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SHORT COMMUNICATION

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Attempts to locate and sample the white shark, *Carcharodon carcharias* (Lamniformes: Lamnidae), along the Italian coasts in the Mediterranean Sea

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Abstract: Described in the present report are documented attempts to tag and sample the white shark, *Carcharodon carcharias* (Linnaeus, 1758), along Italian coasts in the Mediterranean Sea, which took place near the Lampedusa Island in the lower Tyrrhenian Channel of Sicily, off the coast of Rimini in the Adriatic Sea, and of Civitavecchia in the central Tyrrhenian Sea. The project, activated in 2015, was aimed at tagging and sampling specimens of the white shark in order to collect data useful to implement conservation strategies in the Mediterranean Sea. Despite four tagging attempts made in 2017, 2018, 2021, and 2022 with 288 total hours of baiting activity and the use of 1030 kg of chum, no white sharks or any other shark species were sighted.
***Keywords*:** *Carcharodon carcharias*; tagging; Mediterranean Sea; Italian coast; conservation

Saželak: POKUŠAJI LOCIRANJA I UZORKOVANJA VELIKE BIJELE PSINE, *CARCHARODON CARCHARIAS* (LAMNIFORMES: LAMNIDAE), UZ TALIJANSKU OBALU U SREDOZEMNOM MORU. U radu su dokumentirani pokušaji označavanja i uzorkovanja velike bijele psine *Carcharodon carcharias* (Linnaeus, 1758) uz talijansku obalu u Sredozemnom moru. Istraživanje je obavljeno na području oko otoka Lampeduze, u sicilijanskom kanalu u južnom Tirenskom moru, ispred Riminija u Jadranskom moru te kod Civitavecchije u centralnom Tirenskom moru. Projekt, koji je započeo 2015. godine, bio je usmjeren na označavanje i uzorkovanje primjeraka velike bijele psine s ciljem prikupljanja podataka važnih za implementaciju mjera za očuvanje populacije ove vrste u Sredozemnom moru. Unatoč četiri pokušaja označavanja obavljena 2017., 2018., 2021. i 2022. godine, u ukupnom trajanju od 288 sati primamljivanja uz pomoć mamca te 1030 kg mamca, ni jedan primjerak velike bijele psine, ni drugih vrsta morskih pasa, nije primijećen.
Ključne riječi: *Carcharodon carcharias*; označavanje; Sredozemno more; talijanska obala; konzervacija

INTRODUCTION

The great white shark (WS), *Carcharodon carcharias (*Linnaeus*,* 1758) (Lamniformes: Lamnidae), is widely distributed in tropical and temperate regions of all oceans with temperatures ranging from the 5°C of Alaska to 27°C observed in tropical areas, such as Durban (Martin, 2003; Compagno *et al.*, 2005). Recently, it was observed that the WS can reach a depth of 1128 m with temperature variations between 1.6 and 30°C (Skomal *et al.*, 2017). The use of satellite telemetry on WSs off South Africa and the West Coast of the United States (Bonfil *et al.*, 2005; Weng *et al.*, 2007) showed that they can cross ocean basins and use pelagic habitats for months. Despite its distributional range, the species is quite rare. There are currently a few hotspots in which this predator is relatively abundant: California (Chapple *et al*., 2011) and Mexico (Hoyos-Padilla *et al*., 2016) in the Northeast Pacific; United States in the Northwest Atlantic (Klimley and Anderson, 1996); South Africa throughout the coastline into the Mozambiquan Channel (Kock *et al*., 2022); Australia (Bruce and Bradford, 2012), and New Zealand (Francis *et al*., 2015). In Japan (Christiansen *et al*., 2014), in the Mediterranean Sea (Micarelli *et al*., 2011; Micarelli and Sperone, 2016; Moro *et al*., 2020), and in Central Chile (from Punta Angamos to Punta Lavapie) (Martin, 2003), the abundance of this predator is quite low compared to the other areas. Notably, WS is one of the 48 species of sharks that has been observed in Italian waters (Vacchi and Serena, 2010; Serena *et al.,* 2021).

The Mediterranean basin is a model system for both marine ecological and biogeographical research. The unique combination of geological and climatic

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factors has led to the development of characteristic and highly diverse biota, as reflected by the inclusion of the Mediterranean among the most important biodiversity hotspots (Bilecenoglu *et al.*, 2013). The WS has been observed throughout the Mediterranean basin (Bradai and Saidi, 2013; Micarelli and Sperone, 2016; Tiralongo *et al.*, 2020; Kabasakal *et al.*, 2022). The WS population of the Mediterranean Sea is listed as critically endangered by the IUCN Red List, due to a 52-96% decline of its population (Moro *et al.*, 2020). Micarelli *et al.* (2011) showed that in Italian waters 42.2% of the sightings are located along the coasts of Sicily and 39.0% along the coasts of Sardinia, Calabria, Tuscany, and Liguria. The average total length (TL) of sharks observed in Italian waters was 395.70 ±155.72 cm (Micarelli *et al.*, 2011). According to Fergusson (1996), although the WS is essentially rare in the Mediterranean Sea, this area should be classified as one of the global centers of reproduction and abundance for the species. Therefore, it should be a priority to direct efforts on tagging with satellite transmitters specimens along the Sicilian coasts and further localities, where juvenile and adult WSs are seasonally encountered or known to aggregate. Investigations by Leone *et al.* (2020) suggests that the Mediterranean population has an older origin than previously thought and that this isolated population is genetically disconnected from the adjacent Atlantic one. This means that the Mediterranean population can be seriously threatened by factors causing animal losses. In the present study, authors aimed to sample and tag specimens of WSs off the coasts of Sicily, particularly around the waters of the Island of Lampedusa, the most cited of areas in the sightings and catches recorded at various times of the year with peaks during the summer season (Micarelli *et al.*, 2011; Tiralongo *et al.*, 2020). Obtained data could be valuable to better understand WS's spatial movements along the Mediterranean Sea and thereby assisting conservation efforts aimed at this species, even if not sufficient to improve studies on population dynamics.

MATERIAL AND METHODS

Sampling area

Four attempts for tagging and sampling the Mediterranean WS were performed in 2017, 2018, 2021, and 2022 (Fig. 1). Three preliminary areas were selected for these attempts according to the most recent sightings recorded. The selected sites were located at a depth varying between 18 and 35 m, far from the coast, where specimens of WSs had been sighted or fished in the past. The first three areas were:

The Adriatic Sea: three days during the end of October 2017, off the coast of Rimini, in an area close to the following coordinates: 44°12' 86" N; 12° 46' 64" E, from 06:00 in the morning until 19:00, baiting activities were carried out for approximately 13 consecutive hours a day. The boat was anchored at 28 m depth not far from the Antonella hydrocarbon extraction platform. This specific site was chosen after a news report on

Fig. 1. Map depicting the areas of investigation off Lampedusa and Secca di Levante, in Adriatic and central Tyrrhenian Sea.

the sighting of a WS on 26 October 2017, 15 miles off the Adriatic coast close to the mentioned platform by two fishermen (http://www.riminitoday.it/video/squalo-bianco-avvistamento-adriatico-rimini-26-ottobre2017.html).

The central Tyrrhenian Sea: on 15 November 2018, off the coast of Civitavecchia at the following coordinates: 42° 8' 12" N; 11° 47' 27" E, from 10:00 in the morning until 19:00, baiting activities were carried out for nine consecutive hours. The boat was anchored at 35 m depth close to the Asia wreck. This specific site was chosen following reports from fishermen of short fin mako sharks (*Isurus oxyrinchus* Rafinesque, 1810) and occasionally WS sightings.

The Channel of Sicily: three days during November 2021, off the coast of Lampedusa at Secca di Levante (Fig.1, and 2) at the following coordinates: 35° 26' 093" N; 12° 49' 740" E. The third baiting attempt was performed continuously, without interruption, for 72 hours and the boat was anchored at about 18 m depth.

The fourth attempt was performed in July 2022, in the same area of the third attempt, off the coast of Lampedusa at Secca di Levante. Here, the longest-lasting baiting activity was carried out continuously, without interruption, for seven days with prevalent north-west surface currents.

This site was chosen since this area is considered as one of the global centers of reproduction and abundance for the species (Fergusson, 1996).

Data collection and chumming

Four different vessels were used in different sampling areas: a 10 m long boat in the Adriatic Sea in 2017; a 10 m long boat in the central Tyrrhenian Sea in 2018; a 12 m long boat in 2021, and a 10 m long one

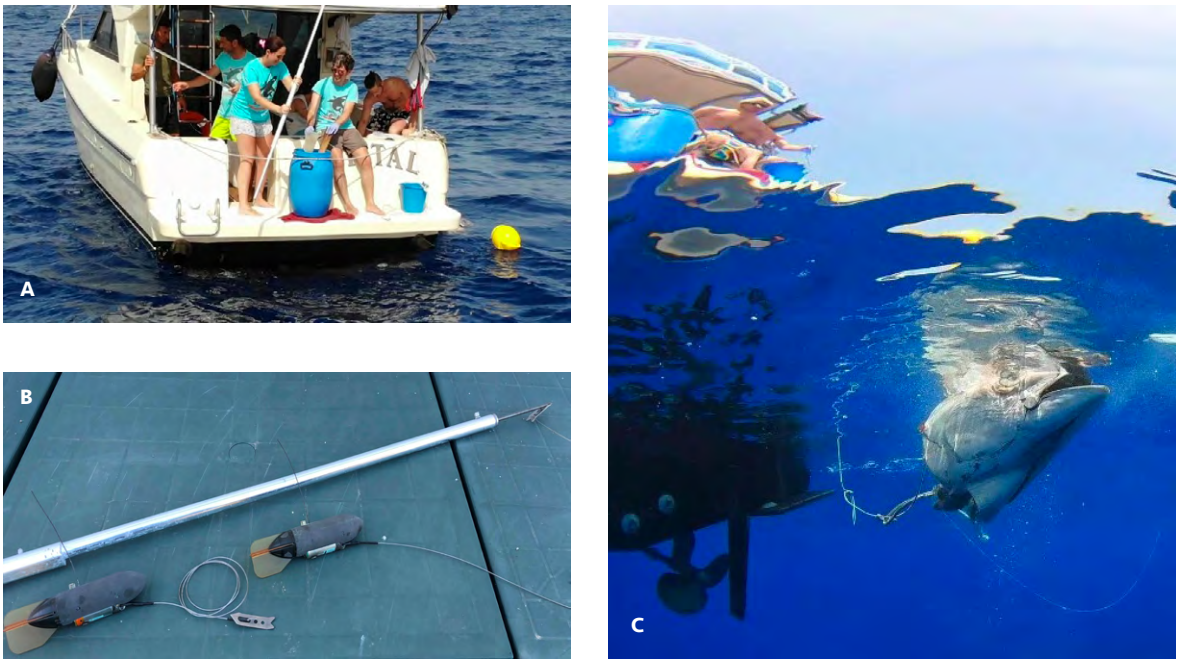

Fig. 2. Chumming in Lampedusa July 2022 (**A**); Pole and Spot-253 (Wildlife-computer), in Lampedusa harbour July 2022 (**B**); Tuna bait in Lampedusa July 2022 (**C**).

in 2022 in the Channel of Sicily. Sharks were attracted using olfactory stimulants (chum), following the methods described by Laroche *et al.* (2007). The chum was a mixture of seawater, cod liver oil, fish blood and, in addition, 2–3 kg slices of tuna and swordfish heads were used as bait and kept at the sea surface by floats as described by Sperone *et al.* (2010) (Fig. 2A,C). Sardines, squid slices, and tuna oil were added to the seawater mixture as commonly used for ecotouristic cage diving activities in Mexico (Torres-Aguilar *et al*., 2015), Australia (Bruce and Bradford, 2013), and South Africa (Laroche *et al*., 2007). Teams of two operators shifted every two hours to proceed with manual chumming and observations, without interruption in 2021 and 2022. In the central Tyrrhenian Sea and in the Adriatic Sea, 50-70 kg and 200 kg of chum were used respectively for a total of 48 hours of observation time. Regarding the two attempts at Secca di Levante, approximately 240 kg and 540 kg of chum were used, respectively (Fig 2 A). Observations made from the boats lasted 24 hours/day as well as underwater observations at nine meters of depth with underwater fishing camera. Observation time lasted 72 hours during the first attempt and 168 hours during the second one, producing a total observation time of 240 hours. The overall duration of these activities depended on the availability of funds for each attempt.

Tagging and sampling tools

The following instruments were available to monitor and tag sharks: two Spot-253 (Wildlife Computers Inc., Redmond, WA, USA) Smart Position and Temperature Transmitting (SPOT) satellite tags (Fig. 2B), a sampling rod, an underwater camera placed at 9 m depth and the sampling steel rod, already used for cetaceans in the Mediterranean Sea and WS's skin-biopsy in South Africa (Marsili *et al.*, 2016). An aerial Drone DJI Mavic air was used two hours during the last attempt in Lampedusa. In order to monitor the arrival of sharks during the night, a night vision device Dsoon Binoculars Night Vision 2K Photo 1080P Video was used.

RESULTS AND DISCUSSION

No WSs or any other shark species were sighted after four attempts carried out over an overall of 288 hours of baiting and observations, during which approximately 1030 kg of chum was used. Observations were performed by two operators and through underwater camera and aerial drone. The average surface water temperature recorded by the underwater camera at 9 meters of depth, only in Lampedusa, was 27.6 ± 0.3°C.

The presence of the WS in the Italian waters has been documented since year 1666 in the MEDLEM database (Mancusi *et al*., 2020). In particular, waters around Sicily showed the highest frequency of records among all the Italian regions. Based on the seasonal pattern, Micarelli *et al.* (2011) suggested that in spring and summer WSs could be attracted by tunas and cetaceans present in the western Mediterranean basin. Indeed, the bluefin tuna comes to spawn in the Mediterranean Sea during spring and summer from the Atlantic Ocean (Block *et al.*, 2001, 2005) and cetaceans are concentrated in the Ligurian and Tyrrhenian Seas during this season (Marsili *et al.*, 2001). In order to suggest and implement conservation strategies to preserve the WS species in the Mediterranean Sea, tagging specimen and following their movements in this basin is an important goal.

The island of Lampedusa is located in the center of the marine area between Sicily, Malta, and Tunisia in a sort of triangle where it is assumed that mature females of WSs move for breeding. Fergusson (2002) suggested that some breeding areas may lie not far away from the neritic shelf close to the Pelagie Islands, extending eastwards and southwards to the Tunisian coats, where neonatal sharks are most regularly caught. Also, Sperone *et al.* (pers.comm.) suggested that around Sicily, and in particular in the Sicily-Tunisian Ridge, female WSs could give birth to pups. Several authors (Micarelli *et al.*, 2011; Moro *et al.*, 2020) agreed with the hypothesis suggested by Cigala-Fulgosi (1990) and by Fergusson (1996) that the waters around Sicily could represent a potential breeding site for this species in the western Mediterranean. In the last years, several records of catches or sightings of WSs close to the Lampedusa Island occurred (Micarelli and Sperone, 2016; Tiralongo *et al.*, 2020) and for this reason this site was chosen for the longest attempt.

Micarelli *et al.* (2011) analyzed the temporal distribution of WS's sightings in the Italian waters and showed that 33.7% occurred in spring, 48.83% in summer, 17.44% in autumn, and 12.05% in winter. In order to chum, on the basis of what was tested by Soldo and Peirce (2005) and proposed from stable isotopes analysis in the vertebrae of WSs by Bevacqua *et al.* (2021), the use of bony fish was privileged, and the technique used in South Africa by Micarelli *et al.* (2021) and Sperone *et al.* (2010), was followed in order to bring WSs closer to the boat. Surely, a further, greater, and more prolonged effort is needed to be able to spot, mark, and sample specimens of WS to evaluate their chances of survival in the Mediterranean Sea. Recently, Kabasakal (2020) reported the occurrence of another nursery ground of WSs in Bay of Edremit (northeastern Aegean Sea, Turkey), which should also be considered as a hotspot and protected, as well in the Gulf of Gabès (southern Tunisia, central Mediterranean Sea) (Bradai and Saidi, 2013).

In the light of activities carried out, the results obtained highlighted the need to provide data of fundamental importance for the species *C. carcharias,* identified by the European Union as a target species for assessing the health status of the Mediterranean (Macias Moy *et al.*, 2018). Extinction risk for charismatic marine animals and bottlenecks in the conservation process underscore the tremendous need to address global threats to marine biodiversity on an appropriately large scale (McClenachan *et al*., 2012).

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Authors' contributions: P.M., F.R.R. and E.S. conceived the ideas; P.M., F.R.R., E.S., A.M., E.Ve., E.Vi., L.M., G.G., M.V. collected the data; P.M., F.R.R., E.S., L.M. and F.T. analyzed the data; P.M., F.R.R. and E.S. directed the writing.

Ethical principles: The study and experimentation protocols were reviewed and approved in accordance 166 with the Directive 2010/63/EU.

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