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Regional movements of great, *Sphyrna mokarran,* and scalloped, *Sphyrna lewini,* hammerhead sharks in the US Atlantic,Gulf of Mexico and the Bahamas: preliminary results

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Note

This is a working paper that contains preliminary data and analyses from satellite and acoustic telemetry data of great and scalloped hammerhead sharks that were tagged in the Bahamas, as well as in Florida and South Carolina in the U.S.A. The data collection for the corresponding project is still ongoing and therefore the data analysis is still in its very early steps. This working paper does not yet include a true abstract, introduction and discussion. Tables and Figures are added at the end of the Results section.

1. Introduction

NA

2. Material and methods

2.1. Satellite telemetry

Between January 2019 and June 2021 a total of 15 (7 female, 8 male) great hammerhead sharks, *Sphyrna mokarran,* were tagged with fin-mounted Smart Position and Temperature tags (SPOT, Wildlife Computers). During the same time span a total of 10 scalloped hammerhead sharks, *Sphyrna lewini,* were tagged with SPOT tags. Tagging efforts were in the Bahamas (Bimini and Andros Island), Florida Keys (FL, U.S.A.), South Carolina (U.S.A.), Tampa (FL, U.S.A.). All tags were configured to have a location uplink limit of 250 transmission per day and 10 uplinks per message. The estimated battery duration ranged from 171 to 300 days.

Locations have been filtered to only include detections of location classes 0-3. Tracks containing all location classes can be found in the Supplementary Material.

2.2. Acoustic telemetry

Between January 2017 and December 2020 a total of XX great hammerhead sharks (X female, Y male) have been monitored using internal acoustic transmitters (V16, Innovasea). The acoustic data has been cleaned for double detections. Movement data before 2017 was analysed and published by Guttridge et al. (2017). Regional movement data from acoustic receivers along

the US Atlantic coast and the Gulf of Mexico were obtained through the Ocean Tracking Network (OTN), the Florida Atlantic Coast Telemetry Network (FACT) and the iTag network.

Acoustic data were for double detections by multiple receivers, which were subsequently removed from the data set. Further, false-positive detections, defined as any single detection transmitter detection occurring alone within 24hrs (see Kessel et al., 2014), were removed from the data set as well.

3. Results

3.1. Sphyrna mokarran

Out of the 15 SPOT-tagged great hammerhead sharks, 14 individuals generated data, with some transmitting every day. Days at liberty ranged from 37 to 286 days. Four tags are currently active and continue to generate regional movement information. All tags generated more location class A and B and less 0 – 3 location class detections (see Table 1).

The sharks showed a high degree of individual variation in their regional movements and migrations. While some sharks migrated up and down the US Atlantic coast, other swam into the Gulf of Mexico, and two males tagged in the Bahamas, did pre-dominantly spend time in the Bahamas EEZ (see Figure 1)

Great hammerhead sharks tagged with internal acoustic tags in Bimini, the Bahamas showed seasonal movements along the US Atlantic Coast as well as the west coast into the Gulf of Mexico.

3.2. Sphyrna lewini

Eight scalloped hammerhead sharks that were tagged with fin-mounted SPOT tags generated regional movement data. The total lengths of tagged individuals ranged from 185 cm to 281 cm for males and from 182 cm to 324 cm for females. Days at liberty ranged from 10, which is a currently active tag, to 404 days. Similar to great hammerhead sharks, the majority of detections were of location classes A and B (see Table 2).

Individual sharks tagged in South Carolina showed relatively similar movement patterns spatially and timing-wise with movement further north during the summer months and movements back down south towards South Carolina in autumn. Shark-ID 198201, which was pregnant during capture, showed a large-scale movement from the Florida Keys to Louisiana, back to the Florida Keys and then north along the US Atlantic coast to South Carolina since her capture on April 21st 2021 (see Figure 3).

Shark details					Monitoring			Locations					
								Tagging		Location classes		Track summary post tagging	
Species	Group	PTT ID	Sex	Length *[cm]* / Maturity *[m/i]*	Tagging date *[yyyy-mm-dd]*	Last detection *[yyyy-mm-dd]*	Days at liberty	*N [dd]*	*W [dd]*	*A, B*	*0-3*		**Tag status**
S.mokarran	Bimini	23596	F	221.4 P / m	2017-11-27	2018-01-03	37	25.69201	-79.31534	96	16	Cape Canaveral	offline
S.mokarran	Bimini	177942	F	260.0 P / m	2019-01-31	2019-05-01	90	25.68896	-79.31326	253	91	Greenville NC, Freeport	offline
S.mokarran	Bimini‡	177941	F	225.0 P / m	2019-02-02	2019-09-14	224	25.70051	-79.31393	458	192	Crystal River FL, Sarasota FL	offline
S.mokarran	Bimini	177940	M	258.0 F / m	2019-04-02	2019-08-20	140	25.68534	-79.31341	533	109	Bimini	offline
S.mokarran	Bimini	180913	M	205.0 F / m	2019-04-22	*NA*	NA	25.69490	-79.31342	0	0	*NA*	PPRM/off
S.mokarran	SC	179472	M	198.0 F / m	2019-08-22	2020-02-07	169	32.3555	-80.0900	38	7	Jupiter FL	offline
S.mokarran	FL Keys	183621	F	268.0 sT / i	2019-10-22	2020-05-31	222	24.89869	-80.51164	509	114	Palm Bay, Crystal River, Naples	offline
S.mokarran	FL Keys	183620	F	220.0 sT / i	2020-01-19	2020-10-31	286	24.68534	-81.05366	509	86	Palm Coast, Naples, Wilmington	offline
S.mokarran	Andros	183623	M	228.0 P / m	2020-03-12	2020-10-13	215	24.42892	-77.69518	820	135	Andros, Abaco	offline
S.mokarran	Andros	200369	F	290.0 sT / m	2020-10-27	2021-06-19*	235	24.5829	-77.69561	168	16	Andros	active
S.mokarran	Andros	200368	F	210.0 P / m	2021-01-12	2021-06-19*	158	24.43333	-77.6964	539	202	Jupiter,Steinhatchee,Fort Myers	active
S.mokarran	FL Keys	183624	M	290.0 sT / m	2021-04-21	2021-06-19*	59	24.75576	-80.72854	56	14	Crystal River	active
S.mokarran	FL Keys	179471	M	335.0 sT / m	2021-04-21	2021-06-09*	49	24.75576	-80.72854	212	20	Mobile, Panama City Beach	active
S.mokarran	FL Keys	198202	M	272.0 sT / i	2021-04-21	2021-06-18*	58	24.84141	-80.81883	124	24	Tampa	active
S.mokarran	Tampa	198204	M	301.0 sT / m	2021-06-08	2021-06-18*	10	27.64841	-82.75336	81	11	Florida Keys	active

Table 1. Satellite tagging summary Sphyrna mokarran. The length measurements are in cm, whereas P describes the pre-caudal length, FL the fork length and sTL describes the stretched total length. The group column describes the area, where the individual has been tagged. Days at liberty are calculated as duration from capture until last detection (all Argos location classes included). Tagging location are in decimal degrees. The last detections description contains major cities/locations at a similar latitude as the key detections. A tag has been characterized as offline if it has not generated any detection with the last 30 days and/or if it has not yet generated any detections. PPRM stands for potential post release mortality. Data was last accessed on June 19th 2021. An active tag is a tag of which the battery life is not yet depleted. * Describes a shark that was transmitting when the data was accessed. ‡ describes a pregnant individual.

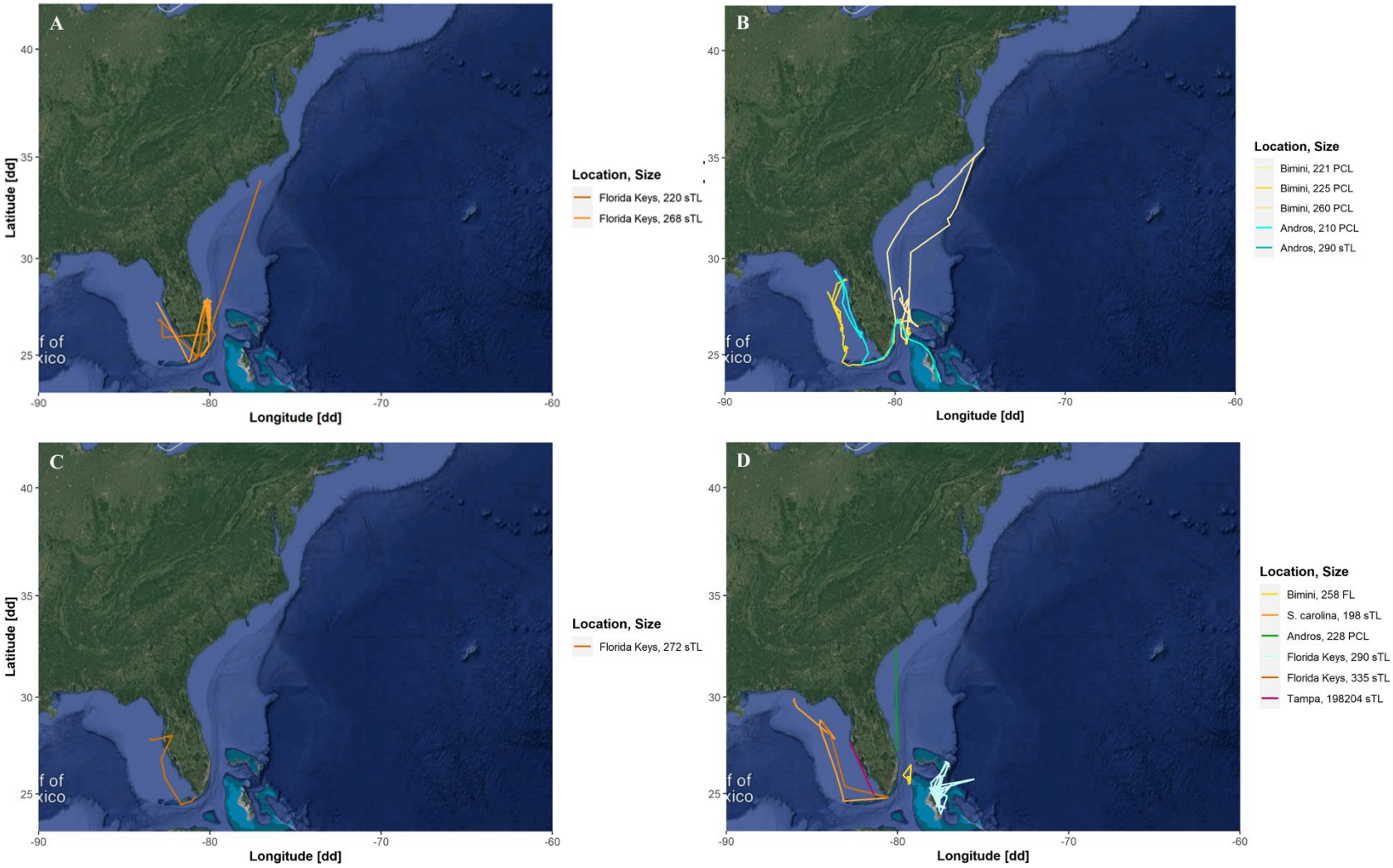

Figure 1. Regional movement tracks of sexually immature female (A), mature female (B), immature male (C) and mature male (D) great hammerhead sharks, *Sphyrna mokarran,* tagged with fin-mounted satellite transmitters in the Bahamas, the Florida Keys (FL), South Carolina, and Tampa (FL). Tracks are coloured based on the tagging location and only location class 0-3 detections have been included.

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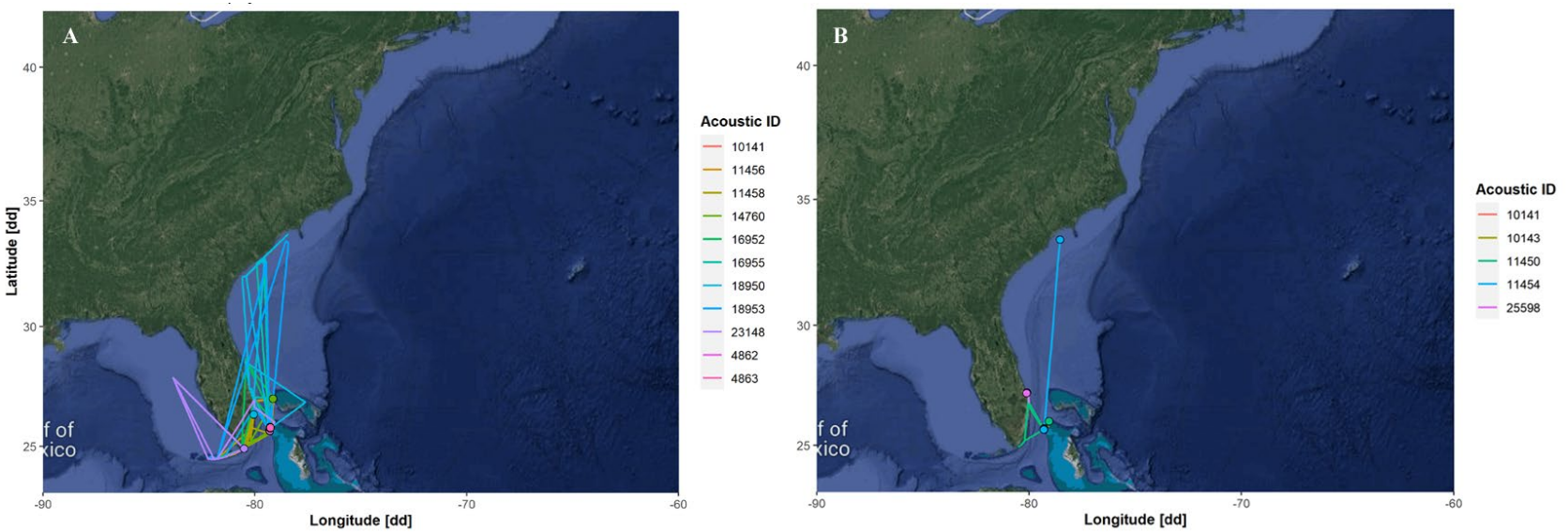

Figure 2. Movement tracks of female (A) and male (B) great hammerhead sharks tagged in Bimini, the Bahamas between January 2017 and December 2020. Movement tracks are coloured based on the ID-number of the acoustic tag.

Shark details					Monitoring			Locations					
								Tagging		Location classes		Track summary post tagging	
Species	Group	PTT ID	Sex	Length *[cm]* / Maturity *[m/i]*	Tagging date *[yyyy-mm-dd]*	Last detection *[yyyy-mm-dd]*	Days at liberty	*N [dd]*	*W [dd]*	*A, B*	*0-3*		**Tag status**
S.lewini	SC	180911	M	277.0 sT / m	2019-05-01	*NA*	*NA*	32.4475	-80.3852	-	-	*NA*	PPRM/off
S.lewini	SC	180910	M	252.0 sT / m	2019-05-06	2020-01-23	262	32.4277	-80.3640	386	144	Montauk, Hatteras	offline
S.lewini	SC	180912	M	280.0 sT / m	2019-05-07	2019-10-27	173	32.3677	-79.5304	813	240	Barnegat Bay, Rodanthe	offline
S.lewini	SC	180914	M	245.0 sT / m	2019-05-09	2019-11-25	200	32.4475	-80.3852	699	187	Asbury Park, Hatteras	offline
S.lewini	FL Keys	183619	M	185.0 sT / m	2019-10-22	2020-05-21	212	24.78379	-80.65561	855	322	Dry Tortugas, Naples	offline
S.lewini	FL Keys	183622	F	182.0 sT / i	2020-01-20	2021-02-27	404	24.78517	-80.66259	148	21	Layton	offline
S.lewini	FL Keys	180915	F	281.0 sT / m	2021-04-21	*NA*	*NA*	24.79162	80.66271	-	-	*NA*	PPRM/off
S.lewini‡	FL Keys	198201	F	324.0 sT / m	2021-04-21	2021-06-18*	58	24.74829	80.72592	121	104	New Orleans, Dry Tortugas, Myrtle Beach	active
S.lewini	SC	198203	M	263.0 sT/ m	2021-05-05	2021-06-08	34	32.6254	-79.7418	136	114	Nags Head	active
S.lewini	Tampa	198205	M	213.0 sT / m	2021-06-09	2021-06-19*	10	27.60756	-82.85134	182	57	Fort Myers, Clearwater	active

Table 1: Satellite tagging summary Sphyrna lewini. The length measurements are in cm, whereas sTL describes the stretched total length. The group column describes the area, where the individual has been tagged. Days at liberty are calculated as duration from capture until last detection (all Argos location classes included). Tagging location are in decimal degrees. The last detections description contains major cities/locations at a similar latitude as the key detections. A tag has been characterized as offline if it has not generated any detection with the last 30 days and/or if it has not yet generated any detections. PPRM stands for potential post release mortality. Data was last accessed on June 19th 2021. An active tag is a tag of which the battery life is not yet depleted. * Describes a shark that was transmitting when the data was accessed. ‡ describes a pregnant individual.

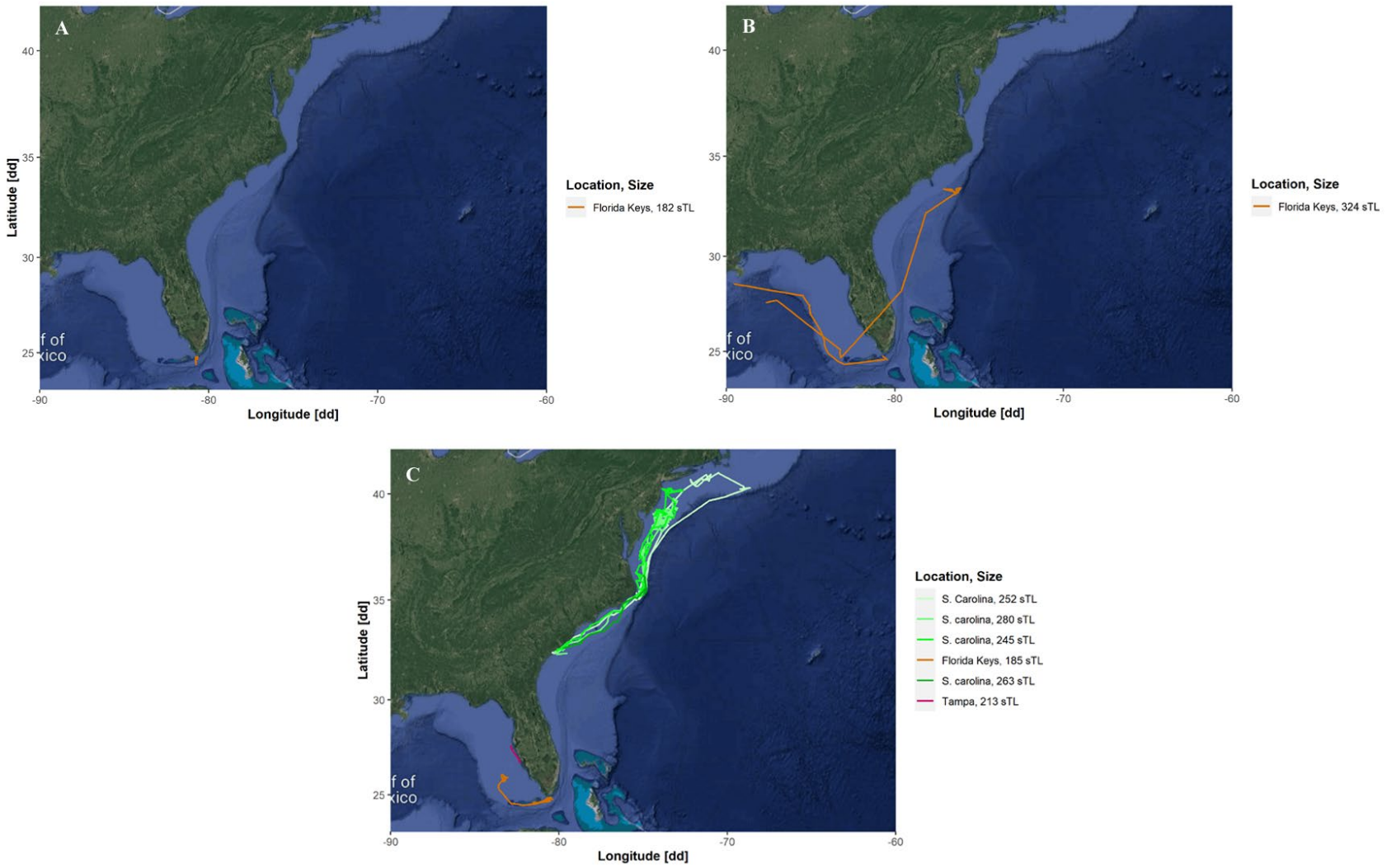

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Figure 3. Regional movement tracks of sexually immature female (A), mature female (B), mature male (C) scalloped hammerhead sharks, *Sphyrna lewini,* tagged with fin-mounted satellite transmitters in the Florida Keys (FL), South Carolina, and Tampa (FL). Tracks are coloured based on the tagging location and only location class 0-3 detections have been included.

4. Discussion

NA

5. References

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