So Excellent a Fishe: A global overview of legal marine turtle fisheries.

Short title: Global overview of legal marine turtle fisheries.

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ABSTRACT

Aim

We provide a global assessment of the current legal direct take of marine turtles, including the scale and species breakdown at country level, and investigate the significance of legal take to marine turtle populations within the wider context of global threats.

Location

World-wide

Methods

We undertook a comprehensive review of literature (>500 publications) and contacted over 150 in-country experts to collate data for countries that permit the legal take of marine turtles (as of 1st January 2013). Current annual take for each country and species was estimated, and estimates were generated for the 1980s, 1990s and 2000s.

Results

Currently 42 countries and territories permit direct take of turtles and collectively take in excess of 42,000 turtles per year, the majority of which (>80%) are green turtles *Chelonia mydas* (Linnaeus 1758). Ten countries account for more than 90% of legal take each year with Papua New Guinea (36.1%) and Nicaragua (22.3%) accounting for more than half of the total global take. Since 1980 we estimate that more than 2 million turtles have been legally taken in these countries, with current levels <60% of those in the 1980s.

Main conclusions

Our results provide the most comprehensive global synthesis of the legal take of turtles in recent years and suggest that legal take has the potential to be a driver of marine turtle population dynamics, comparable to mortality estimates through recorded bycatch. However, it is likely that illegal take, along with bycatch, are significantly under-recorded and far

45 greater than the total level of directed legal take. This hampers the ability to assess the
46 relative impacts of these threats to marine turtles.
47
48 Keywords: direct take, global, legal fisheries, legislation, marine turtle, traditional fisheries
49
50 **(A) INTRODUCTION**
51 Widescale commercial exploitation is thought to have contributed significantly to the global
52 decline in marine turtle populations (Lewis, 1940; Stoddart, 1980; Jackson 1997; National
53 Marine Fisheries Service & U.S. Fish and Wildlife Service, 1998; Broderick *et al.,* 2006;
54 Cornelius *et al*., 2007) leaving many populations at relictual levels (McClenachan *et al*.,
55 2006; Pritchard, 2003; Bell *et al*., 2007). However, the direct take of nesting and foraging
56 marine turtles for meat, shell and other products has taken place for millennia (Groombridge
57 & Luxmoore, 1989; Frazier, 2003; Daley *et al.*, 2008). Artisanal and subsistence take, as part
58 of longstanding traditional fisheries, primarily for local consumption, may historically have
59 been at more sustainable levels (Frazier, 1980), but levels of exploitation increased radically
60 upon western colonisation of the new world (Babcock, 1938; Wayne King, 1995; Mrosovsky
61 1996). Quickly, some of this take proved unsustainable, with the first marine turtle harvest
62 legislation instigated in Bermuda in 1620 to protect "..so excellente a fishe..", prohibiting
63 taking any turtle "under Eighteen inches in the Breadth or Dyameter" (Babcock, 1938;
64 Godley *et al.*, 2004).
65
66 Notwithstanding, large-scale commercial take in areas with remaining abundance continued,
67 with global capture peaking at over 17,000 tonnes in the late 1960s (FAO, 2011), principally
68 fuelled by commercial-scale exploitation and international trade (Fleming, 2001; van Dijk &
69 Shepherd, 2004). For example, during the peak of Mexico's sea turtle exploitation in 1968, it

is estimated that the national take was over 380,000 turtles (Cantú & Sanchez, 1999). The continued international trade of turtle products in the latter half of the 20th century meant that over 2 million turtles (hawksbill *Eretmochelys imbricata*, Linnaeus 1766; green *Chelonia mydas* and olive ridleys *Lepidochelys olivacea*, Eschscholtz, 1829) would have been needed to produce the volume of marine turtle products imported into Japan between 1970 and 1986 (Milliken & Tokunaga, 1987). Against the backdrop of widespread commercial exploitation, a decline in traditional and small-scale turtle fisheries also occurred (Frazier, 1980; Allen, 2007; Bell *et al*., 2010), resulting from increased pressures from human populations and more efficient capture methods (Brikke 2009), often with a corresponding breakdown of associated cultural rituals that would have once promoted more sustainable take levels (Hickey, 2003; Allen, 2007).

Increased conservation awareness at the international scale has led to greater protection of marine turtles and a series of multilateral agreements with associated enabling local legislation coming into force to restrict the trade of turtle products, such as the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) in 1975, which helped to reduce demand and promote regional cooperation in increasing turtle populations. By 1980, 59 countries were signatories to CITES rising to 178 in 2013; and, although subject to considerable debate, marine turtle species have been listed on the IUCN Red List of threatened Species since 1982 (Mrosovsky, 2003; IUCN, 2013).

Despite increasing levels of protection, the direct take of turtles has continued legally in many regions and countries (Bräutigam & Eckert, 2006; Maison *et al*., 2010). Permitted take now tends to be characterised by subsistence use by traditional coastal groups, or small-scale fisheries supplying local markets with meat, and sometimes shell (Bräutigam & Eckert, 2006;

95 Limpus, 2008, Maison *et al*., 2010). The fisheries continue to be an important source of
96 finance, protein and cultural identity in these parts of the world (Hamann *et al*., 2006; Vander
97 Velde, 2008). Although the nature of these permitted fisheries vary greatly among countries
98 and regions, many have been subject to increasing regulations over the past 30 years, with
99 specific legislation put in place to help manage direct take, often limiting species, number,
100 timing or size of turtles targeted (Bräutigam & Eckert, 2006). There is, however, a paucity of
101 information on the direct take from these fisheries at present, despite often being listed as one
102 of the major threats to marine turtle populations (Wallace *et al*., 2010; IUCN, 2013). Here we
103 set out to assess the current legal direct take (hereafter referred to as legal take) of marine
104 turtles globally; as well as recent trends within those countries.
105
106 **(A) METHODS**
107 **(B) Focal countries**
108 In this study we focussed on coastal countries or territories, hereafter referred to as countries,
109 which currently (as of 1st January 2013) permit the legal take of marine turtles and are
110 geographically between 40°N and 40°S. This region covers the majority of the known range
111 of hard-shelled marine turtle species (IUCN 2013). Although some marine turtle species can
112 occur outside this range, there is no significant direct turtle take documented outside these
113 latitudes. Legalised egg harvest was not included in this study.
114
115 The national legislation within these countries was further classified as allowing marine turtle
116 take if protection was absent, unverifiable, incomplete or temporary. National legislation was
117 classified into one of five categories: protection absent (N), legislation allows for a level of
118 directed take of one or more species of turtles (L), full protection but traditional hunting
119 exemptions exist (T), moratorium in place at present (M) and unable to verify legislation (U).

120

121 **(B) Data compilation**

122 We searched relevant databases (eg. Web of Knowledge, Google Scholar, seaturtle.org, Sea
123 Turtle Bibliography at the Archie Carr Center for Sea Turtle Research, SPC Coastal Fisheries
124 Programme) and the broader internet using combinations of relevant keywords ('turtle' with
125 'take', 'harvest' or 'fishery'). Over 500 reports and papers were collated and reviewed to
126 compile data on legal take, with bycatch or incidental take data removed where possible. In
127 the first instance data from actual studies were prioritised, but in the absence of such data
128 estimates by experts found in literature or via personal communications were used. Where
129 data presented in the literature were unclear or incomplete, efforts were made to consult
130 relevant authors. Further consultation with expert individuals living in or known to work in
131 target nations (>150 contacted by email; 106 responded with information) was undertaken to
132 locate further reports and papers and ascertain best estimates of legal take since 1st January
133 2010.

134

135 Data for all seven species of marine turtles (green; hawksbill; loggerhead *Caretta caretta*,
136 Linnaeus 1758; olive ridley; leatherback *Dermochelys coriacea*, Vandelli 1761; Kemp's
137 ridley *Lepidochelys kempii*, Garman 1880; flatback turtle *Natator depressus*, Garman 1880),
138 were collated by country (see Table S1 in Supporting Information; see Appendix S1).

139

140 A median was calculated for any estimates given as ranges. Where a single estimate was
141 provided as an annual estimate for a number of years, the same value was used for each year
142 in the range. Estimates given as a total figure for a number of years were divided equally
143 among those years. Multiple estimates by different authors for the same year were averaged.
144 No attempt was made to extrapolate data where estimates were given for periods less than a

145 year, or when they were not countrywide estimates. In these cases, values were included as
146 minimum values.
147
148 In a small number of highlighted cases (see Table S1; n=8), international trade statistics in
149 bekko (hawksbill turtle shell) were used to calculate estimates for hawksbills, only where no
150 other data could be located. Conversions rates of bekko (kg) to number of turtles were
151 normally given by authors (eg. Fiji 0.7 – 1.1 kg bekko/turtle, Milliken & Tokunaga, 1987).
152
153 **(B) Creating annual estimates for each decade**
154 We calculated the median annual take for each decade (1980s, 1990s, 2000s) for each species
155 by country and for our current estimate the median annual take for the years 2010 -2012.
156
157 Data that had not been identified by species were only included in circumstances where we
158 were confident that the data were not duplicated within other studies. Data were then broken
159 down into species using the best available species composition information from additional
160 studies and reports from that country.
161
162 Where data were missing for a decade we used the temporally closest data to extrapolate. For
163 example where we only had data for the 1990s and 2000s we used the 1990's estimate for the
164 1980s. Where decadal data were only available for the 1980s and 2000s (n=4 countries), we
165 used what we considered would be the most similar estimate for the 1990s, in relation to any
166 changes in legislation or reports of increases/decreases in legal take. Where data for only one
167 decade existed (n = 8 countries), this was used for all other decades. To allow confidence to
168 be assigned to overall estimates, any "estimated" data are highlighted.
169

170 (C) *Current take*

171 Relevant expert individuals contacted between 2011 and 2013 were also asked for comments
172 on present day harvest compared to the last known study or report on take within a country. If
173 the expert was unable to answer or unable to confirm, then take was assumed to have been
174 unchanged from the most recent known estimate.

175

176 **(A) RESULTS**

177 **(B) Legislation**

178 As of 1st January 2013, a total of 42 countries permitted the direct take of marine turtles, four
179 countries had a moratorium on take (Anguilla, Chile, Fiji and the Maldives), although permits
180 for traditional purposes can be granted in Fiji; and four countries had legislation that could
181 not be verified (Algeria, North Korea, Panama and Somalia) (Fig. 1) (see Table S1 for
182 information on type or absence of legislation). A change of legislation to prohibit direct turtle
183 take occurred in three countries (Republic of Congo, South Korea and Trinidad and Tobago)
184 between 1st January 2010 and 1st January 2013. Data from these countries, and also those that
185 prohibited turtle take between 1980 and 2010, are not included in this study.

186

187 **(B) Take by species**

188 We estimate that currently, more than 42,000 marine turtles are caught each year as legal take
189 (n = 42 countries). Over 80% of these are green turtles (37,339; 88.5% of catch), with an
190 estimated 3,456 hawksbill turtles taken each year (8.2%) (Fig. 2). Fewer than 1500
191 loggerhead (1051; 2.5%), leatherback (62; 0.1%) and olive ridley (263; 0.6%) turtles are
192 estimated to be among those legally captured each year. Data on take of flatback turtles were
193 scarce with only a small amount recorded from Papua New Guinea and Australia,

194 approximately 18 turtles.yr^{-1} (Kare, 1995; Kennett *et al*., 1998). No data were found on legal
195 take of Kemp ridley's from 1980 to present day.
196
197 Green turtles were the only species permitted to be taken from all countries within this study,
198 with the exception of countries with a moratorium (although not including Fiji). Leatherbacks
199 had the highest degree of protection and were prohibited from take in 13 of the 42 focal
200 countries examined (31.0%).
201
202 **(B) Global distribution of take**
203 Current permitted take is concentrated in two regions: the wider Caribbean region accounts
204 for 34.6% (14,640 turtles.yr^{-1}) of estimated take from 16 countries (see inset Fig. 3; Fig. 4a)
205 and the Indo-Pacific region accounts for 63.3% (26,675 turtles.yr^{-1}) from 17 countries (Fig. 3;
206 Fig. 4b). No take was known to occur in four of the countries where it was legal (Bosnia and
207 Herzegovina, Niue, Pitcairn Islands and Wallis and Futuna). In 12 countries take was
208 unquantified: in three of these countries take was known to occur but no estimate was
209 available (Kiribati, Nauru, Syria), and nine of these countries only illegal take data were
210 found (Belize, Cayman Islands, Dominica, Indonesia, Atlantic coast of Mexico), including
211 four countries where a moratorium exists (Anguilla, Chile, Fiji, Maldives). Take from the
212 four countries where legislation could not be verified (Algeria, North Korea, Panama and
213 Somalia) is estimated to be 6600 green turtles.yr^{-1} and is not included in the 42,000 estimate
214 (Table S1). A breakdown of take by species for each country is available in Figs S2, S3 and
215 Table S1.
216
217 **(B) Take by country**

The top ten countries with permitted take account for 94.2% (39,716) of marine turtle take per year (Fig. 5). Papua New Guinea (15,217 turtles.yr^{-1}; 36.1%), Nicaragua (9,413 turtles.yr^{-1}; 22.3%) and Australia (6,638 turtles.yr^{-1}; 15.7%) together account for almost three quarters of current permitted take (74.1%; 31,268). Given the preponderance of green turtles, the top ten countries for this species are similar to those for overall take. Papua New Guinea, Australia and Nicaragua do not feature in the top ten for the other four species, apart from a small annual take of hawksbills from Papua New Guinea and Australia and a small annual take of loggerheads from Australia (see Fig. S4).

(B) Past take

The estimated change in annual permitted take of marine turtles in 46 countries that currently allow take of turtles (including the four with current moratoria) over the past 3 decades is illustrated in Fig. 6 and by species in Fig. S1. We estimate more than 2 million turtles have been taken by these countries since 1980. Take has decreased by more than 60% over the past three decades, from an estimated take of 116,420 turtles.yr^{-1} in the 1980s, 68,844 turtles.yr^{-1} in the 1990s and 45,172 in the 2000s with this downward trajectory apparently continuing.

One of the major changes in species taken over the past three decades has been in the cessation of the olive ridley take on the Pacific coast of Colombia from nearly 40,000 turtles.yr^{-1} in the early 1980s to fewer than ten per year in the 1990s and 2000s (see Fig. S1c). There have also been declines in the other four prevalent species since the 1980s within these countries. There has been a >40% decline in green take since the 1980s, a >60% decline in hawksbill and leatherback take and a >30% decline in loggerhead take.

Although it has not been possible to fully separate all legal and illegal take from data from these countries, there is also some illegal take recorded (see Table S1; see Appendix S1). It is estimated that currently some additional 13,150 turtles are illegally taken in these 46 countries each year. Within this study, the Pacific coast of Mexico accounts for the greatest proportion of recorded illegal take with 47.8% (6,644 turtles.yr^{-1}), followed by Indonesia (23.6%; 3,279 turtles.yr^{-1}) and Fiji (23.4%; 3,261 turtles.yr^{-1}) (see Table S1).

(A) DISCUSSION

This study provides the first global synthesis of the reported legal direct take of marine turtles. Our estimate of current legal take, in excess of 42,000 turtles.yr^{-1}, highlights this as a potential threat to at least some marine turtle populations, but also places this threat in the context of others such as bycatch, that is likely to have a greater impact on global stocks. Our study also shows that there has been a 60% decrease in take from the countries within this study since the 1980s, with further decreases in the global take likely as many countries prohibited take during the period 1980 to 2010 (eg. Cuba, Bahamas, Barbados) (Bräutigam & Eckert, 2006). Many green turtle populations, the most heavily targeted species, have also shown large increases in nesting populations in recent decades (Broderick *et al.,* 2006; Chaloupka *et al*., 2008), potentially facilitated through the reduction or cessation in global take at these sites.

Bycatch estimates for marine turtles have been the focus of a number of relatively comprehensive studies in recent years. Wallace *et al*. (2010) estimated a minimum global bycatch of 85,000 turtles between 1990 and 2008 but suggest that this likely underestimates the true total by at least two orders of magnitude (due to <1% fishing effort observed and recorded and underrepresentation of small-scale fisheries in bycatch data). For instance, more recent work by Casale (2011) estimated that there were 44,000 incidental sea turtles

deaths.yr^{-1}alone in the Mediterranean whilst Mancini *et al*. (2011) estimated that there were >1000 deaths.yr^{-1}within one fishery in a lagoon in NW Mexico. Small-scale fisheries in Peru capture tens of thousands of turtles as bycatch annually (Alfaro-Shigueto *et al*., 2011). These few estimates alone strongly suggest that global mortality from bycatch greatly exceeds that of legal take and likely extends into hundreds of thousands per annum. Improvements have been made in some areas however, with comparative declines (~60%) in bycatch reported since 1990 in US fisheries (Finkbeiner *et al*., 2011).

Illegal fishing for turtles also continues to be a major cause of mortality, both in countries within this study and those where take is illegal (Bräutigam & Eckert, 2006; Maison *et al*., 2010; Lam *et al*. 2011). We estimate that a minimum of 65,000 turtles have been taken illegally from Mexico since 2000 (Koch *et al*., 2006; Peckham *et al*., 2008; Mancini *et al*., 2011) and in Nicaragua there is documented take of species other than the permitted green turtles (Lagueux *et al*., 2003). The scale of global illegal take is likely to be severely underreported due to the inherent difficulty in collecting data on such activity. However, a number of reports highlight widespread artisanal fisheries taking thousands of turtles.yr^{-1}across Africa (WWF, 2005; Peñate *et al*., 2007; Catry *et al*., 2009; Marco *et al*., 2010; Humber *et al*., 2011). Elsewhere, several medium-sized illegal turtle fisheries are found in the Caribbean (1000 to 2500 individuals.yr^{-1}), in Venezuela (Bräutigam & Eckert, 2006), Dominican Republic (Fleming, 2001) and Puerto Rico (Moore *et al*., 2003); whilst a black market still exists within the Mediterranean for turtle meat (Nada & Casale, 2008).

The majority of current legal take is of green turtles, although past take of olive ridley turtles was significant, there has been a substantial decline in the legal take of both species since the 1980s. There has also been a corresponding increase in national legislation during this time

293 that focuses on protecting turtles during breeding seasons whilst allowing customary and
294 traditional users to continue fishing, and is likely a reason for the decline in take over the past
295 30 years.
296
297 The majority of countries with legal turtle take are located in small island states in the
298 Caribbean and Pacific (Melanesia, Polynesia, Micronesia). Turtle take in the Caribbean tends
299 to be legislated through closed seasons, size restrictions by species, permits and gear
300 restrictions (Richardson *et al*., 2006); whereas turtle take in the Pacific is characterised by
301 high cultural significance with associated customs (Rudrud, 2007, 2010; Bell *et al*., 2010).
302 Both regions report declines in take over the last 30 years (Eckert *et al*., 1992; Fleming
303 2001), in some cases due to a lack of interest from younger generations (eg. Belize:
304 Bräutigam & Eckert 2006; British Virgin Islands: Sam Davies pers. comm.; Cook Islands:
305 Michael White pers. comm.; Samoa: Juney Ward pers. comm.; Tokelau: Feleti Tulafono pers.
306 comm.).
307
308 However, the three largest legal fisheries persist in Papua New Guinea, in the waters of
309 Australia, and on the Atlantic coast of Nicaragua. Estimates used in this study for Nicaragua
310 are, however, based on data from the 1990s, although current levels of take have decreased
311 since last published estimates (C. Lagueux pers. comm.). There are also complications when
312 estimating take for Papua New Guinea and Australia because the majority of turtle take is
313 centred in remote areas of both countries. Furthermore, turtles are taken across the
314 jurisdictions of Australia and Papua New Guinea by Australian Aboriginal and Torres Strait
315 Islanders, as well as the coastal communities in Papua New Guinea and Indonesia. Estimates
316 for the Torres Strait region (includes Torres Strait Islanders and neighbouring Papua New
317 Guinea communities) in the past have been highly variable, from 5,100 - 6,700 (Kwan, 1991)

to 10,000 per year (Limpus, 1980). This study estimates that the take from the whole of Papua New Guinea and Australia is in the order of 20,000 turtles per annum. However, there are limitations to these data from Australia due to the fact that they have been extrapolated from small data sets with restricted spatial and temporal limitations, and there are known large variations in numbers of nesting turtles each year (Limpus, 2008). Results of recent Australian Government supported community-based management programmes, and bilateral Australia and Papua New Guinea projects are also not yet available (Kennett & Kitchens, 2009; Australian Government 2013).

Although the level of legal take is likely to be relatively low compared to the combined threats of bycatch and illegal take, the existence of a legal fishery has been suggested as providing cover for continued illegal take of turtles (Pritchard, 2003; Reuter & Allan, 2006). Direct take can be more targeted than other causes of marine turtle mortality, often focusing on nesting females (Catry *et al.* 2009; Marco *et al*., 2010), and although many countries within this study prohibit the take of nesting turtles, small numbers of adults can represent a large percentage of the nesting population (Limpus *et al*., 2006; Harris & George, 2008). The impact of direct take can be worsened if high levels of take coincide with the breeding season (Martin *et al*., 2005; Bell *et al*. 2007). The migratory nature of turtles also means that otherwise protected nesting populations can be heavily exploited in nearby countries, such as foraging adult females in Nicaragua from the largest green turtle rookery in Tortugeuro, Costa Rica (Campbell, 2003).

There were several difficulties in assessing the status of legal take, most notably the lack of data across many countries and species. Few fisheries departments contacted had any official data available, and in one country contacted data collection had lapsed unnoticed for 3-4

343 years. A lack of national level monitoring programmes meant that many estimates were
344 based on local studies by research institutions or NGOs, with temporally sporadic data
345 collection (Broderick, 1998; Havea & MacKay, 2009), often generating conservative
346 estimates (Godley *et al.*, 2004).Within our study original research data were used where
347 possible although in certain instances national estimates by authors as part of reports (eg.
348 Kinch 2002) or personal communications were used (eg. Albania: M. White).
349
350 A decline in available papers, reports and official fisheries statistics on legal take in recent
351 years led to an increase in the proportion of estimated data from the 1980s to present day.
352 Many of the current legal turtle fisheries are at the subsistence level or part of small-scale
353 fisheries which can be difficult to monitor, especially in remote regions in island states
354 (Nichols 2003; Andrews *et al*., 2006). Further complications in data collection and analysis
355 can arise in the ambiguity between definitions of direct, opportunistic or incidental take by
356 fishers and researchers (Fuller *et al*., 1992; Godley *et al*., 2004). Small-scale and artisanal
357 fishers will often take turtles opportunistically on fishing trips not specifically targeting
358 turtles (Hoyle, 1994; Fleming, 2001; Petro *et al*., 2007; Alfaro-Shigueto *et al*., 2011). On top
359 of this, fishing effort can range from specialised dedicated groups, to small numbers of
360 occasional, turtle fishers (Godley *et al*., 2004), taking turtles both legally and illegally (Aiken
361 *et al*., 2001; Bräutigam & Eckert, 2006).
362
363 Legislation within many countries examined is unclear, and even officials can be operating
364 under false assumptions of the reality of the legislation (Bräutigam & Eckert, 2006). Multiple
365 pieces of legislation within countries have been passed without consulting prior texts for
366 continuity (Bräutigam & Eckert, 2006) or taking into account local stakeholders (Vanuatu: F.
367 Hickey pers. comm.), with frequent changes in restrictions (Caribbean Nicaragua: K. Garland

368 pers. comm.). Many aspects of legislation associated with legal take can be difficult to
369 monitor and enforce, such as restrictions on turtle size and gear types (Buden 2001).
370 Furthermore legislation that allows for subsistence or traditional take can be hard to enforce
371 due to difficulties in definitions; for example, the Nicaraguan green turtle fishery is defined
372 as for subsistence use only but essentially runs at a commercial level (Campbell, 2003).
373
374 The debates on the continued legal take of marine turtles span a number of complex issues
375 including ecological principles, human rights and animal welfare (Hamann *et al*., 2010), and
376 still features in emotionally charged news articles (Holland, 2013). Undoubtedly, bans on
377 large scale turtle take have helped marine turtle populations to recover (Chaloupka *et al*.,
378 2008), and current illegal take levels in some countries do not rival those of the previously
379 legal turtle fishery (J. Chevalier *in litt.* in Bräutigam & Eckert 2006) or current bycatch
380 (Cornelius *et al*., 2007). Some countries in this study reported that legal take is declining
381 further (Fiji: M. Raicebe pers. comm.; Cayman Islands: J. Blumenthal pers. comm.).
382
383 However, when considering current legal take it should be put in the context of the wider
384 global threats to marine turtles, such as climate change and habitat degradation highlighted as
385 conservation priorities by turtle researchers (Hamann *et al*., 2010). This study has shown that
386 the relative impact of legal take on mortality could be less than the bycatch estimates from
387 the Mediterranean alone (Casale, 2011). However further assessments are warranted to
388 understand where conservation priorities should be focussed due to the paucity of up to date
389 data on direct take, and a lack of both direct take and bycatch information from small-scale
390 fisheries.
391

392 Despite a loss of traditions, turtles remain culturally significant in many countries in this
393 study (especially within Pacific islands), and it is the desire to protect this important cultural
394 resource that has led to control measures on turtle take by governments and traditional
395 authorities (Adams, 2003). Cultural strengthening can play a role in resource management,
396 and the high status awarded to turtles can provide powerful incentives for conservation and
397 management (Adams, 2003; Hickey & Johannes, 2002). Research has indicated that with
398 appropriate management, even depleted populations could recover whilst maintaining a level
399 of take (Chaloupka & Balazs, 2007); although defining what level is sustainable involves a
400 greater knowledge of the threats and links between legal, illegal and bycatch mortality of
401 targeted turtle populations (Hamann *et al*,. 2010).

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BIOSKETCH

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F.H., A.B and B.G conceived the ideas; F.H collected and analysed the data, and led the writing.

FIGURE LEGENDS

Figure 1. The number of countries or territories that permit the direct take of turtles (as of 1st January 2013) showing type of legislation in place or absence. N = Protection absent; L = Legislation allows for a level of harvest of one or more species of turtles; T = Full protection but traditional hunting exemptions exist; M = Moratorium in place only at present; U = Unable to verify legislation.

Figure 2. The current estimate of annual legal take by species (n = 42 countries) (data from 1st January 2010 to 1st January 2013). O. Ridley = Olive Ridley; K. Ridley = Kemp's Ridley.

Figure 3. Estimated current annual legal marine turtle take by country or territory (data from 1st January 2010 to 1st January 2013). Data for the Caribbean (CAR) and Pacific (PAC) regions have been grouped and are shown in further detail in Figures 4(a) and 4(b). No take = no known legal or illegal take; Unquantified take = illegal take data found only or take known to occur but no data available. * = Country with moratorium.

Country abbreviations (countries in brackets indicate dependency): ALB = Albania; AND = Andaman and Nicobar Islands (India); AUS = Australia; BOS = Bosnia and Herzegovina; CHI = Chile; COP = Colombia (Pacific coast); GUY = Guyana; IND = Indonesia; JAP = Japan; KIR = Kiribati; MAL = Maldives; MAR = Marshall Islands: MIC = Federated States of Micronesia; MXA = Mexico (Atlantic coast); MXP = Mexico (Pacific coast); PAL = Palau; PAP = Papua New Guinea; PIT = Pitcairn Islands (UK); SAO = Sao Tome and Principe; SYR = Syria.

Take is also shown for countries with unverified legislation (ALG = Algeria; NKO = North Korea; SOM = Somalia).

Note: Position of symbols is not representative of locations of take data.

Figure 4. Estimated annual current legal marine turtle take for (a) the Caribbean and (b) the Pacific regions highlighted in Figure 3 (data from 1st January 2010 to 1st January 2013). No take = no known legal or illegal take; Unquantified take = illegal take data found only or take known to occur but no data available. * = Country with moratorium.

Country abbreviations (countries in brackets indicate dependency): Figure 4a: ANG = Anguilla (UK); ANT = Antigua and Barbuda; BEL = Belize; BRI = British Virgin Islands (UK); CAY = Cayman Islands (UK); COA = Colombia (Atlantic coast); DOM = Dominica; GRE = Grenada; HAI = Haiti; HON = Honduras; MON = Montserrat (UK); NIA = Nicaragua (Atlantic coast); STK = St. Kitts and Nevis; STL = St. Lucia; STV = St. Vincent and the Grenadines; TUR = Turks and Caicos.

Take is also shown for countries with unverified legislation: PAA = Panama (Atlantic coast). This take was not included in grouped take CAR in Figure 3.

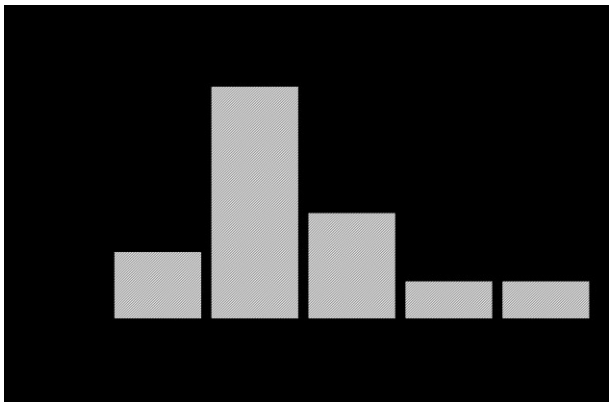
Country abbreviations (countries in brackets indicate dependency): Figure 4b: COO = Cook Islands (New Zealand); FIJ = Fiji; NAU = Nauru; NEW = New Caledonia (France); NIU = Niue; SAM = Samoa; SOL = Solomon Islands; TOK = Tokelau (New Zealand); TON = Tonga; TUV = Tuvalu; VAN = Vanuatu; WAL = Wallis and Futuna (France).

Note: Position of symbols is not representative of locations of take data.

Figure 5. The ten countries with the highest annual legal take of marine turtles as of 1st January 2013. Country abbreviations are: PAP = Papua New Guinea, NIA = Nicaragua (Atlantic coast), AUS = Australia, COA = Colombia (Atlantic coast), SOL = Solomon Islands, PAL = Palau, HAI = Haiti, TON = Tonga, SAO = Sao Tome and Principe; STV = St. Vincent and the Grenadines. *Legislation prohibits take in Principe only since 2009.

Figure 6. The estimated annual legal take of turtles per decade since 1980 for those countries and territories (n = 46) within this study, including those with current moratoria. Current represents data from 1st January 2010 to 1st January 2013 and does not include countries with current moratoria (n = 42).

FIGURES



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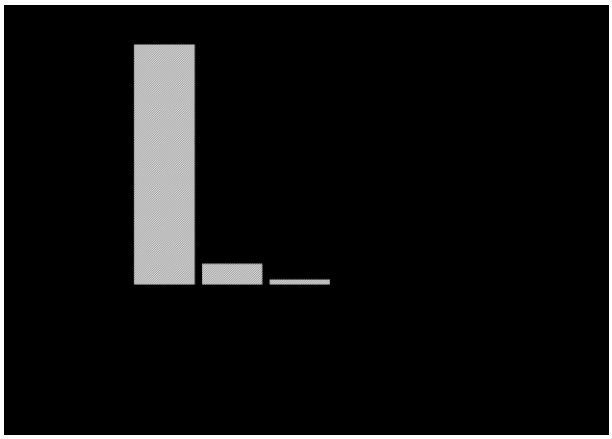

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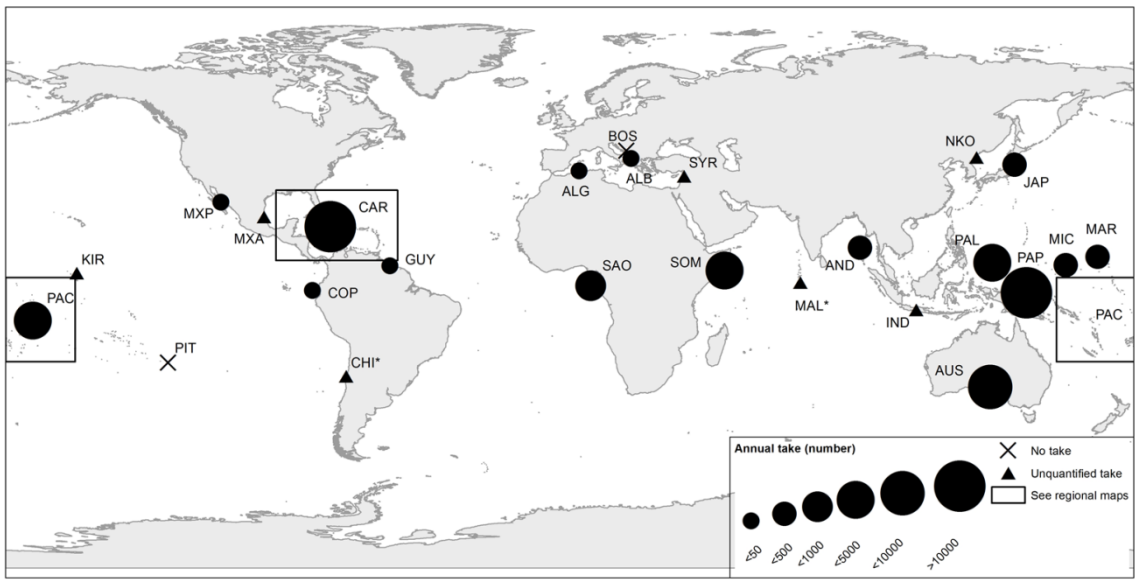
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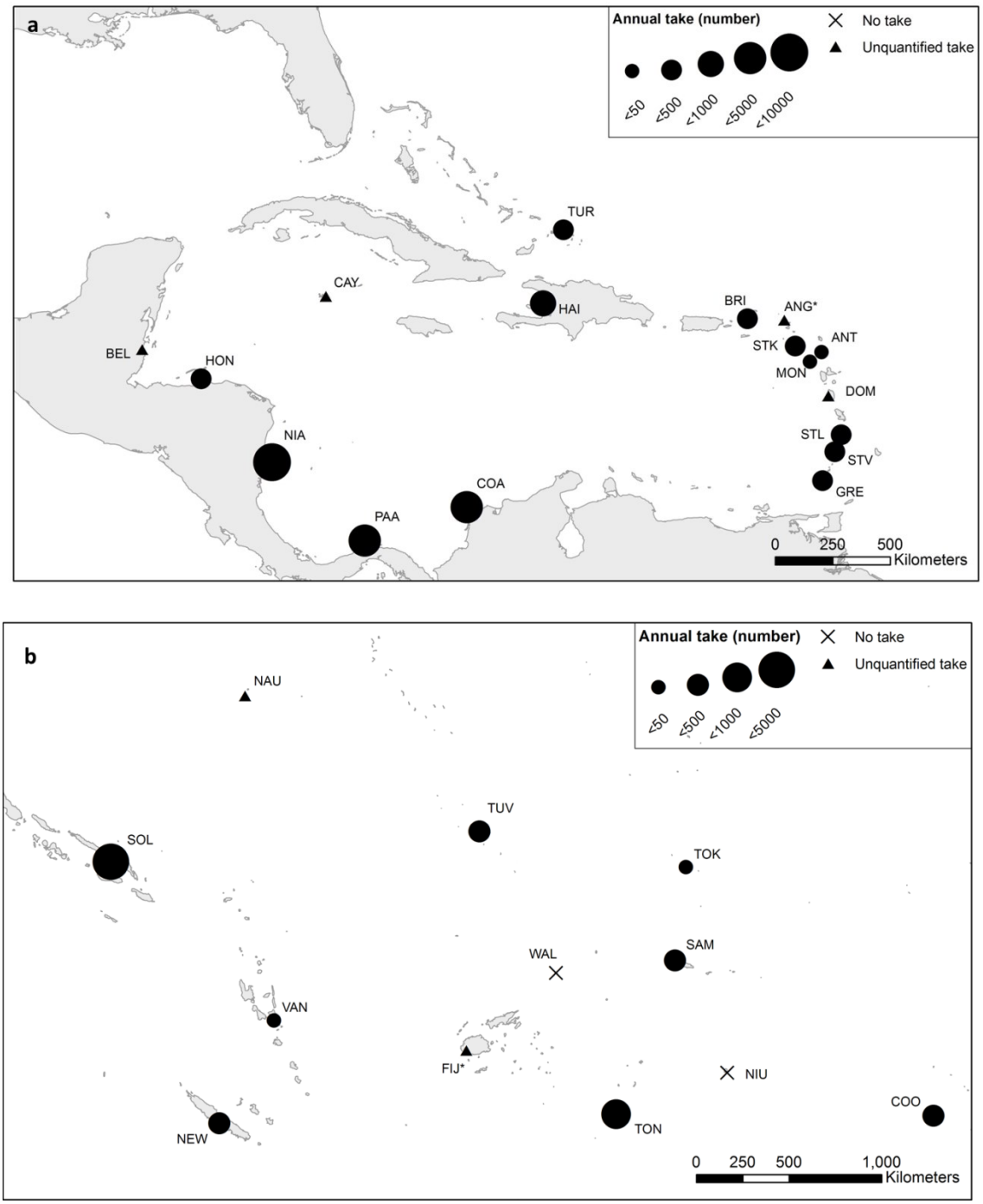
Figure 3.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TUR
CAY
HAI
BRI
ANG*
STK
ANT
MON
BEL
HON
DOM
NIA
STL
STV
GRE
COA
PAA
0 250 500
Kilometers
b
Annual take (number)
No take
Unquantified take
<50
<500
<1000
<5000
NAU
TUV
SOL
TOK
WAL
SAM
VAN
FIJ*
NIU
COO
TON
NEW
0 250 500 1,000
Kilometers

Figure 4.

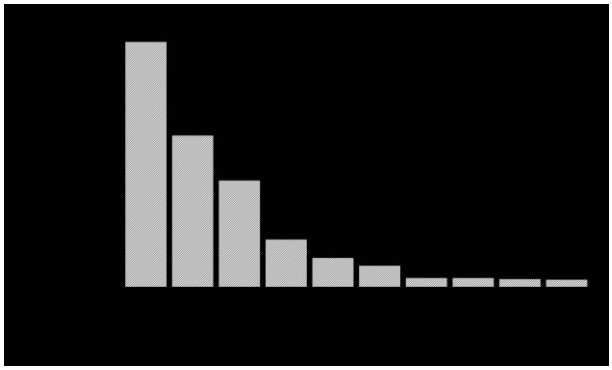

Figure 5.

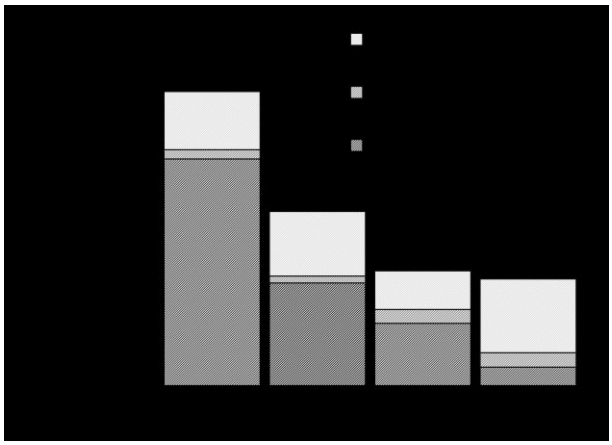

Figure 6.

SUPPORTING INFORMATION

Additional Supporting Information may be found in the online version of this article:

Figure S1 Estimated past annual turtle take.

Figure S2 Estimated global breakdown by species.

Figure S3 Regional estimated global breakdown by species.

Figure S4 Top countries by species for current estimated annual take.

Table S1 Estimated current annual take by species.

Appendix S1 Supporting references.