Submission of information on mobulid species in support of the Northeast (Dubai) and Northwest (Colombo) Indian Ocean EBSA workshops

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The 26 coral atolls which form the Maldives archipelago extend from 7° north down 870 km to half a degree south of the equator in the Indian Ocean (Fig. 1). Located 475 km from the southern shores of India, the Maldives landmass is no more than 128 km across at its widest. Although the country's tiny islands do not naturally reach more than 2.4 m above sea level, outside the atoll rim the reef slope drops steeply to the depths of the Indian Ocean seabed at 2-3,000 m. In the central Maldivian region the atolls form a double chain; here the ocean seafloor between the atolls reaches a maximum depth of 500 m. The Maldives exclusive economic zone contains 3.1% of the world's coral reefs and encompasses 916,000 km² of ocean. By contrast the land area is only 300 km² (Sea Around Us Project 2014).

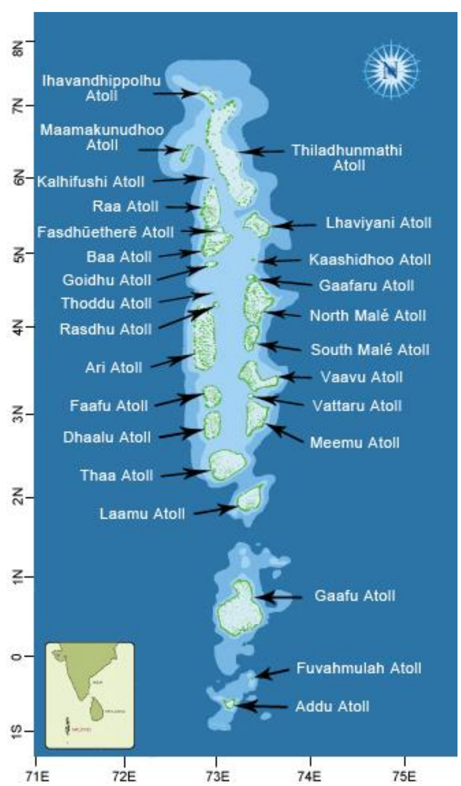

Figure 1. Map of the Maldives Archipelago showing the 26 geographical atolls, illustrated in green. Dark blue indicates where the sea floor exceeds 1,000 m; middle toned blue where it is between 500-1,000 m and the lightest blue where below 500m. The depth of the sea floor inside the lagoon of all the atolls is <100 m. 1° latitude = 111 km.

The Maldives archipelago's 1,196 islands rest upon a string of extinct submerged volcanoes which were created by a volcanic hotspot that punched through a tectonic plate in the Earth's crust approximately 65-45 mya (Ashalatha et al. 1991; Verzhbitsky 2003). The fault line created by this hotspot as it moved north stretches almost 3,000 km in a long line from the Chagos archipelago (British Indian Ocean Territory) in the south, 500 km north to the Maldives archipelago and on again for another 320 km before ending in the Laccadive, Minicoy and Amindivi Islands (known collectively as the Lakshadweep) which lie off the west coast of Southern India. The physical barrier which this Laccadive-Chagos ridge line creates to currents driven by the North Equatorial Current (NEC) generates important nutrient upwelling events which in turn produce primary productivity hot-spots in this region of the central Indian Ocean (Fig.2.). These hot spots support the world's largest population of reef manta rays (*Manta alfredi*) and a significant population of Short-fin pygmy devil rays (*Mobula kuhlii*) (Kitchen-Wheeler et al. 2011; G. Stevens, pers. obs.).

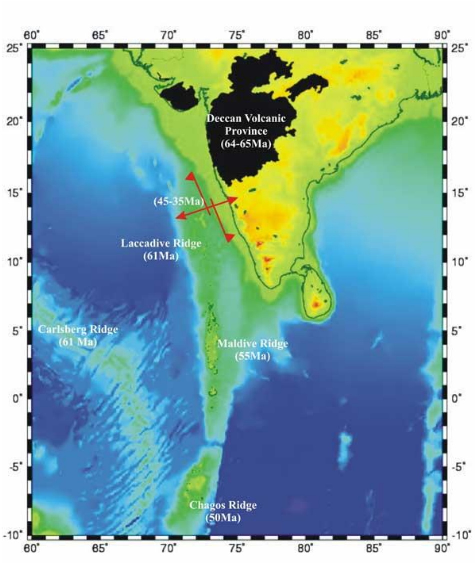

Figure 2. Diagrammatic representation of the Laccadive-Chagos Ridge and geological history of the Indian plate from 65 Ma onwards. Source: mantleplumes.org

Rising 2,000 m from the depths of the Indian Ocean, the Maldivian atolls straddle the Indian Ocean and act as a barrier to the NEC which is driven by the prevailing monsoon winds. The flow of this current through the Maldives' channels has previously been shown to develop island wake eddies as a result of the island mass effect (IME) (Doty & Oguri 1956; Sasamal 2006). These current eddies have been shown to enhance primary productivity on the leeward side of the atolls through deep-water upwellings which brings nutrient rich water into the euphotic zone (Sasamal 2007). Biological productivity is further enhanced in the Maldives by the combined effects of the monsoonal and lunar currents which force water to flow through the atoll channels and into the shallow lagoons, constantly flushing and mixing the water within. The strongest lunar currents are able to overcome the prevailing monsoonal currents which, through the tidal suction mechanism along the channel's outer edges, suck deep plankton laden water from outside the atolls into shallow atoll lagoons (Thompson & Golding 1981; G. Stevens, pers. obs.). Channels between atolls allow larger volumes of water to flow through this region, thereby increasing the rate of vertical advection, generating turbulence and eddy on the leeward sides of islands (Gilmartin & Revelenate 1974). In the centre of the Maldives the parallel chain of atolls act as more of a barrier to the monsoonal current, although the Kardive Channel which runs through the middle of this double chain, breaks the current barrier there. This passage is by far the largest channel between the atolls in the central and northern region of the Maldives archipelago, with a width of 40 km (Fig. 3). Sasamal (2007) showed that primary productivity around the Kardive Channel was intensified by the development of the IME phenomena on the west coast of the archipelago during the northeast monsoon. It is likely a similar phenomenon occurs offshore on the opposite side of the Kardive Channel during the southwest monsoon, when the prevailing current flows to the east.

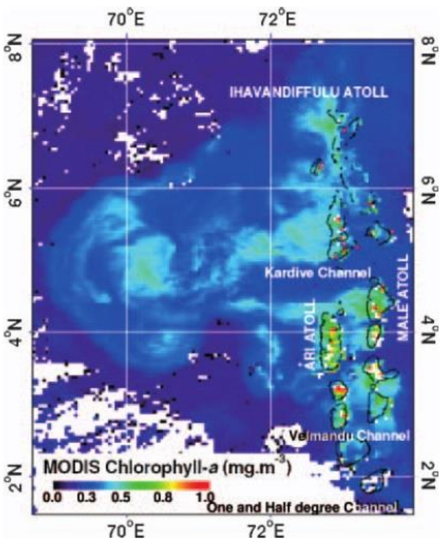

Figure 3. The westward extension of the chlorophyll-a plume off the Maldives central atolls during the northeast monsoon, highlighting the current eddies which are formed by the Island Mass Effect (IME) as the prevailing monsoonal current flows east through the Kardive Channel, increasing primary productivity in this region. Taken from S. Sasamal (2006).

Due to the stronger influences of the South Asian monsoon over the northern and central regions of the Maldives, the greatest manta ray feeding aggregations are generally found along the monsoonal leeward edges of these atolls (Anderson et al. 2011). It is within these regions of the highest productivity that the greatest concentrations of the world's largest known population of reef manta rays feeds all year round, migrating across the archipelago in a general east-west and west-east trend each time the monsoon season changes (Anderson et al. 2011; Kitchen-Wheeler et al. 2011). The Maldives is also a hotspot for cetaceans, with one quarter of the world's cetacean species recorded in the Maldivian waters and the Maldives' beaches are also an important nesting ground for sea turtles. While terrestrial bird species are uncommon, seabirds are plentiful both in the Maldives and the Chagos Archipelagos; the latter is recognized as an important nesting ground for many seabird species.

The Laccadive-Chagos Ridge also appears to act as a corridor for migrating marine megafauna, as indicated by tagging studies of whale sharks (*Rhincodon typus*) (B. Stewart, pers. comm.) and photo-ID studies reef manta rays (G. Stevens, pers. obs.) that move back and forth along this ridge. The strong monsoonal influences in the northern Maldivian atolls also drive the productivity observed in the waters surrounding Sri Lanka. Strong upwellings occur along the southern tip of Sri Lanka, which stimulate high productivity and attract a large number of cetaceans, such as blue whales. This area also appears to be an important feeding area for a number of other pelagic marine species and appears to be a critical habitat for juvenile oceanic manta rays (*Manta birostris*). Like the Chagos-Laccadive ridge, and the southern coast of Sri Lanka, strong upwellings in the northwest Indian Ocean also drive primary productivity, generating productivity hotspots which support significant populations of reef manta rays and other marine life in this region.

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