Sympathy for the devil: a conservation strategy for devil and manta rays

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Background. International trade for luxury products, medicines, and tonics poses a threat to both terrestrial and marine wildlife. The demand for and consumption of gill plates (known as *Peng Yu Sai*, "Fish Gill of Mobulid Ray") from devil and manta rays (subfamily Mobulinae, collectively referred to as mobulids) poses a significant threat to these marine fishes because of their extremely low productivity. The demand for these gill plates has driven an international trade supplied by largely unmonitored and unregulated catches from target and incidental fisheries around the world. Scientific research, conservation campaigns, and legal protections for devil rays have lagged behind those for manta rays despite similar threats across all mobulids. **Methods.** To investigate the difference in attention given to devil rays and manta rays, we examined trends in the scientific literature and updated species distribution maps for all mobulids. Using available information on target and incidental fisheries, and gathering information on fishing and trade regulations (at international, national, and territorial levels), we examined how threats and protective measures overlap with species distribution. We then used a species conservation planning approach to develop the Global Devil and Manta Ray Conservation Strategy, specifying a vision, goals, objectives, and actions to advance the knowledge and protection of both devil and manta rays. **Results and Discussion.** Our literature review

revealed that there had been nearly 2.5-times more "manta"-titled publications, than "mobula" or "devil ray"-titled publications over the past 4.5 years (January 2012- June 2016). The majority of these recent publications were reports on occurrence of mobulid species. These publications contributed to updated Area Of Occupancy and Extent Of Occurrence maps which showed expanded distributions for most mobulid species and overlap between the two genera. While several international protections have recently expanded to include all mobulids, there remains a greater number of national, state, and territory-level protections for manta rays compared to devil rays. We hypothesize that there are fewer scientific publications and regulatory protections for devil rays due primarily to perceptions of charisma that favour manta rays. We suggest that the well-established species conservation framework used here offers an objective solution to close this gap. To advance the goals of the conservation strategy we highlight opportunities for parity in protection and suggest solutions to help reduce target and bycatch fisheries.

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29   **Abstract**

31   **Background.** International trade for luxury products, medicines, and tonics poses a threat to both
32   terrestrial and marine wildlife. The demand for and consumption of gill plates (known as *Peng*
33   *Yu Sai*, "Fish Gill of Mobulid Ray") from devil and manta rays (subfamily Mobulinae,
34   collectively referred to as mobulids) poses a significant threat to these marine fishes because of
35   their extremely low productivity. The demand for these gill plates has driven an international
36   trade supplied by largely unmonitored and unregulated catches from target and incidental
37   fisheries around the world. Scientific research, conservation campaigns, and legal protections for
38   devil rays have lagged behind those for manta rays despite similar threats across all mobulids.
39   **Methods.** To investigate the difference in attention given to devil rays and manta rays, we
40   examined trends in the scientific literature and updated species distribution maps for all
41   mobulids. Using available information on target and incidental fisheries, and gathering
42   information on fishing and trade regulations (at international, national, and territorial levels), we
43   examined how threats and protective measures overlap with species distribution. We then used a
44   species conservation planning approach to develop the Global Devil and Manta Ray
45   Conservation Strategy, specifying a vision, goals, objectives, and actions to advance the
46   knowledge and protection of both devil and manta rays.
47   **Results and Discussion.** Our literature review revealed that there had been nearly 2.5-times
48   more "manta"-titled publications, than "mobula" or "devil ray"-titled publications over the past
49   4.5 years (January 2012- June 2016). The majority of these recent publications were reports on
50   occurrence of mobulid species. These publications contributed to updated Area Of Occupancy
51   and Extent Of Occurrence maps which showed expanded distributions for most mobulid species
52   and overlap between the two genera. While several international protections have recently
53   expanded to include all mobulids, there remains a greater number of national, state, and territory-
54   level protections for manta rays compared to devil rays. We hypothesize that there are fewer
55   scientific publications and regulatory protections for devil rays due primarily to perceptions of
56   charisma that favour manta rays. We suggest that the well-established species conservation
57   framework used here offers an objective solution to close this gap. To advance the goals of the
58   conservation strategy we highlight opportunities for parity in protection and suggest solutions to
59   help reduce target and bycatch fisheries.

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69   **Introduction**

70   International trade poses an increasing threat for many species, including terrestrial fauna

71   like pangolins (*Manis* spp.) and Black Rhino (*Diceros bicornis*) and also a number of marine

72   organisms such as sharks and rays (subclass Elasmobranchii) and seahorses (genus

73   *Hippocampus*). China is a leading importer and exporter due to a high demand for luxury

74   products, medicines, and tonics derived from wildlife (Oldfield, 2003). One of the most rapidly

75   emerging wildlife trade issues is the demand for, and consumption of, the gill plates of devil and

76   manta rays (mobulids) – marketed under the trade name *Peng Yu Sai*, translated as "Fish Gill of

77   Mobulid Ray". Gill plates – the thin, cartilaginous filaments used to filter plankton and small fish

78   from the water column – are key ingredients in a tonic purported to prevent sickness by boosting

79   the immune system and enhancing blood circulation. The first report of gill plate trade was from

80   the Philippines to China in the 1960s, and international trade rapidly expanded in the late 1990s

81   (Acebes, 2013). Traditional Chinese Medicine (TCM) texts first referenced this product in 1976

82   (Shen, Jia & Zhou, 2001), yet recent interviews with practitioners in Guangzhou, China and

83   Singapore stated that *Peng Yu Sai* has no health benefits (O'Malley et al., 2016). Furthermore,

84   toxicological studies suggest there are health risks from consuming the high levels of heavy

85   metals in *Peng Yu Sai* (Wong et al., 2007; Li et al., 2012). It appears that industry marketing of

86   *Peng Yu Sai*, rather than any credible TCM or other medical research, is responsible for its rise in

87   popularity (Whitcraft, O'Malley & Hilton, 2014). Regardless of the veracity of the claimed

88   health benefits for humans, this trade poses considerable risk to devil and manta rays.

89   The life history and ecological traits of mobulids make them highly sensitive to

90   overexploitation. Nine species of devil ray (genus *Mobula*) and two species of manta ray (genus

91   *Manta*) currently make up the subfamily Mobulinae (see examples in Figure 1). We note,

92   however, that manta rays have been reported to be paraphyletic and nested within the genus

93   *Mobula* and, as such, the taxonomy may change in the near future (Aschliman, 2014; Poortvliet

94   et al., 2015). Mobulids are filter-feeding planktivores and piscivores that range widely in tropical

95   and warm-temperate waters. The largest devil ray species attains a maximum disc width

96   (analogous to wingspan, as used for bird morphometrics) of five metres (Giant Devil Ray,

97   *Mobula mobular*; Notarbartolo di Sciara, 1987); the largest manta species can reach up to seven

98   metres disc width (Giant Manta Ray, *Manta birostris*; McClain et al., 2015). Devil and manta

99   rays also have long gestation periods (Marshall & Bennett, 2010), and are thought to produce a

100   single pup (Hoenig & Gruber, 1990; Stevens et al., 2000) every one to three years (Notarbartolo

101   di Sciara, 1988; Compagno & Last, 1999; Homma et al., 1999). Consequently, maximum rates of

102   intrinsic population increase (r_{max}; a commonly used metric which reflects the productivity of

103   depleted populations in absence of density dependence), in large mobulid species are among the

104   lowest of all elasmobranchs (Dulvy et al., 2014; Pardo et al., 2016). Mobulids are taken in a

105   range of targeted fisheries and are also retained or discarded as incidental catch. There is a dearth

106   of species-specific fisheries information because mobulids are often fished and traded under one

107   general category (i.e. all mobulids are landed under the category *manta raya* in Mexican

108   fisheries).

109   Targeted fisheries for mobulids have existed for decades, yet increased demand for

110   mobulid gill plates has fuelled the emergence and expansion of fisheries targeting these species

111   (Alava et al., 2002; Lewis et al., 2015). Devil and manta rays were historically exploited for meat

112   (consumed fresh or dried), and to a lesser extent skin (dried) and cartilage (for shark fin soup

113   filler; White et al., 2006; Acebes, 2013), and there continues to be a market for some of these

114   devil and manta ray products today. Mobulid meat is used in traditional dishes as a cheap source

115   of protein in Southeast Asia, and in South and Central America (Croll et al., 2015). In some

116   countries, such as the Philippines, devil and manta rays are targeted both for their meat, which is

117   consumed domestically, and for their gill plates, which are exported internationally (Alava et al.,

118   2002; Acebes, 2013). In other countries, such as Sri Lanka, targeted fisheries are driven almost

119   exclusively by the gill plate trade (Fernando & Stevens, 2011).

120   Mobulids are also caught incidentally throughout their ranges (White et al., 2006;

121   Rajapackiam, Gomathy & Jaiganesh, 2007; Couturier et al., 2012), as evidenced by at least 30

122   large- and small-scale fisheries in 13 countries (Bonfil & Abdallah, 2004; Dapp et al., 2013;

123   Croll et al., 2015). Mobulids are captured in a wide range of gear types including driftnets, purse

124   seines, gillnets, traps, trawls, and longlines (Croll et al., 2015). Vessels targeting tuna using

125   gillnets, purse seines, and drift nets are known to capture mobulids, and occasionally retain them

126   as valued catch (White et al., 2006; Fernando & Stevens, 2011; Hall & Roman, 2013). For

127   mobulids caught in and released from purse seine nets, tagging studies indicate moderate-to-high

128   rates of post-release mortality, especially for large individuals that can be difficult to release

129   without physical damage (Poisson et al., 2014, Francis & Jones, 2016). The handful of studies

130   that have quantified the number of mobulids caught incidentally in certain fisheries and regions

131   suggest that incidental catch may contribute significantly to fishing mortality (Croll et al., 2015).

132   Given the challenges in understanding and regulating mobulid fisheries and trade,

133   conservation planning is necessary to build capacity and ensure comprehensive and collaborative

134   action among stakeholders (Stanley Price & Soorae, 2003; Hoffmann et al., 2008; IUCN 2008;

135   Harrison & Dulvy, 2014). The IUCN began its systematic approach to conservation planning

136   with species-specific Action Plans for large, terrestrial megafauna developed by the Species

137   Survival Commission Species Specialist Groups. These Species Action Plans developed over

138   time to become Species Conservation Strategies, which included a status review as well as a

139   vision, a set of goals, objectives, actions, and targets developed by a group of stakeholders

140   (IUCN, 2008). Species conservation planning in the marine realm can be particularly

141   challenging. Compared to terrestrial megafauna, marine megafauna often have larger ranges,

142   making for complicated assessment and abatement of multiple threats across multiple

143   jurisdictions (McClenachan, Cooper & Dulvy, 2016). In stark contrast to terrestrial organisms,

144   whose conservation may be significantly advanced by a single country or single organization,

145   marine organisms – especially those where individuals are wide-ranging – require a multi-

146   organization, multi-national approach (Dulvy et al., 2016). This paper combines elements from

147   the IUCN Situation Analysis framework – through which major pressures and key regulations

148   are identified (e.g. Mallon et al., 2015) – and the IUCN Species Conservation Strategy

149   framework – where a vision, and a set of goals, objectives, and actions are developed.

150   Concern that international trade controls for manta rays put in place by the Convention on

151   International Trade in Endangered Species of Wild Fauna and Flora (CITES) would create

152   additional pressure on devil rays, combined with the inherent vulnerability of the entire

153   subfamily, led us to prioritize the development of the Global Devil and Manta Ray Conservation

154   Strategy. A workshop was convened in Durban, South Africa from 9-12 June 2014 to develop a

155   Global Devil and Manta Ray Conservation Strategy. In addition to the workshop attendees,

156   inputs from a wider network of devil and manta ray experts informed the Strategy. This paper

157   summarizes of the current state of devil and manta ray scientific research, conservation, and

158   protection (used here to refer to protection obligation, legal or otherwise, and does not examine

159   protection action or effectiveness), and highlights discrepancies between the two genera. We also

160 introduce the global conservation strategy, a living document aimed at guiding future research,

161 policy, and outreach.

162

163 **Materials & Methods**

164 During both the workshop and the development of this document, a significant dichotomy

165 emerged with respect to the understanding of and concern for devil and manta rays. To illustrate

166 this, we first summarize the trends in scientific research on devil and manta rays by updating (a)

167 the systematic literature analysis of Couturier et al. (2012) and (b) the maps of species

168 distributions, fisheries, and protection (used here to refer to protection obligation, legal or

169 otherwise, and does not examine protection action or effectiveness). Within this context, we then

170 summarise how the species conservation planning process was undertaken by describing the

171 workshop process and strategy development.

172 *Scientific research and expertise on devil and manta rays*

173 In order to examine trends in devil and manta ray scientific research, we extracted scientific

174 papers from the ISI Web of Science Core Collection and Google Scholar on 30 May 2016. Our

175 specific aim was to update the systematic literature conducted up to the year 2011 by Couturier

176 et al. (2012) and, as such, we searched the primary literature for titles that contained 'Mobula',

177 'Manta', or 'Devil ray' published from 2012 to 2016. We exported these results and 'false-

178 positive' papers unrelated to devil or manta rays were removed.

179 *Range, fisheries, and protection mapping*

180 Eleven geographic distribution maps of Extent Of Occurrence (EOO) and Area Of Occupancy

181 (AOO) were generated prior to the workshop and refined during and following the workshop

182 based on current species distribution knowledge. The EOO is defined as "the area contained

183   within the shortest continuous imaginary boundary which can be drawn to encompass all the

184   known, inferred or projected sites of present occurrence of a taxon" (IUCN, 2001; IUCN, 2012;

185   IUCN, 2014). The AOO is defined as "the area within its 'Extent Of Occurrence' that is occupied

186   by a taxon for each country. The measure reflects the fact that a taxon will not usually occur

187   throughout the area of its Extent Of Occurrence, which may, for example, contain unsuitable

188   habitats or may be beyond the maximum depth distribution" (IUCN, 2001; IUCN, 2012; IUCN,

189   2014). The AOO for devil and manta ray species was estimated by including only areas where

190   the presence of a given species had been confirmed.

191   Devil ray and manta ray AOO distribution maps were grouped by genus in order to map

192   and compare: (a) locations of known fishing pressure through target and incidental fisheries

193   (from Croll et al., 2015), and (b) presence of international, regional, and national protection

194   (detailed in Table 1). Information on known fisheries and protections was gathered primarily by

195   consulting mobulid experts who participated in the conservation strategy workshop, and those

196   who were part of the wider network of experts (detailed below). This information was supported

197   by reviewing the devil and manta ray literature.

198   *Development of a Global Devil and Manta Ray Conservation Strategy*

199   The IUCN SSG Global Devil and Manta Ray conservation strategy workshop was attended by

200   18 experts who held knowledge from nine of the 19 Major Fishing Areas as recognized by the

201   Food and Agriculture Organization of the United Nations (FAO; Figure 2a). Fourteen more

202   experts contributed to the conservation strategy through electronic correspondence, and an

203   additional 16 experts provided knowledge during the 2015 Fisheries Society for the British Isles

204   (FSBI) symposium in Plymouth, United Kingdom (27-31 July 2015; Figure 2b). These additional

205   collaborators helped to provide expertise for mobulids in the eastern Indian and the Atlantic

206 Ocean, as no workshop participant self-identified as having knowledge specific to these Major

207 Fishing Areas.

208   Through a series of workshop subgroup discussions and plenary sessions, participants at

209 the strategy workshop developed a vision, goals, objectives, and actions (IUCN, 2008) aimed at

210 rebuilding and conserving devil and manta ray populations. This process largely followed that

211 for the Global Sawfish Conservation Strategy, the first of its kind for a group of elasmobranchs

212 (Harrison & Dulvy, 2014). The devil and manta ray workshop participants included biologists

213 and fisheries scientists, as well as representatives of organizations focused on tourism, education,

214 and policy.

215   The group used Specific, Measurable, Achievable, Relevant/Realistic, and Time-Bound

216 (SMART) criteria as a guide for setting objectives and actions. In some cases, workshop

217 participants prioritized countries or regions based on known threats (i.e. those with large,

218 expanding, and unregulated mobulid incidental or targeted catch). Following the workshop,

219 experts revised the goals, objectives, and actions outlined in the strategy, and collaborated on the

220 development of this paper to provide context for the strategy.

221

222 **Results**

223 *Scientific research and expertise on devil and manta rays*

224 Since the literature review conducted by Couturier et al. (2012), which included all peer-

225 reviewed literature from 1980 to 2011, the search term "mobula" returned 11 peer-reviewed

226 publications, while "manta" returned 50 over the past 4.5 years from 2012-2016 (up to June

227 2016). The term "devil ray" was also searched for, and returned an additional 10 publications.

228 Compared to Couturier et al. (2012), who reported 96 publications with either "manta" or

229 "mobula" in the title over 31 years (1980-2011), our update identified a total of 71 additional

230 publications with "manta", "mobula", or "devil ray" in the title over only the past 4.5 years.

231 Couturier et al. (2012) identified 28 peer-reviewed studies focused on *Mobula* spp. from 1980-

232 2011, whereas our study identified 21 novel peer-reviewed studies focused on *Mobula* spp. over

233 the past four years (2012-2016).

234   For devil rays (21 studies), the research theme (as defined by Couturier et al. 2012) was

235 dominated by "Occurrence" (10); followed by "Anatomy, biology, and morphology" (4), and

236 "Bycatch and fisheries" (3). For manta rays (44 studies), the top two research themes were also

237 "Occurrence" (15) and "Anatomy, biology, and morphology" (13), followed by "Life history and

238 population" (7) and "Bycatch and fisheries" (4). Publications that referred to both devil and

239 manta rays in the title (6 studies) were excluded in this research theme analysis. These results

240 differ from Couturier et al. (2012)'s finding that across all devil and manta ray studies

241 "Taxonomy" was the leading research theme, followed by "Occurrence" and "Bycatch and

242 fisheries."

243 *Range, fisheries, and protection mapping*

244 Novel reports on occurrence of mobulid species updated species-specific Area Of Occupancy

245 and Extent Of Occurrence maps for the eleven species of devil and manta ray (Figure 3).

246 Compared to the previous IUCN Red List distribution maps (IUCN, 2015), these updated maps

247 show larger AOO and EOOs for most mobulids, as new sightings and landings data have been

248 reported. For example, Chilean Devil Ray (*Mobula tarapacana*) is confirmed to be present

249 throughout the Red Sea and Gulf of Aden, whereas previously it was only reported in the upper

250 Red Sea. Generally, there have been range extensions across the central Atlantic with new

251 sightings of Bentfin Devil Ray (*Mobula thurstoni*) in West Africa, ranging across the isolated

252   Atlantic islands of the Canaries, Azores, and Ascension. Furthermore, there were significant new

253   records in the Indo-west Pacific nations of the Philippines, Vanuatu (for the Bentfin Devil Ray),

254   Fiji and Palau (for the Chilean Devil Ray).

255   The devil rays fall within three broad classes of geographical distribution. The three

256   largest-bodied species – at least 1.8 m disc width – have near circumglobal tropical and

257   subtropical geographic ranges: Spinetail Devil Ray (*Mobula japanica*), Chilean Devil Ray, and

258   Bentfin Devil Ray. Three species are found only in the Atlantic Ocean and Mediterranean Sea.

259   The Atlantic Devil Ray (*Mobula hypostoma*) is found only in the western Atlantic and has an

260   apparently disjunct distribution in the Caribbean and northern Gulf of Mexico and also in the

261   South Atlantic continuous along the coastlines of Southern Brazil, Uruguay, and Northern

262   Argentina. The eastern Atlantic counterpart is the Lesser Guinean Devil Ray (*Mobula*

263   *rochebrunei*) that was described from Guinea and is thought to be present in Mauritania,

264   Senegal, Guinea-Bissau, and Angola. Finally, the largest species – the Giant Devil Ray – is

265   apparently only found in the Mediterranean Sea. There are three smaller (approximately 1 m disc

266   width) Indo-Pacific species: two found only in the Indian Ocean and western Pacific Ocean

267   (*Mobula eregoodootenkee* and *Mobula kuhlii*) and one species found only in the eastern Pacific

268   (*Mobula munkiana*). The larger of the two manta ray species, the Giant Manta Ray, has a near

269   circumglobal distribution in tropical and subtropical waters and is most similar to those of the

270   three largest devil ray species, whereas the Reef Manta Ray (*Manta alfredi*) has an Indo-West

271   Pacific distribution.

272   Species-specific differences in international, national, and state/territory protection occur

273   across the 11 mobulid species. The Giant Manta Ray has the largest number of international,

274   national, and state/territory protection of any mobulid species, followed by the Reef Manta Ray

275 (Table 1). Species-specific differences exist within the devil rays. The Giant Devil Ray has a

276 small EOO that coincides with the Mediterranean Sea (Figure 3), yet it has been the subject of

277 numerous national, regional, and international protection commitments from surrounding

278 countries (Table 1). In contrast, the Chilean Devil Ray has a large EOO that overlaps with that of

279 the Giant Manta Ray, but national protection is only afforded in six of the 31 countries in its

280 recorded range (Table 1).

281   When grouped by genus, protections for devil rays under two key international

282 agreements are now equal to those for manta rays (Figure 4), yet national and state/territory

283 legislation for devil rays still lags behind protection for manta rays (Figure 5). Moreover, current

284 national regulations leave devil rays unprotected and manta rays protected in areas where target

285 and incidental fisheries for both genera are known to occur. For example, several mobulid target

286 and incidental fisheries occur in the Indo-Pacific region and most protections in this region apply

287 exclusively to manta rays (i.e. Indonesia, Peru, and the Philippines; see Figure 5).

288 *Development of a Global Devil and Manta Ray Conservation Strategy*

289 Workshop participants agreed on an overall vision for the status of devil and manta rays, and

290 three goals aimed at achieving this vision, as well as a series of sixteen objectives and associated

291 actions to support the goals (see Table 2 for details).

292 **Vision:** *Populations of devil and manta rays that flourish in resilient ocean ecosystems,*

293 *harmoniously with human communities, through knowledge, sustainability, and education.*

294 **Goal A.** The knowledge required to sustain devil and manta rays is generated and communicated

295 **Objectives:**

296   1. Taxonomy: To resolve the taxonomy and define management units of devil and manta

297   rays

298   2. Biology: To determine the productivity, life history, and demography of devil and manta

299   ray populations

300   3. Ecology: To understand the spatial and temporal ecology of devil and manta rays

301   4. Public Communication: Communicate research on biology, ecology, status, threats and

302   socio-economic value, of devil and manta rays to enhance conservation and management

303 **Goal B.** Devil and manta ray populations are maintained at, or recovered to, ecologically

304 relevant levels through managing fisheries, trade and demand.

305 **Objectives:**

306   5. Fisheries Management: Devil and manta ray populations and fisheries are monitored and

307   sustainably managed

308   6. Trade Regulation: Ensuring that trade in all devil and manta ray products is traceable,

309   regulated, and monitored

310   7. Socio-economics and Demand: Reduce the demand for devil and manta ray products and

311   understand the socio-economic drivers to ensure demand does not drive unsustainable

312   fishing

313 **Goal C.** Educated and engaged communities support and benefit from devil and manta ray

314 conservation and management through outreach, capacity building, and fundraising.

315 **Objectives:**

316   8. Tourism: A standardized best practice approach to tourism interaction with devil and

317   manta rays is adopted by tourism operators globally

318   9. Community Engagement: Knowledgeable communities contribute to devil and manta ray

319   conservation and management

320   10. Alternative Livelihoods: Empowered coastal communities benefit from alternative

321   livelihoods that are developed to reduce overexploitation of devil and manta ray

322   populations

323   11. Devil and manta ray Network: Commitments to plans and regulations are encouraged,

324   prioritized, facilitated and fulfilled

325

Discussion

327   There has been a recent quantum leap in scientific research, conservation campaigns, and

328   policy directives aimed at understanding and conserving devil and manta rays. Attention to

329   lesser-known devil rays, however, has clearly lagged behind such initiatives for well-known

330   manta rays. We draw on well-established frameworks for species conservation planning that

331   inoculate against implicit or idiosyncratic values. Using such an approach, we have articulated a

332   first-draft conservation strategy with a common vision and goals for all mobulids. To provide

333   context for the conservation strategy and address potential roadblocks to its success, we (1)

334   examine how this apparent charisma gap between devil and manta rays arose, (2) track the recent

335   path of manta ray protection to see where this protection can be extended to include the devil

336   rays, (3) consider how responsible trade and demand reduction can curtail targeted fishing, and

337   (4) and examine how incidental fishing mortality can be minimized.

338   (1) *How did the charisma gap arise between manta and devil rays?*

339   Tourism and related economic sectors have partially fuelled the conservation activities

340   surrounding manta rays. Translating this success to devil rays, however, may be challenging

341   because of biological differences that make devil rays harder for tourists to easily and reliably

342   access. Both species of manta ray reach a large body size, form predictable aggregations, and are

343 accessible to divers (O'Malley, Lee-Brooks & Medd, 2013). Some species of devil ray also reach

344 a large body size, form predictable aggregations, and are accessible to divers, and as a result may

345 be incorrectly identified as manta rays by tourism operators and tourists (R.H.L. Walls, D.

346 Fernando, personal observations). Other devil ray species, however, form unpredictable and

347 sporadic aggregations and exhibit shy behaviour. For example, while aggregations of leaping

348 Smoothtail Devil Ray (Figure 1d) off Baja California provide great potential for boat-based

349 tourism, they occur over short periods that can be difficult to predict. It is inevitable that sighting

350 frequency and reliability will enable a larger segment of society to engage with manta rays,

351 resulting in greater overall interest in conserving manta rays than for devil rays, despite similar

352 threats across genera.

353   This is not the first charisma gap in species conservation, nor chondrichthyan

354 conservation, and this pattern may be more widespread than is appreciated (McClenachan et al.,

355 2012). For example, an apparent charisma gap occurs in the United States where the 2010 Shark

356 Conservation Act prohibited removal of fins at sea for all sharks landed in United States waters,

357 with an exception for Atlantic Dusky Smooth-hound (*Mustelus canis*), which can be landed with

358 their fins removed according to an exceptionally lenient fin-to-carcass ratio (United States Public

359 Law 111–348, 2011). U.S. Atlantic state bans on shark fins also make exceptions for smooth-

360 hounds as well as the Spiny Dogfish (*Squalus acanthias*). In many places around the world,

361 shark finning has been banned largely based on concerns over cruelty, yet few regulations

362 prohibit the removal of wings from live skates. We caution that variation in public awareness,

363 and care for a biased subset of chondrichthyans and other marine organisms, will lead to

364 problematic asymmetries in scientific knowledge, conservation campaigns, and protective

365 regulations (McClenachan et al., 2012). We suggest using well-established species conservation

366 planning frameworks for a means of bridging the charisma gap.

367 *(2) How can we build upon manta ray protection to benefit devil rays?*

368 Many countries still only apply protective measures to manta rays despite all mobulids being

369 highly sensitive to overexploitation. Those countries offering protection for both devil and manta

370 rays include Australia, Brazil, the Member States of the European Union, Israel, Mexico,

371 Ecuador, New Zealand, and the Maldives (Camhi et al., 2009; Whitcraft, O'Malley & Hilton,

372 2014; Council Regulation (EU), 2015; CITES, 2015; Department of the Environment, 2016).

373 National asymmetries in protection are still apparent in Peru, the Philippines, United Arab

374 Emirates (U.A.E.), and Indonesia, as these countries afford legal protection to one or both

375 species of manta ray, but not yet to devil rays. We hope that a key outcome of our strategy

376 development is a greater awareness of the need for matching protection and conservation of both

377 devil and manta rays.

378   International protection for mobulids has expanded relatively rapidly in recent years, and

379 following an initial lag in devil ray protection, the majority of international agreements now

380 protect all mobulids. The first major international action for mobulids came in 2011 with the

381 listing of just the Giant Manta Ray on Appendix I and II of CMS, obligating the 122 Parties to

382 strictly protect the species and collaborate toward regional conservation. In 2013, the two manta

383 ray species were listed under CITES Appendix II, the world's oldest and largest multilateral

384 environmental agreement with the legal mechanisms in place to hold Parties accountable to trade

385 restrictions. The 183 Parties are thus required to issue permits to export manta rays (or manta ray

386 products) only after demonstrating that they are sourced from legal and sustainable fishing

387 operations (CITES, 2013). In 2014, during the 11th Meeting of the CMS Parties, the remaining

388   ten species of mobulid were listed on Appendix I and II (CMS, 2015). In 2016, during the 17th

389   Meeting of the Conference of the Parties to CITES, all species of *Mobula* were listed under

390   Appendix II (CITES, 2016; Action 6.10). In 2015, the General Fisheries Commission for the

391   Mediterranean (GFCM) became the first Regional Fishery Management Organization (RFMO)

392   to prohibit take of a mobulid species (*Mobula mobular*). This was followed later that year by a

393   binding measure adopted by the Inter-American Tropical Tuna Commission (IATTC). This

394   IATTC measure aims to prevent targeting, retention, and discard mortality for all mobulid

395   species taken in relevant Eastern Tropical Pacific fisheries, but includes notable exceptions for

396   small-scale operations.

397   *(3) Can responsible trade and demand reduction help to decrease target fisheries for gill*

398   *plates?*

399   Trade regulation can lead to both positive and negative outcomes. Trade may cease, or continue

400   at sustainable levels as a result of regulation; or trade may continue illegally, or continue without

401   full regulatory compliance. Trade regulation, therefore, should be promoted and implemented

402   with careful consideration of socio-economic drivers. Sometimes governments find it simpler to

403   rather than regulate trade (Vincent et al., 2014). Regulatory obligations (such a CITES permit

404   processing system) can be challenging to implement, particularly in countries with low capacity

405   for management (Shepherd & Nijman, 2007; Rosen & Smith, 2010). Counter-intuitive to the

406   intended purpose, complete bans can sometimes stimulate wildlife exploitation by driving it

407   underground and creating circumstances for elevated value. An analysis of mainly terrestrial

408   species policies that changed from allowing a regulated trade at sustainable levels to a complete

409   ban on trade, found that trade volumes increased by 135% in the year prior to the ban (Rivalan et

410 al., 2007). The price of rhino horn in Korea rose by 400% two years after a total ban, which

411 fueled a sharp increase in poaching (Rivalan et al., 2007; Biggs et al., 2013).

412   One approach to preventing negative conservation outcomes from trade regulation

413 involves attempting to understand relevant socio-economic drivers and associated stakeholder

414 behaviour. Investigations into the mobulid gill plate trade found it to be centered in Guangzhou,

415 China, and involve only a handful of large suppliers (Whitcraft, O'Malley & Hilton, 2014;

416 O'Malley et al., 2016; Actions 7.3, 7.4, 7.5). Conservation campaigns aimed at consumer

417 demand reduction in Guangzhou, along with stronger Chinese government policies that

418 inadvertently affect wildlife trade, appear to be reducing demand for gill plates (O'Malley et al.,

419 2016, Action 7.7); however, continued monitoring is needed to evaluate and track the success of

420 such consumer behaviour change campaigns. Anecdotal information suggests that trade

421 regulation specific to manta rays may unintentionally increase fishing and trade pressure on devil

422 rays. For example, in Indonesia, where national protection exists for manta rays but not devil

423 rays, fishers have begun to target devil rays to avoid penalties. In this case, fishers claim that

424 devil rays are more challenging to catch than manta rays, and thus were less frequently targeted

425 prior to national manta ray protection (pers. comm. WWF-Indonesia, Wildlife Conservation

426 Society Indonesia Program, Indonesian Ministry of Marine Affairs and Fisheries).

427   Another important consideration of regulating mobulid ray exploitation is the effect on

428 livelihoods and food security of fishing communities. Human populations in many tropical

429 coastal communities are growing rapidly, have low income, and rely heavily on fish for protein

430 and income (Allison et al., 2009). Mobulids provide a source of income and protein in several

431 developing countries, particularly Indonesia and Sri Lanka (Fernando & Stevens 2011; Lewis et

432 al., 2015). Developed nations can increase the effectiveness of conservation measures by helping

433   to facilitate necessary social and economic transitions (McClanahan et al., 2008). Under CITES

434   Appendix II, countries can independently assess the sustainability of exports and determine the

435   allowable level of trade, if any. Countries may prohibit landings of mobulids from fisheries

436   based on depletion, high vulnerability, or precaution, regardless of CITES listings. Some

437   mobulid species may be able to support sustainable fisheries, but this has yet to be documented

438   in practice, and would require robust management and enforcement. All fisheries that catch

439   mobulids, including fisheries where catch is incidental, should be monitored, regulated, and

440   minimized when necessary to ensure that these fisheries are sustainable.

441   *(4) How can the impact of incidental catch on mobulids be reduced?*

442   Incidental catch in both large and small-scale fisheries is a key challenge to the conservation of

443   mobulids, given mortality during capture, evidence for low rates of post-release survival (Francis

444   & Jones, 2016), and increased incentives for fisheries to retain these species for the gill plate

445   trade (Croll et al., 2015). The few available studies on post-release survival in devil rays show

446   that handling following capture may strongly influence post-release survival (Action 5.8),

447   although more research is needed (Action 5.9). In a study where small (142−238 cm disc width

448   (DW), mean 200 cm DW) Spinetail Devil Rays were tagged without being removed from the

449   water as part of a scientific study, post-release survival was relatively high (Croll et al., 2012). In

450   contrast, when large individuals (215−265 cm DW) of the same species were brought on the

451   deck of commercial fishing vessels prior to being tagged and released, post-release survival was

452   low (Francis & Jones, 2016). Researchers found that removing these rays from the water caused

453   significant physical strain with potential for post-release mortality. For tuna purse seine fisheries,

454   releasing large rays directly from the brailer (scoopnet that removes the fish from the purse

455   seine), or lifting them out of the brailer using a canvas sling or scoop, is considered best practice;

456   small and medium rays landed on the fishing vessel deck can be carried by their wings to be

457   released (Poisson et al., 2014).

458   The IATTC's 2015 prohibition on the retention, transshipment, storage, landing, and sale

459   of all devil and manta rays in large-scale, Eastern Tropical Pacific tuna fisheries is a significant

460   step toward mobulid protection, but compliance has yet to be evaluated, and exceptions made for

461   small-scale fisheries compromise the conservation goals that drove the original proposal (Action

462   5.13; IATTC, 2015). Effective implementation of associated requirements for reporting mobulid

463   catch data and ensuring safe releases, as well as provisions for technical assistance and capacity

464   building, is critical to improving the outlook for the species in this region (Action 5.3, 5.4, 5.5).

465   While the IATTC mobulid measure can be seen as progress for some purse seine

466   fisheries, more attention to the incidental catch of mobulids in data-poor trawl fisheries,

467   particularly midwater trawls, is needed. A study on the pelagic megafauna taken incidentally in

468   large-scale European trawl fleets targeting sardinella, sardine, and horsemackerel off the

469   Northwest Africa shelf found that approximately one mobulid is taken for every hour of trawling

470   (Zeeberg, Corten & de Graaf, 2006). More research and management is urgently needed to

471   address threats to mobulids from such trawling operations and, indeed, many other fisheries

472   (Action 5.6).

473

474   **Conclusions**

475   Research and regulations for both devil and manta rays have recently increased substantially, due

476   in large part to these species' high sensitivity to over-exploitation. Manta rays, however, have

477   been a greater focus for scientific investment and protection, owing to the added factors of

478   perceived charisma and importance to the dive tourism industry. To bridge this charisma gap and

479   encourage equal protection for all mobulids, as warranted by similar life history and threats, we

480   present a global conservation strategy that draws on components from well-established and

481   successful species conservation frameworks. We are hopeful that sustained interest and

482   collaborative implementation initiatives from the full range of stakeholders will improve the

483   outlook for these remarkable fishes.

484

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492

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Images of devil and manta rays

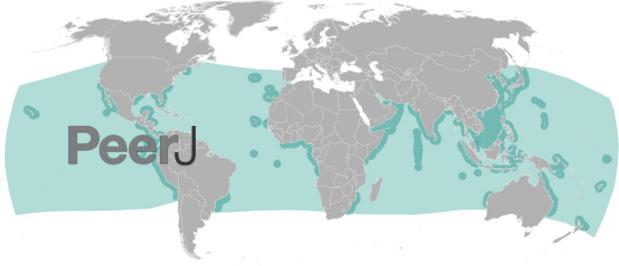
(a) Reef Manta Ray (*Manta alfredi*); (b) Oceanic Manta Ray (*Manta birostris*); (c) Shortfin Devil Ray (*Mobula kuhlii*); (d) Smoothtail Devil Ray (*Mobula munkiana*).

Geographic extent of the expertise that contributed to the Global Devil and Manta Ray Conservation Strategy

Geographic extent of the expertise is shown using Food and Agriculture Major Fishing Areas (FAO MFA) and species Area Of Occupancy (AOO) maps. The dark grey outlines around the countries indicate the presence of one or more mobulid AOO, and the number within each FAO MFA represents the number of species per major fishing area. The degree of colour saturation in each FAO MFA represents the number of experts (A) who attended the workshop, and (B) additional experts who shared information via electronic correspondence and/or from during the Fisheries Society of the British Isles symposium.

Distribution maps for manta and devil ray species

Extent Of Occurrence (EOO) and Area Of Occupancy (AOO) maps for all nine species of devil ray and both species of manta ray.

Mobula japanica

Mobula mobular

Mobula thurstoni

Mobula tarapacana

Mobula eregoodootenkee

Mobula kuhlii

Mobula hypostoma

Mobula rochebrunei

Manta birostris

Manta alfredi

Mobula munkiana

Mobula species   *Manta* species

AOO   AOO
EOO   EOO

Distribution of Parties to CITES and CMS with respect to ranges of mobulid species

Country participation in two key international protection agreements as it relates to each genus; the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) and the Convention on the Conservation of Migratory Species of Wild Animals (CMS) with respect to Area Of Occupancy maps for a single or multiple species of devil (*Mobula* spp.) or manta (*Manta* spp.) ray. Only countries that are known to obtain mobulids in target or incidental fisheries are included, whereas those that do not report target or incidental fisheries for mobulids are blank (see Croll *et al*. 2015 for details). Both nearshore and distant-water fleets are included, thus country of origin may not overlap with mobulid distribution if fisheries operate elsewhere.

Mobula species

Party to
CITES only

Party to neither
CITES nor CMS
(Taiwan)

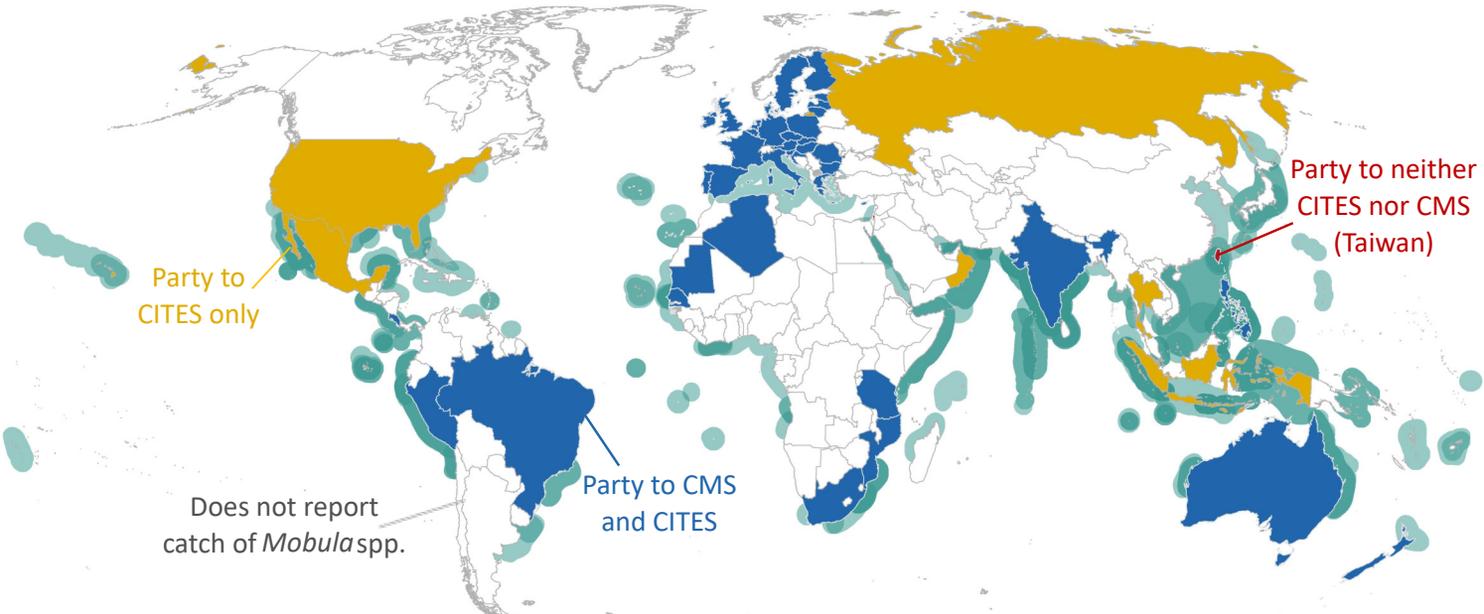
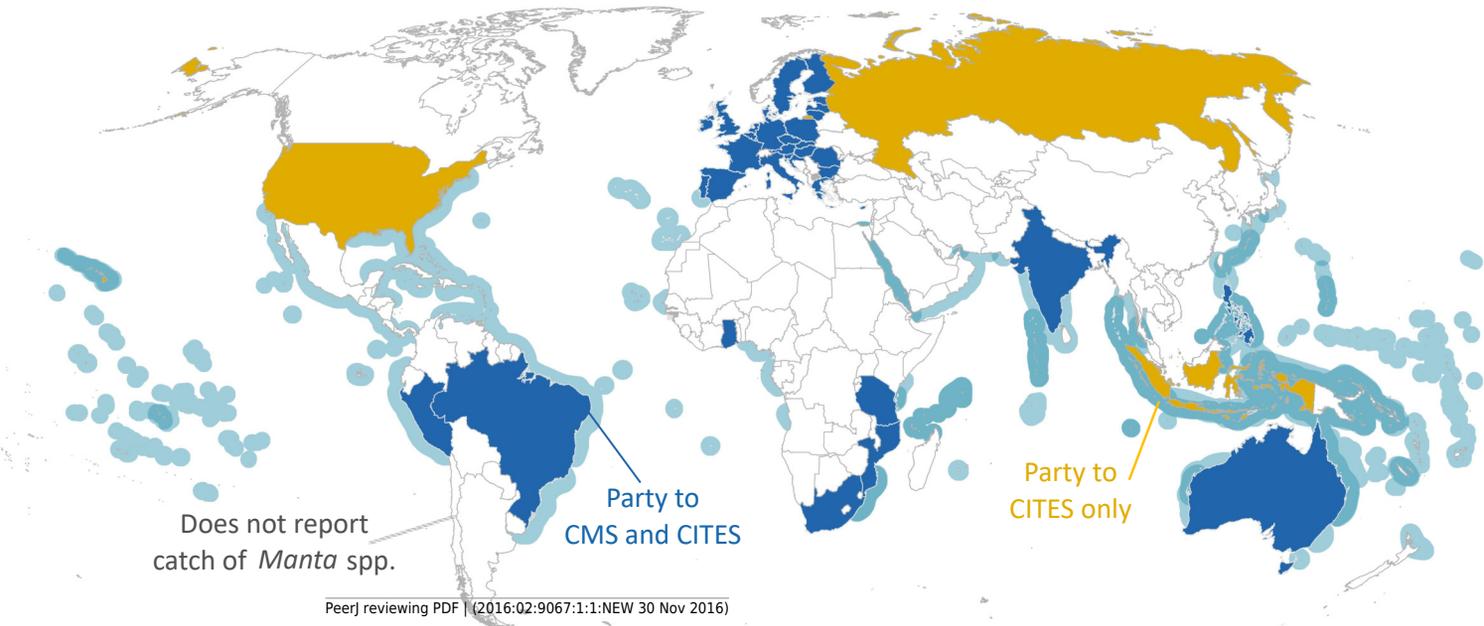
Party to CMS
and CITES

Does not report
catch of *Mobula* spp.

Manta species

Does not report
catch of *Manta* spp.

Party to
CMS and CITES

Party to
CITES only

Distribution of national, territory, and state protections with respect to ranges of mobulid species

National, state, and territorial legislation that restricts fishing and/or trade (excludes international obligations), with respect to Area Of Occupancy maps for a single or multiple species of devil (*Mobula* spp.) and manta (*Manta* spp.) ray. Only countries that are known to obtain mobulids in target or incidental fisheries were included, whereas those that do not report target or incidental fisheries for mobulids are blank (see Croll *et al*. 2015 for details). Both nearshore and distant-water fleets are included, thus country of origin may not overlap with mobulid distribution if fisheries operate elsewhere. Note that the countries of the European Union are grouped and included in this map to be consistent with Croll *et al*. (2015).

Mobula species

Hawaii, USA

Unregulated target or incidental fishing

Florida, USA

Northern Mariana Islands, USA

Philippines

Peru

Indonesia

Raja Ampat Indonesia

Has fishing and trade restrictions

New Zealand

Has fishing restrictions

Manta species

Hawaii, USA

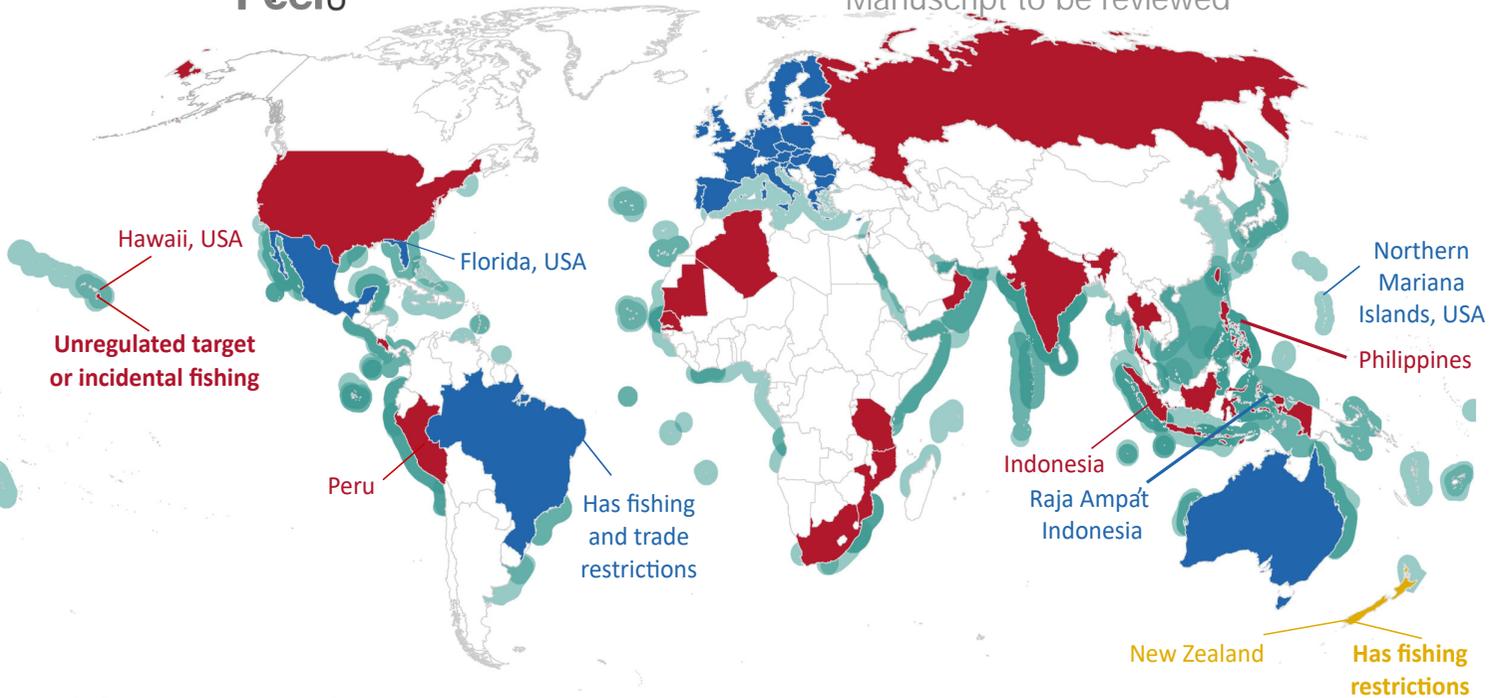
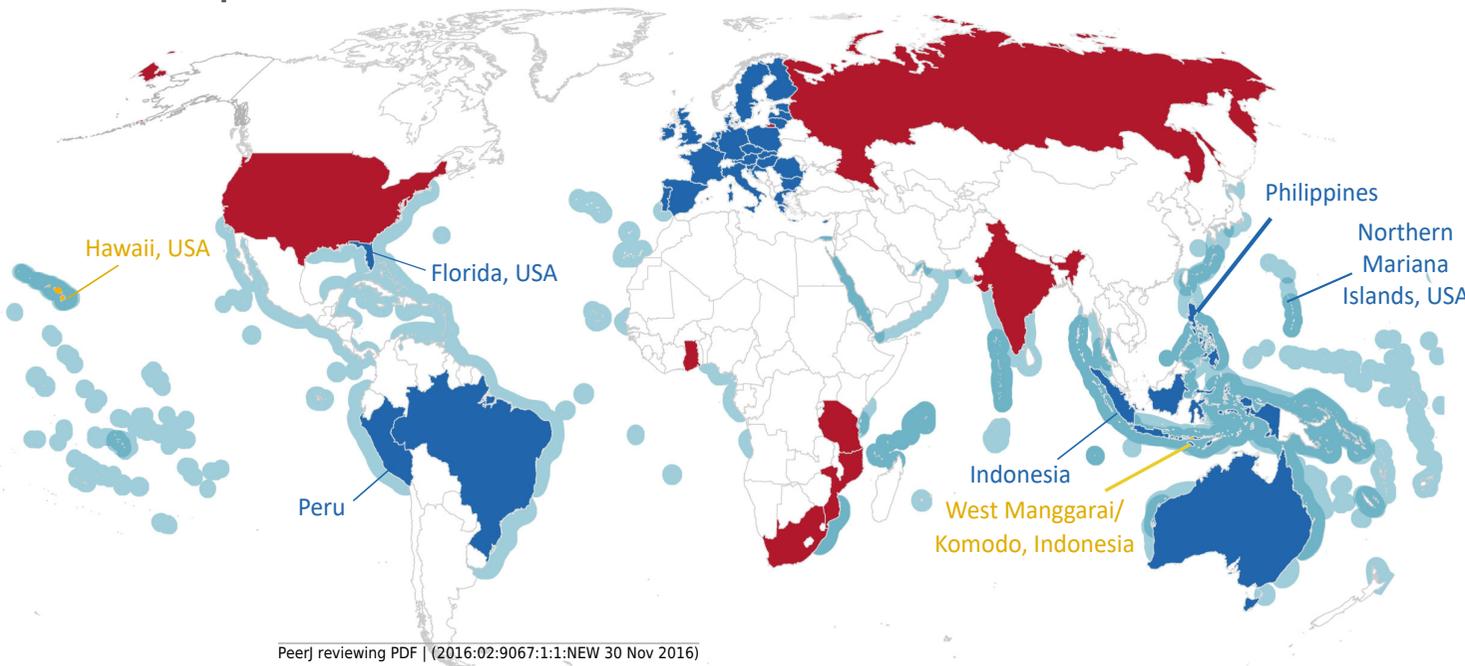
Florida, USA

Philippines

Northern Mariana Islands, USA

Peru

Indonesia

West Manggarai/ Komodo, Indonesia

International, national, and territory/state protections currently in place for devil and manta rays

International, national, territorial, and state legal protection that restricts fishing and/or trade of a single or multiple species of devil (*Mobula* spp.) and/or manta (*Manta* spp.) ray. The term legal protection is used here to refer to protection obligation, legal or otherwise, and does not examine protection implementation success or effectiveness. The date that this legal protection was passed is included in brackets.

	Mobula eregoodootenkee	Mobula hypostoma	Mobula kuhlii	Mobula japanica	Mobula mobular	Mobula munkiana	Mobula rochebrunei	Mobula tarapacana	Mobula thurstoni	Manta alfredi	Manta birostris
International Protections											
CITES (2016)	√	√	√	√	√	√	√	√	√		
IATTC (2015)	√	√	√	√	√	√	√	√	√	√	√
European Union (2015)	√	√	√	√	√	√	√	√	√	√	
GFCM (2015)					√						
CMS Appendices I & II (2014)	√	√	√	√	√	√	√	√	√	√	
CITES Appendix II (2013)										√	√
European Union (2012)											√
CMS Appendices I & II (2011)											√
Barcelona Convention SPA/BD Protocol Annex II (2001)					√						
Bern Convention Appendix II (2001)					√						
National Protections											
Peru (2016)											√
Australia (2015)	√	√	√	√	√	√	√	√	√	√	
Indonesia (2014)										√	√
Maldives (2014)	√	√	√	√	√	√	√	√	√	√	√
United Arab Emirates (2014)										√	√
Brazil (2013)	√	√	√	√	√	√	√	√	√	√	√
Australia (2012)											√
Ecuador (2010)				√		√		√	√		√
New Zealand (2010)				√							√
Mexico (2007)		√		√		√		√	√		√
Croatia (2006)					√						
Israel (2005)	√	√	√	√	√	√	√	√	√	√	√
Malta (1999)					√						
Philippines (1998)											√
Territory and State Protections											
West Manggarai/Komodo, Indonesia Regency (2013)										√	√

Raja Ampat, Indonesia Regency (2012)	√	√	√	√	√	√	√	√	√	√	√
Guam, USA Territory (2011)	√	√	√	√	√	√	√	√	√	√	√
Christmas Island and Cocos (Keeling) Islands, Australian Indian Ocean Territories (2010)										√	√
Hawaii, USA State (2009)[1]										√	√
Yap, Federated States of Micronesia (2008)										√	√
Commonwealth of the Northern Mariana Islands, USA Territory (2007)	√	√	√	√	√	√	√	√	√	√	√
Florida, USA State (2006)	√	√	√	√	√	√	√	√	√	√	√

3   [1] A bill is currently under consideration by Hawaii's state legislature to expand protection to include all sharks and rays.

The Global Devil and Manta Ray Conservation Strategy

The complete text of the Global Devil and Manta Ray Conservation Strategy; including a vision, and a series of goals, objectives, and actions.

1 **Vision:** *Populations of devil and manta rays that flourish in resilient ocean ecosystems,*
2 *harmoniously with human communities, through knowledge, sustainability, and education*.
3
4 **Goal A:** The knowledge required to sustain devil and manta rays is generated and communicated
5 to relevant stakeholders.

Objective 1
TAXONOMY AND STOCK STRUCTURE
Taxonomy of devil and manta rays is resolved, and management units are defined.
The taxonomy of devil and manta rays is still unclear and substantial changes at the species and even genus level are expected. Defining management units will enable more focused and efficient conservation measures for these species, and show where trans-national regulations are necessary.
Actions
1.1 Produce peer-reviewed publications that resolve the species-level taxonomy of devil and manta rays to be used by the scientific and management community.
1.2 Undertake research to define management units of devil and manta ray populations on regional and global scales.
1.3 Refine a list of priority species and regions based on newly defined management units.
1.3.1 Potential priority species include *M. japanica, M. tarapacana, M. mobular.*
1.3.2 Potential priority regions include the Indo-Pacific, Mediterranean Sea, Eastern Pacific, and West Africa.

Objective 2
BIOLOGY
Productivity, life history, and demography of devil and manta rays are determined.
Information describing biological characteristics, such as annual fecundity and age at maturity are needed to fully understand the vulnerability of these species and enable prioritization of conservation and management actions.
Actions
2.1 Produce a standardized data collection methodology and a guide to facilitate mobulid biology data comparison among research groups and countries.
2.2 Define accurate biological parameters (age, growth, maximum age, and age at maturity data) for devil and manta ray populations for use in species assessments, scientific reports, and publications.
2.3 Use population data to determine the rate of natural mortality in devil and manta ray populations for integration into species assessments.

Objective 3
ECOLOGY
Spatial and temporal ecology of devil and manta rays is understood.
Ecological data are needed to inform appropriate management actions that prevent overexploitation of devil and manta rays, preserve connectivity among populations, and protect critical habitats.

Actions
3.1 Consolidate and synthesize available data to determine historic and core distributions of mobulid species, in order to aid recovery and assess potential reestablishment throughout historic ranges.
3.2 Update Extent of Occurrence and point distribution maps of the geographic distribution of devil and manta rays and disseminate this information.
3.3 Describe and define areas of critical habitat and population connectivity (by size, sex and reproductive status) including areas of core use (hot spots, aggregation sites), seasonality of presence, and migratory corridors to produce high resolution geographic outputs for publication and management actions (e.g. place-based protection).
3.4 Understand the role that diet and feeding ecology have in predicting aggregations, movement, and habitat use of devil and manta rays.
3.5 Estimate the abundance of devil and manta ray species using information collected by fisheries-independent research programs (e.g. line transect surveys, photo identification, tagging).

10

Objective 4
STRATEGIC RESEARCH AND COMMUNICATION
Scientific research on biology, ecology, status, threats, and socio-economic value of devil and manta rays to enhance conservation and management is communicated to stakeholders and to the public.
Building an improved understanding of the status and threats that face devil and manta rays among the general public, policy makers, and the conservation and management community is helpful for the implementation of national and international conservation legislation, and will engage the public to support protecting these species.
Actions
4.1 Update International Union for the Conservation of Nature (IUCN) Red List global re-assessments for mobulid species.
4.1.1 Priority species include *Mobula japanica*, *M. tarapacana*, and *M. thurstoni.*
4.2 Produce a global status summary of devil and manta ray fisheries and catches.
4.3 Translate research for the wider conservation and management community including Non-Governmental Organizations (NGOs) as well as fishers, tourism, divers, aquarists, etc. through newsletters, social, print, and traditional media outlets, as information becomes available.
4.4 Interpret research for managers and policy-makers to help inform decisions related to the protection and conservation of devil and manta ray populations as opportunities arise at key management decision points (such as CITES, CMS, Convention for Biological Diversity, RFMO meetings, local management meetings, and national biodiversity initiatives).

12 **Goal B: Devil and manta ray populations are maintained at, or recovered to, ecologically**
13 **relevant levels by managing fisheries, trade, and demand.**

Objective 5
FISHERIES ASSESSMENT AND MANAGEMENT
Devil and manta ray populations, and fisheries in which they are taken, are monitored and

managed for long-term sustainability.
Unmanaged and mostly unmonitored fisheries pose the greatest threat to devil and manta rays. Standardized data collection is needed to assess population trends and inform conservation measures to prevent overexploitation from targeted and incidental mortality.
Actions
5.1 Create incentives for government policy makers to take action on devil and manta ray conservation and management through positive international media opportunities.
5.2 Collate historical landings and market data.
5.3 Develop standardized guidelines for fisheries data collection (e.g. species identification and sizing, tissue samples, reproductive status) and monitoring (e.g. landings, discards, fishing effort, gear types).
5.3.1 Develop observer practices that are specific to devil and manta rays (e.g. tissue samples, reproductive data, size estimation, etc.).
5.3.2 Develop a multilingual identification guide/webpage/app to assist observers/customs officers/scientists/NGOs in identification, data collection, etc.
5.4 Adopt a standardized data collection system across national, state, and/or regional fisheries departments that gathers information on landings, bycatch, and discards using at-sea and landing site observer programs.
5.5 Report national species-specific landings of devil and manta rays to FAO and/or RFMOs.
5.6 Determine areas of overlap between devil and manta ray distributions and relevant fisheries to identify priority areas to minimize bycatch.
5.7 Estimate the total annual volume of devil and manta ray catch in fisheries bycatch globally, by region, and by gear type.
5.8 Develop gears and fishing practices that minimize bycatch.
5.8.1 Review handling and release procedures using different gears and develop and implement best practice procedures where they don't exist.
5.8.2 Produce education and outreach materials about safe release and handling.
5.8.3 Reduce purse seine sets in locations, during times of year, and in set types where mobulids have been identified as bycatch.
5.9 Estimate post-release mortality across various sizes, species, and gear types for devil and manta rays.
5.10 Develop stock assessment methods for devil and manta rays and coordinate the appropriate agencies, NGOs, and/or fisheries scientists to undertake assessments.
5.11 Identify and prioritize species and stocks that require assessment within each RFMO, region, and nation.
5.12 Regularly assess and report the status of devil and manta ray fisheries and estimate sustainable catch levels in each RFMO, region, and nation.
5.13 Implement and enforce protections for devil and manta rays to maintain or recover stocks to ecologically relevant levels in each RFMO, region, and nation.
5.14 Harmonize management arrangements between adjacent nations to ensure consistent assessment of shared stocks and to coordinate data collection.
5.15 Ensure that important devil and manta ray aggregation sites are protected through existing and/or revised spatial and temporal management measures in each RFMO, region, and nation.

Objective 6
TRADE REGULATION
Imports and exports of devil and manta ray products are traceable, monitored, and regulated for sustainability.
Manta rays were listed under CITES Appendix II in 2013, meaning that CITES Parties are obliged to monitor and regulate international imports and exports of manta parts, including gill plates. Supporting efforts to monitor and regulate trade is critical to identifying sources of demand and supply and preventing unsustainable levels of trade.
Actions
6.1 Enforce and implement legislation of international conservation agreements for devil and manta rays (e.g. CITES, CMS, and RFMOs).
6.2 Develop and disseminate identification guides for traded devil and manta ray products.
6.3 Ensure the adoption of customs codes for (a) CITES-listed species, and (b) gill plate products.
6.4 Develop a CITES Non-Detriment Finding (NDF) guide to support the implementation of CITES listings in key devil and manta ray fishing nations.
6.5 Produce country-of-origin standardized certificates for all gill plate exporting and importing states.
6.6 Implement port-state controls (the inspection of foreign vessels by official officers) for all range states.
6.7 Provide catch documentation for individual consignment of gill plates by issuing authorities.
6.8 Conduct market surveys at regular intervals.
6.9 Compare and confirm market survey data with trade data reported by exporters and importers.
6.10 Propose *Mobula* spp. for inclusion on Appendix II of CITES in collaboration with NGOs, scientists, and devil and manta ray range states.

Objective 7
SOCIO-ECONOMICS AND MARKETS
Demand for devil and manta ray products is reduced, and an understanding of socio-economic drivers is informing management.
Demand for devil and manta ray gill plates (*Peng Yu Sai*) has been cited as the leading driver of increased directed fisheries since the late 1990s. Reducing demand for devil and manta ray gill plates and other products including meat, cartilage, and skin will remove a strong economic incentive that is driving overexploitation of these species.
Actions
7.1 Understand the socio-economic value and landscape of consumptive uses of devil and manta rays.
7.2 Understand the socio-economic value and landscape of non-consumptive uses of devil and manta rays.
7.3 Assess the current demand for *Peng Yu Sai* and the level of consumer awareness to the threats posed by the gill plate market.

7.4 Produce a profile of the typical consumer of *Peng Yu Sai* in order to most effectively and efficiently target the demand reduction campaign.
7.5 Determine what the current marketing channels and methods for promoting use of *Peng Yu Sai* are.
7.5.1 Determine the extent of TCM practitioner involvement in recommending or marketing *Peng Yu Sai* and the opinions and attitudes of TCM practitioners regarding *Peng Yu Sai* use and efficacy.
7.6 Update 2011 assessment of *Peng Yu Sai* markets in Guangzhou, China, by collecting samples, conducting and analysing toxicology tests, and producing a report summarizing assessment results.
7.7. Produce material, media, and social media and recruit spokespeople and media partners to join a campaign that draws attention to threats posed by the gill plate market.
7.8 Conduct a follow-up assessment both directly and by third parties to measure effectiveness of the campaign using qualitative (changes in attitudes, level of awareness) and quantitative measures (evidence of reduced consumption, reduction in gill plate sales), measured against a baseline assessment.
7.8.1 Ensure ongoing monitoring of the distribution of Public Service Announcements, short films, and earned media across a variety of media delivery platforms, measured in economic value and target audiences reached.
7.8.2 Communicate with media sources for feedback regarding changes in *Peng Yu Sai* demand and trade.
7.8.3 Communicate with partners and collaborators engaged in monitoring key devil and manta ray landing sites in Indonesia and Sri Lanka for feedback regarding changes in mobulid landings, and reported changes in demand or prices from gill plate traders.

18 **Goal C: Educated and engaged communities are supporting and benefiting from devil and**
19 **manta ray conservation and management through improved livelihoods.**

OBJECTIVE 8
TOURISM
A standardized best practice approach to tourism interactions with devil and manta rays that minimizes harm is adopted and enforced by tourism operators globally.
Non-consumptive use of devil and manta rays through responsibly managed tourism can provide long-term sustainable economic benefits to coastal communities as one alternative to unsustainable fisheries. A standardized best practice guidelines for tourism operators will prevent injury and stress to the animals and environments, while making the businesses that rely on healthy devil and manta ray populations more environmentally sustainable, and ultimately, more successful.
Actions
8.1 Collate and standardize the existing best practices of devil and manta ray tourism interactions (e.g. diving, snorkelling, and watching).
8.2 Develop best practice guidelines for tourism interactions with devil and manta rays.
8.3 Secure adoption of best practice guidelines for tourism interactions with devil and manta rays by the wider tourism community.
8.5 Educate snorkelers as well as recreational and professional SCUBA divers about the

conservation and management of devil and manta rays through development and dissemination of offline and online educational tools including specialty training.

OBJECTIVE 9
COMMUNITY ENGAGEMENT
Knowledgeable communities are contributing to devil and manta ray conservation and management at the local level.
Communicating the benefits of devil and manta ray conservation and including community stakeholders in the process is essential to adoption, implementation, and enforcement of conservation and management measures.
Actions
9.1 Produce and distribute engaging and compelling media to inspire the general public in key fishing countries and globally to support devil and manta ray conservation measures.
9.2 Engage indigenous and local fishing communities in sharing of traditional ecological knowledge and cultural value (e.g. animal totems) of historical species composition, species distribution and temporal occurrence.
9.3 Create and deliver road shows, stage shows, or film events to highlight the conservation status of devil and manta rays in coastal fishing communities that are adjacent to devil and manta ray populations in priority countries (e.g. Philippines, Indonesia, Sri Lanka, and Peru).
9.4 Create interpretive material to communicate the value of devil and manta rays tourism through social media, websites, magazines, print, and television to the government, local communities, and global supporters of NGOs.
9.5 Engage tourism operators and the public to report sightings by submitting ventral photographs to an online identification database.
9.6 Translate a global identification guide for devil and manta rays into the local languages of the priority fishing nations (e.g. Peru, Philippines Indonesia, India, Mexico, and Sri Lanka).

OBJECTIVE 10
ALTERNATIVE LIVELIHOODS
People in coastal communities are engaging in occupations and subsistence activities that are not based on exploitation of devil and manta rays.
Empowering coastal communities to transition away from dependence on unsustainable fishing practices and into alternative livelihoods (e.g. sustainable fisheries, aquaculture, and tourism) is essential to the success of devil and manta ray conservation and management measures and the economic future of the communities.
Actions
10.1 Consult and work with social and climate scientists, and development agencies to identify opportunities for the development of alternative livelihoods for coastal fishing communities and work to ensure that the conservation of devil and manta rays is included in their objectives.
10.2 Identify potential markets for developing ecotourism-based alternative livelihoods in local government (e.g. tourism board and development assistance), and in sustainable tourism businesses (e.g. hotels).
10.3 Develop alternative livelihoods and income opportunities for at least five local

communities in at least five of the main devil and manta ray fishing nations (e.g. Peru, Philippines Indonesia, India, Mexico, and Sri Lanka) to diversify away from fishing for devil and manta rays.
10.4 Build capacity in local communities and among artisanal fishermen through training (business, tourism management, and sustainable fishing and aquaculture practices) and assistance with raising capital for the expenses associated with implementation.

Objective 11
DEVIL AND MANTA RAY NETWORK
Devil and manta ray experts support government and private sector bodies by encouraging, prioritizing, facilitating, integrating, and fulfilling commitments to conservation plans and regulations.
The devil and manta ray network provides an important forum for sharing and propagating conservation knowledge, generating coordinating actions, and monitoring progress.
Actions
11.1 Conduct at least one workshop for representatives of government, policy makers, and trade officials in each priority fisheries country (e.g. Peru, Philippines, Indonesia, India, Mexico, Sri Lanka, and the Gaza Strip) on the conservation status and state of devil and manta ray international trade and provide training in the identification of gill plates and species.
11.2 Connect NGOs and fishing organizations with interested scientists to develop, fund, and implement collaborative projects aimed at gaining government buy-in and building government champions.
11.2.1 Form of a coalition of contributors united toward devil and manta ray conservation with different areas of expertise (e.g. science, policy, media, community outreach) from different regions.
11.2.2 Identify and develop opportunities for collaborative, resource-effective, research and conservation programs (e.g. IUCN Specialist Groups, NGOs) with other aquatic vertebrates that share habitat and threats with devil and manta rays (e.g. cetaceans, whale sharks and other elasmobranchs).
11.2.4 Coordinate comments, speaking opportunities, and advocacy around key government decision meetings.
11.3 Commit to ongoing engagement by NGOs and scientists to articulate and promote devil and manta ray conservation plan goals to governments.
11.3.1 Engage in regular contact and discussion with key government officials.
11.3.2 Attend national and/or RFMO science, bycatch, and/or ecosystem committee meetings.
11.3.3 Prepare written comments to national fisheries and/or environment government leads and/or RFMO chairs.
11.3.4 Serve on government delegations to key decision meetings including CITES and CMS Conferences of Parties and RFMO annual meetings.
11.3.5 Participate in targeted side events at key meetings to bring together various interests toward a common goal.
11.4 IUCN SSG and partners review progress and revise actions under the Global Devil

and Manta Ray Conservation Strategy every three years.
11.5 Ensure a continued stream of financial resources to ensure timely implementation of the Actions included in this Global Devil and Manta Ray Conservation Strategy.