

Supplementary Information Text: Method for estimating length of white shark from drone footage and metadata

The length of the white shark was estimated using manufacturer specifications for the DJI Mavic 3 Pro drone used in the recording (<https://www.dji.com/mavic-3-pro/specs>), the drone-camera recording mode, altitude readings, and several simplifying assumptions.

The camera on the DJI Mavic 3 Pro that was used for the shark footage is a Hasselblad Camera with an 84° diagonal field of view (FOV) that is accurate for footage recorded at a native frame rate of 24 frames per second (FPS). The newborn shark was recorded at 120 FPS, which uses a smaller area of the camera sensor and effectively reduces the FOV by a magnitude known as the crop factor. We describe the crop factor as a decimal number <1 that quantifies the reduction of the effective FOV for high-framerate footage (120 FPS) with respect to the manufacturer-specified 84° FOV for native-framerate footage (24 FPS). We estimated a crop factor of 0.71 for the newborn-shark footage by using test footage to compare the length of an object (in pixels) recorded in Cinema 4K at 24 FPS to that recorded in Cinema 4K at 120 FPS. The object appears ~1.4 times longer at 120 FPS compared to its length at 24 FPS, which is equivalently reduced the FOV from 84° for 24 FPS to 60° for 120 FPS.

The camera in the footage is pointed directly down, and frames were selected to capture the shark near in the central region of the frame to minimize distortion due to an oblique view.

The frame diagonal length (in meters) at a given altitude is given by equation 1,

$$1. \quad D_m = 2 \times a \times \tan \frac{\phi_{120 \text{ FPS}}}{2}$$

D_m = frame diagonal length (meters)

a = drone altitude (in meters)

$\phi_{120 \text{ FPS}}$ = angular FOV at 120 FPS (in degrees)

The shark length (in meters) given by equation 2,

$$2. \quad L_m = D_m \times \frac{L_{px}}{D_{px}}$$

L_m = shark length (meters)

L_{px} = shark length (pixels)

D_{px} = frame diagonal length (pixels)

The shark length was estimated using equations 1 and 2 for 20 different frames that were recorded at altitudes varying from 5.3–91.3 m above sea level (SI Dataset 1). The 20 length

estimates for the shark span 1.3–1.6 m without any discernible correlation with altitude. Their calculated mean and 2-standard-deviation uncertainty (2σ , accounting for 95% of measurements) is 1.5 ± 0.2 m.

Our estimated shark length can be considered a maximum estimate because it does not account for the shark's presence under water, which has a greater index of refraction than air and makes underwater objects appear larger than they are from the air above (Snell's Law). This effect is less significant for shallower objects, and we deem it negligible for our footage because the shark is clearly swimming close to the water surface.

To summarize, we estimate that the newborn white shark has a maximum length of 1.5 ± 0.2 m (mean $\pm 2\sigma$).