Review of Shark Diving Practices at Fuvahmulah, Maldives

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Review of Shark Diving Practices at Fuvahmulah, Maldives

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Contributors:

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Foreword

Fuvahmulah atoll in the Maldives was declared an UNESCO Biosphere Reserve in 2020 due to its varied biodiversity including diverse coral reef ecosystems and significant populations of sharks. Several protected areas sit within the Biosphere Reserve including Farikede MPA, designated to protect oceanic species that utilise the area including pelagic thresher sharks (*Alopias pelagicus*), oceanic manta rays (*Mobula birostris*) and whale sharks (*Rhincodon typus*) amongst others.

In recent years a valuable shark diving industry has developed in Fuvahmulah as it has become globally recognised for its dive encounters with an abundance of elusive marine megafauna species like the aforementioned. Of particular interest is the famous 'Tiger Shark Zoo' or 'Tiger Harbour' dive site, located in the vicinity of Farikede MPA but within the Biosphere Reserve, where divers can experience close encounters with multiple tiger sharks, attracted to the site via provisioning. Local fishery's waste disposal has played a role attracting the sharks to specific locations on the island in great numbers. For the context of this report, the term 'provisioning' refers to the use of any attractant (e.g. bait, chum, feeding, bottle cracking, etc.) as defined by Meyer *et al*. (2021).

The Maldives Ministry of Climate Change, Environment and Energy, and the Fuvahmulah City Council are currently reviewing the management of MPAs and marine industries on Fuvahmulah, including dive practices. Sustainable shark diving throughout Fuvahmulah is important, especially within MPAs, as highly mobile species using the MPAs are likely using other parts of the island also (e.g. tiger sharks at Tiger Harbour). To support the evaluation of current management, this report is focused on the shark diving activities that take place at Fuvahmulah. This report aims to:

- Review current dive practices in Fuvahmulah, including current and past provisioning practices and how the local dive industry has developed current management measures;
- Provide a review of provisioning shark tourism with case studies and examples from different global sites;
- Consider best practices and considerations for developing a unified Code of Conduct for shark diving tourism;
- Explore examples of sustainable fish waste practices from around the world with possible application for Fuvahmulah.

The information collected and collated in this report provides guidance and options that could be considered when developing a sustainable shark diving future for Fuvahmulah. Concepts and findings are discussed within individual chapters, and opportunities for next steps are summarised at the end of the report.

Executive Summary

Global marine tourism has increased rapidly in recent years, with sharks receiving the most attention. Opportunities to observe sharks in their natural environment and raising awareness for declining populations (with over 70% of oceanic species now threatened with extinction) is made available through in-water interactions (e.g. scuba diving, snorkelling or free-diving). In turn, shark interactions generate significant revenues, development avenues and employment opportunities in many regions around the globe.

For this report, current shark diving practices are reviewed within the context of Fuvahmulah Atoll – a UNESCO Biosphere Reserve in southern Maldives. Despite Fuvahmulah's isolated geographic location, the island hosts intricate coral formations and close encounters with elusive marine species which offers a unique shark diving experience for tourists. Due to historical fishing practices, large aggregations of sharks, primarily tiger sharks *Galeocerdo cuvier,* are seen around Fuvahmulah year-round. Coupled with the building of the airport in the 2010s opening up the island to international visitors, the opportunity to get up close to such a large, predatory shark has driven a rapid onset of shark tourism in Fuvahmulah in recent years. The authors visited Fuvahmulah in December 2023 and interviewed local stakeholders in order to understand the present shark diving industry on the island.

The authors conducted a total of 35 interviews with all dive operators (11), council members, community members, local NGOs, fishers and researchers. Through semi-structured interviews, the authors gained insight into current and past practices, priorities, successes, failures, concerns and future hypothetical scenarios. Results from the interviews are summarised in Chapter 1, and further discussed in Chapter 2 in the context of other world operations with tiger sharks. These chapters then set the basis for Chapter 3 where best practices are discussed and options that could be considered in the development of a code of conduct are provided. Chapter 4 presents current fish waste practices in different countries, as well as ideas put forwards by local fishers on Fuvahmulah. We encourage the reader to explore Chapter 5 in more detail where the report main points are summarised. All results, considerations and options put forth in this report are presented with the basis that stakeholder involvement and participation is crucial for a successful and inclusive sustainable shark diving industry in Fuvahmulah.

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1 Tiger Shark Diving Summary Report

1.1 Background

The Maldives is an archipelagic country situated in the northern Indian Ocean, west of India and east of Mauritius and Reunion islands, from approximately 7° north to 0.5° south of the Equator (Naseer & Hatcher, 2004). The Maldives is composed of 26 geographic atolls, grouped into 20 administrative atolls, covering 21,600 km^2 of which only 300 km^2 are land (Sathiendrakumar & Tisdell, 1989). Fuvahmulah is a true oceanic island in southern Maldives located approximately 30 km south of the Equator (David *et al*., 2021), and is the only single-island administrative atoll in the country. This approximately 5 km^2 island is renowned in the Maldives for its greenery and agricultural heritage – rather different to most of the country that hosts multi-island atolls with smaller landmasses. In 2019, approximately 25% of the population in Fuvahmulah worked in the agricultural sector as the primary activity and about 5% fishing. The remaining 70% worked in other industries, although these were not specified but would include government, education and hospitality sectors (Laila, 2019). Fuvahmulah is surrounded by a shallow fringing reef before steeply descending to depths greater than 2,000 m. This close proximity to deep water makes Fuvahmulah rarely diverse where coastal and oceanic species can be seen relatively close to shore (Dandoy, 2023). The island was designated as a UNESCO Biosphere Reserve in 2020, but bioecological assessments and baseline data for sharks remain scarce.

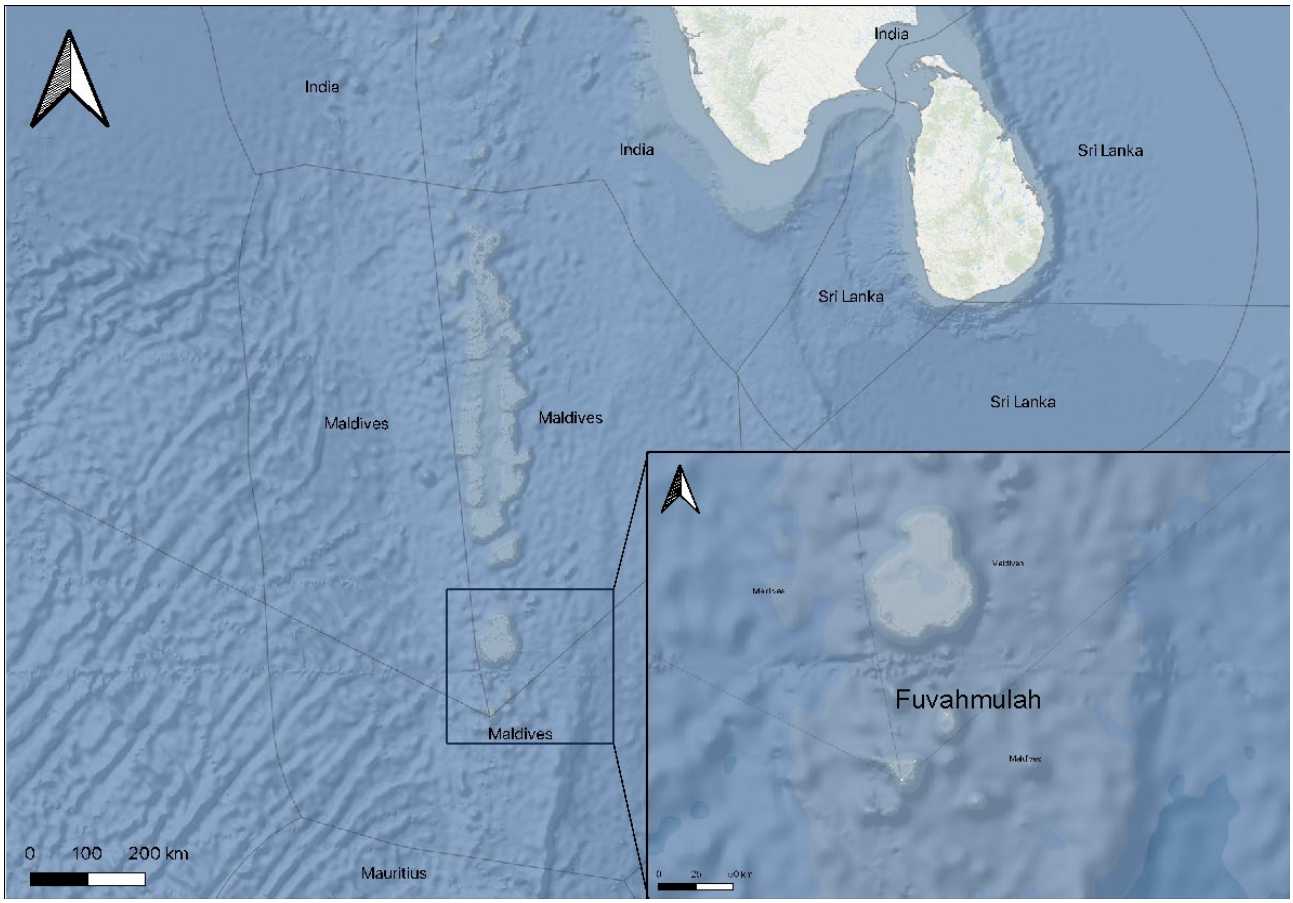

Figure 1. Map of the Maldives, with an inset to the southern atolls and Fuvahmulah. Image © Araujo, Scotts, & Zareer, made with QGIS 3.26).

Tourism in Fuvahmulah was relatively low compared to other Maldivian islands (e.g. those in central Maldives) until recently. A sizeable aggregation of tiger sharks *Galeocerdo cuvier* occurring in Fuvahmulah, coupled with the opening of its airport, has led to the fast development of a tourism industry offering shark diving as the main attraction. Fuvahmulah has been dubbed 'Shark Island' given its regular sightings of many shark species including the elusive pelagic thresher shark *Alopias pelagicus*, schooling scalloped hammerhead sharks *Sphyrna lewini* and the rarely encountered oceanic manta ray *Mobula birostris.* Consistent tiger shark encounters in Fuvahmulah, coupled with sightings of these other rare species, has made Fuvahmulah a globally renowned shark diving destination often referred to as the 'Galapagos of the Indian Ocean'.

Reliable tiger shark encounters are typically associated with provisioning activities (i.e. the use of chum, bait, food, other attractant; Meyers *et al*. 2021), such as that seen at Tiger Beach in the Bahamas, Jupiter in Florida, Beqa Lagoon in Fiji, or at Aliwal Shoal in South Africa (Gallagher & Hammerschlag, 2011). In Fuvahmulah, the sighting of tiger sharks around the island goes back generations, and has been more recently focused at a specific site in the vicinity of the harbour entrance through the discard of fish waste from the fish market. The waste generated from the local fisheries was originally thrown inside the harbour (built in 2004) but was later moved outside the harbour walls due to the unsanitary conditions created by the aggregated waste. This shift created a regular source of food for sharks that would typically be distributed around Fuvahmulah, further offshore or cruising through the area. This predictable occurrence of tiger sharks within close proximity of the harbour did not go unnoticed, and the first dive centre was set-up in 2013 offering close encounters with tiger sharks. Coupled with the island's airport opening in 2011 and being the only such location in the Indian Ocean where 20–30 tiger sharks can be reliably observed in a single, shallow dive, led to the prompt development of tourism. At the time of writing (December 2023), there were 11 registered dive centres on Fuvahmulah offering tiger shark dives at 'Tiger Harbour' (TH) – the main dive site at Fuvahmulah.

Figure 2. Tiger sharks *Galeocerdo cuvier* anticipate a feeding opportunity ahead of a dive group at the Tiger Harbour dive site in Fuvahmulah, Maldives. Photo © Gonzalo Araujo.

Diving tourism in the Maldives comes under the regulation of the Maldives Tourism Act (Law No. 2/99, 1999) and the Maldives Recreational Diving Regulation (2003). As such, any activities and considerations need to be in accordance with this aforementioned legislation.

1.2 Methodology

The authors visited Fuvahmulah in December 2023 to conduct semi-structured interviews with council members, community members, fishers, local NGOs, researchers and dive operators. These semi-structured interviews can be found as Appendices 1-5 on this document. Through these interviews, stakeholders were asked to share their experience and backgrounds, and their relationship with sharks and the dive industry. Questions were asked relating to their views on current practices and any needs or future direction that might improve the sustainability and overall practices of current operations. Between 3 and 13 December 2023, the authors conducted a total of 37 semi-structured interviews, as well as multiple informal conversations with stakeholders on Fuvahmulah. Interviews included 4 Fuvahmulah City Council members, all dive operators on the island (11), 7 with NGOs and researchers, 7 with community members, and 5 with fishers. Interviews lasted an average of 1 hour and 10 minutes. Concerns and opportunities were highlighted by most stakeholders, with the majority understanding the importance of shark diving for the thriving economy of Fuvahmulah.

For some of the questions, a five-point Likert-style scale was used (1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, and 5 = strongly agree) which allows for the quantification of qualitative-based answers (Joshi *et al*. 2015).

Here, the current dive practices at Fuvahmulah are presented and discussed based on the local stakeholder semi-structured interviews, social and traditional media, and grey literature. Ensuring a safe and sustainable shark diving industry at Fuvahmulah is at the centre of this work, and minimising risk is imperative.

Table 1. Summary of interviews conducted between 3 and 10 December 2023 in Fuvahmulah.

Interviewee category	Number of interviews
Community member	7
Dive Operator	12
Fisher	5
Fuvahmulah City Council	4
NGO	3
Researcher	4
Grand Total	**35**

1.3 Results

1.3.1 Current Practices

1.3.1.1 Dive Operations

The earliest scuba dive reported in Fuvahmulah by a local operator was in 2004, with one local operator offering scuba diving with sharks around the island from as early as 2013. The first commercial scuba diving at Tiger Harbour (TH) was in 2015, which quickly gained momentum. Today, the island has 11 registered dive operators diving the site.

Operators vary in size and target market, for example, the smallest dive operator had 70 divers over the year of 2023 whereas the largest had 3,000 individual divers over the same period. Some operators target European divers (mainly Spanish and German) whereas others target East Asian divers. Typically, operators offer 3-dive packages for guests, with one dive always at TH whilst the other two are either at the north or south corner of the island, or along the reef elsewhere. This package configuration is mostly driven by the depth limit and difficulty of diving the north (Thoondu) and the south (Farikede) points, and by the shallow nature of the TH dive (< 10 m). On average, operators conduct the TH dive on most days of the year (range 100–500 dives per day) whilst Farikede is only dived on 193 days per year on average (range 70–300 dives per day) due to the difficulty (strong currents, topography and depth) of the site.

Consistently, the main product offered to divers visiting Fuvahmulah is TH, with operators strongly agreeing that this dive is the most important for their business [Likert scale average of 4.3 (strongly disagree to strongly agree – see Methodology section), range 1–5]. As this is a predictable, exciting, easily accessible dive site that is currently located at the mouth of the harbour, this is unsurprising. Given that TH was dived on 95% of days in the past year (average of 347 days), and other dive sites are not, the 3-dive packages make business sense as there'll always be one guaranteed shark dive for guests.

1.3.1.1.1 Tiger Harbour (TH)

Typical operation at TH

Dive operators are given a two-week or monthly schedule with their respective assigned 30-minute slots per day of diving. Currently, operators get assigned two 30-minute slots per diving day at TH. These 'time slots' are arranged and managed by the dive operators themselves and rotate every 2–4 weeks. The slots can be informally 'exchanged' between operators to accommodate needs, which can foster closer collaboration between operators.

The dive procedure at TH is generally similar for most operators:

1. Tourists are briefed on safety procedures, with emphasis on moving vessels at the surface and tiger shark behaviour;
2. They are dropped to the side of the site and once in a group at the bottom, they move into position;
3. The divers are aligned in a line or slight semicircle with dive guides securing the flanks and behind the divers;
4. A guide then positions themselves centrally, 2–5 m in front of the group and purges their regulator, signalling the vessel to drop the chum/bait;

5. The bait is typically tuna heads and operators use 1–5 on average per 30-minute dive;
6. The bait is either left to drop on its own to the substrate and be caught by a shark, or it is intercepted by a guide who hides the tuna heads amongst coral rocks at the sea floor, whilst being flanked by a second guide. The bait is never handled by a guest diver;
7. The tiger sharks typically move in as soon as the engine of the vessel is above or when the tuna heads enter the water;
8. The dive is typically 45 minutes, with 30 minutes allocated specifically for TH (and the rest of the time used for ascent, descent and moving to the site), unless no other divers appear (i.e. the next group) at which point the dive can be extended;
9. Once the time is up, the divers all move together either down current or to the blue (deeper water and away from the TH);
10. Once safety buoys are deployed, the divers gather as a group and ascend whilst one to two guides stay below to keep an eye on the tiger sharks which sometimes show curiosity until all divers are out of the water (including guides);
11. Divers exit the water and the site.

Although this procedure is somewhat similar, it is not the same for all operators. It has been identified by most operators (10/11) that practices at TH should be standardised from start to end to ensure a consistent product offering and for safety reasons. Dive procedures can differ, for example, some operators do not hide the tuna heads under the coral rubble, some always continue the dive in the blue, whilst others keep the dive as brief as possible following the 30-minute slot at TH. Some operators always carry sticks with them for safety.

Figure 3. Location of the Tiger Harbour (TH) dive site (A): at the entrance of the Fuvahmulah harbour (indicated with a red star; the yellow star is an approximate location of *Rasgefanno neru* – a proposed alternative location for the TH dive site). Divers and tigers sharks can be spotted at Tiger Harbour from above (B).

Chum/bait use

Before 2021, it was not uncommon that instead of using tuna heads specifically, bucket-loads of fish discards were used at TH. Operators described that the amount of waste and blood used caused issues with visibility, and fish waste ending up over a large area – sometimes near or on top of divers. This would consequently lead to a lack of control of where the tiger sharks were expected to occur, and thus potentially increase the risk of something not going according to the dive plan.

From research conducted in December 2023, all operators (n = 11) confirmed that the bait normally used today at TH is tuna. Only the heads are used, which will vary in size and weight depending on availability at the local market, which in turn is dependent on both weather and seasonality. Two species of tuna are typically used: yellowfin *Thunnus albacares* and skipjack *Katsuwonus pelamis.* Both species are caught using handlines or pole and line. The fish are processed in the local market where they get cleaned and only the fillets are retained, whilst the carcass including the head and tail are discarded. Dive operators now use only the heads to create a cleaner and more manageable experience in the water.

The amount of chum/bait used during dives at TH depend on the season and the number of tiger sharks encountered during the previous days. Typically, 1 to 5 heads are used per 30-minute dive slot. When divers enter the water, if the number of tiger sharks and their activity level is high, no chum/bait is used. Tuna heads vary in size and weight, but these are typically 1–5 kg, and one would expect about 2–5 kg of food being used per dive (i.e. 2–3 medium-sized tuna heads). If large tuna heads are available (i.e. approximately 5 kg), only one head might be used per 30-minute dive. Assuming all 22 dive slots are dived during the day (i.e. 7:30 am to 4:30 pm), approximately 100 kg of food might be used. It is likely that this number is larger (> 100 kg per day) during the high season (December to May), and smaller (< 100 kg per day) during the low season (June to November).

Shark behaviour

Past and present researchers, as well as operators, highlighted that on average, year-round, 7.3 tiger sharks are encountered per dive at TH (range 1–32). This number appears to change between the high (10–15; December to May) and low seasons (5; June to November).

On occasions when billfish (e.g. marlin, sailfish) heads were used instead of, or complementary to tuna heads, overall shark activity increased, and thus the overall ability to control all aspects of the dive decreased, increasing the risk of something not going according to the dive plan. This was consistently mentioned by all operators (n = 11) and warrants further attention.

Figure 4. A tiger shark in blue water off Tiger Harbour, Fuvahmulah. Photo © William Tan.

Briefing at TH

Dive briefings for TH are typically thorough. A briefing would usually begin with information about the island and the tiger sharks of Fuvahmulah, followed by safety procedures, namely due to the location of the dive site and the ongoing boat traffic above divers in the water. The briefing would then cover tiger shark behaviour, including instructing divers how to behave and what to do/not do if a shark approaches a diver. Although briefings typically cover these different aspects of the dive, there is no consistency across operators.

Diver to Guide ratio at TH

All operators explicitly said that they follow a maximum of 4 divers per guide ratio. Whilst describing the dive operation however, it was clear that the ratio is typically smaller, wherein there is a guide who handles the bait and there is a guide behind each group of divers, and this would bring the ratio to 1:2–1:3. There was some discrepancy amongst operators however, and it was highlighted that a common rule for all operators would help maintain a standard within Fuvahmulah as well as ensure diver safety is the same throughout. Operators did consistently iterate the importance of having trained guides to ensure diver safety: guides that have gone through shark behaviour and scenario training at TH specifically. When calculated verbatim, the overall average guest to guide ratio was 1.1:1 (range 0.3–4.0). This ratio would increase depending on group size [i.e. smaller dive groups would have a smaller ratio (1:1), whereas larger groups would have larger ratios (1:4)]. The maximum number of divers was typically dictated by the amount of space on the dive vessels, so 12–14 on average, and by the time of year.

1.3.1.1.2 Diving at Farikede MPA

All operators offered diving at Farikede MPA (aka 'south plateau'). However, all operators highlighted the difficulty of diving the site given the strong currents, including down currents, and general depth limits at the site (i.e. thresher sharks are commonly deeper than 30 m, limiting overall bottom time within recreational diving limits). The site is popular for various species of pelagic sharks and rays, with the pelagic thresher *Alopias pelagicus* being a major attraction, but other species such as scalloped hammerheads *Sphyrna lewini*, tigers *Galeocerdo cuvier*, grey reef *Carcharhinus amblyrhynchos* and silvertip *Carcharhinus albimarginatus* sharks are also commonly spotted there. Other species highlighted as being sighted at Farikede include the smalltooth sand tiger shark *Odontaspis ferox*, the whale shark *Rhincodon typus*, whitetip reef shark *Triaenodon obesus*, the oceanic manta ray *Mobula birostris* and devilrays *Mobula* spp.

On average, the site was dived 193 days per year (range 70–300 days, 53% of all days), with operators highlighting that on average 67% of divers participate in diving activities at Farikede – the variability is influenced by conditions, dive experience or other reasons. The average dive group size taken to Farikede is 11.3 (range 4–20), with two dive guides per group on average.

Figure 5. A diver photographs a tiger shark near Tiger Harbour, in Fuvahmulah. Photo © William Tan.

1.3.2 Importance of tiger sharks and TH

When asked about the importance of tiger sharks and 'TH' specifically for their business, answers were consistent. On a Likert scale of 'Not important at all' to 'Very important' (1–5 score on the scale respectively), operators answered 5 very important (100%) for tiger

sharks and 4.3 very important for TH, highlighting that both the species and the predictable site play an important role in their business.

1.3.3 What would happen if food provisioning stopped or was restricted

Operators highlighted that tiger sharks are a common occurrence around Fuvahmulah, even before TH and before the harbour was built. However, historic frequency and numbers are unknown. Operators understand the role played by the fish discards from the fish market on the occurrence of tiger sharks in the vicinity of the harbour. To this extent, most operators (n = 10/11) highlighted that a restriction in the amount of food would likely have little effect on the occurrence of tiger sharks around Fuvahmulah and at TH specifically. Operators highlighted that a limit on the amount of food provided would likely limit the number of tiger sharks observed during the TH dive, however, they acknowledged that tiger sharks were unlikely to just disappear. Operators generally agreed to restricting the food provided if this was regulated equally for all and this was aligned with increasing diver safety and the predictability of dives at TH.

Contrastingly, when asked hypothetically what would happen if food provisioning was stopped and fish waste was discarded a different way, operators highlighted that tiger sharks would likely stop occurring in the vicinity of the harbour/at TH albeit not likely overnight. There was strong opposition from operators to the scenario of stopping food supply for the TH dive – understandably given the linkage highlighted between provisioning and the predictability of tiger shark occurrence at TH, a critical dive for their business (see section above).

1.3.4 Economics

The average price per dive charged for TH is 81 US Dollars (USD) (range 65–108 USD), whereas for other sites is 71 USD (range 55–95 USD). However, most operators sell 3-dive packages which include TH and two other dive sites, averaging 200–250 USD.

Assuming all divers participate in 3-dive packages costing 200–250 USD, and having approximately 12,600 divers as highlighted by operators (range of 70–3,000 divers per operator, cumulative 12,600 per year), this would indicate the dive industry is worth 2,520,000–3,150,000 US Dollars annually on scuba diving packages only at Fuvahmulah, excluding food, transport, accommodation, souvenirs or other expenses. It is also worth noting that most divers visit Fuvahmulah for multi-day diving packages (e.g. 3-, 7-, 14-day) and thus this is the smallest estimate of diving expenditure at Fuvahmulah. Assuming divers do an average of 3-day and 5-day diving packages (i.e. three and five 3-dive days of diving), the aforementioned number would be 7,560,000–12,600,000 US Dollars annually for a 200 US Dollars per 3-dive package, and 9,450,000–15,750,000 US Dollars annually for a 250 USD Dollars per 3-dive package.

1.4 Discussion

Fuvahmulah in southern Maldives is a single-island atoll in the Maldivian archipelago. With the opening of the airport in 2011 and the predictable, shallow water encounters with tiger sharks near the harbour entrance through provisioned fish discards, the diving tourism quickly developed and now receives more than10,000 divers annually. Shark diving in general is regarded as one of the best in the world, not only because of the tiger shark encounters, but because of predictable sightings of pelagic thresher sharks, reef sharks

and other occasional charismatic species (e.g. whale sharks and manta rays). A study conducted in 2023 found that the majority of divers visiting Fuvahmulah (91%, n = 42) visited to encounter specific marine organisms with 62% highlighting tiger sharks, and 91% reporting they had encountered a tiger shark during their visit (Zerr *et al*. 2024). Most respondents (76%) had never visited Fuvahmulah before, however, 24% had visited at least once before, highlighting an incredible return rate for a relatively young diving destination (Zerr *et al*. 2024). With this in mind, it is imperative that this rapidly developing industry is managed sustainably and in-line with local and national plans, and in agreeance with international fora for sustainable tourism with threatened species such as that laid out by the Convention on the Conservation of Migratory Species of Wild Animals (UNEP/CMS/COP12/Doc.24.4.8). Developing a sustainable diving industry for Fuvahmulah, taking into consideration all stakeholder needs, is paramount.

1.4.1 Current Issues/Concerns

1.4.1.1 Location

A common concern raised amongst stakeholders was the location of the TH dive site. Logistically convenient from a dive operator's perspective, it is located in the middle of the boat channel at the harbour's entrance. Boats consistently move above divers, especially during the busy season (December to May) given the continuous use of the TH site. Some operators (n = 5) highlighted willingness to move the dive site out of the harbour's entrance. Although the current site is ideal for all other aspects (i.e. shallow, protected from current, proximity to harbour), it raises safety risks and violates the Maldives diving regulations, as per Section 10:2a wherein no activities can be conducted within 'ports, traffic route accesses, passages and alike'. Given the operators willingness to find a safer dive site, one possible site was suggested north of the current site. In July 2023, a barge ran aground leaving a large area of flattened rubble that is also relatively shallow. Although the site would have more current than TH, it could help regulate shark behaviour by ensuring any bait/chum is always up current from the guests. Another alternative site mentioned by operators was the channel opening "*Rasgefanno neru*" (-0.294256, 73.429765), a rubble site that was previously used for entry /exit of boats prior to the development of the harbour. This site offers easy access at a shallow site, would pose no damage to live coral but would reportedly require some level of excavation to clean up the larger boulders and rubble pieces.

1.4.1.2 Freediving

A quickly growing industry, freediving is also gaining traction in Fuvahmulah. Currently, there is no national-level regulation on freediving. At present, only three dive operators offer freediving with the tiger sharks at TH, with a fourth operator offering freediving with tiger sharks at a reef site adjacent to TH. Freediving sessions in TH are charged between 100 USD and 120 USD. Freediving with tiger sharks is also provisioned.

The practices of scuba diving and freediving at TH include separate briefings and slightly separate safety procedures. Typically done with a minimum of two guides, where one guide stays on the surface with a tethered safety buoy and communicates with divers using a small bell. Freedivers are briefed not to dive towards sharks, rather to settle down and wait instead of swimming or charging the sharks, and are briefed on how to redirect a shark, should a situation arise. Freedivers are also advised to only dive down and come up near the buoy.

Freediving was highlighted as an issue by three operators. The main concerns raised were that whilst on scuba, a guide's movement or a regulator purge can change the direction of the sharks. When freediving, the only way to divert a shark is to physically redirect the sharks away from people (i.e. to gently push them in a different direction). They further highlighted the negative connotations around how these instances are portrayed on social media and the negative impacts and false sense of security created for uninformed or untrained viewers of such content. Operators highlighted concern that this extra use of human-shark contact could desensitise the sharks to usual deterrence techniques and increase anticipatory behaviour which could increase the risk of an incident. Studies relating to the anticipatory behaviour of sharks at provisioning sites and the correlation to incident risk have been analysed (Guttridge *et al*., 2009; Johson & Kock, 2006). However, these don't necessarily relate to human-shark contact so could be investigated further. We can assume though that the more this occurs, the higher the risk of an incident.

Stakeholders (namely operators not conducting freediving activities) and community members also highlighted a general apprehension of having freedivers in the water whilst there is active chumming/baiting on site or nearby (if freediving occurs at the same time as the scuba-based interactions at TH). One operator also highlighted the increased occurrence of sharks going up towards scuba divers in the mid-water column more recently.

Additionally, it was highlighted that having people at the surface at the entrance of the harbour, or vicinity, poses further risk of an incident with a vessel. Lastly, when some of these instances happen outside of the designated TH vicinity, and on the adjacent reefs, the tuna heads provided have been reported to get lodged between the crevices of coral colonies, resulting in sharks ramming into these corals to get to the chum, damaging corals and injuring themselves in the process.

1.4.1.3 Standardisation of practices

At least one dive operator has developed a preliminary document with rules and regulations for diving at TH. The document contains extensive detail on vessel permitting, dive guide training, minimum certifications required for guests at TH, dress code, prohibited practices (e.g. strobes, deco and night diving), guide to guest ratio, dive procedure, and the responsibility of the different parties involved as part of diving TH. This comprehensive document could serve as a good roadmap for developing a unified set of practices. At least one other dive operator worked with the Fuvahmulah City Council in 2022 and 2023 to develop the "Regulation on Management of Marine Areas within the Jurisdiction of Fuvahmulah for Tourism Purposes". This draft legislation was designed to manage dive operations on Fuvahmulah, and covered aspects of safety, procedure, enforcement, implementation, responsibilities of parties involved, and possible fees. Although the content of both these documents is relevant and necessary, clarity around ownership, roles and responsibilities is needed. Incorporating these into a single document with wider stakeholder engagement could lead to participatory legislation to govern all diving activities in Fuvahmulah and make use of relevant points already drafted.

During the interviews, most dive operators (n = 10) highlighted a need for standardising practices at Fuvahmulah while only one reported the current practices as being sufficient.

Other points raised by various stakeholders not currently in practice that would be beneficial to further explore include:

- Dress code underwater and the use of colours/shiny objects;

- Use of lights and strobes;
- Whether and when sharks need/should be redirected by divers;
- Guides use of cameras;
- Interaction hours;
- Emergency response plan (specifically for shark-related incidents);
- Implementation;
- Enforcement; and
- Responsibilities of the different stakeholders.

These points overlap with the two previously drafted regulations, further highlighting the need for a unified approach to regulate activities.

1.4.1.4 Amount and type of bait used

Some operators and researchers expressed concern about how food is provisioned and the impact it has on shark activity levels. Operators also shared that on occasion, the sharks go for the food whilst the tuna heads are sinking down before the guides get a chance to hide it under the coral rubble. It was suggested by some operators and researchers that it would be safer to contain the food for some time before it is released, and the sharks can access it. Therefore, the food could be supplied in a container for the first 10–20 minutes before it is released as such as it is practiced elsewhere (see Chapter 2). If the quantity and type of food delivered was also regulated, this would create more controllable conditions as per researchers and operators' comments.

Given that all operators highlighted a change in shark behaviour (i.e. increased activity and aggression) when billfish heads were used, it would be advisable to strictly restrict the use of bait/chum to tuna heads (i.e. prohibit the use of billfish chum/bait) so that guides and operators can more predictably and safely deal with shark behaviour.

1.4.1.5 Location of other provisioning activities

The popularity of diving at TH has enabled the study of tiger sharks visiting the site. To date, over 250 individual tiger sharks have been identified at the site – one of the largest documented aggregations of tiger sharks in the world as confirmed by marine biologists working in Fuvahmulah. To this extent and given the wide attention to the site and the tiger sharks on the media (including social media), concerns about the number of sharks around the island have been highlighted by members of the community. Coastal community members (fishers, snorkelers, swimmers, surfers) have noted incidents with provisioning or fish waste discarding near areas of recreational use. Such practices could attract the sharks to these areas and potentially increase the human-shark conflict. It would therefore be advisable to restrict provisioning/chumming activities to the TH dive site only.

1.4.1.6 Fishers

1.4.1.6.1 Background

About 5% of Fuvahmulah's working population relies on fishing as the primary activity, whereas approximately 10% as a secondary activity (Laila, 2019). A total of 5 fishers from Fuvahmulah were interviewed for the purpose of this review. The average number of years

fishers had been fishing around Fuvahmulah was 47 years (range 30–58 years). Fishing is carried out both during the day as well as at night, with fishers fishing on around 250 days a year (weather dependent). The main target catch is yellowfin (*Thunnus albacares*) and skipjack tuna (*Katsuwonus pelamis*), as well as reef fish species, and a local deep-sea fish called *'kattelhi'* (*Promethichthys prometheus*), the Roudi escolar. Yellowfin tuna is mainly caught offshore and near fish aggregating devices (FADs). For tuna, 100–300 kg per day was considered the average when fishing was bad, whilst for a good day, 500 kg was reported as the average. Fishing for Roudi escolar is generally done in the evening, after 7:00 pm. Fishing at FADs is typically carried out from 2:00 to 4:30 am where there could be up to 12 boats fishing together. As there is no weighing boat, the catch is sold within the island and fishers rush back to get to the market to have better chances of selling their catch among the buyers. For 3 of the fishers, fishing was the main source of income, and the average daily income earned from fishing ranged from 13 USD to 216 USD.

Prior to the ban on shark fishing in 2010, fishers interviewed also engaged in shark fishing for any offshore and nearshore species. The species caught included whale sharks and spiny dogfish (for their liver oil), reef sharks, hammerhead shark, lemon shark and thresher sharks. The meat was taken for human consumption while fins and skin were sold, generating considerable profit at the time, roughly 65 USD per kg of shark.

1.4.1.6.2 Sharks and fishing

In recent time, fishers reported an abundance of sharks, to the point where fishing effort is hindered in both offshore and nearshore waters. Nearshore species observed (as described by the fishers) include whitetip reef sharks, while offshore species include *dhihthundi, ishakul*, oceanic whitetip shark and sometimes tiger sharks.

From fisher observations from boats, the number of tiger sharks present around the island have increased drastically. In shallow areas where sharks were not seen 'back in the day', sharks are now abundant and seen all around. The increase has been attributed to habituation due to provisioning of tiger sharks for dive tourism. This increase was echoed across all fishers interviewed, and the same sentiment seems to be shared by their colleagues. Fishers reported that in previous years, the sharks did not tend to come for their catch when fishing offshore, but now they gather in groups. An increase in perceived abundance of sharks cannot be interpreted as an actual increase in their abundance. These changed could be attributed to shifts in shark behaviour, a decrease in sharks' food availability, changes driven through the food provisioned, or a combination of all.

Fishers also reported that the increase in shark numbers around the island has negatively affected the number of reef fish around the island. Previously, approximately85 kg of reef fish were caught daily whereas this has now decreased to around 30 kg. Fishers also noted that on average approximately 11 sharks now circle around the boat until a fish is caught, and once one is caught, there could be up to 4 sharks fighting for a single tuna. It is also not uncommon for two-thirds of the fish to be bitten off by sharks by the time the fish is reeled in. This was also noticed for Roudi escolar, where if 12 fish were caught on multiple hooks, fishers are only successful in reeling back 3 of them onto the boat. While fishers acknowledge that there are now more fishing boats than in previous years, they attribute the overall increase in abundance of sharks to the ban on shark fishing (in 2010, a ban on shark fishing throughout Maldives was introduced (Directive 30-D2/29/2010/32), effectively making the whole of Maldives a shark sanctuary).

As fish provides a source of protein for the fishers and their families, the losses in fishing were reported to impact the nutritional needs while also hindering their livelihood. The time

and cost associated with replacing fishing gear is also higher due to increased depredation. One fisher reported having used 1 hook and 1 fishing weight for 3 years in the past. However, at present, one night of fishing requires 14–15 hooks. With every instance of lost gear, the time to prepare and replace gear then ends up limiting fishing time. When asked to rate the impact of tiger sharks on catch, from a 1–5 Likert scale (1 being greatly reduces, 2 being somewhat reduces, 3 being neutral, 4 being somewhat increases and 5 being greatly increases), the number chosen by fishers was consistently 1 (greatly reduces).

Fishers had a negative perception of sharks, with words such as *scary, nuisance*, *depredation*, *enemy* and *menace* used to describe them.

1.5 Future Direction and Considerations

The dive tourism industry is thriving in Fuvahmulah, with consistent considerable growth since 2017, and during the time since the pandemic. Considering six years ago there was only 1 operator and there are now 11, it is clear that there is demand and interest within the dive industry to capitalise on shark interactions. Similarly, the guest houses in Fuvahmulah have grown from 6 to 25 since 2017, in line with diver demand. The main driver for tourists visiting Fuvahmulah is for diving, specifically shark diving, with TH playing a key role in delivering on expectations.

Whilst the industry is expanding and still in its early years, it will be important to ensure that subsequent growth is sustainable and in-keeping with the island's vision and cultural heritage. It will be important to consider the carrying capacity or limits of acceptable change for the industry on Fuvahmulah – determined by the number of divers, dive operators and other industry-related growth on the island. Such an approach would ensure the locals' expectations, the industry standards, and the bioecological aspects are in agreeance. This is particularly important given the island's UNESCO biosphere reserve designation, highlighting the uniqueness and importance to the broader ecosystem. Considering Fuvahmulah is known as the 'green island' in the Maldives, ensuring that this greenery remains an important aspect of Fuvahmulah is critical, and hence sustainable development would be beneficial not only for locals, but also to maintain the heritage of the island.

It would be beneficial for all stakeholders on the island to work together to ensure the future and sustainability of the dive industry on Fuvahmulah. To that effect, stakeholder engagement will be key to any next steps. Stakeholder engagement could help facilitate the development of sustainable management of shark diving on Fuvahmulah. This would ensure all stakeholders have an opportunity to share their thoughts and experiences and facilitate stakeholder involvement at every step of the project to build trust and ownership amongst all involved. Topics for considerations could include, but not be limited to, the following sections based on the information presented herein:

- Regulations for shark interactions in Fuvahmulah (not TH);
- Regulations for TH, including number of people, diver to guide ratio, dress code, bait/chum delivery, amount and type, and location;
- Training of guides, learning from those currently leading dives at TH;
- Stakeholder engagement to reduce conflict (e.g. with fishers);
- Registration, certification and monitoring.

Consideration of the points above would help to address consistency across the industry, both with existing operators but also for any future expansion of the industry. This could also help answer sustainability and safety reservations, as well as ensuring those at the forefront of this industry play a key role in ensuring its future and management. The “Regulation on Management of Marine Areas within the Jurisdiction of Fuvahmulah for Tourism Purposes” spearheaded by the Fuvahmulah City Council raised valid points around implementation and enforcement. The study led by Zerr *et al*. (2024) highlighted that divers were willing to pay a one-off approximately 64 US Dollars (median 50 USD) entry fee for diving in Fuvahmulah. These fees could contribute to a co-managed fund between stakeholder representatives (i.e. government, industry, fishers, NGOs and local communities) to address capital and operational costs linked to the management, implementation, enforcement and monitoring of diving activities in Fuvahmulah – such a fee approach was recently highlighted in a global review to improve budget security and staff capacity to ‘carry out critical management activities’ linked to the success of marine protected areas (Brown *et al*. 2023). A key starting point is to work together with all stakeholders to achieve this and ensure inclusive representation.

2 Global Approaches to Provisioned Shark Diving

2.1 Introduction

Global marine ecotourism continues to gain popularity (Healy *et al*. 2020). Despite many marine species attracting tourists around the world, it is the large, charismatic species such as sharks that draw the most attention (Gallagher & Hammerschlag, 2011). Coupled with the growing understanding that sharks are worth more alive than dead, the non-extractive use of shark resources continues to rise (Gallagher & Hammerschlag, 2011; Gallagher *et al*. 2015; Healy *et al*., 2020).

Shark tourism can be in the form of scuba diving, cage diving, snorkelling, freediving and/or observing from a boat, providing significant economic, social and environmental benefits. It is estimated that the industry caters to over half a million tourists a year, with a global expenditure of 314 million US Dollars per annum, and this figure is expected to double within the next two decades (Cisneros-Montemayor *et al*., 2013). The shark diving industry generates significant revenues, employment and development for national economies and local communities (Gallagher *et al*., 2015). In The Bahamas, shark and ray diving generates 113.8 million USD annually, accounting for 99% of their total revenue (Haas *et al*., 2017). Similarly, in French Polynesia, sharks landed for the fish market are estimated to have an economic value of 1.50 USD per kg (Sumaila *et al*., 2007) compared to an ecotourism value of approximately 1,200 USD per kg (Clua *et al*., 2011).

These activities provide tourists with a mechanism to connect with the natural world, at a time where there are decreasing opportunities to interact with wildlife due to continued biodiversity losses (Orams, 2002). This is particularly relevant for endangered species. Oceanic shark and ray populations have declined by 71% over the past 50 years (Pacoureau *et al*., 2023) and continue to decline amid widespread overexploitation (Worm *et al*., 2023); approximately three-quarters of these species are now threatened with extinction (Pacoureau *et al*., 2023). Shark tourism can serve as a conservation tool (Maljković & Côté, 2011) whilst increasing community interest, awareness, promoting goodwill and changing public perceptions of a predatory species branded with a fearful reputation (Orams, 2002).

However, provisioning in wildlife tourism remains a contentious topic with little consensus regarding how it is managed (Orams, 2002). Such activities within the shark diving industry have raised safety concerns for the divers by scientists and members of the public, alongside concerns about possible negative impacts on shark and ray populations (Gallagher *et al*., 2015). Supplemental feeding has been proven to alter natural foraging behaviour and habitat use, with increased residency at sites due to a learned association or dependency on a food source (Araujo *et al*., 2020; Corcoran *et al*., 2013; Clua *et al*., 2010). This can cause intra- (within species) and interspecific (between different species) aggression amongst individuals, which in turn poses increased risk to tourists in the water (Clua *et al*., 2010; Newsome *et al*., 2004). Physical health concerns correlate with increased energy expenditure (Fitzpatrick *et al*., 2011; Barry *et al*. 2023), injury from vessels and increased risk of disease, on top of a loss of natural caution towards humans (Semeniuk & Rothley, 2008; Newsome *et al*., 2004). Accordingly, provisioning has been banned in French Polynesia, Hawaii, Florida, South Africa and Cayman Islands, with added pressure for bans elsewhere (Gallagher *et al*., 2015). Similarly, shark feeding is currently prohibited in the Maldives under the Maldives Recreational Diving Regulation (Section 13, 1, Series 2003) and is hence one of the main drivers of this work. For the

context of this report, the term ‘provisioning’ refers to the use of any attractant (e.g. bait, chum, feeding, bottle cracking, etc.) as defined by Meyer *et al*. (2021).

Here, we explore global approaches to provisioned shark tourism with case study interviews held with shark diving operators. For the present analysis, ‘provisioning’ refers to the use of fish/fish waste/chum used by dive operators to attract sharks to facilitate close encounters.

2.2 Methodology

2.2.1 Interviews

Within this context, we explored how shark diving operators around the globe carry out their provisioning practices. Operators who advertised provisioned shark dives were identified online and contacted prior to being interviewed. Semi-structured interviews (Appendix 7 of this document) were carried out with diving operators around the globe that use provisioning to attract predatory sharks. Of the 30 shark dive businesses contacted, 14 responses were received – nine of these businesses agreed to contribute to this research. However, due to their busy schedules during the data collection period, contact was lost with four of these businesses. As a result, interviews were supported by web-based analysis for the remaining businesses to compensate for the lack of desired informants.

A total of five interviews took place over the Zoom platform between 1 January and 1 February 2024 with operators based in The Bahamas, Florida, Australia, and South Africa. Operators included business owners, dive instructors/guides and shark handlers/feeders. The interview questions were divided into the following four sections: General Business Operations, Shark Diving Operations, Shark Research and Conservation and Perceptions Towards Sharks (see Appendix 7). Individual operator responses will remain anonymous within this analysis.

2.3 Results

2.3.1 Interviews

2.3.1.1 General Business Operations

The shark diving businesses interviewed included a range of different sizes and scale of operations. They have been running for 10 to 40 years, and have full-time employees ranging from 3–5 for smaller operations to over 100 for full dive resorts. Each dive business offers a range of different trips such as liveaboard stays, general wildlife interaction tours, RIB dives, specific baited shark dives, alongside snorkelling interactions. The number of trips catered per year varied considerably across operations from 30 to 3,285 trips per year, with 1–10 trips a day. The number of guests per trip also varies from between 8–20 across operations. Five of the operators spoken to offer provisioned shark diving and snorkelling encounters, with one operator solely offering opportunistic snorkelling experiences (without provisioning).

2.3.1.2 Shark Diving Operations

Most operators detailed seasonal patterns of the most common shark species that guests can encounter throughout the year. A summary of shark species found at each location

has been provided (Table 2). The shark species guests encounter on specific shark dives ranges anywhere between 10–20 sharks in Florida, 30–40 blacktips on a single dive in South Africa, with 30 Caribbean reef sharks and 10 nurse sharks expected on a typical shark dive in The Bahamas. In Australia, guests encounter an average of 12 grey reef sharks per experience. Most operators highlighted that the more elusive species (e.g. tiger sharks) are seen in much fewer numbers apart from at Little Bahama Bank 'Tiger Beach' where out of the typical 30 sharks encountered, 7 of these would be tiger sharks.

Diving procedures also varied across operations, for example drift dives at a set depth with a bait box on a line, or guests kneeling on the sand in a U-shape/semi-circle or circle where hand-feeding takes place. One operator described their practice as "putting on a show like a circus".

Table 2. A summary of when and where the most common shark species can be encountered based on operator interviews. N/A (not applicable) indicates where operators did not specify seasonality.

Operator	Year-round	Summer	Winter
Florida	Lemon sharks, bull sharks	Sandbar sharks Silky sharks Caribbean reef sharks Dusky sharks Scalloped hammerhead sharks	Tiger sharks Great hammerhead sharks
South Africa	Blacktip sharks	Tiger sharks Zambezi bull sharks	Sand-tiger sharks
The Bahamas	Caribbean reef shark, nurse sharks, tiger sharks, lemon sharks, great hammerhead sharks, bull sharks	N/A	N/A
Australia	Grey reef, whitetip and blacktip reef sharks, leopard sharks, tiger sharks, hammerhead sharks, tawny nurse sharks, lemon sharks, wobbegong sharks, epaulette sharks, whale sharks	N/A	N/A

2.3.1.3 Guidelines & Code of Conduct

All operators highlighted that guest safety was their number one priority. In general, operators provide guests with a detailed boat briefing and dive briefing before dives specific to location, conditions, species and dive plan. Guests are educated on the species they may encounter and why they can be found at each location (e.g. visiting a cleaning station). One operator mentioned that they follow standard PADI diving guidelines for briefings and have their own regulation when it comes to shark-specific regulations for diving with sharks. "Briefings are especially detailed during big shark season" states another operator, with a third stating that they "keep their briefing short but thorough, hitting the key points without losing guests' attention".

These briefings also cover how guests should behave in the water around sharks by maintaining eye-contact with the sharks, staying calm in the water and not making any

sudden or erratic movements that might excite them. A diver's position in the water relative to the bait crate is also addressed, ensuring that guests remain a safe distance from the bait/shark handler. How bait will be delivered to the sharks (i.e. by hand/bait crate) is also described alongside how to act/not to act should a shark get too close. Across operations, guests are also told that they can redirect sharks if they get too close and if there isn't a guide/feeder to assist close by.

For those offering snorkelling experiences the guidelines are similar. Guests are advised not to dive down or splash at the surface as "you look like food" and it "might attract their attention". Snorkelers are always accompanied by a guide/instructor and are told to pay attention to them at all times. One operator has a line in the water for snorkelers to hold onto and look at the shark activity beneath. Guests are also reassured during these briefings, as one operator describes that some of their guests are given this experience as a gift and have never been in the water with sharks before.

An overview of the instructions given during a dive briefing at Tiger Beach in the Bahamas is described below:

- It is the diver's responsibility in the water to stay safe;
- Operator will limit divers time at the surface;
- Divers to refrain from surface swimming;
- Operator allows divers to take cameras down but they are not to be attached to divers as sharks can take them;
- When it comes to feeding – divers are to form a semi-circle or U-shape up current of the bait box and shark handlers;
- It is important for divers to keep the scent trail clear for the sharks to swim up towards the bait crate and then leave again with enough space;
- If the current changes, this may require a repositioning of divers;
- Divers to keep a safe distance from the bait crate (n.b. distance not specified);
- Divers to keep track of the tiger sharks and look 360 degrees around them;
- If the sharks come close, divers should maintain eye contact. If there are multiple tigers, divers should maintain eye contact with the one closest to them;
- Divers are to remain calm and don't swim away as it can increase their interest from sharks;
- It may become necessary to push the sharks away if they get too close (this only occasionally happens);
- Diver should not become fixated on their camera;
- When returning to the boat, divers should swim along the bottom until they are underneath the boat;
- Divers are then to hold onto the tagline for their safety stop;
- Divers should keep looking around and remain vigilant; and
- Operator recommends surfacing with 100 bar left in the divers air tanks.

Shark-specific guidelines relating to dress code, distance to sharks, handling of sharks, the use of lights/strobes, number of divers in the water, guest to guide ratios and minimum qualifications were discussed with operators in more detail. Common themes include a strict dress code, maintaining a safe distance between divers and the bait crate and no touching of sharks, unless they are being re-directed. Guest to guide ratios vary from 1:4–1:14 and all but one operation requires divers to have at minimum an Open

Water/equivalent qualification. These guidelines have been summarised and compared across all operations (Table 3).

2.3.1.4 Provisioning

Each operator utilises a variety of provisioning techniques for their diving practices. These have been summarised in Table 4. Although different operators across sites use different terms for the bait/chum box/crate/drum, this is essentially a container for storage that the sharks cannot access – it needs human intervention to make the bait/chum available.

Table 3. A summary of shark-specific guidelines provided by each operator interviewed.

Operator #	Dress Code	Distance to sharks	Handling of sharks	Chum/bait storage and delivery	Use of lights/strobes	Use of poles/safety sticks	Number of divers in the water	Guide to guest ratio	Minimum dive certification
1.	Divers are required to wear black gear, head to toe (hood, gloves, wetsuit, socks/booties and fins) – no white, orange, yellow, or pink allowed. No exposed jewellery or shiny/ reflective items allowed. No poorly fitting kit or hair dangling loose allowed.	As close as the sharks allow. During drift dives, the sharks are surrounding the divers.	Divers are not allowed to touch or chase sharks at all. Only allowed to touch to redirect during tiger shark season.	Use thawed frozen bait. Line and spear fish on the way out to add fresh blood to the mix. Unused bait is frozen for the following day. Use of 4-gallon milk crates as bait crate underwater.	No lights, strobes or anything that flashes allowed.	No	9–14	1:14, but would recommend 1:7	Open Water Divers
2.	Not that strict on gear colour. Only full-length wetsuits allowed with no visible skin.	Divers must remain a 'certain distance' away from where the chum is in the water. n.b. distance not specified.	Divers are encouraged not to touch the sharks out of respect. Guides handling the bait sometimes must redirect sharks.	Two bait drums are in the water at once. Mostly frozen bait, sometimes fresh fish caught on the day used.	'Sharks pick up on strobes and often bump and nudge them and react to the flashes'. Divers told to keep hands close to the body if using lights or strobes.	No poles used. There's an extra guide in water to stop sharks getting too close to divers.	8–10	1:4 to 1:5	Open Water Divers and Discovery Scuba.

Operator #	Dress Code	Distance to sharks	Handling of sharks	Chum/bait storage and delivery	Use of lights/strobes	Use of poles/safety sticks	Number of divers in the water	Guide to guest ratio	Minimum dive certification
3.	All gear used is black to dark blue, with no vibrant colours allowed.	None.	No touching sharks and no moving around allowed. Handling of the sharks/bait is controlled by the guide feeding the sharks.	A fish on a stick is fed individually in a controlled way for each shark turning round each time for each guest. Fish are stored in an aluminium box that only the guide operates.	'They don't affect the sharks at all. Big camera housings that have protruding objects do affect them though'. Divers told to keep gear as compact and as close to the body as possible.	No.	15–20	1:10	Open Water Divers.
4.	Divers required to wear all mostly dark colours, gloves, hood and fins. All skin must be covered.	No – divers told to not swim away from them.	If necessary, divers told to redirect the sharks.	Bait is put overboard towards the bow and thawed and rinsed a second time. Bait is in a hand crate on the bottom with the guide. Feeding at the bottom so sharks 'are feeding more like scavengers and not near the surface"	Allowed.	The use of poles or safety sticks is determined by the divers, not the operator.	12	1:6	Advanced Open Water with at least 50 dives.

Operator #	Dress Code	Distance to sharks	Handling of sharks	Chum/bait storage and delivery	Use of lights/strobes	Use of poles/safety sticks	Number of divers in the water	Guide to guest ratio	Minimum dive certification
5.	No dress code for guests. Staff have different coloured rash guards for reef snorkels and megafauna interactions. Bright colours are avoided for shark swims.	2-3 m surface swim from tiger sharks. 5 m surface swim with grey reef sharks as easily disturbed.	No touching allowed.	No chum/no bait. It is illegal in the marine park.	No strobes or lights allowed.	No.	Max. 20 on the boat so all 20 can be in water at once. With tiger sharks, no more than 6 in water at any one time, and guests swap in and out.	1:10	Guests must be confident snorkelers, not just swimmers. They have to disclose any physical injuries and sign an indemnity form.

Table 4. A summary of the types provisioning carried out by each operator interviewed.

Operator #	Bait Species	Bait Type	Source of Bait	Quantity Used	Delivery of Bait	Observations
1	• Bonito (preference) • Barracuda • Jack crevalle • Amber jack • Almaco jack • Horseye jack • Cigar minnows	• Thawed frozen bait. • Sometimes blood and oil are added to the chum.	• Locally sourced from fishermen and bait stores. • Do not disclose the intended purpose of the bait to fishermen.	• Bait crate can hold 5–6 kg of cut fish. • Average amount of bait used per dive is 2–3 kg.	• A 4-gallon milk crate is used as a bait container. • Some hand feeding of sharks.	• Use bait in accordance with the fish they expect to see on dives.
2	• Sardines (preference) • Tuna	• Frozen/fresh bait. • Sometimes anchovy oil is added to create a slick.	• Purchased from local fisheries.	• Approximately 10–15 kg of fish is used per dive across two bait containers.	• Two drum systems in the water column at once.	• Sardine run comes past them, so sardines are primarily used. • When fresh tuna carcasses are used, big sharks come instantly.
3	• Red and grey snappers (preference) • Tuna • Grouper • Mahi Mahi • Wahoo	• Frozen bait. • Thawed and rinsed to reduce the amount of blood and oils in the water.	• Sourced from a food services fishery where fish has been freezer burned or has rotten. • Sometimes purchased from restaurants.	• Typically, one fish is used per guest so 10–15 fish, each around 5–6 inches.	• One guide feeding sharks with fish on a stick. • Bait contained in an aluminium box.	• Guides have an element of control over the pace of the sharks. • Choreograph the sharks in a circle in front of each guest.
4	• Snappers (preference) • Tuna	• Thawed frozen bait. • Pre-cleaned so there is little juices or blood to keep the sharks calm.	• Purchased from a wholesale fish company.	• 2–3 kg of bait is used per dive.	• Hand crate on the bottom with the shark feeder.	• Currently do not use tuna as there are enough sharks in the water and tuna excites them. • Keep cutting back on the quantity of bait year on year.
5	N/A	N/A	N/A	N/A	N/A	N/a

2.3.1.5 Safety Concerns

A few shark-related incidents were described by operators during interviews, primarily involving shark handlers and feeders, with some involving guests (Table 5).

Table 5. A summary of shark-related incidents provided by each operator interviewed.

Operator #	Previous Incident Involving Guides (Y/N)	Previous Incident Involving Guests (Y/N)	Description of Incidents
1	Y	N	• This shark guide has had two shark bites on their hands and only has six working fingers as a result after ending up in the chum slick. • They have never had an incident involving any guests.
2	Y	Y	• This shark handler details having been bitten multiple times but “it comes with the job” and that “an incident with a guest is very rare”. • They have had three negative shark-diver interactions in five years. • They detail one incident where a bald diver was nipped on the head by a lemon shark because he took his hood off during a dive. • Another incident involved a guests wrists becoming exposed due to their gloves being too big and a lemon shark grabbed their wrist from behind. • There was another incident when a silky shark rammed a feeder’s neck because a hair braid had fallen out of their hood. • As a shark handler they stated “it’s not a matter of if you’re going to get bit, but when”.
3	Y	N	• This operator describes how tiger sharks are known to mouth at crew members but never draw any blood. • They state, “would you call that a close call or just a kiss?”
4	N	N	• The only close calls they describe is when their photographers dive down to try get pictures of the tiger sharks.
5	N	N	• This operator described no shark-diver related incidents.

Newly qualified divers were also raised as a concern as “they are typically very problematic underwater”. “Too often have we had guests who had never dived in the ocean or outside of their certification course, and every time they have to be sent back to the boat. This means an unhappy guest, which could mean a bad review and also a blow to their self-esteem”. Concerns over the lack of qualification and skill required to be able to take part in snorkel tours were also raised. One operator stated, “half of the time the snorkelers don’t even know how to swim and they’re usually much more terrified of the ocean in general.” This lack of experience in water coupled with possible fear of open water and with sharks causes some guests to panic. They also mentioned that “flailing and screaming is absolutely not allowed on the surface and anyone who does must exit the water immediately as it poses a danger to themselves and others”.

Provisioning remains a contentious topic as identified by interviewees. “There is a tremendous amount of contention at the moment” stated one operator following a few recent shark-related incidents, unfortunately resulting in casualties in their area (unrelated to their practices). “A lot of people disagree with what we do to condition sharks,” said another. “There is no doubt contention with shark provisioning. Some people say that no matter what, we are the reason sharks attack because we’re teaching them to associate humans with food. It’s simply not true, and there’s nothing evidence-based to back up such a claim”.

2.3.1.6 Research and Conservation

All operators showed awareness, willingness and active involvement in research efforts. Efforts to educate and inspire guests were also consistent amongst operations. Species counts, sex ratios and individual photo ID catalogues are carried out on most dives. Other research and conservation initiatives across operators include:

- Collaborations with the American Shark Conservancy to create a Code of Conduct to be used by all of the shark ecotourism boats in their area;
- Annual migration trend analysis;
- Behaviours;
- Removal of fishing gear;
- Tagging;
- Parasite removal;
- Impact of vessel collisions;
- Studies on whether sharks can see colour;
- Collaborations with universities/researchers;
- Impacts of their provisioning activity on sharks.

Operators have also observed changes in shark populations over time since working in their diving industries. One operator has noticed major decreases in shark abundance in their area, especially for tiger sharks. They state how the “Chinese trawlers are just sitting in the water, and you can see them catching them”. Another operator highlights “a large un-natural increase in shark numbers” in their area. They add “20 years ago there was no such thing as shark diving here and it started because of me 40 years ago. We started shark diving, and I knew it all would change, and we have had a big increase but it’s not natural”. Fairly consistent shark numbers were also documented by another operator in the 13 years that he had been working in the area. During the pandemic, species fluctuations

were observed more noticeably. “As there was no diving, there was no provisioning, so the sharks disappeared, and it took them a long time to come back”.

2.3.1.7 Regulations

Regulations varied between operators, with some operating within marine parks and others are operating in areas where sharks are protected and they have strict guidelines to follow. One operator in South Africa stated that there are “*strict rules on what’s allowed*” and “*we are not allowed to feed the sharks. They are called scented dives but sharks don’t eat scent*”. This was followed by “i*f you want action, then we do what we need to do [to deliver the shark action]*” – leading the interviewer to believe that feeding does indeed take place. To adhere to the guidelines like this, a permit is required. In other areas such as Florida, provisioning is prohibited in state waters and “the only government regulation for baiting sharks is that it must be done in federal waters (more than 3 miles offshore)”. In contrast other operators described the lack of any enforced guidelines, rules or regulation in the Bahamas and said it was up to them to have their own. A few operators also expressed their desire to “write up some guidelines because consistency across operations is important e.g. using the same bait, not baiting the surface, feeding other species not just target species”. “A lot of us are pushing for the way we operate to become law rather than a voluntary code for sharks, mantas, tigers” stated another operator in Australia.

2.3.1.8 Perceived Threats to Sharks

Perceived threats that sharks face were generally similar amongst operators; one way or another sharks are at risk due to past or present human activity. One operator simply stated “The human race is the problem”. A common threat given was overfishing both intentional and as bycatch in other fisheries. One operator specifically suggested the fin harvesting industry in particular. The same operator also pointed out that shore-based anglers have the opportunity to work with the American Shark Conservancy on hammerheads by “helping keep the fishermen informed on how to best handle the sharks when caught. In turn this helps increase survival rate post release.” Boating traffic was another threat for the displacement of sharks with “recreational boats zooming around causing collisions”. An ex-commercial fisherman (turned operator) explains that incorrect public perceptions are the biggest threat to sharks and that 20 years ago perceptions were very different. Despite this change and commercial fisheries being banned in the area, they fear “their numbers aren’t quite there for species survival.” Another makes the point “fishing is allowed, in my eyes what we do is nothing compared to all the fishing, and they look at us all upset”. Another highlights the ability to recognise the same shark over time and seeing them with natural scars and unique markings but also “you see them coming back with hooks in their mouths.” They also highlighted that misconceptions relating to sharks, such as being ‘monstrous killers’, remains a threat to them.

2.3.1.9 The Future

Interestingly, whilst operators were generally aware of the issues facing sharks, education of the general public beyond the diving industry is helping. Awareness is more readily expected by divers who expect a higher level of engagement in terms of knowledge and information sharing, linked to information availability and social media, and this is also reflected by the growth in the shark dive industry. However, the increase in the sector warrants attention and all operators highlighted the need for standardised guidelines in

their area, certification, active management and monitoring to ensure a sustainable future. All operators highlighted the need to limit the number of operators at their respective sites, at least whilst sufficient data is lacking to make informed decisions on the impact of the industry on the sharks and their ecosystems.

2.4 Discussion

Wildlife tourism is a growing industry which can provide positive socio-economic incentives (Apps *et al*. 2018), but can also have bioecological impacts on the target species and associated ecosystems, particularly when provisioning activities occur (Orams, 2002). This can vary greatly depending on the species, location and operation. Impacts on activity levels and metabolism have been raised (e.g. Huveneers *et al*. 2018; Araujo *et al*. 2020), along with concerns over residency and changes to movement patterns (e.g. Brunchsweiller *et al*. 2014), parasitic load and intraspecific aggression (Semeniuk *et al*. 2009), and interspecific competitivity and changes to species composition (Brena *et al*. 2015). Thus, provisioning remains contentious, particularly in light of economic incentives and potential benefits that can be harnessed through education and advocacy of tourists to support positive change for sharks (Apps *et al*. 2018). This is a particularly important point in view of a greater than 70% decline in oceanic sharks (Pacoreau *et al*. 2021) and sharks missing from more than 50% of coral reefs surveys around the globe (Sherman *et al*. 2023).

Through semi-structured interviews and web-based analysis of shark diving operators, it is clear that provisioning is commonly employed for predatory sharks across different continents. This facilitates human-shark interactions, especially with oceanic species which would otherwise be practically impossible to encounter. Provisioned tiger shark diving occurs, or used to occur, in many countries including the USA (Hawaii and Florida), French Polynesia, Bahamas, Fiji, South Africa, and Maldives. Other places where tiger sharks are encountered under non-provisioned experiences include the Philippines, Australia (east and west), Mexico (Revillagigedo archipelago), South Africa (NE) and Mozambique. Provisioning examples, and those interviewed and researched in this work, do so namely to create a predictable product with one of the oceans top predators, which is highly desirable (Gallagher & Hammerschlag, 2011; Apps *et al*. 2018). It is possible to draw lessons from all examples in order to guide best practices moving forward, not only in Fuvahmulah, but elsewhere also.

2.4.1 Commonalities Across Sites

2.4.1.1 Dress code and accessories

Some of the main commonalities across sites include strict dress codes (including accessories). Dark, full-cover wetsuits, hoods, gloves, as well as dark fins appear to be common guidelines across sites and countries. Provisioning creates an unnatural scenario for sharks, wherein, the animal might change movement patterns in order to explore a potential feeding opportunity created by chum/bait in the water. Thus, an arriving shark could be looking for a feeding opportunity and anything that might attract its attention (e.g. a silver jewellery, a reflective fin) creates an unnecessary point of interest. Reducing this potential unwanted attention is common across many shark tourism sites globally.

2.4.1.2 Bait confinement and location

From the operators interviewed, any food in-water is contained and is always placed down current from the divers. Moreso, divers never handle bait/chum and gear that comes into contact with the bait/chum is thoroughly washed. Controlling the bait/chum is crucial to controlling shark activity levels and thus ensuring diver safety. Positioning the attractant down current from divers means that sharks coming in to explore the source of stimuli, do not reach the divers before they find the source. It was also highlighted by some operators that given sharks' activity levels, bait is often washed down before entering the water to reduce the plume in-water and thus reduce shark's curiosity levels. These are examples of bait handling and positioning that have shown to improve the safety and control of the dive.

2.4.1.3 Lights/strobes

Some operators indicated that no rules are enforced regarding lights and strobes during shark dives. However, operators did indicate that rapid-burst strobes do increase shark attention. This is likely due to the high electrical pulses generated by these types of flash strobes systems. Regulation of lights (either prohibited or only allowed under special circumstances e.g. experienced shark photographers and warranting extra guides) could help to manage control during dives.

2.4.1.4 Shark behaviour

Many operators interviewed acknowledged the importance of body language and behaviour during shark interactions. Examples of this included maintaining eye contact with the sharks and remaining alert to their location. Although this allows for a level of subjectivity regarding shark behaviour, it is feasible to create simple shark ethograms (i.e. simple catalogue or table of shark behaviour) wherein general shark behaviours are defined and clearly exemplified. Such a tool would help guides in-water identify when a shark, or sharks, are likely to create less manageable conditions during the dive. This could include guide training with consistent, evidence-based information.

2.4.1.5 Guest-to-guide ratios

The number of divers and guides/shark handlers in the water varied the most amongst operations. These guest to guide ratios varied from 1:4 to 1:14. Variations are attributed to different types of shark diving (drift divers might require fewer guides versus on the seafloor interactions where a lower guide to diver ratio might be required), the species and number of sharks expected, and whether hand-feeding was taking place. The general consensus was that added guides in the water would allow for more control over the shark behaviour and prevent any incidents that may occur in the water if a guest was uncomfortable. The fewer the divers in the water at one time, the lower the chance of an incident occurring.

2.5 Conclusions

Whilst provisioned shark diving is very popular across many sites globally, bringing in important economic incentives to local and national economies, concerns remain regarding bioecological impacts and, importantly, diver safety. Incidents remain rare and scarce, however, lessons learnt across different species of shark and localities warrants

the support of more conservative practices following the precautionary principle to minimise issues (Cooney, 2004; Venables *et al*. 2016). Examples of such simple interventions include adequate training and awareness raising, dress codes, delivery of bait/chum, guide-to-diver ratios, positioning of divers in relation to the chum/bait source, and number of persons in the water. Whilst provisioned shark diving operations differ across sites and species, and taking into account local socio-cultural contexts, the commonalities mentioned in this chapter warrant precautionary active management to reduce potential incidents that could have industry-wide implications.

3 Best Practice Options for Ethical and Sustainable Shark Ecotourism at Fuvahmulah

3.1 Background

Shark diving tourism has gained popularity in recent years, now supporting significant socio-economic benefits across many sites globally (Healy *et al*. 2020). However, concerns remain about the bio-ecological implications of shark tourism (see Chapter 2). More generally, long-term sustainable practices are desired and supported by governments, as outlined within the United Nations Sustainable Development Goals (SDG 14: Life Below Water). Whilst achieving this balance requires close cooperation between the dive industry and other stakeholders, it is important that the basis for best practices are consulted on, discussed, adopted and implemented to ensure a sustainable operation.

This chapter aims to describe some of the main considerations for ethical, safe and sustainable shark tourism which could be considered by management authorities and stakeholders in the context of reviewing current operations in Fuvahmulah, Maldives. These considerations cover various aspects relating to diver safety, briefing, provisioning, sustainable dive practices, as well as providing example fee structures that have been implemented elsewhere in the world in the context of shark diving. It is down to the responsible authority to consider, adopt and implement management measures for these activities, based on best practices and other information supplied within this report.

3.1.1 Current laws governing shark diving in Maldives and Fuvahmulah

Diving tourism in Maldives falls under the regulation of the Maldives Tourism Act (Law No. 2/99, 1999) and the Maldives Recreational Diving Regulation (2003). Prior to any operations, diving centres are required to:

- Register with the Ministry of Tourism;
- Obtain a licence after meeting certain conditions; and
- Pay a registration fee of MVR 5,000 (325 US Dollars).

The Ministry of Tourism also has the discretion to monitor diving to ensure that the services meet the guidelines determined by them. Where guidelines fail to be met, the Ministry may suspend licences or issue fines not exceeding MVR 1,000,000 (65,000 USD).

The Maldives Recreational Diving Regulation (2003) provides regulations specific to diving activities across different parameters. These requirements have been summarised in Table 6. It is worth nothing that these laws only govern scuba diving activities and not free-diving, an activity gaining popularity in Fuvahmulah. Regulating free-diving activities is also important to consider within the context of this chapter.

The Maldives Recreational Diving Regulation (2003) also highlights the importance of “plan your dive and dive your plan”. Any changes to the dive plan must be made aware to divers and boat crew. The following rules on diving conditions are also in place:

- swell and/or wave height does not exceed 0.5 m;
- current is nil to slight;

- underwater visibility is greater than 4 m; and
- the dive starts and ends in full daylight.

Measures are also in place to protect the marine environment during diving operations. For example, thorough briefings on buoyancy control to prevent damaging corals and avoiding physical contact with marine animals are addressed. There is only one reference to shark diving in The Maldives Recreational Diving Regulation (2003) where emphasis is put on the fact that “shark feeding is NOT permitted for the divers and the dive centre staff alike.

Table 6. A summary of diving requirements in Maldives as set out by The Maldives Recreational Diving Regulation (2003).

Requirement	Description	Description continued	Description continued	Description continued
Minimum Certification Requirements	1. The minimum certification level for divers wishing to participate in diving in Maldives is an entry level certification from a Recreational Scuba Training Council (RSTC) associated Diver-training agency or a 1 star Confederation Mondiale Des Activities Subaquatiques (CMAS) certification from a CMAS-affiliated diver training agency.	2. A diver is required to submit proof of their training by means of a certificate and proof of a logbook.	3. A diver who cannot submit proof of their experience must complete an orientation dive.	
Supervision of Diving Activities	1. All diving activities must be supervised by Dive Centre staff. If a Dive Centre Staff is found to be negligent in supervision, the Dive Centre staff and the Dive Centre will be subject to appropriate action as deemed fit by the government authorities.	2. In order to function as a Dive Centre Staff, a person must meet all the prerequisites of recognised qualifications of dive staff.	3. A Dive Centre Staff member is required to note the time the divers enter and exit the water.	
Maximum Depth Limitations	1. The maximum depth for all-recreational diving in Maldives is 30 metres. This applies to divers training in Deep Diving Techniques who participate in recreational diving activities within Maldives, tourists, Dive Instructors on or off duty and all instructors and students involved in Advanced and Centre staff, Deep Diving Training.	2. Any person repeatedly and deliberately violating this regulation may be excluded from further diving.	3. Entry level divers may dive to a depth of 20 metres or within the limits as set forth by standards of their certification agency, but not exceeding 20 metres.	

Requirement	Description	Description continued	Description continued	Description continued
Decompression Dive Limitations	1. No decompression diving is allowed in Maldives. This applies to everybody who participates in diving activities within Maldives, tourists and Dive Centre staff, instructors on and off duty, also instructors and students involved in Advanced and Deep Diving Training.	2. This no-stage decompression limitation also applies to live-aboard or safari boats. No exception whatsoever is allowed.	3. Any person repeatedly violating this regulation may be excluded from further diving. A Dive Centre staff repeatedly and deliberately violating this regulation shall be subjected to disciplinary measures.	
Dive Centre Requirements	1. All Dive Centres must be equipped with pure Oxygen and have an emergency plan ready in case of diving related accidents. The emergency plan must include mechanisms for:	1) Searching methods in case of missing divers; 2) Providing First Aid Care; 3) Transport method to the next appropriate medical facility; 4) Reporting to the appropriate Authorities (Police, Coast Guard, Ministry of Tourism, etc.).	2. All Dive Centre staff must be familiar with his/her emergency plan and be able to act appropriately.	3. All Dive Centres must register with the Ministry of Tourism and obtain an operating licence.
Dive Centre Equipment	1. Dive Centres must provide well-maintained dive equipment. Dive cylinders must be hydrostatically tested by a facility authorised to do so by the Ministry of Tourism. Buoyancy Compensators Devices (BCD's) must be approved for recreational diving by the manufacturer and must have a Low Pressure Inflator.	2. Regulators must be approved and maintained for recreational diving by the manufacturer.	3. Dive Centres must provide Alternate Air Sources, depth and timing devices as standard rental equipment.	

Requirement	Description	Description continued	Description continued	Description continued
Dive Boats	1. Dive Boats are the responsibility of the Dive Centre and the crew. Dive Boats must have at least a crew of three, and must be dedicated to the safety of the divers and support the divers in any way they can. The Dive Boats must have sufficient fuel to make the prearranged dive trips and any changes there too.	2. In case weather conditions deteriorate while divers are under water, the crew must be proficient in recalling methods.	3. The Dive Flag shall be clearly visible when the divers are in the water and must be lowered when the last diver has exited the water.	
Safety Considerations	1. The Dive Centre staff must brief the divers prior to every dive. The brief must include information about safety regulations, depth limits, dive site characteristics, currents, entry and exit techniques, environmental considerations and potential hazards.	2. After all dives, a Safety Stop must be made for at least 3 minutes at 5 metres. Divers must commence their safety stop with a tank pressure not less than 50 bars.	3. All Dive Centres must have an Emergency Response Plan.	4. Solitary diving is not allowed under any circumstances.
Qualifications of Staff	1. In order to supervise diving activities or exercise leadership in diving activities, a person must: be a Divemaster (RTSC) or 4 Star diver (CMAS) or equivalent as per 7 RSTC standard, have a Work Permit and a Resident Permit Visa if not a Maldivian national, carry professional liability insurance and personal accident insurance covering diving accidents and chamber treatment.	2. All training and certification of divers is to be done exclusively by Instructors.	3. Instructors must strictly adhere to all the standards that apply to the diver-training program he/she chooses to teach.	

3.2 Best Practice Options for Provisioned Shark Interactions in Fuvahmulah

The use of best practices, defined here as methods, techniques or procedures recognised for producing optimal results/outcomes, are recommended where provisioning of large predatory sharks takes place. 'Provisioning' refers to the act of feeding, baiting, luring or attracting sharks to a given area (Meyer *et al*. 2022). Best practices are usually in the form of Code of Conducts which encompass education, in-water safety, animal treatment, research and environmental sustainability (Lawrence *et al*., 2016). These practices are often developed between multiple stakeholders. Unified practices ensure all operators in one area operate in a similar manner, which in turn mitigates against any potential conflict between operators.

Provisioning activities vary in scale and operation design across the globe. A review of shark diving activities around the world (Chapter 2) identified common themes for diver and shark welfare. Best practices have been identified as a result and are described in this chapter for decision makers to consider as part of any review of management in Fuvahmulah. These guidelines have taken into account lessons learnt from dive guides and divers in Fuvahmulah (Chapter 1) and around the globe (Chapter 2).

Based on the findings of this research, potential information that could be included in a Code of Conduct is presented in the section below. Codes of Conduct should be developed as part of a consultative process through engagement with relevant stakeholders (e.g. dive operators, local governments, scientists, fishers, NGOs and the local community). Suitable monitoring systems are needed to help enforce and ensure the success of Code of Conducts.

3.3 Considerations for developing a draft Code of Conduct

The following section sets out potential considerations when developing a Code of Conduct. The order and the sections mentioned therein are not final nor exhaustive, and input from stakeholders is recommended at all stages. These are adapted from Lawrence *et al*. (2016). Following this process and discussing all considerations, the production of infographics (e.g. Figure 6) would exemplify in simple visual aids the Code of Conduct. A longer, more thorough document can accompany the infographics that can include further information for each consideration. The sections marked with an **(X)** below are for the responsible authority and decision makers to complete based on local regulations and engagement with stakeholders.

3.3.1 Introductory briefing

- Inform all divers in the briefing of the biology, ecology and threats to the target shark species, particularly their habitats and those threatened in the region;
- Convey the Code of Conduct clearly;
- Inform all divers of risks of injury to diver and shark;
- Use this time to paint a positive view on sharks and their importance for our ecosystems;
- Remind divers to remain calm but vigilant at all times;

- Describe the dive procedure from entry to exit; and
- Run through the Emergency Response Plan or equivalent (what to do in an emergency). This should include specifically shark-related incidents.

3.3.2 Environmental Conditions

- Operators to decide on a minimum in-water visibility of **(X)** metres that is safe to conduct the dive (a Secchi disk can be used to minimise subjectivity); and
- A maximum swell of **(X)** metres is deemed safe to conduct the dive.

3.3.3 Signage of the Code of Conduct

- Provide signs and infographics in dive shops, on websites and on boats for tourists; and
- Provide translated versions to encourage engagement and understanding.

3.3.4 Time in proximity

- Describe the arrival at the dive site and the time allowed to interact with the shark(s); and
- For example, at Tiger Harbour it is currently agreed that a maximum of 30-minutes is allocated per dive operator after which the divers will depart the site.

3.3.5 Speed of vessels

- Vessels should keep a maximum of **(X)** knots on approach to the site and when departing; and
- Indicate whether engines should be off whilst divers are in-water.

3.3.6 Distance and positioning

- Divers should be stationed at the bottom and avoid any free swimming,
- Divers should maintain a minimum of **(X)** metres from the shark(s) at all times (it is commonly recommended to maintain a minimum of 2 m from sharks as highlighted in Chapter 2, and in Lawrence *et al*. (2016));
- Divers should remain at a minimum distance of **(X)** metres from the bait crate (maintaining the same recommended distance of 2 m would be beneficial for clarity);
- Divers should always position themselves up-current from the bait crate; and
- Divers should be clearly briefed about their positioning underwater.

3.3.7 Group size

- There should be a maximum of **(X)** divers in the water at any one time (including guides) (based on Chapter 1, current group sizes at Tiger Harbour are limited by boat capacity (12–14 divers));

- There should be a minimum guide to diver ratio at all times (e.g. 1:4) **and adjusted based on divers' level of experience and weather conditions;** and
- A minimum of **(X)** guides should be present in all dives, irrespective of the number of divers (e.g. minimum 3 guides per dive).

3.3.8 Touching

- Touching the sharks should be prohibited; and
- Operators will show divers how to redirect a shark if it gets too close. Redirecting to be used as a last resort only and never by first time divers at the site

3.3.9 Swimming

- Time spent at the surface should be minimised;
- Splashing and/or thrashing arms and legs should be avoided;
- Diver should kneel as close to the bottom as possible during the shark interaction;
- Divers should not swim away from sharks – they should stand their ground and maintain eye contact with the shark(s) closest to them; and
- Divers should not block the shark's direction of travel.

3.3.10 SCUBA

- Divers should be suitably qualified with a minimum of PADI Open Water equivalent and **(X)** recent dives (X = a number which is suitable for the conditions and/or based on local expertise and experience);
- Previous shark diving experience is recommended; and
- Double check all underwater signs and signals with divers.

3.3.11 Dress code

- Divers should wear a dark, full exposure suit including hood and gloves, alongside dark coloured fins;
- No fluorescent or bright colours on any gear, including fins;
- No jewellery or shiny metal objects (including camera D- rings/silver buttons);
- Logos and weight-belt buckles should be taped up using black tape/painted over; and
- No strobes and/or flashing lights on cameras as they excite the sharks.

3.3.12 Tanks

- Given incidents across multiple sites in both the Maldives and elsewhere in the world, it might be cautious to have black/covered tanks; and
- Alternatively, anything to reduce the shiny/reflective nature of scuba tanks.

3.3.13 Code of Conduct

- Guidelines should be clearly displayed at dive centres and on the boat; and
- Having the Code of Conduct readily available online would be beneficial for divers to go over before arrival on site.

3.3.14 Enforcement

- Brief the divers on what happens if the rules are broken or the Code of Conduct is not followed;
- Define who is in charge for the duration of the dive; and
- Dive guides may terminate the dive at any time.

3.3.15 Monitoring

- Self-monitoring and reporting is encouraged to promote continuous improvement;
- Monitoring of the Code of Conduct can be complemented by tourist surveys, wherein simple feedback forms are shared with divers post-diving; and
- Feedback from ongoing monitoring to be discussed at pre-arranged meetings with stakeholders for improvement.

3.3.16 Feeding/provisioning

- Shark feeding is not allowed in the Maldives (see Maldives Diving Regulations, 2003);
- Divers are not to handle the bait;
- Bait is to be locally sourced;
- Only **(X)** (e.g. tuna) should be used as bait (based on results from Chapter 1, bait should be restricted to tuna only and other bait types like billfishes should be restricted);
- Only **(X)** amount of bait should be used per dive (based on findings from Chapter 1, currently about 1–2 tuna heads are used per dive. It would be beneficial to decide on a set amount of bait to be used amongst stakeholders (e.g. 1 tuna head per dive);
- Contain bait within a bait crate so there are no fish by-products within the water column and ensure this is always down-current of divers;
- Thoroughly rinse bait before dives to remove as much oil and blood as possible to limit shark excitement;
- Limit the amount of bait used per dive/day. It may be possible to have encounters with tiger sharks without the use of an attractant on every dive; and
- Explore other methods of using fish by-products to add value and (see Chapter 4) prevent further dumping of fish discards into the harbour.

3.3.17 Other sustainable practices which could be considered to protect sharks and the wider marine ecosystem

- Extra training for buoyancy control to reduce impact on coral and benthic ecosystems;
- Avoid single-use plastics onboard (sachets, stirrers, straws, bottles);
- Use ocean-friendly sunscreen (non-toxic, bio-base);
- Shop local and support local businesses;
- Eat seasonal, sustainable produce; and
- Collect data for local and regional monitoring projects of threatened marine species.

3.3.18 Conservation/diver fee

Collecting fees from shark diving activity can help raise funds to support shark conservation and sustainable management of the marine environment. Fees can contribute to a co-managed fund between stakeholder representatives (i.e. government, industry, fishers, NGOs and local communities) to address capital and operational costs linked to the management, implementation, enforcement and monitoring of diving activities. A fee structure approach was recently highlighted in a global review to improve budget security and staff capacity to 'carry out critical management activities' linked to the success of MPAs (Brown *et al*. 2023). In the context of sharks, fee structures have been successfully employed at various sites around the world. For example, at Malapascua Island in the Philippines – a world-renowned destination for close encounters with endangered pelagic thresher sharks *Alopias pelagicus* – a marine park fee is charged for diving at the site. This fee is designed to be co-managed between the dive industry, the local community and the local government. The fee is used to train and maintain marine patrol at the site where the threshers are normally encountered to ensure no illegal fishing takes place. The site was designated as a MPA, but following reports of illegal fishing, it was necessary to train and employ dedicated patrol guards at the site. The model worked well, wherein, only locals are employed by the scheme and the funds are used for the monitoring and enforcing of the protected area. Operations have now changed as the thresher sharks have shifted to a new area in a new political jurisdiction.

Similarly, at Sipadan in Malaysia Sabah, divers pay 53–74 USD per diving day at Sipadan Island Park (Sabah Parks, Feb 2024). This MPA managed by the government charges the fee to support the monitoring and enforcement of one of Southeast Asia's best protected areas, as recently highlighted in a global assessment of reef-associated shark abundance (MacNeil *et al*. 2020). The island has year-round rangers that guard the park from illegal activities and ensure any diving/tourism-related activities are also conducted in a sustainable manner and in accordance with local regulations.

The Shark Reef Marine Reserve in Fiji was established in 2004 – an ecotourism endeavour co-designed by local communities and a local dive operator, and later ratified by the Government. This endeavour saw the exchange of traditional fishing rights for a levy paid for by divers. The agreement also includes other incentives for the local communities, such as a sponsorship programme for local community members to train to divemaster level and the dive operator procuring and installing moorings and markers (Brunnschweiler, 2009). Divers now pay a fee of approximately 11 USD per diving day in

the reserve for close encounters with sharks which are thriving in this area because of active incentives to manage them (MacNeil *et al*. 2020).

What these examples, and others, have in common is a user-based fee for an active management or conservation action by those managing the sites. This could be in the form of area designation, monitoring, enforcement, research, training, infrastructure development, or ideally, a combination of all. A visitor/diver fee could also provide an opportunity for monitoring and enforcement, wherein divers can be contacted for surveys as discussed above. One commonality across sites is the need for absolute transparency on how the fees are collected, managed and spent, and it would be advisable that funds from a fee structure are managed by a 'board' or appropriate equivalent, and that the roles, duties and responsibilities of this group are clearly specified in a legal document. Given the number of tourists now visiting Fuvahmulah to dive with sharks, a similar model to the ones described herein could help fund management, monitoring and enforcement of any established guidelines. As exemplified in Chapter 1, this would need consultative stakeholder input and representation to ensure equitability.

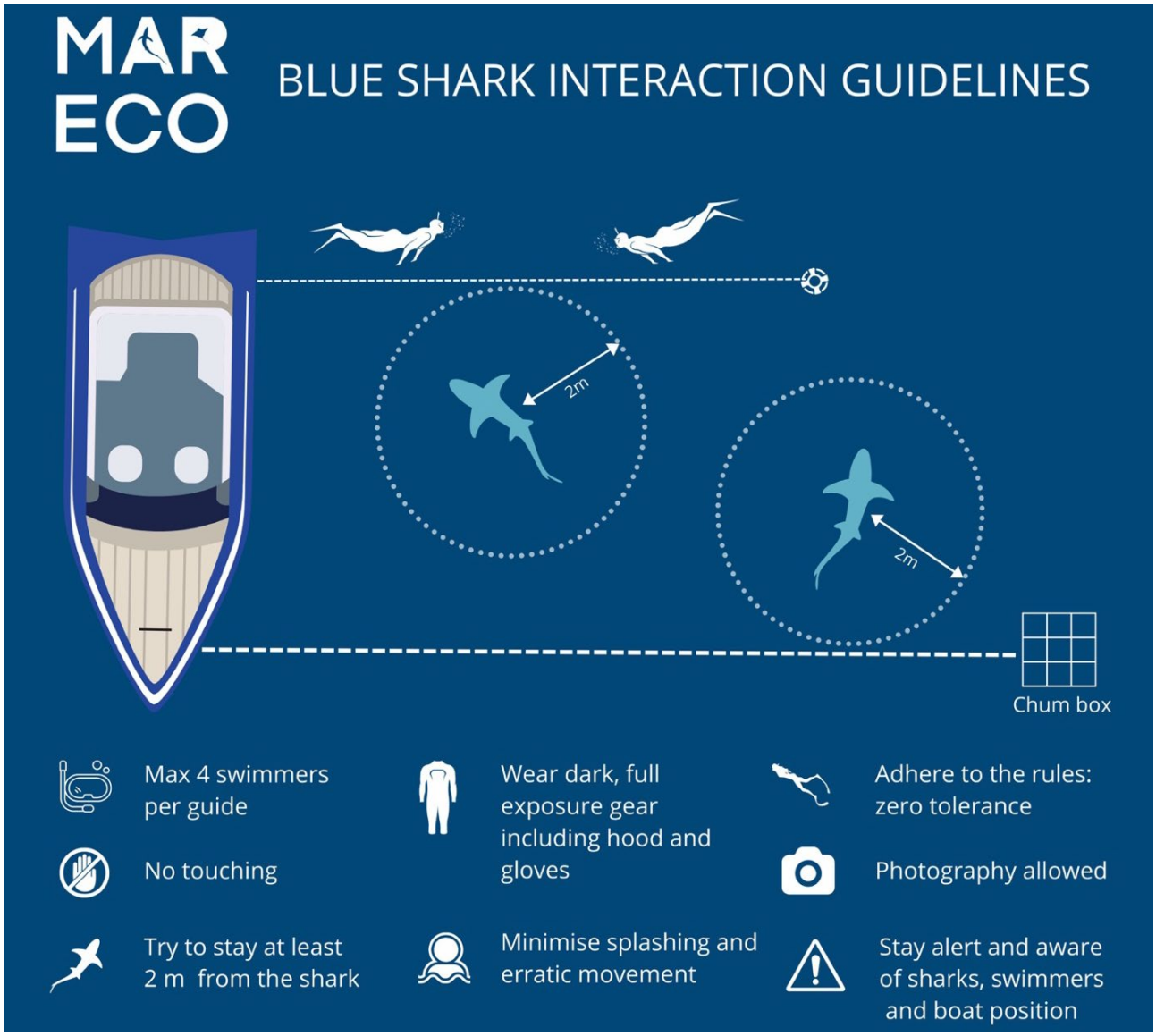

Figure 6. Example infographic of a Code of Conduct developed by stakeholders in the UK for provisioned interactions with blue sharks *Prionace glauca*. Image © Marine Research and Conservation Foundation (MARECO) blue shark Code of Conduct.

3.4 Best recommended practices for non-provisioned shark interactions, including those within MPAs

The considerations described above are equally applicable to non-provisioned interactions with sharks. In non-provisioned scenarios, what is likely to change is for example, the number of divers and the guide to diver ratio. Given that non-provisioned dives rely on chance encounters with sharks in their natural environment (i.e. not guaranteed), some of the rules may not be as relevant. For example, from Chapter 1, diving at Farikede MPA typically involves a larger group per dive guide as it is a relatively short drift dive. Therefore, establishing a guide to diver ratio of 1:8 could be acceptable from a shark interaction perspective. However, from a safety perspective, dive groups of 1:4 are typically recommended as this would allow for extra attention from the guide during a dive. From a diver perspective, a smaller guide to diver ratio also means that should part of the group run out of air before the rest, the group could split and thus allow extra time for those divers with sufficient air.

One major consideration when diving within MPAs is impact. MPAs are typically designated due to their bio-ecological importance, and thus any potential impacts on this should be minimised. Divers can have detrimental impacts on the local ecosystem, particularly substrate ecosystems such as seagrass beds and coral reefs (Wong *et al*. 2018). Therefore, when diving within sensitive areas, guidelines on 'keeping off the substrate' should be followed and encouraged. These rules are laid out in the United Nations Environment Programme's initiative 'Green Fins', or similar programmes designed to ensure sustainable diving practices. These programmes also typically ban anchoring to reduce ecosystem impacts and mooring systems are thus encouraged. Those relevant, could be incorporated into the best diving practices for Fuvahmulah including during shark interaction dives (provisioned or not).

3.5 Conclusions

Responsible and ethical shark diving is complex and must address both socio-economic and bio-ecological considerations. Whether provisioning is involved or not, ensuring diver, animal and environmental safety is always a priority, as well as ensuring the long-term sustainability of any practices involved. In this chapter we present considerations for best practices involving shark diving in Fuvahmulah, Maldives. The considerations presented provide factors that could be considered when developing a Code of Conduct designed in a manner to ensure unified guidelines are to be followed by all operators. These considerations are not exhaustive, but rather designed to generate constructive and inclusive discussions amongst stakeholders. Bringing together the considerations for best practices from this Chapter, together with the input and needs from stakeholders in Chapter 1, and the examples and practices from other global sites from Chapter 2, suggests options to ensure this can be achieved. It is for the responsible authority to prioritise and implement actions/next steps based on the information provided in this report.

4 Sustainable Fish Waste Disposal Best Practices

4.1 Background

Based on our understanding of tiger shark (*Galeocerdo cuvier*) diving practices at Fuvahmulah, Maldives (see Chapter 1), a local tuna fishery has been operating and discarding their fish waste around the island for generations, thus attracting a large number of tiger sharks to the area. The main target species are yellowfin (*Thunnus albacares*) and skipjack tuna (*Katsuwonus pelamis*) which are processed at the local market and the fillets are retained for consumption. The rest of the tuna is discarded, and heads sold (or given) to the local dive operators to be used as bait for their shark dives. Excess tuna waste continues to be dumped outside the harbour (approximately within 1 km from the harbour), attracting more sharks to the vicinity. With increasing diving tourism, exploring sustainable management options for the island's small-scale tuna fishery may benefit Fuvahmulah's island community. In this chapter, we review some of the current international examples of fish waste disposal. Given the current use of fish waste for the provisioned tiger shark diving in Fuvahmulah, potential options on how best to dispose of any waste are both relevant and timely.

4.1.2 Fish Discards

Fisheries and aquaculture production has seen a rapid increase, primarily driven by developing fishing technologies and increased rates of global consumption (Aster, 2018). It is estimated that up to two-thirds of the total amount of fish biomass can be discarded as waste (Coppola *et al*., 2021) (Figure 7). This is either by ocean dumping, incineration or land disposal, representing global environmental and economic concerns (Ahuja *et al*., 2020; Coppola *et al*., 2020). Environmental problems associated with fish waste disposal include air, water and soil pollution and disruption to ecosystems due to their high organic contents (Shavandi *et al*., 2019).

Processing and cleaning fish generates waste and by-products in the form of heads, muscle trimmings, bones, skin, fins, gills, scales and viscera/internal organs (Martinez-Alvarez *et al*., 2015) (Figure 8). Appropriate disposal and recycling of fish waste is a growing priority, with an increasing awareness of utilising 'unwanted' marine resources (Coppola *et al*., 2021). Fish by-products contain valuable proteins, peptides, collagen, chitin lipids, minerals and enzymes that can become a valuable resource if managed properly (Shahidi *et al*., 2019; Mo *et al*., 2018). This not only minimises the environmental impact of fish waste but maximises economic potential, especially in island communities where resources may be limited (Eckelman *et al*., 2014).

Fish by-products are utilised for food, feed, agriculture, biofuel or pharmaceutical industries (Ahuja *et al*., 2020) primarily in the form of: fishmeal, fertilisers, fish oil or direct feeding in aquaculture (Coppola *et al*., 2021). Fish bones are made up of 60–70% minerals, mainly Calcium (Ca) and Phosphorus (P) in the form of hydroxyapatite ($Ca_{10}(PO_4)_6(OH)_2$). Scales are also rich in micronutrients, namely Nitrogen (N), alongside a layer of hydroxyapatite and calcium carbonate ($CaCO_3$) surrounding collagen proteins (Ahuja *et al*., 2020). Other micronutrients identified to be present in pelagic fish tissues include Potassium (K), Magnesium (Mg), Silicon (Si), Sodium (Na), Iodine (I), Selenium (Se) and Aluminium (Al) (Gammarro *et al*., 2013; Goldberg, 1962). Fish blood has also been used as a substitution for the blood of livestock in the food and pet food industries

(Rustad *et al*., 2011). The extraction and purification of these compounds is based on fermentation, enzymatic hydrolysis and acid extraction processes (Coppola *et al*., 2021).

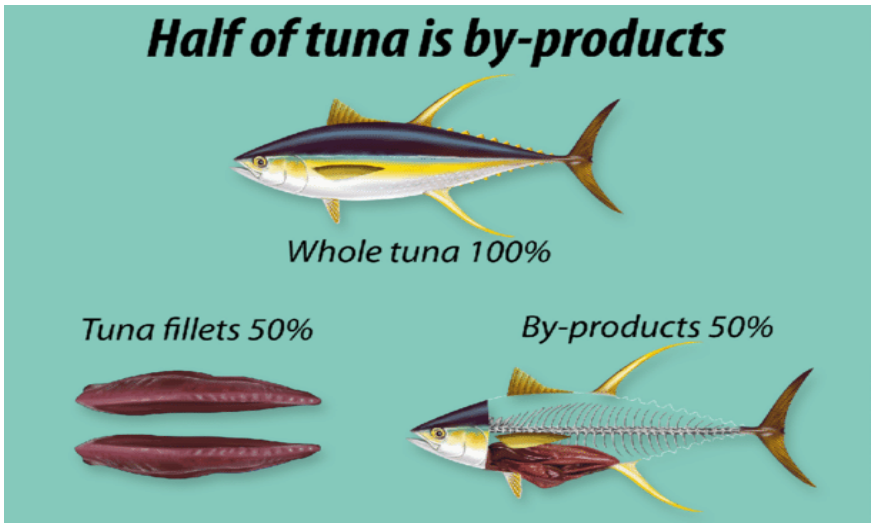

Figure 7. Primary and by-products of the tuna processing sector.
Image from Bergé *et al*., 2014, © Secretariat of the Pacific Community, 2014.

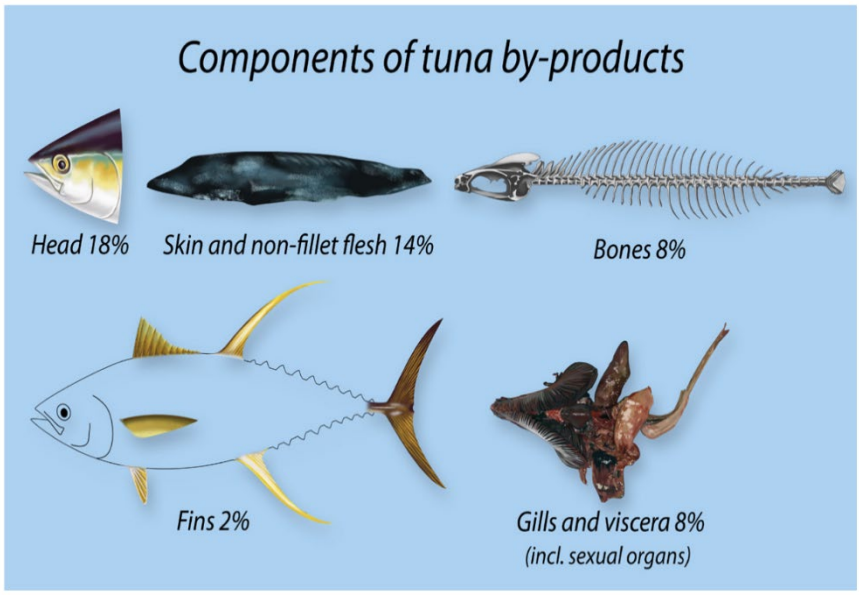

Figure 8. Components of tuna processing by-products by % of total fish biomass.
Image from Bergé *et al*., 2014, © Secretariat of the Pacific Community, 2014

4.2 Sustainable Uses of Fish Discards

4.2.1 Fish Meal and Fish Oil

The evolution of fish meal, defined here as cooked fish products in powder or cake form, production with fresh materials and new, low-temperature processing techniques has led to the development of high-quality feed with high nutritional value (Bimbo & Crowther, 1992). This makes it a valuable, high demand food source in animal feed for the pet industry, alongside aquaculture/fish farm and farming livestock i.e. ruminants or early weaned pigs (Bimbo & Crowther, 1992). Fish meal is often used as a high-protein

supplement, encouraging faster growth and better feed conversion, lowering production costs and changing fat compositions without compromising meat quality (Coppola *et al*., 2021; Gamarro *et al*., 2013).

Fish oils, whether as fat in fish meal or separated into oils, are rich in omega-three fatty acids which deposit into the meat of livestock (Bimbo & Crowther, 1992). It is estimated that the global fish oil market will reach a value of 2,844.12 million USD by 2027, with a value of 1,905.77 million USD in 2019 (Coppola *et al*., 2021). This is mainly driven by the aquaculture industry.

Most fish meal and oil are manufactured using a wet pressing method. First, the fish by-products are cooked to coagulate the proteins and unbind the oil and water. This material is then separated by pressing, resulting in a solid fraction (press-cake) and a liquid fraction (oil, water, suspended proteins and minerals). The remaining components of press liquor fraction are removed by centrifugation where the crude tuna oil is separated and stored in tanks. The liquor fraction is concentrated in evaporators where a tuna soluble concentrate is produced. This is combined with the solid press-cake and dehydrated before being milled and stored (Gamarro *et al*., 2013).

4.2.2 Composting and Fertilisers

Fish by-products can also be composted and converted into organic fertilisers for agricultural and horticultural crops due to their nutritional composition (Coppola *et al*., 2021). Organic fertilisers contain all of the essential properties to rebuild soil condition by improving soil structure and enhancing nutrient absorption from microbial activity (Gamarro *et al*., 2013). This process also promotes the recycling of nutrients from the sea, back to terrestrial environments (Ahuja *et al*., 2020).

4.2.3 Pharmaceuticals and Cosmetics

Fish bones and skin are used for the production of collagen. It is estimated that the marine collagen market could reach 983.84 million USD by 2025 (Coppola *et al*., 2021). Gelatine is derived from collagen through partial hydrolysis. Fish gelatine can be used as an alternative to pork gelatine in food, drug coatings, glues and photographic film. Its primary application is in microencapsulation of pharmaceutical additives and vitamins, alongside uses in nutritional supplements and cosmetics (Rustad *et al*., 2011). Fish by-products represent a cheap source of collagen for the pharmaceutical, cosmetic and food/beverage industries (Coppola *et al*., 2021).

4.2.4 Local Food Production

In some island communities, there is a market for processed fish by-products as a local delicacy. Smoked or dried tuna heads, fins or tails are marketed in local communities where they are consumed for special dishes, namely as soups. Visceral organs are also purchased and made into fish sauce or as local delicacies where conventionally pig by-products are used. Fish roe undergoes further processing into frozen products and is sold domestically (e.g. Philippines, Gamarro *et al*., 2013). Small-scale processing facilities can be set up to produce these products for local consumption.

4.2.5 Biofuel

Biodiesel, derived from the oils of animals and plants, can act as a supplement to diesel derived from petroleum (Arvanitoyannis & Kassaveti, 2008). Fish oil extracted from the fish waste industry is cleaned and purified, where a catalyst is added, and biofuel produced via transesterification. Biofuel using fish waste produces less air toxins, hydrocarbons and CO_2 compared to standard diesel (Yuvaraj *et al*., 2016). This waste-to-energy technology is an effective way to convert fish by-products into renewable energy sources for alternative fuel uses or for electricity generation.

4.2.6 Research, Development & Education

Investing in research, development and education to identify new uses and applications for tuna by-products could lead to scientific and technological innovations that may develop novel products or processes that add value to these resources. Educating fishers and the local community about the importance of sustainable tuna by-product management is also important, increasing awareness of more responsible practices and fostering a sense of environmental stewardship. Partnerships with local conservation organisations to understand the ecological connections of fish by-products as important food sources for local wildlife can guide sustainable management practices. Fish processing facilities can also explore sustainable packaging options for their products that can further reduce the environmental footprint associated with their by-products.

An overview of the products and uses of fish waste (Table 7) and the markets and capacity for them are provided below (Figure 8).

Table 7. An overview of the potential applications, products and uses of fish processing by-products. Table from Bergè *et al*. 2014, © Secretariat of the Pacific Community, 2014.

Applications	**Products**	**Uses**
Agricultural	Fertiliser (silage), compost, pesticide	Soil improvement, pest control
Energy	Biofuel, oxidiser	Energy generation
Animal feed	Meal, oil, protein, silage, minerals	Feed, food supplements
Nutrition (supplements)	Oil, protein, minerals, amino acids	Food supplements, sports nutrition
Human food	Whole or parts of fish, mince, pulp, gelatin, fish stock, fish sauce, liver oil	Unprocessed food, processed food
Pharmaceutical	Omega 3, calcium, chondroitin, collagen, bioactive peptides	Nutraceutical, cosmetics, biotechnology.

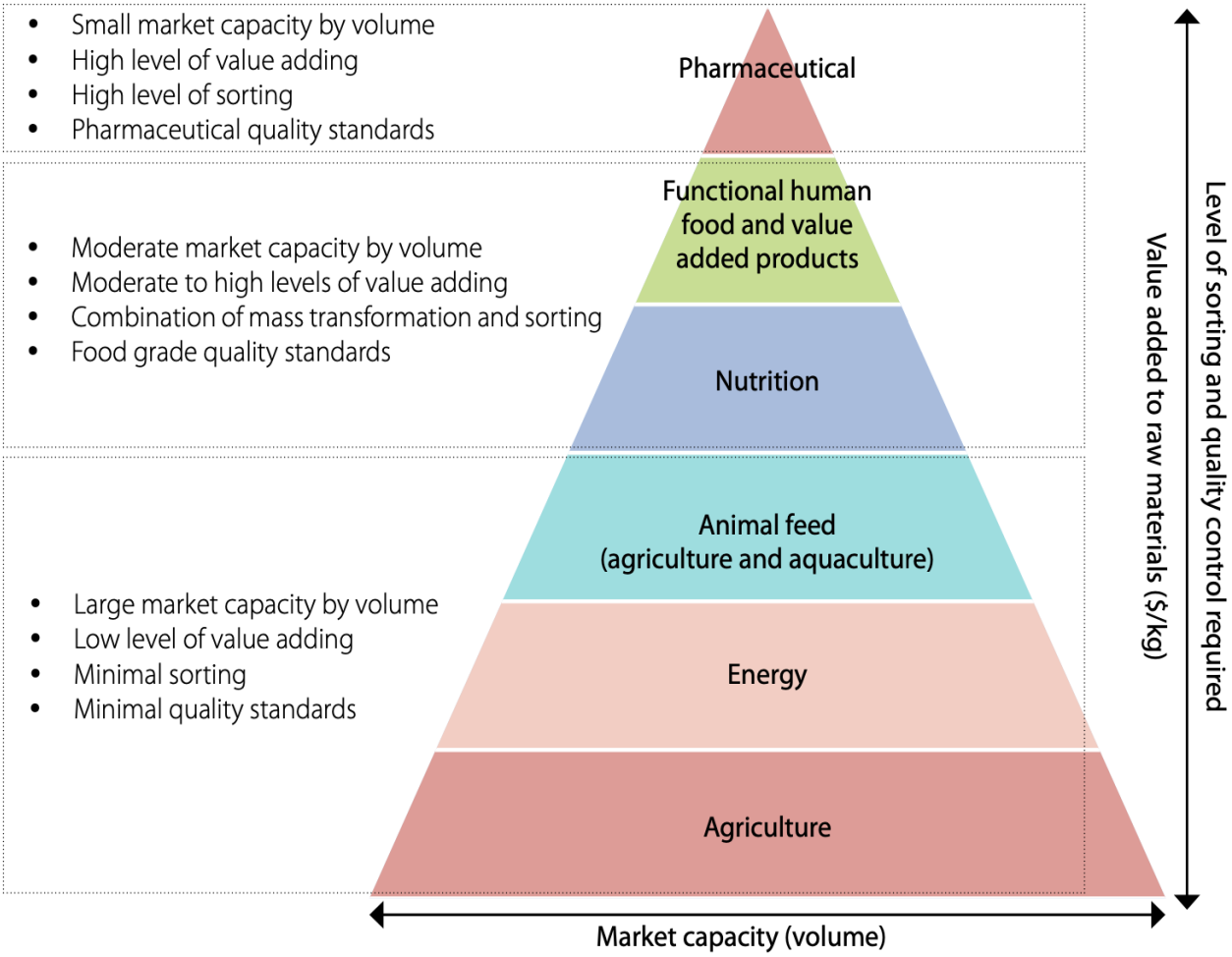

Figure 8. Markets and capacity for fish processing by-products. Image from Bergè *et al*. 2014, © Secretariat of the Pacific Community, 2014.

4.3 Fish Discards Case Studies

The following examples are presented given their similar environmental conditions, accessibility and general economies comparable to the Maldives (based on the United Nations Development Programme).

4.3.1 Philippines

In the Philippines, six tuna species are caught in commercial quantities and landed on Mindanao Island. Large tuna (fresh and sashimi grade) is sold to export processors. The remaining tuna is bought by canneries at seven processing facilities on the island each with their own fish meal production plant. All tuna by-products from the canning industry go towards fish meal production due to its high demand in the domestic market. These fish meals contain 55–60% crude protein for mills to use as their primary protein component. Tuna by-products e.g. heads, bones, fins and skin are also prepared as fried products or used in soups as a daily ingredient for the people of General Santos City. The only by-product that is considered waste is fish blood, washed off during the cleaning process. Small quantities of fish waste are also sent off for research purposes to understand fish oil, omega-three and nutraceutical products. Fish oil production is considered too expensive for the industry in the Philippines to be utilised from tuna by-products (Gamarro *et al*., 2013). The Mindanao tuna industry had a total catch of 211,517 tonnes in 2010, of which

11,729 tonnes were caught using handlines like that used in Fuvahmulah (Gamarro *et al*., 2013).

4.3.2 Thailand

Thailand is the world's leading canned tuna exporter, processing approximately 50% of canned tuna consumed globally and generating significant income. The primary use of tuna by-products in Thailand are also fish meals and fish oil for farming and aquaculture (Gamarro *et al*., 2013) (Figure 9).

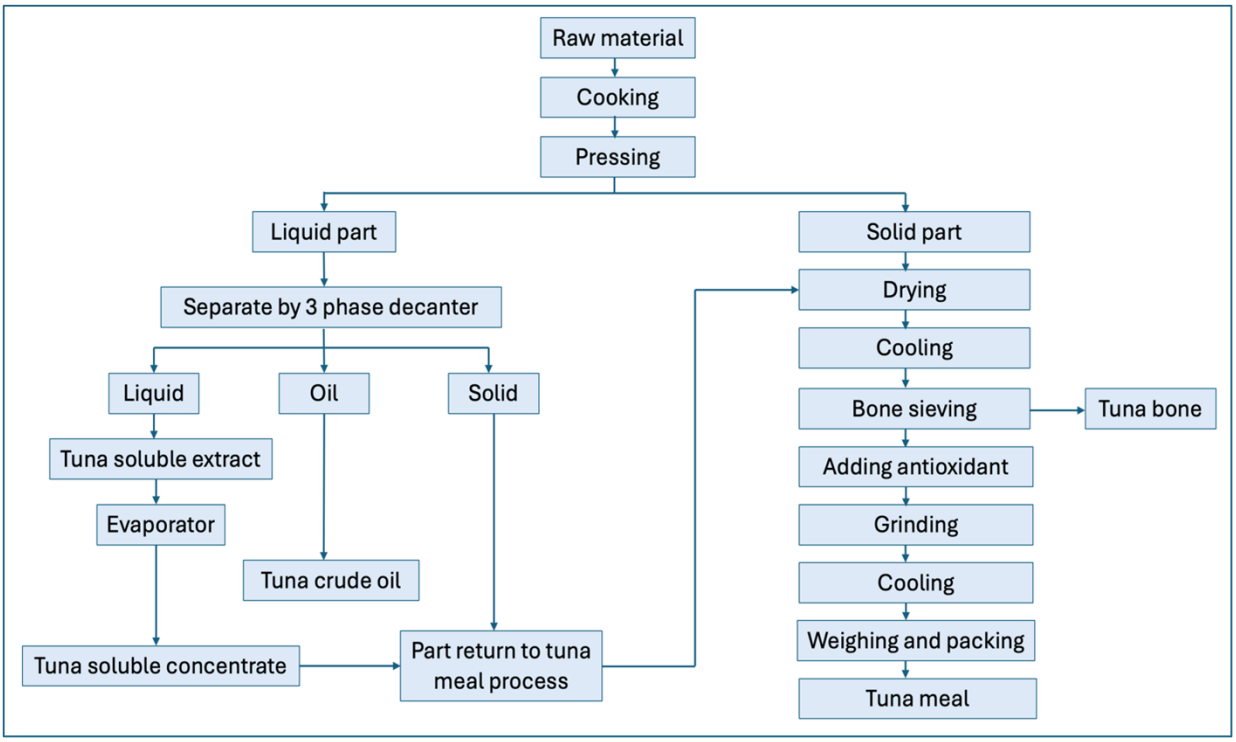

Figure 9. Thailand's tuna by-product processing sequence. After Gamarro *et al*., 2013.

4.3.3 Ecuador

Similarly, tuna by-products play an important role in Ecuador's market whereby fish meal and fish oil are developed from fish waste. Species such as mackerel, anchovy and sand eel are also incorporated for high fish meal demands in Japan and China, where approximately 60% of fish meal is consumed (Gamarro *et al*., 2013).

4.3.4 New Caledonia

In New Caledonia, 1,000 tonnes of tuna by-products are generated each year from the tuna lining industry, which comes at huge environmental and financial costs to the island. BioAgri-NC was introduced, a family run facility offering a consistent and plentiful local supply of fish fertiliser using tuna by-products. Here, tuna heads, bones and fins are ground, liquefied and strained before being bottled up to be marketed widely as organic fertiliser across New Caledonia (Bergè *et al*., 2014) (Figure 10).

Figure 10. A small-scale tuna by-product processing facility, grinding tuna by-products into fertiliser (BioAgri-NC). Image from Bergè *et al*., 2014, © Secretariat of the Pacific Community, 2014.

4.3.5 Samoa

Starkist Samoa Inc. processes around 130,000 MT of fish products per annum, producing significant quantities of waste. These waste products are sorted for supply markets (e.g. consumption/pet-food) and the remaining products mass transformed into fish oil and meal. Some of these products are kept for fish feed in local aquaculture farms where operating costs are reduced. Here, locally produced feed replaces imported feed (Bergè *et al*., 2014).

4.3.6 Bangladesh

A total of 300,000–400,000 metric tonnes of viscera (which includes the guts, liver, spleen and pancreas) is produced each year from fish processing in Bangladesh. From this resource, 200,000 tonnes of powdered fish silage (liquefied fish products with approximately 15% protein as opposed to fish meal which is approximately 65%) can be manufactured with a market value of 25 taka (around 3.5 MVR) per kilogram, reducing the pressure on fish meal production. Using simple methods and low-cost inputs required, fish

waste is upgraded into a powdered silage by taking the liquid product, adding acids and enzymes and dried with rice bran to prepare a powder. Fish silage usage in Bangladesh has proven to increase growth rates, weight-gain and total body length when incorporated into fish's diets in aquaculture, as well as being stored for up to one year without losing its nutrient composition (Hossain & Alam, 2015).

4.3.7 Peru

Peru, a country with a significant fishing industry, has successfully adopted fish meal and fertiliser production from fish discards. Peruvian fisheries, primarily targeting anchovies, generate large amounts of fish by-products. These by-products are utilised to produce fish meal and fish oil, which are valuable commodities for both local and international markets. The fish meal industry supports economic growth in Peru and has created jobs in processing and export. The residual waste from fish meal production can be used as an organic fertiliser, contributing to agriculture industries (Jackson & Shepherd, 2012).

4.3.8 Senegal

In Senegal, small-scale fishing communities have embraced integrated fisheries processing systems. These systems involve collecting fish discards and processing them to extract fish meal and oil. It is estimated that Senegal exports 12,000 metric tonnes of fish meal a year (Yonmo, 2021). Fish meal is used as a protein source for livestock feed, and fish oil is used for various purposes, including cooking and as an ingredient in cosmetics. The practice enhances the economic value of the catch, reduces waste, and contributes to local livelihoods.

These examples demonstrate that value added products from fish discards can be successfully implemented. These initiatives not only reduce waste but also contribute to economic development, job creation, and sustainable resource utilisation, making them valuable strategies for island communities and countries with significant fisheries industries. They help bridge the gap between economic growth and responsible resource management, ultimately benefiting both the environment and local economies.

4.3.9 Equipment Considerations

The specialised equipment and production methods required to effectively process raw materials for specific value-added products varies depending on the scale of the production facility and the quality standards required. Large industrial plants will have more sophisticated and automated equipment (Gammaro *et al*., 2013), while smaller-scale operations may use simpler machinery (Bergè *et al*., 2014). Key pieces of equipment typically needed for fish meal production include grinding and cutting machines to break down solid fish parts for further processing. Cookers or steamers are used to heat the ground fish material, for sterilisation and enzyme inactivation**.** Fish meal production also involves removing moisture from the cooked fish material to achieve the desired moisture content in the final product using direct, indirect or rotary dryers (Gammaro *et al*., 2013). For some production processes, fish oil is extracted. This may involve oil presses or centrifuges to separate the oil from the solids. The fish meal is cooled to reduce its temperature and prevent spoilage, where it is screened and sifted to remove any impurities, such as bones or scales, and achieve the desired particle size distribution (Gammaro *et al*., 2013). Adequate storage and packaging facilities are needed to store the finished fish meal before it is packaged and distributed. This helps maintain the quality of

the product. Adherence to safety and environmental regulations is paramount in by-product manufacturing to ensure product quality and minimal environmental impacts. Quality control equipment such as moisture analysers, protein analysers, and chemical testing devices may be used to monitor the final product. Safety measures and sanitation equipment, including personal protective gear for workers, sanitation stations, and fire safety equipment, are crucial to maintain a safe working environment. To ensure the environmental sustainability of fish meal production, pollution control systems, such as scrubbers and odour control equipment, may be necessary to manage emissions and maintain air and water quality (Coppola *et al*., 2021; Gammaro *et al*., 2013).

4.4 Possibilities for Future Fish Discard Management in Fuvahmulah

Societies around the globe are facing the need to find alternative and sustainable solutions to the ongoing problem of waste disposal (Coppola *et al*., 2020). Transitioning from a linear to circular bioeconomy is important for managing necessary resources for future developments and generations to come (Coppola *et al*., 2021). Establishing facilities for processing fish by-products, including heads, tails, bones and scales can help small-scale tuna industries produce more value from the same amount of resources. These solutions to managing tuna by-products not only provides additional income for the industry but reduces waste and encourages a sustainable well-being in island communities. Collaboration amongst local stakeholders, government agencies, and the private sector is crucial to successfully implementing these sustainable practices and ensuring the long-term viability of the industry.

Sustainable fish waste practices are dependent on the capacity of individual nations producing the by-products and type of by-product available to be processed. The following framework (as proposed by Sharp and Mariojouls, 2012) for potential fish waste management could be considered in Fuvahmulah:

1. Identify the availability and volume of fish waste at a given location,
2. Assess their current uses (if any),
3. Identify potential options and applications to extract value from the waste resource for environmental and/or economic gain.

Bergè *et al*. (2014) also propose a set of criteria and requirements for establishing a fish by-product industry:

- consistent quantity and geographical concentration of by-products, as well as suitable type and quality of by-products for their proposed application;
- suitable infrastructure to maintain quality and facilitate market access;
- ability to comply with sanitary standards;
- financial capacity to invest in value adding technology;
- and availability of research and development to support decision-making for development.

Firstly, a desire to improve current waste dumping practices in Fuvahmulah needs to be identified, alongside the stakeholders who would be actively involved (e.g. fishers, dive operators, governments and local community members). A consistent supply of tuna is caught on the island. Based on these criteria, stakeholders could identify the proportion of fish sold at markets and purchased by dive operators, creating an estimation of the

remaining total fish waste dumped at sea. Current practices may be a waste of valuable resources, disrupting natural ecosystems and causing ecosystem imbalances, resulting in a high abundance of predators in one area. Utilising fish by-products in a more sustainable way could not only lead to economic benefits for locals in the area but could increase the desirability of an eco-friendly, sustainable tourism operation.

There is limited evidence of utilising fish by-products in Maldives. It is estimated that 8–12 tonnes of fish waste are dumped into the ocean at the fish market in Malé every day (Blue Peace Maldives, 2010). So, it may be possible for multiple islands with similar fisheries to work together in collaboration to make more efficient use of fish waste across Maldives. A nationwide fertiliser/compost or fish meal for example for local agriculture could become commercially viable and sustainable, especially over imported, chemical-based fertilisers. This is of particular interest for Fuvahmulah being an agriculturally active island. Dive operators or fishing boats could benefit from the production of biofuel from fish oil, supplementing high fuel costs associated with their industries and reducing environmental emissions.

Moving forward, Fuvahmulah could look to identify a suitable target audience for tuna by-products, either domestic or for export alongside the most economically viable solution, based on their geographic location, capacity, funds and resources available to them. This could be based on the needs or demands of either market for fish meal, fertilisers, biofuel or other uses with a high market capacity. Potentially, Fuvahmulah may be in a strategic geographical location for exporting their resources to neighbouring countries. Partnering with countries that are lacking resources or that are looking to decrease their environmental impact by using more sustainable practices may establish new international relations built on sustainable resources. For example, a nearby country might look to incorporate natural fertilisers produced from fish waste to improve an organic crop yield, adding value to their own products and reducing their environmental impact. Agricultural systems that suffer from long periods of drought and therefore poor soil quality and food for livestock might look to use fish meal as food or organic fertiliser to balance their soils.

Based on these requirements, suitable land with good transport links could be identified; ideally, a processing plant should be in close proximity or with good access to collect and process the waste from the market. Consideration of the impact of increased traffic, air pollution and noise pollution on residents and tourists should also be made. Specific guidelines would be needed to ensure best practices comply with sanitary standards. Funding may need to be identified, this could be private, through international aid or through the local government. Tourists, locals, fishers and dive operators alike could be suitably engaged and educated to understand the importance and benefits of new fish waste practices.

4.5 Considerations from fishers interviewed as part of Chapter 1

Some fishers noted the potential to use fish discards for the production of fish meal and compost, as well as for fish paste *Rihaakuru* from fish heads. Four out of the five fishers were also willing to explore other avenues to use and dispose of fish discards if this were to bring in an additional source of income in place where fishing was not able to meet their needs. The fishers highlighted that the Felivaru ice plant being constructed is also likely to alter how fish is handled, cleaned, stored and sold. The above ideas could be considered for future sustainable fish-waste disposal in Fuvahmulah. Under the current conditions,

wherein fish waste is discarded within the general proximity of the harbour, it would be beneficial to move the dumping location further offshore to avoid unwanted shark presence closer to regular dive sites and other coastal areas.

4.6 Conclusion

Appropriate fish waste management is critical to prevent negative impacts on the marine environment. Sustainable uses of fish by-products e.g. fish meal, fertilisers, biofuel or pharmaceutical uses have been successfully employed in various countries where economic and environmental value has been added to previously wasted resources. In this context, potential options have also been proposed for stakeholders in Fuvahmulah, where a consistent supply of tuna is caught. These suggestions could also be more widely considered across Maldives, given the country's tuna fishing industry. The responsible use of fish waste would support Fuvahmulah's long-term vision of sustainable development.

5 Options to consider around next steps

Marine wildlife tourism remains a quickly growing industry, particularly with sharks. This has been apparent in Fuvahmulah where, following the opening of the airport, tourism has grown exponentially mainly driven by predicable tiger shark encounters. Tourism management is most effective when all stakeholders are considered and work together. Within the context of Fuvahmulah this involves government, dive operators, fishers, NGO's and local communities. A plan for the standardisation of practices in the form of unified diving regulations and safety guidelines have been suggested by the authors to ensure consistency across operations in Fuvahmulah, this could be delivered through the development of a code of conduct for shark interactions at Fuvahmulah. These are based on best practices identified across other provisioned shark diving sites across the globe. Promoting more eco-friendly alternatives to current fish waste disposal practices could also be considered by stakeholders. Subsequent growth also needs to reflect the island's vision and cultural heritage, as well as in-line with UNESCO biosphere reserve guidelines.

Within the chapters of this report, different options for consideration around next steps were highlighted. Through the authors' visit to Fuvahmulah and the interviews conducted, comments were made amongst stakeholders not only relating to diving practices, but to the general development of the industry on the island. It would be beneficial for all stakeholders on the island to work together to ensure the future and sustainability of the dive industry on Fuvahmulah. From Chapters 1-3, some important considerations were highlighted:

- Regulations for Tiger Harbour and shark diving in general, including but not limited to:
  - introductory briefing;
  - time in proximity;
  - number of people;
  - diver to guide ratio;
  - dress code and accessories;
  - bait/chum containment, location and delivery;
  - amount and type of bait/chum;
  - use of lights and strobes;
  - awareness of shark behaviour; and
  - location of the dive site;
- Training and certification of guides;
- Stakeholder engagement to reduce conflict (e.g. with fishers);
- Conservation/diving fee managed through a management board representative of all stakeholders; and
- Registration, certification and monitoring of dive activities.

Note that it remains unknown how much food individual tiger sharks are able to acquire of that provisioned. Restricting the amount of food provisioned is likely to have an impact on the number of individual tiger sharks predictably encountered at TH. However, given that most operators did not disagree with this potential scenario if it were to be equally regulated and to improve diver safety, it could be explored further (see Chapter 1).

It is important to note that when dealing with large, wild, predatory sharks, precautionary active management is crucial to reduce the risk of potential incidents that could have industry-wide implications in the Maldives and beyond (Cooney, 2004; Venables *et al*. 2016). Therefore, the recommendations within this report are designed to encourage active engagement amongst stakeholders to address concerns and ensure a long-term shark diving industry in Fuvahmulah.

Given the continued generation of fish waste as a product of the local tuna fishery, it is important to address concerns raised regarding its disposal. Whilst currently this is discarded offshore from the harbour (except for the tuna heads which are used for the provisioned shark diving), there are possible alternatives that could be of use for Fuvahmulah as mentioned in Chapter 4. Options for consideration could include:

1. Identifying the availability and volume of fish waste generated in Fuvahmulah and identify current uses (i.e. heads for the dive industry, rest is discarded offshore);
2. Consult fishers and community members about potential options and applications to create value added products;
3. Ensure any current waste disposal doesn't take place too close to shore (e.g. needs to be disposed at a minimum of 2 nautical miles offshore).

5.1 Roadmap for best practices implementation in Fuvahmulah

Given the considerations described in this chapter, it is necessary for stakeholders to work together to ensure a sustainable and equitable future for diving in Fuvahmulah. The information within Chapters 1 to 4 lay out key considerations to develop a best-practice plan for shark diving in Fuvahmulah. This includes management of the fish waste and its disposal, addressing the need for a conservation/diver fee and aligning MPA needs with shark diving needs. Whilst a long-term plan is developed for the management of the fish waste, moving the current discard practice further offshore would be beneficial. Similarly, exploring a conservation/diver fee with stakeholders could be explored further as described in Chapter 3.

A potential next consideration would be for the relevant authority to host a workshop with stakeholders, likely after the high season has concluded (May onwards) given the busy schedule of operators during the high diving season (January to April) in Fuvahmulah. The workshop could include the following aims:

1. Jointly develop a Code of Conduct based on input from this report and expertise/ experience from local stakeholders,
2. Ensure recommendations for diving practices align with the Maldives Recreational Diving Regulation (2003) and any other relevant legislation or policy;
3. Jointly develop an action plan with assigned roles, responsibilities, and suggested timeline for implementation;
4. Address other aspects highlighted in this report (see Chapters 1 to 4) as identified as priority by the responsible authority.

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Appendices

Appendices 2 to 7 outline the questions used for the semi-structured interviews.

Appendix 1: Ethical Statement/Disclaimer

The following ethical statement and disclaimer was used for the semi-structured interviews in Appendices 2 to 6. The ethical statement was read out to stakeholders prior to each interview so they understood the purpose of the research. This gave stakeholders an opportunity to ask any questions and consent to taking part in the interviews

The aim of this research is to conduct a review of shark diving practices at Fuvahmulah, Maldives. The Ocean Country Partnership Programme (OCPP) is conducting this research in collaboration with Fuvahmulah City Council and the Ministry of Environment, Climate Change and Energy.

OCPP is a UK-led programme funded by the Blue Planet Fund aimed at supporting sustainable management of marine resources. OCPP has been working in partnership with the Government of Maldives, providing technical assistance for Marine Protected Areas, since 2021.

The information gathered through this interview will help Fuvahmulah City Council and the Ministry of Environment, Climate Change and Energy build an understanding of the current shark diving activities undertaken at Fuvahmulah, including their social and economic importance to the local communities as well as provide an opportunity for stakeholders to share their views and future ambitions for the industry.

Do you have to take part?
You do not have to take part in this interview, and you can withdraw at any time.

How long will it take?
This interview will take around 30 minutes to complete.

Use of your information
Your personal information will not be used in any way and any information you give within this interview will be used only for the purpose of the research. Information will be anonymised and no personal information nor opinions will be distributed.

Consent (note date and time of consent)
Do you understand all of the information I've provided? Do you have any questions?
Do you give consent for me to carry out this interview?
Do you consent for me to record this interview?

Appendix 2. Semi-structured interview for Fuvahmulah City Council members.

Part 1: About you and Fuvahmulah

1. What is your nationality? If you are Maldivian, which province/atoll are you from?
2. When did you become a Council member?
3. What is your job?
4. Do you scuba dive?
5. If so, when did you start diving?
6. What is the main livelihood in Fuvahmulah?
7. Has this changed since the rise of shark tourism in 2017? Please explain.
8. What effect has shark diving tourism had on Fuvahmulah?
9. Why do you think Fuvahmulah is a special place?

Part 2: About shark diving in Fuvahmulah

1. Have you ever been on a dive at 'Tiger Harbour'?
2. If so, if you could use one word to describe that experience, what would it be?
3. How do you feel about current dive practices at 'Tiger Harbour'?
4. Do you have any concerns about current shark diving practices in Fuvahmulah? Please explain.
5. Do you know of any other similar shark diving practices worldwide?
6. Have other local businesses on Fuvahmulah changed as a result of shark tourism? Please explain.
7. What is your relationship with sharks?
8. If you could use one word to describe sharks, what would it be?

Part 3: About the future of Fuvahmulah

1. Do you think current shark diving practices are sustainable?
2. Has there been a push from the Council, or others, to change practices? Please explain.
3. What do you think would be the most beneficial long-term management intervention for the shark diving industry in Fuvahmulah? Please explain.
4. Have you, or the Council, considered fish discard options different to current and past practices? Please explain.
5. What do you think is Fuvahmulah's main resource?
6. What is your vision of Fuvahmulah for the next generation?

- Is there anything else you'd like to share with me?

End of Survey

Reliability related questions:

- Do I believe that the answers given today have been accurate (Y/N)?
- What was the atmosphere of the interview (Relaxed, Tense, Guarded, Rushed, etc.)?

Appendix 3. Semi-structured interview for Fuvahmulah dive centre operators.

Part 1: About you and your experience

1. What is your nationality? If you are Maldivian, which province/atoll are you from?
2. When did you start scuba diving?
3. When did you become a dive professional?
4. When did you start diving in Fuvahmulah?
5. When did you start working as a dive professional in Fuvahmulah?
6. Where do you live?
7. What made you start a dive-based business in Fuvahmulah?
8. Apart from the Maldives, have you interacted with sharks elsewhere in the world? Please elaborate.

Part 2: About your dive operation

1. When did your company start offering shark diving tours?
2. When did you start offering tiger shark specific diving tours?
3. How many boats do you own and operate for dive activities?
4. How many full-time employees do you have?
5. Which is your most popular dive site?
6. How many dives per day, on average, do you offer at 'Tiger Harbour'?
7. How many dives per day, on average, do you offer at other dive sites?
8. Do you know how many dives you conducted at 'Tiger Harbour' in 2022/last 12 months? Specify time period.
9. Do you know how many dives you conducted at other sites in Fuvahmulah in 2022/last 12 months? Specify time period.
10. What is the average cost of a dive with your company at
    a. Tiger harbour;
    b. Others
11. Where are most of your divers from? Please estimate the percentage by major nationality.
12. Are you aware of marine protected areas (MPAs) on Fuvahmulah? Please describe.

Part 3: About shark dives at 'Tiger Harbour'

1. Do you conduct a dive briefing before dives? Please describe.
2. Do you have shark-specific guidelines for 'Tiger Harbour'? Please describe.
3. Do these differ with other operators on the island? Please describe.
4. Is there a minimum certification required to partake in the 'Tiger Harbour' dive?
5. What is the main type of chum/fish used?
6. How much fish discards is provided per dive? Please estimate in either kilograms or number of fish heads/bodies/other.
7. How do you provision the chum/discards?

8. Is this a standard amount amongst operators on the island? Please explain.
9. Do you always use the same amount of fish waste per dive? Please explain.
10. Have you observed changes to shark behaviour during dives as a response to diver activity? Please describe.
11. Do you have a ratio of guides to tourists? Please describe.
12. Is there a time limit on the dive? If so, please explain how this is implemented.
13. How many tiger sharks do you typically see, on average, per dive?
14. How many other species of shark, and how many on average, do you see per dive at 'Tiger Harbour'?
15. Do you have any tiger shark-specific risk mitigation strategies in place?
16. Have you ever had a 'close call' or safety concern during shark dives at 'Tiger Harbour'? Please explain.
17. Have operations changed since you started diving 'Tiger Harbour'? Please explain.
18. Would you support a unified Code of Conduct of Interaction Guidelines for shark dives at 'Tiger Harbour'? If there is a trial one in place, do you support/agree with it, or do you have reservation and/or recommendations for improvement? Please explain.
19. Do you offer non-scuba based interactions with tiger sharks? If yes, please explain how your guidelines differ from the diving-based ones and why.
20. If yes to Q19, on average how many non-scuba trips do you do compared to scuba-based ones, and for how many people? Is the price different to scuba-based interactions?
21. Are you aware of provisioning happening elsewhere than 'Tiger Harbour'? Please explain.

Part 4: About shark dives elsewhere on Fuvahmulah i.e. not provisioned

1. What other species of sharks do you see and where?
2. Do you have shark-specific guidelines for non-provisioned shark dives on Fuvahmulah? Please explain.
3. Are you aware of any Code of Conduct or Interaction Guideline in place in the Maldives for diving with sharks?
4. Would you support a unified Code of Conduct or general guidelines for non-provisioned interactions with sharks in the Maldives?
5. On average, what percentage of your divers dive Farikede MPA?
6. On average, how many dives per year do you do at Farikede MPA, and what would be the average number of divers per dive there?

Part 5: About the future of shark diving in Fuvahmulah

1. What would you say is the main threat to sharks in:
    a. Fuvahmulah;
    b. The Maldives.
2. Are you aware of any contention regarding shark provisioning? Please describe.

3. Are you aware of any laws or regulations governing shark interactions in the Maldives?
4. Do you think current practices at ‘Tiger Harbour’ are sustainable? Please elaborate.
5. How would you improve the sustainability of current practices?
6. What do you think would happen to the tiger sharks if the amount of food provisioned was:
    a. Restricted;
    b. Stopped.
7. On a scale of 1 to 5, with 1 being the least important, and 5 the most important, how important are tiger sharks for your business?
8. On a scale of 1 to 5, with 1 being the least important, and 5 the most important, how would you describe the importance of ‘Tiger Harbour’ for your business?
9. How important is ‘Tiger Harbour’ for your business in comparison to other shark dives?
10. How would you improve management of ‘Tiger Harbour’?
11. Do you support shark research on Fuvahmulah? Please explain.
12. What kind of research would you like to see conducted in Fuvahmulah and why?

Part 6: About your relationship to sharks

1. What is your favourite shark?
2. What is your relationship with tiger sharks?
3. If you had one word to describe tiger sharks, what would it be?
4. Do you support shark conservation? Please explain.

- Is there anything else you’d like to share with me?

End of survey

Reliability related questions:

- Do I believe that the answers given today have been accurate (Y/N)
- What was the atmosphere of the interview (Relaxed, Tense, Guarded, Rushed, etc.)?

Appendix 4. Semi-structured interview for Fuvahmulah community members.

Part 1: About you and Fuvahmulah

1. What is your nationality? If you are Maldivian, which province/atoll are you from?
2. Where do you live now?
3. How long have you lived in Fuvahmulah?
4. What is your occupation?
5. Do you enjoy living in Fuvahmulah? Please explain.
6. What is your relationship with the marine environment?
7. Do you scuba dive?
8. If so, when did you start diving?
9. What do you think is Fuvahmulah's main resource?
10. Why do you think Fuvahmulah is a special place?

Part 2: About sharks in Fuvahmulah

1. How would you describe sharks in only one word?
2. Have you ever seen a shark?
3. Have you ever seen a tiger shark?
4. How do you perceive sharks?
5. Have you ever been on a shark dive in Fuvahmulah?
6. Do you have a connection to the shark tourism industry?
7. Do you have friends or family working in shark diving in Fuvahmulah?
8. How has shark tourism in Fuvahmulah affected you and other members of your community?
9. Do local community members take part in shark dives in Fuvahmulah?
10. What does the local community think of current shark diving practices?
11. Do you have any recommendations that may improve current shark diving practices?
12. What is your vision of Fuvahmulah for the next generation?

- Is there anything else you'd like to share with me?

End of survey

Reliability related questions:

- Do I believe that the answers given today have been accurate (Y/N)?
- What was the atmosphere of the interview (Relaxed, Tense, Guarded, Rushed, etc.)?

Appendix 5. Semi-structured interview for Fuvahmulah fishers.

Part 1: About you and Fuvahmulah

1. What is your nationality? If you are Maldivian, which province/atoll are you from?
2. Where do you live?
3. How long have you been fishing in Fuvahmulah?
4. How often do you go out fishing?
5. What is your target catch?
6. Is this your main source of income? If not, please explain.
7. Do you fish for a) food, b) to sell, c) you enjoy it, d) all of the above.
8. How much do you typically catch per day (kilograms or number of fish per fishing day, average size of fish)?
9. How many days per year do you typically fish?
10. What is your average income from fishing per day?
11. Did you ever target sharks? If yes, what species? If yes, where (nearshore, offshore)?
12. Do you normally see sharks when you are fishing? If yes, what species? If yes, where (nearshore, offshore)?

Part 2: About sharks in Fuvahmulah

1. How would you describe sharks in only one word?
2. Have you ever seen a tiger shark? If so, where was your first sighting?
3. What is your relationship with tiger sharks?
4. Have you ever been in the water with a tiger shark? Please describe.
5. Have you noticed any changes in the number of tiger sharks around Fuvahmulah? Please elaborate.
6. Do you think the number of sharks affect other fishes around Fuvahmulah? Please explain.
7. Have you had, or have, any problems with sharks? Please explain.
8. How would you normally dispose of fish discards?
9. Are you aware of fish discard options?
10. Has this changed since shark diving started? Please explain.
11. Do you make an extra profit from the shark diving supply? If yes, how much extra per day?
12. Would you be willing to dispose of fish discards in a different way?
13. On a scale from 1 to 5, with 1 being greatly reduces, and 5 being greatly increases, how would you rate the impact of tiger sharks on your catch?
14. Do you think sharks are important for marine ecosystems?
15. What is your vision of Fuvahmluah for the next generation?

- Is there anything else you'd like to share with me?

End of survey

Reliability related questions:

- Do I believe that the answers given today have been accurate (Y/N)?
- What was the atmosphere of the interview (Relaxed, Tense, Guarded, Rushed, etc.)?

Appendix 6. Semi-structured interview for Fuvahmulah NGO and Researchers.

Part 1: About you and Fuvahmulah

1. What is your nationality? If you are Maldivian, which province/atoll are you from?
2. Where do you live?
3. What is your job?
4. Who do you work for?
5. When were you in Fuvahmulah?
6. How long were you in Fuvahmulah?
7. Was this your first time visiting Fuvahmulah or the Maldives?
8. What was your main focus on Fuvahmulah?
9. How would you describe your experience in Fuvahmulah?
10. What do you think is special about Fuvahmulah?

Part 2: About shark diving in Fuvahmulah

1. Did you work with one of the dive centres?
2. Did you see sharks whilst in Fuvahmulah? If yes, on how many dives did you do so?
3. If relevant, which shark dives did you take part in? Were these recreational or part of research?
4. Were there any guidelines in place for shark interactions?
5. Did you dive 'Tiger Harbour'? If so, please describe the procedure.
6. What was the maximum number of tiger sharks you saw on your dive?
7. Were there any mandatory or voluntary guidelines in place for this site? Please elaborate.
8. Did the shark diving operators use fish discards to attract sharks to the site?
9. If yes, please indicate how the fish discards were used to attract the sharks.
10. Can you estimate how much food was provisioned per dive? Either in kilograms or number of fish heads/other.
11. Did you ever feel unsafe on a shark dive?
12. Did you ever observe a 'close call' with the sharks? Please explain.
13. Did you feel that safety procedures were followed throughout the dive?
14. Could guidelines have been improved?
15. If relevant based on your experience, what are the most urgent recommendations for management at 'Tiger Harbour' or elsewhere at Fuvahmulah?
16. Would you recommend others to dive 'Tiger Harbour'? Please explain why yes or no.
17. Would you dive 'Tiger Harbour' again? Please elaborate.
18. Have you taken part in other shark dives in other places around the world?
19. If so, how does your experience diving in Fuvahmulah compare to these dives?

- Is there anything else you'd like to share with me?

End of survey

Reliability related questions:

- Do I believe that the answers given today have been accurate (Y/N)?
- What was the atmosphere of the interview (Relaxed, Tense, Guarded, Rushed, etc.)?

Appendix 7. Semi-structured interview for shark diving operators.

Ethical Statement/Disclaimer

The aim of this research is to conduct a review of shark diving practices at Fuvahmulah, Maldives. The Ocean Country Partnership Programme (OCPP) is conducting this research in collaboration with Fuvahmulah City Council and the Ministry of Environment, Climate Change and Energy.

OCPP is a UK-led programme funded by the Blue Planet Fund aimed at supporting sustainable management of marine resources. OCPP has been working in partnership with the Government of Maldives, providing technical assistance for Marine Protected Areas, since 2021.

The information gathered through this interview will help us compare our understanding of the current shark diving activities undertaken at Fuvahmulah, to other places around the globe, including the social and economic importance of shark diving to the local communities as well as providing an opportunity for stakeholders to share their views and future ambitions for the industry.

Do you have to take part?
You do not have to take part in this interview, do not have to answer all the questions and you can withdraw at any time.

How long will it take?
This interview will take around 30 minutes to complete.

Use of your information
Your personal information will not be used in any way and any information you give within this interview will be used only for the purpose of the research. Information will be anonymised, and no personal information nor opinions will be distributed.

Consent (note date and time of consent).

- Do you understand all the information I've provided? Do you have any questions?
- Do you give consent for me to carry out this interview?

Section 1: General Business Operations

Q1. What is your job role within the business?
Q2. How long have you been working for the business?
Q3. How long has the business been operating?
Q4. How many full-time employees does the business have?
Q5. Where do business operations take place?
Q6. What sort of trips does the business offer?
Q7. How many trips do you cater per year?
Q8. How many guests do you cater per trip?

Q9. When did you start scuba diving?

Q10. When did you become a diving professional?

Section 2: Shark Diving Operations

Q1. What is the most common shark species that guests encounter?

Q2. What other shark species do guests encounter?

Q3. How many sharks on average do guests encounter per dive?

Q4. Do you conduct a dive briefing before dives? Please describe.

Q5. Shark-specific guidelines. Do you have guidelines and/or a Code of Conduct relating to the following categories? If yes, please elaborate:

- Dress Code (colour and covering);
- Distance to sharks;
- Handling of sharks;
- Chum/bait storage and delivery;
- Use of lights/strobes;
- Use of poles/safety sticks;
- Number of divers in-water;
- Ratio of guides to divers;
- Any others?

Q6. Is there a minimum certification divers must have to partake in shark dives?

Q7. What is the main type of chum/fish used?

Q8. Where do you get your chum/fish from?

Q9. How much chum/fish is provided per dive? Please estimate in either kilograms or number of heads/bodies/other.

Q10. Did you ever notice a difference in shark behaviour or activity level by the use of a certain type of chum/bait?

Q11. Have you ever had a ‘close call’ or safety concern during a shark dive? Please explain.

Q12. Is there a unified Code of Conduct or Interaction Guidelines for shark dives where you operate?

Q13. Do you offer snorkel/freediving interactions with sharks? If yes, please explain how your guidelines differ from the diving-based ones and why?

Q14. How many other shark diving operations are in your area?

Section 3: Shark Research and Conservation

Q1. Have you noticed a change in the number of shark species since you started shark diving in your area?

Q2. As a business, do you carry out shark research? Please share.

Q3. Are you aware of other shark research in the area? Please explain.

Q5. Are you aware of any contention regarding shark provisioning?

Q6. Are there any government rules or regulations governing shark interactions where you operate, including provisioning (i.e. chumming, feeding, baiting, other attractants)?

Q7. Would you say your diving operations are sustainable? Please elaborate.

Q8. Could you think of any way to improve current shark diving practices?

Section 4: Perceptions Towards Sharks

Q1. What is your favourite shark?

Q2. If you had one word to describe sharks, what would it be?

Q3. What would you say is the main threat to sharks where you operate, and more broadly?

Is there anything else you'd like to share with us today?

End of interview