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Note

Salmon Shark (*Lamna ditropis*) scratching behaviour using floating anthropogenic debris

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Abstract

Observations of animal behaviour in the open ocean are relatively rare. However, while conducting surveys in the Northeast Pacific in the summers of 2019 and 2021, we encountered two Salmon Shark (*Lamna ditropis*) using floating anthropogenic debris to scratch their bodies. We captured the activity with aerial (drone) and underwater cameras. We document and describe this novel behaviour as high energy, high impact, repetitive, fast, and long lasting (e.g., every ~15 s for >20 minutes). We explore these observations in light of traditional ecological knowledge and scientific literature.

Key words: Shark; animal behaviour; scratching; Salmon Shark; *Lamna ditropis*; parasites; marine pollution; changing ocean; traditional ecological knowledge; drone

Sharks are keystone species found throughout the world's oceans, from coastal waters to the high seas. Nearly 30 oceanic species are known (Compagno 2008), but open ocean observations are relatively rare as humans visit these vast areas infrequently. Salmon Shark (*Lamna ditropis*) is a common oceanic and coastal species found in the subarctic and temperate waters of the North Pacific (McFarlane and King 2020). These sharks segregate by size and sex, undergo lengthy seasonal migrations, and follow schools of salmon around the Pacific basin; as members of the endothermic Lamnidae family, they have high metabolism and elevated body temperatures, which enable them to swim relatively fast (Goldman and Musick 2008; Manishin *et al.* 2019; McFarlane and King 2020). In short, they have evolved to be efficient long-distance swimmers in the open ocean. Satellite tagging and tracking technology have enabled the mapping of their large-scale movement offshore (Weng *et al.* 2008; Block *et al.* 2011; Coffey *et al.* 2017; Garcia *et al.* 2021), but little information exists regarding their fine-scale activities and behaviours. Here we describe two encounters with Salmon Sharks hundreds of kilometres offshore from the traditional territories of the Nuu-chah-nulth and Kwakwaka'wakw Nations, what is now known as northern Vancouver Island, British Columbia, Canada (Figure 1, Table 1).

In 2019 and 2021, scientists from the Nuu-Chah-Nulth Tribal Council, Council of the Haida Nation, Fisheries and Oceans Canada (DFO), and partners were conducting deep-sea research in the proposed Tang.ɢ̱wan-ḥačxʷiqak-Tsig̱is Marine Protected Area (MPA). In 2019, we were in the small auxiliary vessel deploying scientific equipment when we intercepted a barnacle-encrusted anthropogenic log (cut flat at both ends) drifting toward a deployed C-PROOF Glider (an autonomous oceanographic profiling instrument;

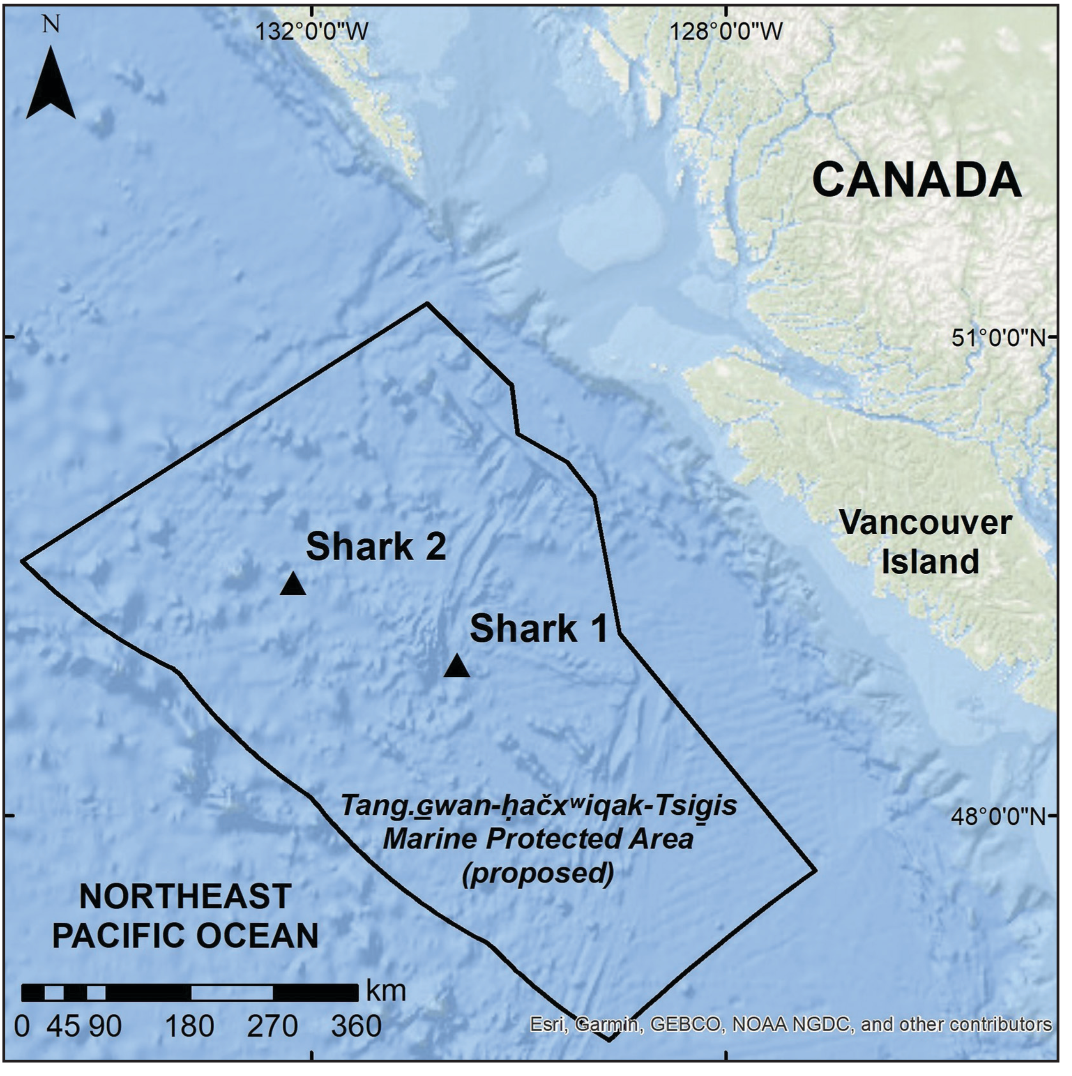

Figure 1. Locations of Salmon Shark (*Lamna ditropis*) observations in the proposed Tang.g̱wan-ḥačxʷiqak-Tsigis Marine Protected Area, offshore from the traditional territories of the Nuu-chah-nulth and Kwakwaka'wakw Nations, of what is now known as Vancouver Island, British Columbia, Canada.

University of Victoria 2022). To avoid damage to the scientific equipment, we used rope to secure the log and tow it out of the vicinity. A shark appeared immediately after the log was released and began exhibiting a scratching behaviour (Figure 2a,b, Figure 3). The team in an auxiliary vessel filmed the interaction above and below water and radioed to launch a drone from the Canadian Coast Guard Ship *John P. Tully* to capture aerial footage. The behaviour was ongoing when the log and shark drifted out of sight. In 2021, we came across another Salmon Shark already engaged in scratching, this time on a square piece of fibreglass (Figure 2c). Again, the team launched a drone from the *John P. Tully* to capture aerial footage of the interaction. Unfortunately, high winds and poor sea state limited the duration of the drone flight and prevented ship-based photography.

The 2019 and 2021 photos and videos were annotated to assess the nature and frequency of the scratching behaviour, count parasites, and measure lengths. VLC media player 3.0.8 Vetrinari (VideoLAN Organization, Paris, France) was used for video playback, ImageJ 1.53m (https://imagej.nih.gov/ij/download.html) was used for reviewing photos, and scaling was based on the known dimensions of the auxiliary vessel. In addition to describing and discussing

TABLE 1. Summary of Salmon Shark (*Lamna ditropis*) scratching behaviour using floating anthropogenic debris in the open ocean of the Northeast Pacific.

	Shark 1, male 1.9 m	Shark 2
Date and time	19 July 2019	25 June 2021
Location	East of Explorer Seamount	Above UN 13 Seamount
Coordinates (lat., long.)	49°00′39.5362″N, 130°36′54.9091″W	49°29′47.1942″N, 132°11′01.1501″W
Distance offshore	250 km	300 km
Footage and camera(s)	From boat and GoPro HERO7* Aerial: DJI Mavic 2 Zoom drone*	Aerial: DJI Mavic 2 Pro drone*
Duration of observation	29 min	20 min
Duration of documentation	GoPro: 26 min, drone: 14 min (11 min overlap)	12 min
Imagery	GoPro: 9 videos totalling 9 min 43 s (mp4, 1920 × 1440) Drone: 14 videos totalling 4 min 49 s (mp4, 2688 × 1512) and 153 stills (20 JPGs and 133 DNGs)	Drone: 13 videos (mp4, 3840 × 2160) and 45 stills (jpeg, 5472 × 3648)
Anthropogenic debris	2-m barnacle-encrusted log	Square of fibreglass, size undetermined
No. of scratching events	48 (GoPro: 10, drone: 24, both: 14)	41
Average frequency (s between events)	16.7 s (avg. for GoPro: 17.3 s; avg. for drone: 15.7 s)	11.4 s

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our findings below, we provide summary information (Table 1), details on our image-based observations (Table S1), example photos (Figure 2), a science field note drawing of the 2019 observation (Figure 3), and example video clips in Video S1 with a shorter sequence at DFO (2019).

The Salmon Shark observed in 2019 was a large male, approximately 1.9 m in length, with visible parasitic copepods (Figure 2b, Video S1; DFO 2019). We filmed 48 repetitive scratching events in 26 min of usable footage i.e. total duration of stop and start recording. The shark followed the log at the surface and hit it with such force that the animal would sometimes breach as it slid across the 2 m length of the log (Figure 2a), crushing and dislodging attached barnacles (Video S1). The shark often contacted the ends of the log, which had the largest clumps of gooseneck barnacles. After making contact, the shark would immediately circle back and repeat the behaviour. On average, scratching occurred every 16.7 s (range 14.5–20.0 s). The shark scratched its ventral, dorsal, and lateral sides and fins (32%, 32%, 24% of the 48 interactions, respectively, and 12% undetermined) and often scratched the same body part repeatedly. Despite forceful slides against the encrusting barnacles, we observed no visible change in the number of large parasites on the dorsal and pectoral fins of the shark (12 copepods) and no visible injuries were sustained (no cuts or blood).

In 2021, unfortunately, we could not resolve the length, sex, or parasites of the shark, the debris-encrusting taxa on the fibreglass, or the size of the fibreglass, because of the constraints associated with use of aerial cameras; however, measuring relative size and distance was still possible. In 2021, the Salmon Shark's behaviour was similar to that in the 2019 observations, with one notable difference: this shark scratched almost exclusively by rolling under the fibreglass with its pelvic fins up (Figure 2c, Video S1). This difference in behaviour could be a response to the differences in debris (i.e., the piece of fibreglass was thin, smaller than the shark, and lay flat on the surface, whereas the log was round, larger than the shark, and protruded above the surface). We captured 41 scratching events in 12 min of usable footage. On average, a scratch occurred every 11.4 s (range 10.6–12.5 s). The shark scratched its ventral side and fins predominately (83% of the 41 interactions, 7% dorsal, and 10% undetermined). The shark stayed close to the fibreglass, circling back when it reached a distance of 3.3 times its body length on average.

In summary, the scratching behaviour of these Salmon Sharks is high energy (partly breaching at times), high impact (dislodging fouling animals on the debris), repetitive (once every ~15 s), fast (short turnaround distance), and long lasting (at least 20 min but could be much longer). This behaviour is very conspicuous, easily noticed in 2019 despite our low-lying perspective, and again in 2021 despite the large swell and choppy conditions. That said, we reviewed local Nuu-chah-nulth traditional ecological knowledge and the scientific literature and found little to no

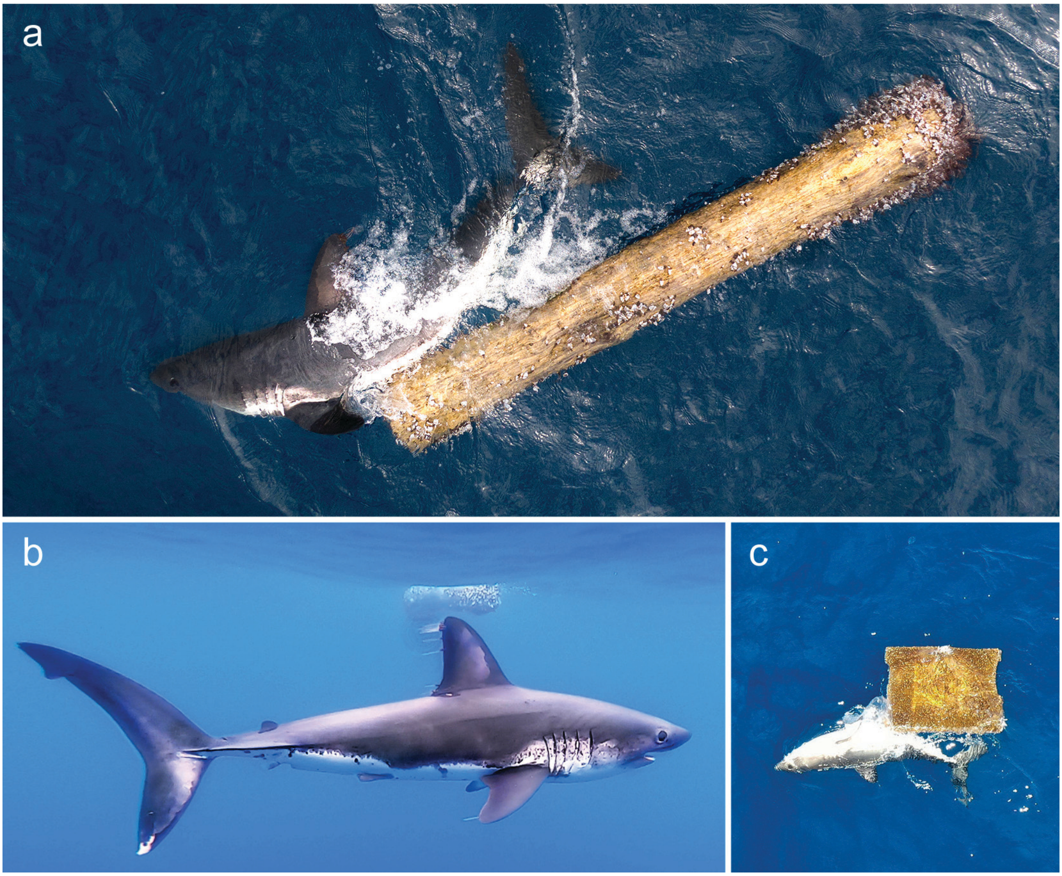

Figure 2. Salmon Shark (*Lamna ditropis*) scratching behaviour using floating anthropogenic debris in the open ocean of the Northeast Pacific in 2019 (a,b) and 2021 (c), captured using drones and an underwater camera. a. Shark using a barnacle-encrusted log. b. Parasitic copepods on the shark's fins. c. Shark using a square of fibreglass. Photos: a. Shelton Du Preez. b, c. Cherisse Du Preez.

pre-existing documentation of this scratching behaviour in Salmon Sharks. We did learn of another Salmon Shark sighting in the coastal waters of Monterey Bay, California, USA, where an individual shark was scratching against a log (K. Cummings pers. comm. 1 May 2021), and we found a single mention in the literature of another shark species, Blue Shark (*Prionace glauca*), scratching with anthropogenic debris (a floating fish box; Lyne and Quigley 2013). However, sharks scratching along natural substrates appears to be more common and has been documented for Bonnethead Shark (*Sphyrna tiburo*; Myrberg and Gruber 1974), Blacktip Shark (*Carcharhinus limbatus*; Ritter 2011), Caribbean Reef Shark (*Carcharhinus perezi*; Ritter 2011), and Grey Nurse Shark (*Carcharias taurus*; Smith *et al*. 2015). Sharks even use other sharks as scratching substrates (Williams *et al.* 2022).

Our novel documentation of Salmon Shark scratching along anthropogenic debris in the open ocean raises potential future research questions. Could oceanic sharks have evolved this scratching behaviour on naturally adrift trees and now be shifting to floating anthropogenic debris? Do encrusting fauna and olfaction contribute to sharks' ability to locate debris? What are the associated costs and benefits of the scratching behaviour?

We surmise that scratching an itch is the most likely benefit and explanation of our observed Salmon Shark behaviour, because we saw no evidence of feeding and no conspicuous conspecifics or other species in the area; so, the behaviour is not likely signalling. Itch sensation and scratching behaviours are primary responses to ectoparasite loads, as documented in primates (Duboscq *et al.* 2016). Williams *et al.* (2022) compiled observations of 47 incidents of fish scratching against sharks; this work contains numerous citations about scratching behaviour in aquatic environments and speculates why fish and sharks

FIGURE 3. A field note drawing in the style of Nuu-chah-nulth traditional art by expedition member and co-author Hawilh-Wayanis (Joshua Watts) illustrating the 2019 shark encounter. A human figure is depicted aboard a vessel witnessing the Salmon Shark (*Lamna ditropis*) scratching behaviour. The rounded or arched shark represents the frequent circling of the animal back to the log. The shark's silhouette includes many faces depicting the visible parasitic copepods. The use of a canoe silhouette honours the Nuu-chah-nulth Peoples' long history as oceanic explorers and fishers. Such Indigenous traditional art is a highly successful way of knowing and sharing ecological knowledge and natural science. Drawing: Hawilh-Wayanis (Joshua Watts).

may scratch. Sharks are highly parasitized animals (Ciara and Healy 2004) and sharks infested with ectoparasites may suffer a variety of health consequences, including anemia and debilitating skin disease (summarized in Oliver *et al.* 2011). We were able to see obvious ectoparasitic copepods in the 2019 footage (Figure 2b, Video S1). Although none of the visible parasites were dislodged, parasite removal may only be a bonus of scratching. The primary driver is likely the ability to respond to the itch sensation with debris during a long, open ocean journey.

When anthropogenic debris includes lines, sharp objects, or fishing gear, scratching behaviour could have a high associated cost, putting Salmon Sharks at risk of injury, entanglement, and even mortality (Parton *et al.* 2019). Floating anthropogenic debris is one of the most pervasive problems plaguing global oceans (Sheavly and Register 2007). Winds and surface currents carry debris across the ocean, concentrating it in massive gyres and along shorelines (Luna-Jorquera *et al*. 2019). Although area-based management, such as the proposed Tang.ɢwan-ḥačxʷiqak-Tsigi̱s MPA, can relieve stressors related to human activities, reducing floating anthropogenic debris requires global actions (Luna-Jorquera *et al.* 2019). The recent and rapid accumulation of debris in the Northeast Pacific Ocean is a source of alarm, particularly for Indigenous coastal communities whose traditional ecological knowledge provides historical context (SSTOA and WTA 2020). The region's debris includes adrift logs from the timber industry (e.g., our 2019 observation), derelict fishing gear, vessels, and mooring buoys (Gonor *et al*. 1988; SSTOA and WTA 2020). Debris impacts wildlife behaviour and fitness and can affect individuals, populations, and species (SCBD 2012). The Secretariat of the Convention on Biological Diversity has reported adverse impacts of debris for more than 663 marine species (SCBD 2012). Some impacts are well studied, particularly those on marine mammals, sea turtles, and sea birds (e.g., entanglement and ingestion, SCBD 2012); however, an ocean full of interactions is yet to be investigated.

In the last decade, drones and underwater cameras have become accessible and affordable, offering new opportunities for documenting and studying animal behaviours and fine-scale activities (e.g., Butcher *et al.* 2021; Schad and Fisher 2022). Drone technology, in particular, has proven extremely valuable for capturing wild shark behaviour, sometimes for the first time (Butcher *et al.* 2021), as in our case. Although the main objective of our 2019 and 2021 expeditions was to study the deep sea, we were able to respond quickly to opportunistic animal encounters at the surface because we had these camera systems and trained operators. As such, our overall Tang.ɢwan-ḥačxʷiqak-Tsig̱is MPA research program has benefited from monitoring pelagic animals in areas that are difficult to access, sharing footage in support of open science (similar to Giersberg and Meijboom 2022), supporting citizen science (e.g., DFO 2022), and science outreach and communication (e.g., DFO 2019). Additional advantages include minimal influence on the animals from the presence of an observer and footage that could be archived and reviewed for multiple objectives (Butcher *et al.* 2021; Giersberg and Meijboom 2022). For example, by resolving the sex of the 2019 shark, we collected rare information regarding the open ocean distribution of male Salmon Sharks (Garcia *et al.* 2021). Research endeavours in unfrequented areas should consider incorporating drone and underwater camera operations to enhance opportunities to photo-document data-deficient species (Schofield *et al.* 2019; Butcher *et al.* 2021; Schad and Fisher 2022), such as marine mammals, sea turtles, and, of course, sharks.

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Author Contributions

Writing – Original Draft: C.D., H.N.G., and L.C.; Writing – Review & Editing: C.D., H.N.G., H.-W., L.C., S.D., and T.N.; Visualization: C.D., H.-W., and S.D.; Conceptualization: C.D., H.N.G., H.-W., L.C., S.D., and T.N.; Investigation: C.D., H.N.G., H.-W., L.C., S.D., and T.N.; Methodology: C.D., H.-W., S.D., and T.N.; Formal Analysis: C.D.; Funding Acquisition: C.D. and T.N.

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Supplementary Materials:

Table S1. Image-based records of Salmon Shark (*Lamna ditropis*) scratching events.

Video S1. Natural history footage of Salmon Shark (*Lamna ditropis*) scratching behaviour.