A Case of a Loggerhead Sea Turtle Severely Injured Due to Aggressive Intraspecific Interactions

Kostas Papafitsoros[1,2,#], Galini Samlidou[1], Eirini Kasimati[1], Dimitris Margaritoulis[1]

[1]*ARCHELON, the Sea Turtle Protection Society of Greece, Athens, Greece*
[2]*Queen Mary University of London, London, UK ([#]k.papafitsoros@qmul.ac.uk)*

While aggressive interactions among sea turtles attributed to mating are well understood (Booth & Peters 1972; Schofield et al. 2006; Bennett & Keuper-Bennett 2008), studies that focus on sea turtle aggression in other contexts are limited and have only recently caught the attention of the scientific community. Low levels of aggression mainly expressed as gentle nudges or "one-off" bites, have been documented for female turtles competing for optimal resting spots before and during the nesting period (Schofield et al. 2007) as well as for access to fish cleaning stations (Schofield et al. 2017). On the other hand, extreme levels of aggression leading to intense bite-dominated interactions can appear where sea turtles compete over limited foraging resources which are perceived as highly valued by individuals. This behaviour has been particularly documented for Mediterranean loggerheads (*Caretta caretta*) and it appears both in natural foraging spots, e.g. small reefs abundant in sponges (Papafitsoros & Schofield 2019; Schofield et al. 2022) and in artificial ones, e.g. typically in small ports where sea turtles feed on fishermen's discards or even intentionally fed (Comis et al. 2015; Theodorou et al. 2022). Elevated aggressive behaviours appear in other sea turtle species as well, such as green turtles (*Chelonia mydas*) and hawksbills (*Eretmochelys imbricata*) - albeit seemingly to a lesser degree than loggerheads - in both natural and artificially created foraging areas (see Smolowitz et al. 2015; Thomson et al. 2015; Gaos et al. 2021). There are also several publicly available videos in social media that support this fact (Kostas Papafitsoros, personal observations). Although aggressive intraspecific interactions are known to affect the occupancy and movements of individual sea turtles at focal sites—be it for resting, cleaning, or foraging—their potential negative impacts on turtle health and well-being have received little attention. One main reason is that sea turtles can efficiently defend themselves from attacks by other animals by performing sharp, rapid circular movements and vertically positioning their carapace which most of the times allows them to avoid bites from predators (Hounslow et al. 2021) but also from conspecifics. Hence serious injuries inflicted by other turtles outside the mating season, seem to be rare.

Here, we report a case involving a male loggerhead sea turtle (with identity code "t652") that sustained severe injuries to its carapace and flippers, which we attribute with high confidence to repeated attacks by conspecifics at an artificially created foraging site within a fishing port in Laganas Bay, Zakynthos Island, Greece, Fig. 1(a-b). Aggressive interactions involving this male occurred over a period exceeding one year and his extensive injuries were attributed to his reduced defensive capabilities due to buoyancy problems and limited agility, which resulted from previous injuries.

The observations took place at the Agios Sostis area, Laganas Bay, Zakynthos, see Fig. 1(b), within and just outside Agios Sostis Port. Among others, the port is commonly used by a small number of small fishing boats, and it attracts long-term resident loggerhead turtles (mainly males) which feed on fishermen's discards. Highly aggressive antagonistic interactions among these resident turtles occur daily during May-October and are typically immediately

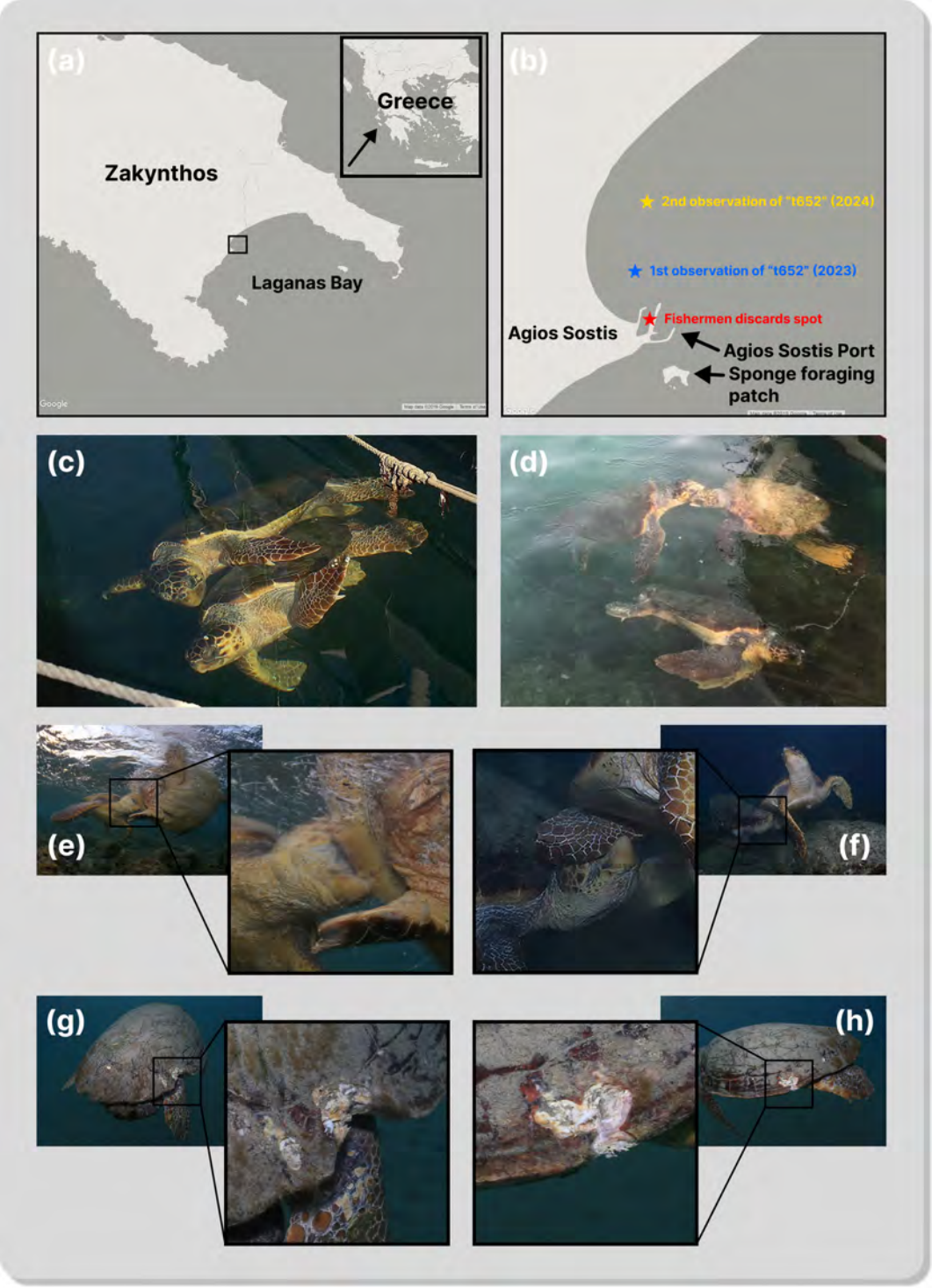

Figure 1. (a) Map of Greece and Laganas Bay, Zakynthos Island. (b) Map which corresponds to the area enclosed by the small square on the left map, showing the approximate locations of the two underwater observations of the male turtle t652 (blue and yellow stars), the location where resident turtles forage on fishermen's discards (red star) as well as a natural foraging patch (sponges) studied in Schofield et al. (2022). (c-d) Examples of aggressive interactions among resident sea turtles over foraging resources (here, fishermen's discards in Agios Sostis Port). (e-f) Examples of turtles biting the carapace and flipper of other turtles during aggressive interactions over foraging resources (here from the natural foraging patch shown in (b)). (g-h) Examples of minor carapace injuries at a male resident turtle frequenting Agios Sostis Port, due to bites by other turtles during aggressive interactions. All photographs by Kostas Papafitsoros.

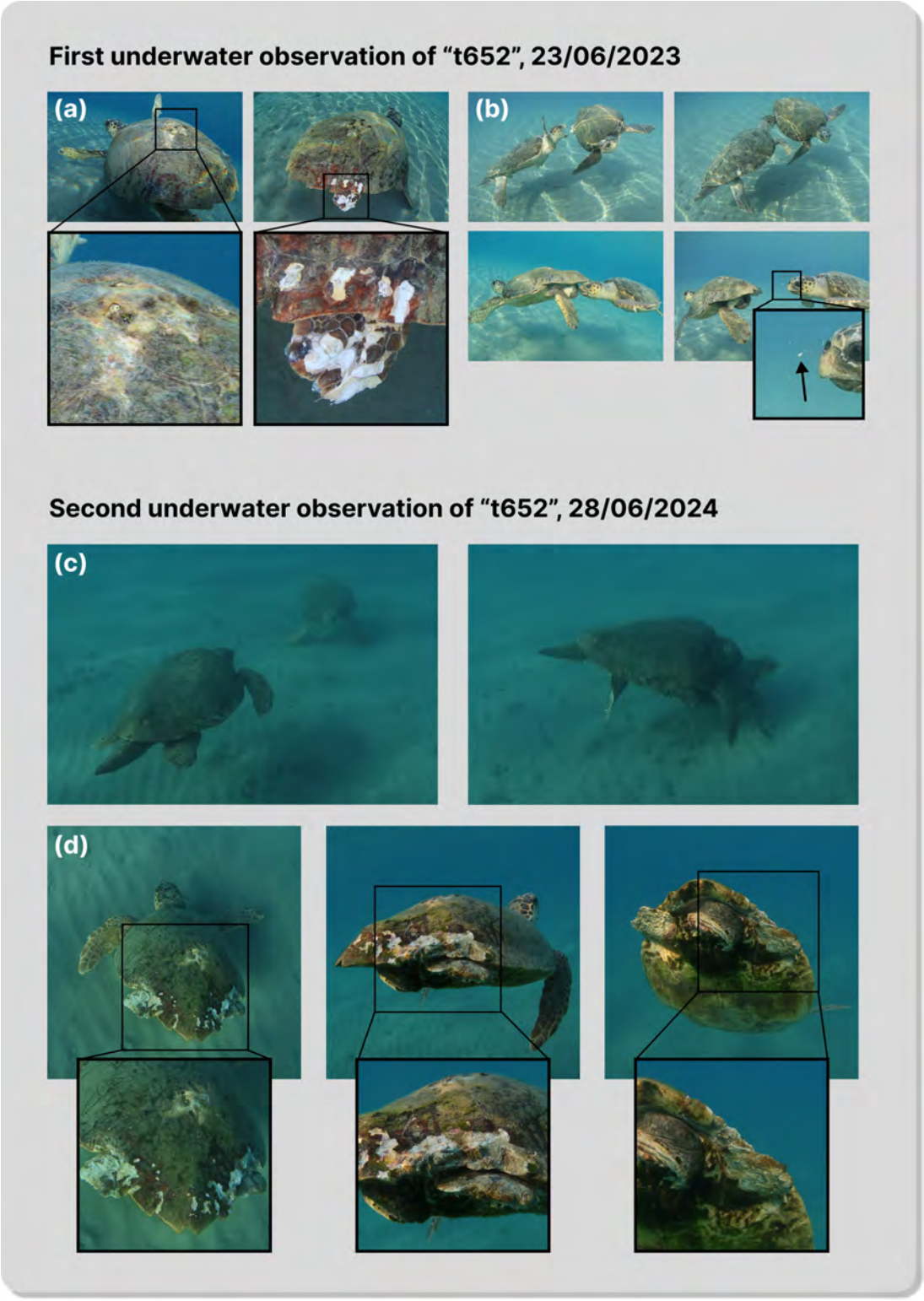

Figure 2. Photographs from the first (a-b) and - after one year - from the second (c-d) underwater observation of the male turtle t652. (a) Details of the carapace injury and deformity as well as biting marks of the hind right flipper and the carapace. (b) Turtle t652 attacked by the resident male SM21-42 who bit t652's hind right flipper twice, see visible scales that were shed off as a result of the last bite (extracted frames from video). (c) Turtle t652 (top right getting attacked by resident male; observe his buoyancy problem which is still present. (d) Details of extensive injuries and biting marks on the posterior part of the carapace and both hind flippers. Photographs of first and second encounter by Kostas Papafitsoros and Galini Samlidou respectively.

triggered upon visual contact (Schofield et al. 2006), see Fig. 1(c-d) for some examples. Due to avoiding circular movements of the defending individuals, bites – if successful – will typically be directed mainly at the hind flippers or the posterior part of the carapaces, see Fig. 1(e-f) for some representative examples from interactions in a nearby reef studied in Schofield et al. (2022), whose location is also shown in Fig. 1(b). These bites can lead to shedding of the outmost keratinous layers of the marginal or supracaudal scutes, see Fig. 1(e-h). These minor injuries are typically healed within weeks (Kostas Papafitsoros, personal observations).

The male loggerhead turtle t652, was first observed and photographed by the first author on 23 June 2023 a few metres outside Agios Sostis Port, during an underwater survey conducted in the context of a long-term photo-identification project, see Schofield et al. (2020) and Papafitsoros et al. (2021) for more details on the methods and general context. The turtle had a carapace deformity, with the posterior part of it bent downwards, Fig. 1(a). An old carapace injury at the fourth central scute could also be observed. We assessed that both the carapace injury and the deformity were likely caused by a boat collision. The turtle also exhibited buoyancy problems with the posterior part of the carapace being elevated. Its tail was tightly curved under the carapace which is a typical protective behaviour. The turtle had extensive bite marks on its marginal scutes above the hind right flipper which were consistent with the previously described marks formed by turtle bites. The flipper itself was severely bitten, and its scales had been shed. We observed that the turtle could hardly move this flipper. During the same observation, the turtle t652 encountered a resident male (with identity code “SM21-42”) which had repeatedly been observed to forage and engage in aggressive interactions in the nearby port. SM21-42 immediately attacked t652 and successfully bit its hind flipper (a video is available). Visible pieces of shed flipper scale tissue were cut off during the second bite, Fig. 2(b). It was evident that the buoyancy and flipper mobility issues of t652 significantly limited its defensive manoeuvring capabilities. During the remaining summer of 2023, t652 was observed four more times in the wider Agios Sostis area via photos in social media where he was identified through photo-identification, see Papafitsoros et al. (2021) for the related methodology. These images confirmed his continued presence in the area but no further interactions with other turtles were recorded.

In June 2024, t652 was observed again by the first two authors, this time inside the Agios Sostis port, evidently to forage on fishermen’s discards. The turtle's condition had significantly worsened as both hind flippers had been partially cut off, accompanied by several deep, recent bite wounds around the carapace. On that occasion, he was observed being attacked by other turtles and it was again evident that he was unable to manoeuvre effectively to avoid the bites. No photos or videos are available from this observation. However, on 28 June 2024, he was found resting on the seafloor a couple of hundred metres from the port, again with obvious buoyancy issues, see Fig. 1(b) for the approximate location. Immediately after the observation started, another resident male turtle (“t396”), also regularly foraging and involved in aggressive fights in the port, approached and attacked him, see Fig. 2(c). The attack itself lasted for only a few seconds as t396 did not follow t652 when the latter swam away. It was assessed that t652’s worsening physical condition, see Fig. 2(d), and buoyancy problems, posed a significant risk of boat collision, a known life-threatening hazard in the area (Papafitsoros et al. 2021). The turtle was thus captured and transferred to ARCHELON’s Sea Turtle Rescue Centre for treatment and rehabilitation.

On 29 June 2024, the day after t652’s capture and removal from the water, the individual was admitted to the Rescue Centre, following a six-hour ferry and bus

Figure 3. Photos of the hind flippers and carapace of t652 upon arrival at ARCHELON's Sea Turtle Rescue Centre on 29 June 2024 (top) and prior his release 11 weeks later, on 11 September 2024 (bottom).

transport. Upon arrival, the turtle's condition and injuries were assessed. His reflexes were good throughout the body, front flippers, eyes and head. However, the reflexes of the hind flippers were hypoactive; the responses were weak and subtle but not absent, which was consistent with the underwater observations. Overall, he had a good body score, while the fresh hind flipper wounds required immediate treatment. The healed old carapace injury had some necrotic tissue present, as well as algae and bacteria that needed to be removed. Due to the severity of the bite wounds on the carapace and hind flippers (see Fig. 3) fluids, antibiotic and painkiller were administered. The turtle was placed later in a tank (1000 litres) where he remained mainly on the surface of the water as he was experiencing buoyancy issues. An X-ray showed that he was clear from foreign body ingestion and lung infection. The turtle started to eat right away when food was offered to him with forceps later that day. Over the course of two months, t652 received topical wound care treatments, either two or three times per week, as well as the aforementioned medication. Every wound treatment always started with the debridement of the necrotic, damaged and infected areas to promote healing and prevent further infection. This was followed by the disinfection of the affected areas, and the procedure was concluded with the use of topical medications and dressings that made direct contact with healthy tissue. More specifically, a topical antibiotic cream (Silver Sulfadiazine cream, known as SSD cream) was used for the first two weeks. This cream was afterwards replaced with honey that continued to improve the healing process. As the wounds were healing, the turtle

Figure 4. Photographs of an adult loggerhead male of Zakynthos, taken right after the mating season (11/06/2019) showing characteristic injuries on front and hind flippers, presumably resulting from bites by other rival males over competition for access to females. Observe the different nature between these injuries and the ones of t652 in Fig. 2, in particular the absence of carapace injuries.

continued to eat very well, and his buoyancy had improved greatly as he was observed resting on the bottom of tank several times. In the meantime, the administration of the antibiotic concluded after five weeks and of the painkiller after six weeks (including its gradual dosage decrease) since his arrival at the Rescue Centre. Due to the overall progress of t652, on 22 August he was moved in one of the big tanks (12000 litres) to assess his ability to dive and forage in a deeper and larger space. In less than a week, the turtle was able to dive and rest of the bottom of the tank perfectly and without any incline. His hind flipper reflexes also improved but without achieving full mobility. He also continued to eat very well on his own, while he interacted with great interest to the environmental enrichment programme that he was provided with daily. This included different ways of presenting the food, e.g. in a PVC pipe or feeding ball, and inserting PVC pipe formations to encourage natural behaviours, e.g. scratching of carapace. The turtle was kept a while longer for further observations in the big tank until he was cleared for release. On 11 September 2024, after almost 11 weeks of rehabilitation, his release took place in Palaia Fokaia, Attica (about 33 km from the Rescue Centre). The turtle has not been observed since.

Even though, we only directly observed the individual t652 on three occasions overall – plus some recordings from social media – we are confident that his injuries were indeed inflicted by other turtles' bites rather than by predators such as monk seals or sharks. First, the type and location of bite marks on the carapace were highly consistent with the ones observed on turtles involved in intraspecific aggressive interactions at this site. Second, we did directly observe t652 being attacked by turtles during all three observations. Third, it is evident that these injuries were gradually inflicted and were not the result of a one-off attack. Fourth, the injuries were not consistent with the ones caused by animals known to predate on turtles. In particular, Mediterranean monk seals (*Monachus monachus*) are known to have attacked turtles on Zakynthos (Margaritoulis & Touliatou 2011) but most of these attacks left the turtles with open body cavities at the soft areas between the plastron and the flippers and were lethal. Similarly, shark attacks are equally severe and leave characteristic tooth marks (Heithaus et al. 2002, 2008) which we did not observe in our case. However, we cannot exclude the possibility that alongside bites from other turtles, t652 was additionally bitten by other animals such as

for instance large fish feeding on its dead skin.

In sea turtles (Schofield et al. 2006; Alderson 2009) as well as in other species (Keevil et al. 2017), injuries resulting from intraspecific aggression are mostly reported in the literature in the context of male-male competition for access to females as well as male-female aggression during mating. These injuries include bites to the flippers, neck, and tail of mating males by rivals attempting to dislodge them from females, see Fig. 4 for a characteristic example. They can also include lacerations on the shoulders of females caused by male claws as well as neck bites inflicted by males on females, presumably to induce them to surface for breathing (Schofield et al. 2006). We remark that the injuries of t652 were not compatible with any of these. Additionally, we are not aware of any cases in which rehabilitation centres have reported admitting sea turtles with injuries resulting from intraspecific aggression. Indeed, since ARCHELON Rescue Centre began operating in 1994, cases of attacks by other animals have accounted for less than 1% of all admissions (Margaritoulis et al. 2025). However, all such incidents involved predatory attacks, with affected individuals exhibiting either dog bites inflicted during nesting (Margaritoulis et al. 2019) or bite wounds inflicted by Mediterranean monk seals (Margaritoulis & Touliatou 2011). Therefore, the case of t652 is a unique one, compared to all the other turtles that have been admitted to the Rescue Centre so far.

Intraspecific interactions over foraging resources tend to be associated with exceptional high levels of aggression in loggerheads which are individual specific with some individuals being significantly more aggressive than others (Schofield et al. 2022). Moreover, aggression levels in these cases are likely to be associated to the perceived value of the prey, with the highest levels appearing to occur in small ports over fishermen's discards. In fact, a 11-year study of aggressive interaction in the nearby sponge foraging patch, reported no serious injuries to turtles resulting from these interactions, even though they were bite-dominated. On the other hand, turtles targeting fishermen's discards in Agios Sostis port seem to have more visible bite marks than the ones naturally foraging for sponges (Kostas Papafitsoros, personal observations). In addition to the unusually high levels of aggression, we attribute this to the fact that the defending turtles do not immediately flee after the attack, likely because they perceive the fishermen's discards as being of high value. Additionally, obstacles such as boats and ropes hinder their defensive manoeuvres by restricting their ability to move freely – indeed turtles have been observed numerous times getting entangled in ropes during these interactions. Successful defence against attacks from both predators and conspecifics requires good physical condition and a capability to manoeuvre efficiently. For instance, Heithaus et al. (2002) noted that loggerheads in Shark Bay, Western Australia are more likely to get injured by sharks than green turtles, which was attributed to the fact that green turtles were faster and manoeuvred better than the loggerheads. In the case of t652, it was clear that his buoyancy problems and hypoactive hind flippers significantly reduced his defensive capacities.

We finally remark that, even though the injuries of t652 were the result of conspecific aggression which occurs over natural foraging spots (Schofield et al. 2022), we cannot disregard the underlying influence of anthropogenic activities that indirectly contributed to this outcome. His old carapace injuries, the most likely cause for his mobility issues, were very likely the result of a boat collision and the aggression itself was largely intensified by the artificial foraging spot established in the port. The findings of the present article adds to the growing list of adverse effects associated with the creation artificial foraging areas whether through fishermen's discard or intentional feeding. Apart from elevated levels of aggression to other turtles, these adverse effects also include: Aggression

towards humans (Theodorou et al. 2022), higher risk of diseases (Stewart et al. 2016; Monzón-Argüello et al. 2018), higher risk of boat collisions and entanglement with fishing equipment (Papafitsoros et al. 2021), adoption of unnatural foraging habits (Comis et al. 2015; Ayas et al. 2025), and increased risk of poaching (Smulders et al. 2021).

Literature cited

Alderson JE (2009) Characterization of injuries and health of injured loggerhead sea turtles (*Caretta caretta*) in coastal waters of the southeastern U.S. MSc Thesis, College of Charleston USA

Ayas D, Mahmutoğlu S, Uluca B, Korkmaz C, Uyan A, Ergüden D, Uysal A, et al. (2025) Feeding related behavioral changes of green sea turtle *Chelonia mydas* in Mersin Bay, Northeastern Mediterranean. Tethys Environmental Science 2(3): 129-137

Bennett P, Keuper-Bennett U (2008) The book of Honu: Enjoying and learning about Hawai'i's sea turtles. University of Hawaii Press

Booth J, Peters JA (1972) Behavioural studies on the green turtle (*Chelonia mydas*) in the sea. Animal Behaviour 20(4): 808-812

Comis C, Valianos N, Betts L (2015) Feeding loggerhead sea turtles increased their social antagonistic interactions in Kefalonia, Greece. Book of Abstracts, 35th Annual Symposium on Sea Turtle Biology and Conservation, Dalaman, Turkey

Gaos AR, Johnson CE, McLeish DB, King CS, Senko JF (2021) Interactions among Hawaiian hawksbills suggest prevalence of social behaviors in marine turtles. Chelonian Conservation and Biology 20(2): 167-172

Heithaus RM, Frid A, Dill L (2002) Shark-inflicted injury frequencies, escape ability, and habitat use of green and loggerhead sea turtles. Marine Biology 140: 229-236

Heithaus RM, Wirsing AJ, Thomson JA, Burkholder DA (2008) A review of lethal and non-lethal effects of predators on adult marine turtles. Journal of Experimental Marine Biology and Ecology 366(1-2): 43-51

Hounslow JL, Jewell OJD, Fossette S, Whiting S, Tucker AD, Richardson A, Edwards D, Gleiss AC (2021) Animal-borne video from a sea turtle reveals novel anti-predator behaviors. Ecology 102(4): e03251

Keevil MG, Hewitt BS, Brooks RJ, Litzgus JD (2017) Patterns of intraspecific aggression inferred from injuries in an aquatic turtle with male-biased size dimorphism. Canadian Journal of Zoology 95(6): 393-403

Margaritoulis D, Kasimati E, Panagopoulou A, Rees AF (2025) Three decades of ARCHELON's Sea Turtle Rescue Centre in Greece: Admissions, causes, and outcomes (1995-2024). [Manuscript submitted for publication]

Margaritoulis D, Theodorou P, Tsaros P, Nestoridou P (2019) Dog attacks on loggerhead turtles nesting in Greece. Marine Turtle Newsletter 158: 22-23

Margaritoulis D, Touliatou S (2011) Mediterranean monk seals present an ongoing threat for loggerhead sea turtles in Zakynthos. Marine Turtle Newsletter 131: 18-23

Monzón-Argüello C, Cardona L, Calabuig P, Camacho M, Crespo-Picazo JL, García-Párraga D, Mayans S, et al. (2018) Supplemental feeding and other anthropogenic threats to green turtles (*Chelonia mydas*) in the Canary Islands. Science of the Total Environment 621: 1000-1011

Papafitsoros K, Panagopoulou A, Schofield G (2021) Social media reveals consistently disproportionate tourism pressure on a threatened marine vertebrate. Animal Conservation 24(4): 568-579

Papafitsoros K, Schofield G (2019) Focal photograph surveys: Foraging resident male interactions and female interactions at fish-cleaning stations. In: Mangel JC, Rees A, Pajuelo M, Córdova F, Acuña N (Comps) Proceedings of the 36th Annual Symposium on Sea Turtle Biology and Conservation. NOAA Tech Memo NMFS-SEFSC-734. National Marine Fisheries Service, Miami, USA, p 253

Schofield G, Katselidis KA, Dimopoulos P, Pantis JD, Hays GC (2006) Behaviour analysis of the loggerhead sea turtle *Caretta caretta* from direct in-water observation. Endangered Species Research 2: 71-79

Schofield G, Katselidis KA, Pantis JD, Dimopoulos P, Hays GC (2007) Female-female aggression: structure of interaction and outcome in loggerhead sea turtles. Marine Ecology Progress Series 336: 267-274

Schofield G, Klaassen M, Papafitsoros K, Lilley M, Katselidis KA, Hays GC (2020) Long-term photo-id and satellite tracking reveal sex-biased survival linked to movements in an endangered species. Ecology 101(7): e03027

Schofield G, Papafitsoros K, Chapman C, Shah A, Westover L, Dickson LCD, Katselidis KA (2022) More aggressive sea turtles win fights over foraging resources independent of body size and years of presence. Animal Behaviour 190: 209-219

Schofield G, Papafitsoros K, Haughey R, Katselidis K (2017) Aerial and underwater surveys reveal temporal variation in cleaning-station use by sea turtles at a temperate breeding area. Marine Ecology Progress Series 575: 153-164

Smolowitz RJ, Patel SH, Laas HL, Miller SA (2015) Using a remotely operated vehicle (ROV) to observe loggerhead sea turtle (*Caretta caretta*) behaviour on foraging grounds off the mid-Atlantic United States. Journal of Experimental Marine Biology and Ecology 471: 84-91

Smulders FO, O'Shea OR, Christianen MJ (2021) Animal-borne video reveals atypical behaviour in provisioned green turtles: A global perspective of a widespread tourist activity. Global Ecology and Conservation 25: e01417

Stewart K, Norton T, Mohammed H, Browne D, Clements K, Thomas K, Yaw T, Horrocks J (2016) Effects of "swim with the turtles" tourist attractions on green sea turtle (*Chelonia mydas*) health in Barbados, West Indies. Journal of Wildlife Diseases 52(2s): 104-117

Thomson JA, Gulick A, Heithaus MR (2015) Intraspecific behavioral dynamics in a green turtle *Chelonia mydas* foraging aggregation. Marine Ecology Progress Series 532: 243-256

Theodorou P, Papafitsoros K, Margaritoulis D (2022) Feeding sea turtles in the wild: The example of loggerheads in Greece. Book of Abstracts, 7th Mediterranean Conference on Marine Turtles, Tetouan, Morocco