

Sea Turtles in the Harbour of Argostoli and the Koutavos Lagoon







Harbour of Argostoli and Koutavos Lagoon

Argostoli is the largest city and the administrative capital of Kefalonia, an island in the Ionian Sea off the coast of western Greece. Its southern coast is a nesting habitat for loggerhead sea turtles (*Caretta caretta*). In recent years, increasing numbers of sea turtles have been observed foraging in the Harbour of Argostoli and the Koutavos Lagoon. Wildlife Sense has monitored the island's nesting beaches and the foraging population in the Harbour of Argostoli and the Koutavos Lagoon since 2013.

Turtles foraging in Argostoli are mostly observed near the fish market, where fishing boats moor in the morning to clear their nets and sell their catch and fish markets discard scraps into the water. Turtles are also observed along the De Bosset stone-built footbridge, which separates the harbour from the shallower Koutavos Lagoon. Turtles can swim freely through several arches along the bridge.

Most sea turtles observed in the area are loggerheads, but a small number of green turtles (*Chelonia mydas*) have also been identified. For many tourists, particularly from cruiseliners that dock at the north end of the harbour during the summer, spotting sea turtles is one of the main attractions in the area.

This report is a summary of the methods and the results of the study of the population of sea turtles in the Harbour of Argostoli and the Koutavos Lagoon by Wildlife Sense during 2021.

Figure 1: The Harbour of Argostoli and the Koutavos Lagoon in Kefalonia, Greece.



Social Interactions and Foraging

Wildlife Sense researchers surveyed the harbour and Koutavos seafront of Argostoli and the DeBosset Bridge on foot to observe sea turtles and record their behaviours from May 20 to October 23. Surveys ran from 7:30 to 12:30 daily and from 17:00 to 18:30 on some days. The survey area was divided into six sectors, which were surveyed by at least six researchers: four along the harbour, one along the bridge, and one along the Koutavos Lagoon (Figure 2). Turtles were observed particularly for social antagonistic interactions between them, interactions with humans, and foraging.

Social antagonistic interactions included passive threat displays (e.g. head-tail circling) and aggressive combat (biting or sparring). Chasing was defined as one turtle closely (<1.5m) following another without mutual visual contact. This could precede or follow a mutual head to tail circling. The closer the turtles were (<1.5m), the more intense the interaction was considered. Aggressive combat, such as biting, was defined as an intense interaction where one turtle bit another. Biting while the turtles were facing was categorized as sparring. These were adapted from Schofield et al. (2007).

Researchers observed and analyzed 1474 social antagonistic interactions between turtles, each comprising of a sequence of behaviours. Chasing was observed in most interactions (n=926, 62.8%), followed by biting (n=800, 54.3%), open circling (>1.5m, n=426, 28.9%), close circling (\leq 1.5m, n=180, 12.2%), and sparring (n=52, 3.5%). These interactions were not found to adhere to the stereotyped sequence reported in Schofield et al. (2007). Instead of a resting spot, sea turtles interacting in this area were often defending or claiming a high nutrition value foraging spot, resulting in aggressive and prolonged interactions.

Out of 1065 foraging observations, the most consumed food was fish (n=616, 57.8%), followed by bivalves along the harbour wall (n=333, 31.3%), seagrass (n=56, 5.3%), human refuse (n=40, 3.8%) and



Figure 2: Six sectors along the harbour, bridge, and lagoon where researchers observed turtle behaviours.

unidentifiable items (n=20, 1.9%). Most fish came from fishing boat discards (n=487, 79.1% of fish) with tourists also feeding fish to sea turtles (n=59, 9.6% of fish).

The frequency of turtles foraging on fish at the seafront of Argostoli was expected and not assumed to represent their foraging habits in the wild. Up to 11 fishing boats docked daily in Sector 2 of the harbour to clear their nets, with non-sellable catch discarded in the sea. Fish markets along Sector 3 and restaurants along Sector 4 and the Koutavos Lagoon often dumped fish and other scraps directly into the sea. These attracted a number of turtles that fed on scraps daily. Due to this high value resource, turtles in

this area exhibited frequent and aggressive behaviours between them. Particular individuals were known to our team and to some fishermen for their territorial dominance, while turtles were frequently spotted with bite marks on their necks and flippers.

Since 2013, most sea turtle foraging and interactions were observed among the fishing boats in Sector 2. In 2021, most foraging events (n=597, 56.1%) were observed in Sector 2, followed by Sector 3 (n=379, 35.6%), but most antagonistic interactions were observed in Sector 3 (n=888, 60.2%) followed by Sector 2 (n=537, 36.4%). In Sector 3, staff from two fish markets frequently discarded bucket-fulls of fish scraps into the sea. These sank to the bottom where turtles could find and eat them. While this attracted many turtles to the area, researchers could not directly see them eating the fish in the murky water but could see their antagonistic interactions while fighting for this limited resource.

Figure 3: Two loggerhead turtles in close circling in the shallow waters of the Koutavos Lagoon.



Turtles tagged and re-captured

From March 28 to November 20, 2021, sea turtles were captured by specially trained swimmers in the Koutavos Lagoon and the Harbour of Argostoli to be tagged, photographed, and measured. Turtles received two metal tags (#681 Inconel, National Band and Tag) on opposing front flippers (Balazs 1999) and one PIT tag (ISO11784/11785 FDX-B) in triceps muscle complex of the front left flipper (Eckert and Beggs 2006). Profile photos were taken from each turtle and entered into the photo ID catalogue (Figure 4). Carapace measurements included straight carapace length (SCLn-t), straight carapace width (SCW), curved carapace length (CCLn-t), and curved carapace width (CCW). The curved and the straight length of the plastron (CPL and SPL) as well as the total tail length, post-cloacal tail length (TTL and PTL, Bolten 1999), and tail extension from carapace (Carapace Tail, Casale et al. 2005) were also measured.

A total of 214 individuals were captured, of which 156 were first captures and 58 had been capured and tagged before. Of these turtles, 133 were male, 55 were female and 26 were too young to determine the sex. Carapace measurements for all turtles captured were (cm \pm SD): CCL: 73.4 \pm 8.5, CCW: 66.6 \pm 7.3, SCL: 68.6 \pm 8.2, and SCW: 53.9 \pm 5.7. Individual measurements affected by carapace injuries were excluded. Plastron measurements were SPL 51.1cm \pm 5.4cm, CPL 53.3cm \pm 5.5cm. Tail measurements were TTL 22.2cm \pm 11.3cm, PTL 4.9 \pm 2.3cm, Tail Extension 6.5 \pm 9.5cm.

Sexually mature males (>70cm CCL, Casale et al. 2005) were briefly palpated to check for soft or "spongey" plastron, an indicator that they were sexually active (Blanvillain et al. 2008). Out of 131 males examined, 48 (36.6%) had spongey plastrons.



Figure 4: Photographs of the carapace (left), top of head (top-right) and both side profiles of head (bottom-right) were taken from all captured turtles for the photo-ID catalog.

Photographic Identification

Photographic Identification (photo-ID) is a non-invasive method used to identify individual turtles in the Bay of Argostoli. Scute patterns on the head and unique features including damage to the carapace can be used to identify a turtle. Photographs taken from turtles that were captured for tagging, dedicated photo-ID surveys with a telephoto lens, and photos taken by use of a drone all contribute to photo-ID. A total of

527 individual sea turtles have been identified and catalogued by Wildlife Sense in Kefalonia since 2013.

The Koutavos Lagoon and Harbour of Argostoli were surveyed on 183 days, usually in the morning, from January 2 to December 16, 2021. A trained photographer spotted sea turtles at distances between 2 and 200m using a telephoto camera and took photographs of turtles as they surfaced to breathe. Photographs were compared to the photo-ID catalogue and added to a known turtle or a new profile was created.



Figure 5: A juvenile green turtle (Chelonia mydas) photographed by drone (left) and telephoto camera (right) on different days in the Harbour of Argostoli. Unique scute patterns on the head helped assign these sightings to the same individual.

During this period in 2021, 340 individual sea

turtles (*Caretta caretta* and *Chelonia mydas*) were identified. More than half (57.9%, n=197) were male, just under a quarter were female (23.5%, n=80), and the rest were too small or unidentified (18.5%, n=63). Out of those turtles, 94 had been identified in previous years and were spotted again in 2021. Ten individual green sea turtles (*Chelonia mydas*) were identified in 2021. Three of them had also been seen in previous years.

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Figure 6: Number of sightings per turtle, ordered from one that was identified on 60 days (left) to many that were only identified once (right).

Frequency of Identification

Some turtles frequented the area more than others. Only 28 turtles were identified over 10 or more days, another 149 were identified twice or more, and 191 turtles were identified only once in 2021 (Figure 6).

The three most frequently identified turtles were Joey (n=60, male), Halfy (n=46, female) and Artemis (n=43, female), who have been spotted in the area over several years. Artemis has been sent to the Sea Turtle Rescue Centre in Athens twice since 2013 and continues to return to Argostoli.

Month of Identification

The time of year individuals were spotted also varied. Some turtles visited the harbour only in summer, as they had done in previous years. Others were observed throughout the year, and some were seen only in the early and later parts of the year, but not during the summer. This seasonality could hint at how each turtle utilized this foraging area in its lifecycle. The months in which each individual turtle was identified in the Koutavos Lagoon and the Harbour of Argostoli are summarized in Figure 7.

The busiest time of year in the study area was May with 162 individuals counted, followed by April with 121. March and June had similar counts (65 and 67), and the remaining months varied from 18 in January to a secondary peak of 40 in October. In December, only drone surveys for photo-ID were conduceted on five days, and four out of the seven identified turtles were green juveniles.



Figure 7: Time of the year, aggregated by month, in which individual turtles were spotted at least once in the study area.

Aerial survey counts

Aerial surveys were conducted using a quadcopter drone over a significant portion of the Koutavos Lagoon and a section of the Harbour of Argostoli. The survey area was covered by four rectangular grid flight missions with a total area of 94 ha (Figure 8). The drone flew at an altitude of 31m above sea level with a speed of 8m/sec and took minimally overlapping orthophotos at regular intervals.

Missions were flown between April and November 2021. The four areas were covered in short succession to minimize double-counting. All four areas were covered on May 17, July 6, and November 20. Partial surveys were conducted on April 9, May 20, September 27, and October 2 (Table 1).

All orthophotos were visually inspected to identify and count sea turtles. When a turtle was spotted near the edge of a photo, adjacent photos were checked to prevent double counting.



Figure 8: Aerial surveys in the Harbour of Argostoli and Koutavos Lagoon were flown in four rectangular grid missions and covered the majority of the lagoon and a section of the harbour. Dots indicate orthophotos taken and rectangles indicate the ground area covered.

Table 1: Area covered and number of turtles counted for each of the four survey areas in the Koutavos Lagoon and the Harbour of Argostoli. A total count is reported only when all four areas were surveyed.

Name	Area(ha)	Turtle Count						
		April 9	May 17	May 20	July 26	Sep 27	Oct 2	Nov 20
Harbour 1	19.7	16	14		25	12	8	6
Lagoon 1	21.6	32	39	24	11	17	12	12
Lagoon 2	21.6		52		9		3	4
Lagoon 3	28.2		8		5			0
Total	91.1		113		50			22

Most sea turtles could be clearly seen and their sex and species could be identified, but it was not possible to conduct photo-ID or to distinguish tagged from untagged turtles from orthophotos taken at an altitude of 31m. Most submerged turtles were clearly visible. In limited cases, they could only be distinguished from rocks or debris after white-balance or colour equalization adjustment.

Population counts from drone surveys indicated that the largest aggregation of sea turtles in the Koutavos Lagoon and Harbour of Argostoli occured in spring and that the number of turtles spotted along the harbour wall and De Bosset bridge in any one day are a fraction of the population that utilizes this area (Figure 9). These support the results from photographic identification.



Figure 9: Turtle frequency heatmap from aerial count on May 20, 2021. Turtles clustered in the north central area of the Koutavos Lagoon. Some turtles were spotted by the DeBosset bridge and the harbour wall.



Figure 10: Deep cuts on turtle flippers from fishing lines and nets was the most common injury in Argostoli.

Injured and dead sea turtles

Wildlife Sense regularly responds to reports of injured, distressed, or deceased sea turtles in Kefalonia. These are reported by Wildlife Sense researchers, the Coast Guard, and locals or visitors. In the Harbour of Argostoli and the Koutavos Lagoon, turtles that are unwell or dead are frequently spotted by the teams that monitor the turtles. During 2021, 56 sea turtles with moderate to severe injures and seven dead turtles were found in the Argostoli area.

Turtles that were found injured or unwell suffered from a variety of causes ranging from underlying health conditions to high impact boat strikes. The most common injury was deep cuts on the flippers caused by fishing line or fishing net entanglement (n=28), often with hooks causing additional injuries. Of these turtles, 18 were still entangled in fishing lines or fishing net wrapped around multiple flippers and their head when they were rescued (Figure 10). The cuts in tissue and muscle could become severe enough to cause limb inflamation, necrosis, a fractured humerus and/or loss of the limb. In some cases, the longline was going into the mouth or coming out of the cloaca, with x-rays revealing ingested hooks.

Propeller strikes (n=16) ranged in severity from small strikes that had penetrated the carapace to a break along its entire length.

Seven turtles had trauma to their heads likely caused intentionally by a human. Indentation marks and severe skull depressions often resembled the shape of fishing equipment. Knife wounds and stabbing, also intentional human inflicted wounds, were observed on two injured turtles. These wounds were found across the bottom part of the neck, with a depth of ~1.5cm and length of 14cm (Figure 11). One of the turtles that had a knife wound also had line entanglement injuries and was counted in both categories. Lastly, one sea turtle was found entangled in blue polyester packaging straps.

Our team provided first aid treatment to 29 of the individuals, while the remaining injured turtles did not require further treatment but were carefully checked when they were spotted again. All first aid was given under consultation of a local veterinarian and, when necessary, communication with ARCHELON's Sea Turtle Rescue Centre in Athens. Five of the turtles were sent to the Rescue Centre for further treatment and rehabilitation.

Seven sea turtles were found dead in this area during 2021. All seven had been previously tagged and had been monitored through the photo-ID programme. Dead turtles were checked for



Figure 11: A live turtle with a wound across the bottom of the neck. Assessment by a vet determined it was caused by use of a knife.

the cause of death. Four turtles had no clear cause of death and two had suffered severe propeller strikes that had severed their carapace and internal organs. One turtle had drowned, which was confirmed by foam coming out of its mouth, and had a large longline hook embedded in its flipper. Stranding sheet with details, measurements, and photos were submitted to the Coast Guard for further reporting.

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