



Novel aerial observations of a possible newborn white shark (*Carcharodon carcharias*) in Southern California

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Abstract The white shark (*Carcharodon carcharias*) is the largest macropredatory fish in the world. Yet, there remains a paucity of data on the early life history and reproduction of this iconic shark. Here, we present aerial observations of an individual white shark that appears to be sloughing a white film from its body. We propose two possibilities for the possession of the white film: (1) this is a newly born white shark with intrauterine substances still adhered to its body, or (2) this white shark has an unknown skin disorder resulting in shedding, discharge, or possibly a microbial growth over the dermal layer. We discuss the possibility that this individual is a newborn and its implications for the Southern California region as a critical birthing location.

Keywords Lamniform shark · Neonate · Nursery

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The white shark (*Carcharodon carcharias*) is an iconic, large predatory shark with a worldwide distribution that attracts considerable interest from both the scientific community and the public (Klimley and Ainley 1996; Domeier 2012a; Huvaneers et al. 2018; Ebert et al. 2021). Despite the high level of interest, there remain some major gaps in white shark life history such as information on breeding and newborns (Klimley 1985; Klimley and Ainley 1996; Domeier 2012a; Huvaneers et al. 2018; Santana-Morales et al. 2020; Anderson et al. 2021). For example, Klimley (1985) suggested that large adult female sharks may use the area from Santa Barbara, California to north Baja California, Mexico to give birth. Recent evidence has supported this as Sebastian Vizcaino Bay (Orñate-González et al. 2017) and Cedros Island near Baja California, Mexico (Tamburin et al. 2020) as well as the coast of Southern California, USA (Anderson et al. 2021) had an abundance of young of the year white sharks that displayed high residency and restricted movements at these areas over the course of a year (Fig. 2). Furthermore, Santana-Morales et al. (2020) reported the smallest known free-living white shark was caught off the Pacific coast near the USA-Mexico international border, measuring 106.6 cm total length (TL) with morphological features similar to that of white shark embryos.

On July 9, 2023, a pale white shark (Fig. 1; Supplemental Video which is available by request/contact authors directly) was spotted via aerial drone (Mavic 3 Pro) 0.4 km off the coast of Carpinteria, CA, USA



Fig. 1 Images of white shark with a white film covering its body observed 0.4 km off the coast of Carpinteria, CA, USA (Photo Credits: Carlos Gauna)

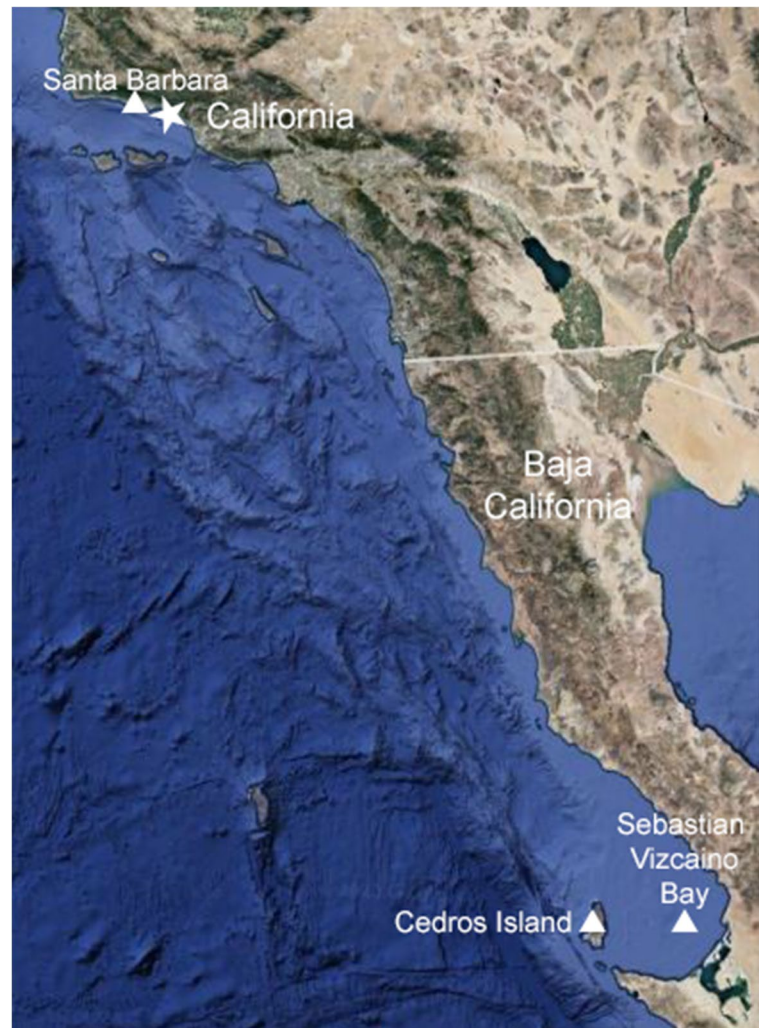
(Fig. 2). Upon close examination of video and photos, the individual's pale color appears to be a thin white film covering the shark. We noted that as the shark was swimming, the whitish film was being sloughed off. During post-video analysis, we estimated the size of the individual to be 1.5 ± 0.2 m TL, although with some uncertainty (Supplementary Information). We also wish to point out that, both days prior and the day of, large likely mature sharks were also recorded in the same area (Fig. 3). We propose two possibilities for this shark's interesting pale color: (1) the whitish film is left over intrauterine substances being sloughed off the shark due to it being a newborn shark, or (2) the whitish film is due to an unknown skin disorder that has not been reported in white sharks before in the published literature.

First, like other lamniform sharks, white sharks are viviparous, and embryonic sharks perform the unique behavior of oophagy (Gilmore 1993; Francis 1996; Uchida et al. 1996; Conrath and Musick 2012; Sato et al. 2016; Ebert et al. 2021). Oophagous sharks will consume eggs and store yolk in their stomachs as a source of nutrition (Gilmore 1993; Francis 1996; Uchida et al. 1996; Sato et al. 2016). In addition, pregnant female white sharks will also produce "uterine milk," a yellowish and milky fluid, for the

embryos to also consume (Sato et al. 2016). However, it remains unclear on the duration of this fluid being produced during the estimated 12-month gestation period (Sato et al. 2016). After the gestation period, an estimated 2–17 pups may be birthed (Ebert et al. 2021). In terms of morphology, the pups are very similar in appearance to near-term embryos as they are notable for being 1–1.6 m TL and with more rounded fin apices (Francis 1996; Uchida et al. 1996; Tomita et al. 2018; Santana-Morales et al. 2020; Ebert et al. 2021). In the Northeast Pacific, Klimley (1985) proposed that from Santa Barbara to Baja California, during late summer and early fall, pregnant female white sharks would give birth to pups. Recent studies have supported this claim as vast amounts of young of the year white sharks have been tagged and monitored in this geographical range and time period (Orñate-González et al. 2017; White et al. 2019; Santana-Morales et al. 2020; Tamburin et al. 2020; Anderson et al. 2021).

Here, we offer one hypothetical scenario for this individual white shark and its whitish film. First, this individual white shark is an estimated 1.5 ± 0.2 m TL (Supplementary Information), well within the size range of newborn sharks (i.e., 1–1.6 m TL), and its overall appearance (i.e., rounded fin apices) is

Fig. 2 Locations with high residency of young of the year white sharks = ▲. Location of the white shark with white film = ★



similar to that of near-term embryos and the smallest reported free-living white shark (Francis 1996; Uchida et al. 1996; Tomita et al. 2018; Santana-Morales et al. 2020; Ebert et al. 2021). Second, this white shark was filmed in both the proposed area and specific time when pups are birthed (Klimley 1985). Third, large likely mature sharks were also recorded in the area with our drone surveillance (Fig. 3) and were also sighted by other researchers in the area (C. Lowe, personal communication). Taking these factors into consideration, a parsimonious interpretation is that the larger sharks may be mature females known to frequent this region (Klimley 1985) and that the pale subject is a newly born individual, possibly being days or even hours old. We propose that the whitish film being sloughed off the body is composed

of intrauterine substances that had adhered to the shark while still in its mother's uterus. Given that white sharks produce "uterine milk," it is within the realm of possibility either this fluid or another fluid could have adhered to the shark right before birth.

In the alternative scenario, this individual white shark has a unique unknown skin disorder. Skin disorders are known to occur in sharks and rays, but it is rare (Gervais et al. 2016; Rodrigues et al. 2023). For example, albinism and leucism have been reported in only 62 (including one reported case of albinism in the white shark) of the 1200 species of elasmobranchs (Smale and Heemstra 1997; Bigman et al. 2016; Arronte et al. 2022; Becker et al. 2023; Rodrigues et al. 2023). It has also been noted that pollution and temperature may affect normal pigmentation

Fig. 3 Images of one of several large likely mature sharks filmed the days prior and the day of in the same area (0.4 km off the coast of Carpinteria, CA, USA) as the pale white shark being spotted (Photo Credits: Carlos Gauna)



Fig. 4 Images of a white shark that has suffered abrasions due to a fishing leader that it retains after being released by fishermen (Photo Credits: Carlos Gauna)



development leading to irregular color patterns (Gervais et al. 2016; Bruckner and Coward 2018). However, the evident sloughing of a semi-opaque layer from the small shark reveals normal pigmentation below; therefore, albinism and leucism are not supported (Fig. 1; Supplemental Video which is available by request/contact authors directly). Skin diseases such as dermatitis and other bacterial infections have been reported in sharks (Leibovitz and Leboutitz 1985; Garner 2013; Pogoreutz et al. 2019; Newton and Ritchie 2022), but none of these reported conditions are similar to the one observed in this individual white shark. Therefore, this may be an unknown skin disorder that has not been reported in the literature before.

Here, we have presented evidence of an individual white shark with a whitish film covering its body, observed off the coast of Southern California. We propose two explanations for this individual's white milky appearance: the first being it is a newborn shark with embryonic substance forming a layer on the shark and the second being the shark has an unknown skin disorder. For the first proposal, previous studies have demonstrated that this region of Southern California, USA, is a critical nursery habitat for white sharks in the Eastern Pacific (Klimley 1985; Domeier 2012b; White et al. 2019; Anderson et al. 2021). If this is indeed a newborn individual, this demonstrates the critical importance of this area in Southern California to Eastern Pacific white sharks. White sharks are highly protected off California (Heneman and Glazer 1996), but incidental catches by fishermen do occur (Lowe et al. 2012; Benson et al. 2018). Although individuals are released, some may retain hooks and fishing leaders that cause stress, damage, and possible subsequent death to the individuals (Fig. 4; Lowe et al. 2012; Benson et al. 2018). Therefore, more effort and stricter management might be required to protect not only this area but the entire coastline extending down to Baja California as well for white shark conservation. In terms of the second proposal, this would represent a previously unknown skin disorder that has not been observed in white sharks or sharks and rays in general. Both hypotheses will require further investigation and additional evidence for support or refutation. Nevertheless, in either case, the use of the aerial drone has provided shark science with another interesting set of information (Butcher et al. 2021). Therefore, future drone observations of sharks in this area will greatly

improve our knowledge and understanding of white shark life history.

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Author contribution CG flew the drone and collected video and pictures of the sharks. CG and PCS both analyzed video and pictures of the sharks. PCS wrote the manuscript. CG and PCS reviewed and edited the text.

Data availability Data is available upon request.

Declarations

Ethics approval Sharks were viewed by drone requiring no protocol approval.

Consent to participate All authors agreed to participate.

Competing interests The authors declare no competing interests.

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