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At-sea distribution of juvenile leatherback turtles: new insights from bycatch data in the Atlantic Ocean

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ABSTRACT: Highly mobile marine species can travel long distances, which in some cases extend over entire ocean basins. This is especially true for sea turtles, which have a spatially complex life cycle that for most species comprises initial development in oceanic habitats. Due to the difficulty involved in accessing open ocean waters and the elusive nature of small individuals, very little is known about the distribution of young oceanic-stage sea turtles. This is particularly true for the leatherback turtle *Dermochelys coriacea*, as studies on this species' young life stages are lacking and therefore represent one of the top research priorities for this taxon worldwide. Here, we report new records (n = 28) of juvenile leatherbacks (≤100 cm curved carapace length, CCL) incidentally captured by longline fisheries and provide information about their distribution and possible dispersal patterns. Juvenile leatherbacks were found in tropical and subtropical waters in the Atlantic, while small individuals (<80 cm CCL) were restricted to the equatorial central Atlantic, between latitudes 3.5° N and 3.1° S. The incidental capture of a leatherback of 40 cm CCL indicates that individuals can be exposed to this threat approximately 1 yr after nest emergence. Lagrangian drifter data used to explore the possible role of ocean currents on post-hatchling dispersal from the main leatherback rookeries in the Atlantic suggested that small leatherbacks found in the equatorial central Atlantic may come from West Africa. Given the limited data on oceanic-stage sea turtles, this study provides additional information on where to look for young leatherbacks and possibly focus future field-based research.

KEY WORDS: *Dermochelys coriacea* · Juvenile sea turtles · Bycatch · Longline fishery · Dispersal patterns · Ocean currents · Buoy trajectory data

1. INTRODUCTION

Sea turtles exhibit a complex life cycle that encompasses a variety of habitats and ecosystems, from terrestrial environments, where oviposition and embryonic development occur, to marine environments (coastal and oceanic waters) where foraging and developmental grounds are located (Miller 1997). Due to the difficulty of accessing open ocean waters and the elusive nature of small individuals, very little information is available on the distribution of young oceanic-stage sea turtles (Mansfield & Putman 2013). This is a common problem for many marine megafauna (Sims et al. 2003, Block et al. 2005, Rowat et al. 2008, Stewart et al. 2018) for which our understanding of the life cycle is limited by a lack of information about the early stages of life, leading to poor management and conservation outcomes.

Studies conducted in the northwest Atlantic have provided empirical information on behavior, habitat

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associations, and diet of hard-shelled juvenile turtles (Witherington et. al. 2012). Additionally, recent studies simulating turtle movement using ocean circulation models have identified locations of possible conservation importance and variations in the distribution, abundance, and survival of simulated turtle cohorts (Gaspar et al. 2012, Putman et al. 2013, Putman & Naro-Maciel 2013, Scott et al. 2017). Further insights into the dispersal, in-water behavior, and orientation have resulted from recent advances in the use of small-scale solar-powered satellite tags on juvenile loggerhead *Caretta caretta*, Kemp's ridley *Lepidochelys kempii*, and green turtles *Chelonia mydas* in the western Atlantic (Mansfield et al. 2014, 2017, Putman & Mansfield 2015). The leatherback turtle *Dermochelys coriacea* is the most pelagic of all sea turtles (Pritchard & Trebbau 1984), and once hatchlings enter the ocean for the first time, very little is known as to where these juveniles go and where they spend their first years (Saba 2013). This is a common problem worldwide for this taxon, with the first period of life of sea turtles also known as the 'lost years' (Carr & Meylan 1980, Putman et al. 2013, Mansfield et al. 2014, Briscoe et al. 2016). Some authors have proposed that juvenile leatherbacks are rarely observed due to their pelagic behavior (Pritchard & Trebbau 1984). In a growth study of leatherbacks which combined data from captive and wild juveniles, Jones et al. (2011) suggested that 75 cm curved carapace length (CCL) is attained rapidly (i.e. within 3 yr), and that 100 cm CCL corresponds to an age of approximately 5 yr.

Information available on the spatial ecology of leatherback turtles in general comes from subadult (>100 cm CCL but not sexually mature) and adult individuals (James et al. 2005, López-Mendilaharsu et al. 2009, Saba 2013, Dodge et al. 2015), whereas the distribution of the elusive juvenile leatherbacks <100 cm CCL is practically unknown (Eckert 2002, Jones et al. 2011, Saba 2013, Huang 2015) and currently represents one of the top research priorities worldwide for this taxon (Wildermann et al. 2018). A global review of juvenile leatherbacks showed that sightings of turtles with <100 cm CCL were restricted to tropical and subtropical waters (less than 30° absolute latitude) or, likewise, ocean temperatures warmer than 26°C (Eckert 2002). However, most of these data came from stranded individuals, providing little information about their distribution at sea.

An examination of bycatch data from longlines and gillnets in the Pacific Ocean revealed that leatherbacks smaller than 96 cm CCL were caught among tropical fisheries (Jones et al. 2011). More recently, a study that analyzed bycatch data in the Atlantic Ocean included reports of juvenile leatherbacks (<100 cm CCL) (Huang 2015), providing novel information about their spatial and temporal distribution in this region.

In the Atlantic Ocean, major leatherback nesting sites exist in French Guiana and Suriname in South America, as well as in Gabon and Congo in Africa; significant nesting also occurs in several other places in the wider Caribbean region and Africa (Spotila et al. 1996, Eckert 2006, Girondot et al. 2007, Witt et al. 2009). Brazil is home to one of the smallest populations of this species in the world, and the only area with regular nesting is on the northern coast of the state of Espírito Santo (around latitude 19° S) (Thome et al. 2007).

Leatherback sea turtles in the Atlantic are adversely impacted by a variety of activities, including incidental capture in commercial and artisanal fisheries, debris ingestion, and intentional harvest (Sales et al. 2008, Mrosovsky et al. 2009, Wallace et al. 2011, 2013, Fossette et al. 2014). The development of appropriate management strategies has been partially hindered by the paucity of data on the biology and whereabouts of the early life stages. Studying small turtles in the wild is labor intensive (e.g. Witherington et al. 2012), and thus preliminary insights into their potential distribution patterns and locations of high-density areas are undoubtedly of great importance for species conservation.

Here, we report new records of juvenile leatherbacks (≤100 cm CCL) incidentally captured in the Atlantic Ocean and provide additional information about their distribution and possible dispersal patterns.

2. MATERIALS AND METHODS

The Brazilian commercial longline fleet is composed of both Brazilian-owned and foreign chartered vessels, and incidental catches of sea turtles by the 2 kinds of fleet were analyzed together in this study. Differences in longline fishing techniques (size of vessels, target species, kind of pelagic longline, number of hooks per set, type of hook and bait, area of operation, etc.) were not considered in this paper, and thus all pelagic longline activities by the Brazilian longline fleet targeting swordfish *Xiphias gladius*, tunas (*Thunnus albacares*, *T. obesus*, *T. alalonga*), mahi-mahi *Coriphaena hippurus*, and sharks were considered as a whole. Accordingly, we present data on juvenile leatherback turtles incidentally captured by the Brazilian commercial longline fishery. The data were collected by the Brazilian on-board observers program, from 2001 to 2008, and subsequently were stored in the TAMAR/SITAMAR database. The area of operation of the fishery fleet comprised both Brazilian exclusive economic zone and adjacent international waters, between latitudes 5° N and 35° S and between longitudes 10 and 55° W.

Date, geographical position (latitude and longitude), and sea surface temperature (SST) of each longline set was recorded. After capture, juvenile leatherback turtles were brought on-board and measured using a flexible tape to the nearest 0.5 cm. Data on hooking location (mouth or external, including entangled or flipper-hooked) and sea turtle condition (alive or dead) were also recorded (Table 1). Only data collected by scientific on-board observers were included in the analysis. In the present study, we restricted data to juvenile leatherback turtles with measured CCLs of ≤100 cm (Saba 2013) given the paucity of observations of individuals within this size class. In addition, because sightings of leatherback turtles <80 cm CCL are extremely scarce in the literature, probably representing fewer than 20 published records worldwide, we used this size to divide the turtles into 2 groups: small juveniles (<80 cm CCL) and large juveniles (80–100 cm CCL). SPSS statistics version 22.0 was used for all analyses.

Lagrangian drifter data were used to infer the possible role of ocean currents in the dispersal of hatchlings from the 2 largest leatherback rookeries in the Atlantic Ocean (i.e. Gabon and French Guiana/Suriname [FGS]). We downloaded surface drifter data freely available from NOAA's Global Drifter Program (www.aoml.noaa.gov/envids/gld). This dataset consists of data from satellite-tracked buoys drogued near the surface (15 m) from 1979 to the present. Drifter locations are estimated from 16 to 20 satellite fixes per day, per drifter. The Drifter Data Assembly Center at NOAA's Atlantic Oceanographic and Meteorological Laboratory assembles these raw data, applies quality control procedures, and interpo-

Table 1. Metadata for each juvenile leatherback turtle incidentally captured by the Brazilian longline fishery fleet from 2001 to 2008, showing individual ID, date (d-mo-yr), capture location (latitude/longitude), condition of the turtle (alive, dead, or unknown), curved carapace length (CCL), sea surface temperature (SST), and hooking location (mouth or external)

Turtle ID	Date	Latitude	Longitude (° W)	Condition	CCL (cm)	SST (°C)	Hooking location
1	25-01-01	25.60°S	34.45	Alive	90	29	Mouth
2	25-07-04	1.02°S	38.95	Alive	64	28	Mouth
3	08-08-04	0.74°S	31.26	Alive	67	29	External
4	10-08-04	2.54°S	30.81	Alive	90	28	Mouth
5	11-08-04	2.24°S	31.03	Alive	98	25	Mouth
6	10-01-05	0.17°S	33.58	Dead	50	27	Mouth
7	05-02-05	20.84°S	22.22	Alive	100	28	External
8	17-02-05	20.73°S	22.65	Alive	100	30	External
9	26-02-05	22.75°S	27.02	Alive	80	27	External
10	28-02-05	22.79°S	26.87	Alive	100	26	External
11	03-05-05	1.88°S	29.92	Alive	96	30	Mouth
12	16-06-05	5.67°N	29.75	Alive	100	25	External
13	25-06-05	16.28°S	28.33	Unknown	100	25	External
14	08-08-05	3.56°N	36.38	Alive	60	27	External
15	14-12-05	0.62°S	25.85	Alive	64	26	External
16	18-02-06	1.12°N	24.17	Alive	86	27	Mouth
17	02-04-06	3.07°S	26.15	Alive	97	27	External
18	13-07-06	3.08°S	31.83	Alive	71	27	External
19	05-08-06	0.81°N	32.03	Alive	90	29	Mouth
20	12-08-06	1.17°S	31.19	Alive	90	28	Mouth
21	01-10-06	0.23°N	12.70	Alive	61	28	External
22	07-12-06	1.08°S	33.72	Alive	63	29	External
23	27-04-07	2.97°N	38.48	Alive	40	28	External
24	30-04-07	3.50°N	32.49	Alive	62	28	External
25	03-05-07	3.73°N	32.50	Alive	80	28	External
26	29-05-07	2.08°N	30.32	Unknown	79	27	External
27	24-11-07	0.93°S	26.33	Alive	63	25	Mouth
28	13-11-08	1.88°S	28.77	Alive	85	27	External

lates them via kriging to regular 6 h intervals. Here we chose satellite-tracked buoys from 2000 to 2011 that drifted near the 2 leatherback rookeries, selecting a particular window with an amplitude of ±7° for longitude and latitude (ca. 1° N to 5° S and 5 to 12° E for Gabon; ca. 10 to 3° N and 55 to 48° W for FGS) during the hatchling emergence period: January to May for Gabon and May to September for FGS. We selected those buoys with a minimum lifetime of 5 mo and a maximum of 14 mos. After applying these filters to the Lagrangian drifter dataset, we obtained 17 individual drifter trajectories, 9 near Gabon and 8 near FGS. We selected a total of 6 buoys from each region, as the rest showed coincident trajectories. This analysis was performed using ArcGIS 10.3 (ESRI).

3. RESULTS

3.1. Turtle captures and measurements

A total of 28 juvenile leatherback turtles (≤100 cm CCL) were incidentally captured by the longline fleet during the study period (Fig. 1). Most of the captured turtles were found alive (89 %); 1 turtle was dead and the condition of 2 others was not recorded by the scientific observers (Table 1). The CCL of the juvenile leatherbacks ranged from 40 to 100 cm (mean ± SD: 79.5 ± 17.5 cm; Fig. 2).

Overall, the SST where juvenile leatherbacks were incidentally captured varied from 25 to 30°C (mean: 27.4 ± 1.45°C; Table 1). There was no difference in SST (t = −0.04, p = 0.97) between the locations where the small (<80 cm CCL, n = 12) and large (80–100 cm CCL, n = 16) juvenile turtles were captured.

The latitude distribution of the captured leatherbacks extended from 5.6° N to 25.6° S. Among these captures, the great majority (68 %, n = 19) occurred between latitudes 5° N and 5° S and longitudes 25–40° W. All records of small juveniles were restricted to latitudes between 3.5° N and 3.1° S, which was significantly different (t = 3.02, p = 0.008) from the broader distribution of large juveniles (Fig. 3).

Half of the capture records (n = 14) were from Brazilian waters and the other half (n = 14) from international waters; 9 individuals were captured in the North Atlantic and 19 in the South Atlantic.

3.2. Fishery interactions

Data were obtained for a total of 683 trips between 2001 and 2008, corresponding to 14 253 sets and 20 041 217 hooks. Throughout this period, 939 leatherback turtles were captured; thus, the 28 juveniles (≤100 cm CCL) described here represented 3 % of the total.

Fig. 1. Juvenile leatherback turtles brought on-board for data collection after being incidentally captured by the Brazilian longline vessels in the Equatorial Atlantic. Source: Projeto TAMAR image data bank

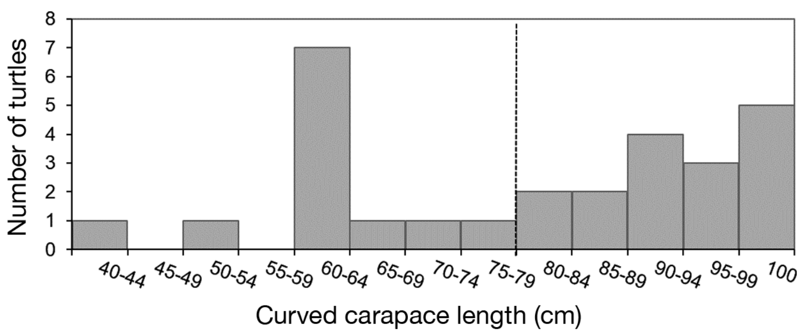

Fig. 2. Size distribution of juvenile leatherback turtles captured incidentally by longline fisheries in the Atlantic Ocean. The dashed line indicates the size used to divide the 2 groups: small (<80 cm curved carapace length, CCL) and large juveniles (80–100 cm CCL)

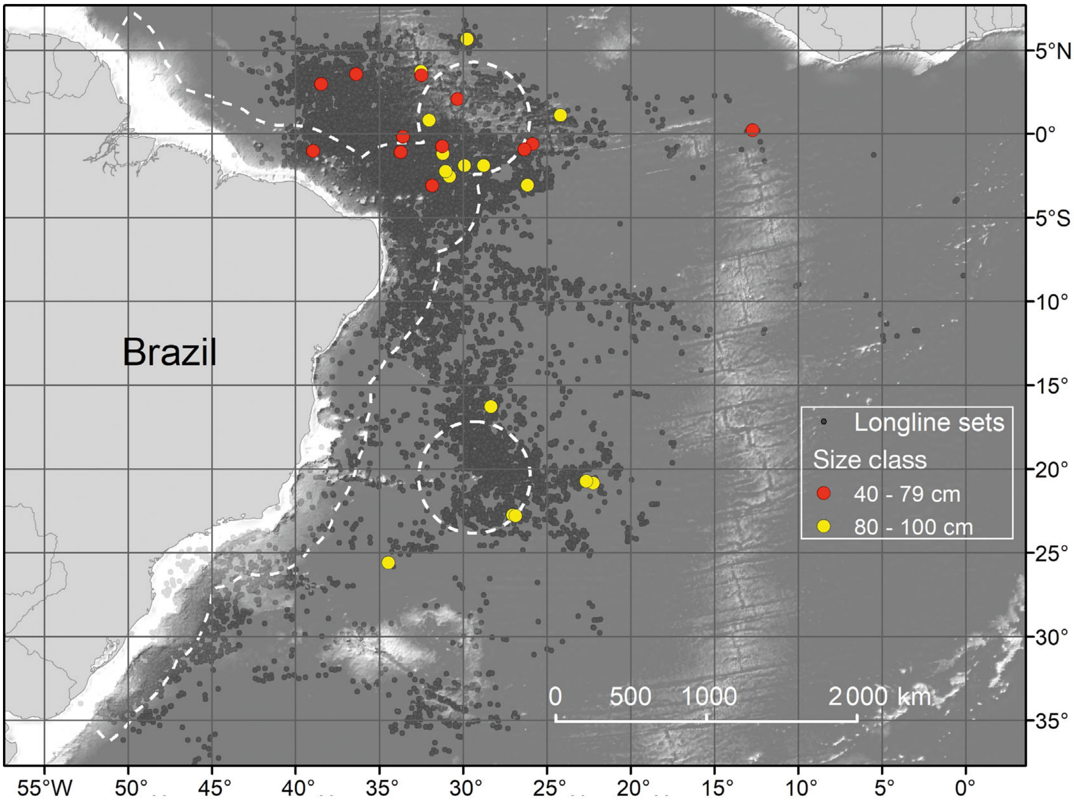

Fig. 3. Location of juvenile leatherback turtles incidentally captured by the Brazilian pelagic longline fleet. Capture locations of small juveniles (red circles) were restricted to the Equatorial Central Atlantic, while the large juveniles (yellow circles) showed a broader distribution. All pelagic longline set locations (grey dots) monitored by the Brazilian on-board observer program, from 2001 to 2008, are shown. The dashed lines indicate the Brazilian exclusive economic zone

Juvenile leatherback turtles were more often found externally hooked or entangled (64%; n = 18) than hooked in the mouth (36%; n = 10). The size of the turtles with mouth hooking ranged from 50 to 90 cm CCL (mean: 81.7 ± 16.4 cm), while the turtles that were externally hooked/entangled varied from 40 to 100 cm CCL (mean: 78.3 ± 18.4 cm). No significant differences were found ($t = -0.49$, p = 0.63) regarding the size of the turtles and the hooking location (i.e. external vs. mouth). Additionally, no significant differences were found when comparing size and hooking location within groups, namely small juveniles (mouth hooking: 59.0 ± 7.8 cm, external hooking: 63.0 ± 10.5 cm; $t = -0.59$, p = 0.56) or large juveniles (mouth hooking: 91.4 ± 4.1 cm, external hooking: 93.6 ± 9.1 cm; $t = -0.62$, p = 0.54).

3.3. Drifter trajectories

Buoys traveling off the FGS coasts drifted in different directions but remained in the northern hemisphere (Fig. 4). Some went northwest towards the Caribbean Sea (n = 4), while one also moved into the Gulf of Mexico and then traveled eastward by drifting into the Gulf Stream. In addition, few buoys displayed circuitous movements off the coasts of FGS (n = 2) and showed that they can also travel northward to the Gulf Stream area. On the other hand, all buoys (n = 6) traveling off the Gabon coast during the hatchling season drifted westward towards the South American continent (Fig. 4).

4. DISCUSSION

Here we report new direct observations of juvenile leatherbacks (≤100 cm CCL) in the Atlantic, providing new insights on the distribution and habitat preferences of leatherbacks during their early life stages (0 to 5 yr of age).

Even though the Brazilian fishery fleet operates throughout a wide range of SST (e.g. between 9 and 32°C), our results indicate that juvenile leatherbacks in the Atlantic occur in tropical and subtropical waters with SSTs of ≥25°C. These results align with

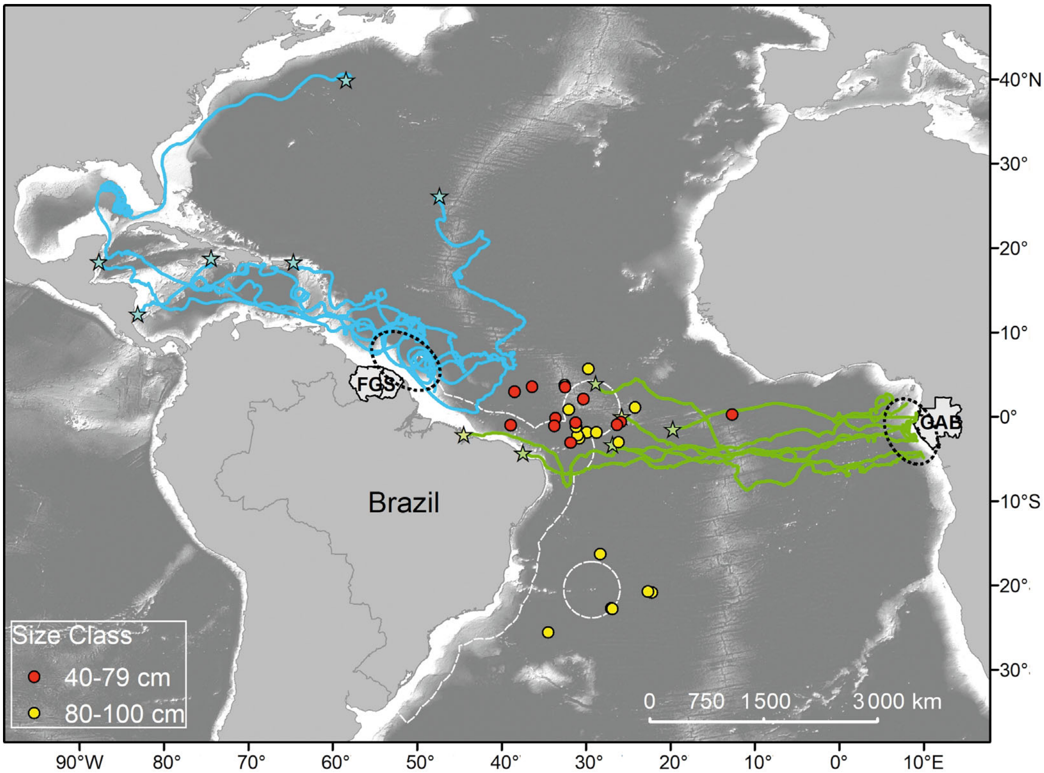

Fig. 4. Trajectories of drifters released near main leatherback turtle rookeries (GAB: Gabon; FGS: French Guiana/Suriname) in the Atlantic Ocean. Dotted black circles show the starting point of the drifters' tracks, and stars show the end point of each trajectory. Green (blue) tracks are drifter buoys on departure off GAB (FGS) during the hatching season. All buoys traveling from GAB drifted westward towards the South American continent, while buoys departing from FGS drifted in different directions but remained in the northern hemisphere (i.e. Caribbean Sea, Gulf of Mexico and Gulf Stream area). Red and yellow circles represent capture locations of small and large juveniles, respectively. The white dashed lines indicate the Brazilian exclusive economic zone

previous studies which documented that leatherbacks <100 cm CCL occurred only in waters warmer than 25–26°C (Eckert 2002, Huang 2015). No differences in water temperature were found between the locations where the small and large juveniles were captured. However, small juveniles (<80 cm CCL) were only found in the equatorial central Atlantic, specifically between latitudes 3.5° N and 3.1° S, suggesting that these early life stages may be restricted to equatorial waters. In contrast, larger juveniles (80–100 cm CCL) exhibited a broader spatial distribution (latitudes 5.6° N to 25.6° S) than the smaller individuals. Obviously, as turtles grow and mature and their swimming ability improves, they may swim to more favorable areas for foraging (Lohmann et al. 2001, Gaspar et al. 2012). This is likely achieved when juveniles reach a certain size at which their food requirements are large enough to lead them towards richer foraging grounds (Gaspar & Lalire 2017). A recent paper that simulated the dispersal of juvenile leatherbacks from their FGS nesting beaches showed that the spatial distributions of both small and large juvenile turtles in the North Atlantic seem to be wider (~5– 30° N) than in the present study, with some turtles arriving off Mauritania within about 4 yr (Lalire & Gaspar 2019).

Several studies have demonstrated that small juvenile turtles can display directional movement beyond what would be expected if their movement depended on passive transport only (Christiansen et al. 2016, Mansfield et al. 2017, Lalire & Gaspar 2019). In addition, regional variation in directional swimming contributes to young sea turtles reaching more favorable developmental habitats (Christiansen et al. 2016, Gaspar & Lalire 2017). This ability to swim independently of currents to exploit areas of higher suitability may explain the spatial distribution observed in the present study of juvenile leatherbacks in the Atlantic, either by staying in equatorial waters (small turtles) or by expanding their range toward higher latitudes (some of the larger individuals).

Based on growth data from Jones et al. (2011), turtles may reach 40 cm CCL around the first year of age, so the equatorial central Atlantic possibly represents a nursery habitat for leatherbacks during the 'lost years.' Another question that arises is: Where did they come from? To answer this question, we explored the possible drift scenarios of hatchlings dispersing from the 2 closest and largest leatherback nesting grounds by looking at passive drifter trajectories. Even though Lagrangian drifters do not provide an exact description of ocean circulation, examining groups of drifter trajectories remains a reliable method to reveal the mean flow in a specific area (Fossette et al. 2012) and is a well-established approach for studying sea turtle dispersal (Monzón-Argüello et al. 2010, Carreras et al. 2013, Proietti et al. 2014).

Young turtles are relatively weak swimmers, and although small amounts of oriented swimming can influence their oceanic distribution (Putman et al. 2012, Mansfield & Putman 2013, Gaspar & Lalire 2017, Mansfield et al. 2017), sea turtle net movement is mostly affected by ocean currents (Monzón-Argüello et al. 2010, Proietti et al. 2012, Putman et al. 2013). For instance, in the South Atlantic, laboratory-reared yearling loggerhead turtles tracked from their natal beaches showed oriented swimming, but trajectories were shaped by the seasonal patterns in the strong currents off the nesting beaches (Mansfield et al. 2017).

Thus, assuming a passive drift during the first year of life (Gaspar et al. 2012) the surface drifter data suggest that the small leatherbacks found in the equatorial central Atlantic may come from nesting beaches in West Africa (i.e. Gabon). Indeed, on the equator, the South Equatorial Current (SEC) is driven directly by the trade winds, which blow from east to west, transporting warm ocean-surface waters in that direction. After the SEC moves away from the African coast, post-hatchlings using this current for transportation will most likely be directed towards the South American continent, supporting our *in situ* observations in the central equatorial Atlantic. In addition, modeled leatherback hatchling dispersal patterns from Central West Africa (3.5° N to 6° S) (Scott et al. 2017) showed that dispersion ranges (i.e. 90% kernel utilization distribution) of hatchlings leaving central/southern Gabon and Congo partially coincided with *in situ* observations in the present study. Regarding the larger juvenile turtles captured further south, their origin is more difficult to assign. They may have originated from West African rookeries, or less likely, due to the small size of the nesting population, have a Brazilian origin. This latter scenario is less clear, but while drifter data may not suggest that individuals leaving Brazilian leatherback nesting beaches would be travelling north, the South Atlantic subtropical gyre could carry them back to the equator. As discussed previously in this section, larger juvenile turtles may expand their range towards the south, including turtles originating from different rookeries.

On the other hand, drifters released in the proximity of nesting beaches in FGS during the hatchling emergence period indicated that the turtles seemed to be directed towards the Caribbean Sea, Gulf of Mexico, and North Atlantic (Fig. 4). Some of these drifters also showed initial trajectories (<2 mo) close to the area where the small juveniles were captured; however, it is less clear whether such small turtles may be able to swim out from the strong flowing currents and remain in waters of the central equatorial Atlantic. Accordingly, simulated initial pathways of leatherbacks born in FGS nesting beaches within the first year (Lalire & Gaspar 2019) appear to largely corroborate drifter trajectories off these beaches in our study.

Interestingly, trajectories of satellite-tracked drifters showed similarities with migratory paths of satellite-tracked females from these 2 rookeries (Fossette et al. 2010, Witt et al. 2011), corroborating the 'hatchling drift scenario' hypothesis. This hypothesis suggests that migration routes of adult turtles are strongly related to hatchling drift patterns, with adults traveling to foraging sites that they experienced in their earlier oceanic juvenile stage (Hays et al. 2010, Scott et al. 2014).

In the Pacific, leatherback turtles as small as 75 cm CCL (up to 3 yr old) were incidentally captured by tropical fisheries (Jones et al. 2011), whereas in the Atlantic Ocean, Huang (2015) found that the Taiwanese longline fishery captured even smaller individuals (n = 5), with a minimum size of 62 cm CCL. In the present study, 39% (n = 11) of the leatherbacks were smaller than 75 cm CCL, indicating that the capture of small juveniles is more frequent than previously thought. This also shows that leatherback turtles as small as 40 cm CCL can interact with longline fisheries. Considering the rapid growth rates of leatherback post-hatchlings (Jones et al. 2011), leatherback turtles can be vulnerable to incidental capture by longline fisheries approximately 1 yr after nest emergence.

Although the direct mortality rate in pelagic longline fisheries is lower compared to other fisheries, such as trawling (Laporta et al. 2012, Monteiro et al.

2016) or driftnets (Fiedler et al. 2012), it may often be underestimated due to the uncertain post-release mortality rates (Swimmer et al. 2014). This means that released turtles could show late mortality due to injuries generated by fishing gear, or from poor handling by fishermen whilst removing the hooks (Parga 2012). In addition, it is worth noting that the number of hooks sampled in this study represents a small fraction of the total effort reported in the same area by the International Commission for the Conservation of Atlantic Tuna. For example, the effort observed by the Brazilian and Uruguayan pelagic longline was among 0.10 to 6.75% of the total effort reported from 2001 to 2008 (Giffoni et al. 2014). This may be indicative of the scale of the impact that longline fishing has on leatherback populations.

The equatorial central Atlantic, where the majority of the juveniles were captured, exhibits extremely high fishing pressure from pelagic longline fleets (Wallace et al. 2013, Fossette et al. 2014, Huang 2015). Therefore, understanding which leatherback populations are impacted by this threat is essential for further population status assessments. Accordingly, here we manage to link bycatch data with remotely sensed ocean current data to show that the majority of small leatherbacks captured by the Brazilian pelagic longline fishery are likely to have originated from West Africa (i.e. Gabon). Therefore, the Brazilian longline fishery as well as others operating in the same area (i.e. Taiwanese fleet, see Huang 2015) are likely having a direct impact on the East Atlantic leatherback population. This highlights the need to coordinate international conservation efforts on an ocean-wide scale for the long-term protection of this transboundary species. Gabon and Brazil are both parties to the Convention on the Conservation of Migratory Species of Wild Animals and so are actively looking to reduce bycatch of species of conservation concern. In this context, the pelagic longline fisheries in the area should be monitored to avoid or minimize interactions with this species. Recently, the Brazilian government prohibited the use of J hooks and, since November 2018, the use of circle hooks became mandatory for all longline vessels targeting swordfish or tuna (Brazil 2017). According to Sales et al. (2010), the use of circle hooks (18/0, 10° offset) reduced the number of leatherback turtles captured by Brazilian vessels by 65%.

In a recent study, Wildermann et al. (2018) identified existing knowledge gaps and research priorities for immature sea turtle life stages worldwide. Among the different species, immature leatherbacks were identified as being in critical need of more research, particularly in areas related to habitat ecology. In this way, studies such as the one presented here help to address key knowledge gaps (namely distribution, dispersal patterns, and threats) for the young oceanic life stages of this species.

In short, the waters of the central tropical Atlantic serve as a nursery area for numerous leatherbacks less than 3 yr old and thus could be defined as a potential 'lost years hotspot' for the species. As a result, this region should be targeted for subsequent field-based research.

Future genetic stock analyses of juvenile leatherback turtles captured in this region would be helpful in clarifying the origin of these individuals. Additionally, this information combined with other methods such as environmental DNA and stable isotopes will provide a more complete picture of the oceanic developmental areas for this species. Lastly, advances in the miniaturization of electronic tags to track neonate leatherbacks from their nesting beaches will be key to solving this puzzle.

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