

# An overview of fisheries and sea turtle bycatch along the Atlantic coast of Africa

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## ABSTRACT

Some of the most productive and diverse marine ecosystems found anywhere in the world are located along the Atlantic coast of Africa. Industrial fishing fleets from Africa and foreign nations exploit the commercially valuable fishing resources in coastal exclusive economic zones (EEZs) and on the high seas. Small-scale artisanal fisheries operate extensively in coastal areas, catching a wide variety of species for subsistence and local trade. Incidental capture of sea turtles in the world's fisheries poses an urgent challenge to conservation and management efforts, and Atlantic Africa is no exception. The region supports important nesting and foraging grounds for five species of sea turtles—loggerheads *Caretta caretta* (Linnaeus, 1758), green turtles *Chelonia mydas* (Linnaeus, 1758), leatherbacks *Dermochelys coriacea* (Vandelli, 1761), hawksbills *Eretmochelys imbricata* (Linnaeus, 1766), and olive ridleys *Lepidochelys olivacea* (Eschscholtz, 1829). This study characterizes the predominant fisheries in the region and compiles the available information on sea turtle bycatch in 21 countries between Mauritania and Namibia; intentional take is also described. Despite the active fisheries in the region, detailed information on sea turtle-fisheries interactions is sparse for most African countries in the eastern Atlantic, highlighting an urgent need to address this gap.

**KEY WORDS:** Sea turtles, bycatch, West Africa, longlines, trawls.

## RESUMEN

Uno de los ecosistemas marinos más productivo y diverso del mundo se encuentra en la costa atlántica africana. Los recursos pesqueros de la zona económica exclusiva (ZEE) y de alta mar, son explotados tanto por la flota pesquera industrial africana como por las extranjeras. Las pesquerías artesanales operan a lo largo de toda la zona costera, capturando una gran variedad de especies para la subsistencia y el comercio local. La captura accidental de tortugas marinas es un reto urgente a nivel global, para la conservación y gestión de sus poblaciones y la zona atlántica de África no es una excepción. Esta región presenta importantes playas de anidación y zonas de alimentación para cinco especies de tortugas marinas: tortuga boba *Caretta caretta* (Linnaeus, 1758), tortuga verde *Chelonia mydas* (Linnaeus, 1758), laúd *Dermochelys coriacea* (Vandelli, 1761), Carey *Eretmochelys imbricata* (Linnaeus, 1766), y olivacea *Lepidochelys olivacea* (Eschscholtz, 1829). Este trabajo describe las pesquerías que se llevan a cabo en la región y reúne la información disponible de la captura accidental de tortugas marinas en 21 países entre Mauritania y Namibia; la captura intencionada también es descrita. A pesar de toda la pesquería que se desarrolla en la zona la información detallada sobre las interacciones entre tortugas marinas y las pesquerías es escasa en la mayoría de los países de la costa atlántica africana, destacando la urgencia de tomar medidas al respecto.

**PALABRAS CLAVE:** Tortugas marinas, captura incidental, África oeste, palangre, arrastre.

## LABURPENA

Mundu mailan den itsas ekosistema anitzenetarikoa eta emankorrenetarikoa Afrikan kostalde atlantiarrean aurkitzen da. Zona ekonomiko eskul-siboko (ZEE) eta ur ozeanikoetako arrantza baliabideak, bertako naiz kanpoko arrantza industrialeko flotek ustiatzen dituzte. Artisau arrantzan diharduten arrantzaleak aldiz kostaldean aritzen dira, espezie ezberdin ugari harrapatuz bai norbanako biziraupenerako baita bertako merkataritzaren sustapenerako ere. Itsas dortoken kontserbazio eta populazioen kudeaketa egokia egiteko harrapaketa akzidentala ekiditzeko nahia, mundu mailako erronka bilakatu da baita Afrikako Atlantiar kostaldean ere. Eskualde honetan, itsas dortoka espezie ezberdinentzat errute hondartza eta elikatze-ko gune garrantzitsuak aurkitzen dira bai benetazko dortoka *Caretta caretta* (Linnaeus, 1758), dortoka berdea *Chelonia mydas* (Linnaeus, 1758), larruzko dortoka *Dermochelys coriacea* (Vandelli, 1761), karei dortoka *Eretmochelys imbricata* (Linnaeus, 1766) eta oliba dortoka *Lepidochelys olivacea*-rentzat (Eschscholtz, 1829). Lan honetan, eskualdean burutzen diren arrantza mota ezberdinak ezagutzera ematen dira, eta harrapaketa akzidentalaren inguruan, 21 herrialde ezberdinetan, eskuaragari den informazioa bateratu da, Mauritaniar hasi eta Namibiara arte; nahitako harrapaketa ere kontuan hartu da. Arrantza jardueraren handia izanagatik ere itsas dortoken eta arrantza jardueraren arteko interakzioen informazioa murriztu da Afrikako atlantiar kostako herrialde guztietan, beraz argi nabarmentzen da gai honen inguruan neurriak hartzeko beharra.

**GAKO HITZAK:** Itsas dortokak, harrapaketa akzidentala, Afrika mendebalde, treta, arraste.

## INTRODUCTION

The Atlantic coast of Africa supports some of the most productive and diverse marine ecosystems found anywhere in the world. The powerful Canary, Guinea, and Benguela Currents each create concentrated areas of marine productivity, where populations of seabirds, sharks, marine mammals, and sea turtles converge to feed in the rich waters (Ukwe *et al.*, 2003; Ukwe *et al.*, 2006). Due to major upwelling in the Canary Current Large Marine Ecosystem (LME), stocks of sardine (*Sardina* spp., *Sardinella* spp.), herring

(*Ilisha* spp.), anchovy (*Engraulis* spp.), mackerel (*Scomber* spp.), and other small pelagic fish flourish and are heavily exploited in the relatively cool waters from Morocco to Guinea Bissau. The fishing activity in this area landed 1.8 million metric tons (mt) in 2006 (Sea Around Us Project 2010) and consists primarily of industrial fleets subsidized by the European Union (Project Global West Africa Assessment 2008). In the more tropical waters of the Guinea Current LME, seasonal upwelling and mixing of waters from the Guinea, Angola, and Benguela currents create zones of high productivity from Guinea Bissau to Angola. With 888,079 mt

landed in 2006 (Sea Around Us Project 2010), the area supports a wide range of industrial and artisanal fisheries—trawlers, longlines and purse seine vessels target small pelagics, tuna species and the commercially valuable bonga shad *Ethmalosa fimbriata* (Bowdich, 1825); mixed gear artisanal fleets catch a variety of coastal species. The Benguela Current LME, characterized as one of the strongest known wind-driven upwelling systems (NOAA, 2003), supports fisheries for horse mackerel (*Caranx* spp.), hake (*Urophycis* spp., *Merluccius* spp.), anchovies and other small pelagic in the waters from Angola to South Africa (Project Global West Africa Assessment 2008). Total fisheries landings for the Benguela Current LME in 2006 totaled 901,870 mt (Sea Around Us Project 2010) and overexploitation of resources is a concern for the region.

These regions sustain a year-round presence of both foreign and domestic fishing vessels, with marine fisheries landings from the Eastern Central and Southeast Atlantic regions totaling 4.7 million tons in 2008 (FAO, 2010). Industrial fleets from many nations (e.g., the European Union, Iceland, Russia, Korea, Japan, China, Taiwan, Latvia, Lithuania, Trinidad and Tobago) operate in international waters and within the exclusive economic zones (EEZs) of nearly every African country in the Atlantic, harvesting fish and crustaceans using a variety of techniques and gear types (MOSES, 2000; ZEEBERG *et al.*, 2006; CATRY *et al.*, 2009). Artisanal fisheries are believed to comprise over 95% of the world's fishermen (MOORE *et al.*, 2010), and Atlantic Africa supports a large and widespread artisanal fisheries. Artisanal fishing efforts predominate in coastal waters, lagoons, and estuaries, and often provide the principal source of protein and employment in coastal villages (UKWE *et al.*, 2006; CHUKWUONE *et al.*, 2009). Additionally, illegal, unreported, unregulated (IUU) fishing by foreign and domestic vessels alike contributes to fisheries landings off the West African coast (FALAYE, 2008; Environmental Justice Foundation < <http://www.ejfoundation.org/>>). Even in countries with existing legislation or fishing permit requirements, efforts to set quotas and reduce bycatch are undetermined by IUU fishing (FALAYE, 2008).

Incidental capture in fisheries, or bycatch, is widely acknowledged as posing an urgent and significant threat to sea turtle populations everywhere (LUTCAGE *et al.*, 1996; SPOTILA *et al.*, 2000; KOTAS *et al.*, 2004; LEWISON *et al.*, 2004; CARRANZA *et al.*, 2006; PETERSEN *et al.*, 2008; SIMS *et al.*, 2008). Along the Atlantic coast of Africa, 5 species of sea turtles are known to occur—loggerheads, *Caretta caretta* (Linnaeus, 1758); greens *Chelonia mydas* (Linnaeus, 1758); olive ridleys, *Lepidochelys olivacea* (Eschscholtz, 1829); hawksbills, *Eretmochelys imbricata* (Linnaeus, 1766); leatherbacks, *Dermochelys coriacea* (Vandelli, 1761)—and this region supports globally important nesting and foraging populations (FRETEY, 2001; FORMIA *et al.*, 2003; WITT *et al.*, 2009; MARCO *et al.*, 2011). Incidental sea turtle capture in African fisheries is widely acknowledged but poorly studied; as a result, detailed information on bycatch for each country's fisheries in the literature ranges from minimal to nonexistent (KELLEHER, 2005; MOORE, 2008; LEWISON *et al.*, 2011; STEWART *et al.*, 2011). The problem is

particularly difficult to monitor in artisanal fisheries, where many of the boats are currently not listed and the number of active boats is unknown. Also artisanal fisheries often operate in remote fishing villages and are not required to keep reliable records of captures including bycatch. Furthermore, intentional take of turtles by fishermen is also widespread along the African coast and remains largely unmonitored and unquantified (FRETEY, 2001).

Recent studies have synthesized global sea turtle bycatch data, including observed fishing effort and bycatch comparisons across gear types (Project Global West Africa Assessment 2008; WALLACE *et al.*, 2010). This study contributes to these efforts and the objectives are to characterize the predominant industrial and artisanal fisheries currently operating along the Atlantic coast of Africa from Mauritania to Namibia and to compile the available information on sea turtle bycatch in the region as exhaustively as possible; intentional take of sea turtles in the artisanal fisheries is also highlighted. The general paucity of information on the incidental and intentional capture of turtles in fisheries represents a great void in the scientific knowledge that is crucial to the conservation and management of sea turtle populations. This paper aims to emphasize the intensity of fishing activity in this region and how little is known about sea turtle bycatch from this extensive coastline.

## METHODS

The fisheries data were compiled from the published literature, conference proceedings, regional reports, and fisheries databases (e.g., FAO, ICCAT, FishBase, Project Global, Sea Around Us Project). This report focused on the target species of each fishery, gear types used, and distinctions made (if any) between industrial and artisanal fleets.

Sea turtle bycatch data were also compiled from the published literature, conference proceedings, regional reports, and various databases (i.e., FAO, ICCAT, Project Global). Intentional take of sea turtles in the artisanal fisheries is also described when available. The 21 countries described in this paper range from Mauritania to Namibia and include the Cape Verde Islands and Sao Tome and Principe (Fig. 1); Morocco and South Africa were excluded because their coastlines include the Mediterranean Sea and Indian Ocean, respectively, which are outside the scope of this paper.

## RESULTS

### Characterizing the Fisheries

#### Industrial Fisheries

Industrial fishing vessels operate within Exclusive Economic Zone (EEZ) waters as well as farther offshore of every country along the coast of Atlantic Africa. A mixture of domestic and international fleets fish in these waters using a wide variety of gear types, including trawls (bottom and mid-water), longlines, and purse seines. The catch composition, target species, and occurrence of bycatch vary for each country and specific gear type. Fo-



Fig. 1.- Map of the Atlantic coast of Africa

reign vessels represent a number of different countries (e.g., France, Iceland, Ireland, Italy, Japan, China, Taiwan, Latvia, Lithuania, the Netherlands, Portugal, Russia, South Korea, Spain, and Uruguay) (FONTENEAU *et al.*, 2000; CARRANZA *et al.*, 2006; UKWE *et al.*, 2006; ZEEBERG *et al.*, 2006; Sea Around Us Project 2010).

### Trawlers

Industrial trawl activity consists of mid-water, bottom (demersal), shrimp, and crab trawls. Pelagic trawlers have been operating in coastal EEZ waters from Western Sahara to Senegal since the 1960s, targeting clupeoids such as sardine [*Sardina pilchardus* (Walbaum, 1792)], sardinella [*Sardinella aurita Valenciennes*, 1847; *Sardinella maderensis* (Lowe, 1838)] and mackerels [*Scomber japonicus* Houttuyn, 1782; *Trachurus trecae* Cadenat, 1950; *Trachurus trachurus* (Linnaeus, 1758)] (BINET, 1997; TER HOFSTEDÉ *et al.*, 2006). ZEEBERG *et al.* (2006) also documented industrial trawl activity in the Mauritanian EEZ by European (Dutch and Irish), Lithuanian, Russian, and Icelandic vessels, which primarily target sardines, sardinella, and horse mackerels. Industrial bottom trawling for demersal fish such as soles (Cynoglossidae), seabreams (Sparidae), croakers (*Pseudotolithus* spp.), threadfins (*Galeoides* spp., *Pentanemus* spp. and *Polydactylus* spp.) and African sicklefish (*Drepane* spp.) occurs in Angola (ICCAT 2005). The incidence of industrial shrimp and crab trawling is highest in coastal, estuarine regions near river deltas, such as those in Guinea-Bissau, Liberia, Côte d'Ivoire, Benin, Cameroon, and Nigeria (FAO 1989; Project Global 2008; CATRY *et al.*, 2009; Sea Around Us Project 2010; VOGT *et al.*, 2010). Commercial trawling for fish also occurs in Nigerian waters (FALAYE, 2008) as well as in the waters of Gabon and Congo. Industrial trawling is illegal in the EEZ of the Cape Verde Islands, but limited enforcement does not effectively exclude foreign fleets (LÓPEZ-JURADO *et al.*, 2003).

### Longliners

Commercial longlining efforts mostly target large, commercially valuable pelagics that are shipped abroad to international markets in the European Union, the United States, and Japan. Pelagic longlines target species such as swordfish *Xiphias gladius* Linnaeus, 1758, blue shark *Prionace glauca* (Linnaeus, 1758), and tunas [*Thunnus albacares* (Bonnaterre, 1788); *Thunnus obesus* (Lowe, 1839); *Thunnus alalunga* (Bonnaterre, 1788)] (RYAN *et al.*, 2002; CARRANZA *et al.*, 2006; PETERSEN *et al.*, 2007). Bottom-set longlines exploit demersal species such as croakers, threadfins, soles, marine catfish (*Arius* spp.), brackishwater catfish (*Chrisichthys* spp.), snapper (*Lutjanus* spp.), grunters (Pomadasyidae), and groupers (*Epinephelus* sp.) (CHUKWUONE *et al.*, 2009). Longline vessels are prominent in the waters of Mauritania, Cape Verde, Gabon, Angola, Namibia, and South Africa, targeting swordfish, tunas, sharks, and billfish (ICCAT 2005; PETERSEN *et al.*, 2007).

### Seine nets (Seiners)

Different purse seines types in the region target tunas and small pelagics such as sardines and anchovies in coastal waters from Mauritania to South Africa, specifically in the Guinea Current Large Marine Ecosystem area extending from Guinea-Bissau to Angola (Project Global 2008). In Côte d'Ivoire, tuna are caught commercially using tuna purse seines (ICCAT 2005), and the Ghanaian industrial fleet uses purse seines to catch sardinella and tuna (FALAYE, 2008).

### Artisanal Fisheries

For many countries along the African coast, artisanal fisheries constitute the majority of the national fleet and like their industrial counterparts target a variety of organisms. Pelagic fish (sardines, sardinellas, mackerels, bonga shad) as well as demersal species (croakers, African threadfin, soles, catfish, and snappers) are important components of the artisanal catch. While most countries engage in both industrial and artisanal fishing with varying gear types and target species for each sector, it appears that Senegal, The Gambia, Sierra Leone, Ghana, and Nigeria have predominantly artisanal fleets (CORMIER-SALEM, 1994; LAE *et al.*, 2004; SYLVANUS, 2007; BRINSON, 2009; BAIO, 2010). The gear types in use include a variety of nets (seines, driftnets, hand trawls, and set gill nets), as well as traps, hand lines, pole lines, and some longlines (ICCAT 2005, Sea Around Us Project 2010); there is also a higher incidence of mixed gear use among artisanal fisheries compared to industrial fleets (MOORE *et al.*, 2010). Artisanal fishery products are often consumed locally, and fishing activity is typically spread along coastlines and throughout inland waters (MOORE *et al.*, 2010).

### Trawls

The broad 'trawl' category includes mid-water, bottom, and shrimp and crab trawls. Shrimp trawl activity is especially concentrated near estuaries and areas of high productivity in The Gambia, Guinea-Bissau, Liberia, Côte

d'Ivoire, Benin, Cameroon, Nigeria, and the Democratic Republic of Congo (FAO 1989; Project Global 2008; CATRY *et al.*, 2009; Sea Around Us Project 2010; VOGT *et al.*, 2010). Mid-water trawling targeting sardinella, bonga shad, mackerels, and other small pelagics also occurs in every country from Senegal to Namibia (ICCAT 2005).

### Longlines

The Gambian fishery targets bonga shad, sardine, sardinella, European anchovy, and mackerels using handlines and longlines (ICCAT 2005). The shrimp fisheries in Nigeria, Cameroon, Gabon, and the Democratic Republic of Congo also target demersal fish using similar gear types (MOSES, 2000; LAE *et al.*, 2004; ICCAT 2005; Project Global 2008). In Angola, artisanal handlines and longlines target seabream species, grouper species, Angola croakers *Miracorvina angolensis* (Norman, 1935), Angola dentex *Dentex angolensis* Poll & Maul, 1953, hakes *Merluccius* spp., and pelagic fish such as sardine and horse mackerel (HONIG *et al.*, 2008).

### Seines and Gillnets

Western Africa has the highest density of gillnet vessels found anywhere in the world (STEWART *et al.*, 2011). Artisanal fishermen utilize a wide variety of net types, including stownets, drift nets, surrounding nets, and seines in addition to the ubiquitous gillnet. The Gambian fishery targets bonga shad, sardine, sardinella, European anchovy, and mackerel using drift nets and gillnets (ICCAT 2005). FAO data indicate that artisanal purse seine fishing in Liberia captures mainly sardinella (60% of total catch in 1986). Fishermen in Sierra Leone use mostly nets (65.4% of total gear) to capture bonga, sardine, and barracuda (*Sphyraena*) (BAIO, 2010). In Ghana, an artisanal drift net fishery targets sailfish and other billfish, tunas, and sharks (BRINSON *et al.*, 2009). Small pelagics are exploited in EEZ waters from Ghana to the Democratic Republic of Congo using purse seines, gillnets, mid-water net trawls, and driftnets (CHUKUWONE *et al.*, 2009). In Nigeria, bonga shad is harvested using artisanal gill nets and semi-industrial purse seines (VAKILY, 1992; MOSES *et al.*, 2000). Similar to industrial crustacean fisheries, artisanal shrimp and crab fishing is practiced in estuaries and inshore systems. Shrimp is harvested in The Gambia estuary using stownets, drift nets, gillnets, surrounding nets, handlines and longlines, accounting for 23% of the total artisanal catch for the 2001-2002 seasons (LAE *et al.*, 2004). The shrimp fisheries in Nigeria, Cameroon, Gabon, and the Democratic Republic of Congo also target demersal fish using similar gear types (MOSES, 2000; LAE *et al.*, 2004; ICCAT 2005; Project Global 2008).

### Weirs, Traps, Hand lines, Pole lines, etc

A number of artisanal fisheries operate using gear types other than the ubiquitous lines and nets. BAIO *et al.* (2010) reported that 13.5% of the gear used by the Sierra Leone artisanal fleet comprises non-net gear types (i.e., crab pots, traps, etc.). Fleets in Ghana, Nigeria, Came-

roon, Gabon, and Democratic Republic of Congo utilize traps in their subsistence fisheries for sardinella, bonga shad, and shrimp (Nigeria) (MOSES, 2000; ICCAT 2005; SYLVANUS, 2007; BAIO *et al.*, 2010).

### Sea Turtle bycatch

Quantitative data on sea turtle bycatch are rare for eastern Atlantic waters, although several studies have surmised that given the degree of fishing activity in close proximity to nesting and foraging areas, sea turtle bycatch rates are probably high (LEWISON *et al.*, 2004b; MOORE *et al.*, 2010; WALLACE *et al.*, 2010). Accurate and reliable bycatch data are difficult to achieve, as direct observation rates are low (<1% of total fleets) and statistics from the region's many small-scale fisheries are still largely incomplete (KELLEHER, 2005; MOORE *et al.*, 2010; WALLACE *et al.*, 2010). Given the limited number of quantitative studies on sea turtle bycatch in the industrial and artisanal fisheries along the Atlantic coast of Africa, information on bycatch is compiled here from several sources that may impart valuable knowledge, including anecdotal accounts, interviews, as well as reports of strandings, entanglements, and injuries that are strongly suspected to be fisheries related. Anecdotal accounts of sea turtle bycatch contain minimal to no information on fishing effort and numbers or species encountered, but do suggest areas that could benefit from future bycatch studies. Interviews with fishermen have been shown to be useful tools in identifying areas and gear types with high probable bycatch rates (GILMAN *et al.*, 2009; LEWISON *et al.*, 2011). Here we summarize all reports of incidental and intentional take of turtles as exhaustively as possible for each country in this region (Table 1).

### Mauritania

In observing 1,424 trawl sets in the industrial Dutch trawl fishery of Mauritania from 2001 to 2005, ZEEBERG *et al.* (2006) recorded the bycatch of 8 sea turtles—leatherback, hawksbill, and loggerhead—but did not provide bycatch rates for each species. Sea turtle bycatch accounted for 1% of total pelagic megafaunal bycatch, and the percentage of days observed monthly ranged from 4 - 88% throughout the five years of the study. Data presented in TER HOFSTEDE *et al.* (2006) suggests that bycatch in the Dutch pelagic trawl fishery off Mauritania comprises less than 10% of the total catch. Lobster fishermen from Brittany, France, were known to catch hawksbills along the coast between Cap Timiris and Saint-Louis, in nets placed at depths of 8 - 15 m; between 1970 and 1975, each boat captured 2 to 3 individuals (< 40cm in carapace length) during the fishing season (MAIGRET, 1983). Other capture records from Mauritania include: 2 loggerheads (45 cm and 80 cm in length) in fishing nets from the Bay of Levrier and Pointes des Crabes on 7 May 1980 and 14 July 1981, respectively (MAIGRET, 1983); one leatherback, weighing 600 kg, in a pelagic trawl on 22 May 1981 in the Bay of Levrier (MAIGRET, 1983; ARVY *et al.*, 1996); and 17 green turtles (16 females and 1 male) weigh-



| Country               | Gear Type  | Artisanal/Industrial Fishery | Species Caught     | References  |
|-----------------------|--|------------------------------|--------------------|---|
| Mauritania            | Pelagic trawl  | Industrial                   | DC, CC, EI         | ZEEBERG <i>et al.</i> 2006  |
| Mauritania            | Net  | Industrial                   | EI, CC,            | MAIGRET 1983  |
| Mauritania            | Pelagic trawl  | Industrial                   | DC                 | MAIGRET, 1983; ARVY <i>et al.</i> 1996  |
| Mauritania            | Purse seine  | Artisanal                    | CM                 | MAIGRET, 1983; ARVY <i>et al.</i> 1996  |
| Mauritania            | Net, harpoon   | Artisanal                    | CM                 | MAIGRET 1975; MAIGRET & TROTIGNON 1977; LE TOQUIN <i>et al.</i> 1980; J. Fretey pers. comm.).   |
| Senegal               | Purse-seiners  | Industrial                   | DC                 | STRETTA <i>et al.</i> (1996)  |
| Senegal               | --   | Artisanal                    | CC, LO, DC, EI, CM | CADENAT 1949; MARCOVALDI & FILIPPINI 1991   |
| Senegal               | Beach seine  | Artisanal                    | CM                 | SABINOT 2003  |
| The Gambia            | Net  | Artisanal                    | LO, EI             | BARNETT <i>et al.</i> 2004; HAWKES <i>et al.</i> 2006   |
| Cape Verde            | Net  | Artisanal                    | CM                 | LOUREIRO 2008   |
| Cape Verde            | Net  | Artisanal                    | CC, CM             | LOPEZ-JURADO <i>et al.</i> (2003)   |
| Cape Verde            | --   | --                           | DC                 | M. de Ponte Machado <i>pers.comm.</i> in Fretey 2001  |
| Guinea Bissau         | --   | Artisanal, semi-industrial   | UI                 | AGARDY 1990; BARBOSA <i>et al.</i> 1998; FORTES <i>et al.</i> 1998; CATRY <i>et al.</i> 2002  |
| Guinea Bissau         | --   | Industrial                   | UI                 | FRETEY 2001   |
| Guinea                | Net  | Artisanal                    | DC                 | Tissandier <i>pers. comm.</i> in Fretey 2001; M. Camara Soumah <i>pers. comm.</i> in Fretey 2001  |
| Sierra Leone          | Gillnet, purse seine                                   | Artisanal                    | CM, EI, CC, DC, LO | MOORE <i>et al.</i> 2010  |
| Sierra Leone          | Net  | Artisanal                    | DC, CC, EI, LO, CM | MOORE 2008; MOORE <i>et al.</i> 2010  |
| Liberia               | --   | Artisanal                    | UI                 | A. Topka <i>pers. comm.</i>   |
| Côte d'Ivoire         | --   | --                           | UI                 | See Table 2   |
| Côte d'Ivoire         | --   | Artisanal                    | CC, LO             | GROOMBRIDGE & LUXMORE 1989  |
| Côte d'Ivoire         | Net  | Artisanal                    | DC, LO, CM, EI     | Poisson <i>pers. comm.</i> in Fretey 2001; Gomez <i>pers. comm.</i> in Fretey 2001; Gomez Penate <i>et al.</i> 2007                           |
| Ghana                 | Purse-seiners  | Industrial                   | UI                 | STRETTA <i>et al.</i> 1996  |
| Ghana                 | --   | Artisanal                    | CM                 | TOMAS <i>et al.</i> 2001  |
| Ghana                 | Gillnet  | Artisanal                    | DC, LO, CM         | AMITEYE & MÖLLER 2000   |
| Benin                 | Gillnet, shark net, seine                              | Artisanal                    | LO, CM, DC         | DOSSA <i>et al.</i> 2007  |
| Benin                 | --   | --                           | UI                 | See Table 2   |
| Togo                  | Net  | Artisanal                    | CM, DC, EI, LO     | Y. Acakpo-Addra <i>pers. comm.</i> in Fretey 2001   |
| Nigeria               | Gillnet  | Artisanal                    | DC, CC, EI, CM     | MOORE <i>et al.</i> 2010  |
| Nigeria               | Net  | Artisanal                    | UI                 | FRAZIER <i>et al.</i> 2007  |
| Nigeria               | Beam crawl   | Artisanal                    | EI                 | AMBROSE <i>et al.</i> 2005  |
| Cameroon              | --   | --                           | CM                 | FRETEY 1999a  |
| Cameroon              | Net, line  | Artisanal                    | LO                 | FRETEY 1999a  |
| Cameroon              | Gillnet, longline                                      | Artisanal                    | CM, EI, LO, DC     | MOORE <i>et al.</i> 2010  |
| Cameroon              | --   | Artisanal                    | CM, LO, EI, DC     | AYISSI <i>et al.</i> 2008   |
| Cameroon              | Trawl  | --                           | LO                 | FRETEY 1998a  |
| Cameroon              | Harpoon  | Artisanal                    | EI                 | FRETEY 1998a  |
| Cameroon              | Net  | Artisanal                    | DC                 | FRETEY 1998a  |
| Equatorial Guinea     | --   | --                           | CM                 | TOMAS <i>et al.</i> 2001  |
| Equatorial Guinea     | Net, harpoon   | Artisanal                    | LO, CM             | FRETEY 1998b; MBA <i>et al.</i> 1998  |
| Equatorial Guinea     | --   | Artisanal                    | CM, EI             | FORMIA <i>et al.</i> 2008   |
| São Tomé and Príncipe | --   | Artisanal                    | DC                 | FRETEY <i>et al.</i> 1999   |
| São Tomé and Príncipe | Net, spear   | Artisanal                    | CM, LO             | Graff 1995a, 1995b  |
| São Tomé and Príncipe | --   | Artisanal                    | LO                 | J. F. Dontaine & O. Neves <i>pers. comm.</i> in Fretey 2001   |
| São Tomé and Príncipe | Net  | Artisanal                    | EI                 | JUSTE 1994  |
| Gabon                 | --   | --                           | UI                 | See Table 2   |
| Gabon                 | Trawl  | Industrial                   | UI                 | BELL & MASSALA 2006   |
| Gabon                 | Trawl  | Industrial                   | LO, DC             | PARNELL <i>et al.</i> 2007  |
| Gabon                 | --   | Artisanal                    | CM                 | TOMAS <i>et al.</i> 2001  |
| Gabon                 | --   | --                           | EI                 | BELLINI <i>et al.</i> 2000  |
| Gabon                 | --   | Artisanal                    | CM, EI             | FORMIA <i>et al.</i> 2003   |
| Congo                 | Net  | Artisanal                    | EI                 | FRETEY 1998c  |
| Congo                 | Gillnet, trawl, beach seine                            | Artisanal                    | CM, LO, EI, DC     | BAL & BREHERET 2006; BAL <i>et al.</i> 2007; BAL & BREHERET 2008; BREHERET & ADELL 2009; FASQUEL & BREHERET 2010; BREHERET <i>et al.</i> 2011 |
| Congo                 | Drift net  | --                           | LO                 | Maloueki ( <i>pers. comm.</i> in Fretey 2001)   |
| Congo                 | Trawl  | --                           | LO                 | PARIS <i>et al.</i> 1997  |
| Dem. Rep. of Congo    | Net  | Artisanal                    | UI                 | OCPE 2006; Verhage 2007   |
| Angola                | Longline   | Artisanal                    | CC, LO, EI, DC     | WEIR <i>et al.</i> 2007   |
| Angola                | Net  | Artisanal                    | UI                 | WEIR <i>et al.</i> 2007   |
| Angola                | --   | --                           | LO, DC             | WEIR <i>et al.</i> 2007   |
| Angola                | Net, handline, beach seine                             | Artisanal                    | UI                 | CARR & CARR 1991  |
| Namibia               | Trawl, nets (gillnet, driftnet), beach seine, longline | --                           | CM, DC, CC, EI     | BIANCHI <i>et al.</i> 1993  |
| Namibia               | Pelagic longline                                       | Industrial                   | UI                 | HONIG <i>et al.</i> 2008  |
| Gulf of Guinea        | Pelagic longline                                       | Industrial                   | DC, LO             | CARRANZA <i>et al.</i> 2006   |
| Benquela Current LME  | Pelagic longline                                       | Industrial                   | UI                 | HONIG <i>et al.</i> 2008  |
| Atlantic Ocean        | Pelagic longline                                       | Industrial                   | DC, CC             | LEWISON <i>et al.</i> 2004  |

**Table 1.-** Summary of reported sea turtle take in the fisheries from Mauritania to Namibia. Gear type is indicated when available. (DC= *Dermochelys coriacea*; CC = *Caretta caretta*; CM = *Chelonia mydas*; EI = *Eretmochelys imbricata*; LO = *Lepidochelys olivacea*; UI = unidentified species).

hing 40 – 50 kg in an artisanal purse seine on 27 September 1980 at Marguerite Island (MAIGRET, 1983; ARVY *et al.*, 1996). At Banc D'Arguin, which supports one of the most important foraging areas for green turtles (FRETEY, 2001), Imagrues fishermen have long been documented to catch turtles with nets and harpoons for consumption (MAIGRET, 1975; MAIGRET and TROTIGNON, 1977; LE TOQUIN *et al.*, 1980; J. Fretey *pers. comm.*).

### Senegal

STRETTA, *et al.* (1996) reported sea turtle bycatch by French and Spanish tuna boats along the West African coast and only 1 leatherback was caught in Senegalese waters, but bycatch by trawlers is known to occur and has not been quantified (SABINOT, 2003). In February 2009 the United States' National and Oceanic Atmospheric Administration conducted an observer training workshop in Dakar, which gave the Senegalese government the necessary training and skills to evaluate bycatch in their industrial fisheries. Captures of loggerheads, olive ridleys, leatherbacks, hawksbills and green turtles by shark fishermen were reported between 1945 and 1950 (CADENAT, 1949). Between April 2001 and September 2002, at least 21 green turtles were captured by beach seines in Palmarin, and between 1995 and 2000, hundreds of green turtles were reported to have been captured in this region (SABINOT, 2003). Intentional take of sea turtles for consumption by fishermen commonly occurs in Senegal (SABINOT, 2003). Some of the sea turtle take may be affecting turtles migrating from waters as far away as Brazil; a juvenile hawksbill tagged in Atol das Rocas, Brazil, in January 1990 was captured and killed in Dakar in July 1990 (MARCOVALDI & FILIPPINI, 1991).

### The Gambia

Bycatch in the artisanal fishery and by trawlers has been stated as a threat to sea turtle populations in the Gambia (BARNETT *et al.*, 2004). Two dead juvenile green turtles bearing injuries indicative of interactions with the nearby gillnet fishery were recorded on morning surveys in 2006 (HAWKES *et al.*, 2006).

### Cape Verde

Exploitation of sea turtles in the Cape Verde Islands for meat and traditional dates back several centuries (LOUREIRO TORRÃO, 2008). Today, incidental and intentional captures of sea turtles are still considered serious threats to sea turtles in Cape Verde (LAZAR HOLCER, 1998; LÓPEZ-JURADO *et al.*, 2003). LÓPEZ-JURADO *et al.* (2003) recorded the entanglement of 10 loggerhead turtles in an abandoned trawl net on Boavista Island in the Cape Verde archipelago; these turtles measured 62 – 89 cm in curved carapace length. On the island of Santiago, LOUREIRO (2008) noted landings of 4 juvenile green turtles by artisanal fishermen. The capture of a leatherback was reported by fishermen in May 1999 (M. de Ponte Machado *pers. comm.* in FRETEY, 2001).

A study to evaluate bycatch in the artisanal fisheries has recently been launched in the islands (E. Abella Perez *pers. comm.*).

### Guinea Bissau

Bycatch of sea turtles in the demersal fisheries for shrimp, fish and squid in the region, and semi-industrial and artisanal fisheries for shark, barracuda and other large fish may be a significant source of mortality in Guinea Bissau (AGARDY, 1990; BARBOSA *et al.*, 1998; FORTES *et al.*, 1998; CATRY *et al.*, 2002). Between 1000 and 2000 turtles were estimated to be killed in the commercial shrimp fishery annually (FRETEY, 2001). Twelve turtles tagged on the nesting beach in 2006/2007 were caught over the next 2 years by fishermen in the Gulf of Guinea (Ghana, Cameroon, Gabon, and the continental territory of Equatorial Guinea) (TOMAS *et al.*, 2010).

### Guinea

In Guinea, artisanal fishermen accidentally capture sea turtles in their nets, and 85% of the fishermen indicated that they do not actively hunt for turtles (LÉTOURNEAU, 1996). Other capture records in local nets include: a 142 cm leatherback at Conakry on 27 July 1989 (Tissandier *pers. comm.* in FRETEY, 2001) and a 183 cm leatherback at the landing site of Téménétaye on 23 June 2000 (M. Camara Soumah *pers. comm.* in FRETEY, 2001).

### Sierra Leone

Interviews (n = 693) with artisanal fishermen in 2006 and 2007 throughout Sierra Leone reported that 45% of sea turtles recorded as bycatch were caught in gillnets, which make up 50% of the artisanal gear (followed by purse seines (37%) and longlines (26%)) (MOORE *et al.*, 2010). The species caught, though unconfirmed, were said to include greens turtles, hawksbills, leatherbacks, loggerheads, and olive ridleys. Currently, an extensive study is underway by the Conservation Society of Sierra Leone to evaluate sea turtle bycatch in the artisanal fisheries of Sierra Leone. Bycatch evaluation in the industrial fisheries of Sierra Leone is in the development phase.

### Liberia

Little information is available on sea turtle bycatch in Liberia, although it is known to occur (A. Topka *pers. comm.*). The Liberian Sea Turtle Project managed by the local NGO Save my Future Foundation (SAMFU) is launching a study in 2011 to evaluate sea turtle bycatch in the artisanal fisheries. Meanwhile, fishermen and communities participating in the sea turtle project are encouraged to release turtles caught in their nets. In May 2011, the United States' National and Oceanic Atmospheric Administration conducted an observer training workshop in Monrovia, which will help the Liberian government evaluate and address bycatch issues in their industrial fisheries.

### Côte d'Ivoire

The FAO has reported large catches of unidentified marine turtle species from Côte d'Ivoire since 2000 (Table 2). Incidental catch of adult leatherbacks and olive ridleys and immature greens and hawksbill in nets is common (GÓMEZ PENATE *et al.*, 2007). Other reports include a leatherback captured in local nets at San Pedro port on 6 January 1984 (Poisson *pers. comm.* in FRETEY, 2001) and an adult male ridley captured by fishermen on 26 April 2000 at Monogaga (Gómez *pers. comm.* in FRETEY, 2001). GROOMBRIDGE LUXMORE (1989) describe a turtle fishery operation out of Abidjan that caught mainly loggerheads and olive ridleys—516 turtles were landed in 1967 and 797 in 1968.

### Ghana

STRETTA *et al.* (1996) reported capture of 3 unidentified sea turtles by French and Spanish tuna boats along the Ghana coast. In several coastal villages in Ghana in 2000, 12 leatherbacks, 4 olive ridleys, and 1 green turtle were either observed captured in fishing nets or discovered dead, having drowned in nets; no data on fishing effort were recorded (AMITEYE & MØLLER, 2000). Tag returns from fishermen in Ghana provide evidence for the incidental capture of post-nesting green turtles migrating from Bioko Island, Equatorial Guinea (TOMÁS *et al.*, 2001). Bycatch studies in artisanal fisheries are currently being initiated in Ghana (P. Allman *pers. comm.*), and in April 2008, the United States' National and Oceanic Atmospheric Administration conducted an observer training workshop in Accra, so that the industrial fisheries could begin quantifying their bycatch.

### Benin

DOSSA *et al.* (2007) observed 705 fishing sets from 21 groups of fishers from November 2004 to February 2005 and recorded bycatch of 33 olive ridleys, 2 greens, and 1 leatherback, predominantly in shark nets and gillnets (80.6% and 19.5%, respectively); overall capture rate of the sets was 5.1%. Currently, NGO Nature Tropicale is monitoring bycatch around Grand Popo (J. Fretey *pers. comm.*). The FAO has reported catches of unidentified marine turtle species since 2000 (Table 2).

### Togo

Accidental captures of green turtles, leatherbacks, hawksbills, and ridleys in fishing nets has been observed (Y. Acakpo-Addra *pers. comm.* in FRETEY, 2001). Currently, the local NGO Agbo-Zegue is surveying for bycatch along the Togo coastline (J. Fretey *pers. comm.*).

### Nigeria

In a survey of the artisanal shrimp beam-trawl fishery in Nigeria from January to December 2002, 2 hawksbills were recorded as bycatch in a total of 62 landings from 5 canoes (AMBROSE *et al.*, 2005). Unidentified sea turtles have been reported stranded entangled in plastic fishing mesh (FRAZIER *et al.*, 2007). Interviews (n = 648) with artisanal fishermen throughout Nigeria in 2006 and 2007 showed that 71% of turtle bycatch (leatherbacks, loggerheads, hawksbill, and green turtles) occurred in gillnets, though gillnet use was reported as the second highest among the gear types (33%), behind that of purse seines and stow nets (50%) (MOORE *et al.*, 2010).

### Cameroon

Accidental and intentional captures of green turtles less than 78 cm in size are common in Cameroon year round, and during the nesting season fishermen caught female olive ridleys with a net or a line (FRETEY, 1999a). Between 1999 and 2001, 400 turtles (green, olive ridley, hawksbill, and leatherback) were caught incidentally in coastal artisanal fisheries in Cameroon; however, detailed information on bycatch rates for each species or fishing effort is not available (AYISSI *et al.*, 2008). Interviews (n = 904) with artisanal fishermen in Cameroon in 2006 and 2007 showed that gillnets were used most (53% of gear), followed by longlines (36%), and that sea turtle bycatch rates (for leatherbacks, olive ridleys, hawksbills, and greens) corresponded accordingly (60% for gillnets, roughly 30% for longlines) (MOORE *et al.*, 2010). Trawlers are known to illegally fish close to shore and bycatch of turtles is high (FRETEY, 1999b); carapaces of 2 olive ridleys caught in a shrimp trawler were on display at a bar in Douala and one of them was 82 cm in length (FRETEY, 1998a). The young fishermen of Lolabe III were reported to harpoon many juvenile hawksbills in front of their village (the smallest measured about 30 cm), whereas other fishermen complained about leatherbacks getting entangled in their nets and destroying them (FRETEY, 1999a). A study quantifying bycatch in the artisanal fisheries is currently underway in Cameroon (I. Ayissi *pers. comm.*).

### Equatorial Guinea

The FAO reported catches of unidentified species of marine turtles in 2001, with no additional catches reported since (Table 2). Though fishing effort was not quantified, tag returns from fishermen in Equatorial Guinea provide evidence for the incidental capture of post-nesting green turtles migrating from Bioko Island, Equatorial Guinea (TOMÁS *et al.*, 2001).

| Country              | 2000         | 2001         | 2002         | 2003          | 2004        | 2005        | 2006        | 2007       | 2008       | 2009        |
|----------------------|--------------|--------------|--------------|---------------|-------------|-------------|-------------|------------|------------|-------------|
| Benin <sup>20*</sup> | 5            | 1            | 2            | 1             | 1           | 1           | 1           | 0          | 0          |             |
| Côte d'Ivoire        | 50           | 71           | 0            | 0             | 0           | 0           | 0           | 0          | 0          | 0           |
| Equatorial Guinea    | 1*           | 1*           | 1*           | 1*            | 2*          | 2*          | 2*          | 3          | 5          | 2           |
| Gabon                | 51           | 238          | 843          | 1107          | 25          | 34          | 36          | 5          | 4          | 4*          |
| <b>Total</b>         | <b>122 t</b> | <b>315 t</b> | <b>845 t</b> | <b>1110 t</b> | <b>28 t</b> | <b>37 t</b> | <b>39 t</b> | <b>9 t</b> | <b>9 t</b> | <b>6* t</b> |

**Table 2.-** Countries with reported sea turtle catch in the FAO database (FAO Fishery Statistical Collections 2011; <http://www.fao.org/fishery/statistics/global-capture-production/4/en>). Catch is reported in metric tons (t). Asterisk (\*) indicates that the value is based on calculated estimate.

Intentional take is common and in northern mainland Equatorial Guinea many olive ridleys were reported to be captured by Iduma fishermen, often 6 to 7 animals at a time with nets of large mesh size; capture of green turtles was also recorded (FRETEY, 1998b). On the islands of Corisco and Cabo San Juan, fishermen use special nets (8 x 14 m with a mesh size of 0.5 m) to catch green turtles; 2 or 3 of these nets apparently can catch 30 turtles in a month, although this number should be cautiously interpreted (MBA *et al.*, 1998). Surveys by FRETEY (1998b) indicated that approximately 60 green turtles (sometimes other species as well) are captured by net or harpoon each year around Corisco. FORMIA *et al.* (2008) estimated that 300-500 turtles (green turtles and hawksbills) are captured annually by the Benga fishermen in Corisco Bay that straddles Equatorial Guinea and Gabon to meet the growing demands for turtle meat in the cities. Efforts to quantify bycatch in the artisanal fisheries are underway in Equatorial Guinea (A. Formia *pers. comm.*).

### Sao Tome and Principe

Juvenile leatherbacks measuring between 14 cm and 21 cm have been accidentally captured in the artisanal fisheries around the waters of Ilheu Cabras and Boné de Jóquei (FRETEY *et al.*, 1999). However, intentional take is quite widespread. Fishermen use special turtle nets, spears, or just mask and snorkel to capture green turtles and olive ridleys (GRAFF, 1995a, 1995b). In Ilheu Cabra, the capture of 15 olive ridleys (mostly females) by local fishermen was recorded between early September and early December 1998 (J. F. Dontaine & O. Neves *pers. comm.* in FRETEY, 2001). Based on local surveys, JUSTE (1994) estimated that at least 100-150 reproductive adult hawksbills are killed each year in the nets and on the beach.

### Gabon

The FAO has reported catches of unidentified species of marine turtles since 2000 (Table 2). In 1982, FAO fisheries statistics recorded a catch of 2 tons of unidentified sea turtles in Gabon (GROOMBRIDGE LUXMORE 1989), STRETTA *et al.* (1996) reported on sea turtle bycatch by French and Spanish tuna boats along the Gabon coast. In a recent observer program in Gabon supported by the FAO, 2 unidentified sea turtle species were recorded on an industrial trawler fishing between 14 March 2006 and 8 April 2006 in 175 hauls (LETOCKA BELL MADOUNGOU MASSALA, 2006). Bycatch data noted by Gabon's Direction Générale de Pêche et l'Aquaculture for artisanal and industrial fisheries combined from 1996 to 2003 varied from no bycatch in 1996 to over 1000 tons of sea turtle bycatch in 2003; the species indicated included loggerheads and leatherbacks combined, although identification of loggerheads might be erroneous.

In stranded turtles recorded in southern Gabon and northern Congo in 2005 and 2006, 1 olive ridley and 2 leatherbacks were found to have wounds consistent with fisheries related interactions (PARNELL *et al.*, 2007). Though fishing effort was not quantified, tag returns from fishermen

in Gabon provide evidence for the incidental capture of post-nesting green turtles migrating from Bioko Island, Equatorial Guinea (TOMÁS *et al.*, 2001). Interestingly, a hawksbill tagged in Fernando do Noronha, Brazil, in November 1994 was captured by a fisherman in April 1999 at Cap Esterias (BELLINI *et al.*, 2000).

### Republic of the Congo

Accidental capture of a hawksbill, about 40 cm in length, in the net of a fisherman from Mvandji, was reported in the late 1990s by FRETEY (1998c). Maloueki (*pers. comm.* in FRETEY, 2001) reported the catch of 24 female olive ridleys in driftnets in 1999 in Madingou (from the lagoon of Mvandji to the lagoon of Conkouati). PARIS *et al.*, (1997) reported the accidental capture in trawls of 9 olive ridleys whose carapace length varied from 60-76 cm.

More recently a release program for turtles caught incidentally in artisanal nets initiated by project RENATURA has documented large numbers of sea turtle bycatch since the program was launched on 17 September 2005 in Loango Bay, Congo. Within one year of the program's implementation, a total of 1,326 turtles were released alive, but fishing effort was not recorded (BAL *et al.*, 2007). Of the turtles released, 48 % (n = 632) were green turtles (mean CCL = 59.1 cm, range = 8 – 130 cm; SD = 10.0, n = 631); 32 % (n = 431) olive ridleys (mean CCL = 65.9 cm, range = 24 – 81 cm; SD = 8.2, n = 429); 13 % (n = 168) hawksbills (mean CCL = 58.6 cm, range = 31.5 – 77 cm; SD = 9.0, n = 167); 7% (n = 92) leatherbacks (mean CCL = 134.3 cm, range = 89 – 180.3 cm; SD = 20.2, n = 50); and 3 unidentified species, but the description suggested loggerheads (BAL & BRÉHERET, 2006; BAL *et al.*, 2007). During the 2006/2007 nesting season, 1,093 turtles were released in Longo Bay and Pointe-Noire Bay between October and March, of which 209 were leatherbacks, 360 were olive ridleys, 432 green turtles, and 92 hawksbills (BAL BRÉHERET 2007). Between January and July 2008, BAL BRÉHERET (2008) released 637 accidentally captured turtles in Loango Bay and Pointe-Noire Bay between October and March, of which 48 were leatherbacks, 106 were olive ridleys, 477 were green turtles, and 6 were hawksbills. BRÉHERET ADELL (2009) reported the accidental capture of 1486 turtles between August 2008 and July 2009 around Loango Bay and Pointe-Noire Bay. FASQUELL BRÉHERET (2010) reported that 1467 accidentally captured turtles were released in the same bays between August 2009 and July 2010 (8 leatherbacks, 5 olive ridleys, 1426 green turtles, and 28 hawksbills). From September 2010 to February 2011, 1233 turtles were accidentally captured (5 leatherbacks, 21 olive ridleys, 1204 green turtles, and 3 hawksbills) (BRÉHERET *et al.*, 2011). It is important to note that the number of sites at which accidental captures were monitored varied among years.

### Democratic Republic of the Congo

Accidental captures of sea turtles occur in the artisanal fisheries, and fishermen often sell the turtles to recover



the costs of net repair due to turtle entanglement (OCPE 2006; VERHAGE, 2007). Apparently, there is no longer an industrial fishery in the country because of the civil war and economic problems (J. Fretey *pers. comm.*).

### Angola

While sea turtle bycatch data is not officially recorded for Angola, there is evidence for widespread sea turtle bycatch in artisanal fisheries (FORMIA *et al.*, 2003; PETERSEN *et al.*, 2007; WEIR *et al.*, 2007; HONIG *et al.*, 2008; MOORE, 2008). WEIR *et al.*, (2007) reported instances of hawksbill, loggerhead, leatherback, and olive ridley interactions with the artisanal longline fishery in the Namibe Province of Angola; the year-round fishery is small and bycatch of sea turtles is reported to be 2-3 animals per month. In Palmerinhas, 48 strandings recorded had evidence of net marks (WEIR *et al.*, 2007); discarded fishing nets were also observed to entangle 'several' olive ridleys and a leatherback in the same area (WEIR *et al.*, 2007). There does not appear to be a directed take fishery for sea turtles, but incidentally caught individuals in small-mesh gill-nests, hand lines, or beach seines are consumed (CARR & CARR, 1991; WEIR *et al.*, 2007). Fishermen at the coastal village of Mucuio are reported to care for injured and incidentally caught turtles and then return them to the sea (WEIR *et al.*, 2007; HONIG *et al.*, 2008).

### Namibia

BIANCHI *et al.* (1993) confirmed that green turtles, leatherbacks, loggerheads and hawksbills are incidentally caught in shrimp trawlers, gillnets, set nets, beach seines, longlines, and/or driftnets. The Namibian industrial pelagic longline fleet *alone* is estimated to claim 700 turtles per year (PETERSEN *et al.*, 2007). Data collected by an onboard observer in 2006 from the Namibian pelagic longline fleet recorded 38,000 hooks (18 sets), but no sea turtle bycatch data were officially recorded for the fleet (HONIG *et al.*, 2008).

### Regional bycatch records

CARRANZA *et al.* (2006) documented incidental capture of both leatherbacks (16 individuals, CPUE 0.38) and olive ridleys (9 individuals, CPUE 0.64) during 18 sets (23,400 hooks total) in the Gulf of Guinea by pelagic longlines. When sea turtle bycatch is not specifically measured in commercial fisheries, known fishing effort (i.e. number of hooks, sets, etc.) can be extrapolated to arrive at probable estimates of yearly incidental capture. LEWISON *et al.* (2004) calculated that 30,000-60,000 leatherbacks and 150,000-200,000 loggerheads were taken as bycatch in the Atlantic as a whole in 2000. Pelagic longline fleets operating in the southern and central regions of the Benguela Current LME (which includes Angola, Namibia, and South Africa) are estimated to catch 4,200 sea turtles every year (PETERSEN *et al.*, 2007). Using extrapolations from published longline effort and bycatch rates,

HONIG *et al.* (2008) give a range of 7,600 to 120,600 incidentally caught each year in pelagic longline fisheries in the Benguela Current LME.

Observers occasionally present on board the French purse seiners in the eastern Atlantic (Gulf of Guinea) recorded captures of 3 species of sea turtles and a few unidentified turtles from 2006-2007—green turtles, olive ridleys, and Kemp's ridleys *Lepidochelys kempii* (Garman, 1880); their occurrence per set varied between 0 -1.87% and all turtles were released alive during observer trips (CHASSOT *et al.*, 2009).

## CONCLUSIONS

Despite very active fisheries in the region, overall bycatch data are quite sparse and even nonexistent for some countries. Nevertheless, bycatch is probably extensive and quite high in the region and the impact of the different fisheries needs to be urgently evaluated so that mitigation measures can be subsequently developed.

It is generally agreed that bycatch rates are best obtained by consistent onboard observation of fishing activity. On industrial fleets, governments can enforce extensive observer coverage, but in small-scale fisheries, which according to the FAO incorporates >95% of the world's fishermen, implementation of onboard observation in artisanal fleets comes with substantial challenges. Many boats in developing countries are simply too small to accommodate onboard observers (MOORE *et al.*, 2010; LEWISON *et al.*, 2011). Also, small-scale fisheries tend to operate diffusely, increasing the cost of maintaining adequate observer coverage and sampling. Fishing villages and ports can be remote and difficult to travel to and from, further increasing the costs of a consistent observer program. MOORE *et al.* (2010) have suggested that interviews show promise as a cost-effective tool to assess bycatch, especially if scientific studies can simultaneously gather similar information on fishing effort and bycatch rates to confirm the statistical robustness of the interviews.

Intentional take by fisheries is widespread and conservation programs in the various countries need to actively work towards minimizing this source of mortality and finding alternative sources of protein when necessary as well as compensation for prohibiting turtle take. Finally, prevalence and gravity of IUU fishing in African waters is not to be underestimated as it puts additional pressure on stocks that are already being fished at unsustainable levels, complicating stock management and bycatch monitoring efforts. While most IUU fishing is done by foreign industrial fleets (of non-African origin, usually from Asian countries), vessels from the West African countries themselves are also part of the problem: neighboring countries often cross each other's EEZs or venture inside the five nautical mile coastal zone reserved for artisanal fishing (VOGT *et al.*, 2010).

Given that the Atlantic coast of Africa supports globally important nesting and foraging areas for endangered sea turtles, it is essential to quantify bycatch in each of the major fis-

heries in the region, implement existing laws protecting turtles, minimize IUU fishing, and estimate and address intentional take of turtles in the local fisheries. Efforts must be directed to address the paucity of regional data so that wise and effective conservation and management strategies may be adopted for maintaining fish stocks and reducing bycatch.

## ACKNOWLEDGEMENTS

We would like to thank Nagore Zaldúa-Mendizabal for giving us the opportunity to collaborate on this project, Jacques Fretey for creating the map, and the reviewers whose comments improved the paper.

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