# The pros and cons of shark feeding

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## Introduction

Feeding wild animals is a common practice in the ecotourism industry. Operators do so both on land and under water to gather fauna at particular spots so that they can be viewed by tourists. Operators would otherwise be unable to guarantee their customers sightings of particular animals that are generally shy and reclusive. The practice is often controversial because although it has undeniable advantages for humans — discounting the inherent danger of attack by large predators — it involves potentially negative effects for wild animals. Shark feeding is no exception and much has been written on the issue, although, until recently no scientific studies were available, despite sharks being emblematic animals in the Pacific. The gap has now been filled with a project implemented jointly by the Secretariat of the Pacific Community (SPC) and the French Centre de recherche insulaire et Observatoire de l'environnement (CRIOBE) in Moorea, French Polynesia.

## Moorea's lemon sharks

French Polynesia is a high-end tourist destination in the Pacific. Water sports are highly developed there amid crystal-clear waters and coral reefs with brightly coloured fauna. Diving sites such as Rangiroa, Bora Bora and Moorea have a worldwide reputation, due in large part to their imposing, but docile sharks. The sicklefin lemon shark, *Negaprion acutidens* (Box 1) is the star attraction of Moorea and Bora Bora, where thousands of divers flock every year to watch amazing underwater shark feeding sessions, with animals sometimes measuring more than three metres long. Because they are fed by humans (usually tuna or mahi mahi scraps), these normally solitary sharks can congregate in large numbers, sometimes up to 15 or so in a space of just a few hundred square metres. Groups of about a dozen divers at a time are taken to depths of 15–20 metres, where small cages containing food are placed out of reach of opportunist sharks and other fish. Attracted by the smell, sharks prowl about the cages to the astonished gaze of the divers for several minutes. The food is then released, and a hectic swirl ensues — including not just the imposing lemon sharks (Figs. 1 and 2),[1] but also dozens of reef fish and smaller, but extremely lively, nervous blacktip reef sharks.

Under the Marine Management Plan (PGEM) as applied to Moorea Island, this shark-oriented ecotourism activity has been restricted since 2002 to the outer reef slope. At the Bathys Diving Club, formerly TopDive diving instructor Nicolas Buray has developed extraordinary expertise in visually recognising about 40 lemon sharks that regularly visit the feeding site. Because of his natural science knowledge, Buray was supervised by CRIOBE Director Serge Planes and CRISP Coordinator Eric Clua from 2006–2010 while undertaking an EPHE[2] qualification on Moorea's lemon shark population. The qualification gave rise to a scientific publication on a recognition method for these sharks using photo identification (Buray et al. 2009).

*Figure 1. Nine lemon sharks congregating at the Moorea feeding spot, near Oponuhu Bay.*

*Figure 2. Lemon shark (2.8 m) searching for food hidden in the coral under the watchful eye of a diver.*

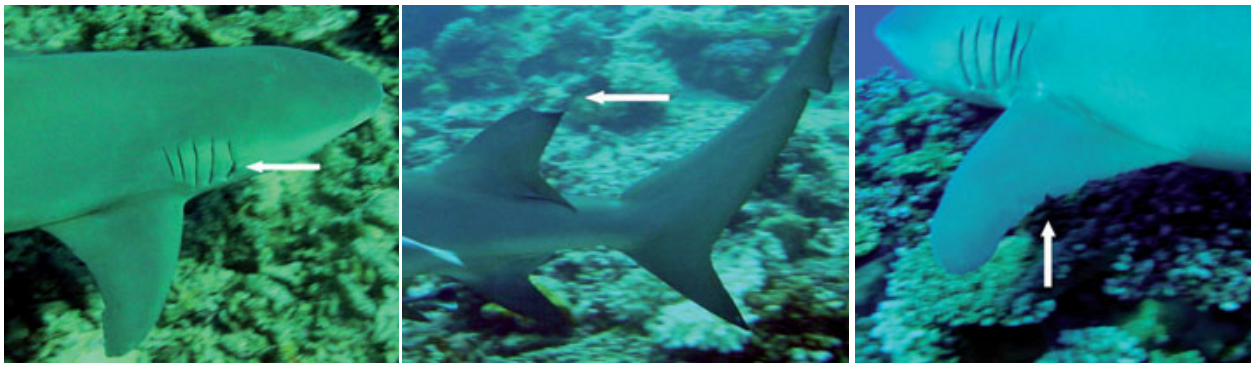

*Figure 3. Distinctive marks are used to identify individual sharks: scar on the right-hand gills (a), severed apex on the second dorsal fin (b) and notches in the left-hand pectoral fin (c).*

Because the lemon shark's skin is an even yellowish-beige, the idea was to first sort the animals by sex and overall size, and then compile distinguishing traits for each individual, using scars or notches and slits in the fins or other spots (Fig. 3). As a result of the study, each shark could be identified individually, which was the first step towards observing their behaviour with regard to feeding over a period of months or even years, as was the case from 2006–2010. As well as observing sharks, Buray carried out underwater biopsies for genetic testing (see Box 2 on p. 44).

## Advantages of feeding

Positive aspects of shark feeding are real and deserve to be mentioned. The first is the profit it generates for the local economy through tourism, which will be dealt with in detail below. The second involves shark biology. According to some authors, feeding helps low-density animals to meet and, thus, reproduce. The third argument concerns the shark's image. In many societies, sharks have a poor, deeply rooted, although undeserved, reputation that has been reinforced by the success of sensationalist films such as "Jaws". Improving their image is crucial, considering the danger they face worldwide from overfishing, with over 50 million sharks being caught yearly, particularly to supply the sharkfin market (Clarke et al. 2006). The struggle to ensure their survival, which some scientists and non-governmental organisations are engaged in, could never be won without favourable public opinion. Feeding is, therefore, a useful tool for promoting the concept that sharks are not killing machines thirsting for human blood, as some irresponsible films would have us believe. Through shark feeding, thousands of divers around the world have swum at close quarters with these animals with their razor-sharp teeth and extra-powerful jaws and suffered few if any attacks at all. If people looked objectively at the figures, they would realise that fatal shark attacks in

**Box 1. Sicklefin lemon shark**

There are two lemon-shark species: the Indo-Pacific *Negaprion acutidens*, dubbed "sicklefin" because of its sickle-shaped pectoral fins, and the Atlantic *N. brevirostris*, which is easily identified by its even yellowish-beige coat and a highly developed second dorsal fin that is nearly as large as the first. It is a placental viviparous shark that prefers lagoons and bears its young for about 12 months. It prefers to give birth in areas near mangroves. Juveniles tend to live inside lagoons while adults are more often found on outer reef slopes. It is a somewhat solitary and territorial shark at the adult stage and can be irascible and aggressive with humans. It has a powerful jaw full of razor-sharp teeth and tends to eat fish. It has a lifespan of approximately 25 years and can grow up to 3.5 metres long.

Sicklefin lemon shark (*Negaprion acutidens*)

the last decade varied from one to two a year, according to International Shark Attack File, which is extremely low. By way of comparison, mortality from insect stings has been estimated at between 0.09 and 0.45 deaths per million people per year (Annila 2000),[3] or 550–2,700 deaths per year worldwide (total population of 6 billion). One wonders how many people objectively think of bees as being hundreds of times more dangerous than sharks.

## Potentially negative effects

Despite the positive aspects of shark feeding, in the long term it involves a number of potential hazards. These include i) human interaction, in which sharks could attack and kill, even involuntarily; ii) ecosystem interaction in which the ecosystem may be deprived of these super predators' beneficial effects while they wait for free food at a particular spot; and iii) sharks themselves, whose biology and ecology have been disturbed. It has been demonstrated (Guttridge et al. 2009) that sharks' learning abilities are extremely well developed and feeding quickly leads to dependence when food is easily available, as well as to sharks' becoming accustomed to the presence of humans. Humans are soon associated with food and otherwise wary, distant sharks no longer hesitate in approaching humans and even entering into close contact with them. This significantly heightens the risk of accidental biting (e.g. a shark biting a diver's limb that it mistakes for food) or intentional biting out of domination or territorial instincts. In such cases sharks ward off potential competitors, much as a dog would near its dish. Regarding the ecosystem, confining several normally solitary, territorial sharks in a restricted area means they are no longer active in their respective territories.

It is common knowledge that sharks act as "dustmen", ridding their environment of dead or sick animals. The negative "domino effect" of disappearing large sharks has also been observed, such as the exponential increase in rays, sharks' usual prey, in the North Atlantic. Recent studies tend, however, to show that their importance to the ecosystem as "motors of evolution" is as diffuse as it is crucial. By daily catching prey such as fish, particularly smaller, less wary ones, sharks force the fish to devote more energy to reproduction and, therefore, breed faster while at the same time selecting for fitter individuals. In other words, the more sharks there are, the more fit fish there are as well. Although this undeniable effect is difficult to assess in scientific terms, the negative effects for the sharks themselves can, nevertheless, be evaluated, as demonstrated by the joint SPC-CRIOBE team from 2006–2010, following over 1,000 dives. By analysing 39 individual lemon sharks, it could be demonstrated that they became increasingly faithful to the feeding site as the years went by (Clua et al. 2010). This trend implies that there is a heightened risk of inbreeding within the population, even though there was contact between resident and non-resident sharks during the mating season from September to November. During this period, some females that are not seen during the rest of the year enter the site, while some males leave it temporarily. Such exchanges do indeed contribute to genetic variety. This is also the time when skirmishes between sharks reach a peak, as competition for mates compounds clashes over food. This uneasy period also heightens the mauling hazard for humans, so much so that the research team suggested that French Polynesian authorities impose a feeding freeze during the mating season. Not only can shark feeding be dangerous during mating season, but it also keeps the same lemon sharks within a restricted area, favouring inbreeding within a population (lemon sharks) for which low genetic variety is already a problem.

The information was obtained by adding DNA samples from juveniles in the area, which were mainly offspring of the group under investigation, to adult samples (Mourier et al. submitted). A lack of genetic variety is synonymous with low resistance to external stress, such as potentially fatal diseases.

## Economic value of sharks through ecotourism

Although the researchers warned authorities of the inherent risks of shark feeding, the idea was not to obtain a ban on it. Ecotourism generates large revenues for the local economy, as it does everywhere in the world where it is practised. Shark feeding occurs in the Bahamas and Maldives with the grey reef shark (*Carcharhinus* sp.) and in South Africa with the great white shark (*Carcharodon carcharias*) and tiger shark (*Galeocerdo cuvier*) north of Durban. In the South Pacific outside of French Polynesia, the only truly developed shark feeding venture is on Beqa Island in Fiji, off southern Viti Levu, with bulldog sharks (*Carcharhinus leucas*). "Cage diving", attracting sharks with teaser bait, but not feeding them, has been developed in Hawaii with the Galapagos shark (*C. galapagensis*) and sandbar shark (*C. plumbeus*). Several publications emphasise the economic advantages of such ecotourism activities. In Fiji, for example, part of the dividends earned by diving clubs, amounting yearly to several tens of thousands of Fijian dollars, are paid to villages lying adjacent to the reserved area, where bulldog sharks congregate, in return for not fishing in it. All of the studies deal with the issue in general terms, and do not provide specific figures for sharks. On Moorea, it was calculated that direct profits generated by shark diving provided a yearly revenue of USD 5.4 million and that one lemon shark contributed USD 2.3 million over its 20-year lifespan. By basing the study on separately identified individuals, it was possible to calculate individual yearly contributions that averaged USD 315,000 for each of the 13 resident sharks, which accounted for 73% of onsite observations. The most productive resident female alone contributed USD 475,000 (Clua et al. in press). Shark fishing has been banned in French Polynesia since 2006, but evidence has

come to light of poaching by local fishermen (Fig. 4). The researchers supposed that if local fishermen were provided with precise figures on the economic value of a single shark, even a lemon shark, they could better appreciate the fact that a shark is worth much more alive than dead. They would, of course, need to have a direct or indirect stake in the profits generated by ecotourism shark feeding. That, however, is a matter for the local authorities.

*Figure 4. Lemon shark with a hook to the left of its mouth and potentially fatal knife gouges, probably inflicted by a fisherman.*

## Other economic advantages of sharks

In order to convince marine world stakeholders (e.g. tourism operators, fishers, tourists, coastal populations) and political decision-makers of the economic advantages of keeping sharks within their ecosystems, the SPC-CRIOBE team envisages taking up the daunting challenge of calculating other contributions sharks make to local and world economies. This requires looking beyond their direct value in terms of contributions to ecotourism, as described above, and beyond the market value of shark fisheries that are easily quantifiable by consulting market prices, even if these were sustainable (which is highly unlikely). As previously mentioned, sharks contribute to ecosystems that are richer in fishery resources, which are useful to humans, and this more indirect value needs to be better understood. Sharks also have an "optional" value as reservoirs of active ingredients in therapeutic applications, such as squalene.[4] Finally, in the Pacific probably more than elsewhere in the world, sharks also have what is known as a "non-use" value, whether it is an "existence value" (the intrinsic worth assigned to a common property), a "heritage value" (the importance attached to being able to transmit it to future generations), or a "cultural value". The latter is extremely difficult to define, but undeniably present throughout the Pacific, where the shark is often a "totem" animal into which the souls of ancestors are re-incarnated. It is traditionally respected and not fished. Increasing demand from Southeast Asia for sharkfins is, however, spreading farther into Pacific Island states and inciting local fishermen to catch sharks and chop off their fins, discarding the rest of the animal. What do the spirits of the elders think of this? May they inspire their Polynesian, Micronesian or Melanesian descendants to behave as worthy heirs of an extraordinary marine heritage?

## Conclusion

To feed or not to feed. The answer no doubt lies somewhere between the two. In any case, if feeding contributes to saving sharks, then perhaps this justified feeding. It obviously should be done with due heed paid to the negative aspects raised above. Scientists are providing fisheries managers with increasing amounts of information for reaching the right compromises, as humans' quest for a fun-seeking approach to nature should not prevail over the welfare and survival of wild animals, as many believe. Humans are nothing more than an intelligent but whimsical animal with too much power — the only one that can destroy the ecosystem in which it lives.

## Acknowledgements

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## References

Annila I. 2000. Bee venom allergy. Clinical and Experimental Allergy 30(12):1682–1687.

Buray N., Mourier J., Planes S. and Clua E. 2009. Underwater photo-identification of sicklefin lemon sharks, Negaprion acutidens, at Moorea (French Polynesia). Cybium 33:21–27.

Clarke S.C., McAllister M.K., Milner-Gulland E.J., Kirkwood G.P., Michielsens C.G.J., Agnew D.J., Pikitch E.K., Nakano H. and Shivji M.S. 2006. Global estimates of shark catches using trade records from commercial markets. Ecology Letters 9:1115–1126.

Clua E., Buray N., Legendre P., Mourier J. and Planes S. 2010. Behavioural response of sicklefin lemon sharks (Negaprion acutidens) to underwater feeding for ecotourism purposes. Marine Ecology Progress Series 414:250–266.

Clua E., Buray N., Legendre P., Mourier J. and Planes S. (in press). Business partner or simple catch? The economic value of the sicklefin lemon shark in French Polynesia. Marine and Freshwater Research.

Guttridge T.L., Myrberg A.A., Porcher I.F. Sims D.W. and Krause J. 2009 The role of learning in shark behaviour. Fish and Fisheries 10:450–469.

Mourier J., Clua E., Buray N., Legendre P. and Planes S. (submitted). Genealogic tree of Lemon shark population reveals a weak resilience pattern. Proceedings of the Royal Society B.

**Box 2. Underwater sports: Undersea biopsies**

Biopsies consist of sampling a piece of skin (sometimes with fat and muscle) for genetic testing. On Moorea, such tests assessed the degree of kinship between two individual sharks over one or two generations. The tests were carried out using an underwater crossbow and arrow with a puncher at the tip, usually used for whale biopsies. The punch is made up of a hollow tube with a sharp rim and round stop preventing the shark from being pierced to depths of more than 2 or 3 cm. Inside it, barbs hold the flesh in as the arrow is expelled and bounces off the shark (Fig. 5a). The arrow is usually shot at the fin's base so it can cross it and take a core sample, increasing the chances of obtaining a piece of skin (Fig 5b). The sampling is painless for a shark that suffers far more violent attacks from other sharks, but it is often very surprised and sometimes reacts by turning on the shooter. Needless to say, such situations become fairly unpleasant.


*Figure 5. a: Scientific diver displaying a punch containing a piece of flesh following a biopsy; b: Scientific diver shooting at lemon shark's dorsal fin for a biopsy.*

1 All pictures in this article are by Nicolas Buray. © Copyright reserved.
2 A qualification awarded by École pratique des hautes études (a practical postgraduate studies institution) equivalent to a two-year master's degree in the French university system.
3 Post-mortem studies suggest that this is could be an underestimation (http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&list_uids=3233724&dopt=Abstract)
4 Squalene is a substance known for its medically proven antioxidant and colon-cancer-inhibiting properties.



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