Western Indian Ocean JOURNAL OF Marine Science

Volume 18 | Issue 2 | Jul – Dec 2019 | ISSN: 0856-860X

Chief Editor José Paula

Western Indian Ocean
JOURNAL OF
Marine Science

Chief Editor **José Paula** | Faculty of Sciences of University of Lisbon, Portugal

Copy Editor **Timothy Andrew**

Published biannually

Aims and scope: The *Western Indian Ocean Journal of Marine Science* provides an avenue for the wide dissemination of high quality research generated in the Western Indian Ocean (WIO) region, in particular on the sustainable use of coastal and marine resources. This is central to the goal of supporting and promoting sustainable coastal development in the region, as well as contributing to the global base of marine science. The journal publishes original research articles dealing with all aspects of marine science and coastal management. Topics include, but are not limited to: theoretical studies, oceanography, marine biology and ecology, fisheries, recovery and restoration processes, legal and institutional frameworks, and interactions/relationships between humans and the coastal and marine environment. In addition, *Western Indian Ocean Journal of Marine Science* features state-of-the-art review articles and short communications. The journal will, from time to time, consist of special issues on major events or important thematic issues. Submitted articles are subjected to standard peer-review prior to publication.

Manuscript submissions should be preferably made via the African Journals Online (AJOL) submission platform (http://www.ajol.info/index.php/wiojms/about/submissions). Any queries and further editorial correspondence should be sent by e-mail to the Chief Editor, wiojms@fc.ul.pt. Details concerning the preparation and submission of articles can be found in each issue and at http://www.wiomsa.org/wio-journal-of-marine-science/ and AJOL site.

Disclaimer: Statements in the Journal reflect the views of the authors, and not necessarily those of WIOMSA, the editors or publisher.

ISSN 0856-860X

Cover image: *Macrophthalmus depressus* at Saco da Inhaca, Mozambique (© Jose Paula, 2014)

Assessing the effectiveness of LED lights for the reduction of sea turtle bycatch in an artisanal gillnet fishery – a case study from the north coast of Kenya

Timothy Kakai [1,*]

[1] Coastal & Marine Resource Development, PO Box 10222-80101, Bamburi, Mombasa, Kenya

* Corresponding author: timothymunyikana@yahoo.com

Abstract
Artisanal gillnet fisheries exist throughout the world's oceans and have been responsible for high bycatch rates of sea turtles. Three sites on the north coast of Kenya, i.e. Watamu, Ngomeni, and Bwana Said, were studied with the overall objective of assessing the effectiveness of LED lights in the reduction of sea turtle bycatch in the bottom-set gillnet fishery. A total of 10 boats with pairs of control and illuminated nets were deployed during the study, with 56 turtles caught in control nets, while 30 were caught in illuminated nets. The mean catch per unit effort (CPUE) of target species was similar for both control and illuminated nets. In contrast, the mean CPUE of sea turtles was reduced by 64.3% in illuminated nets. This statistically significant decrease ($p < 0.04$) in sea turtle catch rate suggests that net illumination could be an effective conservation tool. Some useful data on fish catch rates with and without LED lights were also obtained, and interviews with fishermen suggested that they believe that the lights are effective at reducing marine turtle bycatch in their gill nets when set at night. The issues associated with implementing the use of LED lights included increased net handling times, equipment costs, and limited awareness among fishermen regarding the effectiveness of this technology. These challenges need the support of other stakeholders, especially national government, so as to implement this strategy of reducing turtle bycatch more widely.

Keywords: mortality; sea turtles; bycatch; small-scale fisheries; gillnet; LED lights

Introduction
Five species of sea turtle have been documented from Kenyan waters (Frazier, 1975). These are the green turtle (*Chelonia mydas*), hawksbill turtle (*Eretmochelys imbricata*), loggerhead turtle (*Caretta caretta*), olive ridley turtle (*Lepidochelys olivacea*) and leatherback turtle (*Dermochelys coriacea*). Some of these sea turtles are known to nest on sandy shores in Kenya, while most forage in a diverse range of marine habitats, which include coral reefs, seagrass meadows, and mangrove swamps off Kenya (Wamukoya *et al.*, 1997; Okemwa *et al.*, 2004).

As with global sea turtle populations, those in Kenya also face increasing anthropogenic threats that put the populations at risk (IUCN, 2007). Typical threats include entanglement in fishing gear, poaching and illegal trade of eggs, meat, and shells, coastal development which destroys nesting habitat and disorientates sea turtles, plastic pollution and other marine debris, and global warming. The primary risk to sea turtles is entanglement or capture in the gear used in commercial and artisanal fisheries (IUCN, 1995; Spotila *et al.*, 2000; Lewison *et al.*, 2004; Alfaro-Shigueto *et al.*, 2010). In Kenya a significant number of sea turtles, among them endangered green sea turtles, are killed each year from the purse seine and gillnet fisheries (Wamukota, 2009; Watamu Turtle Watch, 2014; Fisheries Department, 2014). Although it is illegal to capture sea turtles in Kenya, the incidental capture of these animals remains a major threat to turtle populations in the region (WWF, 2009; KMFRI, 2016).

Bycatch in fisheries has been recognised as a global threat to sea turtles (WWF, 2009). The interaction of

http://dx.doi.org/10.4314/wiojms.v18i2.4

small-scale coastal gillnet fisheries with sea turtles is documented to equal, or in some cases exceed, interactions with industrial pelagic fisheries (FAO, 2009). It has been estimated that over 70% of sea turtle interactions with fisheries worldwide end-up in capture (Molony, 2005; FAO, 2009; Alfaro-Shigueto *et al.,* 2011) and this poses a significant source of mortality for sea turtles (Hays-Brown, 2003; WWF, 2016). Watamu Turtle Watch in Kenya reported more than 273 turtle mortalities per annum related to interactions with fisheries within Watamu coastal fishing of Watamu (pers. comm, September 20, 2015). This rate of incidental capture and mortality poses a great threat to sea turtle management and population recovery and has thus been the focus of recent conservation work. Several studies have suggested that illuminating fishing nets with LED lights can reduce sea turtle capture by up to 40% without any significant impact on the catch of targeted fish (Wang *et al*., 2010, 2013). These studies used either light-emitting diode (LED) light sticks or chemical light sticks to illuminate portions of nets.

To help limit the negative impacts of fisheries, bycatch reduction technologies (BRTs) have been developed for a limited number of fisheries (Cox *et al*., 2007). Much effort has focused on the use of circle hooks in longline fisheries (Gilman *et al*., 2006; Serafy *et al*., 2012) and the use of Turtle Excluder Devices (TEDs) in shrimp trawl fisheries (Crowder *et al*., 1994, 1995; Watson *et al*., 2005; Lewison and Crowder, 2006; Read, 2007; Jenkins, 2011). However, the development of bycatch mitigation measures for gillnets, one of the most ubiquitous gear types, has been comparatively slow (Melvin *et al*., 1999; Gilman *et al*., 2006).

Kenya has an estimated 4,450 boats in its fisheries (KMFRI, 2016; Fisheries Department, 2016) that fish six days per week for target species such as the blue shark (*Prionace glauca)*, flounder species (*Paralichthys* spp.), guitarfish (*Rhinobatos planiceps*), kingfish (*Scomberomorus cavalla*), and shortfin mako shark (*Isurus oxyrinchus)*. Since five species of sea turtles make use of the same waters as the fishing vessels (Amiteye, 2002), it is critical and imperative to quantify sea turtle mortality and assess the potential of LED lights in reducing sea turtle captures as a bycatch reduction tool.

Clearly, protecting Kenya's sea turtles is extremely important for the global recovery of the species. This study sought to 1) quantify the present sea turtle capture rate in the gill net fisheries, 2) compare capture rates in gill net fisheries with unmodified and modified (gear illumination with LED lights) fishing gear, and 3) compare catch quantity and composition of target fish species in unmodified and modified fishing gear. It was hypothesised that LED lights would reduce sea turtle bycatch, and would not have any impact on the target species fished.

Methods

The Kenyan coast spans approximately 600 km in a north-north east to south-south west direction, between 1^{o} and 4^{o} S on the Indian Ocean (UNEP, 1998; Okwema, *et al*., 2004). The study was undertaken between December 2016 to December 2017 at Watamu, Ngomeni and Bwana Said landing sites, approximately 105 - 150 km north of Mombasa. The sites host a large gillnet fishery and an abundance of sea turtles.

Sensitization of fishermen about the project was undertaken at the start of the research period, and the Split-Block Sampling Design (Fisher, 1925; Box *et al.*, 2005) used in data collection. Nets were operated as pairs so as to ensure the experimental and control nets were carried by the same boats to minimize the errors. The catch from the nets were categorized into three groups: target species (fish sold), bycatch (discarded fish), and other (catch kept by the fishermen for consumption or retained for bait in other unrelated fisheries). The turtle species, curved carapace length (CCL; notch to tip (cm)), the rate of turtle bycatch, and fate of by-catch was recorded. Live sea turtles were released in accordance with internationally recognized guidelines (Epperly *et al*., 2004). Turtle catch-per-unit-effort (CPUE) for each net was calculated as the number of turtles captured/([net length/100 m]) x ([net soak time/12 h]). Data were also collected on fishing method, gear type, design and operation, target fish catch composition, and weight. The total target species CPUE was calculated as the number of individuals of target species/([net length/400 m] x [net soak time/12 h]).

Out of 30 boat captains identified at the start of the study, 10 were randomly selected to participate in the net trials. Each of the boats was equipped with bottom-set gill nets. Six boats at Bwana Said, two boats at Watamu and two boats at Ngomeni Participated in the study, based on the relative importance of each landing site. After the project the boat captains were interviewed through a questionnaire, primarily to determine the effect of the LED lights.

The fishing boats were provided with paired sets of gillnets (1 and 2) at the start of the study. Group 1 nets (control) were to fish without any modification, and Group 2 nets were fitted with gear modification/illumination (Deep Drop LED Fishing light 2,100 ft Green) (Fig. 2A) placed every 15 meters along the gillnet float line. The gillnets were made of multifilament twine (Fig. 2B) and were composed of multiple net panels 50 m long by 3 m high. The number of gillnet panels set each evening varied, depending on the fishing crew, but averaged 5 panels per night. Nets were typically deployed in the late afternoon, soaked overnight, and retrieved the following morning. For each deployment, both the control and illuminated net were set.

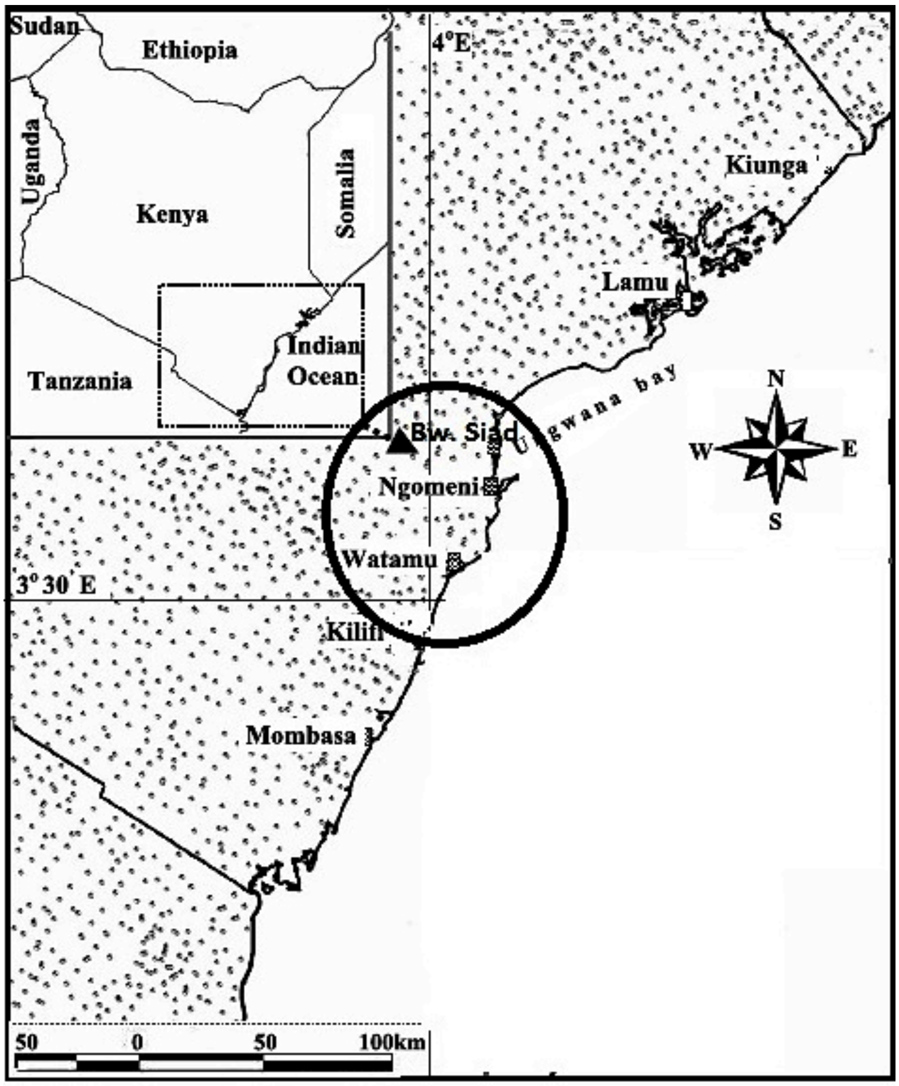

Figure 1. Map of the study area; Watamu, Ngomeni, and Bwana Said landing sites

Each boat captain then continued their fishing operations as per usual, fishing in the same areas for the same amount of time that they normally fished. Trained observers/fishermen recorded all catch and by-catch information. Plastic flipper tags were fixed to all sea turtles captured to determine recapture rates. Support items were provided for fishing boats used in the research and observers were given free LEDs as motivation to sustain interest in the research.

In order to detect statistical differences between the catch rates for the control illuminated nets, the mean CPUE values for both were compared using a t-test. Additionally, 2-sample t-tests were used to analyse differences in body size for sea turtles and target fish between control and illuminated nets. The study used the randomization test to analyse the catch data and test the null hypothesis that there would be no difference in sea turtle catch rate, total target catch rate, and CPUE between experimental and control nets. Data

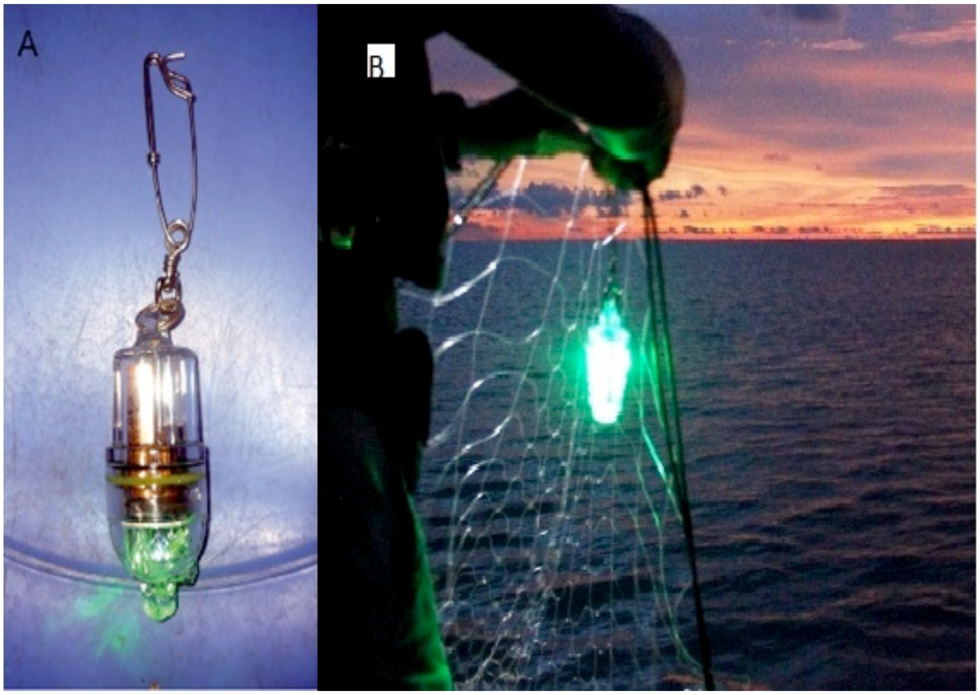

Figure 2. (A) Example of the LED light used during the study. (B) LED fitted on a bottom-set gillnet.

were re-sampled several times using the software RESAMPLING STATS for Excel (v. 4.0). This analysis measures the strength of evidence against a null hypothesis instead of estimating significance at a certain level.

Results

The study deployed 10 boats with paired control and experimental nets. The number of panels in each net varied slightly among boats and between trips as panels were sometimes added to increase target species catch, or were detached for repair. Therefore, net length varied, with control nets averaging 0.62 km ± 0.03 SE, while illuminated nets averaged 0.60 km ± 0.02 SE (Table 1). Soak time for control nets averaged 17.10 hrs ± 0.39 SE), while experimental nets averaged 17.40 hrs ± 0.39 SE (Table 1). Fishing effort was determined by combining net length and soak time (km x 24 hrs soak). The mean fishing effort averaged 0.41 ± 0.02 SE (km x 24 h) for control nets, while illuminated nets averaged 0.40 ± 0.01 SE (km x 24 h) (Table 1). A total of 86 sea turtles were caught during the study period. Of these, 56 were caught in the control nets constituting 41 green, 9 hawksbills, 5 loggerheads, and 1 olive ridley turtle. The illuminated nets caught 30 turtles of which 21 were green, 5 hawksbills and 4 loggerhead turtles.

Analysis with the two-sample t-test indicated that sea turtle CPUE was significantly higher in control nets (mean CPUE = 1.40 (± 0.16 SE) as compared with experimental nets (mean CPUE = 0.50 ± 0.06 SE, indicating a 64.3% reduction in mean catch rate ($p = 0.04$) (Table 3; Fig. 3). The paired nets were concurrently used to examine the effects of LED illumination on total target fish catch rates, composition and weight. A total of 12,987 individual target fish (46,581 kgs) were kept for market. Control nets caught 695 target fish (23,539 kgs) with a mean CPUE

Table 1. Summary of fishing effort by net type (control = without LED illumination, illuminated = with LED illumination) for paired gill net sets in the study area.

Net type	Sets	Set duration (h)		Net length (km)		Fishing effort (km x 24 h)	
		Mean ± SE	Range	Mean ± SE	Range	Mean ± SE	Range
Control	80	17.10 ± 0.39	2.83-24.07	0.62 ± 0.03	0.32-1.28	0.41 ± 0.02	0.07-1.10
Illuminated	80	17.40 ± 0.39	3.75-24.33	0.60 ± 0.02	0.32-1.15	0.40 ± 0.01	0.09-0.75

Table 2. Summary of target species and sea turtles (number caught) by net type (control = without LED illumination, illuminated = with LED illumination).

Net type	Sets	Total effort (Km x 24 h)	Target species caught	Turtles caught
Control	80	48.96	695	56
Illuminated	80	47.71	603	30

Table 3. The outputs and mean catch per unit effort of target species and sea turtles (control = net without LED illumination, illuminated = net with LED illumination).

Response variable	Mean CPUE Control (mean ± SE)	Mean CPUE Illuminated (mean ± SE)	% diff.	p
Target Species	10.62 ± 0.71	10.35 ± 0.86	-2.5	0.78
Sea turtles	1.40 ± 0.16	0.50 ± 0.06	-64.28	0.04

of 10.62 ±0.71 SE, whereas experimental nets caught 603 target fish (23,042 kgs) with a mean CPUE of 10.35 ±0.86 SE (Table 3; Fig. 3), which was statistically similar (P = 0.78).

Fishermen interviewed after the completion of the project generally believed that the lights were effective at reducing marine turtle bycatch in their gillnets, although turtle bycatch was still present.

Discussion, conclusion and recommendations

Artisanal fishing in Kenya is a major source of income for more than 300,000 people in coastal communities with few economic opportunities other than those related to fishing (Fisheries Department, 2014). These important fisheries also account for significant sea turtle mortality (WWF, 2009). The purpose of this study was to investigate bycatch measures to reduce turtle bycatch without compromising target

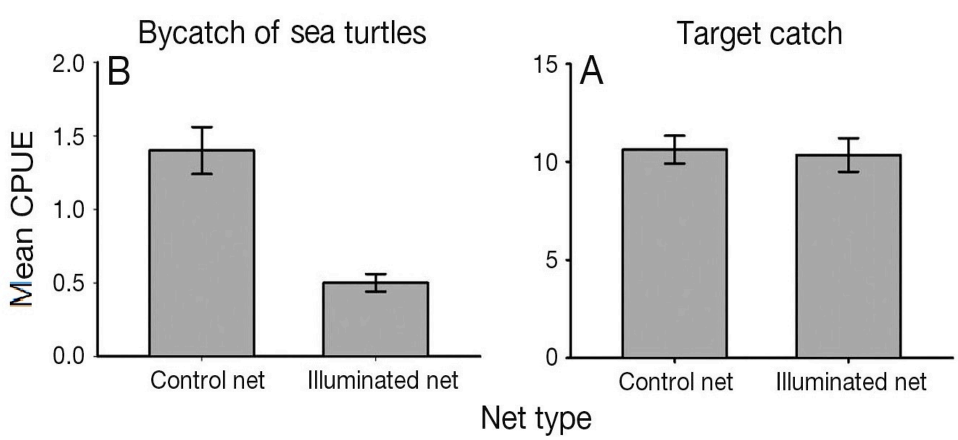

Figure 3. (A) Comparison of the mean CPUE of sea turtles between control and illuminated nets, and (B) comparison of the mean CPUE of target species between control (without LED illumination) and illuminated (with LED illumination) nets, showing no significant difference.

catches. This study showed that green LEDs attached to bottom-set gillnets in northern Kenya considerably reduce sea turtle bycatch, without adversely affecting target species catch rates. This technique could potentially serve as an effective sea turtle bycatch reduction device (BRD) for this type of fishery. This study demonstrates that, if this intervention was well managed and widely implemented, it could potentially promote the long-term stability of both sea turtle populations and local fisheries.

Sea turtles interact with gillnets globally (Wallace *et al*., 2010). It will therefore be important to replicate this study in multiple locations and fisheries to assess the effectiveness of net illumination with a variety of gears, environmental conditions, and catch compositions (Southwood *et al*., 2008; Gilman *et al*., 2010). In order to effectively implement this BRD or other mitigation methods, any future studies need to consider costs and implications for fishermen, impacts on the catch of their target species, and the effect on other bycatch species (Cox *et al*., 2007). Trials of this BRD in small-scale fisheries could serve as an important step in the global conservation of sea turtles. The cost of LEDs spread across multiple years still represents an untenable amount for Kenya's artisanal fishers. This means that efforts are needed at national or international levels to leverage financial support if this BRD is to be broadly implemented. To encourage this support, it would be useful to calculate the approximate cost (LEDs, gear etc) of preventing a single sea turtle interaction. This could then also be used to compare the costs of alternative conservation measures such as fisheries closures, time-area based closures, and development of marine reserves (Balmford *et al*., 2004; McClanahan *et al*., 2006).

Notwithstanding the challenges of implementing net illumination in artisanal fisheries (e.g. cost, LED design, fisher awareness), the results from this study emphasize the effectiveness of controlled fisheries experiments for the testing of bycatch reduction measures in artisanal gillnet fisheries. Future studies on net lighting should examine possible effectiveness as a multi-taxa technological tool for seabirds and marine mammals as these animals also rely on visual cues to a large extent (Jordan *et al.,* 2013; Martin and Crawford 2015). In addition, continued development of LED lights and their power sources could improve their efficiency and ensure optimal performance. Solar powered LEDs could also be developed in order to reduce the cost and waste associated with batteries. Fishermen involved in the trials were mainly positive and provided essential feedback, which included the suggestion that LED light sticks should be designed specifically for net fisheries. Such continuous associations with fishermen and their communities will be critically important for the continued development and testing of net illumination as well as other bycatch reduction strategies for artisanal fisheries.

Acknowledgements

This research project was made possible by a WIOMSA (MARG I) research grant and co-funded by the Marine Stewardship Council-UK. I thank Dr Andrew Wamukota, Dr Nina Wambiji and Dr. Maarifa Mwakumanya for supervising this work and thanks also to my Research assistants Ibrahim Ahmed and Teddy Wani for their enthusiastic support. I thank the fishermen and their families at Watamu, Ngomeni, and Bwana Said for their support on each fishing trip. LED lights were partly provided by IDEA Wild. I finally thank Kenya Wildlife Service for the permit to do research that led to this work.

References

Alfaro-Shigueto J, Mangel J, Pajuelo M, Dutton PH, Seminoff JA, Godley BJ (2010) Where small can have a large impact: Structure and characterization of small-scale fisheries in Peru. Fisheries Research 106: 8-17

Alfaro-Shigueto J, Mangel J, Bernedo F, Dutton PH, Seminoff JA, Godley BJ (2011) Small-scale fisheries of Peru: A major sink for marine turtles in the Pacific. Journal of Applied Ecology 48: 1432-1440

Amiteye BT (2002) Distribution and ecology of sea turtles in Ghana. MPh Thesis. University of Ghana, Legon. 115 pp

Balmford A, Gravestock P, Hockley N, McClean CJ, Roberts CM (2004) The worldwide costs of marine protected areas. Proceedings of the National Academy of Sciences, United States of America 101: 9694-9697

Box G, Hunter W, Hunter S (2005) Statistics for experimenters: design, innovation, and discovery, 2nd edition. Wiley-Interscience, New York. 672 pp

Cox TM, Lewison RL, Zydelis R, Crowder LB, Safina C, Read AJ (2007) Comparing the effectiveness of experimental and implemented bycatch reduction measures: The ideal and the real. Conservation Biology 21: 1155-1164

Crowder LB, Crouse DT, Heppell SS, Martin TH (1994) Predicting the impact of turtle excluder devices on loggerhead sea turtle populations. Ecological Applications 4: 437-445

Crowder LB, Hopkins-Murray SR, Royle JA (1995) Effects of turtle excluder devices (TEDs) on loggerhead sea turtle strandings with implications for conservation. Copeia 1995: 773-779

Epperly S, Stokes L, Dick S (2004) Careful release protocols for sea turtle release with minimal injury. National Oceanic and Atmospheric Administration Technical Memorandum NMFS-SEFSC-524, Miami, Florida. 42 pp

Food and Agriculture Organization (2009) Food and Agriculture Organization guidelines to reduce sea turtle mortality in fishing operations. Rome. 128 pp

Fisher RA (1925) Statistical methods for research workers. Biological monographs and manuals. Oliver and Boyd, Edinburgh. 239 pp

Fisheries Department (2014) Frame survey report. Ministry of Fisheries Development, Kenya. Provincial Headquarters, Mombasa. 143 pp

Fisheries Department (2016) Marine artisanal fisheries frame survey report, Mombasa, Kenya. 88 pp

Frazier JG (1975) Marine turtles of the Western Indian Ocean. Oryx 13: 164-175

Gilman E, Zolett E, Beverly S, Nakano H, Davis K, Shiode D, Dalzell P, Kinan I (2006) Reducing sea turtle by-catch in pelagic longline fisheries. Fish and Fisheries 7: 2–23 Gilman E, Gearhart J, Price B, Eckert S, Milliken H, Wang J, Swimmer Y, Shiode D, Abe O, Peckham SH, Chaloupka M, Hall M, Mangel J, Alfaro-Shigueto J, Dalzell P, Ishizaki A (2010) Mitigating sea turtle by-catch in coastal passive net fisheries. Fish and Fisheries 11: 57-88

Hays-Brown C (2003) Satellite telemetry suggests high levels of fishing-induced mortality in marine turtles. Marine ecology progress series, United Kingdom 262: 305-309

International Union for Conservation of Nature (1995) A global strategy for the conservation of marine turtles. International Union for Conservation of Nature, United Kingdom. 30 pp

International Union for Conservation of Nature (2007) Marine turtle specialist group: 2007 Red List status assessment of the hawksbill turtle (*Eretmochelys imbricata*). 119 pp

Jenkins L (2011) Reducing sea turtle bycatch in trawl nets: A history of National Marine Fisheries Service turtle excluder device (TED) research. Marine Fisheries Review 74: 26-44

Jordan LK, Mandelmann JW, McComb DM, Fordham SV, Carlson JK Werner TB (2013) Linking sensory biology and fisheries bycatch reduction in elasmobranch fishes: a review with new directions for research. Conservation Physiology 1 [doi: 10.1093/conphys/cot002]

Kenya Marine and Fisheries Research Institute (2016) Marine artisanal fisheries frame survey Report, Mombasa, Kenya. 88 pp

Lewison RL, Crowder LB, Read AJ, Freeman SA (2004) Understanding impacts of fisheries bycatch on marine megafauna. Trends in Ecology and Evolution 19: 598-604

Martin GR, Crawford R (2015) Reducing bycatch in gill nets: A sensory ecology perspective. Global Ecology and Conservation 3: 28-50

McClanahan TR, Marnane MJ, Cinner JE, Kiene WE (2006) A comparison of marine protected areas and alternative approaches to coral-reef management. Current Biology 16: 1408-1413

Melvin EF, Parrish JK, Conquest LL (1999) Novel tools to reduce seabird bycatch in coastal gillnet fisheries. Conservation Biology 13: 1386-1397

Molony B (2005) Estimates of the mortality of non-target species with an initial focus on seabirds, turtles and sharks. First meeting of the Scientific Committee of the WCPFC. SC1-EB-WP-1. Noumea, New Caledonia. 8-19 August, 2005

Okemwa G.M, Nzuki S, Mueni E (2004) The status and conservation of sea turtles in Kenya. Marine Turtle Newsletter 105: 1-7

Read A (2007) Do circle hooks reduce the mortality of sea turtles in pelagic longlines? A review of recent experiments. Biological Conservation 135: 155-169

Serafy JE, Cooke SJ, Diaz GA, Graves JE, Hall M, Shivji M, Swimmer Y (2012) Circle hooks in commercial, recreational, and artisanal fisheries: Research status and needs for improved conservation and management. Bulletin of Marine Science 88: 371-391

Southwood A, Fritsches K, Brill R, Swimmer Y (2008) Sound, chemical, and light detection in sea turtles and pelagic fishes: Sensory-based approaches to bycatch reduction in longline fisheries. Endangered Species Rescue 5: 225-238

Spotila JR, Reina RD, Steyermark AC, Plotkin PT, Paladino FV (2000) Pacific leatherback turtles face extinction. Nature 405: 529-530

United Nation Environmental Programme (1998) Eastern Africa atlas of coastal resources: Kenya (EAF/14). United Nations Environment Programme, Kenya. 119 pp

Wallace BP, Lewison RL, McDonald SL, McDonald RK, Kot CY, Kelez S, Bjorkland RK, Finkbeiner EM, Helmbrecht S, Crowder LB (2010) Global patterns of marine turtle bycatch. Conservation Letters 3: 131-142

Wamukota A, Okemwa G (2009) Trends and threats regarding sea turtles in Kenya. In: Hoorweg J, Muthiga N (eds) Advances in coastal ecology, people, processes and ecosystems in Kenya – African Studies Centre, Laden 20. pp 4

Wamukoya GM, Kaloki FP, Mbendo, JR (1997) Sea turtle recovery action plan for Kenya (STRAP). Kenya Sea Turtles Conservation and Management Technical Report Series. 69 pp

Wang J, Fisler S, Swimmer Y (2010) Developing visual deterrents to reduce sea turtle bycatch in gillnet fisheries. Marine Ecology Program Series 408: 241-250

Wang J, Barkan J, Fisler C, Godinez-Reyes C, Swimmer Y (2013) Developing ultraviolet illumination of gillnets as a method to reduce sea turtle bycatch. Biology Letters 9 (5): 20130383 [doi.10.1098/rsbl.2013.0383]

Watamu Turtle Watch (2014) Watamu Beach turtle watch nest and protection, Kenya: bycatch release report. 17 pp

Watson JW, Epperly SP, Shah AK, Foster DG (2005) Fishing methods to reduce sea turtle

mortality associated with pelagic longlines. Fish Aquatic Science 62: 965–981

World Wide Fund for Nature (2009) Simple and painless? The limitations of spillover in environmental campaigning. World Wide Fund for Nature, United Kingdom, Godalming, United Kingdom [www.wwf.org.uk/strategies for change]

World Wide Fund for Nature (2016) Illegal take and trade of marine turtles in the Indian Ocean region [http://wwf.panda.org/wwf_news/?240870/]