First records of bentfin devil ray (*Mobula thurstoni*) and the examination in physical factors of its habitat in the western waters of Morotai Island (North Moluccas)

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Abstract. Bentfin devil ray (*Mobula thurstoni*) was recorded for the first time in Morotai waters on 3rd March 2017. In a conservation management context, it is important to clarify the population of *Mobula thurstoni* and their relations with their habitat. Thus, we examined the existence of *Mobula thurstoni* with the physical parameters: depth, temperature, visibility, current, weather, and tidal. We measured the existence of *Mobula thurstoni* with the Underwater Visual Census (UVC) combined with Diver Operated Video (DOV) census. The research from 3rd March to 14th July 2017 (50 dives) showed the Frequency of Occurencen (FO) is 50% per single dive. The highest aggregation of 30 *Mobula thurstoni* was recorded at 14th May 2017 and the average sighting was 3.1 *Mobula thurstoni* per single dive. Among the examined parameters, it was found that strong factor affecting the sighting of *Mobula thurstoni* were at the depth of 30-35 m, temperature of 30°C, visibility of 16-20 m, low current (< 1 knot), sunny weather, and tidal category of B. Analysis of UVC and DOV results show that the research location was categorised as feeding location for the *Mobula thurstoni*.

1. Introduction

Mobula rays and manta rays are categorized in mobulidae family and they are distributed globally in both tropical and subtropical oceans. The mobulidae consists of two genera and 11 species [1] that are harmless and feed mainly on zooplankton, shrimps, crabs, and small fishes [2, 3]. Recently, the manta genera were redifined and they have at least two genus: the reef manta *Manta birostris* (Walbaum, 1792) and the giant manta *Manta alfredi* (Krefft, 1868). The mobula genus comprises of nine recognized species: the giant devil ray *Mobula mobular* (Bonnertere, 1788), the Atlantic devil ray *Mobula hypostoma* (Bancroft, 1831), the spinetail devil ray *Mobula japonica* (Mueller and Henle, 1841), the shortfin devil ray *Mobula kuhlii* (Mueller and Henle, 1841), the Chilean devil ray *Mobula tarapacana* (Philippi, 1893), the bentfin devil ray *Mobula thurstoni* (Lloyd, 1908), the pygmy devil ray *Mobula eregooodoatenkee* (Bleecker, 1959), the lesser Guinean devil ray *Mobula rochebrunei* (Vaillant, 1979), and the Munk’s devil ray *Mobula munkiana* (Notarbartolo-di-Schiara, 1988).

*Mobula thurstoni* was known to occupy shallow neritic waters [4]. It has worldwide distribution with the species reported from Indonesia [5, 6], the Arabian sea [7], Peru [8], Oman [9], the Philippines [10], Chile [11], Mexico [12, 13], the Western Atlantic [4], the South China Sea [15], the Red Sea [16], the
Gabon, Congo, Senegal and Angola [17], the Sao Tome e Principe [18], the Saint Peter and Saint Paul Archipelago [19], the Australia, Mariana Islands, Ecuador, Maldives [20], the tropical Eastern Pacific [21], India [22], and Sri Lanka [23].

*Mobula thurstoni* is classified as near threatened (NT) by the International Union for Conservation of Nature and Natural Resources IUCN [4] with the exact population size is largely unknown. It is estimated that of 9% of all mobulids (409) that were taken as bycatch in drift gillnets fishing for skipjack tuna in the southern waters of Indonesia [5] is *Mobula thurstoni*. In the southern water of Indonesia, approximately 155 *Mobula thurstoni* have landed at Tanjung Luar, Lombok Island and 109 others at Cilacap, Central Java between 2001 and 2005 [24]. In Lamakera, East Nusa Tenggara, 200-300 *Mobula spp.* were caught annually as they were harpooned during annual traditional harvesting [6]. There was a decline for the *Mobula thurstoni* catch’s number data in 2013-2014 shows the 75% decline in Tanjung Luar and 77% decline in Cilacap.

*Mobula thurstoni* is presumed to be long lived and slow growing according to Coutirier et al. [25] with the number of pup of one per birth and disc wide of 650-850 at birth [13]. The largest size of *Mobula thurstoni* was ever recorded was 1,870 mm disc width from Bohol Sea, the Philippines [26]. It has estimated that *Mobula thurstoni* has age of maturity when its disc width (DW) is 1,538 mm [5]. In all recorded specimens, female *Mobula thurstoni* were potentially having the larger size than of male [3, 26, 5].

Bentfin devil ray in the Bohol Sea, the Philippines, feed almost exclusively on the specific krill family of euphausiids: *Euphausia diomedeae* (89.66 %) with the trace of copepod, polychaete larvae, and plant seed as the remaining diet [26]. In the Eastern Pacific, the examination of the stomach of *Mobula thurstoni* indicated that this species is extremely specialized in its feeding habits, which comprise of euphausiids species of *Nyctiphanes simplex* (86.7 %), *Mysidium sp.* (11.1 %), and the remaining is copepod, megalopa larvae, hyperiids amphipods, fish eggs, *Nemastocels diff.*, and stomatopods larvae [3]. However, bentfin devil ray also has the capability to alter its diet depends on the availability of krill by feeding predominantly on Euphausiids spp. (*Nyctiphanes simplex*) in the summer and *Mysidium* spp. in the winter [27].

2. Methodology
Fifty research dives were conducted on one coral reef (research station) around the west waters of Morotai Island in March – June 2017. Selection of the station is based on previous accidental sighting of unknown Mobulid in 2013. The research station was located at N 02° 09’ 18.15” E 128° 12’ 24.43, which is shown on the Morotai Island’s map (figure 1) below as Devil Ray Point.
Materials used for this research were: SCUBA diving gear, underwater slate, transect meter, squeezable empty mineral water bottle, GPS locator, and underwater camera. For analysis purposes, the following tools were used: SPSS™, Microsoft Excel™ 2007, and Field Guide to the Identification of Mobulid Rays. Survey was conducted at the research station regularly between February to June 2017.

Examination of the abundance of *Mobula thurstoni* was performed using Underwater Visual Census (UVC) combined with Diver Operated Video (DOV) census. UVC has been used to estimate the densities of the reef fishes since 1950s [28]. There were two methods of UVC: transect count (an experienced diver swam at constant speed along the transect and noted the reef fish species observed on a slate) and point count (an experienced diver stayed at a vantage point and noted the surrounding reef fish species observed on a slate). UVC with transect and point counts have relatively similar level of significance (p = 0.054 and 0.048 for 10 ha count respectively), therefore both census are deemed reliable Watson *et al.* [29] to be selected for small survey area. A novel method, which is a combination of UVC and diver operated video (DOV), presents great potential to count the abundance of reef fishes in a research station [30].

The physical factors measured and recorded during the survey were: depth, temperature, visibility, current, weather, and tides. As an addition, visual observation was performed to categorize the behavior of the bentfin devil ray during research dives. Reef fish survey was performed in order to obtain the abundance of cleaner fish in the research location. Identified reef fishes were then classified into their cleaning habits based on classification on www.fishbase.org. The density of zooplankton in the research location was also examined to observe the specific species of zooplankton existed that was related to *Mobula thurstoni*.

3. Results

3.1 *Mobula thurstoni* existence

The first devil ray documented in Morotai was on March 3rd, 2017, as shown below in figure 2. Based on the *Field Guide on the Identification of Mobulid Rays Indo-West Pacific* [31], *Mobula thurstoni* has the following distinctive features: 1) ventral mouth; 2) white-tipped dorsal fin; 3) lack of spine at the base of the tail; 4) long tail that equals with disc width in length when fully intact; 5) short necked appearance; 6) short cephalic fins, length from the tip of each fin to the corner of mouth is less than 16% of the total disc width; 7) white ventral marking does not extend above the eyes; 8) tail base that was dorsoventrally compressed closed to the dorsal fin; 9) pectoral fin anterior margin that has a distinctive
double curvature; 10) small sub-circular spiracle under the margin of the pectoral fin where it meets the body; 11) coloration: general deep blue-back on dorsal surface; white ventral surface anteriorly, while the distal half has a silver-brown sheen; 12) the top of the head has a dark band which stretches across the head behind the eyes.

![Figure 2](image_url)

**Figure 2.** Appearance of *Mobula thurstoni* in research station (a) Ventral (b) dorsal.

### 3.2 *Mobula thurstoni* abundance

Research dives between March 3rd and July 14th, 2017 showed the average sighting of *Mobula thurstoni* of 3.1 per dive with the maximum number of individual sighted in one dive was 30 *Mobula thurstoni* on May 14th, 2017. The existence of *Mobula thurstoni* in every research dive in the research stations is shown in figure 3, while table 1 shows the abundant indices of *Mobula thurstoni*. Figure 4 shows 6 probabilities of physical parameters that affected the sighting of *Mobula Thurstoni* and the dominant sighting was at the depth of 30-35 m, temperature of 30 °C, visibility of 16-20 m, low current (< 1 knot), sunny weather, and tidal category of B.

| Abundance Indices               | Sighting (dive) |
|---------------------------------|-----------------|
| Number of dives                 | 50              |
| Total sighting                  | 24              |
| Total abundance of 1 individu   | 8               |
| Total abundance of 2-10 individu| 6               |
| Total abundance of > 10 individu| 8               |
| Mean sighting frequency (%)     | 50              |
| Number individuals per sighting | 6.2             |
| Number individuals per dive     | 3.1             |
We examined the existence of *Mobula thurstoni* with 6 physical parameters. Each parameters had 4 categories that are formed from the results. The categories of tidal in figure 4(f) shows that A is high to low tide, B is low tide, C is low tide, and D is low to high tide. Figure 4 shows probability of *Mobula thurstoni* sighting that was calculated from total sighting (24 dives) and each parameter’s categories.

**Figure 3.** Existence of *Mobula thurstoni* in research stations.

**Figure 4.** Probability of *Mobula thurstoni* sighting on various physical parameters (a) depth (b) temperature (c) visibility (d) current (e) weather (f) tidal.
3.3 Behavior of Bentfin Devil Ray
The research of *Mobula thurstoni* behavior in Morotai Island waters posed several states: feeding, swimming, and cleaning. Pictures captured on their behavior are shown in figure 5 below, representing all those three states mentioned above.

![Figure 5](image)

**Figure 5.** Behavior of *Mobula thurstoni* in research station (a) feeding (b) swimming (c) cleaning.

4. Discussion
4.1 *Mobula thurstoni* existence and abundance
Examination of the existence of mobula ray confirmed that the species of *Mobula thurstoni* existed in the Western Waters of Morotai Islands. even though there was no real specimen collected from the fishermen, the photographic physical identification resulted in 8 out of 12 of distinctive features of *Mobula thurstoni* that were confirmed, as shown in the figure 2. No size measurement was conducted during research survey due to the difficulty in getting near the *Mobula thurstoni* to obtain a minimum parallax measurement error as they always got away when they were approached.

Despite the number of samplings that were far lower (50 dives compared to 4,222 dives), the probability of sighting of *Mobula thurstoni* in Western Water of Morotai (50 %) was extremely higher than the sighting likelihood in Eastern Pacific that was only 0.5 % [32]. The mean number of individuals per sighting was 6.3 and sighting record of 30 individuals indicated that the research area has a potential for large school of *Mobula thurstoni* for recreational diving attraction.

The dominant physical factors that affected the sighting of *Mobula thurstoni* were at the depth of 30-35 m, temperature of 30 °C, visibility of 16-20 m, low current (< 1 knot), sunny weather, and tidal category of B.

Figure 6 shows R-square from 6 parameters: depth (0.14), temperature (0.75), visibility (0.1), current (0.67), weather (0.9), and tidal (0). R-square is always between 0-1. If R-square is close to 1, then the model fits your data. Temperature, current, and weather had R-square close to 1. Thus, the 3 parameters had correlation to Mobula sighting at the research station.

Temperature can significantly influence poikilotherm physiological process, and this is likely a key benefit to staying in warm shallow waters, despite the decreased opportunities for foraging [33]. As a filter feeder, current helps *Mobula thurstoni* to catch more prey. The research was done during the summer. it was predicted that in the summer, there was abundance of giant devil rays in the area occupied by the Pelagos Sanctuary, the Sardinian Sea, and the Central Tyrrenhenian Sea. Seasonal movements may be related to possible energetic advantages deriving from warmer waters if this species thermoregulates like other mobulids Alexander [2] or to the localized availability of high density of prey Canese [35] e.g. mesopelagic and epipelagic fish in the Strait of Messina [36]. Research in other seasons is recommended to know the abundance of *Mobula thurstoni* in each season.

By having these dominant parameters, a potential underwater tourism of mobula ray sighting can be developed in the future as an alternative to fisheries. To increase the quality of research, it is suggested to explain scientifically why each factor contributes to the sightings.
Figure 6. Correlation and regression of *Mobula thurstoni* sighting and its physical parameters (a) depth (b) temperature (c) visibility (d) current (e) weather (f) tidal.

4.2 *Mobula thurstoni* behavior

One of the early indications of the sighting was that the research location was considered as a feeding station for *Mobula thurstoni*. Table 2 shows that the highest number of *Mobula thurstoni* sighting was during feeding (14 dives). During feeding, mobulids were generally observed to swim forward with an open mouth creating a passive water flow through the gill raker apparatus, a behavior referred to as ram filter feeding [37, 38, 39]. Understanding the foraging ecology of threatened species will aid in their conservation and management since feeding behavior often determines critical habitat use and spatial patterns that are important in preventing or mitigating targeted or incidental capture and other human impacts [40].

The cleaning behavior of *Mobula* spp. has never been documented prior to 2016 Murie *et al.* [25] and none of the research on the *Mobula thurstoni* cleaning has been conducted. Interaction between *Mobula kuhlii* and the blue streak cleaner wrasse, *Labroides dimidiatus*, were observed in Mozambique [25]. The difference between *Mobula kuhlii* cleaning behavior in Mozambique and the *Mobula thurstoni*
behavior in Morotai was the latter’s cleaning activity can be conducted even with only single individual while the previous one cited that the *Mobula kuhlii* preferred to aggregate (more than one individual) while cleaning [41].

### Table 2. Behavior of *Mobula thurstoni* in research station.

| Behavior    | Sighting (dive) |
|-------------|-----------------|
| Feeding     | 14              |
| Swimming    | 6               |
| Cleaning    | 4               |

4.3. *Mobula thurstoni* and zooplankton density

Morotai Island Waters lies in the tip of NECC (North Equator Counter Current) area and classified as very rich area of zooplankton [42]. Previous marine survey showed that the research location had zooplankton’s density of 0.757 – 1.070 mg/m³ and categorized as the highest (approximately 600 individuals per m³) in Morotai Waters [43]. *Mobula thurstoni* study in the Philippines revealed that the zooplankton species of Euphausiids was their dominant preys [26].

5. Conclusion

The existence of *Mobula thurstoni* (Lloyd 1908) was confirmed through the identification of the photographs and videos. Among the examined parameters, it was found that factors that strongly affecting the sighting of *Mobula thurstoni* were depth (30-35 m), temperature (30 °C), visibility (16-20 m), low current (< 1 knot), sunny weather, and tidal category of B. Early indication of research site categorized as feeding station was supported by the fact the most sighting was observed during feeding behavior.

6. References

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