



## Rare or just unknown? The occurrence of the giant devil ray (*Mobula mobular*) in the Adriatic Sea

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### Summary

The presence of the giant devil ray (*Mobula mobular*) in the Adriatic Sea was evaluated based on new records collected through field research, information from interviews with fisherman and marine biology experts, and a review of existing data from the literature and Internet sources. Presented are 14 new records of 20 individual giant devil rays collected between 2008 and 2011, doubling the number of animals recorded in the Adriatic in the previous 125 years. In total, 28 records of 42 giant devil rays exist for the Adriatic to date. The cryptic life history of the species, its pelagic distribution and lack of systematic data collection have resulted in a low number of historical records. The results suggest that the species is not as rare as previously considered. Occurring mainly in the central and southern Adriatic Sea from early spring to early autumn, its appearance coincides with the general increase in local prey abundance. Interaction with fisheries is identified as a source of potential mortality, and the monitoring of multi-gear schemes should be carried out at the regional level. Further research on the distribution and abundance of the giant devil ray is crucial for the elaboration of any effective conservation strategy for this endangered species.

### Introduction

The giant devil ray (*Mobula mobular*, Bonnaterre 1788) is a large marine vertebrate and hence may be regarded as a 'charismatic marine megafauna'. It can reach up to 5.2 m in disc width (DW), although specimens of about 3 m DW are most common (Serena, 2005). Although large marine species such as mammals, sea turtles and elasmobranchs have attracted human interest for centuries (Brusina, 1888, 1889; Sella, 1995; de Maddalena, 2010; Notarbartolo di Sciara and Birkun, 2010), the presence of the giant devil ray in the Adriatic remains relatively unknown and the species is considered as rare (Jardas, 1985, 1996; Jardas et al., 2008).

This large epipelagic batoid fish inhabits the entire Mediterranean Sea and possibly adjacent Atlantic waters (Serena, 2005). Due to its geographic distribution and rare records outside the Mediterranean, *M. mobular* is considered as an endemic elasmobranch in the region (Notarbartolo di Sciara and Bianchi, 1998). The giant devil ray has been recorded in a number of Mediterranean countries including Albania (Rakaj, 1995), Algeria (Hemida et al., 2002) Croatia (Šoljan, 1948; Jardas, 1996), France (Capapé et al., 1990; Capapé

et al., 2006), Greece (Bearzi et al., 2006), Italy (Notarbartolo di Sciara and Bianchi, 1998), Israel (Golani and Levy, 2005), Malta (Schembri et al., 2003; Burgess et al., 2010), Tunisia (Bradai and Capapé, 2001) and Turkey (Akyol et al., 2005), demonstrating a basin-wide distribution. *M. mobular* mostly inhabits deep pelagic waters where it feeds on plankton, predominantly krill and small schooling fish (Notarbartolo di Sciara, 2005). Throughout its range the giant devil ray is believed to live in low numbers, although population estimates are not available (Notarbartolo di Sciara et al., 2006).

Due to its limited range, inferred low densities and presumed unsustainable interactions with fisheries, the giant devil ray has been listed as Endangered (EN A4d) on the IUCN Red List (Notarbartolo di Sciara et al., 2006). *M. mobular* is also included in Appendix II of the Convention on the Conservation of European Wildlife and Natural Habitats (Bern Convention, 1979) and Annex II of the Convention for the Protection of the Mediterranean Sea Against Pollution (Barcelona Convention, 1976). In the Adriatic Sea the giant devil ray is legally protected in Italy and Croatia; in Albania, any fishing, transportation, landing and/or trade thereof is forbidden (Prot. No. 1179, 2005). This paper is a critical review of existing literature and presents new records of the giant devil ray in the Adriatic Sea, providing new insight on the distribution of this endangered species in the region.

### Materials and methods

#### Study area

The Adriatic is a semi-enclosed sea with a surface area of circa 138 000 km<sup>2</sup>, connected to the Mediterranean through the narrow (72 km wide) but deep (780 m) Strait of Otranto (Cushman-Rosin et al., 2001) (Fig. 1). The northern sub-basin is shallow, with an average depth of 35 m. The 100 m bathymetric contour line roughly separates the northern basin from the central Adriatic (Artegiani et al., 1997). The central Adriatic is a transition zone from the shallow northern region to the deep southern basin; this central area is represented by the 270 m deep Jabuka (Pomo) pit (Russo and Artegiani, 1996) and the 170 m deep Palagruža (Pelagosa) sill. The southern sub-basin has a maximum depth of 1200 m consisting of around 55% of the surface area but about 80% of the total volume of the Adriatic Sea (Cushman-Rosin et al., 2001), and as such can be considered as oceanic habitat (Fonda-Umani, 1996).

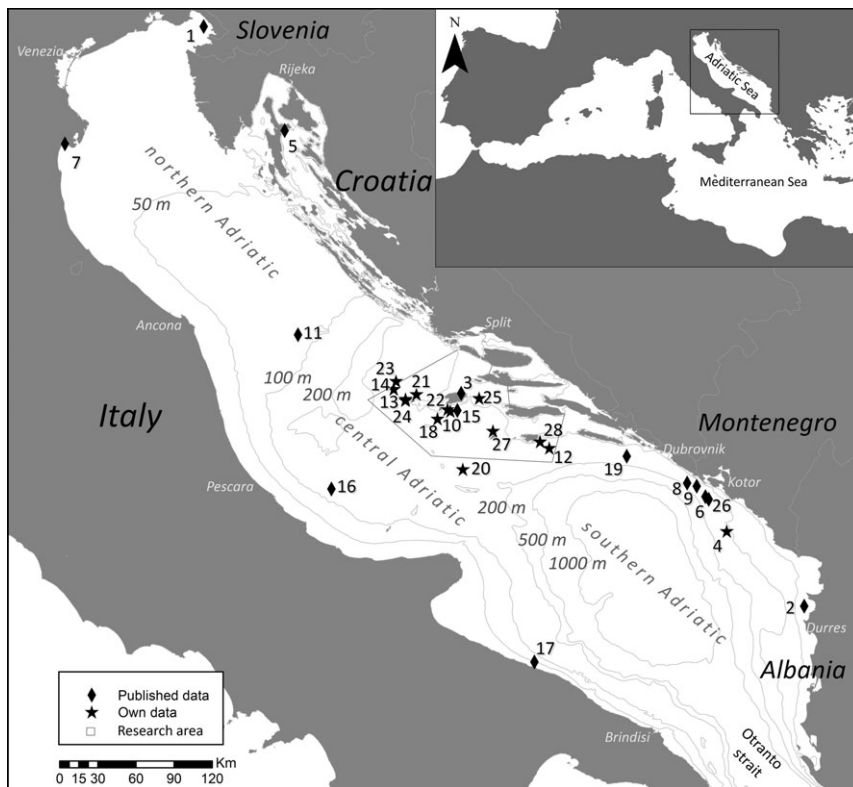


Fig. 1. Locations of *M. mobular* found in the Adriatic Sea, with bathymetric contour lines and sub-basin division. Numbers correspond to record numbers in Table 1

#### Data collection

Three basic types of data are presented: (i) new records collected through field research, (ii) information obtained through interviews with fisherman and marine biology experts, and (iii) a review of the existing data from the literature and Internet sources.

Field data was collected during boat-based surveys targeting a local common bottlenose dolphin (*Tursiops truncatus*) population in the archipelago of Vis and Lastovo islands (central Adriatic Sea) (Fig. 1). Surveys were carried out regularly between April/May and September in four consecutive years from 2008 to 2011. In total, 146 surveys were completed with over 12 000 km covered in good conditions (sea state < 2 Bf, clear visibility). While surveying the area, the present authors also conducted informal interviews with local fishermen. To assess the reliability of their observations, detailed descriptions of the animals were requested. Most fishermen mentioned the 'white ears' (cephalic fins), animal size (estimated) and a 'dark stripe on the head' as prominent features of the species (Notarbartolo-Di-Sciara, 1987). Due to its distinct morphology, size and coloration, misidentification of *M. mobular* with other batoids in the Adriatic is highly unlikely, especially at close range. In addition, the authors contacted a number of marine biology researchers and local scientists for their unpublished records of this species in the Adriatic Sea.

Furthermore, a critical analysis of published historical and current records was carried out, including scientific 'grey literature', local popular articles from various Adriatic countries, and Internet sources. Synonyms were checked according to the *Mobula* genus revision of Notarbartolo-Di-Sciara (1987). The Internet search was conducted using different key words or combination thereof, including Latin and local names of the species, countries and activities (such as 'observation', 'record', or 'by-catch'). Records were evaluated for

reliability based on the description and/or available photo or video documentation; only those with pictures and/or reliable descriptions were considered and retained.

#### Results

Presented are 28 records of 42 individual *M. mobular* recorded in the Adriatic Sea to date. Of these 42 giant devil rays, records of 20 specimens are new for the Adriatic Sea and six further records were available on the Internet and local newspapers. Only 16 *M. mobular* findings were previously described in the scientific literature (Table 1 and references therein). Data on the time (date/month) of finding/observation were available for 32 of 42 specimens. Most of the records (25 of 32 individuals) originate from the summer (June–August), with two records of two *M. mobular* in the spring (March–May) and three records of five giant devil rays in the autumn (September–November). The disk width (DW) is given as reported in the literature or in cases of observations as estimated; DW ranged from 1.3 to 3 m.

Most of the new records (12 observations of 18 specimens) came as sightings from field surveys in the area of Vis and Lastovo islands (Fig. 1). Each sighting lasted between 10 and 30 min from a distance of about 5–20 m. All observed *M. mobular* were swimming close to the surface, from 0 to 5 m depths, and generally showed no signs of being disturbed when approached. In all but one occasion the giant devil rays swam slowly in a parallel course to the boat. On one occasion a solitary individual circled the boat for over 10 min and then left; on another occasion while diving together with a *M. mobular*, the fish showed an interest in interacting, swimming in close proximity to the divers and apparently 'waiting' for them to follow. In the largest observed group of four giant devil rays swam in pairs, with the two leaders closely followed by the other pair. In all

Table 1  
Records of *M. mobular* in the Adriatic Sea (DW – estimated disc width)

| Record No. | Location                        | Date       | DW (m) | Number of animals | Note                                       | Reference                            |
|------------|---------------------------------|------------|--------|-------------------|--|--------------------------------------|
| 1          | Trieste                         | -          | -      | 1                 | 'Accidental in Adriatic', capture          | (Faber, 1883)                        |
| 2          | Lalzi Bay                       | -          | -      | 5                 | 'Very rare', net-capture                   | (Rakaj, 1995)                        |
| 3          | Vis Island                      | 1993       | -      | 1                 | Caught in the harbour                      | (Jardas, 1996; Jardas et al., 2008)  |
| 4          | Budvanska seka, 23 km off coast | July 2000  | 2.6    | 1                 | Trammel net capture                        | Own data                             |
| 5          | Cres Isl, cape Tarej            | 24.6.2005  | -      | 2                 | Observed by divers                         | (Dulčić and Lipej, 2002)             |
| 6          | Prevlaka, 13 km SW              | 21.9.2005  | 2      | 1                 | Caught by longline                         | (Ivanović, 2005)                     |
| 7          | Goro Lagoon                     | 17.11.2006 | 1.31   | 1                 | Caught inside the lagoon, male             | (Zaccaroni et al., 2007)             |
| 8          | Molunat                         | 2007       | -      | 1                 | Observed                                   | (Bijelić, 2007; Jardas et al., 2008) |
| 9          | Dubrovnik                       | -          | -      | 1                 | Data from the map                          | (Jardas et al., 2008)                |
| 10         | Vis Island                      | -          | -      | 1                 | Data from the map                          | (Jardas et al., 2008)                |
| 11         | Central Adriatic                | 30.4.2008  | 3      | 1                 | Pelagic pair-trawl capture, released, male | (Scacco et al., 2009)                |
| 12         | Lastovo Island                  | 27.6.2008  | 2.5    | 2                 | Video                                      | Own data                             |
| 13         | Sv.Andrija Island               | 20.7.2008  | 1.6    | 1                 | Observed                                   | Own data                             |
| 14         | Sv.Andrija Island               | 20.7.2008  | 1.8    | 4                 | Photo and video                            | Own data                             |
| 15         | Vis Island                      | 5.8.2008   | 2      | 1                 | Observed                                   | Own data                             |
| 16         | Central Adriatic                | 5.8.2008   | 2      | 1                 | Observed                                   | (Anonymous, 2008b)                   |
| 17         | Bari                            | Sep. 2008  | -      | 3                 | Observed                                   | (Anonymous, 2008a)                   |
| 18         | Sv.Andrija Island               | 15.7.2009  | 1.8    | 2                 | Observed                                   | Own data                             |
| 19         | Pescara, 15 km E                | Aug. 2009  | -      | 2                 | Photo                                      | (Marevivo, 2009)                     |
| 20         | Palagruža Island                | 24.5.2010  | 2.5    | 1                 | Photo                                      | Own data                             |
| 21         | Biševo Island                   | 3.7.2010   | 2      | 1                 | Video underwater                           | Own data                             |
| 22         | Biševo Channel                  | 9.7.2010   | 1.8    | 2                 | Photo                                      | Own data                             |
| 23         | Jabuka Island                   | 23.7.2010  | 2      | 1                 | Observed                                   | Own data                             |
| 24         | Jabuka Island                   | 23.7.2010  | 2      | 1                 | Video underwater                           | Own data                             |
| 25         | Vis Island                      | 24.8.2010  | 2      | 1                 | Observed                                   | Own data                             |
| 26         | Mamula Isl, 13 km SW            | 3.6.2011   | 2      | 1                 | Trammel net capture                        | (Kosić, 2011)                        |
| 27         | Sušac Island                    | 26.8.2011  | -      | 1                 | Observed                                   | Own data                             |
| 28         | Lastovo Island                  | 26.8.2011  | -      | 1                 | Observed                                   | Own data                             |

cases they did not appear to be feeding (which would be indicated by 'un-curved' cephalic fins; Notarbartolo di Sciara, pers. comm.) and there were no obvious aggregations of plankton or fish in the area. However, nearby schools of small clupeid fish were observed.

Interviewed fishermen working in the open sea areas of the central and southern Adriatic confirmed observations of giant devil rays. Three fishermen from the Island of Vis and seven from the Island of Hvar who regularly bottom trawl or sport fish in the area were interviewed. All confirmed occasional sightings of the species in open waters. When asked about direct catch or by-catch of the species, most had heard of events, but could not give any specific details; they never caught *M. mobular* themselves. In contrast to the regular observations made by the fishermen, researchers reported few encounters. When colleagues and experts in Croatia, Italy, Montenegro and Albania were consulted only two additional records (Nos. 4 and 20; Table 1) were collected.

The literature review on the zoology and ichthyology of the giant devil ray indicates that it is a species known to occur in the Adriatic. In total there are 14 records (16 animals) of different types collected from the 19th century to the present day, from various Adriatic Sea locations (Table 1). The first known records originate from the end of the 19th century, when the species was listed as *Dicerobates giornaie*, Lac. (Stossich, 1880) whereby a specimen was caught in the Gulf of Trieste and noted under the same synonym by Faber (1883). Of these records, six provide only the observation/catch location but no details on the particular

specimen. Other records present partial data on sightings with different levels of precision (some state only the area and/or some type of interaction, others give the month of observation). Only two records give complete information on the specimen, including the measured DW and sex (Nos. 7 and 11; Table 1). In searching the Internet, five observational records were found with nearly complete sighting information (i.e. date/month, location, number of specimens).

## Discussion

With 14 new reports of 20 individual giant devil rays collected between 2008 and 2011, the number of *M. mobular* recorded in the Adriatic Sea has doubled that of the previous 125 years of incidental data (1883–2008; Table 1 and references therein). The present results show that the giant devil ray is not as rare as previously considered (Jardas et al., 2008), and that the low number of records in the Adriatic Sea can be attributed in part to the cryptic life history of this species. Moreover, most of the new observations (18 specimens) came from field research, suggesting that such an increase in the number of records over this 4-year period is due to systematic data collection.

The seasonal distribution of records with a peak in the summer suggests the existence of a temporal pattern of occurrence, similar to some other large pelagic vertebrates such as the leatherback sea turtle, *Dermochelys coriacea* (Lazar et al., 2008). Although little is known of the feeding habits of the giant devil ray, it is generally considered to be



a plankton feeder, also feeding on pelagic crustaceans and small schooling fish (Celona, 2004; Serena, 2005). Celona (2004) suggested that the seasonal increase in abundance of giant devil rays in the Strait of Messina between late spring and summer may be due to the seasonal availability of prey. The earliest seasonal observations of the giant devil ray in the present study are from the area of open waters in the central Adriatic in April and May (Fig. 1). This distribution coincides with appearance of large quantities of sardines and anchovies (Skrivanić and Zavodnik, 1973; Benović et al., 1984; Regner, 1996). The majority of the current sightings, however, were made in areas closer to the coast late in the spring and throughout the summer (Table 1). Although observations may be biased by the greater observation effort closer to the coast, research trips were carried out from April/May to September, with sightings occurring only at the end of June and during July and August. This increase in the number of sightings closer to the central Adriatic islands and along the western coast is likely to be connected to the migration of sardines along the eastern coast (Skrivanić and Zavodnik, 1973) and anchovies on the western coast of the Adriatic Sea (Regner, 1996).

When the spatial distribution of records is considered, most findings originate from the southern and central Adriatic sub-basins (Fig. 1). This conforms to the proposed local geographic range of the species (Notarbartolo di Sciara et al., 2006). The giant devil ray is an epipelagic species that spends most of its time (81.5%) in surface waters between 0 and 50 m, although it is capable of diving to depths of 700 m (Canese et al., 2011). Spatial distribution of the giant devil ray in the Adriatic coincides with the distribution of other oceanic species, such as the Cuvier's beaked whale (*Ziphius cavirostris*), sperm whale (*Physeter macrocephalus*), the leatherback turtle (Holcer et al., 2007; Lazar et al., 2008; Bearzi et al., 2011), and oceanic developmental stages of green turtle (*Chelonia mydas*) and loggerhead turtle (*Caretta caretta*) (Lazar et al., 2004, 2010; Casale et al., 2007).

The giant devil ray is a species of conservation concern, protected under the Bern and Barcelona conventions. Nevertheless, no action has yet been taken to develop basic elements for assessing its true conservation status, such as population estimates and threat evaluations. Although interactions of *M. mobular* with fisheries in the Adriatic have been documented for swordfish drifting longlines (Marano et al., 1983; Bello, 1999), pelagic pair trawlers (Scacco et al., 2009), bottom longlines and trammel nets (Table 1 and references therein), no precautionary measures are in place to mitigate human-induced mortality. Moreover, in the Mediterranean the giant devil ray has also been by-catch in purse seiners (di Natale, 1998; Notarbartolo di Sciara et al., 2006), a fishery responsible for the majority of fish caught in the Adriatic Sea. The importance of purse seiners, in terms of their possible impact on the giant devil ray in the Adriatic, is further stressed when considering that 89% of the total Croatian pelagic fish catch for 2009 used this gear (IOR, 2011). In addition, purse seiners operating off the regions of Abruzzo and Apulia (IREPA, 2009) constitute about 30% of the total Italian pelagic catch. This fishery in the southern and the central sub-basins is potentially the most detrimental for giant devil rays in the Adriatic Sea due to their feeding habits and epipelagic behaviour (Canese et al., 2011).

However, with the exception of the Italian pelagic/mid-water trawlers operating in the northern and central sub-basins (Fortuna et al., 2010), no other by-catch monitor-

ing exists in the Adriatic Sea that is known to the present authors. Hence extent of the fishery: giant devil ray interaction is beyond the current knowledge for this region. Furthermore, the Adriatic Sea is frequented primarily by large individuals, with DWs ranging between 2 and 3 m (Table 1). In a K-selected species with life history similar to giant devil rays, these size classes are the most sensitive to anthropogenic perturbations (Heppell et al., 2000; Heppell et al., 2005). Given the protected status and the estimated population decline (Notarbartolo di Sciara et al., 2007), an assessment of the impact of fisheries at Adriatic level coupled with further research on the distribution and abundance, should be underlined as a priority for the elaboration of an effective conservation and management strategy for giant devil rays in the region.

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