



## So excellent a fishe: a global overview of legal marine turtle fisheries

Frances Humber<sup>1,2</sup>, Brendan J. Godley<sup>2</sup> and Annette C. Broderick<sup>2\*</sup>

<sup>1</sup>Blue Ventures Conservation, Level 2 Annex, Omnibus Business Centre, 39-41 North Road, London N7 9DP, UK, <sup>2</sup>Marine Turtle Research Group, College of Life and Environmental Sciences, University of Exeter, Cornwall Campus, Penryn TR10 9EZ, UK

### 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 the 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 1 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, is significantly under-recorded and far greater than the total level of directed legal take. This hampers the ability to assess the relative impacts of these threats to marine turtles.

### Keywords

Direct take, global, legal fisheries, legislation, marine turtle, traditional fisheries.

\*Correspondence: Dr Annette C. Broderick, Marine Turtle Research Group, College of Life and Environmental Sciences, University of Exeter, Cornwall Campus, Penryn TR10 9EZ, UK.  
E-mail: a.c.broderick@exeter.ac.uk

### INTRODUCTION

Widescale commercial exploitation is thought to have contributed significantly to the global decline in marine turtle populations (Lewis, 1940; Stoddart, 1980; Jackson, 1997; National Marine Fisheries Service & U.S. Fish and Wildlife Service, 1998; Broderick *et al.*, 2006; Cornelius *et al.*, 2007) leaving many populations at relictual levels (Pritchard, 2003; McClenachan *et al.*, 2006; Bell *et al.*, 2007). However, the direct take of nesting and foraging marine turtles for meat, shell and other products has taken place for millennia (Groombridge & Luxmoore, 1989; Frazier, 2003;

Daley *et al.*, 2008). Artisanal and subsistence take, as part of longstanding traditional fisheries, primarily for local consumption, may historically have been at more sustainable levels (Frazier, 1980), but levels of exploitation increased radically upon western colonization of the New World (Babcock, 1938; Wayne King, 1995; Mrosovsky, 1996). Quickly, some of this take proved unsustainable, with the first marine turtle harvest legislation instigated in Bermuda in 1620 to protect ‘..so eccellente a fishe..’, prohibiting taking any turtle ‘under Eighteen inches in the Breadth or Dyiameter’ (Babcock, 1938; Godley *et al.*, 2004).

Notwithstanding, large-scale commercial take in areas with remaining abundance continued, with global capture peaking at over 17,000 tonnes in the late 1960s (FAO, 2011), principally fuelled by commercial-scale exploitation and international trade (Fleming, 2001; van Dijk & 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; Aylesworth, 2009; Maison *et al.*, 2010). Permitted take now tends to be characterized by subsistence use by traditional coastal groups, or small-scale fisheries supplying local markets with meat, and sometimes shell (Bräutigam & Eckert, 2006; Limpus, 2008; Maison *et al.*, 2010). The fisheries continue to be an important source of finance, protein and cultural identity in these parts of the world (Hamann *et al.*, 2006; Vander Velde, 2008). Although the nature of these permitted fisheries vary greatly among countries and regions, many have been subject to increasing regulations over the past 30 years, with specific legislation put in place to help manage direct take, often limiting species, number, timing or size of turtles targeted (Bräutigam & Eckert, 2006). There is, however, a paucity of information on the direct take from these fisheries at present, despite often being listed as one of the major threats to marine turtle populations (Wallace *et al.*, 2010; IUCN, 2013). Here, we set out to assess the current legal direct take (hereafter referred to as legal take) of marine turtles globally; as well as recent trends within those countries.

## METHODS

### Focal countries

In this study, we focussed on coastal countries or territories, hereafter referred to as countries, which currently (as of 1 January 2013) permit the legal take of marine turtles and are geographically between 40°N and 40°S. This region covers the majority of the known range of hard-shelled marine turtle species (IUCN, 2013). Although some marine turtle species can occur outside this range, there is no significant direct turtle take documented outside these latitudes. Legalized egg harvest was not included in this study.

The national legislation within these countries was further classified as allowing marine turtle take if protection was absent, unverifiable, incomplete or temporary. National legislation was classified into one of five categories: protection absent (N), legislation allows for a level of directed take of one or more species of turtles (L), full protection but traditional hunting exemptions exist (T), moratorium in place at present (M) and unable to verify legislation (U).

### Data compilation

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

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

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

were not countrywide estimates. In these cases, values were included as minimum values.

In a small number of highlighted cases (Table S1;  $n = 8$ ), international trade statistics in bekko (hawksbill turtle shell) were used to calculate estimates for hawksbills, only where no other data could be located. Conversion rates of bekko (kg) to number of turtles were normally given by authors (e.g. Fiji 0.7–1.1 kg bekko/turtle, Milliken & Tokunaga, 1987).

### Creating annual estimates for each decade

We calculated the median annual take for each decade (1980s, 1990s and 2000s) for each species by country and for our current estimate the median annual take for the years 2010–2012.

Data that had not been identified by species were only included in circumstances where we were confident that the data were not duplicated within other studies. Data were then broken down into species using the best available species composition information from additional studies and reports from that country.

Where data were missing for a decade, we used the temporally closest data to extrapolate. For example, where we only had data for the 1990s and 2000s, we used the 1990s estimate for the 1980s. Where decadal data were only available for the 1980s and 2000s ( $n = 4$  countries), we used what we considered would be the most similar estimate for the 1990s, in relation to any changes in legislation or reports of increases/decreases in legal take. Where data for only one decade existed ( $n = 8$  countries), this was used for all other decades. To allow confidence to be assigned to overall estimates, any 'estimated' data are highlighted.

### Current take

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

## RESULTS

### Legislation

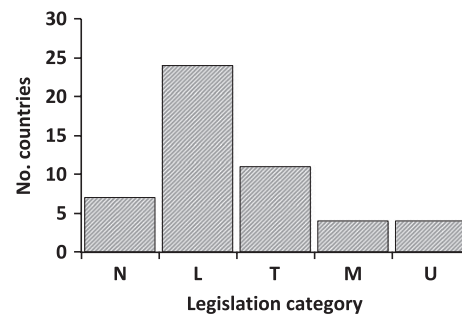
As of 1 January 2013, a total of 42 countries permitted the direct take of marine turtles, four countries had a moratorium on take (Anguilla, Chile, Fiji and the Maldives), although permits for traditional purposes can be granted in Fiji; and four countries had legislation that could not be verified (Algeria, North Korea, Panama and Somalia) (Fig. 1) (see Table S1 for information on type or absence of legislation). A change of legislation to prohibit direct turtle take occurred in three countries (Republic of Congo, South Korea

and Trinidad and Tobago) between 1 January 2010 and 1 January 2013. Data from these countries, and also those that prohibited turtle take between 1980 and 2010, are not included in this study.

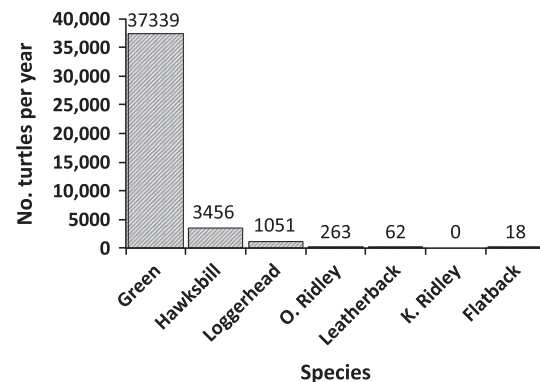
### Take by species

We estimate that currently, more than 42,000 marine turtles are caught each year as legal take ( $n = 42$  countries). Over 80% of these are green turtles (37,339; 88.5% of catch), with an estimated 3456 hawksbill turtles taken each year (8.2%) (Fig. 2). Fewer than 1500 loggerhead (1051; 2.5%), leatherback (62; 0.1%) and olive ridley (263; 0.6%) turtles are estimated to be among those legally captured each year. Data on take of flatback turtles were scarce with only a small amount recorded from Papua New Guinea and Australia, approximately 18 turtles year<sup>-1</sup> (Kare, 1995; Kennett *et al.*, 1998). No data were found on legal take of Kemp's ridley turtles from 1980 to present day.

Green turtles were the only species permitted to be taken from all countries within this study, with the exception of countries with a moratorium (although not including Fiji).



**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 1 January 2010 to 1 January 2013). O. Ridley = Olive Ridley; K. Ridley = Kemp's Ridley.

Leatherbacks had the highest degree of protection and were prohibited from take in 13 of the 42 focal countries examined (31%).

### Global distribution of take

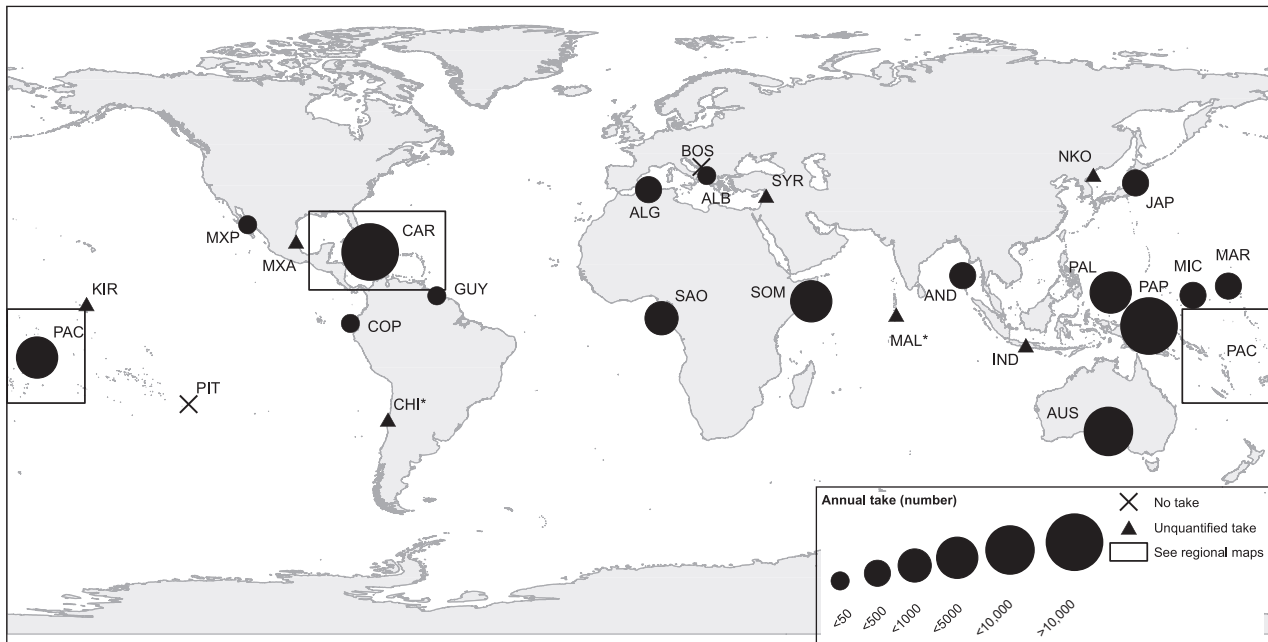
Current permitted take is concentrated in two regions: the wider Caribbean region accounts for 34.6% (14,640 turtles year<sup>-1</sup>) of estimated take from 16 countries (see inset Figs 3 & 4a) and the Indo-Pacific region accounts for 63.3% (26,675 turtles year<sup>-1</sup>) from 17 countries (Figs 3 & 4b). No take was known to occur in four of the countries where it was legal (Bosnia and Herzegovina, Niue, Pitcairn Islands and Wallis and Futuna). In 12 countries, take was unquantified: in three of these countries, take was known to occur but no estimate was available (Kiribati, Nauru and Syria), and nine of these countries only illegal take data were found (Belize, Cayman Islands, Dominica, Indonesia and Atlantic coast of Mexico), including four countries where a moratorium exists (Anguilla, Chile, Fiji and Maldives). Take from the four countries where legislation could not be verified (Algeria, North Korea, Panama and Somalia) is estimated to be 6700 turtles year<sup>-1</sup> and is not included in the 42,000 estimate (Table S1). A breakdown of take by species for each country is available in Figures S2, S3 and Table S1.

### Take by country

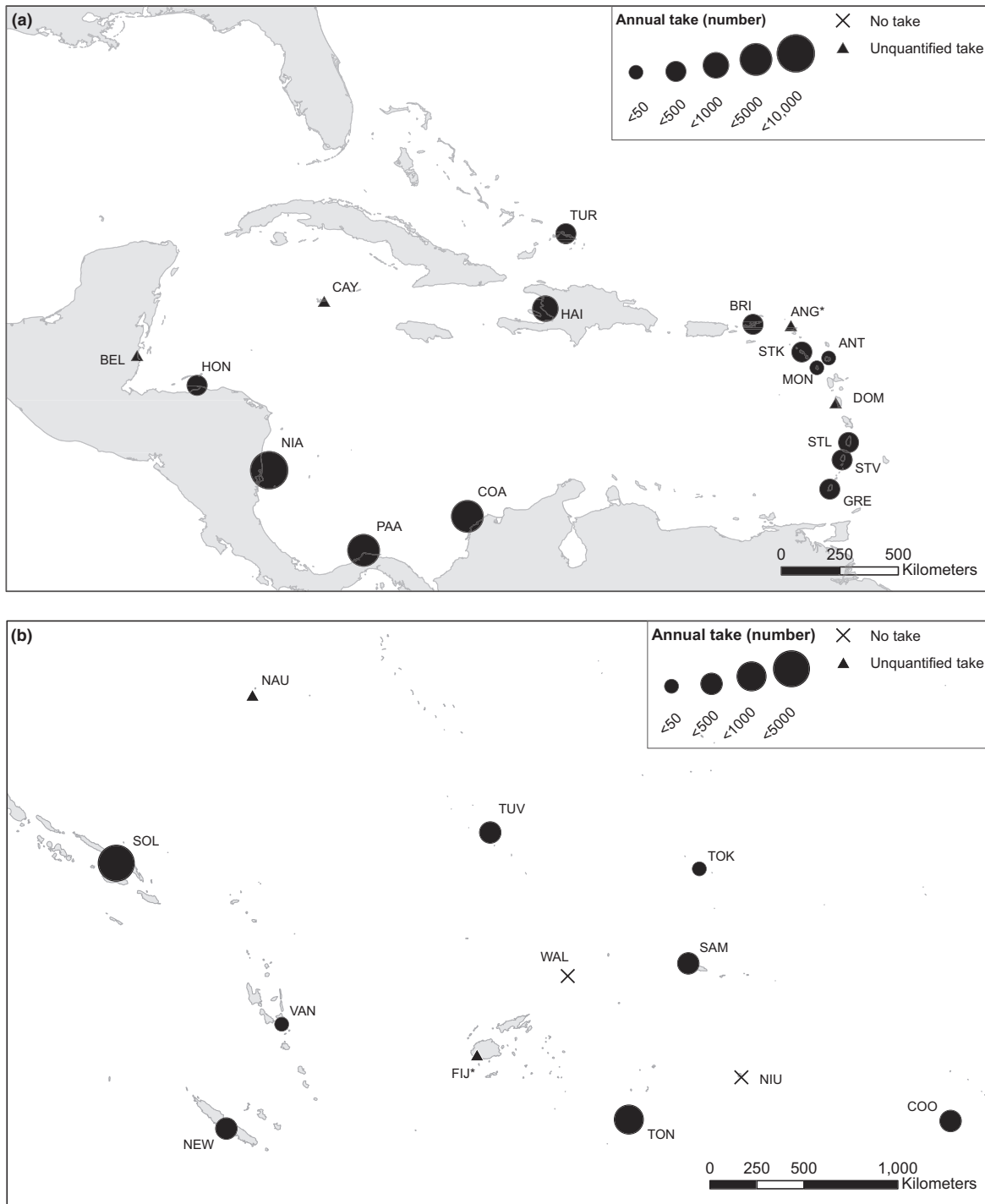
The top ten countries with permitted take account for 94.2% (39,716) of marine turtle take per year (Fig. 5). Papua New Guinea (15,217 turtles year<sup>-1</sup>; 36.1%), Nicaragua (9413 turtles year<sup>-1</sup>; 22.3%) and Australia (6638 turtles year<sup>-1</sup>; 15.7%) together account for almost 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 countries 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 (Figure S4).

### 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 Figure S1. We estimate that 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 year<sup>-1</sup> in the 1980s,

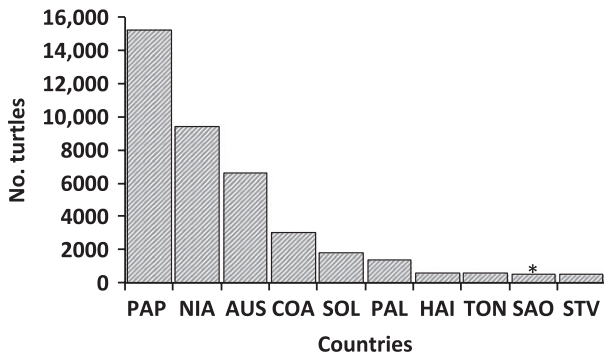


**Figure 3** Estimated current annual legal marine turtle take by country or territory (data from 1 January 2010 to 1 January 2013). Data for the Caribbean (CAR) and Pacific (PAC) regions have been grouped and are shown in further detail in Fig. 4a,b. No take = no known legal or illegal take; Unquantified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

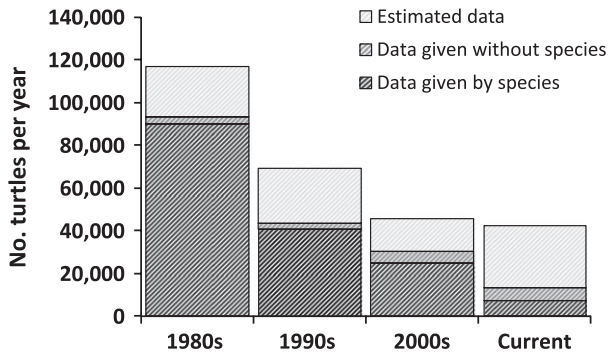


**Figure 4** Estimated annual current legal marine turtle take for (a) the Caribbean and (b) the Pacific regions highlighted in Fig. 3 (data from 1 January 2010 to 1 January 2013). No take = no known legal or illegal take; Unquantified take = illegal take data found only or take known to occur but no data available. \*Country with moratorium. Country abbreviations (countries in brackets indicate dependency): (a) 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 Fig. 3. Country abbreviations (countries in brackets indicate dependency): (b) 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 10 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 1 January 2010 to 1 January 2013 and does not include countries with current moratoria ( $n = 42$ ).

68,844 turtles year<sup>-1</sup> in the 1990s and 45,387 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 year<sup>-1</sup> in the early 1980s to fewer than ten per year in the 1990s and 2000s (Figure 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 13,900 turtles are illegally taken in these 46 countries each year. Within this

study, the Pacific coast of Mexico accounts for the current greatest proportion of recorded illegal take with 47.8% (6644 turtles year<sup>-1</sup>), followed by Indonesia (23.6%; 3279 turtles year<sup>-1</sup>) and Fiji (23.4%; 3261 turtles year<sup>-1</sup>) (see Table S1).

## 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 year<sup>-1</sup>, 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 1980–2010 (e.g. Cuba, Bahamas and 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 turtle deaths year<sup>-1</sup> alone in the Mediterranean whilst Mancini *et al.* (2011) estimated that there were > 1000 deaths year<sup>-1</sup> 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 under-reported due to the inherent difficulty in collecting data on such activity. However, a number of reports highlight widespread artisanal fisheries taking thousands of turtles per years

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 (1000–2500 individuals year<sup>-1</sup>), 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 1980s. There has also been a corresponding increase in national legislation during this time that focuses on protecting turtles during breeding seasons whilst allowing customary and traditional users to continue fishing, and is likely a reason for the decline in take over the past 30 years.

The majority of countries with legal turtle take is located in small island states in the Caribbean and Pacific (Melanesia, Polynesia and Micronesia). Turtle take in the Caribbean tends to be legislated through closed seasons, size restrictions by species, permits and gear restrictions (Richardson *et al.*, 2006), whereas turtle take in the Pacific is characterized by high cultural significance with associated customs (Rudrud *et al.*, 2007; Bell *et al.*, 2010; Rudrud, 2010). Both regions report declines in take over the last 30 years (Eckert *et al.*, 1992; Fleming, 2001), in some cases due to a lack of interest from younger generations (e.g. Belize: Bräutigam & Eckert, 2006; British Virgin Islands: S. Davies pers. comm.; Cook Islands: M. White pers. comm.; Samoa: J. Ward pers. comm.; Tokelau: F. Tulafono pers. comm).

However, the three largest legal fisheries persist in Papua New Guinea, in the waters of Australia and on the Atlantic coast of Nicaragua. Estimates used in this study for Nicaragua are, however, based on data from the 1990s, although current levels of take have decreased since last published estimates (C. Lagueux pers. comm.). There are also complications when estimating take for Papua New Guinea and Australia because the majority of turtle take is centred in remote areas of both countries. Furthermore, turtles are taken across the jurisdictions of Australia and Papua New Guinea by Australian Aboriginal and Torres Strait Islanders, as well as the coastal communities in Papua New Guinea and Indonesia. Estimates for the Torres Strait region (includes Torres Strait Islanders and neighbouring Papua New Guinea communities) in the past have been highly variable, from 5100 to 6700 (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 with 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 Tortuguero, 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 years. A lack of national level monitoring programmes meant that many estimates were based on local studies by research institutions or NGOs, with temporally sporadic data collection (Broderick, 1998; Havea & MacKay, 2009), often generating conservative estimates (Godley *et al.*, 2004). Within our study, original research data were used where possible although in certain instances national estimates by authors as part of reports (e.g. Kinch, 2002) or personal communications were used (e.g. Albania: M. White).

A decline in available papers, reports and official fisheries statistics on legal take in recent years led to an increase in the proportion of estimated data from the 1980s to present day. Many of the current legal turtle fisheries are at the subsistence level or part of small-scale fisheries, which can be difficult to monitor, especially in remote regions in island states (Nichols, 2003; Andrews *et al.*, 2006). Further complications in data collection and analysis can arise in the ambiguity between definitions of direct, opportunistic or incidental take by fishers and researchers (Fuller *et al.*, 1992; Godley *et al.*, 2004). Small-scale and artisanal fishers will often take turtles opportunistically on fishing trips not specifically targeting turtles (Hoyle, 1994; Fleming, 2001; Petro *et al.*, 2007; Alfaro-Shigueto *et al.*, 2011). On top of this, fishing effort can range from specialized dedicated groups, to small numbers of occasional, turtle fishers (Godley *et al.*, 2004), taking turtles both legally and illegally (Aiken *et al.*, 2001; Bräutigam & Eckert, 2006).

Legislation within many countries examined is unclear, and even officials can be operating under false assumptions of the reality of the legislation (Bräutigam & Eckert, 2006). Multiple pieces of legislation within countries have been

passed without consulting prior texts for continuity (Bräutigam & Eckert, 2006) or taking into account local stakeholders (Vanuatu: F. Hickey pers. comm.), with frequent changes in restrictions (Caribbean Nicaragua: K. Garland pers. comm.). Many aspects of legislation associated with legal take can be difficult to monitor and enforce, such as restrictions on turtle size and gear types (Buden & Edward, 2001). Furthermore, legislation that allows for subsistence or traditional take can be hard to enforce due to difficulties in definitions; for example, the Nicaraguan green turtle fishery is defined as for subsistence use only but essentially runs at a commercial level (Campbell, 2003).

The debates on the continued legal take of marine turtles span a number of complex issues including ecological principles, human rights and animal welfare (Hamann *et al.*, 2010), and still features in emotionally charged news articles (Holland, 2013). Undoubtedly, bans on large-scale turtle take have helped marine turtle populations to recover (Chaloupka *et al.*, 2008), and current illegal take levels in some countries do not rival those of the previously legal turtle fishery (J. Chevalier *in litt.* in Bräutigam & Eckert, 2006) or current bycatch (Cornelius *et al.*, 2007). Some countries in this study reported that legal take is declining further (Fiji: M. Raicebe pers. comm.; Cayman Islands: J. Blumenthal pers. comm.).

However, when considering current legal take it should be put in the context of the wider global threats to marine turtles, such as climate change and habitat degradation highlighted as conservation priorities by turtle researchers (Hamann *et al.*, 2010). This study has shown that the relative impact of legal take on mortality could be less than the bycatch estimates from the Mediterranean alone (Casale, 2011). However, further assessments are warranted to understand where conservation priorities should be focussed due to the paucity of up-to-date data on direct take, and a lack of both direct take and bycatch information from small-scale fisheries.

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

## ACKNOWLEDGEMENTS

The authors would like to those who provided data, assistance and comments on direct turtle take including Semese

Alefaio, Mohamud Hassan Ali, Diego Amorocho, Marcio Aronne, Althea Arthurton, Jorge Azocar, Laurence Bachet, George Balazs, Patrice Bartholomew, Lui Bell, Karin Bilo, Carl-Jørgen Bindslev, Janice Blumenthal, Liza Boura, Nathalie Breheret, Michael Brooke, Donald Buden, Charles Caillouet, Carlos Cantu, Michelle Cazabon, Claudia Ceballos, Didiher Chacon, Rodolfo Chang, Michele Christian, Mykl Clovis-Fuller, Nathaniel Cornuet, Eduardo Cuevas, Sam Davies, Carlos Delgado, Monte Depaune, Kiki Dethmers, Hussein Yussuf Dualeh, Stephen Dunbar, Karen Eckert, Lucine Edwards, Abdalla Nassir Elawad, Rudy van der Elst, Environmental Protection Agency Guyana, Richard Farman, Marina Fastigi, Marie-Louise Felix, Lara Ferreira, Rogério Ferreira, Angela Formia, Jack Frazier, Katy Garland, Alexandre Girard, Shannon Gore, James Gumbs, Mark Hamann, Hideo Hatase, Francis Hickey, Tetha Hitipeuw, Julia Horrocks, Crafton Isaac, Asuka Ishizaki, David Jaén, Emma Kabua, Michelle Kalamandeen, Vince Kerr, Jeff Kinch, Tarik Kupusovic, Donna Kwan, Cythnia Lagueux, Thomas Le Berre, Carl Lloyd, Tricia Lovell, Isaias Majil, Agnese Mancini, Rosalie Masu, Mike McCoy, Carolina Montalván, Dae Yeon Moon, Bruno Mugneret, Elizabeth Munro, Maggie Muurmans, Poasi Fale Ngaluafe, Wallace J. Nicholls, Steven Palik, Nancy Papatathanasopoulou, Emile Pemberton, Ray Pierce, Nicolas J. Pilcher, Alwyn Ponteen, Peter Pritchard, Meli Raicebe, Christian Ramofafia, Caroline Reddy, Alan Rees, Adib Saad, Lidia Salinas, Linda Searle, Tom Stringell, Hiroyuki Suganuma, Lise Suveinakama, James Tafatu, Nenenteiti Teariki-Ruatu, Tara Teel, Dawit Tesfamichael, Yannick Tessier, Turang Teuea-Favae, Tokyo Metropolitan Government, Jorge Torrens, Feleti Tulafono, Bishnu Tulsie, Falasese Tupau, Neomai Turaganivalu-Ravitu, Nancy VanderVelde, Hilde Vanleeuwe, Colette Wabnitz, Juney Ward, Michael White, Jean Wiener, I.B. Windia Adnyana and Sarita Williams-Peter. ACB and BJB would like to thank the UK Darwin Initiative for the Survival of Species. FH would like to thank Blue Ventures Conservation for their support. We acknowledge the help of Samir Gandhi in the production of Figs 3 & 4, Figure S2 & S3. The authors also acknowledge the input of the Editor and the three referees that helped improve the manuscript.

## REFERENCES

- Adams, T. (2003) *Turtle fisheries in the Pacific Community area*. Marine Resources Division, Secretariat of the Pacific Community, New Caledonia.
- Aiken, J.J., Godley, B.J., Broderick, A.C., Austin, T., Ebanks-Petrie, G. & Hays, C.G. (2001) Two hundred years after a commercial marine turtle fishery: the current status of marine turtles nesting in the Cayman Islands. *Oryx*, **35**, 145–151.
- Alfaro-Shigueto, J., Mangel, J., Bernedo, F., Dutton, P.H., Seminoff, J.A. & Godley, B. (2011) Small-scale fisheries of Peru: a major sink for marine turtles in the Pacific. *Journal of Applied Ecology*, **48**, 1432–1440.



- Allen, M.S. (2007) Three millennia of human and sea turtle interactions in Remote Oceania. *Coral Reefs*, **26**, 959–970.
- Andrews, H.V., Tripathy, A., Aghue, S., Glen, S., John, S. & Naveen, K. (2006) The status of sea turtle populations in the Andaman and Nicobar Islands of India. *Towards an Integrated and Collaborative Sea Turtle Conservation Programme in India: a UNEP/CMS-IOSEA Project Report* (ed. by K. Shanker and H.V. Andrews), pp. 71–82. Centre for Herpetology/Madras Crocodile Bank Trust, Tamil Nadu.
- Australian Government (2013) Traditional Use of Marine Resources Agreements. Available at: <http://www.gbrmpa.gov.au/our-partners/traditional-owners/traditional-use-of-marine-resources-agreements> (accessed July 2013).
- Aylesworth, A. (2009) *Oceania regional assessment: Pacific island fisheries and interactions with marine mammals, sea-birds, and sea turtles*. Project GloBAL, Beaufort, NC. Available at: <http://bycatch.env.duke.edu> (accessed October 2010).
- Babcock, H.L. (1938) The sea-turtles of the Bermuda Islands, with a survey of the present state of the turtle fishing industry. *Proceedings of the Zoological Society of London (A)*, **107**, 595–601.
- Bell, C., Solomon, J., Blumenthal, J., Austin, T., Ebanks-Petrie, G., Broderick, A. & Godley, B. (2007) Monitoring and conservation of critically reduced marine turtle nesting populations: lessons from the Cayman Islands. *Animal Conservation*, **10**, 39–47.
- Bell, L.A.J., Favae, T.T., Nenenteiti, T.-R., Bebe, R., Anderson, P. & Siota, C. (2010) *Kiribati marine turtles profile*. Secretariat of the Pacific Regional Environment Programme (SPREP), Apia.
- Bräutigam, A. & Eckert, K.L. (2006) *Turning the tide: exploitation, trade and management of marine turtles in the Lesser Antilles, Central America, Colombia and Venezuela*. TRAFFIC International, Cambridge, UK.
- Brikke, S. (2009) Local perceptions of sea turtles on Bora Bora and Maupiti islands, French Polynesia. *SPC Traditional Marine Resource Management and Knowledge Information Bulletin*, **26**, 23–28.
- Broderick, D. (1998) *Subsistence hunting of marine turtles in the Solomon Islands. Patterns of resource use in Kia, Wagina and Katupika communities, Isabel and Choiseul Provinces*. Report to the Ministry of Forests, Environment and Conservation and the Ministry of Agriculture and Fisheries, Solomon Island Government.
- Broderick, A.C., Frauenstein, R., Glen, F., Hays, G.C., Jackson, A.L., Pelembe, T., Ruxton, G.D. & Godley, B.J. (2006) Are green turtles globally endangered? *Global Ecology and Biogeography*, **15**, 21–26.
- Buden, D.W. & Edward, A. (2001) Abundance and utilization of sea turtles on Pohnpei, Federated States of Micronesia: Islanders' perceptions. *Micronesica*, **34**, 47–54.
- Campbell, C.L. (2003) *Population assessment and management needs of a green turtle, Chelonia mydas, population in the western Caribbean*. Doctor of Philosophy, University of Florida.
- Cantú, J.C. & Sanchez, M.E. (1999) *Trade in sea turtle products in Mexico*. Teyeliz A.C., Mexico.
- Casale, P. (2011) Sea turtle by-catch in the Mediterranean. *Fish and Fisheries*, **12**, 299–316.
- Catry, P., Barbosa, C., Paris, B., Indjai, B., Almeida, A., Limoges, B., Silva, C. & Pereira, H. (2009) Status, ecology, and conservation of sea turtles in Guinea-Bissau. *Chelonian Conservation and Biology*, **8**, 150–160.
- Chaloupka, M. & Balazs, G.H. (2007) Using Bayesian state-space modelling to assess the recovery and harvest potential of the Hawaiian green sea turtle stock. *Ecological Modelling*, **205**, 93–109.
- Chaloupka, M., Bjorndal, K., Balazs, G.H., Bolten, A.B., Ehrhart, L.M., Limpus, C.J., Sugauma, H., Troëng, S. & Yamaguchi, M. (2008) Encouraging outlook for recovery of a once severely exploited marine megaherbivore. *Global Ecology and Biogeography*, **17**, 297–304.
- Cornelius, S.E., Arauz, R., Fretey, J., Godfrey, M.H., Márquez-M, R. & Shanker, K. (2007) Effect of land-based harvest of *Lepidochelys*. *Biology and conservation of Ridley Sea Turtles* (ed. by P.T. Plotkin), pp. 231–251. The Johns Hopkins University Press, Baltimore.
- Daley, B., Griggs, P. & Marsh, H. (2008) Exploiting marine wildlife in Queensland: the commercial dugong and marine turtle fisheries, 1847–1969. *Australian Economic History Review*, **48**, 227–265.
- van Dijk, P.P. & Shepherd, C.R. (2004) *Shelled out? A snapshot of bekkō trade in selected locations in south-east Asia*. TRAFFIC, Southeast Asia.
- Eckert, K.L., Overing, J.A. & Lettsome, B.B. (1992) *WIDE-CAST sea turtle recovery action plan for the British Virgin Islands*. CEP Technical Report No. 15. UNEP Caribbean Environment Programme, Kingston, Jamaica.
- FAO (2011) *FishStatJ – software for fishery statistical time series Version 2.0.0*. Food and Agriculture Organization of the United Nations. Available at: <http://www.fao.org/fishery/statistics/software/fishstatj/en> (accessed 2 March 2013).
- Finkbeiner, E.M., Wallace, B.P., Moore, J.E., Lewison, R., Crowder, L.B. & Read, A.J. (2011) Cumulative estimates of sea turtle bycatch and mortality in USA fisheries between 1990 and 2007. *Biological Conservation*, **144**, 2719–2727.
- Fleming, E.H. (2001) *Swimming against the tide: recent surveys of exploitation, trade, and management of marine turtles in the northern Caribbean*. TRAFFIC North America, Washington, DC.
- Frazier, J. (1980) Exploitation of marine turtles in the Indian Ocean. *Human Ecology*, **8**, 329–370.
- Frazier, J. (2003) Prehistoric and ancient historic interactions between humans and marine turtles. *The biology of sea turtles*, Volume II (ed. by P.L. Lutz, J.A. Musick and J. Wyneken), Vol. 2, pp. 1–38. CRC Press, Boca Raton, FL.

- Fuller, J.E., Eckert, K.L. & Richardson, J.I. (1992) *WIDE-CAST sea turtle recovery action plan for Antigua and Barbuda*. CEP Technical Report No. 16. UNEP Caribbean Environment Programme, Kingston, Jamaica.
- Godley, B.J., Broderick, A.C., Campbell, L.M., Ranger, S. & Richardson, P. (2004) *An assessment of the status and exploitation of marine turtles in the United Kingdom Overseas Territories in the Wider Caribbean*. Final Project Report for the Department of Environment, Food and Rural Affairs and the Foreign and Commonwealth Office, London.
- Groombridge, B. & Luxmoore, R. (1989) *The green turtle and hawksbill (Reptilia: Cheloniidae): world status, exploitation and trade*. CITES Secretariat of the Convention on International Trade in Endangered Species of Wild Flora and Fauna, Cambridge.
- Hamann, M., Limpus, C.J., Hughes, G., Mortimer, J.A. & Pilcher, N.J. (2006) *Assessment of the conservation status of the Leatherback turtle in the Indian Ocean and South East Asia, including consideration of the impacts of the December 2004 tsunami on turtles and turtle habitats*. IOSEA Marine Turtle MoU Secretariat, Bangkok.
- Hamann, M., Godfrey, M.H., Seminoff, J.A. *et al.* (2010) Global research priorities for sea turtles: informing management and conservation in the 21st century. *Endangered Species Research*, **11**, 245–269.
- Harris, E.H. & George, S. (2008) *Nesting ecology and conservation of Marine Turtles in the Commonwealth of Dominica, West Indies: 2008 Annual Project Report* (ed. by K.L. Eckert). Prepared by the Dominica Sea Turtle Conservation Organization (DomSeTCO), in partnership with WIDE-CAST, for the Ministry of Agriculture, Fisheries and Forestry (Forestry, Wildlife and Parks Division), Roseau, Dominica, West Indies.
- Havea, S. & MacKay, K.T. (2009) Marine turtle hunting in the Ha'apai Group, Tonga. *Marine Turtle Newsletter*, **123**, 15–17.
- Hickey, F. (2003) Traditional marine resource management in Vanuatu: world views in transformation; sacred & profane. *Putting Fishers' Knowledge to Work, Fisheries Centre Research Reports 2002*. Volume 11 Number 1 (ed. by N. Haggan, C. Brignall and L. Wood), pp. 117–137. Fisheries Centre, University of British Columbia, Canada.
- Hickey, F.R. & Johannes, R. (2002) Recent evolution of village based marine resource management in Vanuatu. *SPC Traditional Marine Resource Management and Knowledge Information Bulletin*, **13**, 8–21.
- Holland, M. (2013) *Horror video shows sea turtles and dugongs being killed in barbaric fashion by Torres Strait Islanders*. July 1, 2013. The Daily Telegraph (Australia). Available at: <http://www.dailytelegraph.com.au/news/nsw/torres-strait-islanders-hunting-animals-under-native-titles-act-slammed-by-animal-welfare-groups/story-fni0cx12-1226672204034> (accessed July 2013).
- Hoyle, M. (1994) Continuing sea turtle exploitation in Antigua and Barbuda, West Indies. *Marine Turtle Newsletter*, **64**, 21–22.
- Humber, F., Godley, B.J., Ramahery, V. & Broderick, A.C. (2011) Using community members to assess artisanal fisheries: the marine turtle fishery in Madagascar. *Animal Conservation*, **14**, 175–185.
- IUCN (2013) *IUCN Red List of threatened species, version 2013.1*. Available at: <http://www.iucnredlist.org> (accessed March 2013).
- Jackson, J.B.C. (1997) Reefs since Columbus. *Coral Reefs*, **16** (Suppl), S23–S32.
- Kare, B.D. (1995) *A review on the research and fisheries of barramundi, reef fish, dugongs, turtles and Spanish mackerel in the Papua New Guinea side of the Torres Strait*. Joint FFA/SPC workshop on the management of South Pacific inshore fisheries, South Pacific Commission, Noumea, New Caledonia.
- Kennett, R. & Kitchens, J. (2009) *Dugong and Marine Turtle Project. Project Final Report to National Heritage Trust Regional Competitive Component*. North Australian Indigenous Land & Sea Management Alliance, Darwin.
- Kennett, R., Munungurritj, N. & Yunupingu, D. (1998) The Dhimurru Miyapunu project. *Marine turtle conservation and management in northern Australia, Proceedings of a workshop held at the Northern Territory University, Darwin, 3–4 June 1997* (ed. by R. Kennett, A. Webb, G. Duff, M. Guinea and G. Hill), pp. 69–75. Centre for Indigenous Natural and Cultural Resource Management & Centre for Tropical Wetlands Management, Northern Territory University, Darwin.
- Kinch, J. (2002) *The development of a monitoring program for the management and sustainable use of sea turtle resources in the Milne Bay Province, Papua New Guinea*. A proposal prepared for the South Pacific Regional Environment Program, Apia, Western Samoa.
- Koch, V., Nichols, W.J., Peckhamb, H. & Toba, V.d.I. (2006) Estimates of sea turtle mortality from poaching and bycatch in Bahía Magdalena, Baja California Sur, Mexico. *Biological Conservation*, **128**, 327–334.
- Kwan, D. (1991) The artisanal sea turtle fishery in Daru, Papua New Guinea. Sustainable development for traditional inhabitants of the Torres Strait region: Proceedings of the Torres Strait Baseline Study Conference, Kewarra Beach, Cairns, Queensland. Workshop Series No. 16, D (ed. by D. Lawrence and T. Cansfield-Smith), pp. 239–240. Great Barrier Reef Marine Park Authority, Townsville.
- Lagueux, C.J., Campbell, C. & McCoy, M.A. (2003) Nesting and conservation of the hawksbill turtle, *Eretmochelys imbricata*, in the Pearly Cays, Nicaragua. *Chelonian Conservation and Biology*, **4**, 588–602.
- Lam, T., Ling, X., Takahashi, S. & Burgess, E.A. (2011) *Market forces: an examination of marine turtle trade in China and Japan*. TRAFFIC East Asia, Hong Kong.
- Lewis, C.B. (1940) The Cayman Islands and marine turtles. *Herpetology of the Cayman Islands Bulletin of the Institute of Jamaican Sciences Series, no. 2* (ed. by C. Grant), pp. 56–65. Institute of Jamaica, Kingston.

- Limpus, C.J. (1980) The green turtle, *Chelonia mydas* (L), in eastern Australia. *Management of turtle resources. Research Monograph 2* (ed. by L. Fien), pp. 5–22. James Cook University of North Queensland, Townsville.
- Limpus, C.J. (2008) *A biological review of Australian marine turtles. 2. Green Turtle Chelonia mydas (Linnaeus)*. Queensland Government Environmental Protection Agency.
- Limpus, C.J., Boyle, M. & Sunderland, T. (2006) New Caledonian loggerhead turtle population assessment: 2005 Pilot Study. *Proceedings of the Second Western Pacific Sea Turtle Cooperative Research and Management Workshop. Volume II: North Pacific Loggerhead Sea Turtle* (ed. by I. Kinan), pp. 77–92. Western Pacific Regional Fishery Management Council, Honolulu.
- Maison, K.A., Kinan-Kelly, I. & Frutchey, K.P. (2010) *Green turtle nesting sites and sea turtle legislation throughout Oceania*. U.S. Dep. Commerce, NOAA Technical Memorandum. NMFS-F/SPO-110.
- Mancini, A., Senko, J., Borquez-Reyes, R., Póo, J.G., Seminoff, J.A. & Koch, V. (2011) To poach or not to poach an endangered species: elucidating the economic and social drivers behind illegal sea turtle hunting in Baja California Sur, Mexico. *Human Ecology*, **39**, 743–756.
- Marco, A., López, O., Abella, E., Varo, N., Martins, S., Gaona, P., Sanz, P. & López-Jurado, L.F. (2010) Massive capture of nesting females is severely threatening the Caboverdian loggerhead population. *Proceedings of the Twenty-eighth Annual Symposium on Sea Turtle Biology and Conservation* (ed. by K. Dean and M.C. Lopez-Castro), pp. 93–94. NOAA Technical Memorandum NMFS-SEFSC-602, Miami.
- Martin, C.S., Jeffers, J. & Godley, B.J. (2005) The status of marine turtles in Montserrat (Eastern Caribbean). *Animal Biodiversity and Conservation*, **28**, 159–168.
- McClenachan, L., Jackson, J.B.C. & Newman, M.J.H. (2006) Conservation implications of historic sea turtle nesting beach loss. *Frontiers in Ecology and the Environment*, **4**, 290–296.
- Milliken, T. & Tokunaga, H. (1987) *The Japanese sea turtle trade, 1970–1986. A special report prepared by TRAFFIC (Japan)*. The Center for Environmental Education, (Washington, DC).
- Moore, M.K., Bemiss, J.A., Rice, S.M., Quattro, J.M. & Woodley, C.M. (2003) Use of restriction fragment length polymorphisms to identify sea turtle eggs and cooked meats to species. *Conservation Genetics*, **4**, 95–103.
- Mrosovsky, N. (1996) Sea turtles. Past and present utilisation. *Wildlife resources. A global account of economic use* (ed. by H.H. Roth and G. Mertz), pp. 88–96. Springer, Toronto.
- Mrosovsky, N. (2003) *Predicting extinction: fundamental flaws in IUCN's Red List system, exemplified by the case of sea turtles*. Available at: <http://members.seaturtle.org/mrosovsky/> (accessed December 2011).
- Nada, M. & Casale, P. (2008) *Marine turtles in the Mediterranean Egypt: threats and conservation priorities*. WWF Italy, Rome.
- National Marine Fisheries Service & U.S. Fish and Wildlife Service (1998) *Recovery plan for U.S. Pacific populations of the East Pacific green turtle (Chelonia mydas)*. National Marine Fisheries Service, Silver Spring, MD.
- Nichols, W.J. (2003) *Biology and conservation of sea turtles in Baja California, Mexico*. Doctor of Philosophy with a major in wildlife ecology University of Arizona, Tucson.
- Peckham, S.H., Maldonado-Diaz, D., Koch, V., Mancini, A., Gaos, A., Tinker, M.T. & Nichols, W.J. (2008) High mortality of loggerhead turtles due to bycatch, human consumption and strandings at Baja California Sur, Mexico, 2003 to 2007. *Endangered Species Research*, **5**, 171–183.
- Peñate, J.G., Karamoko, M., Bamba, S. & Djadji, G. (2007) An update on marine turtles in Côte d'Ivoire, West Africa. *Marine Turtle Newsletter*, **116**, 7–8.
- Petro, G., Hickey, F.R. & Mackay, K. (2007) Leatherback turtles in Vanuatu. *Chelonian Conservation and Biology*, **6**, 135–137.
- Pritchard, P.C.H. (2003) Global status of sea turtles: an overview. *Inter-American convention for the protection and conservation of sea turtles first meeting of the parties, final report* (ed. by IAC Secretariat), pp. 81–93. Secretariat Pro Tempore, Inter-American Convention for the Protection and Conservation of Sea Turtles, San José, Costa Rica.
- Reuter, A. & Allan, C. (2006) *Tourists, turtles and trinkets: a look at the trade in marine turtle products in the Dominican Republic and Colombia*. TRAFFIC North America, Washington, DC.
- Richardson, P., Broderick, A., Campbell, L., Godley, B. & Ranger, S. (2006) Marine turtle fisheries in the UK Overseas Territories of the Caribbean: domestic legislation and the requirements of multilateral agreements. *Journal of International Wildlife Law and Policy*, **9**, 223–246.
- Rudrud, R.W. (2010) Forbidden sea turtles: traditional laws pertaining to sea turtle consumption in Polynesia (including the Polynesian Outliers). *Conservation and Society*, **8**, 84–97.
- Rudrud, R.W., Kroeker, J.W., Leslie, H.Y. & Finney, S.S. (2007) The sea turtle wars: culture, war and sea turtles in The Republic of the Marshall Islands. *SPC Traditional Marine Resource Management and Knowledge Information Bulletin*, **21**, 3–29.
- Stoddart, D.R. (1980) Little Cayman: ecology and significance. *Atoll Research Bulletin*, **241**, 171–180.
- Vander Velde, N. (2008) *A sea turtle genetic sampling, data collection and analysis project in the Marshall Islands*. Women United Together in the Marshall Islands (WUTMI), Majuro.
- Wallace, B.P., Lewison, R., McDonald, S.L., McDonald, R.K., Kot, C.Y., Kelez, S., Bjorkland, R.K., Finkbeiner, E.M., Helmbrecht, S. & Crowder, L.B. (2010) Global patterns of marine turtle bycatch. *Conservation Letters*, **3**, 1–12.

Wayne King, F. (1995) Historical review of the decline of the green turtle and the hawksbill. *Biology and conservation of sea turtles. Revised edition* (ed. by K.A. Bjorndal), pp. 183–188. Smithsonian Institution Press, Washington, DC.

WWF (2005) *Recent news from the WWF Africa & Madagascar marine turtle programme*. WWF, Gland.

## 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.

## BIOSKETCHES

**Frances Humber** is Conservation Programmes Manager at Blue Ventures Conservation and a PhD student at the

University of Exeter. She is interested in increasing the knowledge of the status of traditional and artisanal fisheries through community-based assessment, in particular the traditional shark and turtle fisheries of Madagascar.

**Annette Broderick** is a Senior Lecture in Conservation Biology at the Centre for Ecology and Conservation, University of Exeter. Her research focuses on the exploitation and status of marine vertebrate populations, in particular marine turtles.

**Brendan Godley** is Professor of Conservation Science at the Centre for Ecology and Conservation, University of Exeter. His research largely focuses on the study of marine vertebrates, but more recently has involved invasive species and the impacts of renewable energy facilities.

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

---

Editor: Omar Defeo