

1 **Extinction risk, reconstructed catches, and management of chondrichthyan fishes in the**  
2 **Western Central Atlantic Ocean**

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## 73 **ABSTRACT**

74 Chondrichthyan fishes are among the most threatened vertebrates on the planet because  
75 many species have slow life histories that are outpaced by intense fishing. The Western Central  
76 Atlantic Ocean, which includes the greater Caribbean, is a hotspot of chondrichthyan  
77 biodiversity and abundance, but is historically characterized by extensive shark and ray fisheries  
78 and a lack of sufficient data for effective management and conservation. To inform future  
79 research and management decisions, we analyzed patterns in chondrichthyan extinction risk,  
80 reconstructed catches, and regulations in this region. We summarized the extinction risk of 180  
81 sharks, rays, and chimaeras using contemporary IUCN Red List assessments and found that over  
82 one-third (35.6%) were assessed as Vulnerable, Endangered, or Critically Endangered largely  
83 due to fishing. Reconstructed catches from 1950 to 2016 reached their peak in 1992, then  
84 declined by 40.2% through the end of the series. The United States, Venezuela, and Mexico were  
85 responsible for most catches and hosted large proportions of the regional distributions of  
86 threatened species; these countries therefore held the greatest responsibility for chondrichthyan  
87 management. The abundance and resolution of fisheries landings data were poor in much of the  
88 region, and national-level regulations varied widely across jurisdictions. Deepwater fisheries  
89 represent an emerging threat, although many deepwater chondrichthyans currently find refuge  
90 beyond the depths of most fisheries. Regional collaboration as well as effective and enforceable  
91 management informed by more complete fisheries data, particularly from small-scale fisheries,  
92 are required to protect and recover threatened species and ensure sustainable fisheries.

## 93 **KEYWORDS**

94 Fisheries, IUCN Red List, marine policy, rays, sharks, threats

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## 99 1. INTRODUCTION

100 Fishing has outpaced the slow life histories of many sharks and their relatives (class  
101 Chondrichthyes, hereafter 'sharks and rays'; Cortés, 2000; Worm et al., 2013) and has led to an  
102 estimated one-third (37.5%) of sharks and rays being threatened with extinction (Dulvy et al.,  
103 2021a). Oceanic sharks and rays present a striking example; between 1970 and 2018, an 18-fold  
104 increase in relative fishing pressure reduced their global abundance by 71% (Pacoureaux et al.,  
105 2021). Sharks inhabiting coral reefs are similarly threatened, with fishing likely responsible for  
106 sharks being absent from almost 20% of reefs surveyed globally (MacNeil et al., 2020). The  
107 depletion of shark and ray populations could lead to ecosystem-level consequences (Burkholder  
108 et al., 2013; Estes et al., 2016; Ferretti et al., 2010) because many of these fishes are apex or  
109 mesopredators that range widely and may affect ecosystem processes through predation and  
110 associated risk effects, competition, nutrient transport, and bioturbation (Flowers et al., 2021;  
111 Heithaus et al., 2008, 2010; Heupel et al., 2014).

112 Increased concern for fisheries impacts on sharks and rays in recent decades gave rise to  
113 numerous initiatives developed to stem or reverse population declines at the national and  
114 international level (Shiffman & Hammerschlag, 2016). In 1991, for example, the International  
115 Union for Conservation of Nature (IUCN) Species Survival Commission (SSC) Shark Specialist  
116 Group (SSG) was founded to promote the sustainable use and conservation of sharks and rays  
117 (Fowler et al., 2005), and, in 1993, the United States implemented its Fishery Management Plan  
118 for sharks in the Atlantic Ocean (NMFS, 1993). Additionally, in the late 1990s, the United  
119 Nations (UN) Food and Agriculture Organization (FAO) developed the International Plan of  
120 Action for Conservation and Management of Sharks (IPOA–Sharks), which recommended  
121 countries create and implement their own National Plans of Action for sharks and rays (NPOA–  
122 Sharks; FAO, 1999). Other management measures (e.g., trade restrictions) were introduced over  
123 the next twenty years, but their full implementation is a challenge (Lawson & Fordham, 2018),  
124 and their effectiveness remains to be demonstrated on a global scale (Davidson et al., 2016).

125 In the wider Caribbean, robust shark and ray management is lacking (Davidson et al.,  
126 2016; Fowler et al., 2005), and any existing management has been described as a patchwork of  
127 inconsistent measures (Kyne et al., 2012). Further, the wider Caribbean was recently one of the  
128 most data-deficient regions for sharks and rays in the world (Dulvy et al., 2014). According to

129 the IUCN Red List of Threatened Species (hereafter ‘IUCN Red List’) in 2012, nearly half  
130 (47%) of the region’s shark and ray species were assessed as Data Deficient and nearly one in  
131 five (19%) were assessed in a threatened category, primarily due to overfishing (Kyne et al.,  
132 2012). Some historical accounts and archaeological data suggest that fishing had depleted large  
133 marine vertebrates in the Caribbean even before modern fishing technology and scientific  
134 research expanded in the mid-1900s (Jackson et al., 2001; McClenachan et al., 2006; Wing &  
135 Wing, 2001), although these conclusions are debated (e.g., see Baisre, 2010; McClenachan et al.,  
136 2010). As recently as the 1950s, however, sharks were still described as highly abundant (Viele,  
137 1996; Ward-Paige et al., 2010), possibly illustrating the ‘shifting baselines’ concept (Pauly,  
138 1995).

139 Contemporary trends in shark abundance in the wider Caribbean have been derived from  
140 time-series catch data from fisheries-independent surveys and United States-based fisheries  
141 (including the pelagic longline fleet that covers much of the Caribbean). These data suggest  
142 declines in the abundance or size of some coastal (Cortés et al., 2002; Hayes et al., 2009;  
143 McClenachan, 2009) and oceanic sharks (Baum & Blanchard, 2010; Cortés et al., 2007; Jiao et  
144 al., 2009), particularly following intense fishing in the 1980s (Bonfil, 1997; Castro, 2013;  
145 Musick et al., 1993). The magnitudes of some widely-reported declines in the region’s shark  
146 abundance are debated (see Baum et al., 2003; Baum and Myers, 2004; Burgess et al., 2005).  
147 Fisher surveys (Graham, 2007) and spatial variation in relative abundance also suggest fishing  
148 caused declines in some coastal shark populations – abundance is often highest in heavily  
149 managed exclusive economic zones (EEZs; MacNeil et al., 2020), marine reserves (Bond et al.,  
150 2012; MacNeil et al., 2020), shark sanctuaries (Clementi et al., 2021), and remote areas far from  
151 human population centers (Ward-Paige et al., 2010). There are, however, signs of recent stability  
152 and/or recovery in some better-studied shark populations in the United States (Carlson et al.,  
153 2012; Peterson et al., 2017), The Bahamas (Hansell et al., 2018; Talwar et al., 2020), and Belize  
154 (Bond et al., 2017), largely due to targeted management that began in the 1990s (Castro, 2013;  
155 Ward-Paige, 2017). Otherwise, a lack of data has challenged the assessment of shark population  
156 trends.

157 Ray (superorder Batoidea) population trends are poorly known in the wider Caribbean and,  
158 for coastal species, trends vary spatially. Precipitous declines in sawfish (Pristidae) abundance  
159 are well documented across the entire region, for example (Bonfil et al., 2017; Fernandez-

160 Carvalho et al., 2014; Thorson, 1982), but at least one highly managed, well-studied population  
161 of Smalltooth Sawfish (*Pristis pectinata*, Pristidae) is stable and likely recovering in the United  
162 States (Brame et al., 2019). Diver observations from 1994 to 2007 suggest that Yellow Stingray  
163 (*Urobatis jamaicensis*, Urotrygonidae) abundance declined on coral reefs but increased in some  
164 areas where predator populations were overfished (e.g., Jamaica; Ward-Paige et al., 2011).  
165 Important ray (and shark) habitats such as coral reef, seagrass, and mangrove ecosystems (White  
166 & Sommerville, 2010) have also been degraded in the wider Caribbean (Jackson et al., 2014;  
167 Polidoro et al., 2010; Waycott et al., 2009), which can lead to range contractions and increased  
168 extinction risk (Yan et al., 2021).

169 Chimaera (i.e., ghost shark, order Chimaeriformes) population trends are unknown in the  
170 wider Caribbean, but chimaeras typically reside offshore, are caught as bycatch, and have little  
171 commercial value (Finucci et al., 2021). Globally, their contribution to total chondrichthyan  
172 catch is very low (Dulvy et al., 2014). Further, chimaeras primarily reside at depths beyond the  
173 maximum depth of most Caribbean fisheries (Finucci et al., 2021). Their populations, along with  
174 the populations of deepwater sharks and rays, are probably stable as a result (Dulvy et al., 2014),  
175 but remain understudied.

176 Recently, there have been efforts to reduce data deficiency and improve management for  
177 sharks and rays in the region. In 2017, the FAO Western Central Atlantic Fishery Commission  
178 (WECAFC), a regional fisheries advisory body that hosts members that fish or are located in  
179 FAO Major Fishing Area 31 (Western Central Atlantic, ‘WCA’) and the northern part of FAO  
180 Major Fishing Area 41 (Southwest Atlantic), convened the first meeting of the working group on  
181 shark and ray conservation and management. The working group highlighted the need to  
182 coordinate national and regional management and made several specific recommendations  
183 regarding shark and ray fisheries (WECAFC, 2018). It also reviewed a Regional Plan of Action  
184 (RPOA–Sharks), a regionally tailored version of the IPOA–Sharks meant to facilitate  
185 collaboration in research, data collection, and management. Formal adoption of the RPOA–  
186 Sharks was intended for early 2020 (WECAFC, 2019), but it remains in draft form at the time of  
187 this writing.

188 To inform future research and upcoming management decisions, we summarize updated  
189 global assessments of shark and ray extinction risk for species found in the WCA using data



190 from the IUCN SSC SSG's Global Shark Trends Project (Kyne et al., 2020; Dulvy et al., 2021a).  
191 We analyze extinction risk according to taxonomy, maximum depth of occurrence, and trophic  
192 position. We then examine key threats, particularly fishing, and review current shark and ray  
193 management at the international and country (states and territories) level.

194

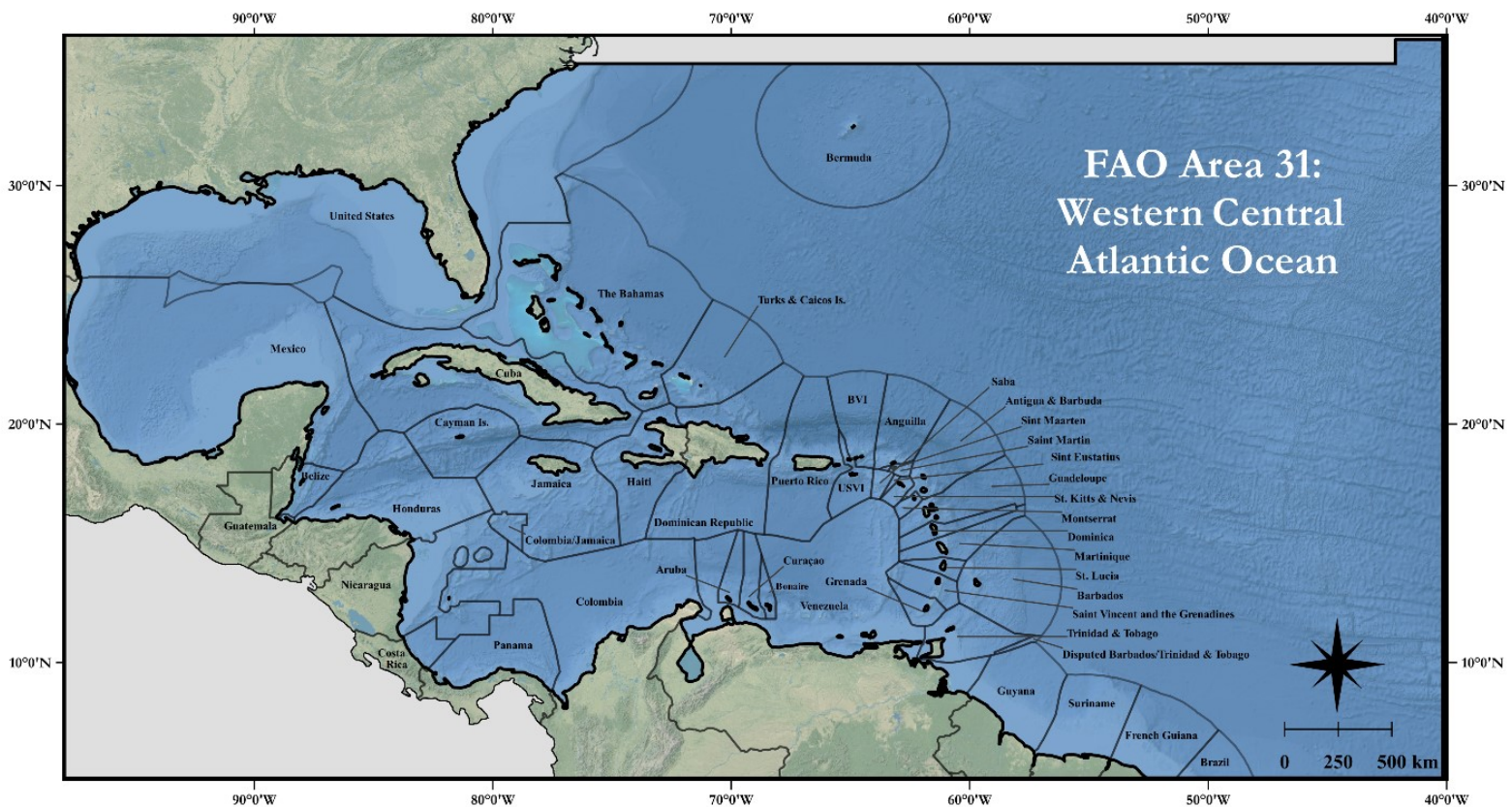
## 195 **2. MATERIALS AND METHODS**

### 196 **2.1 Application of the IUCN Red List Categories and Criteria**

197 Twenty regional experts and members of the IUCN SSC SSG met for five days at the  
198 Cape Eleuthera Institute in Eleuthera, The Bahamas in June 2019. The IUCN Red List  
199 Categories and Criteria (Version 3.1) were applied to 113 species of sharks and rays following  
200 the Guidelines for Using the IUCN Red List Categories and Criteria (IUCN, 2012; IUCN  
201 Standards and Petitions Subcommittee, 2019). Assessments were conducted at the global level  
202 (i.e., for the entire global population of each species). Data were collated on the taxonomy,  
203 distribution, population status, habitat and ecology, major threats, use and trade, and  
204 conservation measures for each species from peer-reviewed literature, fisheries statistics, grey  
205 literature, and consultation with species and fisheries experts. For details on each of the eight  
206 IUCN Red List Categories and the five Criteria used to assess each category of extinction risk,  
207 see Mace et al. (2008), IUCN (2012), and IUCN Standards and Petitions Subcommittee (2019).  
208 Briefly, a species is Extinct (EX) when no individuals remain alive and Extinct in the Wild (EW)  
209 when it only survives in captivity or in naturalized populations outside its previous range.  
210 Critically Endangered (CR) species face an *extremely high risk* of extinction in the wild,  
211 Endangered (EN) species face a *very high risk* of extinction in the wild, and Vulnerable (VU)  
212 species face a *high risk* of extinction in the wild. These CR, EN, and VU species are considered  
213 threatened. Near Threatened (NT) species are close to qualifying or are likely to qualify for a  
214 threatened category in the future, and Least Concern (LC) species are widespread or abundant  
215 taxa not currently qualifying for, nor close to qualifying for, a threatened category. Data  
216 Deficient (DD) species lack sufficient information on either their distribution or population status  
217 to adequately assess their extinction risk, and could potentially be LC, CR, or any Category in-  
218 between.

219 Draft assessments were prepared in the IUCN Species Information Service online  
220 database, then reviews were solicited from at least two experts trained in applying the IUCN Red  
221 List Categories and Criteria with knowledge of the species and fisheries at hand. A summary of  
222 the assessments was also provided to the entire IUCN SSC SSG (174 members) for their consult  
223 and input prior to submission to the IUCN Red List Unit (Cambridge, UK) for further review and  
224 quality checks. Assessments were then published on the IUCN Red List (version 2021-1,  
225 [www.iucnredlist.org](http://www.iucnredlist.org); IUCN, 2021; see Data S3, Dulvy et al., 2021a). The assessments drafted at  
226 this workshop made up the majority of those included in this study; the remainder were  
227 conducted in the same manner at workshops elsewhere (e.g., oceanic species were assessed  
228 during a 2018 workshop in Dallas, Texas in the southern United States).

## 229 2.2 Geographic & taxonomic scope



230  
231 **Figure 1:** Map of United Nations Food and Agriculture Organization (FAO) Major Fishing  
232 Area 31 in the Western Central Atlantic Ocean. National boundaries (Flanders Marine Institute,  
233 2019) are in dark grey and other FAO Areas are shaded grey. Map base layer source: Esri®



234 The WCA extends from the eastern coast of French Guiana (5°00'N latitude) to the  
235 southeastern coast of the United States (36°00'N latitude). It includes the Atlantic Ocean, Gulf of  
236 Mexico, and Caribbean Sea from the east coast of North, Central, and South America to  
237 40°00'W longitude (Figure 1; FAO, 2021). It includes waters attributed to 13 continental states,  
238 13 island states, and over 20 territories (associated with Colombia, France, the Netherlands,  
239 United Kingdom, and United States), encompassing 14.6 million km<sup>2</sup>.

240 We included all marine chondrichthyans assessed on the IUCN Red List that occur in the  
241 WCA, including residents and migrants. We excluded freshwater chondrichthyans because their  
242 fisheries and management are separate from marine fishes and focused our narrative less on  
243 chimaeras and oceanic sharks than other groups because they were evaluated in recent  
244 publications (Finucci et al., 2021; Pacoureau et al., 2021). We used the nomenclature and  
245 authorities listed in the online Catalog of Fishes (Eschmeyer et al., 2017) and revisions of *Sharks*  
246 *of the World* (Ebert et al., 2013, 2021) for sharks and chimaeras and *Rays of the World* (Last et  
247 al., 2016) for rays. We used only global assessments, all of which were available online  
248 ([www.iucnredlist.org](http://www.iucnredlist.org); IUCN, 2021). This review therefore reports the global status of species  
249 occurring in the WCA rather than a region-specific assessment, although we note that the  
250 assessments of endemic species are limited to the WCA.

### 251 **2.3 Analyzing habitat, trophic level, and threat data**

252 We coded each species according to the IUCN Major Threats and Habitats Classification  
253 Schemes ([http://www.iucnredlist.org/technical-documents/classification-schemes/habitats-](http://www.iucnredlist.org/technical-documents/classification-schemes/habitats-classification-scheme-ver3)  
254 [classification-scheme-ver3](http://www.iucnredlist.org/technical-documents/classification-schemes/habitats-classification-scheme-ver3) and [http://www.iucnredlist.org/technical-documents/classification-](http://www.iucnredlist.org/technical-documents/classification-schemes/threats-classification-scheme)  
255 [schemes/threats-classification-scheme](http://www.iucnredlist.org/technical-documents/classification-schemes/threats-classification-scheme)) (Salafsky et al., 2008). Species were assigned to one or  
256 more of the following habitat classifications: deep benthic, oceanic, neritic, wetlands, intertidal,  
257 and coastal/supratidal according to their known depth distribution. We extracted the maximum  
258 depth of each species' depth distribution from the IUCN Red List assessments and compared it  
259 across categories of extinction risk. We also extracted trophic level estimates from FishBase  
260 (Froese & Pauly, 2021) for each species, then compared trophic levels across categories of  
261 extinction risk. We attempted to analyze these data with linear models, but model residuals failed  
262 the Shapiro-Wilk test of normality even after data transformation, so we used a non-parametric  
263 Kruskal-Wallis test and a post-hoc Dunn's test to detect differences in both cases. We accounted

264 for multiple comparisons by adjusting p-values using the Benjamini-Hochberg method. Lastly,  
265 we coded threats to each species as either present or absent and summarized those threats for all  
266 species and then for threatened species only.

## 267 **2.4 Species distributions and conservation responsibility**

268 We mapped the distribution of chondrichthyans in the WCA using IUCN Red List species  
269 distribution shapefiles that were built according to taxonomic records summarized in FAO  
270 species catalogues (see Dulvy et al., 2014; Dulvy et al., 2021a), *Rays of the World* (Last et al.,  
271 2016), revisions of *Sharks of the World* (Ebert et al., 2013, 2021), and recent capture data, expert  
272 input, and species checklists (e.g., Mejía-Falla et al., 2019; Tavares, 2019; Weigmann, 2016).  
273 Ranges were clipped to the minimum and maximum depth of each species. We set the maximum  
274 depth for species without a known depth range to the maximum confirmed depth of the family.  
275 We produced a species richness map for all sharks and rays by counting the number of polygons  
276 where species distribution maps overlapped. We then used natural neighbor interpolation to  
277 interpolate between counts and clipped the output to exclude land. Due to imperfections in the  
278 underlying data, these counts should be interpreted for broadscale patterns only. Maps were  
279 created with QGIS3 ([www.qgis.org](http://www.qgis.org)).

280 We estimated jurisdiction-specific conservation responsibility (CoR) to highlight the  
281 jurisdictions with the greatest responsibility for conserving globally threatened sharks and rays  
282 within the WCA as follows: we assigned threat scores to each species according to their  
283 extinction risk, where LC was assigned a zero, NT a one, VU a two, EN a three, and CR a four.  
284 No species were assessed as EX or EW. For each jurisdiction (including all countries as well as  
285 international waters), we multiplied the threat score of every species present by its proportional  
286 range within the WCA in that jurisdiction (Kyne et al., 2020; Rodrigues et al., 2014). We took  
287 the sum of those values for each jurisdiction to calculate raw CoR values, then normalized them  
288 from 0 to 1 to compare CoR across jurisdictions (where a 1 was assigned to the country with the  
289 highest CoR). We then produced a map displaying CoR using Jenks natural breaks classification,  
290 which reduces within-class variance and maximizes between-class variance.

## 291 **2.5 Reconstructed fisheries catch data**

292 We extracted reconstructed catch data from the Sea Around Us Project database  
293 ([www.seaaroundus.org](http://www.seaaroundus.org)) to examine trends in shark and ray catches from 1950 to 2016 (Pauly et

294 al., 2020). The Sea Around Us database provides estimates of unreported catches (e.g., discards,  
295 subsistence, recreational, and small-scale catches) combined with official figures reported by  
296 member countries to the UN FAO (Zeller et al., 2016). We used data for the functional groups  
297 ‘small to medium sharks  $\leq 90$  cm’, ‘large sharks  $\geq 90$  cm’, ‘small to medium rays  $\leq 90$  cm’, and  
298 ‘large rays  $\geq 90$  cm’ within FAO Area 31 only and then examined patterns in catches over time  
299 by fishing entity (i.e., country) and taxonomy (Pauly & Zeller, 2015). Many countries in the  
300 WCA have EEZs that extend beyond FAO Area 31, but we did not include catches from those  
301 areas (e.g., southern Brazil or the Pacific coast of Central American countries). We did include  
302 catches from foreign fleets (e.g., Spain) that occurred in the area.

## 303 2.6 Management

304 We collated the most recent stock assessment results for sharks and rays in the WCA from  
305 the International Commission for the Conservation of Atlantic Tunas (ICCAT;  
306 [https://www.iccat.int/Documents/Meetings/Docs/2017\\_SCRS\\_REP\\_ENG.pdf](https://www.iccat.int/Documents/Meetings/Docs/2017_SCRS_REP_ENG.pdf)) and the United  
307 States’ National Oceanic and Atmospheric Administration  
308 (<https://www.fisheries.noaa.gov/national/population-assessments/fishery-stock-status-updates>).  
309 Assessments indicate a status of ‘overfishing’, ‘overfished’, or ‘unknown’, where overfishing  
310 refers to fishing mortality or total catch compromising a stock’s capacity to continuously  
311 produce maximum sustainable yield, overfished refers to a stock having a low population size  
312 that threatens its ability to reach maximum sustainable yield, and unknown refers to a stock that  
313 lacks definitions of overfishing and/or overfished or lacks the data to make a determination.

314 We estimated jurisdiction-specific Chondrichthyan Management Responsibility (CMR) to  
315 reconcile CoR with historical shark and ray fishing and current shark and ray management. The  
316 holistic CMR can identify countries that are responsible for high catches of threatened species  
317 while rewarding for management in an attempt to highlight 1) countries that may have a high  
318 CoR but very low historical catches of sharks and rays and therefore perceive no need for robust  
319 management, and 2) countries that may have no modern fisheries for sharks and rays because  
320 previous fishing already depleted local populations, leading to limited management where it is  
321 urgently required. We calculated CMR using the equation:

322 **Eq 1:** *Chondrichthyan Management Responsibility* = 
$$\frac{\text{Catch-weighted CoR}}{\text{Management Engagement}}$$

323 where 1) catch-weighted CoR is a country's raw CoR (non-normalized) multiplied by its total  
324 reconstructed catch (metric tons; mt) of sharks and rays from 1950 to 2016, and 2) Management  
325 Engagement (ME) is a country's percent engagement (0 to 100%) with thirteen management  
326 tools (assigned present or absent). These tools were the following:

- 327 • Fishing and Finning (3 tools): a ban on shark fishing; a ban on ray fishing; a ban on  
328 finning (e.g., a requirement to land fins with associated carcasses or naturally attached)
- 329 • UN FAO Plans (2 tools): NPOA–Sharks or RPOA–Sharks, UN FAO National or  
330 Regional Plan of Action to Prevent, Deter and Eliminate Illegal, Unreported and  
331 Unregulated (IUU) Fishing (NPOA–IUU or RPOA–IUU)
- 332 • Other Regulations (1 tool): a single category that included time/area closures, a ban on  
333 exports or imports of shark or ray products, species-specific measures, or gear restrictions  
334 relevant to sharks and rays
- 335 • Party / Signatory / Cooperator to (7 tools): WECAFC; ICCAT; Convention on  
336 International Trade in Endangered Species of Wild Flora and Fauna (CITES);  
337 Convention on the Conservation of Migratory Species of Wild Animals (CMS); CMS  
338 Memorandum of Understanding – Sharks (CMS MOU – Sharks); Protocol for Specially  
339 Protected Areas and Wildlife (SPAW) to the Convention for the Protection and  
340 Development of the Marine Environment of the Wider Caribbean Region; Port State  
341 Measures to Prevent, Deter and Eliminate Illegal, Unreported and Unregulated Fishing  
342 (PSM).

343 We collected this information by searching the scientific and grey literature, UN FAO  
344 documents, and news sources. We relied largely on summaries in other reports (Baker-Médard &  
345 Faber, 2020; WECAFC, 2018; Koubrak et al., 2021; Kyne et al., 2012; Ward-Paige, 2017; Ward-  
346 Paige & Worm, 2017). Where a country's status was unclear or incomplete, we contacted in-  
347 country representatives for additional information. In few cases, all parties involved were unsure  
348 of the status of a country relative to a management tool, in which case we used our best  
349 judgement in assigning status. Thus, this summary represents our best effort at collating these  
350 data, but it may contain errors, particularly where complex overlap occurs between island,  
351 national, and international jurisdictions (e.g., Kingdom of the Netherlands). We note that these

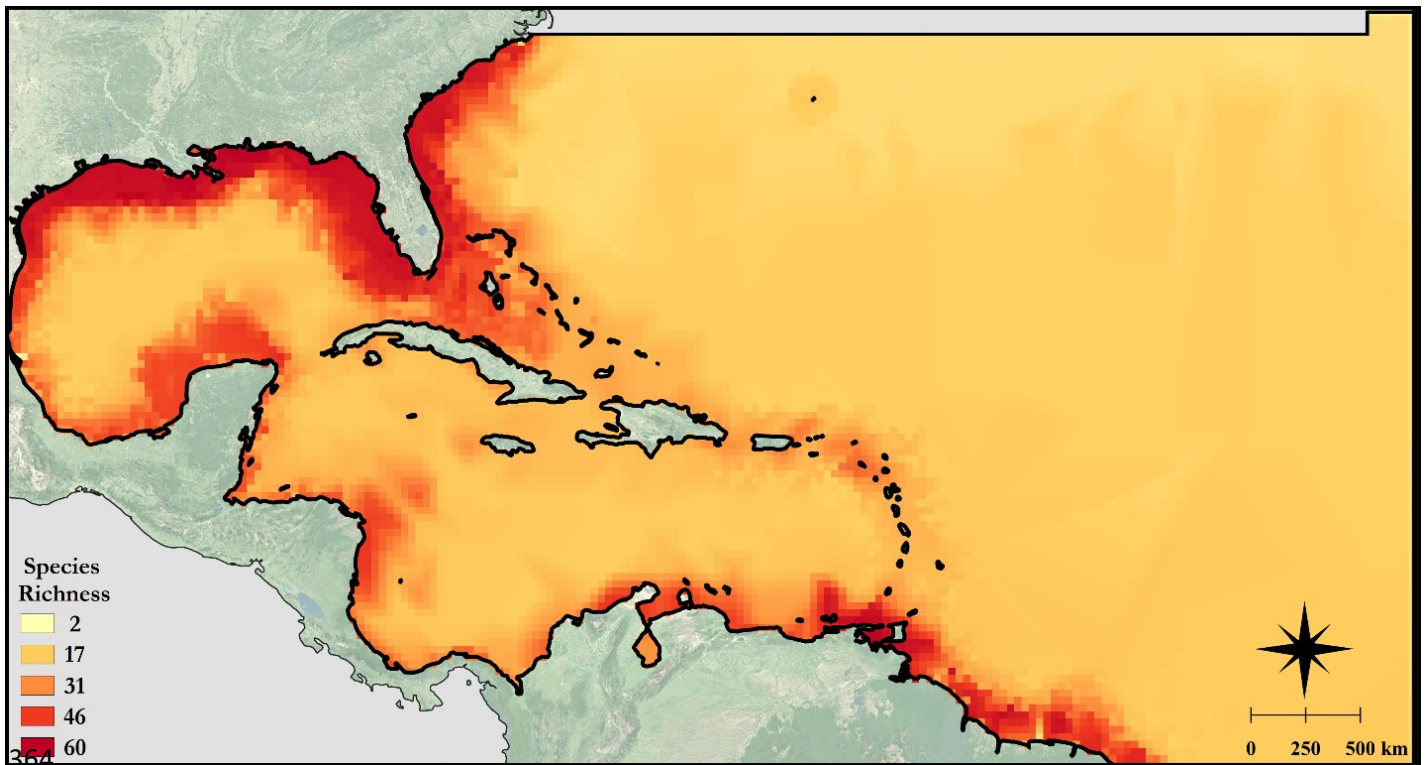
352 13 management tools are not equivalent, and, in some cases, their presence could lead to  
353 unintended negative consequences (Castellanos-Galindo et al., 2021).

354 We omitted jurisdictions where the underlying data structure did not align across CMR  
355 components (e.g., where reconstructed catch data were unavailable) except in the case of Saint  
356 Martin, St. Barthelemy, and Sint Maarten, which we grouped. We used the mean of their ME and  
357 the sums of their CoR and reconstructed catches in this calculation. We then normalized CMR  
358 from 0 to 1 for ease of interpretation, where the larger the CMR, the more *unmitigated* risk and  
359 responsibility. We also used linear regression to analyze the relationships between CMR  
360 components, where a p-value < 0.05 was considered significant.

361

### 362 3. RESULTS

#### 363 3.1 Species diversity



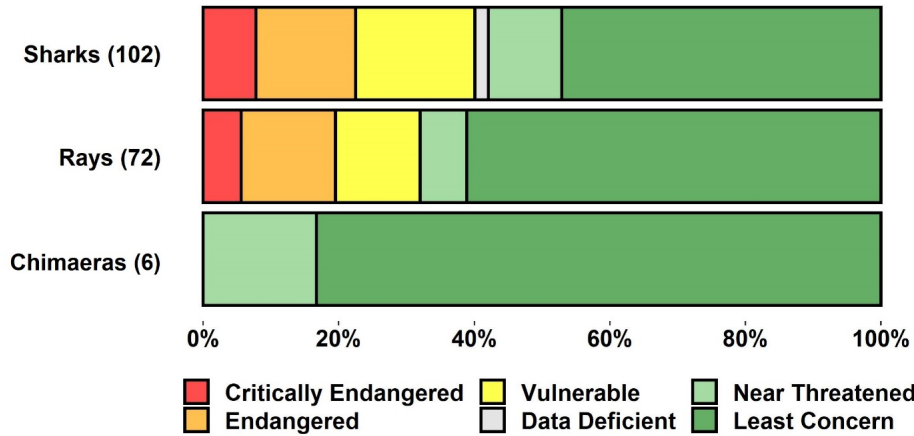
365 **Figure 2:** Chondrichthyan species richness in the Western Central Atlantic Ocean based on  
366 species distribution maps from the IUCN Red List database (IUCN, 2021). Pixel size is roughly  
367 1025 km<sup>2</sup>. Areas outside of United Nations Food and Agriculture Organization Major Fishing  
368 Area 31 are shaded grey. Map base layer source: Esri®



369 We identified 180 assessed shark and ray species in the WCA, which represent 15% of the  
370 1,199 species assessed in the Global Shark Trends Project (Dulvy et al., 2021a). This included  
371 102 sharks, 72 rays, and 6 chimaeras from 12 orders, 46 families, and 83 genera (Table S1). We  
372 identified 66 endemic species (36.7% of all species) and 14 near-endemic species (where a small  
373 portion of the species' range extended into another FAO Area; 7.8% of all species). Species  
374 richness was highest along the continental margins of North and South America and lowest in  
375 oceanic waters (Figure 2). The neritic assemblage was dominated by carcharhiniforms and  
376 myliobatiforms (60.4%;  $n = 58$  of 96), the oceanic assemblage was dominated by squaliforms  
377 and carcharhiniforms (61.4%;  $n = 35$  of 57), and the deep slope was dominated by rajiforms and  
378 squaliforms (58.4%;  $n = 59$  of 101).

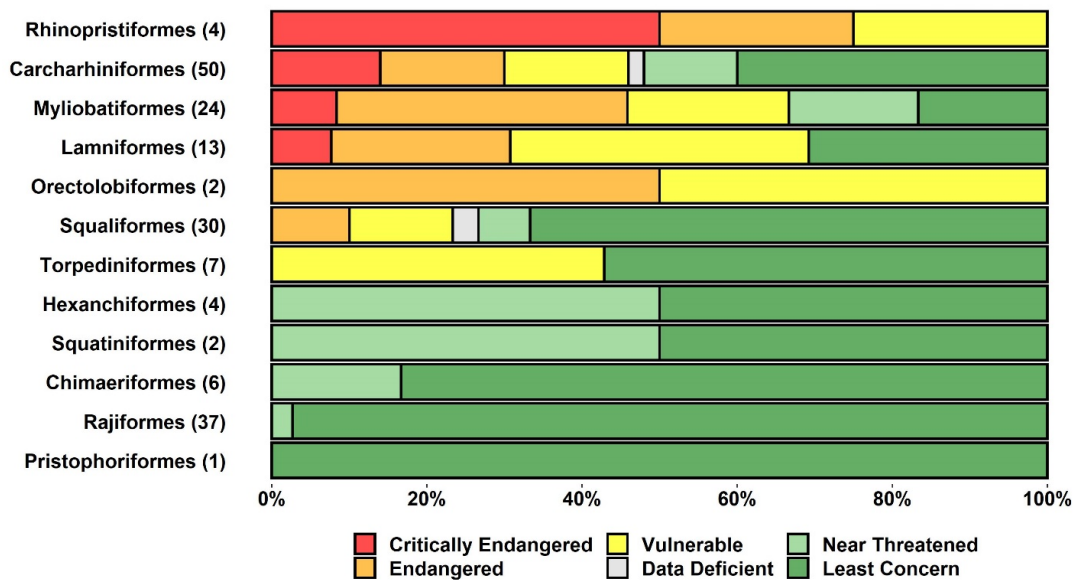
### 379 **3.2 Extinction risk: descriptive patterns in taxonomy, habitat associations, and trophic** 380 **level**

381 Over one-third (35.6%,  $n = 64$  of 180) of all shark and ray species in the WCA were  
382 threatened with an elevated risk of extinction (Table 1). Twelve species (6.7%) were Critically  
383 Endangered, 25 species (13.9%) were Endangered, and 27 species (15%) were Vulnerable.  
384 Seventeen (9.4%) were Near Threatened, over half (53.9%,  $n = 97$ ) of all species were Least  
385 Concern, and two (1.1%) species were Data Deficient (Roughskin Spurdog (*Cirrhigaleus asper*,  
386 Squalidae) and Carolina Hammerhead (*Sphyrna gilberti*, Sphyrnidae)). All threatened species  
387 met Criterion A ('population reduction measured over the longer of ten years or three  
388 generations') and sub-criterion A2 ('population reduction observed, estimated, inferred, or  
389 suspected in the past where the causes of reduction may not have ceased or may not be  
390 understood or may not be reversible'; IUCN, 2012). All NT species nearly met these same  
391 criteria. Either sub-criterion A2b (population reduction based on 'an index of abundance  
392 appropriate to the taxon') or A2d (population reduction based on 'actual or potential levels of  
393 exploitation'; IUCN, 2012) was also cited in each of these assessments. No species met Criterion  
394 B (limited geographic range), Criterion C (small population size and decline), Criterion D (very  
395 small or restricted population), or Criterion E (quantitative analysis indicating a probability of  
396 extinction in the wild exceeding certain thresholds in the future). Out of 180 assessed species,  
397 around half (48.9%,  $n = 88$ ) had a decreasing population trend, 8 (4.4%) had an increasing  
398 population trend, 70 (38.9%) were listed as stable, and 14 (7.8%) had an unknown population  
399 trend.



400

401 **Figure 3:** Percentage of sharks, rays, and chimaeras found in the Western Central Atlantic in  
 402 each IUCN Red List of Threatened Species category. The number of species in each group  
 403 appears in parentheses

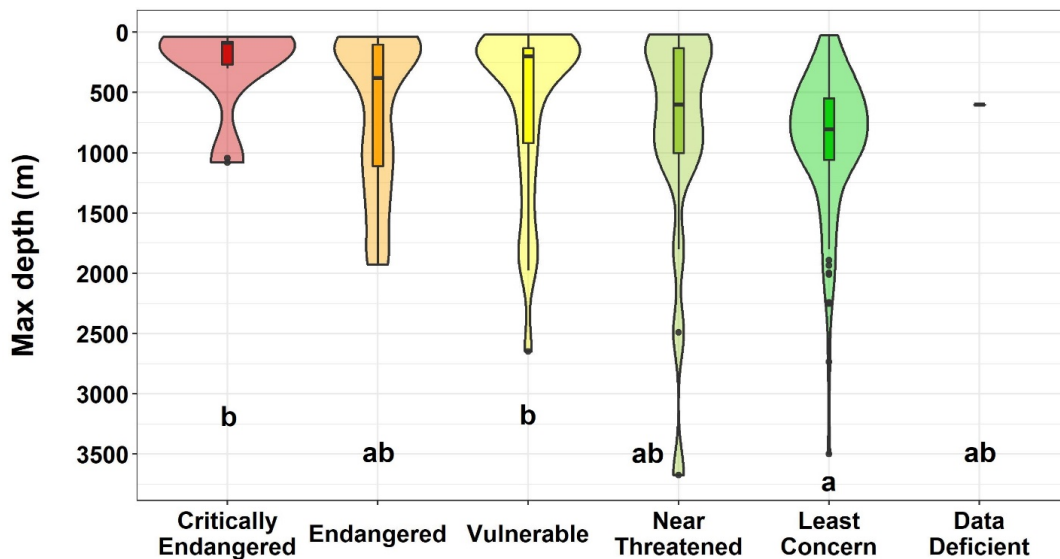


404

405 **Figure 4:** Percentage of each chondrichthyan order found in the Western Central Atlantic by  
 406 IUCN Red List of Threatened Species category. The number of species in each order appears in  
 407 parentheses

408 Contrary to the global trend (Dulvy et al., 2021a), sharks were more threatened than rays in  
 409 the WCA, with 40.2% ( $n = 41$ ) of sharks and nearly one-third of rays (31.9%,  $n = 23$ ) threatened  
 410 with extinction (Figure 3). Seven (58.3%) of the twelve orders included at least one threatened  
 411 species (Figure 4). All species in Rhinopristiformes (100%,  $n = 4$ ) and Orectolobiformes (100%,

412  $n = 2$ ) were threatened. Over two-thirds of species in Lamniformes (69.2%,  $n = 9$ ) and  
413 Myliobatiformes (66.7%,  $n = 16$ ) were threatened. Nearly half (46%,  $n = 23$ ) of the species in  
414 Carcharhiniformes, the most speciose order in the WCA, were threatened. Notably, the second  
415 most speciose order, Rajiformes, included no threatened species. Of the 45 families in the region,  
416 25 (55.6%) included at least one species in a threatened category.



417

418 **Figure 5:** Violin plot of maximum depths of occurrence for all chondrichthyans found in the  
419 Western Central Atlantic by IUCN Red List of Threatened Species category. Each dot represents  
420 an outlier, horizontal black lines indicate the median, and boxes indicate the interquartile range.  
421 Letters represent results of Dunns' post hoc tests for differences in maximum depth between  
422 extinction risk categories, where those sharing the same letter are not significantly different

423 Sixteen families included only species assessed as LC. Nearly all (95.7%,  $n = 22$ ) species in  
424 Rajidae, the most speciose family in the region, were LC. Most (80.4%,  $n = 78$ ) species assessed  
425 as LC were associated with depth ranges deeper than 200 m; only 11.9% ( $n = 12$  of 101) of  
426 species found deeper than 200 m were threatened, and of those the majority (58.3%,  $n = 7$  of 12)  
427 were assessed as VU. Extinction risk varied with depth (Kruskal-Wallis  $\chi^2 = 21.06$ ,  $df = 5$ ,  $p <$   
428  $0.05$ ), where the maximum depth of LC species ( $906 \pm 588$  m; mean  $\pm$  SD) was significantly  
429 greater than the maximum depth of CR ( $289 \pm 390$  m; mean  $\pm$  SD;  $z = -3.63$ ,  $p < 0.05$ ) and VU  
430 species ( $613 \pm 729$  m; mean  $\pm$  SD;  $z = 2.98$ ,  $p < 0.05$ ; Figure 5). Further, of 78 species with an  
431 increasing or stable population trend, 83.3% ( $n = 65$  of 78) were associated with the 'marine

432 deep benthic' habitat type. There were no differences in trophic levels reported in FishBase  
433 among extinction risk categories (Kruskal-Wallis  $\chi^2 = 6.82$ ,  $df = 5$ ,  $p = 0.23$ ).

### 434 3.3 Endemicity & risk

435 Of the 66 assessed species endemic to the WCA, 26 were sharks, 36 were rays, and 4 were  
436 chimaeras. The top three orders by number of endemic species were Rajiformes ( $n = 29$ ),  
437 Carcharhiniformes ( $n = 15$ ), and Squaliformes ( $n = 8$ ). Two-thirds of the chimaeras in the WCA  
438 (66.6%;  $n = 4$  of 6) were endemic.

439 No endemic species were assessed as DD. Eighty-nine percent ( $n = 59$  of 66) of endemic  
440 species were assessed as LC, and 4.5% ( $n = 3$  of 66) were assessed as NT. Among sharks, many  
441 (72%,  $n = 18$  of 25) of the endemic, non-threatened species were lanternsharks (Etmopteridae)  
442 and deepwater catsharks (Pentanchidae and Scyliorhinidae). Among rays, many (75.8%,  $n = 25$   
443 of 33) were hardnose skates (Rajidae) and pygmy skates (Gurgesiellidae). No endemic chimaeras  
444 were in a threatened category, but one endemic shark and three endemic rays were, including the  
445 Venezuelan Dwarf Smoothhound (*Mustelus minicanis*, Triakidae; EN), Venezuelan Round Ray  
446 (*Urotrygon venezuelae*, Urotrygonidae; EN), Colombian Electric Ray (*Diplobatis colombiensis*,  
447 Narcinidae; VU), and Brownband Numbfish (*Diplobatis guamachensis*, Narcinidae; VU). Three  
448 near-endemic rays were also threatened – the Painted Dwarf Numbfish (*Diplobatis picta*,  
449 Narcinidae; VU), Atlantic Guitarfish (*Pseudobatos lentiginosus*, Rhinobatidae; VU), and  
450 Chupare Stingray (*Styracura schmardae*, Potamotrygonidae; EN).

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### 460 3.4 Conservation responsibility



462 **Figure 6:** Map of chondrichthyan conservation responsibility for each jurisdiction in the  
463 Western Central Atlantic Ocean, where scores are normalized by the maximum score (attributed  
464 to the USA) to display from 0 to 1. National boundaries are in dark grey (Flanders Marine  
465 Institute, 2019). Regions outside of United Nations Food and Agriculture Organization Major  
466 Fishing Area 31 are shaded grey. Map base layer source: Esri®

467 The five countries with the highest conservation responsibility (CoR) were the United  
468 States, Venezuela, Mexico, Guyana, and The Bahamas (Figure 6). International waters had the  
469 third highest CoR of all jurisdictions (Table S2). Combined, these six jurisdictions accounted for  
470 66.8% of all CoR in the region.

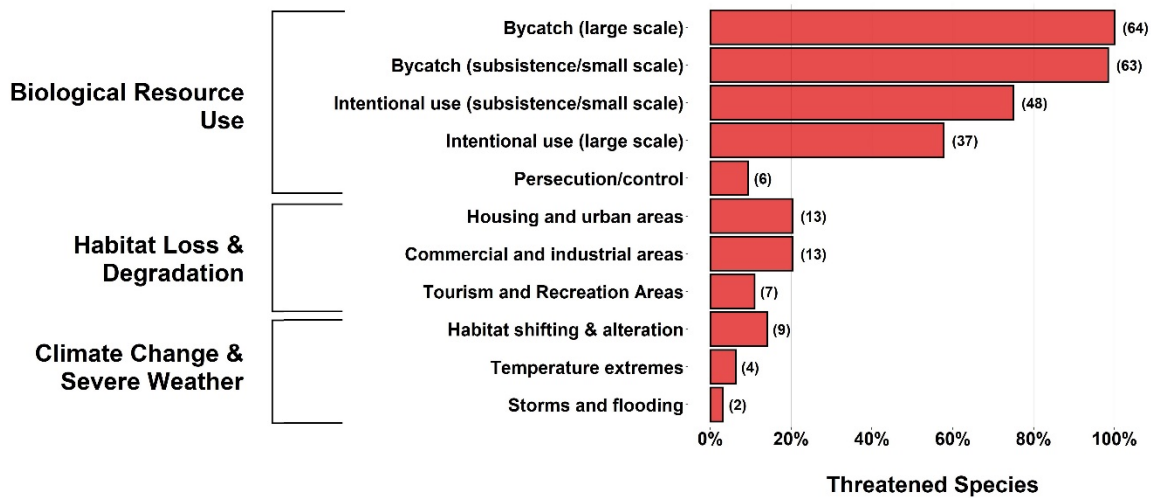
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472

473



### 474 3.5 Key threats



475

476 **Figure 7:** Percentage of threatened sharks and rays in the Western Central Atlantic ( $n = 64$ )  
 477 affected by the most common threats listed in IUCN Red List assessments. The number of species  
 478 affected by each threat appears in parentheses

479 ‘Biological resource use’ and, more specifically, ‘fishing and harvesting aquatic resources’,  
 480 imperiled most sharks and rays (87.8%,  $n = 158$  of 180). Threatened species were taken both  
 481 incidentally and intentionally in large and small-scale fisheries; all threatened species were  
 482 captured incidentally (100%,  $n = 64$  of 64) and most were captured intentionally (81%,  $n = 52$  of  
 483 64; Figure 7). The threat of overfishing was compounded by habitat loss and degradation and  
 484 climate change. Habitat loss and degradation imperiled one quarter (26.6%,  $n = 17$  of 64) of  
 485 threatened species primarily through residential and commercial development (and associated  
 486 habitat modifications), which affected 20.3% ( $n = 13$  of 64) of species. Less common pathways  
 487 to habitat loss and degradation included agriculture and aquaculture (6.3%,  $n = 4$  of 64), energy  
 488 production and mining (4.7%,  $n = 3$  of 64), transportation and service corridors (4.7%,  $n = 3$  of  
 489 64), human intrusions and disturbance (4.7%,  $n = 3$  of 64), natural systems modifications (e.g.,  
 490 dams; 1.6%,  $n = 1$  of 64), and invasive and other problematic species (1.6%,  $n = 1$  of 64).  
 491 Climate change and severe weather imperiled 14.1% ( $n = 9$  of 64) of threatened species. Lastly,  
 492 pollution (particularly land-based) imperiled 6.3% ( $n = 4$  of 64) of threatened species.

493

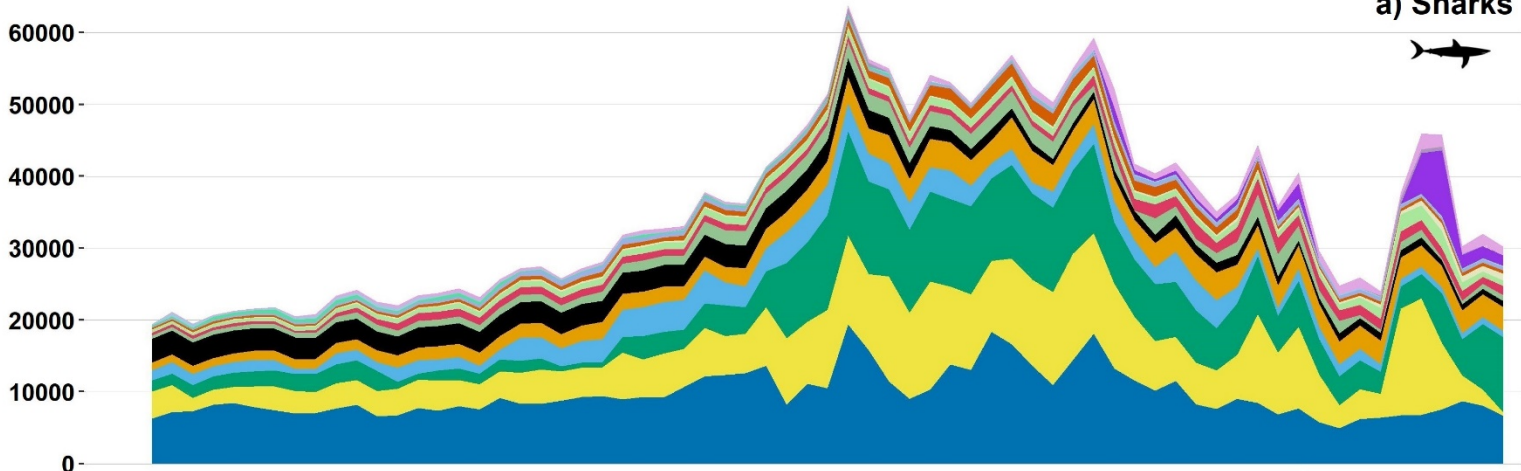
494

## 495 3.6 Reconstructed fisheries catches

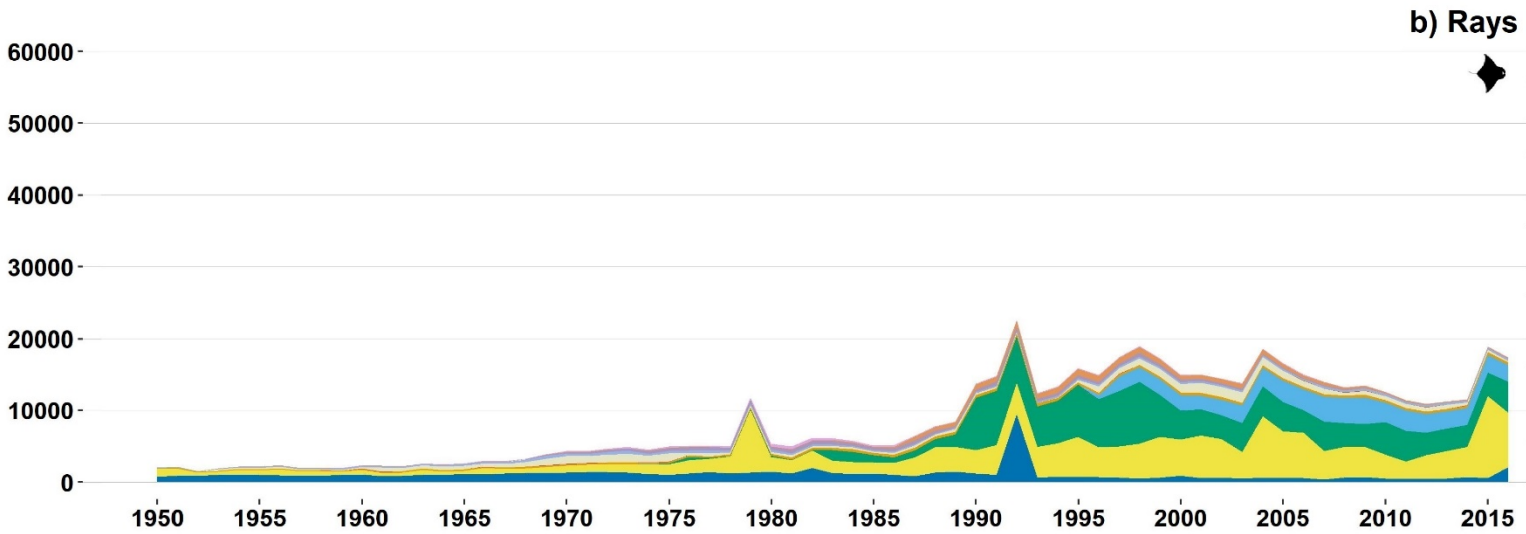
### 496 3.6.1 Sharks

497

a) Sharks



b) Rays



498

499 **Figure 8:** Reconstructed catches of a) sharks and b) rays in the Western Central Atlantic from  
500 1950 to 2016 by country. Those with < 10,000 metric tons of cumulative shark and ray catches  
501 across all years are grouped as 'Other'. Catch data from Pauly et al. (2020) and underlying  
502 EEZ boundaries from Claus et al. (2014)

503

504 Reconstructed shark catches in the WCA more than tripled in 34 years from 1950 (19,458  
505 mt) to 1984 (63,815 mt), plateaued until 1997 (between 48,536 mt and 59,329 mt), then halved  
506 over the next decade (2010: 24,015 mt; Figure 8a). In 2011, catches increased to 37,763 mt, due  
507 in part to a 451% increase in Venezuelan catches from 2010 to 2011. Spanish catches also rose  
508 dramatically from 2009 (0.39 mt) to 2012 (5,701 mt). By 2014, catches of both countries  
509 declined to 24.9% of what they were in 2012. By 2016, the total reconstructed catch of sharks in  
510 the WCA was half (47.4%) of the peak catch in 1984.

511 Most shark catches in the region, as well as overall trends in catches, can largely be  
512 attributed to fishing by the United States, Venezuela, Mexico, Cuba, the Dominican Republic,  
513 and Jamaica (Table 2). Cuba's maximum annual catch of 4,562 mt occurred in 1977 during a  
514 period of elevated catches from 1968 to 2003, when 3,295 mt ( $\pm$  801 SD) were taken per year.  
515 Outside of that period, in 1950 – 1967 and 2004 – 2016, the average annual catch was 1,323 mt  
516 ( $\pm$  343 SD) per year. Jamaica's maximum annual catch peaked early in 1950 (3,336 mt) and  
517 catches declined noticeably from 1978 (3,160 mt) to 1994 (834 mt), then remained low around a  
518 mean annual catch of 1,079 mt ( $\pm$  248 SD). In contrast, catches by the Dominican Republic  
519 increased four-fold from a low in 1950 (1,079 mt) to a peak in 1993 (4,390 mt), then remained  
520 high around a mean annual catch of 3,277 mt ( $\pm$  247 SD) through the end of the time series.  
521 Foreign fleets were responsible for 2.06% (49,468 mt) of all shark catches.

522 Taxonomic resolution in shark-specific catches was poor; 51.9% of all shark catches  
523 were listed only as Elasmobranchii or Chondrichthyes. Much of the regional shark catch from  
524 1950 to 2016 was requiem shark (listed as Carcharhinidae or *Carcharhinus*), which made up  
525 17.7% (426,597 mt) of all catches. Among all recorded shark species, Atlantic Sharpnose Shark  
526 (*Rhizoprionodon terraenovae*, Carcharhinidae) made up the largest proportion of catches at 4.5%  
527 (109,109 mt), followed by Atlantic Nurse Shark (*Ginglymostoma cirratum*,  
528 Ginglymostomatidae; 3.9%, 92,942 mt), Tiger Shark (*Galeocerdo cuvier*, Galeoceridae; 3.1%,  
529 73,567 mt), Blacktip Shark (*Carcharhinus limbatus*, Carcharhinidae; 2.6%, 62,075 mt), Blue  
530 Shark (*Prionace glauca*, Carcharhinidae; 2.1%, 50,505 mt), Bonnethead Shark (*Sphyrna tiburo*,  
531 Sphyrnidae; 2.0%, 49,256 mt), and Shortfin Mako (*Isurus oxyrinchus*, Lamnidae; 2.0%, 48,690  
532 mt). From 2012 to 2013, Spain notably caught 14,318 mt of Blue Shark (96% of their total  
533 catches of all species during that period). Every other species made up less than 2% of the total

534 catches, although some may be caught in much higher proportions but are difficult to identify at  
535 the species level.

### 536 **3.6.2 Rays**

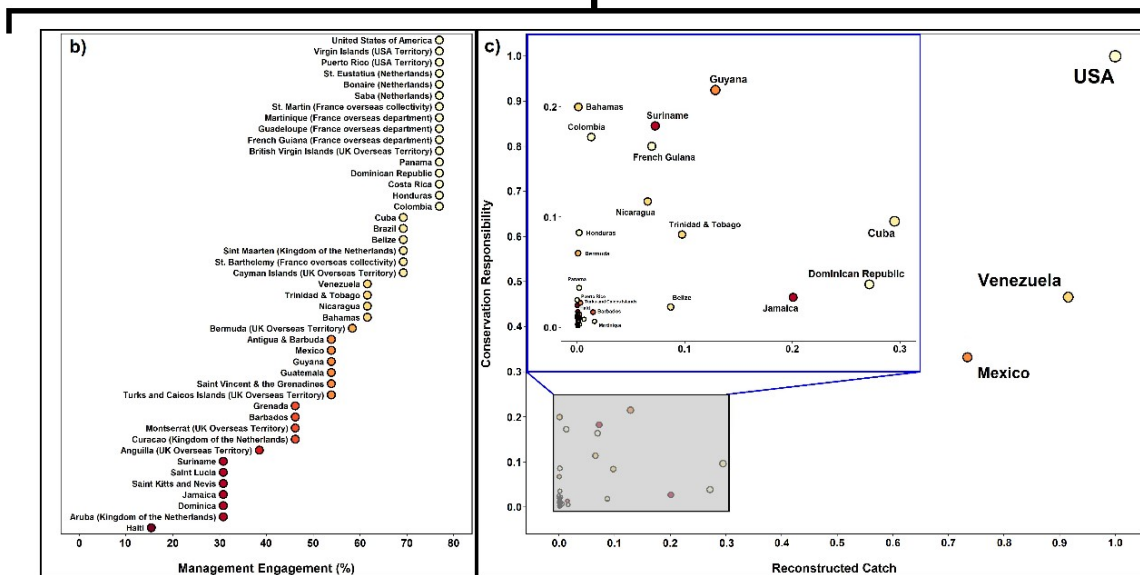
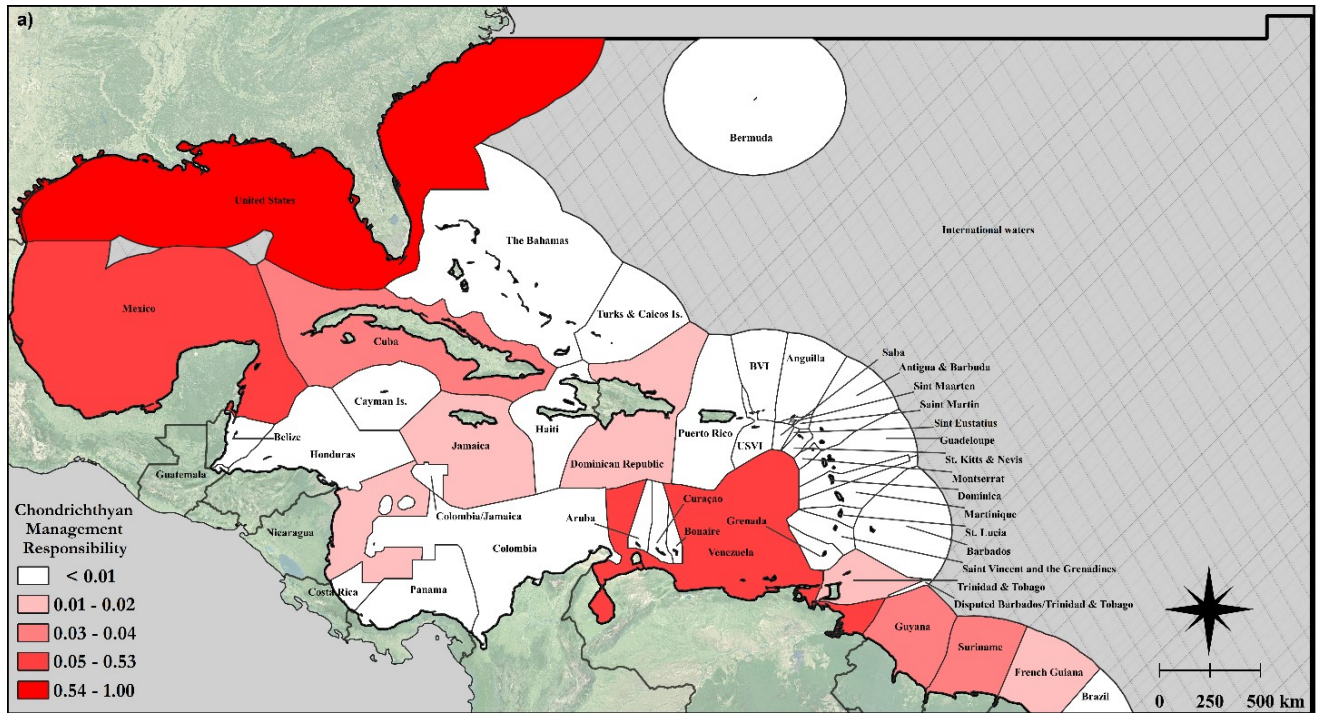
537 Reconstructed ray catches increased by an order of magnitude from 1950 (2,076 mt) to  
538 the peak in 1992 (22,587 mt), then fluctuated between that and a low of 10,892 mt until the end  
539 of the series (Figure 8b). Venezuela, Mexico, and the United States were responsible for the  
540 largest catches of rays (Table 2). Cuba's catches increased in the 1990s to contribute  
541 substantially to regional catches by 1997 (although national landings data show this increase  
542 occurring a decade earlier; PAN-Tiburones, 2015). Catches of rays in the United States were  
543 unusually high in 1992 (9,477 mt; 94% of which were stingrays (Dasyatidae)), otherwise they  
544 ranged between 408 mt and 2,130 mt. Foreign fleets were responsible for 6.46% (36,758 mt) of  
545 all ray catches. As with sharks, taxonomic resolution among recorded ray catches was poor; two-  
546 thirds (69%) of all rays were listed as only Batoidea or Rajiformes. The Southern Guitarfish  
547 (reported as *Rhinobatos percellens*, now *Pseudobatos percellens*, Rhinobatidae) was caught  
548 more than any other listed ray species (73,800 mt, 13% of rays) and is EN.

### 549 **3.7 Management**

550 Some shark and ray species (13.9%,  $n = 25$  of 180) were listed on at least one of the  
551 following: CITES, CMS, or SPAW. Twenty species were listed on CITES (Appendix I: 2  
552 species, Appendix II: 18 species; Table S1), all of which were also listed on CMS (Appendix I:  
553 11, Appendix II: 9 species). Nine species were listed on SPAW (Annex II: 2, Annex III: 7  
554 species), all of which were also listed on CITES and CMS. Three species were listed on only  
555 CMS in Appendix II: Dusky Shark (*Carcharhinus obscurus*, Carcharhinidae; EN), Blue Shark  
556 (NT), and Spiny Dogfish (*Squalus acanthias*, Squalidae; VU).

557 Stock assessments were conducted for the Gulf of Mexico, Atlantic, North Atlantic, or  
558 Northwest Atlantic populations of 42 (23.3%,  $n = 42$  of 180) shark and ray species that occur in  
559 the WCA. Six (14.3%,  $n = 6$  of 42) stocks were overfished and eight (19.1%,  $n = 8$  of 42) were  
560 not overfished (Table S1). Overfishing was occurring in four (9.5%,  $n = 4$  of 42) stocks and not  
561 occurring in ten (23.8%,  $n = 10$  of 42). Twenty-eight (66.7%,  $n = 28$  of 42) stocks were assigned  
562 an overfished / overfishing status of 'unknown'.





563

564 **Figure 9:** Chondrichthyan Management Responsibility (a) and its components, which include  
 565 management engagement with thirteen shark and ray management tools (b) and catch-weighted  
 566 conservation responsibility (c). The Chondrichthyan Management Responsibility Score is  
 567 normalized by the maximum score (attributed to the USA) to display from 0 to 1. Note that some  
 568 jurisdictions were omitted and others grouped due to the structure of the underlying data. Catch  
 569 data from Pauly, Zeller, and Palomares (2020) and underlying EEZ boundaries from Claus et al.  
 570 (2014)



571 The type and degree of shark and ray management varied in the WCA (Table 3; see Table  
572 S3 for full details and references). The United States had the most detailed management  
573 framework that included species-specific catch quotas, time-area closures, gear restrictions, size  
574 restrictions, and more. Other countries in the region engaged very little with shark and ray  
575 management (e.g., Haiti; Figure 9b). Eleven countries prohibited commercial or all shark (n =  
576 10) or ray (n = 9) fishing, although Honduras' prohibition on shark fishing included a notable  
577 exception for the retention and sale of incidentally caught sharks.

578 Many countries were party to some international agreements, but not others, resulting in a  
579 complex matrix of obligations and regulations that in some cases varied even at the island level  
580 (e.g., Kingdom of the Netherlands). Of all international management mechanisms, WECAFC  
581 had the highest participation (100%), which meant that all countries were also covered by its  
582 RPOA–IUU and will be covered by its RPOA–Sharks once it is finalized. Participation in CITES  
583 was also high (97.8%); only Haiti was a non-party. The PSMA, a binding agreement that  
584 combats IUU fishing, had the lowest participation (44.4%).

585 Three countries had 92% of Chondrichthyan Management Responsibility (CMR): the  
586 United States, Venezuela, and Mexico (Figure 9a). Just ten countries accounted for 99.3% of  
587 CMR: the United States, Venezuela, Mexico, Guyana, Suriname, Cuba, Jamaica, French Guiana,  
588 Dominican Republic, and Trinidad and Tobago (Table S4). Of those, Suriname and Jamaica had  
589 noticeably low Management Engagement (ME) despite having either high Conservation  
590 Responsibility (CoR; Suriname) or high historical catches (Jamaica; Figure 9c). There was no  
591 relationship between ME and either total reconstructed catch or CoR. However, there was a  
592 positive relationship between CoR and total reconstructed catch ( $p < 0.05$ , adjusted  $r^2 = 0.74$ ).

593

#### 594 **4. DISCUSSION**

595 We provide the first comprehensive reassessment of extinction risk for sharks and rays that  
596 occur in the WCA and find this region to be a microcosm of the global challenge to their  
597 conservation. Thirty-six percent of sharks and rays in the WCA are threatened with an elevated  
598 risk of extinction, which is similar to the percentage of sharks and rays threatened globally  
599 (Dulvy et al., 2021a). An even larger proportion – nearly half of all sharks and rays in the WCA  
600 (48.9%) – exhibit a decreasing population trend across their global range. Overfishing is the

601 overwhelming threat to their populations and has driven declines in all threatened species. The  
602 United States, Venezuela, and Mexico overshadow all other countries in the WCA in terms of  
603 total reconstructed catch, conservation responsibility, and management responsibility for sharks  
604 and rays. National-level regulations and engagement with international management mechanisms  
605 vary widely. In light of these findings, we consider patterns in species richness and extinction  
606 risk, highlight species of concern, discuss fisheries trends such as finning, the importance of  
607 small-scale fisheries, and shrinking refuge at depth, and identify opportunities for improved  
608 management.

#### 609 **4.1 Species diversity**

610 The WCA is a hotspot of shark and ray biodiversity (Carpenter, 2002; Weigmann, 2016),  
611 particularly for endemic (Derrick et al., 2020), evolutionarily distinct (Stein et al., 2018), and  
612 deepwater species (e.g., skates; Dulvy et al., 2021a; McEachran & Miyake, 1990). It is  
613 comparable to temperate areas of high richness such as the Northeast Atlantic and Southeast  
614 Pacific Ocean, but, like coral reef diversity, this Caribbean fauna is only around half as rich as  
615 the speciose Indo-West Pacific region (Weigmann, 2016). Species richness in the WCA is  
616 highest on the continental shelf, with notably high species richness in large areas of U.S. waters  
617 (e.g., along the productive shelf in the Gulf of Mexico) and along the northern coast of South  
618 America, particularly at the dynamic boundary between the tropics and subtropics (Dulvy et al.,  
619 2014, 2021; Ward-Paige et al., 2010). Longline fishery data suggest high species richness of  
620 oceanic sharks along Venezuela's islands and coast as well as the Guyana shelf, particularly  
621 where seasonal upwelling occurs and freshwater from the Orinoco River and Guyanese river  
622 drainages meets the Caribbean Sea (Castellanos et al., 2002; Cervigón, 2005; Muller-Karger &  
623 Varela, 1990; Tavares & Arocha, 2008). Similarly, marine bony fishes exhibit high species  
624 richness along continental Venezuela and Colombia, which could be driven by these same  
625 patterns and enhanced by rocky coastlines (Cervigón, 2005; Linardich et al., 2019; Robertson &  
626 Cramer, 2014).

627 We caution that species distributions are best understood in regions with extensive sampling  
628 but are still imperfectly known; U.S. waters, for example, exhibit high species richness and  
629 simultaneously receive substantial research effort and funding (Linardich et al., 2019;  
630 Miloslavich et al., 2010; Robertson & Cramer, 2014). Elsewhere, data gaps are more common,

631 and distributions are particularly challenging to assign to countries in the southern and eastern  
632 Caribbean Sea. Deepwater species distributions are data-poor, and records are sometimes limited  
633 to a single specimen, which often reflects a lack of deep-sea fisheries and research (e.g.,  
634 American Pocket Shark (*Mollisquama mississippiensis*, Dalatiidae), Kyne & Herman, 2020a;  
635 Campeche Catshark (*Parmaturus campechiensis*, Pentanchidae), Kyne & Herman, 2020b).

## 636 4.2 Extinction risk

### 637 4.2.1 Spatial & temporal comparisons

638 The proportion of threatened sharks and rays in the WCA is higher today (35.6%) than it  
639 was in 2012 (18.5%; Kyne et al., 2012), but is similar to the modern global estimate (32.6 –  
640 45.5%; Dulvy et al., 2021a). This change is largely due to new information being incorporated  
641 into species assessments. Only three species had a genuine change (i.e., a real change in the rate  
642 of decline, population size, range size, or habitat) in IUCN Red List Category since their last  
643 assessment, where the status of all three worsened: Blacknose Shark (*Carcharhinus acronotus*,  
644 Carcharhinidae; previously NT, now EN), Night Shark (*Carcharhinus signatus*, Carcharhinidae;  
645 previously VU, now EN), and Whale Shark (*Rhincodon typus*, Rhincodontidae; previously VU,  
646 now EN). None of these three species are endemic to the WCA, although much of the Blacknose  
647 Shark's range is in this region.

648 Globally, most threatened sharks and rays occur in coastal shelf waters, particularly in the  
649 tropics (Dulvy et al., 2021a); we found the same trend for the subset of WCA species, where CR  
650 and VU species occurred significantly shallower than LC species. As such, the bulk of  
651 Conservation Responsibility (CoR) fell on the countries with the largest EEZs that included the  
652 most coastal, shelf-associated habitats (e.g., the United States, Venezuela, and Mexico) with two  
653 exceptions. International waters and The Bahamas had high CoR despite consisting of only  
654 oceanic habitats or being an insular nation, respectively. International waters, in particular, cover  
655 a large proportion of the distributions of wide-ranging and highly threatened species in the  
656 WCA. The Bahamas also includes large expanses of threatened shark and ray habitat, supports  
657 high species richness that characterizes the Florida Straits region, and has well-studied sharks  
658 and rays.

659 The WCA was previously one of the most data-deficient regions in the world for sharks  
660 and rays (Dulvy et al., 2014). The proportion of DD species dropped from 47% ( $n = 71$  of 151

661 assessed species) in 2012 (Kyne et al., 2012) to just 1.1% ( $n = 2$  of 180) in 2021, marking  
662 substantial progress in reducing data-deficient blind spots that can lead to flawed species-specific  
663 management (Walls & Dulvy, 2020). Seventy-seven species that we included in our review,  
664 some of which were not previously recognized in the WCA, were assessed as DD in 2012. Of  
665 those, the vast majority (76.6%,  $n = 59$  of 77) are now LC and some (7.8%,  $n = 6$  of 77) are NT.  
666 Eleven (14.3%,  $n = 11$  of 77) species formerly assessed as DD are now threatened at the global  
667 level, including two CR (Smalltail Shark (*Carcharhinus porosus*, Carcharhinidae) and  
668 Scoophead Shark (*Sphyrna media*, Sphyrnidae)), five EN (Bramble Shark (*Echinorhinus brucus*,  
669 Echinorhinidae), Lesser Devilray (*Mobula hypostoma*, Mobulidae), Chilean Devilray (*Mobula*  
670 *tarapacana*, Mobulidae), Venezuelan Dwarf Smoothhound, and Chupare Stingray), and four VU  
671 species (Bullnose Ray (*Myliobatis freminvillii*, Myliobatidae), Southern Eagle Ray (*Myliobatis*  
672 *goodei*, Myliobatidae), Brazilian Sharpnose Shark (*Rhizoprionodon lalandii*, Carcharhinidae),  
673 and Atlantic Nurse Shark). These eleven species need to be recognized and incorporated into  
674 management plans in the WCA with an emphasis on the endemic Venezuelan Dwarf  
675 Smoothhound and near-endemic Chupare Stingray.

676 The Roughskin Spurdog is the only previously assessed species that remains DD. It is a  
677 poorly known deepwater species (73 – 600 m depth range) that may be caught as bycatch, but the  
678 degree to which fishing affects its population is unknown (Finucci et al., 2020). The Carolina  
679 Hammerhead is the other modern DD species. It was recently described, is difficult to identify  
680 (Quattro et al., 2013), and was assessed as DD because its depth and geographic distribution, and  
681 hence interaction with fisheries, could not be determined (VanderWright et al., 2020). Given that  
682 all other hammerhead sharks (Sphyrnidae) in the WCA are threatened, however, this status could  
683 be masking a high level of extinction risk to the Carolina Hammerhead.

#### 684 **4.2.2 Species of concern**

685 The WCA hosts a number of threatened oceanic sharks (e.g., mackerel sharks  
686 (Lamnidae), thresher sharks (Alopiidae), and some requiem sharks (Carcharhinidae)) and rays  
687 (e.g., devil rays (Mobulidae)), particularly in the Gulf of Mexico and U.S. Atlantic (Dulvy et al.,  
688 2021a; Pacoureau et al., 2021). Fisheries mortality has caused significant population declines in  
689 some of these species (e.g., Oceanic Manta Ray (*Mobula birostris*, Mobulidae); Miller and  
690 Klimovich, 2017); they are among the most threatened groups of sharks and rays in the region

691 along with hammerheads, sawfishes, guitarfishes (Rhinobatidae), and very large, highly  
692 migratory species (e.g., Whale Shark), all of which are recognized as groups of extreme  
693 conservation concern (Dulvy et al., 2016; 2021; Pacoureau et al., 2021). These species are  
694 prominent on CITES, CMS, and SPAW appendices and annexes, which highlights the need for  
695 international cooperation in managing these species and for countries to meet their national-level  
696 commitments to these agreements.

697         Among the four threatened endemics in the WCA, the VU Colombian Electric Ray and  
698 VU Brownband Numbfish are considered irreplaceable based on their small ranges (Dulvy et al.,  
699 2014). Although they are relatively productive, both species are captured in poorly managed and  
700 intense artisanal demersal trawl fisheries throughout their small geographic ranges in Colombia  
701 and Venezuela and are suspected to have declined by 30–49% over the past three generations  
702 (Pollom, Herman, et al., 2020b; Pollom, Herman, et al., 2020c). The other two endemic  
703 threatened species in the WCA are the EN Venezuelan Dwarf Smoothhound and the EN  
704 Venezuelan Round Ray. The former is targeted and caught as bycatch in trawl and longline  
705 fisheries off Venezuela and Colombia; it was inferred to have declined by > 99% over the past  
706 three generations based on declining landings of smoothhounds (Triakidae) in Venezuela  
707 (Pollom, Lasso-Alcalá, et al., 2020). The latter is captured in demersal trawl fisheries and  
708 artisanal beach seine fisheries in Colombia but is now rarely observed in catches in Venezuela;  
709 its population is suspected to have declined by 50–79% in the last ten years (Pollom, Herman, et  
710 al., 2020a).

711         The threatened near-endemic species (Painted Dwarf Numbfish, Atlantic Guitarfish, and  
712 Chupare Stingray) are also subject to high fishing pressure in parts of their ranges (Dulvy et al.,  
713 2021b; Pollom et al., 2020; Pollom, Charvet, Faria, et al., 2020a). The Painted Dwarf Numbfish  
714 is captured in intense demersal trawl fisheries throughout its small range off northern South  
715 America from at least as far west as Venezuela to Brazil (Pollom, Charvet, Faria, et al., 2020a)  
716 and is considered irreplaceable (Dulvy et al. 2014). It may find some refuge from fishing at depth  
717 (Pollom, Charvet, Faria, et al., 2020a). The Atlantic Guitarfish finds some refuge from trawl  
718 fisheries in the U.S. Gulf of Mexico but is a common bycatch species in Mexican shrimp trawl  
719 fisheries and exposed to intense unmanaged fisheries elsewhere (Pollom et al., 2020). The  
720 Chupare Stingray similarly has refuge at the northern part of its range (e.g., The Bahamas) but is  
721 subject to high fishing pressure along the coasts of Venezuela, Colombia, the Guianas, and



722 northern Brazil, where it is presently very rare (Dulvy et al., 2021b). Although the Daggernose  
723 Shark (*Isogomphodon oxyrinchus*, Carcharhinidae; CR), and Wingfin Stingray (*Fontitrygon*  
724 *geijskesi*, Dasyatidae; CR) are not near-endemic to the WCA, we consider them ‘irreplaceable’  
725 because of their threatened status and small ranges that extend from eastern Venezuela to the  
726 northern coast of Brazil (Dulvy et al., 2014; Pollom, Charvet, Faria, et al., 2020b; 2020c).

727 Research is required on the life history, distribution, abundance, and fishery interactions  
728 of all threatened endemic, near-endemic, and irreplaceable species, the vast majority (77.8%,  $n =$   
729 7 of 9) of which are rays. Conservation responsibility for these species falls solely on countries  
730 in the WCA, namely Venezuela, Colombia, Suriname, Guyana, French Guiana, and Brazil. We  
731 recommend these countries monitor the status and prioritize the management of these species.

### 732 **4.3 Fisheries trends**

733 Shark and ray catches peaked in the WCA (1992) before they peaked globally (2003;  
734 Davidson et al., 2016; Pauly et al., 2020), but regional and global trends followed a similar  
735 pattern: there was a substantial increase in catches and landings from 1950 to the 1990s/2000s,  
736 followed by a period of decline. In the WCA, reconstructed catches declined 40.2% between  
737 1992 and 2016 while overall fishing effort rose in the region by about 1.1% annually after 1950  
738 (Anticamara et al., 2011). Thus, regional catch-per-unit-effort has probably declined by greater  
739 than 50% over the equivalent of three generations for many shark and ray species (which would  
740 result in a population reduction sufficient for a species to qualify as Endangered), suggesting  
741 fishing is driving their extinction risk in the WCA.

#### 742 **4.3.1 Finning**

743 Some of the most intense shark fishing in the WCA occurred from the 1970s to the early  
744 1990s (Bonfil, 1997; Musick et al., 1993) as negative attitudes towards sharks and the demand  
745 for and trade in shark fins increased (Castro, 2013; Worm et al., 2013). With increased demand,  
746 some local fin prices also rose, even quadrupling in Guatemalan markets by the mid-2000s  
747 (Graham, 2007). Numerous countries in the WCA participated in the fin trade (e.g., Guyana,  
748 Trinidad and Tobago; Fowler et al., 2005); 21% of CR Scalloped Hammerhead (*Sphyrna lewini*,  
749 Sphyrnidae) fins sampled in Hong Kong, for example, came from the western Atlantic  
750 (Chapman et al., 2009). But the global volume of fins imported into Hong Kong (i.e., demand)  
751 decreased by 2013 (Shea & To, 2017) and was expected to decrease further in both Hong Kong

752 and China in subsequent years (Dent & Clarke, 2015). Fin prices also dropped in some parts of  
753 the WCA as the global trade in shark meat products increased 4.5% per year from 2000 to 2011  
754 (Dent & Clarke, 2015). In some places, meat overtook fins as the most profitable shark product  
755 (e.g., northeastern Brazil; Martins et al., 2018). By the mid-2010s, the contribution of Scalloped  
756 Hammerhead fins from the Southwest Atlantic, Caribbean Sea, and Northwestern Atlantic  
757 randomly sampled in Hong Kong markets was roughly 8.5% (Fields et al., 2020). Silky Shark  
758 (*Carcharhinus falciformis*, Carcharhinidae) fin trimmings similarly sampled in markets in Hong  
759 Kong and mainland China suggested almost no contribution from Atlantic populations  
760 (Cardeñosa et al., 2020) despite the Silky Shark being the second most common species in the fin  
761 trade at that time (Cardeñosa et al., 2018). These limited insights and a lack of evidence in the  
762 literature suggest little contemporary large-scale shark finning (the removal of fins and  
763 discarding of its carcass at sea) in the WCA (Kyne et al., 2012), although finning does occur  
764 illegally (e.g., finless carcasses are frequently landed at northern Brazilian ports notwithstanding  
765 national law; Feitosa et al., 2018). Fins from landed carcasses also enter the fin trade through  
766 legal pathways in even the WCA's most highly managed and developed fisheries (e.g., United  
767 States; Dulvy et al., 2017; Ferretti et al., 2020).

#### 768 **4.3.2 The importance of small-scale fisheries & landings data**

769 Even at low levels of effort, small-scale fishing can significantly reduce the biomass of  
770 slow-growing fishes such as sharks and rays (Pinnegar & Engelhard, 2008) and affect critical life  
771 stages (e.g., juveniles in possible nursery habitats; Tagliafico et al., 2021). In the WCA, the size,  
772 economic contribution, and catch of small-scale fleets has been increasing for decades  
773 (Baremore et al., 2021; Canty et al., 2019), and overfishing is occurring in nearly double the  
774 percentage of small-scale fisheries (46%) as it is in commercial fisheries (28%; Singh-Renton &  
775 McIvor, 2015). The significance of small-scale fishing is highlighted by Mexico and Venezuela,  
776 which we identified as two of the top three shark and ray fishing nations in the WCA; small-  
777 scale fishing boats comprise 97% of the marine fishing fleet in Mexico (Fernández et al., 2011),  
778 and artisanal sources supply 94% of the shark catch in Venezuela (Marquez et al., 2019; Tavares,  
779 2019). Yet, the WCA's small-scale fisheries are managed less intensely than its large-scale  
780 commercial fisheries (Singh-Renton & McIvor, 2015), and, for those affecting sharks and rays,  
781 small-scale fisheries are poorly known (Kyne et al., 2012) while large-scale fisheries are better-

782 studied (e.g., see SouthEast Data, Assessment, and Review reports, [http://sedarweb.org/sedar-](http://sedarweb.org/sedar-projects)  
783 [projects](http://sedarweb.org/sedar-projects); Bonfil, 1997; Peterson et al., 2017; Tavares & Arocha, 2008).

784 The small-scale fisheries impacting sharks and rays in the WCA are heterogeneous and  
785 widespread, and their effort and catch are poorly described (Bonfil, 1997). We found surprisingly  
786 little information on ray landings in the WCA and stress further monitoring despite few directed  
787 ray fisheries in the region (e.g., in the United States, Cuba, and Mexico; Pérez-Jiménez &  
788 Mendez-Loeza, 2015; WECAFC, 2018). Further, the WCA's country-level landings statistics  
789 reported to the FAO have very low species-specific resolution (Dulvy et al., 2014; WECAFC,  
790 2018), with over half of shark and ray catches identified as only 'chondrichthyan',  
791 'elasmobranch', 'batoid', or 'rajiform'. Mexico, despite being the third largest shark and ray  
792 fishing country in the WCA, records catches in only three categories – small sharks (< 1.5 m),  
793 large sharks (> 1.5 m), and rays (Pérez-Jiménez & Mendez-Loeza, 2015). Venezuela, despite  
794 being the second largest shark and ray fishing country in the WCA, recorded sharks and rays as a  
795 single category until 1990, then in three groups (miscellaneous sharks, *Mustelus* spp., and  
796 miscellaneous rays) until 2007, after which finer level identification was confounded by a lack of  
797 training for fisheries monitoring staff (Tavares, 2019). The situation in smaller shark and ray  
798 fishing nations is similar; in Guatemala, only two government fisheries staff monitor its entire  
799 ~150 km Caribbean coast, which hinders landings verification (Hacohen-Domené et al., 2020).  
800 This poor resolution is not compatible with effective species-specific management. Some recent  
801 studies have begun to fill these gaps by monitoring small-scale fisheries landings (e.g., Guyana –  
802 Kolmann et al., 2017; Venezuela – Marquez et al., 2019; Panama – Návalo et al., 2021). In the  
803 Belizean shark fishery, for example, a new low-cost method of analyzing fisher-contributed  
804 secondary shark fins was successful in determining species and size composition of catches and  
805 may prove valuable across the WCA in the future (Quinlan et al., 2021). More research on  
806 fishing effort, catch, and baseline abundance data is required to assess populations and adapt  
807 management priorities (Bizzarro et al., 2009; Kyne et al., 2012; Pérez-Jiménez & Mendez-Loeza,  
808 2015).

### 809 **4.3.3 Shrinking refuge at depth**

810 Since 1950, global fisheries have increasingly expanded into the deep sea (Morato et al.,  
811 2006). In the Atlantic Ocean, deepwater sharks like gulper sharks (Centrophoridae) and kitefin

812 sharks (Dalatiidae) occurring as deep as 1000 m were reported in fisheries landings as early as  
813 1990 (Morato et al., 2006). Although we found many endemic and LC species in the WCA to be  
814 associated with deep habitats that can provide refuge from fishing pressure (Dulvy et al., 2014,  
815 2021; Walls & Dulvy, 2021), we note that this refuge may be shrinking as fishing activities  
816 continue to develop in the region's deep waters (Arana et al., 2009; Baremore et al., 2016).

817 In the WCA, many deepwater habitats (> 200 m) are accessible to small-scale fishers  
818 due to the proximity of these habitats to shore, and consequently deepwater sharks and rays are  
819 already caught as bycatch and sometimes targeted. Along the MesoAmerican Barrier Reef, for  
820 example, this access coupled with declining yields in coastal fisheries led to the emergence of  
821 small-scale deepwater fisheries that use longlines, hook and line, traps, and gillnets to target 'red  
822 snappers' (e.g., Queen Snapper (*Etelis oculatus*, Lutjanidae), Silk Snapper (*Lutjanus vivanus*,  
823 Lutjanidae), Blackfin Snapper (*Lutjanus buccanella*, Lutjanidae)) and groupers (e.g.,  
824 Yellowedge Grouper (*Hyporthodus flavolimbatus*, Serranidae), Misty Grouper (*Hyporthodus*  
825 *mystacinus*, Serranidae)) between 100 and 550 m (Baremore et al., 2021; WECAFC, 2018). Most  
826 small-scale deepwater fisheries in the WCA similarly target this snapper and grouper complex.  
827 Off Guatemala, fishers catch and discard some small deepwater sharks and chimaeras, while they  
828 target or retain others for meat or liver oil (Finucci et al., 2021; Hacothen-Domené et al., 2020;  
829 Polanco-Vásquez et al., 2017). In Venezuela, overfishing of shallow water stocks has led to  
830 deepwater (200–800 m) fishing north of Isla de Margarita and Paria Peninsula (eastern region,  
831 near Trinidad) and along the coast of Falcón (western region, near Aruba), where endemic and  
832 near-endemic species of deepwater sharks, rays, and chimaeras are now caught (OM Lasso-  
833 Alcalá, *unpublished data*). Deepwater sharks are also targeted in Honduras (Baremore et al.,  
834 2016) and caught off Saba Bank (de Graaf et al., 2017), Curaçao (Van Beek et al., 2013), Belize  
835 (Quinlan et al., 2021), northern Cuba (Ruiz-Abierno et al., 2021), and the southern Gulf of  
836 Mexico (Pérez-Jiménez & Mendez-Loeza, 2015). In the northern Gulf of Mexico, deep reef-fish  
837 longline fisheries and shrimp trawl fisheries also catch deepwater sharks as bycatch, most of  
838 which are discarded (Scott-Denton et al., 2011; Scott-Denton & Williams, 2013; Zhang et al.,  
839 2014), and, in The Bahamas, recreational fishers often catch small deepwater sharks while  
840 targeting red snappers with electric reels (BS Talwar, *pers. obs.*). Across these WCA fisheries,  
841 the Dusky Smoothhound (*Mustelus canis*, Triakidae; NT), Cuban Dogfish (*Squalus cubensis*,  
842 Squalidae; LC), Atlantic Sixgill Shark (*Hexanchus vitulus*, Hexanchidae; LC), Sharpnose

843 Sevengill Shark (*Heptranchias perlo*, Hexanchidae; NT), Night Shark (EN), gulper sharks  
844 (*Centrophorus* spp., Centrophoridae; EN where assessed), and some catsharks (Scyliorhinidae;  
845 LC) are the most common deepwater species in landings (Baremore et al., 2021; de Graaf et al.,  
846 2017; Hacothen-Domené et al., 2020; Marquez et al., 2019; Quinlan et al., 2021; Scott-Denton et  
847 al., 2011; Van Beek et al., 2013).

848           Although many of the WCA's deepwater sharks and rays are now currently assessed as  
849 LC, our knowledge of their biology and ecology remains incredibly limited. These species also  
850 typically lack stock assessments (Table S1; Baremore et al., 2021; Kyne & Simpfendorfer,  
851 2010), and many are intrinsically vulnerable to overfishing due to their life histories (García et  
852 al., 2008; Simpfendorfer & Kyne, 2009; Rigby & Simpfendorfer, 2015). Thus, a precautionary  
853 approach to their management should be emphasized if deepwater fisheries are further developed  
854 in the WCA (Simpfendorfer & Kyne, 2009), which some governments appear to be pursuing  
855 (e.g., Belize; Baremore et al., 2021; Kyne et al., 2012).

#### 856 **4.4 Management opportunities and priorities**

857           The WCA is geopolitically complex, with more maritime boundaries in the Caribbean alone  
858 than in any other Large Marine Ecosystem (Martinez et al., 2017). It also contains highly  
859 developed, large countries with extensive fisheries management regimes (e.g., United States)  
860 alongside economically challenged small island developing states with limited management  
861 capacity (e.g., Haiti). Nutrient-rich continental shelves host industrial fisheries while nutrient-  
862 poor coral reefs support artisanal fisheries a short distance away (Singh-Renton & McIvor,  
863 2015). It is not surprising that approaches to shark and ray management vary widely in the region  
864 and that challenges to improved management and regular stock assessment include consistency  
865 and harmonization in data collection, fisheries monitoring, funding, training, and enforcement.  
866 Our findings underscore the objectives of the WECAFC RPOA-Sharks in meeting these  
867 challenges (WECAFC, 2018).

868           Chondrichthyan Management Responsibility and its components (catch-weighted CoR and  
869 ME) should be interpreted carefully and only within the WCA; a country may have large shark  
870 and ray fisheries elsewhere that were not considered in our analysis. Catch-weighted CoR uses  
871 reconstructed catch data from the Sea Around Us Project which improves often low-resolution  
872 and sometimes incomplete data self-reported by countries to the FAO (Maharaj et al., 2018).



873 Colombia's reconstructed catch data for sharks and rays is underestimated, for example, because  
874 Colombia does not report ray catches from large-scale fisheries, and many years of shark and ray  
875 landings data are missing from government records (Caldas et al., 2009). Despite reconstructed  
876 catch data for Colombia showing no ray catches from 1950 to 2016, recent data indicate that rays  
877 represent 7.2% of the total volume of small-scale fish and invertebrate catches at three locations  
878 in the Colombian Caribbean (Squalus Foundation – AUNAP, *unpublished data*). Thus,  
879 Colombia's catch-weighted CoR and non-normalized CMR are underestimated. Still, most  
880 fishing in the Colombian Caribbean is small-scale and results in far fewer shark and ray catches  
881 than in the WCA's major shark and ray fishing nations (PA Mejía-Falla, *pers. obs.*). Normalized  
882 CMR, while imperfect due to these and similar errors in the underlying data, provides a relative  
883 comparison between national-level catches at the best resolution available.

884 Taken as a relative measure, Chondrichthyan Management Responsibility can provide a  
885 blueprint for regional management priorities and leadership. The countries with the highest CMR  
886 in the WCA – the United States, Venezuela, and Mexico – have large expanses of nutrient-rich  
887 ecosystems along the continental shelf which support their high reconstructed catches and  
888 elevate their CoR. Even if these countries were fully engaged with every management  
889 mechanism (i.e., had 100% ME), they would still dominate CMR because their catch-weighted  
890 CoR is so high relative to other countries. A high CMR does not necessarily indicate current  
891 overfishing, however. Despite leading the WCA in CMR (and catch-weighted CoR), the United  
892 States currently offers *some* of the best examples of sustainable shark and ray fishing in the  
893 world and acts as a refuge for many threatened sharks and rays (Ferretti et al., 2020;  
894 Simpfendorfer & Dulvy, 2017), some of which have experienced preliminary recoveries in U.S.  
895 waters (Peterson et al., 2017). Alternatively, Mexico and Venezuela host data-poor fisheries  
896 where reference points and stock status are largely unknown, and institutional management  
897 capacity is lacking (Pérez-Jiménez & Mendez-Loeza, 2015; Tavares, 2019). Mexico, for  
898 example, is not a party to SPAW, CMS, or CMS MoU Sharks; it falls in the lower 50% of WCA  
899 countries in management engagement despite its very high CMR.

900 The WCA's other major historical shark and ray fishing nations (e.g., Cuba, Dominican  
901 Republic, Jamaica) and those with high CoR (e.g., Guyana, Suriname, and French Guiana)  
902 formed a second set of countries with significant CMR. Jamaica and Suriname stand out as  
903 countries requiring improved management given their high CMR but low ME. Haiti's lack of

904 shark and ray management also requires immediate action. The high CoR of international waters  
905 calls attention to the importance of managing highly migratory sharks and rays through  
906 international fisheries management bodies (Tavares & Arocha, 2008; Walls & Dulvy, 2021).  
907 Given 100% participation of WCA countries in WECAFC, its upcoming RPOA–Sharks provides  
908 a unique opportunity to achieve that end, particularly given WECAFC’s broad taxonomic and  
909 geographic jurisdiction. In comparison, ICCAT’s jurisdiction is limited to oceanic species caught  
910 by fleets targeting tunas and tuna-like fishes (WECAFC, 2018). However, currently WECAFC  
911 does not have the authority to adopt binding management measures.

912 Improved enforcement is required in much of the WCA, particularly in small-scale fisheries  
913 (Kyne et al., 2012; Martins et al., 2018; Saavedra-Díaz et al., 2016). Sharks and rays are caught  
914 and landed despite protected status in numerous countries (Feitosa et al., 2018; Gallagher et al.,  
915 2015; Van Beek et al., 2013). Along Guatemala’s Caribbean coast, limited fisheries patrols and a  
916 lack of funding for enforcement have resulted in unregulated fishing in Guatemalan waters and  
917 roving bandit dynamics in neighboring EEZs such as Belize and Honduras (Berkes et al., 2006;  
918 Graham, 2007; Hacothen-Domené et al., 2020). Shark fins may also move across international  
919 borders to be sold in poorly regulated markets (Kyne et al., 2012). Ineffective management and  
920 enforcement of marine protected areas (MPAs) is also common (Bustamante et al., 2014; Perera-  
921 Valderrama et al., 2018). In addition, extractive activities are allowed in many MPAs; only 0.5%  
922 of the protected areas in the Caribbean associated with European Union and UK Overseas  
923 Territories prohibit all extractive activities (Martinez et al., 2017). Generally, funding for  
924 enforcement is insufficient and the detection of illegal activity is too infrequent to encourage  
925 compliance (although it varies by sub-region; Singh-Renton & McIvor, 2015). At the  
926 international level, even when a country is party to an international agreement or treaty, it may  
927 not have implemented national regulations to meet its commitments (which are sometimes  
928 voluntary or non-binding; e.g., IPOA–Sharks, CMS MoU Sharks; Fischer et al., 2012). The  
929 following WCA countries, for example, either partially meet or do not meet their mandatory  
930 commitments to protected sharks and rays on CMS Appendix I: Antigua and Barbuda, Cuba,  
931 Costa Rica, Honduras, Jamaica, Netherlands (Aruba and Curaçao), Panama, and the United  
932 Kingdom (Bermuda, Anguilla, Montserrat, and the Turks and Caicos) (Lawson & Fordham,  
933 2018).

934 Although we focused primarily on fisheries, national priorities can be established using other  
935 value frameworks that provide alternative justification for shark and ray management. Shark and  
936 ray tourism, for example, can offer a profitable, non-consumptive alternative to fishing for some  
937 species and some people (Gallagher & Hammerschlag, 2011; Kyne et al., 2012). The Bahamas  
938 provides an example of how a small island developing state without sufficient fisheries  
939 management and enforcement (Sherman et al., 2018) is still able to benefit from the non-  
940 extractive use of sharks and rays. As a regional leader in shark and ray ecotourism, it boasts the  
941 world's largest shark diving economy, which generates \$113.8 million USD annually (Haas et  
942 al., 2017). Although The Bahamas has a rich and abundant shark and ray fauna, over 90% of  
943 national expenditures from shark dives came from dives focused on the Caribbean Reef Shark  
944 (*Carcharhinus perezi*, Carcharhinidae; Haas et al., 2017), which is one of the most abundant and  
945 ubiquitous reef-associated sharks in effectively managed areas in the WCA (MacNeil et al.,  
946 2020) and also offers tourist appeal in other locations (e.g., Belize; Graham, 2014). The Cayman  
947 Islands also offers a long-standing example of successful non-extractive use; 'Stingray City', off  
948 Grand Cayman, features tens of Southern Stingrays (*Hypanus americanus*, Dasyatidae) that  
949 interact with tourists in what may be the oldest example of shark and ray tourism in the world  
950 (Ormond et al., 2016). This site plays a major role in ray-specific tourism generating up to \$50  
951 million USD annually for the Cayman Islands (Vaudo et al., 2018), while shark-associated  
952 diving and non-extractive use generates an additional \$46.8 – \$62.6 million USD every year  
953 (Ormond et al., 2016). Although shark and ray ecotourism is not without its challenges  
954 (Gallagher & Huvneers, 2018), under the right circumstances it can have a net conservation and  
955 economic benefit (Gallagher et al., 2015) and may be appropriate for countries with low  
956 reconstructed catches and high CoR (e.g., Colombia).

#### 957 **4.5 Conclusions**

958 Sharks and rays are among the most threatened vertebrates on our planet, second only to the  
959 amphibians (Dulvy et al., 2021a). Protecting CR and EN sharks and rays from fishing,  
960 particularly endemic and near-endemic species, remains a regional and global priority (Dulvy et  
961 al., 2021a). Unmonitored small-scale fisheries in the WCA likely contribute heavily to shark and  
962 ray declines and may grow to threaten some shelf-associated deepwater species. Effective and  
963 enforceable fisheries management informed by basic species-specific data on abundance and  
964 catch is urgently required across the WCA. Managing shark and ray fisheries has the potential to

965 reduce mortality, halt declines, and promote recovery while supporting food security and  
966 livelihoods through sustainable fishing of less-threatened species (Booth et al., 2019; Dulvy et  
967 al., 2021a). A robust management toolbox is available to achieve that end (Booth et al., 2020;  
968 MacNeil et al., 2020), but improved implementation of locally appropriate tools is required  
969 (Davidson et al., 2016).

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## **DATA AVAILABILITY STATEMENT**

Underlying data are available through the Sea Around Us Project database ([www.seaaroundus.org](http://www.seaaroundus.org)) and IUCN Red List website ([www.iucnredlist.org](http://www.iucnredlist.org)).



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**Table 1:** The number and percentage of chondrichthyans found in the Western Central Atlantic by IUCN Red List of Threatened Species category. Totals for the threatened categories, which include Critically Endangered, Endangered, and Vulnerable, appear in italics

<b>IUCN Red List category</b>	<b>Red List status: All species (%)</b>	<b>Red List status: Sharks (%)</b>	<b>Red List status: Rays (%)</b>	<b>Red List status: Chimaeras (%)</b>
Critically Endangered	12 (6.7)	8 (7.8)	4 (5.6)	0 (0)
Endangered	25 (13.9)	15 (14.7)	10 (13.9)	0 (0)
Vulnerable	27 (15)	18 (17.6)	9 (12.5)	0 (0)
Near Threatened	17 (9.4)	11 (10.8)	5 (6.9)	1 (16.7)
Least Concern	97 (53.9)	48 (47.1)	44 (61.1)	5 (83.3)
Data Deficient	2 (1.1)	2 (2)	0 (0)	0 (0)
<i>Total threatened</i>	<i>64 (35.6)</i>	<i>41 (40.2)</i>	<i>23 (31.9)</i>	<i>0 (0)</i>

**Table 2:** Total reconstructed catch of sharks and rays in the Western Central Atlantic (WCA; FAO Major Fishing Area 31) from 1950 to 2016 by country. Note that each country’s catch outside of the WCA was omitted. Underlying data is from Sea Around Us (Pauly et al., 2020). mt, metric tons

Origin of fleet	Country	Shark catch (mt)	Ray catch (mt)	Shark & Ray catch (mt)
WCA	United States	646,031	74,292	720,323
	Venezuela	467,135	192,310	659,445
	Mexico (Atlantic)	387,410	141,355	528,765
	Cuba	159,636	52,724	212,360
	Dominican Republic	177,517	17,894	195,411
	Jamaica	144,568		144,568
	Guyana	92,368		92,368
	Trinidad & Tobago	69,138	1,051	70,189
	Belize	62,514		62,514
	Suriname	17,562	34,473	52,035
	French Guiana	49,564	265	49,829
	Nicaragua (Caribbean)	31,093	16,049	47,142
	Martinique (France)	11,603	44	11,647
	Barbados	10,665		10,665
	Colombia	9,278		9,278
	Costa Rica (Caribbean)	4,544		4,544
	Turks & Caicos Isl. (UK)	2,180		2,180
	Antigua & Barbuda	1,565		1,565
	Grenada	1,479		1,479
	Panama (Caribbean)	1,201		1,201
St Martin†	1,178		1,178	
Honduras (Caribbean)	1,168		1,168	
Saint Vincent & the Grenadines	1,083	10	1,093	
Guatemala (Caribbean)		872	872	

<b>Origin of fleet</b>	<b>Country</b>	<b>Shark catch (mt)</b>	<b>Ray catch (mt)</b>	<b>Shark &amp; Ray catch (mt)</b>
	Guadeloupe (France)	701	96	797
	Saint Barthelemy (France)	723		723
	Bahamas	720		720
	Curaçao	664		664
	Saint Lucia	522	59	581
	Cayman Isl. (UK)	485		485
	Bermuda (UK)	438		438
	Aruba (Netherlands)		301	301
	Bonaire (Netherlands)	279		279
	Dominica	129	0	129
	Montserrat (UK)	63	0	63
	Haiti	15	39	55
	British Virgin Isl. (UK)	37		37
	Brazil	26		26
	Anguilla (UK)		12	12
	Saba and St. Eustatius (Netherlands)			
	Saint Kitts and Nevis			
	U.S. Virgin Islands (USA)			
	Puerto Rico (USA)			
<b>Foreign</b>	Spain	28,405		28,405
	South Korea	4,079	14,561	18,640
	France		16,363	16,363
	Japan	1,972	5,834	7,807
	Unknown Fishing Country	7,746		7,746
	Taiwan	6,320		6,320
	Portugal	673		673
	China	111		111



<b>Origin of fleet</b>	<b>Country</b>	<b>Shark catch (mt)</b>	<b>Ray catch (mt)</b>	<b>Shark &amp; Ray catch (mt)</b>
	Vanuatu	75		75
	Canada	64		64
	Netherlands	22		22
	Philippines	0.2		0.2
	Denmark	0.1		0.1
	Sweden	0.0001		0.0001
	<b>Total</b>	<b>2,404,751</b>	<b>568,603</b>	<b>2,973,354</b>

**Table 3:** Country-level management information, where NPOA–Sharks is a National Plan of Action for the Conservation and Management of Sharks; RPOA–Sharks is a Regional Plan of Action for the Conservation and Management of Sharks; other regulations include time/area closures, a ban on exports of shark or ray products, species-specific measures, or gear restrictions relevant to chondrichthyans; NPOA–IUU is a National plan of action to prevent, deter and eliminate Illegal, Unreported and Unregulated (IUU) Fishing; RPOA–IUU is a Regional plan of action to prevent, deter and eliminate Illegal, Unreported and Unregulated (IUU) Fishing; PSM is the Agreement on Port State Measures; WECAFC is the Western Central Atlantic Fishery Commission; CITES is the Convention on International Trade in Endangered Species of Wild Fauna and Flora; ICCAT is the International Commission for the Conservation of Atlantic Tunas; CMS is the Convention on the Conservation of Migratory Species of Wild Animals; CMS Sharks MoU is the Memorandum of Understanding on the Conservation of Migratory Sharks; and SPAW is the Convention for the Protection and Development of the Marine Environment of the Wider Caribbean Region Specially Protected Areas and Wildlife Protocol. ‘Coop.’ stands for cooperator (a special status in ICCAT with similar rights and obligations to a contracting party) and ‘Sig.’ stands for signatory (where a country has yet to ratify CMS). ‘N/A’ stands for not applicable (where a country is beyond the convention area of an international mechanism). Cells containing a ‘No’ are highlighted in grey. ‘Country’ refers to all states and territories. Full annotated table available in Supporting Information

Country	Shark fishing ban	Ray fishing ban	Finning ban	NPOA– or RPOA– Sharks¶	Other regulations	NPOA– or RPOA–IUU	PSM	WECAFC ††	CITES ‡‡	ICCAT §§	CMS ¶¶	CMS Sharks MoU†††
Anguilla	No	No	No	No	No	RPOA	No	Yes	Yes	Yes	No	No
Antigua & Barbuda	No	No	Yes	NPOA	Yes	NPOA, RPOA	No	Yes	Yes	No	Yes	No
Aruba	No	No	No	No	No	RPOA	No	Yes	Yes	No	No	No
Bahamas	Yes	No	Yes	No	Yes	RPOA	Yes	Yes	Yes	No	No	No
Barbados	No	No	No	No	No	RPOA	Yes	Yes	Yes	Yes	No	No
Belize	No	Yes	Yes	NPOA‡, RPOA	Yes	NPOA, RPOA	No	Yes	Yes	Yes	No	No
Bermuda	No	No	Yes	No	No	RPOA	No	Yes	Yes	Yes	Yes	Yes
Bonaire	Yes	Yes	Yes	No	Yes	RPOA	No	Yes	Yes	No	Yes	Yes

Country	Shark fishing ban	Ray fishing ban	Finning ban	NPOA– or RPOA– Sharks¶	Other regulations	NPOA– or RPOA–IUU	PSM	WECAFC ††	CITES ‡‡	ICCAT §§	CMS ¶¶	CMS Sharks MoU†††
Brazil	No	No	Yes	NPOA	Yes	RPOA	No	Yes	Yes	Yes	Yes	Yes
British Virgin Islands	Yes	Yes	Yes	No	Yes	RPOA	No	Yes	Yes	Yes	Yes	Yes
Cayman Islands	Yes	Yes	Yes	No	No	RPOA	No	Yes	Yes	Yes	Yes	Yes
Colombia	Yes	Yes	Yes	NPOA	Yes	RPOA	No	Yes	Yes	No	No	Yes
Costa Rica	No	No	Yes	NPOA, RPOA	Yes	RPOA	Yes	Yes	Yes	Coop.	Yes	Yes
Cuba	No	No	Yes	NPOA	Yes	RPOA	Yes	Yes	Yes	No	Yes	No
Curaçao	No	No	No	No	No	RPOA	No	Yes	Yes	Yes	Yes	No
Dominica	No	No	No	No	No	RPOA	Yes	Yes	Yes	No	No	No
Dominican Republic	Yes	Yes	Yes	RPOA	Yes	RPOA	No	Yes	Yes	No	Yes	No
French Guiana	No	No	Yes	No	Yes	RPOA	Yes	Yes	Yes	Yes	Yes	Yes
Grenada	No	No	No	No	No	RPOA	Yes	Yes	Yes	Yes	No	No
Guadeloupe	No	No	Yes	No	Yes	RPOA	Yes	Yes	Yes	Yes	Yes	Yes
Guatemala	No	No	Yes	NPOA, RPOA	Yes	RPOA	No	Yes	Yes	Yes	No	No
Guyana	No	No	Yes	No	No	RPOA	Yes	Yes	Yes	Coop.	No	No
Haiti	No	No	No	No	No	RPOA	No	Yes	No	No	No	No
Honduras	Yes†	No	Yes	RPOA	Yes	RPOA	No	Yes	Yes	Yes	Yes	No
Jamaica	No	No	No	No	No	RPOA	No	Yes	Yes	No	Sig.	No
Martinique	No	No	Yes	No	Yes	RPOA	Yes	Yes	Yes	Yes	Yes	Yes
Mexico	No	No	Yes	NPOA	Yes	RPOA	No	Yes	Yes	Yes	No	No
Montserrat	No	No	No	No	No	RPOA	No	Yes	Yes	Yes	Yes	Yes
Nicaragua	No	No	Yes	NPOA, RPOA	No	RPOA	Yes	Yes	Yes	Yes	No	No
Panamá	No	No	Yes	NPOA, RPOA	Yes	RPOA	Yes	Yes	Yes	Yes	Yes	No
Puerto Rico	No	No	Yes	NPOA	Yes	NPOA, RPOA	Yes	Yes	Yes	Yes	No	Yes
Saba	Yes	Yes	Yes	No	Yes	RPOA	No	Yes	Yes	No	Yes	Yes
Saint Kitts and Nevis	No	No	No	No	No	NPOA, RPOA	Yes	Yes	Yes	No	No	No
Saint Lucia	No	No	No	No	No	RPOA	No	Yes	Yes	No	No	No

Country	Shark fishing ban	Ray fishing ban	Finning ban	NPOA– or RPOA– Sharks¶	Other regulations	NPOA– or RPOA–IUU	PSM	WECAFC ††	CITES ‡‡	ICCAT §§	CMS ¶¶	CMS Sharks MoU†††
Saint Vincent & the Grenadines	No	No	Yes	No	No	RPOA	Yes	Yes	Yes	Yes	No	No
Sint Maarten	Yes	Yes	Yes	No	Yes	RPOA	No	Yes	Yes	No	Yes	No
St. Barthelemy	No	No	Yes	No	Yes	RPOA	Yes	Yes	Yes	No	Yes	Yes
St. Eustatius	Yes	Yes	Yes	No	Yes	RPOA	No	Yes	Yes	No	Yes	Yes
St. Martin	No	No	Yes	No	Yes	RPOA	Yes	Yes	Yes	Yes	Yes	Yes
Suriname	No	No	No	No	No	RPOA	No	Yes	Yes	Coop.	No	No
Trinidad & Tobago	No	No	Yes	No	No	RPOA	Yes	Yes	Yes	Yes	Yes	No
Turks and Caicos Islands	No	No	No	No	Yes	RPOA	No	Yes	Yes	Yes	Yes	Yes
United States	No	No	Yes	NPOA	Yes	NPOA, RPOA	Yes	Yes	Yes	Yes	No	Yes
Venezuela	No	No	Yes	NPOA	Yes	RPOA	No	Yes	Yes	Yes	No	No
Virgin Islands	No	No	Yes	NPOA	Yes	NPOA, RPOA	Yes	Yes	Yes	Yes	No	Yes
<b>Percent Participation</b>	<b>22.2</b>	<b>20.0</b>	<b>71.1</b>	<b>35.6</b>	<b>60.0</b>	<b>100</b>	<b>44.4</b>	<b>100</b>	<b>97.8</b>	<b>64.4</b>	<b>53.3</b>	<b>42.2</b>

† Formed in 2011, but modified in 2016 to allow the retention and sale of incidentally caught sharks.

‡ NPOA specifically for sharks on the high seas.

§ Lawson and Fordham (2018)

¶ Note that there is a draft WECAFC Regional Plan of Action that has yet to be adopted. <http://www.fao.org/ipoa-sharks/national-and-regional-plans-of-action/en/>

†† Members: <http://www.fao.org/fishery/rfb/wecafc/en#Org-OrgsInvolved>

‡‡ Parties: [https://cites.org/eng/disc/parties/chronolo.php?order=field\\_official\\_name&sort=asc](https://cites.org/eng/disc/parties/chronolo.php?order=field_official_name&sort=asc)

§§ Parties: <https://iccat.int/en/contracting.html>

¶¶ Parties: <https://www.cms.int/en/parties-range-states>

††† Parties: <https://www.cms.int/sharks/en/signatories-range-states>

‡‡‡ Parties: <https://www.car-spaw-rac.org/?Who-we-are>

## Supporting Information

**Table S1:** List of chondrichthyans included in this review, including their category of extinction risk according to global assessments by the IUCN, their CITES Appendix, CMS Appendix, and SPAW Annex status, and results of stock assessments according to the United States or ICCAT by region (where ‘Atl’ is Atlantic and ‘GoM’ is Gulf of Mexico). Overfishing refers to fishing mortality being higher than it is at maximum sustainable yield and overfished refers to a stock having a low population size that threatens its ability to reach maximum sustainable yield. Species are organized alphabetically within broad taxonomic groups

Group	Scientific Name <sup>†,‡</sup>	Common Name	IUCN	CITES <sup>§</sup>	CMS <sup>¶</sup>	SPAW <sup>††</sup>	Stock Assessment Results <sup>‡‡</sup>		
							Overfishing	Overfished	Region
Sharks	<i>Alopias superciliosus</i>	Bigeye Thresher Shark	VU	II	II		Unknown	Unknown	Atl
	<i>Alopias vulpinus</i>	Common Thresher Shark	VU	II	II		Unknown	Unknown	Atl, GoM
	<i>Apristurus canutus</i> <sup>†</sup>	Hoary Catshark	LC						
	<i>Apristurus parvipinnis</i> <sup>†</sup>	Smallfin Catshark	LC						
	<i>Apristurus riveri</i> <sup>†</sup>	Broadgill Catshark	LC						
	<i>Carcharhinus acronotus</i>	Blacknose Shark	EN				Yes	Yes	Atl
	<i>Carcharhinus altimus</i>	Bignose Shark	NT				Unknown	Unknown	Atl
	<i>Carcharhinus brevipinna</i>	Spinner Shark	VU				Unknown	Unknown	Atl, GoM
	<i>Carcharhinus falciformis</i>	Silky Shark	VU	II	II	III	Unknown	Unknown	Atl, GoM
	<i>Carcharhinus galapagensis</i>	Galapagos Shark	LC				Unknown	Unknown	Atl
	<i>Carcharhinus isodon</i>	Finetooth Shark	NT				No	No	Atl, GoM
	<i>Carcharhinus leucas</i>	Bull Shark	VU				Unknown	Unknown	Atl, GoM
	<i>Carcharhinus limbatus</i>	Blacktip Shark	VU				No	No	Atl, GoM
	<i>Carcharhinus longimanus</i>	Oceanic Whitetip Shark	CR	II	I	III	Unknown	Unknown	Atl, GoM
	<i>Carcharhinus obscurus</i>	Dusky Shark	EN		II		Yes	Yes	Atl, GoM
	<i>Carcharhinus perezi</i>	Caribbean Reef Shark	EN				Unknown	Unknown	Atl
	<i>Carcharhinus plumbeus</i>	Sandbar Shark	EN				No	Yes	Atl, GoM
	<i>Carcharhinus porosus</i>	Smalltail Shark	CR				Unknown	Unknown	Atl
	<i>Carcharhinus signatus</i>	Night Shark	EN				Unknown	Unknown	Atl
	<i>Carcharias taurus</i>	Sand Tiger Shark	CR				Unknown	Unknown	Atl
<i>Carcharodon carcharias</i>	White Shark	VU	II	I		Unknown	Unknown	Atl	



Group	Scientific Name <sup>†,‡</sup>	Common Name	IUCN	CITES <sup>§</sup>	CMS <sup>¶</sup>	SPA <sup>W††</sup>	Stock Assessment Results <sup>‡‡</sup>		
							Overfishing	Overfished	Region
	<i>Centrophorus granulosus</i>	Gulper Shark	EN						
	<i>Centrophorus uyato</i>	Little Gulper Shark	EN						
	<i>Centroscyllium fabricii</i>	Black Dogfish	LC						
	<i>Centroscymnus coelolepis</i>	Portuguese Dogfish	NT						
	<i>Centroscymnus owstonii</i>	Roughskin Dogfish	VU						
	<i>Cetorhinus maximus</i>	Basking Shark	EN	II	I		Unknown	Unknown	Atl
	<i>Chlamydoselachus anguineus</i>	Frilled Shark	LC						
	<i>Cirrhigaleus asper</i>	Roughskin Spurdog	DD						
	<i>Dalatias licha</i>	Kitefin Shark	VU						
	<i>Deania profundorum</i>	Arrowhead Dogfish	NT						
	<i>Echinorhinus brucus</i>	Bramble Shark	EN						
	<i>Eridacnis barbouri</i> <sup>†</sup>	Cuban Ribbontail Catshark	LC						
	<i>Etmopterus bigelowi</i>	Blurred Lanternshark	LC						
	<i>Etmopterus bullisi</i> <sup>†</sup>	Lined Lanternshark	LC						
	<i>Etmopterus carteri</i> <sup>†</sup>	Carter Gilbert's Lanternshark	LC						
	<i>Etmopterus gracilispinis</i>	Broadbanded Lanternshark	LC						
	<i>Etmopterus hillianus</i> <sup>‡</sup>	Caribbean Lanternshark	LC						
	<i>Etmopterus perryi</i> <sup>†</sup>	Dwarf Lanternshark	LC						
	<i>Etmopterus pusillus</i>	Smooth Lanternshark	LC						
	<i>Etmopterus robinsi</i> <sup>†</sup>	West Indian Lanternshark	LC						
	<i>Etmopterus schultzi</i> <sup>†</sup>	Fringefin Lanternshark	LC						
	<i>Etmopterus virens</i> <sup>†</sup>	Green Lanternshark	LC						
	<i>Galeocerdo cuvier</i>	Tiger Shark	NT				Unknown	Unknown	Atl, GoM
	<i>Galeus antillensis</i> <sup>†</sup>	Antilles Catshark	LC						
	<i>Galeus arae</i> <sup>†</sup>	Roughtail Catshark	LC						
	<i>Galeus cadenati</i> <sup>†</sup>	Longfin Sawtail Catshark	LC						
	<i>Galeus springeri</i> <sup>†</sup>	Springer's Sawtail Catshark	LC						
	<i>Ginglymostoma cirratum</i>	Atlantic Nurse Shark	VU				Unknown	Unknown	Atl, GoM
	<i>Heptranchias perlo</i>	Sharpnose Sevengill shark	NT				Unknown	Unknown	Atl
	<i>Hexanchus griseus</i>	Bluntnose Sixgill Shark	NT				Unknown	Unknown	Atl

Group	Scientific Name <sup>†,‡</sup>	Common Name	IUCN	CITES <sup>§</sup>	CMS <sup>¶</sup>	SPA <sup>W††</sup>	Stock Assessment Results <sup>‡‡</sup>		
							Overfishing	Overfished	Region
	<i>Hexanchus vitulus</i> <sup>†</sup>	Atlantic Sixgill Shark	LC				Unknown	Unknown	Atl
	<i>Isistius brasiliensis</i>	Smalltooth Cookie-cutter Shark	LC						
	<i>Isistius plutodus</i>	Largetooth Cookie-cutter Shark	LC						
	<i>Isogomphodon oxyrinchus</i>	Daggernose Shark	CR						
	<i>Isurus oxyrinchus</i>	Shortfin Mako Shark	EN	II	II		Yes	Yes	North Atl (ICCAT)
	<i>Isurus paucus</i>	Longfin Mako Shark	EN	II	II		Unknown	Unknown	Atl
	<i>Lamna nasus</i>	Porbeagle	VU	II	II		No	Yes	Northwest Atl (ICCAT)
	<i>Megachasma pelagios</i>	Megamouth Shark	LC						
	<i>Mitsukurina owstoni</i>	Goblin Shark	LC						
	<i>Mollisquama mississippiensis</i> <sup>†</sup>	American Pocket Shark	LC						
	<i>Mustelus canis</i>	Dusky Smoothhound	NT				No	No	Atl; GoM smoothhound complex
	<i>Mustelus higmani</i>	Smalleye Smoothhound	EN						
	<i>Mustelus minicanis</i> <sup>†</sup>	Venezuelan Dwarf Smoothhound	EN						
	<i>Mustelus norrisi</i>	Narrowfin Smoothhound	NT				No	No	GoM smoothhound complex
	<i>Mustelus sinusmexicanus</i> <sup>†</sup>	Gulf of Mexico Smoothhound	LC				No	No	GoM smoothhound complex
	<i>Negaprion brevirostris</i>	Lemon Shark	VU				Unknown	Unknown	Atl, GoM
	<i>Odontaspis ferox</i>	Ragged-tooth Shark	VU						
	<i>Odontaspis noronhai</i>	Bigeye Sand Tiger	LC				Unknown	Unknown	Atl
	<i>Oxynotus caribbaeus</i> <sup>†</sup>	Caribbean Roughshark	LC						
	<i>Parmaturus campechiensis</i> <sup>†</sup>	Campeche Catshark	LC						
	<i>Prionace glauca</i>	Blue Shark	NT		II		No	No	North Atl (ICCAT)
	<i>Pristiophorus schroederi</i> <sup>†</sup>	Bahamas Sawshark	LC						

Group	Scientific Name <sup>†,‡</sup>	Common Name	IUCN	CITES <sup>§</sup>	CMS <sup>¶</sup>	SPAW <sup>††</sup>	Stock Assessment Results <sup>‡‡</sup>		
							Overfishing	Overfished	Region
	<i>Pseudocarcharias kamoharai</i>	Crocodile Shark	LC						
	<i>Pseudotriakis microdon</i>	False Catshark	LC						
	<i>Rhincodon typus</i>	Whale Shark	EN	II	I	III	Unknown	Unknown	Atl
	<i>Rhizoprionodon lalandii</i>	Brazilian Sharpnose Shark	VU						
	<i>Rhizoprionodon porosus</i>	Caribbean Sharpnose Shark	VU				Unknown	Unknown	Atl
	<i>Rhizoprionodon terraenovae</i>	Atlantic Sharpnose Shark	LC				No	No	Atl, GoM
	<i>Schroederichthys maculatus</i> <sup>†</sup>	Narrowtail Catshark	LC						
	<i>Schroederichthys tenuis</i> <sup>‡</sup>	Slender Catshark	LC						
	<i>Scyliorhinus boa</i>	Boa Catshark	LC						
	<i>Scyliorhinus hesperius</i> <sup>†</sup>	Whitesaddled Catshark	LC						
	<i>Scyliorhinus meadi</i> <sup>†</sup>	Blotched Catshark	LC						
	<i>Scyliorhinus retifer</i> <sup>‡</sup>	Chain Catshark	LC						
	<i>Scyliorhinus torrei</i> <sup>†</sup>	Cuban Catshark	LC						
	<i>Somniosus microcephalus</i>	Greenland Shark	VU						
	<i>Somniosus rostratus</i>	Little Sleeper Shark	LC						
	<i>Sphyrna gilberti</i>	Carolina Hammerhead	DD						
	<i>Sphyrna lewini</i>	Scalloped Hammerhead	CR	II	II	III	Yes	Yes	Atl, GoM
	<i>Sphyrna media</i>	Scoophead Shark	CR						
	<i>Sphyrna mokarran</i>	Great Hammerhead Shark	CR	II	II	III	Unknown	Unknown	Atl, GoM
	<i>Sphyrna tiburo</i>	Bonnethead Shark	EN				Unknown	Unknown	Atl, GoM
	<i>Sphyrna tudes</i>	Smalleye Hammerhead	CR						
	<i>Sphyrna zygaena</i>	Smooth Hammerhead Shark	VU	II	II	III	Unknown	Unknown	Atl, GoM
	<i>Squaliolus laticaudus</i>	Spined Pygmy Shark	LC						
	<i>Squalus acanthias</i>	Spiny Dogfish	VU		II		No	No	Atl Coast
	<i>Squalus clarkae</i> <sup>‡</sup>	Genie's Dogfish	LC						
	<i>Squalus cubensis</i>	Cuban Dogfish	LC						
	<i>Squatina david</i> <sup>†</sup>	David's Angelshark	NT						
	<i>Squatina dumeril</i> <sup>‡</sup>	Sand Devil	LC				Unknown	Unknown	Atl
	<i>Zameus squamulosus</i>	Velvet Dogfish	LC						
Rays	<i>Aetobatus narinari</i>	Whitespotted Eagle Ray	EN						

Group	Scientific Name <sup>†,‡</sup>	Common Name	IUCN	CITES <sup>§</sup>	CMS <sup>¶</sup>	SPAW <sup>††</sup>	Stock Assessment Results <sup>‡‡</sup>		
							Overfishing	Overfished	Region
	<i>Bathytoshia centroura</i>	Roughtail Stingray	VU						
	<i>Benthobatis marcida</i> <sup>†</sup>	Caribbean Blind Numbfish	LC						
	<i>Breviraja claramaculata</i> <sup>†</sup>	Brightspot Skate	LC						
	<i>Breviraja colesi</i> <sup>†</sup>	Lightnose Skate	LC						
	<i>Breviraja mouldi</i> <sup>†</sup>	Mould's Skate	LC						
	<i>Breviraja nigriventralis</i> <sup>†</sup>	Blackbelly Shortskate	LC						
	<i>Breviraja spinosa</i> <sup>†</sup>	Spinose Skate	LC						
	<i>Cruriraja atlantis</i> <sup>†</sup>	Atlantic Pygmy Skate	LC						
	<i>Cruriraja cadenati</i> <sup>†</sup>	Broadfoot Pygmy Skate	LC						
	<i>Cruriraja poeyi</i> <sup>†</sup>	Poey's Pygmy Skate	LC						
	<i>Cruriraja rugosa</i> <sup>‡</sup>	Rough Pygmy Skate	LC						
	<i>Dactylobatus armatus</i> <sup>†</sup>	Skillet Skate	LC						
	<i>Dactylobatus clarkia</i>	Hook Skate	LC						
	<i>Diplobatis colombiensis</i> <sup>†</sup>	Colombian Electric Ray	VU						
	<i>Diplobatis guamachensis</i> <sup>†</sup>	Brownband Numbfish	VU						
	<i>Diplobatis picta</i> <sup>‡</sup>	Painted Dwarf Numbfish	VU						
	<i>Dipturus bullisi</i> <sup>‡</sup>	Tortugas Skate	LC						
	<i>Dipturus garricki</i> <sup>‡</sup>	San Blas Skate	LC						
	<i>Dipturus olseni</i> <sup>†</sup>	Spreadfin Skate	LC						
	<i>Dipturus oregoni</i> <sup>†</sup>	Hooktail Skate	LC						
	<i>Dipturus teevani</i>	Caribbean Skate	LC						
	<i>Fenestraja atripinna</i> <sup>†</sup>	Blackfin Pygmy Skate	LC						
	<i>Fenestraja cubensis</i> <sup>†</sup>	Cuban Pygmy Skate	LC						
	<i>Fenestraja ishiyamai</i> <sup>†</sup>	Plain Pygmy Skate	LC						
	<i>Fenestraja plutonia</i> <sup>†</sup>	Pluto Pygmy Skate	LC						
	<i>Fenestraja sinusmexicanus</i> <sup>†</sup>	Gulf Pygmy Skate	LC						
	<i>Fontitrygon geijskesi</i>	Wingfin Stingray	CR						
	<i>Gurgesiella atlantica</i> <sup>‡</sup>	Atlantic Pygmy Skate	LC						
	<i>Gymnura altavela</i>	Spiny Butterfly Ray	EN						
	<i>Gymnura lessae</i> <sup>‡</sup>	Lessa's Butterfly Ray	LC						

Group	Scientific Name <sup>†,‡</sup>	Common Name	IUCN	CITES <sup>§</sup>	CMS <sup>¶</sup>	SPA <sup>W††</sup>	Stock Assessment Results <sup>‡‡</sup>		
							Overfishing	Overfished	Region
	<i>Gymnura micrura</i>	Smooth Butterfly Ray	NT						
	<i>Hypanus americanus</i>	Southern Stingray	NT						
	<i>Hypanus guttatus</i>	Longnose Stingray	NT						
	<i>Hypanus sabinus</i> <sup>‡</sup>	Atlantic Stingray	LC						
	<i>Hypanus say</i>	Bluntnose Stingray	NT						
	<i>Leucoraja garmani</i>	Rosette Skate	LC						
	<i>Leucoraja lentiginosa</i> <sup>†</sup>	Freckled Skate	LC						
	<i>Leucoraja yucatanensis</i> <sup>†</sup>	Yucatán Skate	LC						
	<i>Mobula birostris</i>	Oceanic Manta Ray	EN	II	I		III		
	<i>Mobula hypostoma</i>	Lesser Devilray	EN	II	I				
	<i>Mobula mobular</i>	Giant Devilray	EN	II	I				
	<i>Mobula tarapacana</i>	Chilean Devilray	EN	II	I				
	<i>Mobula thurstoni</i>	Bentfin Devilray	EN	II	I				
	<i>Myliobatis freminvillii</i>	Bullnose Ray	VU						
	<i>Myliobatis goodei</i>	Southern Eagle Ray	VU						
	<i>Narcine bancroftii</i> <sup>†</sup>	Caribbean Numbfish	LC						
	<i>Neoraja carolinensis</i> <sup>†</sup>	Carolina Dwarf Skate	LC						
	<i>Pristis pectinate</i>	Smalltooth Sawfish	CR	I	I		II		
	<i>Pristis pristis</i>	Large-tooth Sawfish	CR	I	I		II		
	<i>Pseudobatos lentiginosus</i> <sup>‡</sup>	Atlantic Guitarfish	VU						
	<i>Pseudobatos percellens</i>	Southern Guitarfish	EN						
	<i>Pseudoraja fischeri</i> <sup>†</sup>	Fanfin Skate	LC						
	<i>Pteroplatytrygon violacea</i>	Pelagic Stingray	LC						
	<i>Rajella fuliginea</i> <sup>†</sup>	Sooty Skate	LC						
	<i>Rajella purpuriventralis</i> <sup>†</sup>	Purplebelly Skate	LC						
	<i>Rhinoptera bonasus</i>	American Cownose Ray	VU						
	<i>Rhinoptera brasiliensis</i>	Brazilian Cownose Ray	VU						
	<i>Rostroraja ackleyi</i> <sup>†</sup>	Ocellate Skate	LC						
	<i>Rostroraja bahamensis</i> <sup>†</sup>	Bahama Skate	LC						
	<i>Rostroraja cervigoni</i> <sup>†</sup>	Venezuela Skate	NT						



Group	Scientific Name <sup>†,‡</sup>	Common Name	IUCN	CITES <sup>§</sup>	CMS <sup>¶</sup>	SPAW <sup>††</sup>	Stock Assessment Results <sup>‡‡</sup>		
							Overfishing	Overfished	Region
	<i>Rostroraja eglanteria</i>	Clearnose Skate	LC						
	<i>Rostroraja texana</i> <sup>†</sup>	Roundel Skate	LC						
	<i>Schroederobatis americana</i> <sup>†</sup>	American Legskate	LC						
	<i>Springeria folirostris</i> <sup>†</sup>	Leafnose Legskate	LC						
	<i>Springeria longirostris</i> <sup>†</sup>	Longnose Legskate	LC						
	<i>Styracura schmardae</i> <sup>‡</sup>	Chupare Stingray	EN						
	<i>Tetronarce occidentalis</i>	Western Atlantic Torpedo Ray	LC						
	<i>Torpedo andersoni</i> <sup>†</sup>	Caribbean Torpedo	LC						
	<i>Urobatis jamaicensis</i> <sup>†</sup>	Yellow Stingray	LC						
	<i>Urotrygon microphthalmum</i>	Smalleye Round Ray	CR						
	<i>Urotrygon venezuelae</i> <sup>†</sup>	Venezuelan Round Ray	EN						
Ghost Sharks	<i>Chimaera bahamaensis</i> <sup>†</sup>	Bahamas Ghostshark	LC						
	<i>Chimaera cubana</i> <sup>†</sup>	Cuban Chimaera	LC						
	<i>Hydrolagus alberti</i> <sup>†</sup>	Gulf Chimaera	LC						
	<i>Hydrolagus mirabilis</i>	Large-eyed Rabbitfish	LC						
	<i>Neoharriotta carri</i> <sup>†</sup>	Dwarf Sicklefins Chimaera	NT						
	<i>Rhinochimaera atlantica</i>	Broadnose Chimaera	LC						

<sup>†</sup>Endemic to FAO Area 31

<sup>‡</sup>Near-endemic to FAO Area 31

<sup>§</sup>Convention on International Trade in Endangered Species of Wild Fauna and Flora. Retrieved from:

<https://cites.org/eng/app/appendices.php>

<sup>¶</sup>Memorandum of Understanding on the Conservation of Migratory Sharks. Retrieved from: <https://www.cms.int/sharks/en/species>

<sup>††</sup>Specially Protected Areas and Wildlife. Retrieved from: <http://www.car-spaw->

[rac.org/IMG/pdf/annexes\\_i\\_ii\\_iii\\_of\\_spaw\\_protocol\\_revised\\_cop10\\_honduras\\_2019.pdf](http://www.car-spaw-rac.org/IMG/pdf/annexes_i_ii_iii_of_spaw_protocol_revised_cop10_honduras_2019.pdf)

<sup>‡‡</sup>Stock status updates as of June 30, 2021. Results retrieved from: <https://www.fisheries.noaa.gov/national/population-assessments/fishery-stock-status-updates> and [https://www.iccat.int/Documents/Meetings/Docs/2017\\_SCRS\\_REP\\_ENG.pdf](https://www.iccat.int/Documents/Meetings/Docs/2017_SCRS_REP_ENG.pdf)

**Table S2:** Conservation responsibilities (CoRs) for all chondrichthyans in the Western Central Atlantic Ocean across 44 countries and territories as well as international waters. CoR is a function of extinction risk and proportional species distributions within a given jurisdiction and is normalized from 0 to 1

Country	CoR
United States	1.0000
Venezuela	0.4655
International waters	0.4121
Mexico	0.3330
Guyana	0.2152
The Bahamas	0.1997
Suriname	0.1827
Colombia	0.1726
French Guiana (France)	0.1641
Nicaragua	0.1141
Cuba	0.0962
Honduras	0.0859
Trinidad & Tobago	0.0841
Bermuda (UK)	0.0673
Dominican Republic	0.0389
Panama	0.0358
Jamaica	0.0274
Puerto Rico (USA)	0.0250
Turks and Caicos Islands (UK)	0.0222
Haiti	0.0199
Belize	0.0185
Aruba (Netherlands)	0.0143
Barbados	0.0138
Cayman Islands (UK)	0.0124
Antigua & Barbuda	0.0121
Anguilla (UK)	0.0100
Guadeloupe (France)	0.0094
British Virgin Islands (UK)	0.0093
Grenada	0.0088
Brazil	0.0087
Bonaire/St. Eustatius/Saba (Netherlands)	0.0078
Costa Rica	0.0073
US Virgin Islands (USA)	0.0064
Curaçao (Netherlands)	0.0058

Country	CoR
Saint Vincent & the Grenadines	0.0057
Martinique (France)	0.0053
Dominica	0.0032
Saint Kitts and Nevis	0.0025
Saint Martin, Saint Barthelemy (France)	0.0024
Saint Lucia	0.0022
Colombia/ Jamaica	0.0019
Guatemala	0.0012
Montserrat (UK)	0.0011
Sint Maarten	0.0002
Disputed Barbados/Trinidad & Tobago	0.0001

**Table S3:** See separate Excel file.

**Table S4:** Chondrichthyan Management Responsibility Scores ('CMR Score') for countries in the Western Central Atlantic Ocean. CMR Score is a function of each country's engagement with thirteen management tools that range from national-level fishing bans to participation in international trade agreements (called Management Engagement), extinction risk and proportional species distributions within a given jurisdiction (called Conservation Responsibility), and total reconstructed catch of sharks and rays from 1950 to 2016. CMR Scores are normalized from 0 to 1, where the highest score (USA) was assigned a 1. The higher the CMR Score, the more unmitigated responsibility to manage sharks and rays. Note that some territories were omitted due to the nature of the underlying data

Country	Chondrichthyan Management Responsibility Score
United States	1.00000
Venezuela	0.53274
Mexico	0.34925
Guyana	0.03942
Suriname	0.03300
Cuba	0.03150
Jamaica	0.01373
French Guiana (France)	0.01135
Dominican Republic	0.01055
Trinidad & Tobago	0.01025
Nicaragua	0.00933
Colombia	0.00222

Belize	0.00178
Barbados	0.00034
The Bahamas	0.00025
Honduras	0.00014
Turks and Caicos Islands (UK)	0.00010
Martinique (France)	0.00009
Panama	0.00006
Bermuda (UK)	0.00005
Costa Rica	0.00005
Antigua & Barbuda	0.00004
Grenada	0.00003
Aruba	0.00001
Saint Vincent & the Grenadines	0.00001
Guadeloupe (France)	0.00001
Cayman Islands (UK)	0.00001
Curaçao (Netherlands)	0.00001
Haiti	0.00001
Saint Martin, St. Barthelemy, Sint Maarten (France, Netherlands)	0.00001
Saint Lucia	0.00000
Bonaire, Sint Eustatius, Saba (Netherlands)	0.00000
Guatemala	0.00000
Dominica	0.00000
British Virgin Islands (UK)	0.00000
Brazil	0.00000
Anguilla (UK)	0.00000
Montserrat (UK)	0.00000
Puerto Rico (USA)	0.00000
Saint Kitts and Nevis	0.00000

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