suitable nesting habitats. Indeed, while the community is mainly made of migratory species in Suriname and Brazil (de Boer *et al.* 2014, Willems *et al.* 2017, Daudt *et al.* 2019), the seabird community off French Guiana seems to be a mix of breeding and migratory species (see also Dujardin & Tostain 1990). This specificity of French Guiana is due to the presence of the isolated and rocky Île du Grand Connétable, which is unique in the Guianas and constitutes a major nesting site for several seabird species (Dujardin & Tostain 1990). Other factors that may account for these apparent differences between the community compositions include the geographic and seasonal effort of the surveys.

### Noteworthy records

#### *Laridae*

The presence of Sooty Tern in French Guiana has been known for a long time, as it nests in the Île du Grand Connétable Island Natural Reserve. However, an unidentified disease in 2009 resulted in an 80% decline of the nesting population, which has been limited to 10–20 nesting pairs since then (Hauselmann *et al.* 2013). As the

species was the one most frequently observed during our study, in particular on the slope area between June and November, we hypothesized that most of the individuals we encountered came from the colonies at Dry Tortugas National Park in Florida, USA, which is located 3700 km away from French Guiana. Around 30000 pairs nest on these islands and recent studies have shown that after reproduction, individuals from this colony rapidly scatter up to the Guianas from July to November (Colchero *et al.* 2010, Huang *et al.* 2017). Hence, the French Guiana slope may be of major importance for this Sooty Tern population from Florida. During the OSL campaign, seabird associations were recorded. The association we observed most frequently, by far, was groups of Sooty Terns feeding on the slope. About two thirds of the flocks were monospecific, and when other species associated to the group, it was mainly Brown Noddy and shearwaters (mainly the Great Shearwater). Sooty Terns are well known to aggregate into large flocks when foraging and to associate with other species, in particular Brown Noddy, shearwaters, and jaegers; examples have been noted in the tropical Pacific (Ballance *et al.* 1997), the Indian Ocean (Jaquemet *et al.* 2004), and waters off Suriname (de Boer *et al.* 2014). Most of the time, we observed these flocks feeding on the same prey taken by large pelagic fishes, among which we were able to identify blackfin tuna *Thunnus atlanticus*, yellowfin tuna *Thunnus albacares*, common dolphin *Coryphaena hippurus*, and skipjack tuna *Katsuwonus pelamis*. During the rainy season in June–July, we also often sighted these pelagic feeding flocks associated with large *Sargassum* rafts. Contrary to what is often observed in other parts of the world, these flocks were never sighted in association with dolphins or fisheries.

The Least Tern, like the other *Sternula* species, is usually constrained to coastal habitats, but their migration and wintering behaviors, notably for the Caribbean populations, are poorly known (Thompson *et al.* 2020). In French Guiana, during migration, they are often observed on mudflats edging mangroves. However, the observations collected in the present work (five groups, sighted on the slope area) showed that the species may also be sighted far away from the coast. This offshore migration is well known along the Pacific coast, where Least Terns have been observed 2–30 km (most < 18 km) off the western coast of Baja California, Mexico, in late April and early May, in association with feeding flocks of other seabirds (Howell & Engel 1993). However, this behavior has been poorly described in the Atlantic so far, although some offshore observations of the species in Brazil support this hypothesis: Lees *et al.* (2015) recorded Least Terns foraging 30 km off the coast of Natal state in Brazil. The species may then have a more pelagic distribution along Atlantic coast during migration and wintering than previously described.

#### *Stercorariidae*

The Long-tailed Jaeger was first recorded in French Guiana opportunistically in 2011 during exploratory drilling operations (Girondot 2012, Claessens *et al.* 2014). During our campaigns, 13 groups of Long-tailed Jaegers were sighted: one in March, four between late June and late July, and eight in October–November. The observations collected in March and October–November coincide with the migration of the species between its nesting sites in Svalbard and northeastern Greenland and its wintering area off southwestern coast of Africa (Gilg *et al.* 2013). However, interestingly, four sightings were collected in June and late July. This may indicate that some immatures summer in French Guiana

waters, similar to what has been suggested in Suriname (Willems *et al.* 2017).

#### *Oceanitidae*

During our campaigns in June 2018, we identified a Black-bellied Storm Petrel (Appendix 1). This is the first observation in French Guiana of the species, which nests between December and April on subantarctic islands of the Indian, Atlantic, and Pacific oceans (del Hoyo *et al.* 1992). Outside of the breeding period, it migrates to subtropical and tropical pelagic waters but rarely crosses the equator. In northern Brazil, some observations of this species have been recorded in both Fernando de Noronha Archipelago and Saint Peter and Saint Paul Archipelago (Teixeira *et al.* 1986), but there are no records along the continental coasts. In southern Brazil, the first documented sighting was in the state of Rio Grande do Sul in 2013 (Petry *et al.* 2016). In the North Atlantic, the Black-bellied Storm Petrel has been seen offshore in the vicinity of Madeira and the Canary Islands, and four observations have been recorded off Cape Hatteras in North Carolina, USA (Carboneras *et al.* 2020). The observations collected in the United States and in French Guiana highlight the dispersal capacity of the Black-bellied Storm Petrel outside its breeding period and contribute to knowledge of its winter distribution, which is not well known (Carboneras *et al.* 2020).

#### *Hydrobatidae*

During our campaigns, four observations of the Band-rumped Storm Petrel (*Hydrobates castro*; Appendix 1) were made in favorable weather conditions (two in January–March and two in June–July), and two additional sightings were recorded in bad weather conditions (Beaufort > 4) conditions in March. These were the first reported occurrences of the species in French Guiana waters. However, the presence of the species in the region was expected, as it is known to spread in the tropical Atlantic after reproduction in Macaronesia. Furthermore, during this dispersion period, the species is known to forage around *Sargassum* rafts (Haney 1986), which have increased in both size and frequency since 2011 off the Guianas (Gower *et al.* 2013; Johnson *et al.* 2013). In addition, the sighting of Bulwer's Petrel *Bulweria bulwerii* during the OSL campaigns and a recent study on the dispersal of the Desertas Petrel *Pterodroma deserta* (Bugio's Petrel in Ramírez *et al.* 2013) confirm that seabirds nesting in Macaronesia may disperse off the Guianas, among other places. A recent molecular, acoustic, and morphologic study revealed that in the tropical Atlantic, Band-rumped Storm Petrel may be confused with Monteiro's Storm Petrel *Hydrobates monteiroi* (Carboneras *et al.* 2018). It is not possible to ascertain that the individuals observed in January–March were Band-rumped Storm Petrels, as this period falls outside the nesting season of both species in the Azores, which is their nesting site closest to French Guiana. The identification of the individuals sighted in June and July as Band-rumped Storm Petrel is more certain, as it is the reproduction period for Monteiro's Storm Petrel.

#### *Procellariidae*

The Procellariidae encountered most often in our study included Great, Manx, and Audubon's Shearwaters. All these species were recorded mainly in the slope area. Great Shearwater undertakes a trans-equatorial migration, departing from their breeding grounds in the South Atlantic in April and May, moving northwest off South America, up to Canada, past Greenland, and then to the

northeastern Atlantic before returning south in November to their breeding colonies (Carboneras 1992). During our study, the species was sighted primarily from May to July, a pattern that corresponds to individuals passing the region during their migration to winter sites, as has been observed in Suriname (de Boer *et al.* 2014). Manx Shearwaters breed at locations in the North Atlantic and winter off South America from September to March (Hamer 2003). The species was recorded in French Guiana mainly from June to November. Hence, similar to Suriname, our records involved either birds that were passing the region during their migration or non-breeding sub-adults summering (May–September) off the mid-Atlantic coast and southeastern United States (Willems *et al.* 2017). The Audubon's Shearwater was sighted in March, June, July, and October during our study. The species is known to breed in the Bahamas, West Indies, Nicaragua, Panama, and northeastern Brazil (Kirwan *et al.* 2020). Precheur (2015) studied the movements of some individuals nesting in Martinique (in the Lesser Antilles) and showed that adults fly to French Guiana to feed regularly while nesting (January–July), frequently outside the reproduction period (July–November), and rarely during the pre-breeding period (November–January). Hence, our sightings correspond mainly to breeding individuals. The Sooty Shearwater sighting collected during the OSL survey (Appendix 1) was the second observation recorded of the species in French Guiana. The first one was an opportunistic sighting recorded on the Île du Grand Connétable in 2016 (K. Pineau pers. comm.). Willems *et al.* (2017) also recorded the species once, offshore from Suriname in May 2015.

#### *Sulidae*

The Red-footed Booby *Sula sula* is known to occur throughout tropical regions outside its breeding periods, but it is rarely sighted in French Guiana (Claessens *et al.* 2014). Indeed, only two individuals were sighted during our campaigns: one in February and one in April. Apart from that, another one was recorded opportunistically during the exploratory drilling operations performed in 2011 (Girondot 2012, Claessens *et al.* 2014), and a dead individual was observed on Île du Grand Connétable in 2014 (Rufaray *et al.* 2019). Nine observations of the species have also been recorded offshore from Suriname during seismic surveys conducted between 2012 and 2015 (de Boer *et al.* 2014, Willems *et al.* 2017). In contrast, Masked Booby seems to be common in French Guiana waters: 14 sightings were recorded from February to October during our campaigns, and the species was frequently observed during the exploratory drilling operations conducted in 2011 (Girondot 2012, Claessens *et al.* 2014). Unexpectedly, we did not record any Brown Booby during our campaigns, although it is the booby species most frequently recorded on Île du Grand Connétable, with 15 records since 1980 (Rufaray *et al.* 2019).

## CONCLUSIONS

Our study allowed the first opportunity to highlight some of the major characteristics of the seabird community off French Guiana at the species scale, encompassing the entire EEZ and all seasons, including species diversity, associations, distribution, frequency, and seasonality. We also provided new information on the ecology of some species. Our results underlined not only the high species diversity in the marine avifauna of French Guiana but also the diversity of usage in the area: it is a major nesting site for some tropical species as well as a major foraging area for wintering, summering, and migrating species, either pelagic or

neritic. Therefore, the preservation of seabirds in French Guiana is important at both the local scale and from a global point of view. In addition, all EEZ habitats (coast, shelf, slope, and oceanic) were found to be important to seabirds, as all these areas seemed to be the preferred habitat of several species that are common in the territory. In recognition of the importance of the Île du Grand Connétable for seabird reproduction, the island and its close surrounding waters (i.e., a radius of 5 km around the island) became a nature reserve in 1992. In light of our results, protecting only the nesting colonies seems insufficient; we recommend setting up Marine Protected Areas to protect major seabird foraging areas in a significant surface of the coastal, shelf, and slope habitats.

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