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BEYOND THE CARIBBEAN: THE MIGRATION PATH OF JUVENILES FROM *CARETTA CARETTA*

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Abstract: Sea turtles are larger vertebrates, with a complex life cycle in which they exploit different marine resources throughout their ontogeny, in this process they migrate and frequent environments ranging from spawning and hatching beaches, open pelagic and neritic environments.
Due to its ecosystem importance in different environments and its high degree of threat, it is of vital importance to know the migratory dynamics through the different environments used.
Satellite remote sensors have allowed the study of these processes in vertebrate populations globally, due to the information gap that exists around the migration of *C. caretta* in the Caribbean and its relationship with the marine ecosystems exploited in its ontogeny. satellite tags and coded plastic plates in order to determine the route of the loggerhead turtle in the Caribbean and its passage to the Gulf of Mexico.
It was possible to follow two juveniles from the spawning beach to their final point of transmission, the first specimen lasted 9 days and traveled 500Km and the second a transmission of 38 days and traveled 1417Km with one transmission. end on the island of Cuba. Additionally, it was possible to report seven specimens with the help of the plastic tag, four in the Greater Antilles, one in the Gulf of Mexico and the furthest in the Florida Keys, a single individual chose rumba southwest and was seen 96 days later. from its introduction to 380 km in the San Bernardo Islands in the southern Caribbean.
These results clearly show the course chosen by juveniles of *C. caretta* in the Caribbean, which start in a northerly direction towards the Greater Antilles, then towards the Strait of Yucatán and later on the Gulf of Mexico. This route corresponds to the migration of juveniles in their pelagic stage, taking into account that later the sub-adults and adults adopt neritic habits after their transatlantic migration. In this sense, the need to carry out conservation work involving the pertinent institutions in the migratory route of the loggerhead turtle is evident.
Keywords: satellite remote sensing, migratory route.

INTRODUCTION

Among the unique characteristics of the life cycle of sea turtles, perhaps the least studied and most intriguing, is the one corresponding to the period called by Carr (1986) as "the lost years" due to the lack of information on the biology of these organisms. It ranges from the entrance to the sea in search of the open ocean, a stage in which pelagic habits predominate, until the appearance in neritic stages of sub-adults with ages from 7 to 11.5 years and lengths between 46 to 64 cm in curved length. from the shell (Wyneken and Salmon, 1992; Bolten and Balazs, 1995; Bolten et al., 1998; Bjorndal et al., 2000; Bjorndal et al., 2003; Erb and Wyneken, 2019).

It is worth noting the swimming ability between and with the sea currents of the loggerhead turtle (Papi and Luschi, 1996; Gatto et al., 2020), which uses magnetic orientation in search of feeding and reproduction areas (Lohmann et al, 2001; Avens et al., 2003; Lohmann and Lohmann, 2003; Hays et al., 2014; Scott et al., 2014). These navigation tools, together with the influence of oceanographic factors, allow you to perform migrations locally, due to seasonality and food availability (Henwood, 1987; Mansfield et al., 2009, 2014; Harrison et al., 2021) or at the oceanic level., where they can cover intercontinental distances in search of energy resources and breeding grounds (Bowen et al., 1995; Resendiz et al., 1998; Musick and Limpus, 1997; Nichols et al., 2000; Bjorndal et al., 2001; Witherington, 2002; Bolten, 2003; Schroeder, 2003; Shimada

et al., 2020; Harrison et al., 2021). This is how individuals have been reported on the coasts of the European continent introduced in North America (Mansfield et al., 2009; Mansfield et al., 2014) and in Japan introduced in California (North America) (Resendiz et al., 1998).

Different methods have been used in order to resolve the migratory routes of sea turtles, the relationship between hatchling dispersal and particle transport in ocean currents (Le Gouvello et al., 2020; Dubois et al., 2021), the use of individual numbered plastic tags that are placed on the fin of each specimen allows monitoring in recapture events (Henwood, 1987; Bowen et al., 1995; Resendiz et al., 1998; Nichols et al., 2000) and satellite devices attached to the shell that record the point location by emitting signals with the point of location and displacement, which can be related to the physicochemical aspects of each particular place and date (Renaud and Carpenter, 1994; Mansfield et al., 2004; Polovina et al., 2004; Pabón-Aldana et al., 2012; Shimada et al., 2020).

In the Caribbean there are four species of sea turtles, of which *C. caretta* is the most frequent in nesting processes (Amorocho et al., 1999; Amorocho, 2003) and they constitute 85% of the approximately 4,200 juveniles introduced on the coast. north of the Colombian Caribbean for the processes of initial impulse in 18 years of work (ProCTMM per. comm.). One of the great gaps in the knowledge of the biology of *C. caretta* in the region is to answer what is the geographical area and the niche in its life cycle? And what corridors does it use to reach such? Since after entering the sea it is possible that it exploits local resources constituting a resident group in the area or that, on the contrary, they carry out migrations at oceanic level. In order to address these questions, the use of plastic and satellite tags was implemented for individuals from the Program for the Conservation of Marine Mammals and Turtles (ProCTMM), making it possible to propose the migratory route of *C. caretta* in the Caribbean and subsequent entry into the Gulf of Mexico.

METHODOLOGY

In order to know the destination and the routes used by *C. caretta* neonates and juveniles in the southern Caribbean, the recapture method was used through the marking of individuals belonging to the initial impulse process of the ProCTMM introduced since 2009. with Rototag-type plastic tags, following the manual of methods recommended by Eckert and Beggs (2006), which suggests that the tag be attached to the intermediate tissue of the first and second scales of the right front fin (Figure 1 A). The individuals belonging to the nests were collected in the sector known as Los Cocos and Palomino in northern Colombia, which has extensive beaches ideal for the nesting process of the loggerhead turtle, likewise morphometric measurements, photographic records and characteristics were taken. distinctive to each individual. With the location points, the linear distance traveled was calculated; this distance corresponds to the minimum possible between both points, taking into account that in the reports for North America, the crossing between the Yucatan peninsula and the island of Cuba is mandatory.

In order to obtain a more detailed perspective of the migratory routes of this species, satellite tracking devices were implemented in two juveniles from rearing processes. To do this, a SPOT 287C satellite transmitter (Wildlife Computers Inc.) was used, adhered to the carapace of each specimen using Pure 110+ epoxy and then "antifoulig" paint was applied to prevent the adhesion of epibionts to the device (Figure 1B).

The information of the two individuals with

a satellite device was downloaded through the Argos portal in CVS formats, from which coordinates of each location point, day and date were extracted, later they were filtered according to the level of precision of each following what was suggested by Hays et al., 2001, where having a greater amount of data with high precisions (LC1, LC2 and LC3) those with less accuracy (LCA and LCB) are discarded; Once the final data was obtained, they were spatialized through the ArcGis 10.3 program. To estimate the possible routes made by the individuals reported from the plastic tags, we used the superimposition of georeferenced images of the routes of oceanographic drifting buoys released in the southwestern Caribbean by the National Oceanographic Association Program - NOPP (NOPP, 2012) and reported particle transport pathways

Figure 1. Images of a specimen identified as Aminta. A Specimen with plate. B Example with satellite device.

(Le Gouvello *et al.*, 2020; Dubois *et al.*, 2021).

RESULTS

Between 2009 and 2022, it was possible to mark and introduce 1,151 juveniles of *C. caretta*, during this period, seven individuals were reported through the plastic tag, with journeys between 384 and 2,500 km. The first report was received in July 2009 corresponding to a 9-month-old juvenile (A0130) in the city of Pensacola (USA) after three months of its introduction and 2500 km traveled. The second individual, called ¨Charlie¨ (A0234) reported in June 2012, was the specimen with the longest duration, with 335 days from the moment of introduction until its report in Grassy Kay (USA) at more than 1600 km from the point of introduction, recently in 2021 three reports of juveniles introduced that same year were received, the loggerhead A2993 was reported on the island of Haiti 24 days after its introduction and a distance traveled of 800 km. Then it was possible to see the turtle A3118 in Cuba with a duration of three months and about 1450 km traveled, in addition the presence of juvenile B0058 was identified in the San Bernardo Archipelago 380 km southwest of the point of introduction in Palomino (Colombia), being the only individual to choose this course. Finally, in the year 2022, reports of two specimens have been received. On July 2, the B3029 turtle traveled an estimated 750 km to reach the southwestern peninsula of Port-Salute, Haiti, and the most recent was the loggerhead. B0117, which traveled 1000 km to Arcahaie (Haiti), these last two juveniles were part of the introduction on May 21 at Guachaca beach,with 10 months of age (Table 1). The first individual introduced with a satellite tag was named ¨AMINTA¨ in May 2016, which began its journey towards the northwest (NW) towards La Guajira (Colombia) where it made a turn to head N towards the Greater Antilles and then turn to the northeast (NE) reaching a distance of 500 km and a displacement of 56 km/day,

although it had a transmission duration of only 9 days, possibly due to detachment of the transmitter. The following year, in May 2017, a second satellite transmitter was attached to the loggerhead known as ¨Petrona¨ (A1398), emitting a signal on the Colombian coast for 11 days, subsequently heading northwest (NW), after a month it was detected about the Cayman Islands, following its course until reaching the coast of Cienfuegos, Cuba. After 38 days of transmission, it headed towards the Bay of Pigs where it lasted 6 days, then it lasted 13 days moving between the Cayos Blancos del Sur and Cayo Diego Pérez until day 138, when its transmission ended.

The weight of the reported turtles ranged between 743 g and 11,300 g, being ¨Pensacola¨ the smallest and which moved the greatest linear distance, although it is worth highlighting ¨Charlie¨ which was reported in Florida and which was the most plausible involves crossing the Yucatan peninsula, this is the furthest report from the point of introduction. On the other hand, ¨Petrona¨ was the largest turtle and was in charge of evidencing the route between Colombia and Cuba by satellite.

Taking into account the departure and arrival points of each of the individuals marked with plastic plates and superimposing the images of the drifting buoys (NOPP, 2012; Figure 2 A and B), the They identified those with a path that possibly described a displacement that was close to the reporting point of each individual, in order to suggest a possible route.

DISCUSSION

When analyzing the migratory routes of C. caretta juveniles in the southern Caribbean, it is evident that they prefer to choose a northerly course through the Caribbean current, until they reach the Greater Antilles, although initially they carry out a process of local exploration, possibly in search of energy resources required in movements at oceanic level, a fact consistent with the behavior of swimming frenzy in this stage of the life cycle (Papi and Luschi, 1996; Gatto et al., 2020) and their ability to face the prevailing current, using strategies on the route to increase efficiency in displacement, with the maximum speed reported being 70 km/day (Meylan *et al.*, 1983; Girard, 2009; Mansfield *et al.*, 2014; Hays *et al.*, 2014).

Of the seven recaptures obtained, six were in this direction, where three individuals were reported in Haiti, two in Cuba, and two in North America, which suggests that after crossing the Caribbean they opted to go through the Strait of Yucatan taking advantage of the current to enter the system of the Gulf of Mexico and current of La Florida. Once there, they continue the route favoring the loops of the current, which is why they can reach the southern coast of the USA where the availability of energy resources is greater (Harrison et al., 2021). This is the possible reason why ¨Pensacola¨ and ¨Charlie¨ were reported in this area, which is consistent with the data obtained through recaptures and satellite telemetry in the region. (Meylan *et al.*, 1983; Renaud y Carpenter 1994; Girard *et al.*, 2009)

The turtles carrying satellite transmitters confirmed the data obtained from the recaptures, although initially they opted for a northeasterly course towards La Guajira carrying out coastal explorations, and then headed north directly to the island of Cuba. The first individual ¨Aminta¨ transmitted by 9 days which were enough to determine its maximum speed of 56 km per day $^{-1}$ which is considerable in terms of navigation, although less than the maximum recorded for the species (Meylan et al., 1983). For its part, Petrona registered a speed of 37 km day-1, the second fastest, although it must be noted that it transmitted until its arrival in Cuba

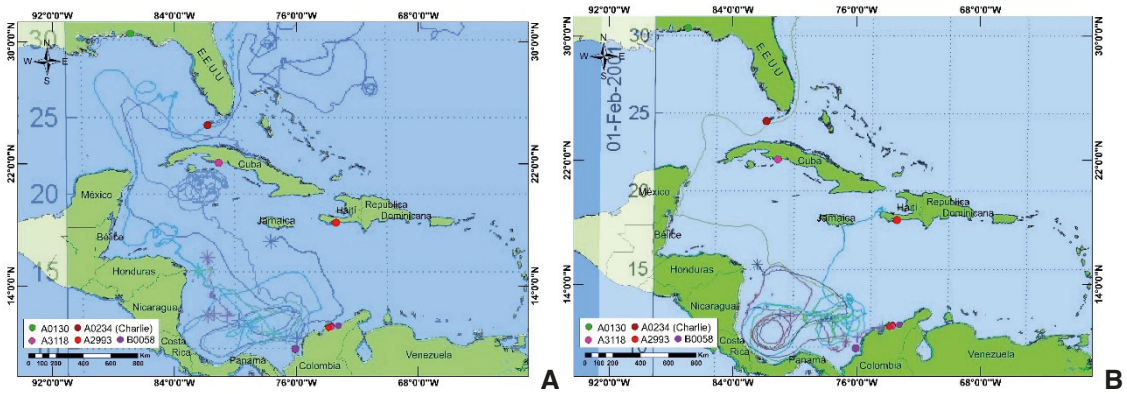

Figure 2. Overlay of georeferenced images of oceanographic drifting buoy routes released in the southwestern Caribbean by the National Oceanographic Association Program - NOPP (NOPP, 2012) with the departure and arrival points of the specimens with plastic tags.

Introduction date	# de ind.	ID	Date of report	Int. Age (months)	Final location	Minimum distance traveled (km)	Time (days)	Km día^{-1}
March, 2009	150	Pensacola (A0130)	4/07/2009	6	Pensacola (USA)	2600	210	13
June, 2012	232	Charlie (A0234)	8/05/2013	23	Grassy Kay (USA)	2360	335	7
May, 2016	350	*Aminta	2016	12	Caribe central	*500	9	56
Mayo, 2017	154	*Petrona (A1398)	27/05/2017	12	Cuba	*1417	38	37
March, 2021	265	A2993	29/03/2021	18	Haití	800	24	33
March, 2021	265	A3118	5/06/2021	18	Cuba	1450	92	15
March, 2021	55	B0058	23/06/2021	18	San Bernardo (Colombia)	380	96	4
July, 2022		B3029	02/07/2022	12	Port-Salute (Haití)	750	43	17
August, 2022		B0117	24/08/2022	13	Arcahaie (Haití)	1000	154	6

Table 1. Turtle reports: *C. caretta* in the greater Caribbean. * Specimens tracked by means of satellite telemetry

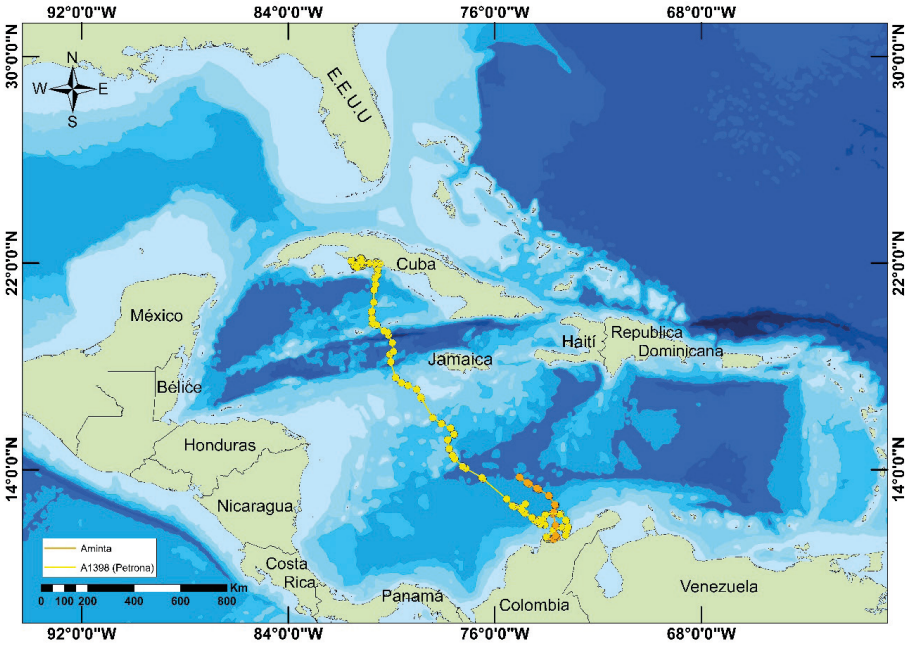

Figure 3. Route made by Petrona (yellow, A1398) and Aminta (orange)

ID	Weight (g)	LCC (cm)	ACC (cm)
Pensacola (A0130)	743	17,9	13,6
Charlie (A0234)	980	18,5	14,5
*Aminta		25,0	
*Petrona (A1398)	11300	48,0	41,8
A2993	5115	38,4	32,9
A3118	3415	32,0	27,5
B0058	4300	33,5	29
B3029	1065		17,8
B0117	430		

Table 2. Morphometric measurements of reported loggerhead turtles belonging to the ProCTMM. *Copies tracked by means of satellite telemetry

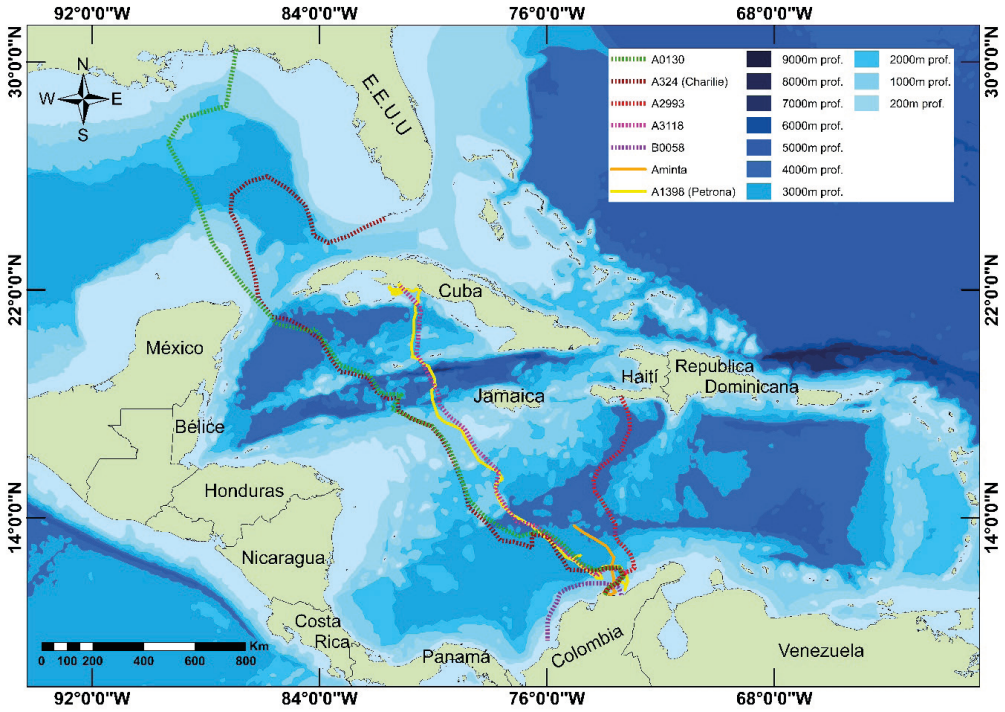

Figure 3. Migration routes of C. caretta individuals introduced by ProCTMM. Petrona (yellow) and Aminta (orange), specimens marked with a satellite device. In dotted lines). Specimen tag A0130 reported from Pensacola, Florida in 2009 (dark green), Charlie, Specimen tag A234 reported from Grassy Kay, Florida in 2013 (light green), and Specimen tag number A2993 intercepted by WIDCAST Haiti members in 2021 (red and fuchsia).

38 days after its introduction in the southern Caribbean.

Regarding the movements made by the individuals with plastic marks, and taking into account the routes of the oceanographic drift buoys, it can be seen that these reptiles can make use or not of the surface currents according to the requirements of their movement. For this reason, some possible routes are suggested (Figure 3), where the specimen found in Cuba (A3118) could have covered most of its journey using the Caribbean current and then left and headed north towards the Cuban coast. The individuals reported in the United States possibly followed the same route along the Caribbean current, later taking the Yucatán and Laso currents, where one of them (A0130) deviated in the direction of Pensacola, Florida, while the other (A0234) followed the Florida Current to reach Grassy Kay. On the other hand, the specimen introduced in Palomino (B0058), possibly moved along the Panama-Colombia Counter Current and headed towards the Rosario Islands, Colombia; while the turtles found in Haiti (A2993, B3039 and B0117) may have initially moved with the Caribbean current, leaving it and joining the anticyclonic gyre of the southern part of the island to reach their destination.

Although it was not possible to record individuals beyond Florida, satellite tracking has shown the importance of the southern USA, the northern Greater Antilles and the Bahamas as feeding grounds and the starting point for crossing the Atlantic by means of from the northern turn towards the Azores islands where they adopt neritic habits (Henwood, 1987; Bolten et al., 1994; Mansfield et al., 2009, 2014; Harrison et al., 2021), and is consistent with the results obtained in studies molecular studies based on mitochondrial DNA (Bolten et al., 1998; Shamblin et al., 2014), which have revealed the genetic structure of C. caretta in the western Atlantic and its connectivity with areas such as the Mediterranean, the west coast of Africa, South America and the Caribbean.

REFERENCES

Amorocho, D. (2003). **Monitoring nesting loggerhead turtles (Caretta caretta) in the central Caribbean coast of Colombia**. *Marine turtle newsletter*, *101*, 8-13.

Amorocho, D., Cordoba, J. A. B., & Miklin, S. H. (1999). **Current status of nesting sea turtles in the northern Colombian Caribbean**. *Marine Turtle Newsletter*, (85), 6-7.

Avens, L., & Lohmann, K. J. (2003). **Use of multiple orientation cues by juvenile loggerhead sea turtles Caretta caretta**. Journal of Experimental Biology, 206(23), 4317-4325.Aviso. 2010. Live Access Server. LAS V7.0 Beta Version 6 UI. Available online: ttp://las.aviso.oceanosbs.com.

Bjorndal, K. A., Bolten, A. B., & Martins, H. R. (2000). **Somatic growth model of juvenile loggerhead sea turtles Caretta caretta: duration of pelagic stage**. Marine Ecology Progress Series, 202, 265-272.

Bjorndal, K. A., Bolten, A. B., Koike, B., Schroeder, B. A., Shaver, D. J., Teas, W. G., & Witzell, W. N. (2001). **Somatic growth function for immature loggerhead sea turtles, Caretta caretta, in southeastern US waters**. Fishery Bulletin, 99(2), 240-240.

Bjorndal, K. A., Bolten, A. B., Dellinger, T., Delgado, C., & Martins, H. R. (2003). **Compensatory growth in oceanic loggerhead sea turtles: response to a stochastic environment**. Ecology, 84(5), 1237-1249.

Bolten, A. B. (2003). **Active swimmers-passive drifters: the oceanic juvenile stage of loggerheads in the Atlantic system**. Loggerhead sea turtles, 63-78.

Bolten, A. B., & Balazs, G. H. (1995). **Biology of the early pelagic stage—the 'lost year.**'. Biology and Conservation of Sea Turtles, Revised edition. Smithsonian Institute Press, Washington, DC, 579.

Bolten, A. B., Martins, H. R., Bjorndal, K. A., & Gordon, J. (1993**). Size distribution of pelagic-stage loggerhead sea turtles (Caretta caretta) in the waters around the Azores and Madeira**. ARQUIPÉLAGO. Ciências Biológicas e Marinhas Life and Marine Sciences, 11, 49-54.

Bolten, A. B., Bjorndal, K. A., Martins, H. R., Dellinger, T., Biscoito, M. J., Encalada, S. E., & Bowen, B. W. (1998). **Transatlantic developmental migrations of loggerhead sea turtles demonstrated by mtDNA sequence analysis**. Ecological Applications, 8(1), 1-7.

Bowen, B. W., Abreu-Grobois, F. A., Balazs, G. H., Kamezaki, N., Limpus, C., & Ferl, R. J. (1995). **Trans-Pacific migrations of the loggerhead turtle (Caretta caretta) demonstrated with mitochondrial DNA markers**. *Proceedings of the National Academy of Sciences*, *92*(9), 3731-3734.

Burke, R. L. (2015). **Head-starting turtles: learning from experience**. Herpetological Conservation and Biology, 10(1), 299-308.

Carr, A.1982. **Notes on the behavioral ecology of sea turtles**. Pages 19–26 in K. A. Bjorndal, editor. Biology and conservation of sea turtles. Smithsonian Institution Press,Washington, D.C., USA.

Carr, A. (1986). **Rips, FADS, and little loggerheads**. Bioscience, 36(2), 92-100.

Carreras, C., Pascual, M., Tomás, J., Marco, A., Hochscheid, S., Castillo, J. J.,... & Cardona, L. (2018). **Sporadic nesting reveals long distance colonisation in the philopatric loggerhead sea turtle (Caretta caretta)**. Scientific reports, 8(1), 1-14.

Clusa, M., Carreras, C., Pascual, M., Gaughran, S. J., Piovano, S., Giacoma, C.,... & Cardona, L. (2014). **Fine-scale distribution of juvenile Atlantic and Mediterranean loggerhead turtles (Caretta caretta) in the Mediterranean Sea**. Marine biology, 161(3), 509-519.

Coyne, M.S. y B.J. Godley. (2005). **Satellite Tracking and Analysis Tool (STAT): an integrated system for archiving, analyzing and mapping animal tracking data**. Marine Ecology Progress Series 301: 1-7.

Donnelly, M. (1994). **Sea turtle mariculture:/a review of relevant information for conservation and commerce**.

Eckert, K.L. y Beggs J. (2006). **Marcado de Tortugas Marinas. Un Manual de Métodos Recomendados**. Red de Conservación de Tortugas Marinas del Gran Caribe (WIDECAST) Informe Técnico No. 2. Edición Revisada. Beaufort, North Carolina USA. 40 pp.

Erb, V., & Wyneken, J. (2019). **Nest-to-surf mortality of loggerhead sea turtle (Caretta caretta) hatchlings on Florida's east coast.** Frontiers in Marine Science, 6, 271.

Gatto, C. R., & Reina, R. D. (2020). **The ontogeny of sea turtle hatchling swimming performance**. Biological Journal of the Linnean Society, 131(1), 172-182.

Girard, C., Tucker, A. D., & Calmettes, B. (2009). **Post-nesting migrations of loggerhead sea turtles in the Gulf of Mexico: dispersal in highly dynamic conditions**. Marine Biology, 156(9), 1827-1839.

Harrison, C. S., Luo, J. Y., Putman, N. F., Li, Q., Sheevam, P., Krumhardt, K.,... & Long, M. C. (2021**). Identifying global favourable habitat for early juvenile loggerhead sea turtles**. Journal of the Royal Society Interface, 18(175), 20200799.

Hays, G. C., Christensen, A., Fossette, S., Schofield, G., Talbot, J., & Mariani, P. (2014). **Route optimisation and solving Z ermelo's navigation problem during long distance migration in cross flows**. Ecology letters, 17(2), 137-143.

Henwood, T. A. (1987). **Movements and seasonal changes in loggerhead turtle *Caretta caretta* aggregations in the vicinity of Cape Canaveral, Florida (1978–84)**. Biological Conservation, 40(3), 191-202.
Lohmann, K. J., Cain, S. D., Dodge, S. A., & Lohmann, C. M. (2001). **Regional magnetic fields as navigational markers for sea turtles**. Science, 294(5541), 364-366.

Lohmann, K. J., & Lohmann, C. M. F. (2003). **Orientation mechanisms of hatchling loggerheads**. Loggerhead sea turtles, 44-62.

Mansfield, K. L., Wyneken, J., Porter, W. P., & Luo, J. (2014). **First satellite tracks of neonate sea turtles redefine the 'lost years' oceanic niche**. Proceedings of the Royal Society B: Biological Sciences, 281(1781), 20133039.

Mansfield, K. L., Saba, V. S., Keinath, J. A., & Musick, J. A. (2009). **Satellite tracking reveals a dichotomy in migration strategies among juvenile loggerhead turtles in the Northwest Atlantic**. Marine Biology, 156(12), 2555-2570.

Meylan, A. B., Bjorndal, K. A., & Turner, B. J. (1983). **Seaturtles nesting at Melbourne beach, Florida, II. Post-nesting movements of Caretta caretta**. Biological Conservation, 26(1), 79-90.

Mortimer, J. A. (1995). **Headstarting as a management tool. Biology and Conservation of Sea Turtles**, 613-615.

Musick, J. A., & Limpus, C. J. (1997). 1997. **Habitat utilization and migration in juvenile sea turtles**. The biology of sea turtles, 51-81.

Narazaki, T., Sato, K., & Miyazaki, N. (2015). **Summer migration to temperate foraging habitats and active winter diving of juvenile loggerhead turtles Caretta caretta in the western North Pacific**. Marine Biology, 162(6), 1251-1263.

Nichols, W. J., Resendiz, A., Seminoff, J. A., & Resendiz, B. (2000). **Transpacific migration of a loggerhead turtle monitored by satellite telemetry**. *Bulletin of Marine Science*, *67*(3), 937-947.

NOPP. (2012). National Oceanographic Partnership Program. Disponible en internet: http://drifters.doe.gov/.

Pabón-Aldana, K., Noriega-Hoyos, C. L., & Jaúregui, G. A. (2012). **First satellite track of a head-started juvenile Hawksbill in the Colombian Caribbean**. Marine Turtle Newsletter, 133, 4-7.

Papi, F., & Luschi, P. (1996). **Pinpointing'Isla Meta': the case of sea turtles and albatrosses**. *The Journal of experimental biology*, *199*(1), 65-71.

Polovina, J. J., Balazs, G. H., Howell, E. A., Parker, D. M., Seki, M. P., & Dutton, P. H. (2004). **Forage and migration habitat of loggerhead (*Caretta caretta*) and olive ridley (Lepidochelys olivacea) sea turtles in the central North Pacific Ocean**. Fisheries Oceanography, 13(1), 36-51.

Prosdocimi, L., Bugoni, L., Albareda, D., & Remis, M. I. (2015). **Are stocks of immature loggerhead sea turtles always mixed?**. Journal of Experimental Marine Biology and Ecology, 466, 85-91.

Renaud, M. L., & Carpenter, J. A. (1994). **Movements and submergence patterns of loggerhead turtles (Caretta caretta) in the Gulf of Mexico determined through satellite telemetry**. Bulletin of Marine Science, 55(1), 1-15.

Resendiz, A., Resendiz, B., Nichols, W. J., Seminoff, J. A., & Kamezaki, N. (1998). **First confirmed east-west transpacific movement of a loggerhead sea turtle, Caretta caretta, released in Baja California, Mexico**.

Ross, J.P. (2000). **La crianza y reproducción en cautiverio de tortugas marinas: una evolución de su uso como estrategia de conservación** In: K.L. Eckert, K. Bjorndal, A. Abreu-Grobois & M. Donnelly (Eds). Técnicas de Investigación y Manejo para la Conservación de las Tortugas Marinas. Grupo Especialista en Tortugas Marinas UICN/CSE Publicación No. 4. pp. 225-231.

Scott, R., Biastoch, A., Roder, C., Stiebens, V. A., & Eizaguirre, C. (2014). **Nano-tags for neonates and ocean-mediated swimming behaviours linked to rapid dispersal of hatchling sea turtles**. Proceedings of the Royal Society B: Biological Sciences, 281(1796), 20141209.

Shimada, T., Limpus, C. J., Hamann, M., Bell, I., Esteban, N., Groom, R., & Hays, G. C. (2020). **Fidelity to foraging sites after long migrations**. Journal of Animal Ecology, 89(4), 1008-1016.

Shamblin, B. M., Bolten, A. B., Abreu-Grobois, F. A., Bjorndal, K. A., Cardona, L., Carreras, C.,... & Dutton, P. H. (2014). **Geographic patterns of genetic variation in a broadly distributed marine vertebrate: new insights into loggerhead turtle stock structure from expanded mitochondrial DNA sequences**. PLoS One, 9(1), e85956.

Witherington, B. (2002). **Ecology of neonate loggerhead turtles inhabiting lines of downwelling near a Gulf Stream front**. Marine Biology, 140(4), 843-853.

WILDLIFE COMPUTERS. (2006). SPOT5 User guide. 25 pp.

Wyneken, J. (1997). **Sea turtle locomotion: mechanisms, behavior, and energetics**. The biology of sea turtles, 1, 165-98.

Wyneken, J., & Salmon, M. (1992). **Frenzy and postfrenzy swimming activity in loggerhead, green, and leatherback hatchling sea turtles**. Copeia, 478-484.

ZAR, J. 2010. Biostatistical Analysis. Fifth Edition. Prentice Hall. New Jersey. 944p.