Zoologia Caboverdiana 10, 2, 26–34
Available at www.scvz.org

Artigo original | Original article

High marine predation of loggerhead turtle hatchlings at Boavista, Cabo Verde

Alínio Louro [1], Leila Almeida [2], Adolfo Marco [3,] *, Samir Martins [4] & Evandro P. Lopes [1, 5, 6]

[1] *ISECMAR/UTA, Instituto de Engenharias e Ciências do Mar da Universidade Técnica do Atlântico, CP 163, Ribeira de Julião, São Vicente, Cabo Verde*
[2] *Cabo Verde Natura 2000, Sal Rei, Boavista, Cabo Verde*
[3] *Estación Biológica de Doñana, CSIC, C/ Américo Vespucio s/n, 41092, Sevilla, Spain*
[4] *BIOS.CV, Conservação da Biodiversidade e Desenvolvimento Sustentável, Sal Rei, Boavista, Cabo Verde*
[5] *CIBIO, Centro de Investigação em Biodiversidade e Recursos Genéticos, InBIO Laboratório Associado, Campus de Vairão, Universidade do Porto, 4485-661 Vairão, Vila do Conde, Portugal*
[6] *BIOPOLIS Program in Genomics, Biodiversity and Land Planning, CIBIO, Campus de Vairão, 4485-661 Vairão, Portugal*

* *Corresponding author e-mail: amarco@ebd.csic.es*

RESUMO

A ilha da Boavista suporta a maior abundância de ninhos da subpopulação do Atlântico Nordeste de tartaruga comum *Caretta caretta*. Cerca de 80–85% estão concentrados no lado este da ilha. Os predadores marinhos nesta área têm um impacto importante sobre os neonatos de *C. caretta* perto da costa. Estudar este impacto permite estimar o recrutamento para posteriormente delinear novas medidas de conservação para a espécie. Este estudo estimou a predação de neonatos de *C. caretta* no mar com base em sensos visuais e inquéritos aos pescadores e peixeiras da Boavista. Os resultados revelaram que os predadores de neonatos são principalmente peixes demersais, especialmente garoupas vermelhas *Cephalopholis taeniops*. A mortalidade estimada perto da costa foi muito alta. A análise do conteúdo estomacal dos predadores revelou que os neonatos não constituem a principal presa dos peixes. No entanto, há a necessidade de reproduzir o estudo em outras áreas da ilha para ter uma visão mais ampla e mais dados para comparações espaciais e temporais.

Palavras-chave: Atlântico Oriental, conteúdo estomacal, inquéritos, peixes, predação

ABSTRACT

Boavista Island supports the highest abundance of nests of the Northeast Atlantic subpopulation of loggerhead turtle *Caretta caretta*. Around 80–85% of them are concentrated on the east side of the island. Marine predators in this area have an important impact on *C. caretta* hatchlings near the coast. Studying this impact allow us to estimate recruitment to later delineate new conservation measures for the species. This study estimated the predation on *C. caretta* hatchlings at sea based on visual census and surveys of fishermen and fishmongers on Boavista. Results revealed that predators of hatchlings are mainly demersal fishes, especially red groupers *Cephalopholis taeniops*. Estimated near-coast mortality was very high. The analysis of stomach contents of predators revealed that hatchlings do not constitute the key prey of fishes. Despite this, there is a need to reproduce the study in other areas of the island to have a broader view and further data for spatial and temporal comparisons.

Keywords: Eastern Atlantic, stomach contents, surveys, fishes, predation

INTRODUCTION

The loggerhead sea turtle *Caretta caretta* population of the East Atlantic is listed as threatened by the International Union for Conservation of Nature (IUCN) Red List of Threatened Species (Casale & Marco 2015). The vast majority of the nests of the Northeast Atlantic are in the Cabo Verde Archipelago (Wallace *et al*. 2010). This increases the importance of the conservation actions of the species in this archipelago (Monzón-Arguello *et al*. 2010). In Cabo Verde, Boavista is the main nesting area, with 80–85% of the total nesting occurring along 40 km of beach in the eastern half of the island (Marco *et al*. 2012, Laloë *et al*. 2020, Patino-Martinez *et al.* 2021).

Hatchlings entering the sea are highly vulnerable to predation (Witherington & Salmon 1992, Thums et al. 2019). The abundance of marine predators in the coastal area has an important role in hatchling survival (Marco *et al*. 2012). Information about predators and predation rates on turtle hatchlings near the coast can be crucial for estimating recruitment (Mazaris *et al*. 2005) and delineating management measures (Booth *et al*. 2019).

Knowledge about predation in turtle hatchlings is still limited (Pitcher et al. 2000), since it has been estimated by following hatchlings with observers in different ways that can scare away its predators or reduce hatchling's swimming speed, thus altering natural predation rates (Stewart & Wyneken, 2004). The vast majority of related studies have too small sample sizes to draw accurate conclusions and many studies are based on theoretical considerations (Witherington & Salmon 1992, Gyuris 1994, Glen 1996). Previous studies show that hatchlings are most often predated in coastal waters, when they are near or crossing coral reefs, artificial structures, and rocky bottoms (Thums *et al*. 2019, Reising *et al*. 2015, Oñate-Casado *et al*. 2021). The rates of predation of hatchlings in the sea obtained for several turtle species so far are highly variable. For instance, Gyuris (1994) obtained predation rates in hatchlings of green turtle *Chelonia mydas* of 31%, Thums *et al*. (2019) of 72% in hatchlings of flatback turtles *Natator depressus* (Garman 1880), Reising *et al*. (2015) and Oñate-Casado *et al*. (2021) of 6.9% and 19.4%, respectively, for hatchlings of hawksbill turtles *Eretmochelys imbricate* (L., 1766). For loggerhead turtles, Türkecan & Yerli (2007) estimated a predation rate of hatchlings of 4.8% after a 30-minutes follow-up. Whelan & Wyneken (2007) found a rate of 4.6% after 15 minutes following *C. caretta* hatchlings after they entered the sea.

The present study is pioneer in Cabo Verde and aims to contribute to the knowledge of loggerhead sea turtle predator species and their hatchling mortality rates at sea.

MATERIAL AND METHODS

The study took place between the 1st of October and the 22nd of November 2020, on Boavista Island that host the main nesting rookery of Cabo Verde (Fig. 1).

Three methodologies were used: surveys, dissection of potential predatory fishes of the turtle hatchlings and follow-up of hatchlings to estimate mortality in coastal waters.

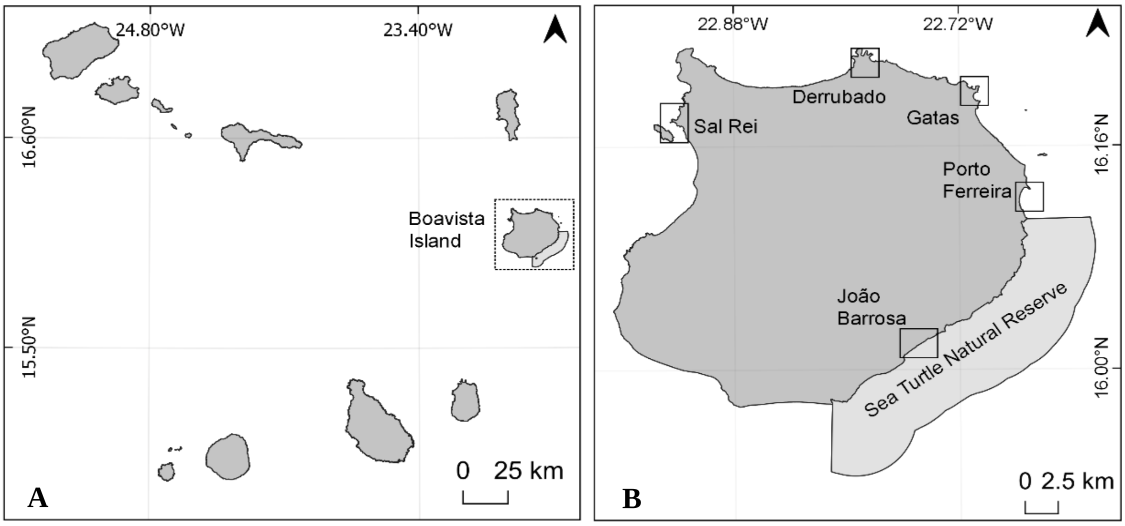

Fig. 1. Study area and study sites. **A)** Map of the Cabo Verde Archipelago, highlighting its location and Boavista Island, the study area. **B)** Location of the study sites. João Barrosa beach (Sea Turtle Natural Reserve) was the site where the follow-up of hatchlings was carried out to estimate mortality in coastal waters. The four harbours on Boavista, where surveys and dissection of potential predatory fish were carried out, are also mapped.

The interviews were oral, anonymous, and registered on data sheets and randomly targeted 66 artisanal fishermen and 23 fishmongers from the main four harbours of the island (Fig. 1), as well as five cooks (as they frequently detect preyed turtle hatchlings when preparing fish) from some restaurants of Sal Rei. The questionnaires directed to fishermen were related to their fisheries and fishing areas while those directed at the fishmongers and cooks were related only to the potential predators. The abundance of nests per zones was obtained from Marco *et al.* (2012).

The morphological analysis of stomach contents of 334 potential predators of 17 different species (1–66 stomachs per species) was performed to verify the presence and relative frequency of loggerhead turtle hatchlings as estimates of the importance of hatchlings in their trophic ecology. Fish species were considered as predators if at least one hatchling was found in the stomachs (Fig. 2).

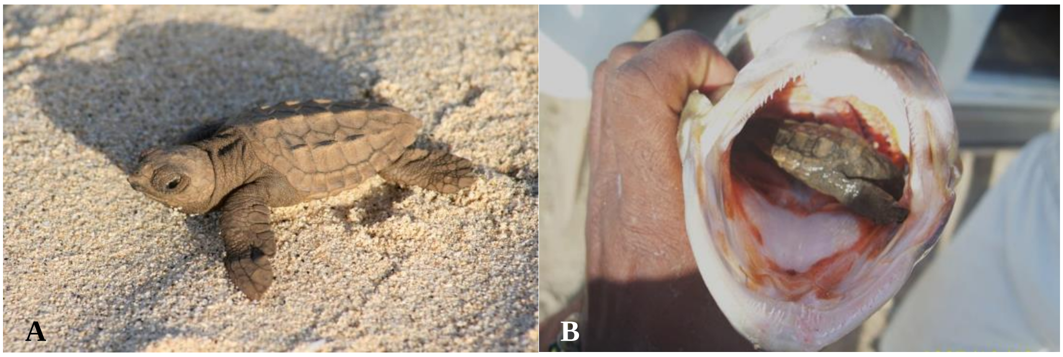

Fig. 2. Loggerhead turtle *Caretta caretta* hatchlings of Boavista, Cabo Verde. **A**) Hatchling found on the beach (photo by A. Marco) and **B**) captured by a fish predator (photo by S. Martins).

The experimental estimation of mortality rate in coastal waters was carried out on João Barrosa beach (Fig. 1). The experiment consisted of a follow-up of individual hatchlings swimming in the sea for 30 minutes and counting how many were captured by fish. Similar methodologies have been used in other studies (Türkecan & Yerli 2007, Reising *et al.* 2015, Thums *et al.* 2019, Oñate-Casado *et al.* 2021). The mortality rate for eight different scenarios was calculated taking into account two scenarios of distance from the shore to the end of the continental platform (6000 and 10000 m), two estimations of the swimming speed of hatchlings (5 and 12 m/min; O'Hara 1980; Wyneken & Salmon 1992), and two experimental estimations of capture rate based in the results of the experimental tests. The experimental capture rate (C) was calculated using the equation: C= Np/ N*100 (Np= number of predated hatchlings; N= number of total hatchlings). The estimate of mortality (M) in time and distance function was made through the equation: M= C*Ns (C= capture rate at different scenarios; Ns= number of surviving hatchlings in 30 min).

RESULTS

A total of 18 fish species were identified as potential predators of turtle hatchlings (Fig. 3). The interviews listed 13 potential predators (Table 1). The bluespotted seabass *Cephalopholis taeniops* was the most frequently mentioned (29.45% of the times) and the blue runner *Caranx crysos* was the second most cited (13.69% of the times). Most fishing areas identified by fishermen largely coincided with *C. caretta* nesting areas.

Seven out of 334 fish individuals corresponding to 18 different species had one loggerhead turtle hatchling in the stomach content. Three hatchlings were found in three bluespotted seabreams and the remaining four in a blue runner, a pigsnout grunt, a golden African snapper and a dusky grouper (Table 1). On average, 2.1% of all fishes had a hatchling on their stomach – 16.2% in demersal fishes and 0.8% in pelagic fishes (Table 1). The 85.7 % of captures of hatchlings were found in demersal species.

Of the 34 monitored hatchlings, one was clearly predated and a second disappeared. Two capture rates were obtained in the first 30 minutes (1/33= 3% and 2/34= 5.9%, if the disappeared hatchling is considered as predated or excluded, respectively. Using these values of experimental hatchling mortality rate, we estimated an average mortality for eight different scenarios of 73.9%, ranging from 40.4 to 98.3% (Table 2).

Fig. 3. Most common potential predators of loggerhead turtle hatchlings in Boavista waters (all photos by A. Louro except mentioned otherwise). **A)** Bluespotted sea bass *Cephalopholis taeniops*, **B)** golden African snapper *Lutjanus fulgens*, **C)** Atlantic emperor *Lethrinus atlanticus*, **D)** brown moray *Gymnothorax unicolor*, **E)** blacktip shark *Carcharhinus limbatus*, **F)** smoothhound *Mustelus mustelus*, **G)** dusky grouper *Epinephelus marginatus* (photo by S. Martins), **H)** island grouper *Mycteroperca fusca*, **I)** yellowfin tuna *Thunnus albacares* (photo by E. P. Lopes), **J)** blue runner *Caranx crysos*, **K)** black jack *Caranx lugubris*, **L)** common dolphinfish *Coryphaena hippurus* (photo by E. P. Lopes), **M)** greater amberjack *Seriola dumerili* (photo by E. P. Lopes), and **N)** wahoo *Acanthocybium solandri* (photo by R. Freitas).

Table 1. Group, common and scientific names of the studied potential fish predators of loggerhead turtle hatchlings. The absolute (Nf) and relative (%f) frequency of individuals of each fish species is mentioned in the surveys and dissected. The number (Nh) and proportion (%h) of individuals of each dissected fish species with loggerhead turtle hatchlings found in their digestive system is also given.

Group	Potential predator		Surveys		Dissections			
	Common name	**Scientific name**	**Nf**	**%f**	**Nf**	**%f**	**Nh**	**%h**
Demersal	bluespotted sea bass	*Cephalopholis taeniops*	43	29.5	74	22.2	3	4.1
	golden African snapper	*Lutjanus fulgens*	1	0.7	62	18.6	1	1.6
	Atlantic emperor	*Lethrinus atlanticus*	2	1.4	18	5.4	0	0.0
	brown moray	*Gymnothorax unicolor*	7	4.8	10	3.0	0	0.0
	sharks and rays	*Elasmobranchii*	19	13.0	9	2.7	0	0.0
	dusky grouper	*Epinephelus marginatus*	16	10.9	7	2.1	1	14.3
	pigsnout grunt	*Pomadasys rogerii*	0	0.0	5	1.5	1	0.0
	Bermuda chub	*Kyphosus sectatrix*	0	0.0	1	0.3	0	0.0
	island grouper	*Mycteroperca fusca*	7	4.8	1	0.3	0	0.0
Pelagic	yellowfin tuna	*Thunnus albacares*	9	6.2	66	19.8	0	0.0
	blue runner	*Carans crysos*	20	13.7	36	10.8	1	13.9
	black jack	*Caranx lugubris*	1	0.7	0	0.0	0	0.0
	common dolphinfish	*Coryphaena hippurus*	15	10.3	16	4.8	0	0.0
	amberjack	*Seriola* spp.	4	2.7	15	4.5	0	0.0
	wahoo	*Acanthocybium solandri*	2	1.4	10	3.0	0	0.0
	yellowmouth barracuda	*Sphyraena viridensis*	0	0.0	2	0.6	0	0.0
	rainbow runner	*Elagatis bipinnulata*	0	0.0	1	0.3	0	0.0
	bluefish	*Pomatomus saltatrix*	0	0.0	1	0.3	0	0.0
All			146	100	334	100	7	2.1

Table 2. Estimation of mortality rate (M) of *Caretta caretta* hatchlings using an experimental study of predation rate and eight ecological scenarios. Different scenarios (Scenario) are the result of combining two capture rates (C) measured in experimental trials conducted during 30 minutes, two estimated mean hatchling swimming speed (Speed) based on personal observations, and two scenarios of distance (Distance) of platform from the shore where predation is more likely.

Scenario	C (%)	Speed (m/min)	Distance (m)	M (%)
1	3.0	5	6000	70.4
2	5.9	5	6000	91.2
3	3.0	5	10,000	87.0
4	5.9	5	10,000	98.3
5	3.0	12	6000	40.4
6	5.9	12	6000	64.4
7	3.0	12	10,000	57.9
8	5.9	12	10,000	81.8

DISCUSSION

In this study, a small portion of fish that were listed as potential predators of *C. caretta* hatchlings around Boavista Island, were proven to be actual predators. These predators belong to the Serranidae, Carangidae, Lutjanidae, Muraenidae and Scombridae families and Elasmobranchii subclass. Species of these families are described as predators of sea turtle hatchlings in other countries in previous studies. For example, Gyuris (1994) referred serranids, followed by lutjanids and elasmobranchids as the most observed predators in Australia for green turtle hatchlings. Stewart & Wyneken (2004) previously listed a Carangidae species proved to be a predator on Boavista (*Caranx crysos*) as a predator to loggerhead turtle hatchlings in Florida (USA).

The number of stomach samples was low for some species, which may result on a biased low-frequency value of hatchlings in the stomachs of some predators. Thus, sample sizes for some of these species should be increased in future studies. For example, the blacktip shark *Carcharhinus limbatus* (Valenciennes 1839) and the smoothhound *Mustelus mustelus* (L., 1758), even though no hatchlings have been found inside their stomachs, are potentially one of the largest turtle predators following previous studies (Bashir *et al.* 2020). The juveniles of these predator species are abundant in the shallow waters near the nesting beaches of Boavista (S. Martins, pers. obs.). According to Bashir *et al.* (2020), there is often predation of turtle hatchlings near beaches by juvenile sharks that roam around. In addition, the depth and distance of the fishing areas concerning the turtle nesting areas are two factors that may be the cause of low frequencies of hatchlings in fish's stomachs that were brought from local fish markets. According to fishermen, fishing activity usually takes place at more than 10 m deep and the most frequented fishing banks are far from the eastern area of Boavista (Monteiro *et al.* 2008). According to Oñate-Casado *et al*. (2021), as the distance from the coast and depth increases, the risk of turtle predation decreases and the chances of survival increase.

The mortality was estimated at João Barrosa beach, so it is only applicable to ecologically similar areas to the south/ southeast of the island. This is due to the high coastal diversity of Boavista which does not allow generalizing this rate to the whole island. The abundance of marine predators on Boavista and the high density of hatchlings may be the main explanations for the high mortality as both are directly related to predation levels in an area (Pilcher *et al.* 2000, Reising *et al.* 2015). The average mortality rate of hatchlings in different rookeries is highly variable. The results found in Boavista are very different compared to most of the other studies. Mortality rate for loggerhead hatchlings in the first 15 min in the water was 5–26% in Florida (Wyneken *et al.* 2000, Stewart & Wyneken 2004, Whelan & Wyneken 2007). In Australia, mortality in the first hours in the water was 72% for flatback turtle hatchling (Thums *et al.* 2019) and 31% for green turtle hatchlings in the first 15–60 min (Gyuris 1994). The 46.7% of olive ridley hatchlings were predated in the first 2 hours in Pacific Honduras (Pilcher *et al.* 2000). The 57% of hawksbill hatchlings were predated in the water in the first 30 min into the water in Antigua (Reising *et al.* 2015).

In the stomach contents, a maximum of one hatchling was found by individual predator. This may be due to the strategy of hatchlings dispersion after born or the ambush predator's behaviour. According to Scott *et al*. (2014), hatchlings always swim alone, which make it harder for predator to catch more than one individual simultaneously. The low frequencies of occurrence of hatchlings on fish stomachs suggest that are occasional preys in the fish diet. The fact that hatchlings are available for only a maximum of four months per year (Marco *et al*. 2012) may be an important factor to explain why fishes are generalists, especially predators far from the nesting zone. Previous similar studies in Florida showed that only 11 of 217 fishes had a loggerhead turtle hatchling in their stomach (Stewart & Wyneken 2004).

Characterizing predation of hatchlings in coastal waters remain challenging for researchers, as the methods for estimating predation are not very efficient (Stewart & Wyneken 2004). Estimates require assumptions to be made, integrating a large amount of data from fisheries and predators. The present study provides an estimate of the mortality of hatchlings in one beach on Boavista, but the overall estimate for the entire island was not possible due to the lack of crucial information such as abundance and distribution of predators. For this reason, it is recommended to replicate the study in different parts of the island to have further data for spatial and temporal comparisons. We also advise sampling fish predator's guts in waters close to the turtle nesting beaches to further study their impact.

ACKNOWLEDGEMENTS

We thank all the staff and volunteers from Cabo Verde Natura 2000 and BIOS.CV for their support. We appreciate G. Barbosa, V. Brito, O. Rodrigues and J. Patino-Martínez's help for sampling. This study was possible with the efforts of the fishermen and fishmongers. We also thank the national environmental authorities of Cabo Verde for the permits. This study was supported by MAVA's Project "Tartaruga Boa Vista".

REFERENCES

Bashir, Z., Abdullah, M., Ghaffar, M. & Rusli, M.U. (2020) Exclusive predation of sea turtle hatchlings by juvenile blacktip reef sharks *Carcharhinus melanopterus* at a turtle nesting site in Malaysia. *Journal of Fish Biology*, 97, 1876–1879.

Booth, D.T., Oñate-Casado, J., Rusli, M.U. & Stewart, T. (2019) Towing a float decreases swim speed but does not affect swimming during offshore swimming in sea turtle hatchlings. *Chelonian Conservation and Biology*, 18, 112–115.

Casale, P. & Marco, A. (2015) *Caretta caretta (North East Atlantic subpopulation)*. The IUCN Red List of Threatened Species 2015, e.T83776383A83776554. Download from https://www.iucnredlist.org/species/ 83776383/83776554 on 17/09/2022.

Glenn, L. (1996) *The orientation and survival of loggerhead sea turtle hatchlings (*Caretta caretta L.*) in the nearshore environment*. MS thesis. Florida Atlantic University, Boca Raton, USA, 62 pp.

Goodenough, J., McGuire, B. & Wallace, R.A. (2001) *Perspectives on Animal Behavior, 2nd edition.* John Wiley and Sons, Inc., New York, USA, 542 pp.

Gyuris, E. (1994) The rate of predation by fishes on hatchlings of the green turtle (*Chelonia mydas*). *Coral Reefs*, 13, 137–144.

Laloë, J. O., Cozens, J., Renom, B., Taxonera, A. & Hays, G.C. (2020) Conservation importance of previously undescribed abundance trends: increase in loggerhead turtle numbers nesting on an Atlantic Island. *Oryx*, 54, 315–322.

Marco, A., Abella, E., Liria-Loza, A., Martins, S., López, O., Jiménez-Bordón, S., Medina, M., Oujo, C., Gaona, P., Godley, B.J. & López-Jurado, L.F. (2012) Abundance and exploitation of loggerhead turtles nesting in Boa Vista Island, Cape Verde: the only substantial rookery in the eastern Atlantic. *Animal Conservation*, 15, 351–360.

Mazaris, A.D., Fiksen, Ø. & Matsinos, Y.G. (2005) Using an individual-based model for assessment of sea turtle population viability. *Population Ecology*, 47, 179–191.

Monteiro, P., Ribeiro, D., Silva, J. A., Bispo, J., & Goncalves, J.M.S. (2008) Ichthyofauna assemblages from two unexplored Atlantic seamounts: Northwest Bank and João Valente Bank (Cape Verde archipelago). *Scientia Marina*, 72, 133–143.

Monzón-Argüello, C., Rico, C., Naro-Maciel, E.E., Varo-cruz, N., López, P., Marco, A. & López-Jurado, L.F. (2010) Population structure and conservation implications for the loggerhead sea turtle of the Cape Verde Islands. *Conservation Genetics*, 11, 1871–1884.

O'Hara, J. (1980). Thermal influences on the swimming speed of loggerhead turtle hatchlings. *Copeia*, 773–780.

Oñate-Casado, J., Booth, D.T., Vandercamere, K., Sakhalkar, S.P. & Rusli, M.U. (2021) Offshore dispersal and predation of sea turtle hatchlings I: A study of hawksbill turtles at Chagar Hutang Turtle Sanctuary, Malaysia. *Ichthyology & Herpetology*, 1, 180–187.

Patino-Martinez, J., Dos Passos, L., Afonso, I., Teixidor, A., Tiwari, M., Székely, T. & Moreno, R. (2022) Globally important refuge for the loggerhead sea turtle: Maio Island, Cabo Verde. *Oryx*, 56, 54–62.

Pitcher, N.J., Enderby, S., Stringell, T. & Bateman, L. (2000) Nearshore turtle hatchling distribution and predation. *In:* Pilcher, N. & Ismail, G. (Eds), *Sea Turtles of the Indo-Pacific*. ASEAN Academic Press, UK, pp. 151–166.

Reising, M., Salmon, M. & Stapleton S. (2015) Hawksbill nest site selection affects hatchling survival at a rookery in Antigua, West Indies. *Endangered Species Research*, 29, 179–187.

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

Stewart, K.R. & Wyneken, J. (2004) Predation risk to loggerhead hatchlings at a high-density nesting beach in Southeast Florida. *Bulletin of Marine Science*, 74, 325–335.

Thums, M., Pattiaratchi, C., Whiting, S., Pendoley, K., Ferreira, L. & Meekan, M. (2019) High predation of marine turtle hatchlings near a coastal jetty. *Biological Conservation*, 236, 571 –579.

Türkecan, O., & Yerli, S.V. (2007) Marine predation on loggerhead hatchlings at Beymelek Beach, Turkey. *Israel Journal of Ecology & Evolution*, 53, 167–171.

Wallace, B.P., Di Matteo, A.D., Hurley, B.J., Finkbeiner, E.M., Bolten, A.B., Chaloupka, M.Y., Hutchinson, B.J., Abreu-Grobois, F.A., Amorocho, D., Bjorndal, K.A., Bourjea, J., Bowen, B.W., Briseño-Dueñas, R., Casale, P., Choudhury, B.C., Costa, A., Dutton, P.H., Fallabrino, A., Girard, A., Girondot, M., Godfrey, M.H., Hamann, M., López-Mendilaharsu, M., Marcovaldi, M.A., Mortimer, J.A., Musick, J.A., Nel, R., Pilcher, N.J., Seminoff, J.A., Troëng, S., Witherington, B. & Mast, R.B. (2010) Regional management units for marine turtles: a novel for framework for prioritizing conservation and research multiple scales. *Plos One*, 5, E15465.

Whelan, C.L. & Wyneken, J. (2007) Estimating predation levels and site-specific survival of hatchling loggerhead seaturtles (*Caretta caretta*) from South Florida beaches. *Copeia*, 3, 745–754.

Witherington, B.E. & Salmon, M. (1992) Predation on loggerhead turtle hatchlings after entering the sea. *Journal of Herpetology*, 26, 226–228.

Wyneken, J. & Salmon, M. (1992). Frenzy and postfrenzy swimming activity in loggerhead, green, and leatherback hatchling sea turtles. *Copeia*, 1991, 478–484.

Wyneken, J., Fisher, L., Salmon, M. & Weege, S. (2000) Managing relocated sea turtle nests in open-beach hatcheries. Lessons in hatchery design and implementation in Hillsboro Beach, Broward County, Florida. *In:* Kalb, H., Wibbels, T. (Eds), *Proceedings of the Nineteenth Annual Symposium on Sea Turtle Conservation and Biology*. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-SEFSC-443, USA, pp. 193–194.

Received 21 July 2022
Accepted 12 December 2022