

## SHORT COMMUNICATION

### Seasonal arrival and feeding of injured coastal sharks at fish farms in the Eastern Mediterranean

Adi Barash<sup>1\*</sup>, Renanel Pickholtz<sup>2</sup>, Hagai Nativ<sup>3</sup>, Shahar Malamud<sup>1,2</sup>,  
Aviad Scheinin<sup>1,3</sup>, Dan Tchernov<sup>1,3</sup>

<sup>1</sup> Leon Charney School of Marine Sciences, University of Haifa, Haifa, ISRAEL

<sup>2</sup> School of Zoology, Tel Aviv University, Tel Aviv, ISRAEL

<sup>3</sup> Morris Kahn Marine Research Station, Sdot-Yam, ISRAEL

\*Corresponding author: adibarash@hotmail.com

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#### Abstract

Every summer coastal sharks (mostly sandbar sharks, *Carcharhinus plumbeus*) come to feed at open-sea fish farms near the Israeli coast, ever since their opening. Three of these sharks appear to suffer injuries of various degrees. At least one of the injured individuals, which suffers from a broken lower jaw, has been sighted at the fish farms every year since 2011. Providing a constant source of food to supplement feeding of wildlife has been shown to have both negative and positive impacts on wild populations and individuals. It may be possible that injured sharks, who have reduced abilities to find food in the wild, rely on such human related food sources to survive. Implications on the long-term effect of provisional feeding on sharks are discussed.

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The decline in global shark population over the last few decades is well documented (Dulvy *et al.* 2014; Ward-Paige and Worm 2017). In the Mediterranean, large predatory sharks have become particularly scarce (Ferretti *et al.* 2008), mainly due to overfishing in the region (Dulvy *et al.* 2016). Another cost incurred by sharks is fishing related injuries, due to longlines, fishing nets and fish handling (McAuley *et al.* 2007; Mandelman *et al.* 2008; Molina and Cooke 2012). It is estimated that 15% of released (non-finned) sharks die from fishing-related injuries (approximately 100 million sharks a year) (Worm *et al.* 2013). In long-lived animals, injury and mortality of adult individuals has a practically high impact on the reproductive rate of local populations (McAuley *et al.* 2007), which is of great concern for rare or endangered species.

Year-round and seasonal supplemental feeding of wildlife has been shown to have both negative and positive impacts on wild populations and individuals. For example, supplemental feeding may promote pathogen prevalence and dependency on human provided food (Orams 2002) but can have positive implications on individuals' health and survival (Murray *et al.* 2016).

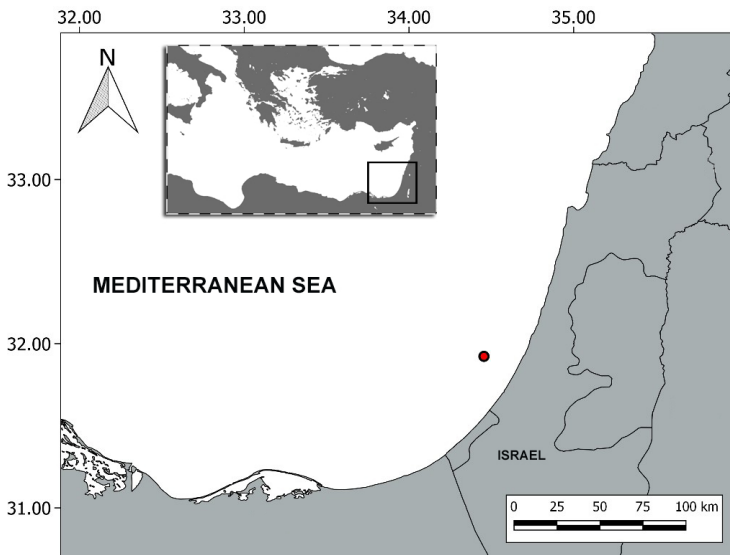
Fish cages are a steady source of food that creates a dependency of the sharks on the latter to various degrees (Pemberton *et al.* 1991; Orams 2002). For example, Papastamatiou *et al.* (2011) reported that sandbar sharks, *Carcharhinus plumbeus*, near the Island of Oahu, Hawaii, have been detected repeatedly at fish farms for up to 2.5 years. Moreover, although fish farms did not appear to disrupt seasonal movement patterns (e.g., for reproduction), individuals have repeatedly returned to the same site.

Since 2006, sea bream (*Sparus aurata*) are farmed in open-water fish cages, several miles off the Israeli Mediterranean coast (Figure 1). Approximately one year after the cages were stocked for the first time, carcharhinid sharks have been documented near the underwater enclosures. Large numbers of coastal sharks (mostly sandbar sharks, *Carcharhinus plumbeus*) and other large marine predators such as Atlantic bluefin tuna (*Thunnus thynnus*) are sighted every summer at the cages (Figure 2) ever since (with the exception of 2016 when the farm closed down, for which we have no data). Visual surveys of sharks at the cages are conducted as part of a long-term monitoring survey of marine apex predators. During the dives we documented three large sandbar shark females (*C. plumbeus*) with obvious injuries (Figure 3). Shark no. 1 was missing the upper lobe of its tail. Shark no.2 had what seemed to be a fractured tail, and shark no. 3 had a full broken lower jaw. The injuries seemed to be old injuries, and the sharks were in good health condition otherwise. The shark with the broken jaw seems as if it would not be able to feed on its own, but this certain individual has been seen by the farm workers every summer since 2011.

If feeding at the fish cages has only the benefit of obtaining easy food, then one would expect to find sharks with higher competitive abilities (large body size, physically intact). The presence of injured sharks at the fish cages can indicate that feeding in the fish farms may be lesser alternative to feeding elsewhere.

Very few describe the individuals attracted to provisional feeding and the effect on natural selection. These studies refer to rising aggression and possible selection toward aggressive animals (Orams 2002; Murray *et al.* 2016). In the case of the sharks described above this is not likely to be the case, since they have not displayed aggressive behaviors, and have reduced competitive capabilities due to their injuries. Most animals avoid the presence of human out of an evolutionary instinct of self-preservation. An animal that habituates to humans does so at a high cost of incurring risk (Orams 2002). It is possible that the injured

sharks mentioned above are more prone to forgo this instinct since their marginal value is higher.



**Figure 1.** Regional map showing the general location of the fish farms (red dot).

Providing food to sharks that have fishing related injuries, could be considered to be a positive action – by reinforcing mature adults that have been harmed by human activity. However, it should be ruled out that such feeding does not tamper with selection processes by boosting not only sharks that were injured by fishing, but also certain individuals that otherwise would have been naturally selected out.



**Figure 2.** A large number of sandbar sharks (*Carcharhinus plumbeus*) (n=25) swimming around the fish cages (July 2017). Photographed by Hagai Nativ.



**Figure 3.** Injured sharks at the fish cages: A) A female shark missing the upper lobe of the caudal fin, B) A female shark with a deformed, likely fractured caudal fin, C) A shark with a broken jaw. Photographed by Hagai Nativ (A, C) and Shahar Malamud (B).

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### **References**

Dulvy, N., Allen, D., Ralph, G., Walls, R. (2016) The Conservation Status of Sharks, Rays and Chimaeras in the Mediterranean Sea (Brochure). IUCN, Malaga, Spain.

Dulvy, N.K., Fowler, S.L., Musick, J.A., Cavanagh, R.D., Kyne, P.M., Harrison, L.R., Carlson, J.K., Davidson, L.N., Fordham, S.V., Francis, M.P. (2014) Extinction risk and conservation of the world's sharks and rays. *Elife* 3. doi: 10.7554/eLife.00590

- Ferretti, F., Myers, R.A., Serena, F., Lotze, H.K. (2008) Loss of large predatory sharks from the Mediterranean Sea. *Conservation Biology* 22: 952-964.
- Mandelman, J.W., Cooper, P.W., Werner, T.B., Lagueux, K.M. (2008) Shark bycatch and depredation in the US Atlantic pelagic longline fishery. *Reviews in Fish Biology and Fisheries* 18: 427.
- McAuley, R.B., Simpfendorfer, C.A., Hall, N.G. (2007) A method for evaluating the impacts of fishing mortality and stochastic influences on the demography of two long-lived shark stocks. *ICES Journal of Marine Science* 64: 1710-1722.
- Molina, J.M., Cooke, S.J. (2012) Trends in shark bycatch research: current status and research needs. *Reviews in Fish Biology and Fisheries* 22: 719-737.
- Murray, M.H., Becker, D.J., Hall, R.J., Hernandez, S.M. (2016) Wildlife health and supplemental feeding: a review and management recommendations. *Biological Conservation* 204: 163-174.
- Orams, M.B. (2002) Feeding wildlife as a tourism attraction: a review of issues and impacts. *Tourism Management* 23: 281-293.
- Papastamatiou, Y.P., Itano, D.G., Dale, J.J., Meyer, C.G., Holland, K.N. (2011) Site fidelity and movements of sharks associated with ocean-farming cages in Hawaii. *Marine and Freshwater Research* 61: 1366-1375.
- Pemberton, D., Brothers, N., Copson, G. (1991) Predators on marine fish farms in Tasmania. *Papers and Proceedings of the Royal Society of Tasmania* 25: 33-35.
- Ward-Paige, C.A., Worm, B. (2017) Global evaluation of shark sanctuaries. *Global Environmental Change* 47: 174-189.
- Worm B., Davis B., Kettner, L., Ward-Paige, C.A., Chapman, D., Heithaus, M.R., Kessel, S.T., Gruber, S.H. (2013) Global catches, exploitation rates, and rebuilding options for sharks. *Marine Policy* 40: 194-204.