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Ecological Risk Assessment

and

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Executive Summary

Interactions between sea turtles and fishing activities have been listed as a significant threat to sea turtles. This study aimed to assess which sea turtle species/populations in the Indian Ocean (IO) are at risk from interactions with tuna-related fisheries. The approach used was a desktop study to compile (1) all available data on sea turtle population demographics, rookery sizes and at-sea distributions; and (2) collate all information of longline, purse seine and gillnet effort and sea turtle interactions in the Indian Ocean.

A paucity of data on fishing effort for certain gear types, bycatch rates and sea turtle life history militated against a fully quantitative ecological risk assessment approach, and hence a semi-quantitative, categorical scoring approach was adopted to assess the *relative risks* of different gear types to different sea turtle species and populations. Combining all population demographic information with rookery size information, and rating each category as low (1), medium (2) and high (3) productivity, allowed for species-independent productivity scores (P) to be generated. The available fishing effort and spatial distribution of tuna-related fisheries, plus other species-specific attributes (such as turtle distributions) were used to rate the susceptibility of each sea turtle population to being caught per fisheries gear type (longlines, purse seine, and gillnets). The likelihood of being caught (as Susceptibility, S) was also rated according to low (1), medium (2) and high (3). An overall Euclidian value rating vulnerability (V) to each of the three fisheries was obtained per sea turtle population in the IOTC region.

In total, 20 populations or regional management units (RMUs) were identified for the six species of sea turtles across the Indian Ocean. Satellite tracking information indicated that sea turtles occur at high densities in coastal (neritic) waters. However, these data are heavily biased towards tagged post-nesting female distributions. The distributions do however reflect the 'high value', breeding age-classes (i.e. sub-adults and adults).

Limited data on sea turtle bycatch (numbers and rates) were obtained from participating countries, with total data contributions constituting three longline data sets, one summary, and one report on purse seine activities. In the absence of fishing effort or turtle bycatch data in gillnets, catches (and bycatch) were inferred.

From the limited data on longlining and purse seining received, the former posed the greater apparent risk to sea turtles. We estimate that ~3,500 turtles.y^{-1} are caught in longlines, followed by ~250 turtles.y^{-1} in purse seine operations. For gillnetting, after the extensive literature survey, and recognising the important differences between artisanal and commercial gillnetting and between drift and anchored gillnets, we were forced to lump all gillnet data into a single category. Using the two approaches to estimate gillnet impacts on sea turtles, we calculated ~ 52,425 turtles.y^{-1} and 11,400 – 47,500 turtles.y^{-1} are caught in gillnets (with a mean of the two methods being 29,488 turtles.y^{-1}). These values do not seem unrealistic as anecdotal/published studies reported values of >5000 – 16 000 turtles.y^{-1} for each of just India, Sri Lanka and Madagascar. Of these reports, green turtles are under the greatest pressure from gillnet fishing, constituting 50-88% of catches. Loggerhead, hawksbill and olive ridley turtles are caught in varying proportions depending on the region.

The Ecological Risk Assessment (ERA) methodology requires that where data are missing, a precautionary approach is adopted and a low productivity or high risk score assigned. The highest vulnerability ratings were obtained for data deficient species or small RMUs. Results were mixed with no particular gear type or species rating as consistently highly vulnerable. Generalising though, it seems like loggerheads have mixed vulnerabilities but the small RMUs (i.e. Bay of Bengal, BoB and South Western Indian Ocean, SWIO) are vulnerable to all fisheries types but in particular gillnets. Green turtles are generally the least vulnerable as they have the largest populations, but are still

vulnerable to gillnetting in the Arabian Gulf (AG). All three leatherback turtle RMUs (southwest Indian Ocean, Bay of Bengal and South Pacific) are small and hence vulnerable to all fishing pressures. Similarly, small populations of hawksbill turtles (like the East Central Indian Ocean) are vulnerable to all fisheries (particularly gillnetting) whereas hawksbill turtles in the Arabian Gulf and the SWIO are reasonably balanced by rookery size and pressure. Olive ridley turtles have low productivity scores (mostly as a result of data deficiencies) but from the reports do not seem to interact with the reported fisheries. However, the data paucity is a great concern so there is low confidence in this result. The information available for flatback turtles in the South East Indian Ocean suggests that this population can sustain the current fishing pressures: the RMU is large, with an increasing trend and few reports of interactions with fisheries.

High priorities for future work include nesting beach demographic information, distribution of non-breeding size classes (juveniles and males), detailed demographic information from captured turtles (e.g. sex, size and species), as well as post-release survival rates. It was encouraging to note the large number of sea turtle action plans (and other exemplary practice) developing across the region.

Introduction

Ecosystems-based fisheries management (EBFM) has called for the re-evaluation of priorities in fisheries from single-species management (of target stocks) to multi-species management with the consideration of non-target (bycatch) species, habitat impacts and the ecosystems effects of removing/disturbing particular trophic levels (Pikitch et al., 2004). This change is in recognition of wide impacts to marine ecosystems from fishing, including those sustained by non-target species such as sea turtles, birds and marine mammals, but also the social and economic cost associated with changes in ecosystems functioning, habitat degradation or regime shifts (Pikitch et al., 2004). However, to achieve EBFM is difficult; it requires a large amount of data and a good understanding of ecosystems functioning. In the absence of these, EBFM should be implemented "through the judicious use of the precautionary principle" (Pikitch et al., 2004). Amongst other measures, it is therefore prudent to reduce excessive bycatch or incidental catches of protected species (e.g., sea turtles, seabirds and marine mammals) or juvenile phases of target species. This project is a first step to evaluate the impacts of tuna-related fisheries on sea turtles in the Indian Ocean, and identify additional mitigation measures (where necessary) to reduce impacts on sea turtles and their habitats in an attempt to reduce ecosystems impacts.

The biology and life history of sea turtles make them particularly vulnerable to human activities. Sea turtles are air-breathing, slow growing and late maturing marine reptiles with a pan-tropical distribution. Their natal philopatry results in strong population structure despite their wide distribution (Seminoff and Shanker, 2008). Most species reach sexual maturity only after ~ 25 years (variable among species/populations). Sea turtles use a variety of habitats to complete their life history, ranging from coastal-terrestrial breeding beaches to neritic and pelagic feeding habitats. High densities at/near breeding beaches makes them vulnerable to natural predators, targeted traditional take or egg harvesting, whereas coastal developments frequently disturb and/or destroy nesting habitat. In coastal (neritic) waters sea turtles are exposed to artisanal (e.g. gillnets) as well as commercial fishing activities (such as prawn trawling). On the high seas, sea turtles interact with industrial fisheries such as longlining or purse seining. Overlap with fishing activities results in drowned sea turtles caught in (active or discarded) fishing gear, cuts or other injuries due to boat strikes or pollution. In the case of demersal fisheries such as trawling, fishing operations also destroy sensitive feeding habitat like coral reefs and sea grass beds. Given the life history of turtles, the effects of fishing on populations and the large spatial overlap between sea turtles and human activities, it is not surprising that most sea turtles are listed as endangered by the IUCN (Table 1).

Table 1. IUCN threat status for all marine turtle species caught in fisheries activities within the IOTC area of competence.

Common name	Scientific name	IUCN threat status
Leatherback turtle	*Dermochelys coriacea*	Critically Endangered
Hawksbill turtle	*Eretmochelys imbricata*	Critically Endangered
Loggerhead turtle	*Caretta caretta*	Endangered
Green turtle	*Chelonia mydas*	Endangered
Olive ridley turtle	*Lepidochelys olivacea*	Vulnerable
Flatback turtle	*Natator depressus*	Data deficient

Conservation measures targeted in waters off nesting beaches, where turtles occur in dense aggregations, have been relatively successful. Coastal conservation measures frequently include physical protection on the beach for nesting females, nests and hatchlings, and marine protected areas (including a beach component) to protect nesting and internesting habitats. Many sea turtle populations have shown significant recovery after the implementation of these coastal protection measures, for example, green turtles (*Chelonia mydas*) of Aldabra Atoll (Mortimer, 1985), Grande Glorieuse and Europa islands (Lauret-Stepler et al., 2007), Ascension Island (Godley et al., 2001) and Hawaii (Balazs and Chaloupka, 2004), hawksbill turtles (*Eretmochelys imbricata*) from Cousin Island and Aldabra Atoll (Seychelles) (Wood, 1986), and leatherbacks from French Guiana/Suriname and Gabon (Fossette et al., 2008), the Caribbean (Dutton et al., 2005) and Florida (Stewart et al., 2011). In other cases, coastal conservation has been insufficient to maintain or recover turtle populations, for example, Pacific leatherbacks where some nesting beaches are protected but at-sea threats cause unsustainable mortality (Spotila et al., 2000).

Fishing impacts on sea turtle populations globally are considered one of the most important factors affecting their conservation (Finkbeiner et al., 2011). However, impacts are dependent on gear type, and spatial and temporal distribution of effort (Donoso and Dutton, 2010). Artisanal fisheries tend to use low-technology fishing gear, operate inshore (neritic waters) and for short periods (a few hours). Artisanal gillnet fishing is typically non-selective, and in addition to the traditional notion of pelagic fish as target species, sea turtles, sharks, marine mammals constitute valuable catches. Commercial fisheries in contrast, tend to be more target-specific, are technologically advanced and operate out at sea for extended periods. Seabirds, turtles and marine mammals are generally treated as low-value (bycatch) and discarded. Bycatch mitigation measures are thus primarily employed in commercial fishing operations, and sea turtles are often reported as released alive. However, there is little information on post-release survival to adequately gauge impacts (see Swimmer and Gilman (2012).

The IOTC, in recognising the impact of fisheries operations on sea turtles, adopted Resolution 12/04, on the conservation of sea turtles (http://www.iotc.org/English/resolutions.php.). The resolution's objectives will be achieved in conjunction with the Indian Ocean – South-East Asian Martine Turtle Memorandum of Understanding (IOSEA), including implementation of the United Nations Food and Agriculture Organisation (FAO) guidelines to reduce sea turtle bycatch in fishing operations (as adopted by 26th FAO-COFI, March 2005). In particular, the resolution urges CPCs to collect data on sea turtle bycatch in fishing operations. However, with few exceptions, data have not been collected or reported systematically (IOTC document IOTC-2012-WPEB08-09), and an analysis of available data is missing.

Ecosystem impacts of fishing can be objectively evaluated within an ERA framework (Arrizabalaga et al., 2011). Determining vulnerability to fisheries is straightforward for data-rich taxa, but much more challenging for bycatch taxa, where data collection has not been a priority (Ormseth and Spencer, 2011). Patrick et al. (2009) modified a previous Productivity-Susceptibility Analysis (PSA) framework to assess the sensitivity for these data-poor conditions. The intent of a PSA is to express the population productivity (*P*, such as age to maturity and fecundity (see Table 2) of the population under investigation in relation to the likelihood of being caught in a particular fishery (i.e. susceptibility, S). This likelihood is often expressed as the spatial overlap between the fishery and the non-target species, the fishing intensity and gear selectivity (Ormseth and Spencer, 2011).

Here, we collated all available information on interactions between turtles and commercial and artisanal fisheries, and synthesized these data in an ERA. Because of inadequate bycatch and sea turtle distribution data for all size classes of sea turtles in the IOTC region, a quantitative approach to bycatch risk was not possible, and a semi-quantitative ERA was undertaken using a PSA framework.

Methods

A semi-quantitative, level 2 ERA requires high-resolution information on sea turtle bycatch in IOTC fisheries (longline, purse seine, gillnet and others) as well as detailed population demographic information for sea turtles. It also requires knowledge on the spatial overlap in time between fishing effort and sea turtle distribution. In the absence of these data, only a level 1 ERA was possible, which allowed for a qualitative evaluation of the interactions between (some) fisheries and different species of sea turtles in the Indian Ocean. This level 1 assessment was conducted following the methodology suggested by Milton (2001), modified by others (Arrizabalaga et al., 2011, Ormseth and Spencer, 2011) using some indication of population productivity and susceptibility to capture in different fisheries.

Demographic information was obtained for sea turtles species nesting on beaches facing the Indian Ocean (SUPPLEMENTARY I). The offshore spatial distribution of sea turtles (presence/absence) were mapped using information obtained from satellite tracking studies (without compromising the integrity of these studies). Productivity information was obtained for each specific sea turtle RMU (following Wallace et al. (2010a). Ten population-related criteria were identified but information was available for eight of these (Table 2). The susceptibility analysis focussed on the horizontal and vertical overlap of turtles and fisheries operations, as well as estimated mortality rates per fishery. Eight criteria were identified but data were only available for four (Table 2). Productivity and susceptibility criteria were assigned scores (1-3) with three as the highest productivity and the greatest risk to each RMU, respectively.

Productivity Assessment

Population designation and size

Sea turtles exhibit extremely high natal site fidelity, and genetic analysis suggests that there is little reproductive interaction between regional populations of sea turtles. Therefore, each of the six turtle species have been divided into 20 RMUs within the Indian Ocean (Wallace et al., 2010a). Data on rookery size (based on the number of nesting females), population trends and age at maturity were obtained from published studies and then compared to global databases to confirm current size (especially if the published literature was >10 years old). In particular, recent data were obtained from the IOSEA's online reporting system (http://ioseaturtles.org/), along with the SWOT/OBIS-SEAmap (http://seamap.env.duke.edu/swot) programmes.

Population Demographics

Population productivity is highly dependent on local conditions that influence nest success (% nests producing hatchlings) and emergence success (% eggs per nest emerging as hatchlings), mean number of eggs per female, the number of clutches per female per season and the remigration interval (i.e. the period between successive breeding seasons) (Table 2). In most instances, some information was available on these population parameters; where it was not, species-specific values were used. For example, reports of high egg harvesting (India) or fox predation (Western Australia) caused low nest success, while emergence success may still be high for nests that do produce eggs. Age at maturity (or time of first nesting) was estimated from published information specific to the species where it was not available for the specific population. Maximum age and generation length are important parameters but as no information is available they were ignored (Table 2). (Full details on the designation and productivity scores are available from SUPPLEMENTARY I.) Population trend and RMU size were up-weighted relative to other criteria (Table 2).

It should be noted that this assessment is not a 'red-list assessment' or alternative thereof for species or RMUs. We used data only from the last decade where available and assessing the impacts only in a select number of fisheries. The assessment therefore reviews a small fraction of the anthropogenic impacts on sea turtles in the Indian Ocean.

Susceptibility Analysis

A population's vulnerability of is related to the nature of its species, the population size, and the type and magnitude of threats faced throughout its distribution. Adult turtles (particularly females) of small populations, facing a range of threats will be both vulnerable and valuable for population growth. Conversely, post-hatchlings and juvenile turtles of large populations will be the least vulnerable/valuable, if the take is not disproportionately high such as in the Mediterranean (Wallace et al., 2010b). This principle, of Relative Reproductive Value (RRV) as designed by Bolten et al. (2011) was applied in assessing the vulnerability scores of sea turtles interacting with IOTC fisheries.

Spatial Distribution of sea turtles

The IOSEA online reporting system and Seaturtle.org (http://seaturtle.org/tracking/) lists metadata on satellite telemetry and in some instances track information on sea turtles. In the majority of cases, these data come from post-nesting females. Combining information on sea turtle nesting site and post-nesting migration provide some insight into foraging habitat, which were mapped to provide an indication of adult sea turtle distributions, and so the relative size of the RMU to the IOTC region. Only presence/absence data per 2.5° X 2.5° grid across the IOTC region were used. For specific track information for project listed under SUPPLEMENTARY I, readers are referred to Seaturtle.org. Data were also sourced from published information and specific projects (like IFREMER in collaboration with Kelonia and the University of Reunion) that have tracked juvenile sea turtles caught in fisheries (IOTC-2012-WPEB08-INF-02).

Fisheries

Data on sea turtle catches were solicited from the national contact points from each IOTC CPC. The timeframe to submit data was approximately four weeks to allow for analysis. Requests included assurances about data confidentiality. The response was poor, restricted to longline fisheries, and had to be supplemented from published literature, unpublished reports or online data sets (such as http://www.seaaroundus.org/) (SUPPLEMENTARY II).

Upon inspection of the longline bycatch data received, it was clear that there was confusion in species identification, even in data from scientific observers. For example, flatback turtles were regularly recorded as captured off South Africa, far outside the known range of the species. We assumed that leatherback turtles were least likely to be misidentified, and consequently bycatch data were grouped into leatherback and hard-shelled turtles. In addition, the ability of observers to recognise the health status of captured turtles was doubtful as the proportion of animals reported as 'released alive' declined over time. Other minor concerns include discrepancies in logbook and observer data, mixed purpose data (i.e. research and commercial fishing data), spatial and temporal representivity, as well as low overall observer coverage. Longline bycatch data are therefore expressed as CPUE (caught and/or killed) for leatherbacks and for all other hard-shelled species combined. Further, no size information was received for any turtle. No information was obtained on purse seine data and hence once particular (multi-year) study by Clermont et al. (2012b) was used to scale purse seine effort and catches. In the absence of any tuna-specific gillnet data two different methods were used to estimate total gillnet catches (see SUPPLEMENTARY II for detailed methods).

To scale fisheries (gillnetting, longlines and purse seining) against each other would be useful as it could operate as a proxy of fishing pressure, where good information exists from one fishery and relative rates can be estimated. Regrettably, this was impossible from the data received. Thus, to obtain some indication of intensity per gear type, data for each of the three gear types were downloaded from the Seas Around Us Programme (www.seasaroundus.org). These are not actual catch data but estimates for each gear type based on reported catches/landings per species (Watson et al., 2006). Due to differences in sizes of EEZ or fishing areas, landing estimates are not directly comparable and hence normalised per surface area (landing in tons/fishing area in km^2). The relative intensity of each gear type ($tons.km^{-2}$) per fishing region (LMEs or High Seas) was then expressed as a percentage of total catch estimate.

MRAG (2012) estimated the contribution to total catches of gillnet catches (targeting tuna and tuna-like species) relative to longline and purse seining (in India and Sri Lanka) as 47% (gillnet), 9% (longline) and 12% (purse seine) for the data reported to IOTC for the period 2006 -2010. Thus, gillnet landings were six times higher than for longlines. Using the Seas Around Us Project database per LME for the period 2000 – 2006 (Table 5), reported gillnet landings 15x that of longlining (Table 5). Due to the unselective nature of gillnets it was assumed that turtle bycatch should be of a similar ratio to longline bycatch (or more), especially since gillnets tend to operate in the same spatial dimensions (i.e. surface coastal waters) as most sub/adult sea turtle do.

Susceptibility Criteria

The four fisheries-related criteria in the PSA included (1) the spatial overlap of each RMU with the IOTC region (calculated as a number of 2.5^{o} squares out of 1068 squares); (2) the number of satellite tracks deployed as an estimated confidence score; (3) a bycatch estimate (relative to natural mortality), and (4) spawner biomass (as the number of adult females nesting per annum in the RMU). Estimating bycatch mortality across all 20 RMUs for the different fisheries was impossible given the data paucity (three longline and one purse seine data set) and no detailed population information. Each RMUs was therefore assigned the same susceptibility score for distribution (1-3) irrespective of gear type.

No data or estimates were available on natural mortality for any of the species within these RMUs or any of the fishing gear types. However, a number of studies on survivorship (from the Pacific and Atlantic oceans) are available (see SUPPLEMENTARY III for a summary). Most of these studies cannot differentiate between survivorship of different age classes although it has been established that large turtles have a lower natural mortality (5 – 10%, M. Chaloupka pers. comm.). Generic mortality values for hard-shelled and leatherback turtles for the IO region were therefore applied across this ocean basin. The threat posed per gear type in the IO was compared to natural mortality, on the assumption that the IO is comparable to the studies outlined in SUPPLEMENTARY III. Due to the lack of specific information about the nature of turtle bycatch (no life-history classes, including age and sex), and given the importance of breeding-aged females, we scored fishing mortality was scored as follows. If annual estimated catches were equivalent to 30% of estimated adult female numbers (or RMU size) it was scored as low (score = 1). If the catch rate was equivalent to (or 100% of) that of the estimated adult female numbers or RMU size, it was rated as medium (score = 2), and as high (score = 3) when the values exceeded 100%. A catch of 30% of the estimated adult female numbers probably represents a catch of ~1.5-3% of adult females, assuming adults constitute 10% of a normal population and a sex ratio of 1:1 males to females). All the susceptibility criteria were weighted equally (Table 2) for all gear types assessed. The matrix was visualized as reversed Productivity score (*P*) on the x-axis (high productivity indicates low vulnerability) and susceptibility score (*S*) on the y-axis. In addition, Euclidean distances between ($\sqrt{(P-3)^2+(S-1)^2}$) provided a quantitative measure of overall vulnerability (Ormseth and Spencer, 2011).

State of Implementation

The state of Implementation of Resolution 12/04 was reviewed by inspecting all documents presented at recent IOTC WPEB meetings and national reports related to sea turtles. Such documents were available for 19 of 21 countries, following general compliance and fishery specific implementation. (See SUPPLEMENTARY IV for national reports consulted).

Table 2 Description of productivity and sensitivity measures used in this assessment (modified from Ormseth and Spencer (2011).

Productivity	Score	Weight	Susceptibility	Score	Weight
1. Recent Population trend (Recent trend 5 – 10 Years)	Uncertain* or Decline: 1 Stable: 2 Increase: 3	20%	**1. Management Strategy/Recovery Plan**	Wallace et al 2011 Threat Score	20%
2. RMU Size/clades (no. nesting females)	Very small: 1; Small:1.5 Medium: 2; Large:2.5; Very Large: 3	30%	2. **Spatial Overlap of RMU with IOTC Region** (possible fished area)	Low: <30 Medium: 30 – 60 High:>60 blocks	20%
3. Age at Maturity (Data Deficient but estimated or used species specific estimates)	>30 years: 1 16 – 30 Years: 2 <16 years: 3	10%	3. **Confidence estimate in distribution data** (based on the number of tracks)	Low (<5): 1 Medium (5 – 30): 2 High (>30): 3	20%
4. Maximum Age	Data Deficient (not scored)		**4. Geographic Concentration:** Overlap of high-density area with high density fishing area.	Data Deficient (not scored)	
5. Generation length: as age to maturity + ½ of max reproductive lifespan.	Data Deficient (not scored)		**5. Vertical Overlap** (% overlap of operational diving depths per fishery)	Data Deficient (not scored)	
6. Natural survivorship: Nest Success (inferred from literature on land based threats if not stated explicitly)	Low (<50%): 1 Medium (50 – 75%): 2 High (>75%): 3	5%	**6. Bycatch estimate** (L, M, H) relative to natural mortality#.	Low :1 Medium: 2 High: 3	20%
7. Natural survivorship: Hatching and Emergence Success (% of nests producing eggs)	Low (<50%): 1 Medium (50 – 75%): 2 High (>75%): 3	5%	**7. Spawner Biomass:** Number of breeding females per annum. (Inverse score of RMU size)	Very small: 3; Small:2.5 Medium: 2; Large:1.5; Very Large: 1	20%
8. Number of eggs per female	Low (<90 eggs): 1 Medium (90-120): 2 High (>120%): 3	10%	**8. Temporal Overlap** between fisheries and turtle distribution.	Data Deficient (not scored)	
9. No. clutches per individual per season	Low (< 4 nests): 1 Medium (4-6): 2 High (>6): 3	10%			
10. Remigration Interval	Low (> 4 years): 1 Medium (4-2.6): 2 High (<2.6): 3	10%			

* Applied precautionary approach; # Natural mortality for adult turtles was 5-10%. Values were rated as low at 30% catch rate to total estimated adult female numbers, medium at 100% and high >100% of estimated adult female numbers (or RMU size). For hard-shelled turtles this translates roughly as low if <500 individuals are caught and high if >1500 individuals are caught.

Results

Productivity Analysis

Of the 20 RMUs evaluated, the green turtles of the South Western Indian Ocean (Cm-SWIO=25.5/30; 85%) was the most productive population and the loggerhead turtle population in the Bay of Bengal (Cc-BoB=13/30; 43%) was rated as the least productive population (Table 3; SUPPLEMENTARY I). Other large/productive populations include loggerhead turtles of the Arabian Gulf (Cc-AG=21/30; 70%), green turtles of the southeast Indian Ocean around Western Australia (Cm-SEIO=23/30; 77%) and hawksbill turtles of the SWIO (Ei-SWIO=22/30; 73%). The small (and/or data deficient) populations include olive ridley turtles of the Western and East Indian Ocean (Lo-WIO=14.5/30; 48%, Lo-EIO=14.5/30; 48%). These ratings were strongly influenced by rookery size (which in turn is an effect of productivity).

Susceptibility Analysis

Longlining is a widely used fishing method with much turtle bycatch reporting globally, while purse seining and gillnetting are reported less frequently. All 19 countries for which information was available have longline fisheries, and seven countries had purse seine fleets. Gillnet fisheries are widely used but poorly monitored with no observer or bycatch reports available. A literature survey indicated that gillnetting spans artisanal and semi-commercial scales, with little distinction between these (SUPPLEMENTARY II). However, it is expected as an unselective fishery, to have a great impact on turtles.

Distribution Criteria

The susceptibility of any RMU to fishing activities is dependent on the extents of vertical and horizontal overlaps. No information was available on the vertical overlap per RMU. Even though it is recognised as a highly relevant criterion it is difficult to score beyond a theoretical estimate. The horizontal distribution was estimated by the presence/absence data of satellite tracks (SUPPLEMENTARY I) and reported effort per gear type. This was further refined by adding a confidence estimate based on the number of satellite tags applied per species (see Table 2 for criteria). Some regions (e.g. the Arabian Gulf and Western Australia) had large satellite tracking datasets for species with restricted distributions (such as hawksbill and flatback turtles). The spatial overlap of these RMUs with fishing effort thus provide reliable estimates. Leatherback turtles are under-represented, as are olive ridley turtles in the Bay of Bengal (despite the existence of significant tracking effort). All RMUs overlapped between 1–12% with the IOTC region.

Bycatch estimates for longlining

Only three sets of bycatch data were received, representing longline fishing activities and sea turtle bycatch in two continental EEZs (exclusive Economic Zones) and one high seas fishery. These data were from Australia and South Africa for the past ~10 years, and from Portugal on high seas catches for 2011-2012. The data were from logbooks and observer reports, and were not extrapolated to the fishery. In addition, the National Report from Korea included limited information about turtle catches in 2009. Total reported longline fishing effort was concentrated in the northern and western Indian Ocean, with very little total effort south of 40°S or east of 90°E (Fig. 1).

Table 3: Productivity scores for eight demographic parameters per sea turtle population (RMU) in the IOTC region.

	Recent Population trend	RMU Size/clades	Age at Maturity	Natural mortality: Nest Success	Natural mortality: Emergence Success	Number of eggs per female	No. nests per individual per season	Remigration Interval	Weighted Total	Productivity Score expressed as % of max
Cc-SWIO	3	1.5	1	3	2	2	1	2	19	63
Cc-AG	1	3	2.5	3	2	2	1	2	21	70
Cc-BoB	1	1.5	2.5	1	1	1	1	1	13	43
Cc-SEIO	1	2	1	1	2	3	1	2	16.5	55
Cm-SWIO	3	3	1	3	2	3	2	2	25.5	85
Cm-AG	1	2.5	1	2	2	2	2	1	17.5	58
Cm-NEIO	1	2	1	1	2	2	2	1	15.5	52
Cm-SEIO	2	3	1	2	2	3	3	1	23	77
Dc-SWIO	2	1.5	3	2	2	2	3	2	20.5	68
Dc-BoB	1	2	3	2	2	1	3	1	18	60
Dc-SP	1	2	3	3	3	1	2	2	19	63
Ei-SWIO	1	3	1	2	2	3	2	3	22	73
Ei-AG	1	3	1	2	2	2	2	2	20	67
Ei-BoB	1	2	1	2	2	2	2	2	17	57
Ei-ECIO	1	1.5	1	2	2	2	2	2	15.5	52
Ei-WA	1	3	1	2	2	2	2	2	20	67
Lo-WIO	1	1.5	3	1	1	2	1	1	14.5	48
Lo-EBoB	1	3	3	1	1	2	1	1	19	63
Lo-EIO	1	1.5	3	1	1	2	1	1	14.5	48
Nd-SEIO	2	3	2	1	3	1	1	1	20	67

Grey shaded = estimate, applying a precautionary approach; Green shading = highly productive populations, and red shading are underperforming population.

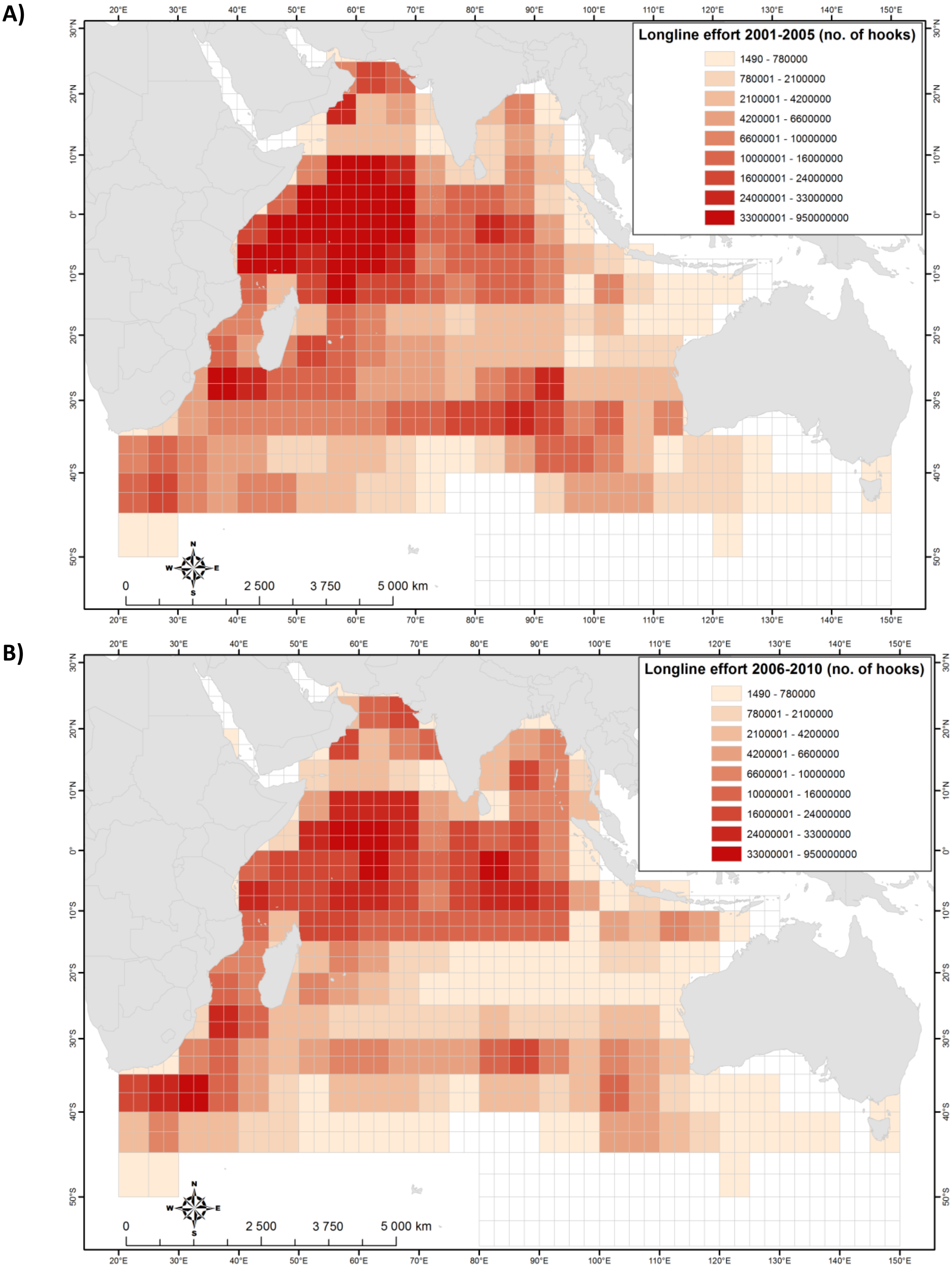

Figure 1: Distribution of longline fishing effort across the IOTC region for the years 2000 – 2005 (A) and 2006 – 2010 (B).

In total, 24 cumulative years of observed data were received, representing 45 million hooks deployed, with 2,675 sea turtles captured. Of these, only eight (0.3%) were reported as dead, and the rest were reported as released alive. Of the total catch, ~10% (286 individuals) were leatherback turtles with a reported mortality of 38% (thus three of the eight dead turtles). No details were given with regards to hooking, foul-hooking or entanglement rates/numbers. Leatherback turtle mortality was higher than for other turtles. Considering all catch data (i.e. including released alive or discarded dead), leatherback turtle catch rates ranged 4 - 7 turtles/million hooks (n=3 datasets reporting leatherback turtle captures). Capture rates for other species combined were more variable, ranging from 3.5 - 26.9 turtles/million hooks, at a mean catch rate of 12.7 turtles/million hooks. Extrapolating (with caution) across the region suggest that 1,000 – 2,500 hard-shelled turtles, and < 1,000 leatherback turtles are caught per annum in the IOTC region (using reported fishing effort levels).

Bycatch estimates for purse seine fishery

For the purse seine fishery, we received no data and hence used recent literature (presented to the IOTC working party meeting 2012; see Clermont et al. (2012a). Reported turtle bycatch rates in the purse seine fishery are low, with <1% of sets capturing turtles. Furthermore, most of these capture events involve a single individual, which is typically released alive (Hall in prep., as cited by Clermont et al. 2012). Clermont et al. (2012a) investigated sea turtle bycatch in the Atlantic and Indian oceans over a 15-year period (1998 -2011) as reported by observer programs of the Spanish- and French - operated fisheries. More than 230,000 sets were deployed, of which 15,913 were observed. Of these, 6,515 were deployed around drifting FADs and the rest (9 398) were targeting free-swimming schools (FSC) (Clermont et al., 2012a). A comparison of the Indian and Atlantic oceans (Table 4) indicated that catch rates were similar between oceans, at ~ 220 – 250 turtles caught per annum in total.

There were clear species-specific differences in the observed bycatch rates. In the Indian Ocean, olive ridley turtles were most frequently caught (n=73), followed by hawksbill (n=40), green (n=37), loggerhead (n=18) and leatherback turtles (n=6). Many turtles (n=63) were not identified to species (Clermont et al., 2012a). The spatial distribution of these catches was almost exclusively off the coast of Somalia towards the Arabian Gulf (0-10^{o} north and 50-60^{o} east) (Fig. 2).

Table 4: Combined sea turtle bycatch across all species for all sets of the Spanish and French purse seine fishery in the Atlantic and Indian Oceans between 1998-2011 (as reported by (Clermont et al., 2012a).

	Atlantic ocean 1995-2010	Indian Ocean 2003-2010
Extrapolated total catch (indiv. caught)	3500	2000
Annual bycatch (estimated) ±SD	218±150	250±157
Survival rate (%) to be released alive	91%	77%
Annual estimated mortality	**22**	74

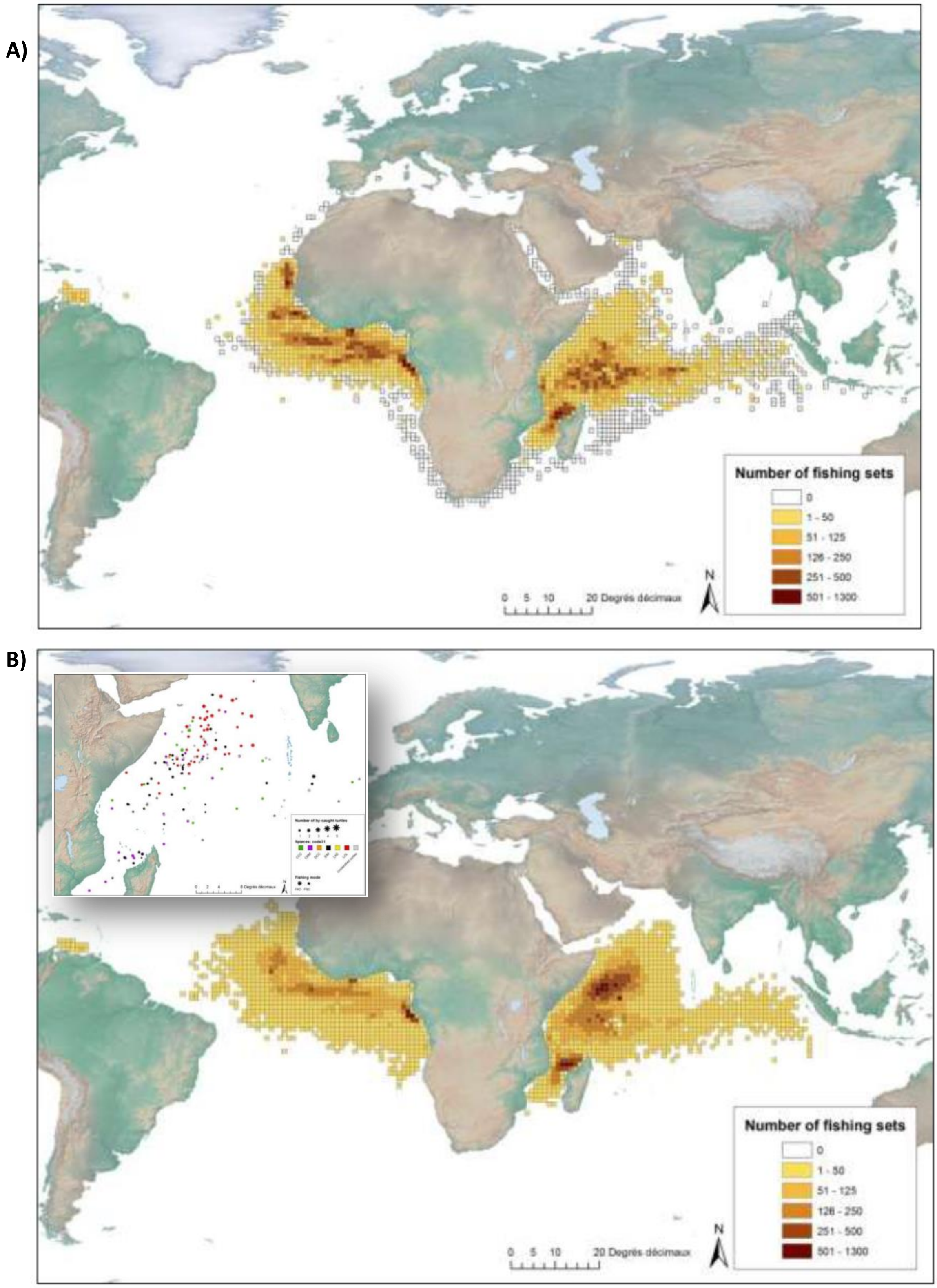

Figure 2. Total purse seine fishing effort on FSC (A) and FADs (B) per 1º square for the French and Spanish fleets from 1995-2011 in the Atlantic and Indian oceans (from Clermont et al 2012). The inset shows observed interactions with sea turtles in sets on both FSCs and FADs, for the same period, in the Indian Ocean.

Bycatch estimates for the gillnet fishery

No turtle interactions with gillnet fishing were available, so catch ratios per species were used from the literature. Bycatch estimates were patchy, with mostly short-term case studies available for some countries (SUPPLEMENTARY II). An IOTC region-wide assessment was therefore only possible through inference. From the unweighted exposure index (following Waugh et al. (2011); Fig. 3) with linear and exponential extrapolations, we estimated that the total turtle bycatch (in all gillnet fisheries not only tuna-related gillnetting) across the IOTC region could range between 11,400 and 47,500 turtles.y^{-1}. No information was available on mortality or post-release survival. Of these projected interactions, coastal species such as green turtles would constitute ~ 58% of the catch, with loggerhead and hawksbill turtles each contributing ~ 20% (depending on the LME), olive ridley turtles ~6% (with the exception of the Bay of Bengal where this is expected to be higher but data are not available), and leatherback turtles ~2%. In an experimental fishery in Western Australia (Prince et al. (2012), species captured were reported to be in the same order of importance as reported here, although the relative proportions varied. Green turtles constituted 88% of the interactions, whereas loggerhead and hawksbill turtles were 9% and 2%, respectively.

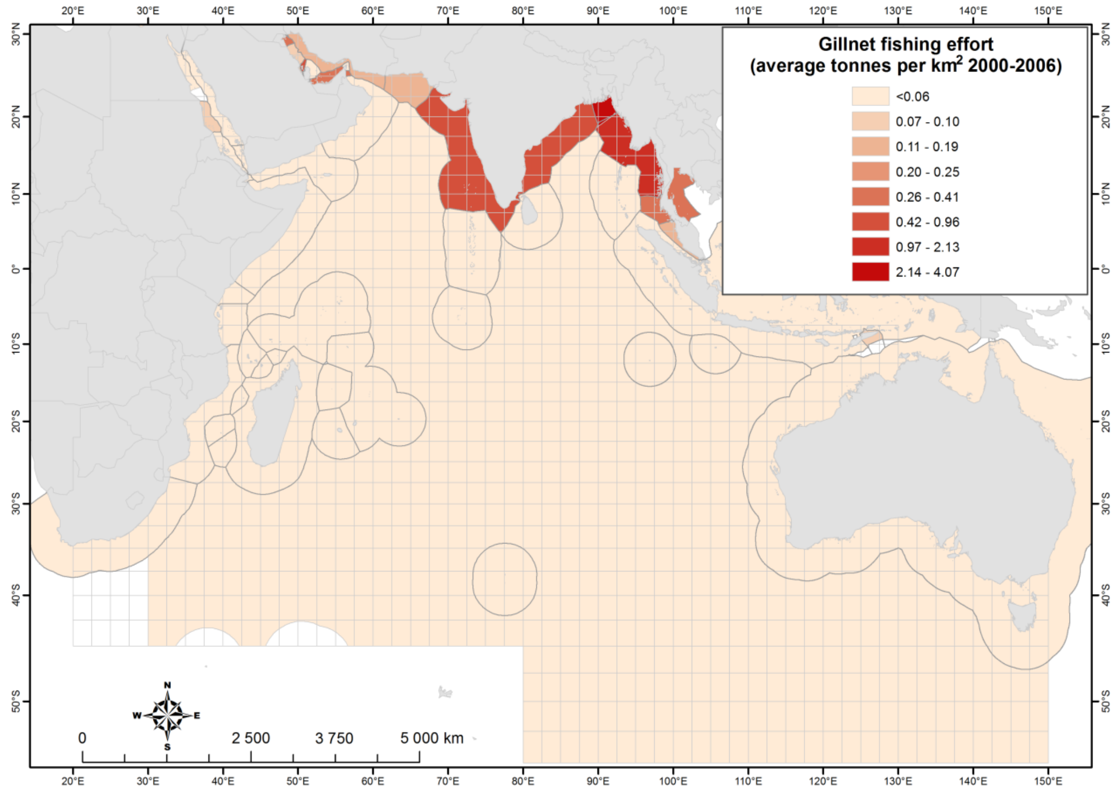

Figure 3: A proxy for gillnet fishing effort as the average catch per tons.km-2 across the IOTC region. Catch data obtained from Seas Around Us Project (http://www.seaaroundus.org/).

Scaling fishing pressure to gear type

An alternative method of estimation was obtained by comparing the ratios between gillnet:longling:purse seine catches obtained from global databases such as Seas Around Us Project. These catch statistics were compared to assess the order of magnitude of the potential gillnet impacts (see SUPPLEMENTARY II). It is projected that the gillnet turtle bycatch across the regions could be as much as ~ 18,200 – 52,400 turtles per annum (using gillnet:longline catch ratios). Whichever estimate is used (either the catch statistics or unweighted pressure index), gillnets tend to catch an order of magnitude more fish and so it is expected to catch an order of magnitude more turtles.

Estimating turtle catches per gear type

Combining the estimated catch rates per fishery suggested that total sea turtle catch from the three main gear types of concern spans three orders of magnitude. Purse seines fishing catch ~250 turtles.y^{-1}, longline fishing catches about 3,500 turtles.y^{-1} and gillnet fishing catches ~30,000 turtles.y^{-1} (with estimates ranging from 11,460–47,516 turtles.y^{-1} and 18,200–52,400 turtles.y^{-1}, depending on the method). This indicates a relative catch (not necessarily mortality) of ~10% for longlining, 1% for purse seining and 89% for all gillnetting. Applying the catch breakdown per species as per longline reports, EU purse seiners and estimated gillnet catches (per SUPPLEMENTARY II) the catch per species was calculated (Table 6).

Because purse seine information was limited to the Western Indian Ocean no estimates were available for flatback turtles. If the precautionary approach was applied to this species it would be assigned maximum threat score (for fishing pressure/bycatch rate). However, despite an extensive literature search little information was obtained for Western Australian flatback turtles in any fisheries, it is assumed a low risk (relative to habitat related pressures). The susceptibility scores to each of the three fisheries are listed in Table 7.

Table 6. Relative fraction of each species caught per gear type. (Species are Cc = *Caretta caretta*, Cm = *Chelonia mydas*, Dc=*Dermochelys coriacea*, Ei=*Eretmochelys imbricata*, Lo=*Lepidochelys olivacea*, Nd=*Natator depressus*, Iu = Unidentified).

Fishery	Cc	Cm	Dc	Ei	Lo	Nd	Ui
Longline (LL) (10%)	26%	2%	40%	0%	9%	0%	22%
Purse seine (PS) (1%)	10%	21%	3%	23%	42%	0%	36%
Gillnet (GN) (89%)	20%	53%	2%	10%	14%	1%	0%

The susceptibility scores were highly dependent on the size of the population and the availability of information. The smallest rookeries and the data deficient RMUs (such as the South Pacific leatherback turtles that migrate into the IO but for which we had no information) were rated amongst the most threatened in all fisheries (Dc-SP>2.5 LL=Longline, PS=Purse seine, GN=gillnet) (Table 7). However, loggerhead turtles from the Bay of Bengal and leatherback turtles from the south Western Indian Ocean were also ranked most susceptible to longlining and gillnetting (Cc-BoB=2.38 LL & Cc-BoB=2.88 GN; Dc-SWIO=2.63 LL & GN), with hawksbill turtles from ECIO ranking most susceptible to longline and purse seining (Ei-ECIO=2.38) and to gillnetting (Ei-ECIO=2.88) and Ei-BoB (>2.25) for all fisheries.

Table 5A. Relative Fisheries catch (tons) ratings based on gear type (Data from Seas Around Us Project http://www.seaaroundus.org). Estimated catch (tons.kg) per gear type for (avg.) landings between 2000 and 2006. **B.** Data normalised per surface area to indicate intensity (tons kg.km^{-2}). The contribution (tons kg.km^{-2}) then expressed as a % of the total catch to indicate relative success per gear type. E.g. 28% of the catch (per tons kg.km^{-2}) in the Agulhas LME were obtained from gillnets as opposed to 5% from longlines and 21% from purse seines.

A. LME	Surface Area (km2)	Gillnets	Longline tuna	Purse seines	Driftnets	Set gillnets	Other
Agulhas LME	2,615,294	82788	14742	63497			137102
Somali LME	844,524	24702	2595	4167			15598
Red Sea	480,385	24723		5924			82871
Arabian Sea	3,950,421	970287		236783	91283		1860623
Bay of Bengal	3,657,502	2340138		165060	32542		1167320
North Australian Shelf	722,214	12092	282	5474			43243
North-west Australian Shelf	911,812	13374	783	3378		1986	28920
Western Central Shelf	543,577	4912	752	975		627	12510
South Australian Shelf	1,046,368	6833	2247	1963			21352
South-east Australian Shelf	1,199,787	4617	1579	1512			22375
WIO High Seas	17,027,045	130729	158000	248945			249286
EIO High Seas	22,176,590	624299	102053	106201			185720

B. LME	Gillnets(tkg.km^2)	Longline tuna_km^2	Purse seines_km2	Driftnets_km2	Set gillnets_km2	Other
Agulhas LME	0.032 **(28%)**	0.006 (5%)	0.024 (21%)			0.052 (46%)
Somali LME	0.029 **(53%)**	0.003(5%)	0.005 (9%)			0.018 (33%)
Red Sea	0.051 (22%)		0.012 (5%)			0.173 (73%)
Arabian Sea	0.246 **(31%)**		0.060 (8%)	0.023 (3%)		0.471 (59%)
Bay of Bengal	0.640 **(63%)**		0.045 (4%)	0.009 (1%)		0.319 (31%)
North Australian Shelf	0.017 (20%)		0.008 (9%)			0.060 (71%)
North-west Australian Shelf	0.015 **(28%)**	0.001 (2%)	0.004 (7%)		0.002 (4%)	0.032 (59%)
Western Central Shelf	0.009 **(25%)**	0.001 (3%)	0.002 (6%)		0.001 (3%)	0.023 (64%)
South Australian Shelf	0.007 (23%)	0.002 (6%)	0.002 (6%)			0.020 (65%)
South-east Australian Shelf	0.004 (16%)	0.001 (4%)	0.001 (4%)			0.019 (76%)
WIO High Seas	0.008 (17%)	0.009 (**19**%)	0.015 **(32%)**			0.015 (32%)
EIO High Seas	0.028 **(61%)**	0.005 (11%)	0.005 (11%)			0.008 (17%)

Productivity-Susceptibility Analysis

Combing the (reversed) productivity score and susceptibility scores provided a visual interpretation of vulnerability to each fishery sector (Figs. 4-6). RMUs located in the upper right corner are most vulnerable and those at the lower left corner as least vulnerable to each of the three gear types. In general, the RMU rankings for the fisheries are more or less consistent, being a function of RMU size.

PSA per gear type

Vulnerability was further quantified by calculating Euclidean distance using the Productivity (P) and Susceptibility (S) scores. A low P and S score will equate to a large vulnerability Score (Table 8). The most data-deficient species and two RMUs (Dc-SP & Cc-BoB) were rated as most vulnerable (Table 8). Of the species/RMUs with a reasonable amount of information available, leatherback turtles (BoB & SWIO) were rated as most vulnerable to longlining, SWIO leatherback turtles to longlining and SWIO loggerhead turtles to gillnetting (Table 8). The RMUs least vulnerable to fishing were green turtles of the SWIO and EIO as well as hawksbill and loggerhead turtles of the Arabian Gulf (Fig. 4-7; Table 8). It is important to note that these ratings only pertain to tuna-related fisheries and all gillnet fisheries (which may be biased towards tuna-related fisheries) but does not include information or vulnerability scores on any other fishing industries like trawling which may have a relative large impact on turtles. These values are therefore not representative of the overall threat score to turtles (per RMU).

PSA per species

Comparing vulnerability across species indicate that loggerhead turtles (Fig. 7A) range from being highly vulnerable (BoB) to reasonably robust (AG) as opposed to green turtles which are moderately or least vulnerable of all species (Fig. 7B). Leatherback turtles are sensitive to all fisheries (due to the small size of the rookeries) (Fig. 7C) while hawksbill turtles have mixed vulnerabilities (Fig. 7D). For olive ridley turtles, the Arribada RMU (EBoB) is the most robust whereas the WIO and EIO RMUs are highly vulnerable to gillnets (Fig. 7E). Flatback turtles are ostensibly quite robust to selective fisheries like longlining but more susceptible to net fisheries (both purse seine and gillnets; Fig. 7F). However, the Western Australian population of flatback turtles, with a restricted neritic distribution is under-exposed to pelagic fisheries.

Table 7. Susceptibility scores per RMU per fishery. Low susceptibility is scored 1 and high as 3.

	RMU Proportion of IOTC region	Confidence Level (#SAT TAGS)	Spawner Biomass (Inv.nesting females)	Longline threat	Longline Rank	Purse seine threat	Purse seine Rank	Gillnet threat	Gillnet Rank
Cc-SWIO	3	2	2.5	1	2.13	1	2.13	3	2.63
Cc-AG	3	1	1	1	1.50	1	1.50	1	1.50
Cc-BoB	3	3	2.5	1	2.38	1	2.38	3	2.88
Cc-SEIO	1	3	2	1	1.75	1	1.75	1	1.75
Cm-SWIO	2	1	1	1	1.25	1	1.25	1	1.25
Cm-AG	3	2	1.5	1	1.88	1	1.88	2	2.13
Cm-NEIO	2	1	2	1	1.50	1	1.50	2	1.75
Cm-SEIO	2	2	1	1	1.50	1	1.50	1	1.50
Dc-SWIO	3	2	2.5	3	2.63	1	2.13	3	2.63
Dc-BoB	2	2	2	3	2.25	1	1.75	2	2.00
Dc-SP	3	3	2	3	3.00	1	2.50	3	3.00
Ei-SWIO	2	3	1	1	1.75	1	1.75	2	2.00
Ei-AG	2	1	1	1	1.25	1	1.25	2	1.50
Ei-BoB	3	3	2	1	2.25	1	2.25	2	2.50
Ei-ECIO	3	3	2.5	1	2.38	1	2.38	3	2.88
Ei-WA	3	3	1	1	2.00	1	2.00	2	2.25
Lo-WIO	1	2	2.5	1	1.63	1	1.63	3	2.13
Lo-EBoB	1	3	1	1	1.50	1	1.50	1	1.50
Lo-EIO	1	2	2.5	1	1.63	1	1.63	3	2.13
Nd-SEIO	2	1	1	1	1.07	1	1.25	1	1.25

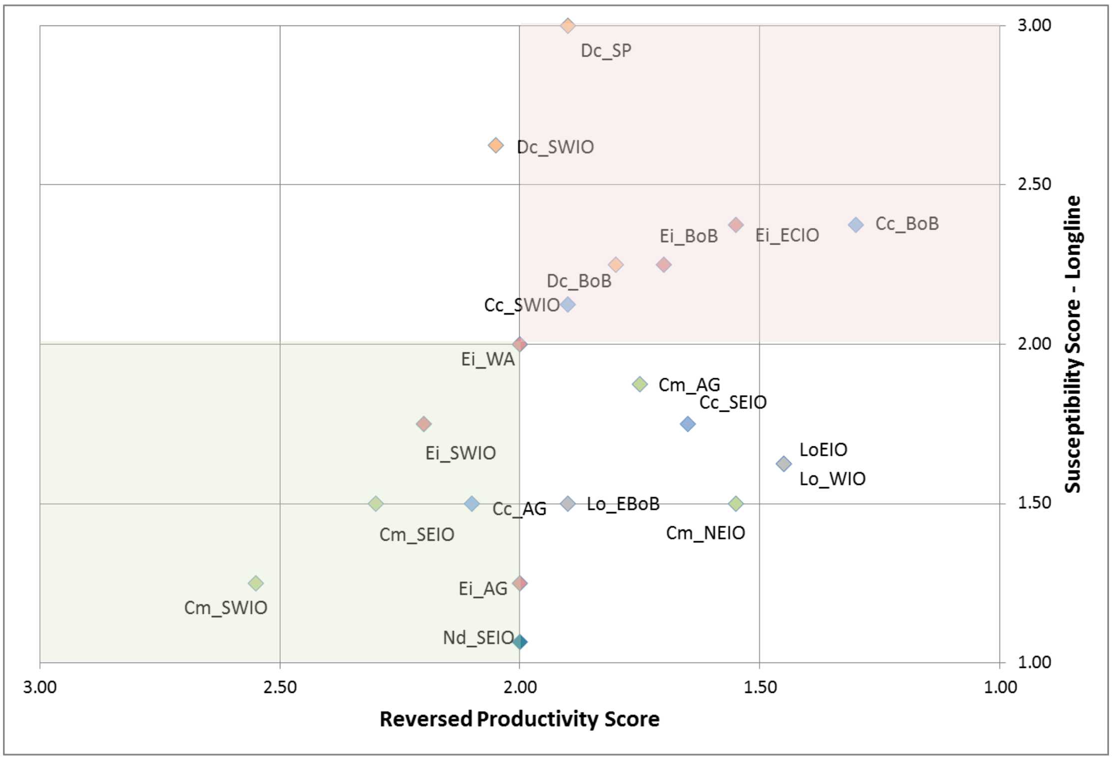

Figure 4: Productivity (x) and Susceptibility (y) scores for longline fisheries in 20 sea turtle RMUs in the IOTC region. (Top-right corner = most vulnerable and bottom-left least vulnerable.)

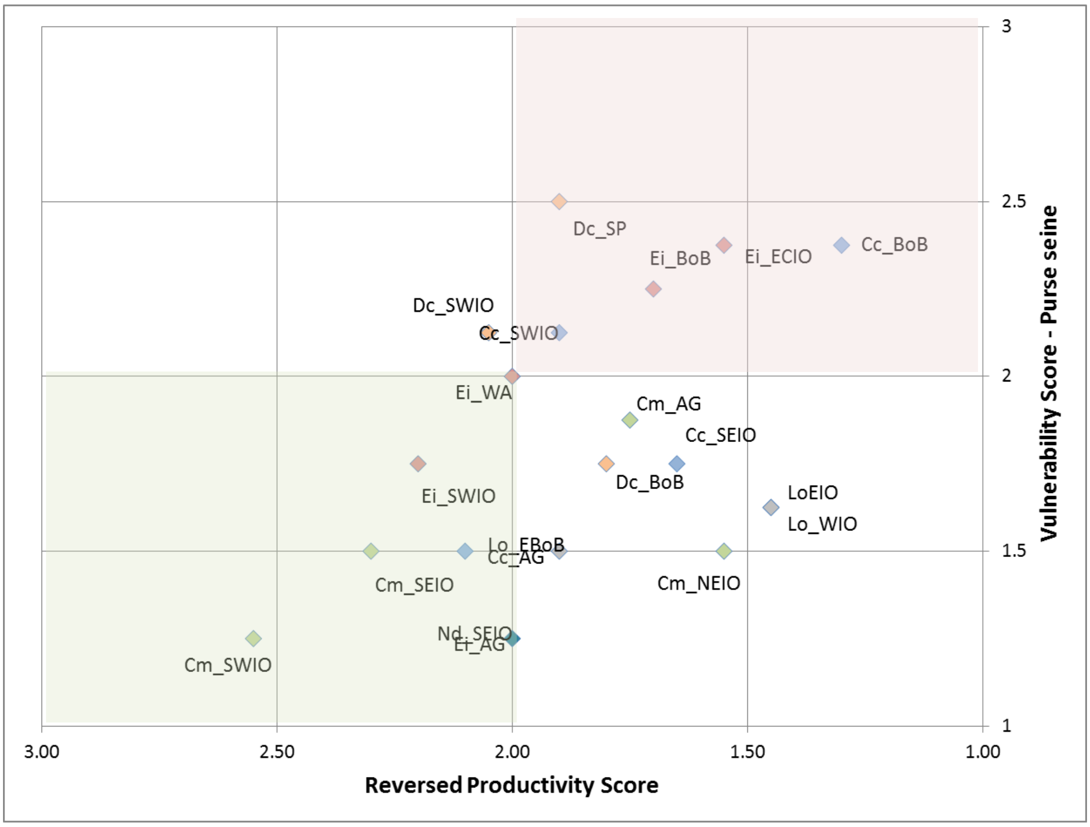

Figure 5: Productivity (x) and Susceptibility (y) scores for purse seine fisheries in 20 sea turtle RMUs in the IOTC region. (Top-right corner = most vulnerable and bottom-left least vulnerable.)

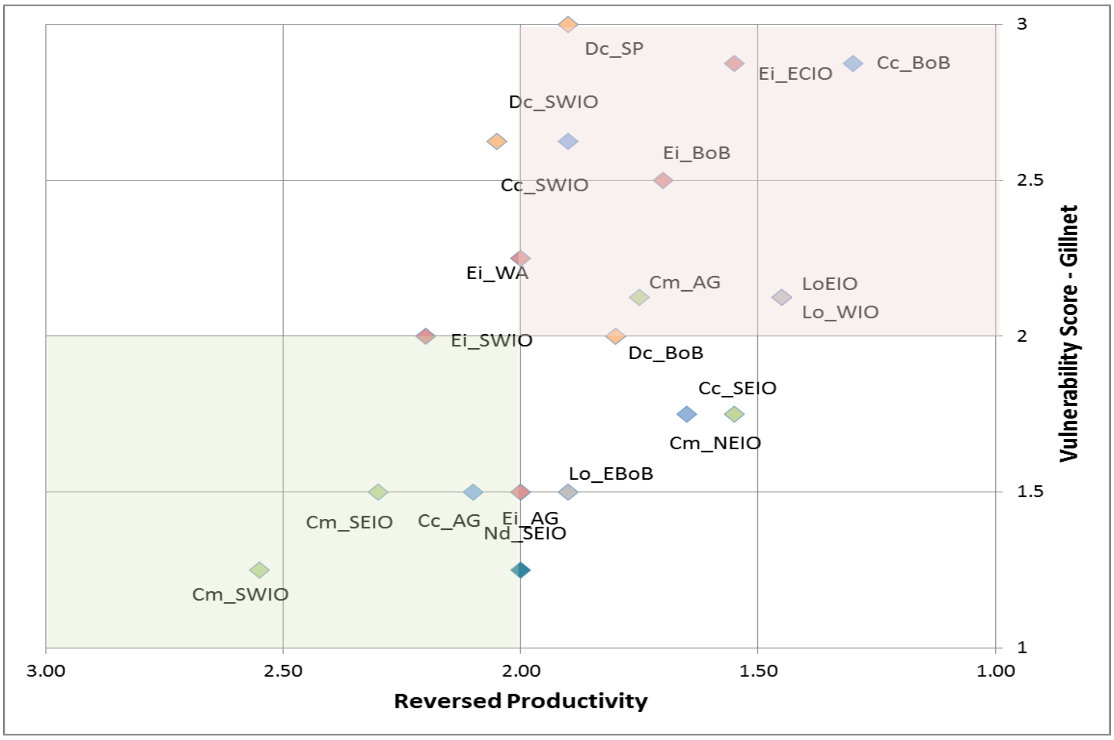

Figure 6: Productivity (x) and Susceptibility (y) scores for commercial gillnet fisheries in 20 sea turtle RMUs in the IOTC region. (Top-right corner = most vulnerable and bottom-left least vulnerable.)

Table 8. Calculated vulnerability scores of 20 Indian Ocean sea turtle RMUs to three tuna-related fisheries (longline, purse seine and gillnets), ranked by score per gear type.

RMU	Longline	RMU	Purse seine	RMU	Gillnet
Dc-SP	2.28	Cc-BoB	2.19	Cc-BoB	2.53
Cc-BoB	2.19	Ei-ECIO	2.00	Ei-ECIO	2.37
Ei-ECIO	2.00	Dc-SP	1.86	Dc-SP	2.28
Dc-SWIO	1.88	Ei-BoB	1.80	Ei-BoB	1.98
Ei-BoB	1.80	Lo-WIO	1.67	Cc-SWIO	1.96
Dc-BoB	1.73	Lo-EIO	1.67	Lo-WIO	1.92
Lo-WIO	1.67	Cc-SWIO	1.57	Lo-EIO	1.92
Lo-EIO	1.67	Cc-SEIO	1.54	Dc-SWIO	1.88
Cc-SWIO	1.57	Cm-NEIO	1.53	Cm-AG	1.68
Cc-SEIO	1.54	Cm-AG	1.53	Cm-NEIO	1.63
Cm-NEIO	1.53	Dc-SWIO	1.47	Ei-WA	1.60
Cm-AG	1.53	Dc-BoB	1.42	Dc-BoB	1.56
Ei-WA	1.41	Ei-WA	1.41	Cc-SEIO	1.54
Lo-EBoB	1.21	Lo-EBoB	1.21	Ei-SWIO	1.28
Ei-SWIO	1.10	Ei-SWIO	1.10	Lo-EBoB	1.21
Ei-AG	1.03	Nd-SEIO	1.03	Ei-AG	1.12
Cc-AG	1.03	Ei-AG	1.03	Nd-SEIO	1.03
Nd-SEIO	1.00	Cc-AG	1.03	Cc-AG	1.03
Cm-SEIO	0.86	Cm-SEIO	0.86	Cm-SEIO	0.86
Cm-SWIO	0.51	Cm-SWIO	0.51	Cm-SWIO	0.51

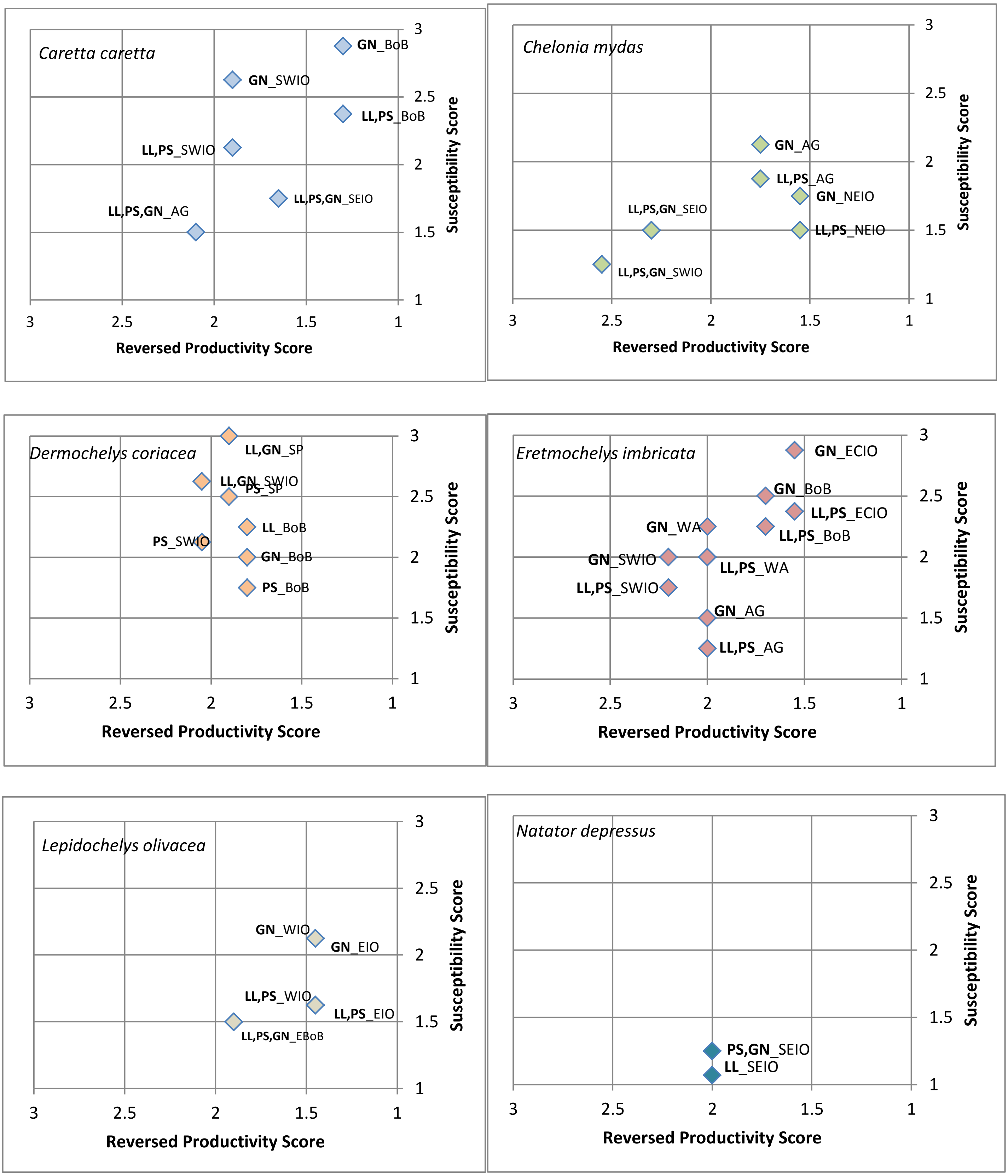

Figure 7: Productivity (x) and Susceptibility (y) scores by species: A) loggerhead turtles; B) green turtles; c) leatherback turtles; d) hawksbill turtles; e) olive ridley turtles and f) flatback turtles (Upper right corner = most vulnerable and lower-left least vulnerable.) LL=Longline, PS=Purse seine and GN=gillnet.

State of Implementation

Information on the level of compliance of CPCs with the recommendations in Resolution 09/06, drawn from National Reports submitted to the IOTC Scientific Committee. Most CPCs mention efforts towards implementing the resolution (Table 9) without providing much detail. The level of compliance was assessed from data compiled between 2006 – 2011 (Table 10). Of the 33 CPCs, two states (United Kingdom and Senegal) are exempt from reporting on compliance with the resolution because they have no active fleet in the Convention Area. Of the remaining (31) countries (including South Africa), 18 have reported on the resolution to the Science Committee in some way, as required by the resolution. The level of detail, however, varies widely. Few CPCs report bycatch rates or numbers of turtles caught by species. Nine CPCs currently submit catch information, mostly non-raised observer records or observer records that represent <5% coverage. Four of the nine CPCs (South Africa, Australia, France, European Union) report extrapolated bycatch rates and fate of turtles caught, from which an estimation of mortality rate can be made.

Table 9. Relative reporting of turtle bycatch information by CPCs in the IOTC area.

Category of reporting	State of reporting
CPCs reporting on resolution	**18 (58%)**
• Bycatch numbers - non-raised	**5 (16%)**
• Bycatch rate - raised	**4 (13%)**
• Implementation progress	**9 (29%)**
CPCs not reporting on resolution	**13 (42%)**

With only 29% of CPCs reporting on turtle bycatch, the level of compliance with marine turtle reporting is poor. A positive sign is increased efforts to comply with the resolution in recent years.

Most countries have reported some attempt to comply with the regulations or are in the process of doing so (encouraged or under implementation). Clear shortcomings include the estimation of mortality, reporting on successful mitigation measures or research on mitigation measures (see SUPPLEMENTARY IV).

Table 10 Summary on the state of implementation of the regulations of Resolution 09/06 as compiled from National Reports submitted to the IOTC Scientific Council (in 2006 – 2011).

Compliance with Resolution 12/04 on the conservation of turtles for relevant CPC's	Australia	Belize	China	EU Portugal	EU Spain	India	Indonesia	Iran	Japan	Kenya	Korea (Republic)	Mauritius	Philippines	Seychelles	Sri Lanka	South Africa	Taiwan (China)	Thailand	Vanuatu
Fishery type lonline (LL) purse seine (PS) Gillnet (GN)	LL;PS	LL	LL	LL	LL;PS	LL	LL;PS; GN	LL;PS	LL	LL;PS	LL	LL;PS	LL	LL;PS	LL;G N	LL	LL	LL;P S;GN	LL
General all CPC's																			
Collect and report interaction data to IOTC	YES	no	YES	YES	YES	no	YES	no	YES	no	YES	no	YES	no	no	YES	no	no	no
Estimation of total mortality	YES	no	no	?	YES	no	no	no	no	no	no	no	no	no	no	YES	no	no	no
Report on successful mitigation measures	YES	no	?	?	YES	no	no	no	YES	no	no	no	no	no	no	YES	no	no	no
Report progress of implementation of resolution	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	no	YES	no	YES	YES	YES	YES
Bring on board if practicable, and foster recovery of any incidentally caught turtle	YES	YES	?	YES	?	?	?	no	?	no	?	YES	?	no	no	YES	no	YES	encouraged
Ensure awareness off and use proper mitigation, identification, handling and de-hooking techniques	YES	YES	?	YES	?	YES	under imple ment ation	under imple mentat ion	?	no	?	YES	?	no	YES	YES	no	no	?
Undertake research trial for mitigation measures which may minimize adverse effects on marine turtle	YES circle hooks	no	YES circle hooks	no	YES FADs	YES	no	no	YES LL impact	no	no	no	?	no	no	YES LL impact s	no	no	no
Report results of research trial to Scientific committee	YES	no	?	no	YES	YES	no	no	YES	no	no	no	?	no	no	YES	no	no	no
Gillnet vessels																			
Collect and report interaction data	NA	NA	NA	NA	NA	NA	no	NA	NA	NA	NA	NA	NA	NA	no	NA	NA	no	NA
Longline vessels																			
Collect and report interaction data	YES	no	YES	YES	YES	no	YES	no	YES	no	YES	no	YES	no	no	YES	YES	no	no

Compliance with Resolution 12/04 on the conservation of turtles for relevant CPC's	Australia	Belize	China	EU Portugal	EU Spain	India	Indonesia	Iran	Japan	Kenya	Korea (Republic)	Mauritius	Philippines	Seychelles	Sri Lanka	South Africa	Taiwan (China)	Thailand	Vanuatu
Carry line cutters and de-hookers	YES	YES	?	YES	?	YES	?	no	?	no	?	YES	?	no	no	YES	?	no	?
Use of circle hooks - not mandatory	no	YES	under implementation	?	?	?	?	no	encouraged	no	?	?	?	no	no	encouraged	?	no	encouraged
Purse seine vessels																			
Collect and report interaction data	Yes	NA	NA	NA	YES	NA	no	no	NA	no	NA	NA	NA	no	NA	NA	NA	no	NA
Where practicable avoid encirclement	?	NA	NA	NA	?	NA	no	no	NA	no	NA	NA	NA	no	NA	NA	NA	no	NA
If encircled or entangled, take measures to safely release any incidentally caught turtle	YES	NA	NA	NA	?	NA	no	no	NA	no	NA	NA	NA	no	NA	NA	NA	no	NA
Take measures to safely release any observed turtle entangled in FAD's or other fishing gear	YES	NA	NA	NA	?	NA	no	no	NA	no	NA	NA	NA	no	NA	NA	NA	no	NA
If a turtle is entangled in the net, stop net roll, disentangle and assist in its recovery before returning it to the water	?	NA	NA	NA	?	NA	no	no	NA	no	NA	NA	NA	no	NA	NA	NA	no	NA
Carry and employ dip-nets for the handling of turtles	YES	NA	NA	NA	?	NA	no	no	NA	no	NA	NA	NA	no	NA	NA	NA	no	NA
Encourage vessels to adopt FAD designs that reduce the incidence of entanglement	?	NA	NA	NA	?	NA	no	no	NA	no	NA	no	NA	under implementation	NA	NA	NA	no	NA
Other relevant information																			
Observer programme in place	YES	YES	YES	YES	YES	under consideration	YES	YES	YES	YES	YES	under implementation	no	under implementation	no	YES	YES	no	no

Discussion

There were essentially five questions posed in this project. First, what are the characteristics of sea turtle population in the Indian Ocean (IO) and how are they spatially distributed? Second, what is the extent (spatio-temporal distribution of effort) of IOTC fisheries that interact with sea turtles? Third, what is the extent of overlap and interactions between sea turtles and IOTC fisheries? Fourth, what are the levels of compliance amongst CPCs to bycatch regulations regarding turtles? And five, are there exemplary practices from member (or other) nations that can be promoted?

The highly variable quality, and general lack of data in many instances, highlight the need to improve turtle bycatch data recording and reporting systems across all IOTC fisheries. However, from the data received it is apparent that purse seine fishing has very low, (probably) non-significant impacts on turtles. There are concerns though about the unknown impacts of ghost fishing from (lost) FADs. Longline fishing also appears to catch an order of magnitude more turtles than purse seine, but still relatively low numbers of turtles. The actual mortality rate is not known but is likely to be lower. That said, the robustness of the datasets is limited and impacts from longlining are highly significant in some areas because of the turtle populations. Of greatest concern though is the gillnet fishing. This fishery (which may intend to catch tuna-related species) frequently catch reef species (in artisanal operations) or vulnerable bycatch due to the highly non-selective nature of the gear. Further, it is undertaken on a massive scale in the Indian Ocean, and poorly managed and inadequately reported. The total turtle catch is an order of magnitude higher than turtles interacting with longlines, and is expected to have a higher total mortality compared to longline or purse seine fishing. The likely risks to turtles from gillnet fishing dwarf the likely effects of the other two gear types for most RMUs.

Because sea turtle nesting takes place on land, their distribution is invariability aggregated around coastal waters. This is true for at least breeding males and females, eggs and hatchlings. Post-hatchlings and juveniles are more widely distributed by oceanic currents but these patterns are poorly mapped (McClellan and Read, 2007). Some satellite tracks have revealed complex spatial patterns and unlike the rookeries, which are mostly discrete, mixing takes place on the high seas, especially of younger size classes. It is therefore difficult to assign any individual caught/encountered at sea to a home population without a genetics mixed-stock analysis in place. For this report proximity to nearest (significant) rookery was assumed to indication of the home population (e.g. loggerheads caught in the south-western Indian Ocean, SWIO, belong to the SWIO RMU irrespective of size). Bycatch (e.g. gillnetting) was assigned proportionately to the size of the rookery, if there was no indication of proximity.

Abundance estimates and trend projections were available for most populations, especially the larger rookeries, like green turtles from the French Iles Esparse (Lauret-Stepler et al., 2007), hawksbill turtles in the south and north Western Indian Ocean (Mortimer and Donnelly, 2007), and loggerhead turtles of Oman (Baldwin et al., 2003). However, detailed information on the nesting biology, remigration period, hatching and emergence success were available from only long-term programmes in South Africa (Baldwin et al., 2003, Hughes, 1996) and (eastern) Australia (Limpus, 2008a, Limpus, 2009). Further, as the state and distance of the foraging grounds affects nesting biology (Limpus, 2008b, Limpus, 2008c), information across RMUs was applied very cautiously. When species-specific information, such as the number of eggs laid per was required, it did not matter if it was from a different RMU (Limpus, 2007). When there was absolutely no information available or none could be inferred (e.g. nesting biology for loggerhead turtles for the Bay of Bengal) the population parameters were scored as Data Deficient. When these principles were applied, the data deficient rookeries were always identified as “least productive” and the large, well-known sites as most productive. There was great correspondence with the values obtained in this assessment, and the conservation priority setting procedure applied by Wallace et al. (2011).

The distribution of animals was mapped from available satellite tracking information. There is a bias in the spatial information using only one class from a population, because reproductively valuable females are mostly restricted to neritic waters whereas juveniles occur mostly in oceanic waters (Finkbeiner et al., 2011). However, recent studies have indicated that this is not as segregated as previously thought as female loggerheads (at least) spend some time in the oceanic environment. Distribution maps indicated that tracked animals do move offshore, with about half of the IOTC region overlapping with turtle distribution (SUPPLEMENTARY I). Size information of animals caught in the fisheries will be the only way to differentiate size class-specific mortality and so the true impact of the fishery. As with most fisheries these data are not recorded unless there is a dedicated observer programme in place (Finkbeiner et al., 2011).

Of the fisheries investigated, gillnetting was by far the most widely used, but longlining was the best reported (and managed). We estimate that longline operations catch ~ 3500 turtles per annum across the IOTC region. However, this is reported catch and there is little information on mortality rates or post-release survival rates. It is, however, important to note that there was no quantitative gillnet information available for the IOTC region and no reliable turtle bycatch estimates for this gear type. As an alternative, the catch projections of longlines:gillnets were used or the unweighted gillnet pressure index (derived by Waugh et al., 2011) trained against ‘known’ turtle catches including for Madagascar, India, and South Africa with a bather protection programme using gillnets, that have been monitored for 30 years (Wallace et al., 2010b, Humber et al., 2011, Brazier et al., 2012). Shanker and others (Humber et al., 2011, Shanker et al., 2003) have indicated that the artisanal fisheries in Madagascar (10 000 – 16 000 indiv.y^{-1}) and India (~ 100 000 indiv.y^{-1}) may overshadow all IOTC-related fishery mortalities in this assessment. The overall threat posed by longline and purse seine fisheries in IOTC region seems to be relatively small (Wallace et al., 2008). However, the impact on specific RMUs may be large. Nel et al. (2013) suggested that longlining around the South African coast (including the Atlantic) might have been partly responsible for the lack of growth in the South African leatherback population. The impacts of these fisheries were therefore assessed against the productivity scores of twenty sea turtle populations in the Indian Ocean.

The olive ridley turtles of both western and eastern Indian Ocean as well as loggerhead turtles of the Bay of Bengal were consistently rated as vulnerable. This corresponds to the findings of Wallace et al. (2011) which listed these populations amongst the highest conservation priority. The large populations of green and hawksbill turtles in the Arabian Gulf were relatively buffered against fishing impacts due to the large size and coastal distribution.

Sea turtles are at risk to longline fisheries by two mechanisms; they are either hooked and drown when preying on baited hooks, or they are entangled and/or foul-hooked when swimming across monofilament branchlines, which are typically 15-40 m long. Efforts to minimise these risks have focused almost exclusively on reducing hooking from ingestion of baited hooks (Swimmer and Gilman, 2012). We found no data on entanglement rates with fishing gear within this study.

A global review of onboard measures to reduce turtle bycatch in tuna longline fishing revealed only two key options to reduce impacts (Gillman et al., 2006). First is the use of large (18/0) circle hooks instead of "J" or Japanese tuna hooks. This measure reduces the total incidence of hooking and the incidence of deep-hooking (when the entire hook is swallowed and becomes lodged deep in the animal's mouth or oesophagus). Second is the use of finfish bait (e.g. mackerel) instead of squid (Gillman et al., 2006, Watson et al., 2005). It is hypothesised that the softer flesh of finfish can be "nibbled off" in small bites and so turtles avoid the hooks, instead of swallowing in one bite the tougher squid bait with hook.

Because most turtle species are epi-pelagic throughout most of their at-sea life stages and are seldom encountered at depths below 60 m; setting longlines below this depth should result in fewer interactions between turtles and fishing gear. However, prescribing a minimum setting depth of below 60 m is not likely to be practical, nor enforceable, as features such as thermoclines which affect fishing are sometimes shallower than this depth. However, if times or areas where turtle bycatch is highest can be identified, time-area closures need not be the only tool to mitigate those mortality risks. Requiring deep-set lines may be considered as a practical option to allow fishing to continue in high-risk fishing areas while reducing the risk. As others have noted (Gillman et al., 2006, Petersen et al., 2009), there remains an urgent need to develop new approaches to mitigate turtle bycatch in longline fisheries.

Purse seine fishing is designed to catch schooling fish. A purse seine is made of a long wall of netting, of varying length with a floating section at the surface and a weighted line at the bottom keeping the net stretched. Turtles are known to associate with fish aggregating devices (FADs), either natural or artificial, where they may rest, seek protection or food. Turtles may get encircled in the purse seine nets and/or entangled in the materials used to make artificial FADs. Turtles can get entangled in artificial FADs either by climbing on to them and getting entangled in the nets keeping the raft structure together, or by getting caught in the nets hanging underneath, which can be as long as 55 metres. Turtles can then get injured or drown if they are not able to free themselves. An unknown percentage of drifting FADs get lost, resulting in unquantifiable ghost fishing; this may be a major cause of turtle mortality (Amandè et al., 2011).

There are very few studies quantifying the mortality rate either as a direct cause of purse seine net entanglement or FAD entanglement including ghost fishing (Amandè et al., 2011, Clermont et al., 2012a). Studies however, indicate that turtles are rarely caught during purse seine operations *per se* and when this happens, the majority can be released alive. The main threat therefore seems to be related to FADs and ghost fishing, meaning that eliminating the use of net material from FADs or improving their design to minimize entanglement could be the technological solution to the problem. Research in to alternative FAD construction has been the main focus for mitigating turtle bycatch in this fishery (Franco et al., 2009). The main challenge has been to find a turtle-friendly alternative to the hanging nets and raft surface net-cover, found in traditionally constructed FADs.

The International Seafood Sustainability Foundation (ISSF) has issued guidelines for the design of FADs that reduce the likelihood of entanglement during a transition period while fishers still use mesh in constructing FADs. Guidelines for environmentally friendly FADs that do not use mesh and eliminate the risk of entanglement have also been published.

There is growing evidence that small-scale gillnet fishing may be the largest single threat to some turtle populations. However only a small number of quantitative studies are available on the extent of turtle by-catch in the gillnet fishery, particularly in the Indian Ocean (Gilman et al., 2010, Wallace et al., 2010b). To illustrate, a global review of turtle bycatch done by (Wallace et al., 2010b), reported 78 turtles reported caught in gillnets in the Western Indian Ocean and 5,251 in the Eastern Indian Ocean. A gillnet is a curtain of netting that hangs in the water, suspended by floats and weights or anchors. They hang in the water at various depths and are usually made up with monofilament material of varying mesh sizes. The methods used varied between commercial and artisanal, with the latter sometimes anchoring the nets and sometimes not. To assess the impacts specific to commercial tuna-related gillnetting is impossible with available data. However as gillnet fishing is extremely non-selective, it is somewhat moot if a particular gillnet set catches tuna and turtles, only tuna, only turtles or neither tuna nor turtles. We could not identify those catches from the available data and here we report all gillnet catches. This yielded broad estimates (10,000–52,000 turtles caught per annum). Quantitative estimates of mortality rates as well as mitigation options for the reduction of turtle bycatch in gillnet fisheries should be a priority. To date most studies focused on modifying gear designs and switching fishing methods.

Turtles are rare animals in comparison to tunas. Furthermore, their abundance in the Indian Ocean is dwarfed by their abundances in other ocean basins (with the exception of loggerhead turtles on Masirah Island, Oman, green turtles on the French Iles Esparses and olive ridley turtles in Orissa, India). For example, Lewison et al. (2004) estimated that the loggerhead and leatherback populations in the Pacific Ocean were 335,000 and 160,000 individuals respectively, whereas the populations of the Indian Ocean is likely to be a fraction of that. Thus, turtle captures in longline and purse seine fishing are relatively rare events, requiring very large datasets to overcome the statistical complications related to observing rare events and raising low coverage rates from observer data to the entire ocean basin’s effort. Further, gillnets are widely used, but rarely covered by observers. Thus, a core recommendation for improving data quality and quantity would be to ensure that all CPCs comply with the minimum 5% observer coverage, and that turtle interactions are recorded and reported relative to observed effort in National Reports and in Observer Trip Reports. Although it seems obvious, bycatch data must always be reported as both total number of bycatch events (stratified by fate – dead or alive) *and* with the relevant fishing effort. Without both it is impossible to calculate either nominal or standardised CPUEs or to combine multiple datasets (across nations/years). Gillnet data for the IOTC region frequently came from interview surveys. These are useful to indicate the prevalence of turtle-fisheries interactions but it is near-impossible to quantify mortality from them.

The ability of observers to correctly identify turtle species remains a significant concern. Some observer data obtained recorded quite high numbers of flatback turtle bycatch, for example. However, the data were from areas where flatback turtles do not occur (like the South African EEZ), and are clearly an example of systematic misidentification.

Reporting styles vary widely. A key confusion in almost all National Reports reviewed, as well as some research papers (Petersen et al., 2009) is the non-distinction between catch/capture/bycatch and mortality. All observer reports and national reports should make clear how many turtles (by species) were captured and released alive and how many were dead or died before release. Further, an indication of turtle size would be useful, as it would allow for an in indication of the age class being impacted.

Related to the need to discriminate between bycatch and mortality, is the lack of understanding of factors affecting post-release survival. This is a key issue, because in both purse seine and longline fishing, the reported ratio of live:dead captures is very high, meaning remarkably few animals are known to have been killed by these fisheries relative to the numbers reported as caught. However, handling techniques and the state of the animal at hauling are known to play a significant role in their post-release survival (Swimmer and Gilman, 2012).

To raise observed bycatch data to total fishing effort it is desirable to stratify the data as finely as possible, so as to ensure that appropriate rates are applied to appropriate strata. However, this requires two types of information currently lacking. First is the nature of bycatch (time, area, environmental variables, covariables, etc.) that will make a sensible stratification of fishing data. Second, the more finely stratified a dataset is, the greater the observer coverage that is needed to ensure adequate statistical power for each stratum. However, we note with concern that a EU research programme in Atlantic and Indian Ocean purse seine fleets, the authors of IOTC2012WPEB08/35 concluded that the rarity and apparent randomness of turtle interactions meant that despite massive observer effort, there was insufficient power to determine causal factors driving bycatch events or to raise the observed interaction rates to the rest of the EU fleet's effort. Thus it seems unlikely that national observer programmes operating at a target minimum of 5% coverage will ever yield sufficient data to allow robust estimates of fishing impacts on turtles. Several statistical models (Lawson, 2006) have shown that for relatively rare bycatch events such as seabird or turtle interactions, to bring confidence estimates down to acceptable levels, minimum observer coverage levels required are around 20%.

Recommendations

Data Management

- Data on gillnet effort and interactions with turtles are completely lacking, although this method of fishing, and the areas in which they occur (inshore, and therefore often close to nesting beaches) are likely to pose the greatest risk to turtle conservation in the Indian Ocean. Improving data collection and reporting for the coastal gillnet fisheries of the Indian Ocean is the highest priority recommendation.

- Cumulative effects were not evaluated in this study and results should therefore be interpreted with caution. Thus to evaluate the impact of fisheries on these turtles it should be conducted across multiple fisheries, assessing a variety of gears (Finkbeiner et al., 2011).

- Improving the quality of data in National Reports and standardising the reporting into tables with bycatch numbers (dead and released alive) and effort data, and compliance to specific components of conservation measures. This is critical to improve both quality and quantity of turtle bycatch data.

National Reporting

- Amend the National Report template so that CPCs report against the prescribed mitigation measures (by fishery) according to the conservation measure in force.

- Require that each CPC submits to the Secretariat, possibly as an annex to the National Reports, a full copy of the fishing permit conditions for the period of the report.

- All observer reports and national reports should make clear how many turtles (by species) were captured and released alive and how many were dead or died before release.

- Bycatch numbers should be converted to a rate per observed effort and raised to total fishing effort (by fishery). Alternatively, catch and mortality rates should be calculated and total fishing effort, and proportion of effort observed (to indicate level of confidence in calculations) should be reported.

Training & Capacity Building

- Improve training in turtle species identification for observers and skippers.

- Research into factors affecting post-release survival of turtles.

- Expanding the regional observer scheme's coverage to achieve at least 20% coverage.

Gear Modifications

- Research into new technologies and approaches to mitigate turtle bycatch in all gear types is a second priority.

Guidelines for transitional FADs that reduce the risk of entangling:

- For the surface structure only smaller mesh netting of 2.5 inch (7 cm) stretched mesh or less should be used for wrapping it up tight.
  Log-shaped (i.e. cylindrical or spherical floats naturally deter turtles from climbing onto the device, and should be used in preference to flat rafts.

- For the underwater structure, the netting should be rolled up and securely tied in to "sausages". These 'sausages' should be constructed from netting of 2.5 inch (7 cm) stretched mesh or less so that, if the sausages unwind, the netting will not entangle marine life.
  If panels are preferred, only a single panel should be used and the panel should be, weighted to keep it taut. The panel should consist of either a solid sheet (e.g., canvas) or netting with a stretched mesh of 2.5 inches (7 cm) or less.

Guidelines for environmentally friendly non-entangling FADs:

- The surface structure should either not be covered or only covered with non-meshed material.
  If a sub-surface component is used, it should not be made from netting but from non-meshed materials such as ropes or canvas sheets.

- To reduce the amount of synthetic marine debris, and to promote environmentally friendly FADs, the use of natural or biodegradable materials should be promoted.

Demersal gillnet fishing

- Illumination of the net using green light sticks.
- Reducing net vertical height (narrower profile nets).
- Increasing tie-down length or eliminating tie-downs.
- Attach shark silhouettes to the line – although very effective in reducing bycatch it also affected catch of target species.

Surface gillnet fishing

- Reducing net vertical height (narrower profile nets).

Of the above techniques, only net illumination in the demersal fishery did not affect catch rates of target species. More research is needed in effective and commercially viable solutions taking into account the socioeconomic context of the fishery, as well turtle and target species suitability of bycatch mitigation methods. There is also a need to improve the limited understanding level of threat that gillnet fisheries pose to turtle populations.

Exemplary practices

Through the active involvement of government agencies and NGOs, some CPCs are implementing turtle bycatch mitigation measures that should be followed by others.

Raising local awareness through community programs

The Indian Wildlife (Protection) Act, 1972, protects all five species of marine turtles (green, hawksbill, leatherback, loggerhead and olive ridley) found in India's waters. Awareness campaigns have been implemented for the conservation of marine turtles under the Wildlife Protection Act. One such example is the Olive Ridley Turtle Project in Orissa, India, which is the single most important breeding area for the species in the Indian Ocean. Since 1995 youths from the local communities help tag turtles and collect data. They provide protection during the nesting and hatching seasons. The programme also provides education and training workshops (Sridhar, 2005).

National Plans of Action (NPOA) for the conservation of marine turtles

Several CPCs are either preparing NPOAs for turtles (e.g. Japan and Korea) or have developed them (e.g. Kenya). Some countries, including Mauritius, Thailand and Australia, have implemented legislation that specifically protects marine turtles. E.g. Mauritian Fisheries and Marine Resources Act 1998 (FMRA 1998).

Port sampling programme

Port sampling programs, such as the one implemented by Thailand, are a good example of ways in which information on bycatch can be collected by port inspectors. However it is very important that the inspectors are well trained in species identification and handling procedures. These programs can supplement an observer programme to achieve more coverage of bycatch species.

Species identification guides

The distribution of the IOTC Marine Turtle Identification Cards and handling procedures is one of the recommendations of the 12/04 Resolution. These are now available for download on the IOTC website and countries are encouraged to hand them out to their fishing fleets.

Incentives to reduce gillnet fishing

Sri Lanka has launched incentive schemes to induce gillnetters to take up longline fishing in an effort to minimize the negative impacts to marine turtles and other bycatch species. This measure should be encouraged to be taken up by other CPCs with gillnet fleets given that gillnet fishing is currently thought to be the most detrimental to marine turtles.

Improve species identification

Japan is currently photographing bycatch species caught by their fisheries as a way to minimize misidentifications. The need for accurate identification of bycatch species is paramount for population estimates and to guide mitigation measures. Photo identification may however be time consuming due to the shortage of experts in the field.

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SUPPLEMENTARY MATERIAL

S1: Turtle RMU Descriptions

S2: Gillnetting Review

S3: Survivorship/Mortality Estimates

S4: State of Implementation of sea turtle mitigation measures across RFMOs

Brief description of each sea turtle RMU

Loggerhead Turtles (*Caretta caretta*)

There are four identified RMUs for this species relevant to the IOTC region.

1. South Western Indian Ocean (Cc-SWIO):

Loggerheads nest across three countries (South Africa, Mozambique and Madagascar). No detailed genetic evaluation has yet been conducted for this stock. Most of the information available comes from South Africa with a 50-year beach-nesting programme which include a notching programme on loggerheads used to identify age to maturity. The population is increasing, and growing exponentially over the last decade, but is still classified as a small (to medium) stock. The combined numbers of the annual nesting females is <1000 females.y^{-1} (Nel et al., 2013). South Africa has applied ~20 satellite tags to loggerhead females mapping both interesting and post-nesting migrations (DEA/Oceans and Coast, Unpublished data). All the females (but one) spent the entire time on the continental shelf accept for three females that made excursions across the Mozambique Channel to the continental water off Madagascar.

2. Arabian Gulf (Cc-AG)

The Arabian Gulf hosts the largest loggerhead rookery on Masirah Island with nesting contained along the remote coast towards the border with Yemen, and on Hanliyat Island (Baldwin et al., 2003). This RMU has seen sporadic monitoring and the information is not easily available. However, available information suggest a rookery size ranging 20 000 – 40 000 nesting females per annum. The population trend is not known (Baldwin et al., 2003) but an evaluation is currently under review (Baldwin, pers. com). In recent years, a large number of individuals have been satellite tagged (~54, mostly adult females from Masirah Island including both interesting and post-nesting migrations; see www.Seaturtle.org).

3. Bay of Bengal (Cc-BoB)

Loggerhead nesting seems to take place along the south of Sri Lanka in relatively low numbers; <100 individuals (Ekanayake et al., 2002). No nesting sites have been reported of loggerheads in India or Bangladesh (www.ioseaturtles.org). Nesting of loggerheads were reported in Myanmar (Thorbjarnarson et al., 2000) although recent (2012) reports from Myanmar (www.ioseaturtles.org) does not confirm loggerhead nesting, and nesting events are therefore assumed to be incidental. This population is therefore classified as very small (<100 females.y^{-1}).

4. SE Indian Ocean (Cc-SEIO)

The loggerhead rookeries of Western Australia are reported to be the third biggest in the world with nesting taking place at a number of localities between Shark Bay and the northern edge of Ningaloo Marine Park on the southern North West Shelf (Limpus, 2008d). In the absence of a detailed population genetic study the data are grouped for these rookeries into a single RMU (Wallace et al., 2010, Limpus, 2008d). Data are not collated across these rookeries hence trend analyses are difficult although analyses are underway (B. Prince and S. Trocini pers. com). Baldwin et al., (2003) listed the sizes of the key rookeries in this population, and collectively are estimated to range 1000 – 2000 nesting females.y^{-1}. It may be bigger but is unlikely to exceed 5000 (B. Prince pers. com). It thus still rated as a medium sized rookery. The average clutch size for Bungelup Beach and Dirk Hartog Island is 123.44±27.72 (±SD; n=169) with hatching and emergence success good; >70% (S. Trocini, Unpublished Data).

Green Turtles (*Chelonia mydas*)

5. South Western Indian Ocean (Cm-SWIO)

Nesting takes place along both the east African mainland coast from northern Mozambique to Kenya, as well as all of the Indian Ocean islands including Madagascar. Current genetic information suggest at least three stocks - a south, central and northern Mozambique Channel stocks (Bourjea et al., 2007). Collectively this RMU is rated as very large (i.e. ~ 10 000 adult nesting females per annum (Lauret-Stepler et al., 2007, Wallace et al., 2010) and is most likely underestimated (G. Hughes & S. Ciccione, pers.com).

6. Arabian Gulf (Cm-AG)

Green turtle nesting is taking place along many beaches of the Arabian Gulf. Listed from west to east, these rookies are distributed along the Red Sea coast, the Gulf of Aden, the Gulf of Oman, the Persian Gulf, the coast of Pakistan, west India (Gujarat) (Sunderraj et al., 2006) and the Maldives (www.ioseaturtles.org). There is no population genetics information available so this will be grouped into one RMU. The rookery in Oman (Ras Al had) seems to be the largest with an estimated number of females to be ~6000 (Bowen et al., 1992). The RMU's collective size is therefore categorized as 'Large' with >5 000 nesting females per annum. The Gujarat coast (est. 300 females.y^{-1}) and presumably many other beaches of this region) is threatened by development and industrial developments, while egg harvesting (~ 40%) and fishing mortality in trawl and gill net fisheries are ongoing (Sunderraj et al., 2006).

7. North East Indian Ocean (Cm-NEIO)

The combined rookery size of green turtles in the north-eastern section of the Indian ocean is estimated as moderate (1000 – 5000 nesting females.y^{-1}). Scattered nesting takes place from Sri Lanka and the east coast of India to northern Java. The main nesting sites are in Sri Lanka (Rekawa beach with ~752 green turtles (Ekanayake et al., 2002), Bangladesh, Myanmar (ca. 500 -750 females.y^{-1}; (Thorbjarnarson et al., 2000) and particularly Sumatra (Indonesia), with an estimated several hundred nesting females per annum (Stringell et al., 2000). Egg poaching seems to be a large problem, compounded by gillnet fishing.

8. South East Indian Ocean (Cm-SEIO)

This include the green turtle nesting sites along the coast of Western Australia (WA), the eastern edge of the Northern Territories, Ashmore, Catrier and Scott Reef Islands but excludes the populations in the Gulf of Carpentaria. Even though this population is historically (genetically) linked to the Indian Ocean (Limpus, 2008b), the foraging ground seems to be towards the east or are restricted in the Gulf of Carpentaria (Limpus, 2008b) and thus unlikely to overlap with the IOTC fisheries. It is suggested to be the largest green turtle population in the Indian Ocean with "tens of thousands" of females breeding on the WA beaches. There are no long-term census data and trend analyses but the expectation (preliminary analysis) is that the population is stable (Limpus, 2008b). The largest threat to turtles and turtle habitat in this region seems to be the expanding oil and gas industry. Conversely, a significant proportion of both nesting and foraging ground is protected in MPAs.

Leatherback turtles (*Dermochelys coriacea*)

9. South Western Indian Oceans (Dc-SWIO)

Leatherback turtle nesting occurs in an extended rookery along the South African- Mozambique border although the nesting is dispersed and the total population size very small (<100 nesting females.y^{-1}) (Nel et al., 2013). For the most part this rookery and inter-nesting habitat is well-protected with threats from other fisheries fairly low (Bourjea et al., 2008). Longlining is thought to be the biggest threat to this population particularly in the South African EEZ (Nel et al., 2013). Dutton et al., (1999) suggested that this is an isolated population (with historical links to the central Atlantic populations) but is now isolated. It is therefore treated as a single RMU. Approximately 30 post nesting migration tracks have been obtained through satellite telemetry with a small fraction of the data published in (Lambardi et al., 2008), but the bulk of the data unpublished (Oceans and Coast Unpublished data, N. Robinson, Unpublished Data). This data confirm that the post-nesting distribution is takes place outside of the South African EEZ, entering multiple nations's EEZ and the high seas in the Southern Oceans, Atlantic and Indian Ocean. This attribute make leatherbacks particularly vulnerable to high-seas fisheries.

10. Bay of Bengal (Dc-BoB)

Leatherback nesting occurs in at least three locations in the Bay of Bengal; these being Sri Lanka, the Nicobar-Andaman Island complex and northern Sumatra (Indonesia). Andrews and Shanker (2002 cited by Andrews et al. (2006)) indicated that the total combined nesting should be in the order of ~1000 individuals. However, no significant (high-density) single rookery seems to exist for this species in this region. Recent surveys of Galathea Beach (Great Nicobar) indicated a rookery size 200 - 600 nests by ~145 females (Shanker and Andrews, 2006); Little Andaman has fewer than 100 nests (Swaminathan et al., 2011) and Sri Lanka (Rekawa) around 200 females per annum (Ekanayake et al., 2002) . Current information thus suggests that the number of nesters of 500 females.y^{-1} is more realistic (not taking into account inter-annual variation). These estimates also include the Sumatra and Thailand rookeries (~ 5 females per annum; Aurregi (2007) in SWOT Vol 2; Muurmans, M, 2008 & 2009 in SWOT & OBIS-SEAMAP).

11. South Pacific (Dc-SP)

The rookeries located in Bali, East Java and the Northern Territories of Australia are artificially grouped with the South Pacific RMU (following Wallace et al. (2010)). The main rookeries of the South Pacific are located in Papua and Papua New Guinea (PNG) (Benson et al., 2011, Dutton et al., 2007b) which combined forms a very large rookery (Dutton et al., 2007b) but is declining (Tapilatu et al., 2013). Satellite tracks have indicated that leatherbacks do not enter the IOTC region via the Timor/Arafura Sea but rather around the east coast of Australia via the Tasman Sea (Benson et al., 2011). However, there is low-level nesting in the Gulf of Carpentaria (Limpus, 2009) but with no information on the post-nesting distribution. However, individuals from the South Pacific rookeries may enter the IOTC region along the north coast of Australia. The other rookeries the IOTC region (Bali and East Java) are very small. Only three nesters have been reported to have nested in Bali (Steering Committee, 2008) and 14 nesters East Java in recent years. Ngagelan reported 10 females.y^{-1} (Steering Committee, 2008). There is no genetic information available to discern these nesting locations from those of Papua and PNG and therefore are grouped with this very large population (Dutton et al., 2007a). There are occasional strandings in Western Australia (B. Prince Pers.com) but no confirmed nesting.

Hawksbill turtles (*Eretmochelys imbricata*)

12. South Western Indian Ocean (Ei_SWIO)

Mortimer and Donnelly (2007) reviewed the global status of hawksbill populations. This review indicated that nesting occurs along most of the islands and continental shores along the Mozambique channel (north of Inhambane) with Madagascar (~1000 females.y^{-1}), Seychelles (~625 females.y^{-1}) and the British Indian Ocean Territories (~300-700 females.y^{-1}) hosting the largest of these stocks. The combined RMU is therefore evaluated to be very large (>1000 females.y^{-1}) but still a fraction of the population size a century ago. Population trends for all the rookeries were described as either unknown, depleted, or declining (including the relatively well-protected populations of the Seychelles (Mortimer and Donnelly, 2007). Hawksbill turtles were harvested (on a large scale for a long time across several countries) for turtle shell (bekko) trade. Satellite tagging to date (eight tags on post nesting females) suggest that these individuals stay on the waters of the Seychelles Banks (Mortimer and Balaz, 1999) or migrate to foraging areas of northern Madagascar (www.seaturtle.org). It is during these excursions that females will be vulnerable to high-seas fisheries. Mortimer and Broderick (1999) indicated that there is no mtDNA differentiation between juvenile hawksbills of the Seychelles and Chagos Islands and until better information is available these hawksbill rookeries will be grouped as one RMU (following Wallace et al. (2010)).

13. Arabian Gulf (Ei-AG)

Nesting takes place along the shores of the Red Sea, Arabian Sea, Gulf of Oman and the Persian Gulf (Mortimer and Donnelly, 2007), with the largest rookeries in Oman (~600-800 females.y^{-1}), Iran (500 – 1000 females.y^{-1}) and possibly Eritrea. Significant nesting also takes place along the islands of the Maldives (~460 – 767 females.y^{-1}). The other nesting sites (Egypt, Sudan, Somalia, Kuwait, Saudi Arabia etc.) will contribute an additional (>1100 females.y^{-1}). This would therefore be rated as a very large RMU. A number of hawksbills have been satellite tracked in recent years (post-2008) from the Arabian coast. These tracks indicated restricted distribution of post-nesting females mostly to the EEZ's of the Arabian Gulf countries (see www.Seatrutle.org). Hawksbills seem to face few threats on land but there was traditional egg harvest (up to the 1980's) in Oman (Ross, 1981). Artisanal fisheries pressure seems to be extremely high along the entire northern Indian Ocean.

14. Bay of Bengal (Ei-BoB)

The Nicobar-Andaman group of islands host the larger congregation of hawksbill turtles in the Bay of Bengal with about 250 nesting females.y^{-1} (Mortimer and Donnelly, 2007). The other rookeries like in Myanmar are very small (<10 females.y^{-1}). The Ei-BoB is therefore rated as a medium sized hawksbill RMU. Conservation is not yet contributing to the recovery of this population as is still declining (Mortimer and Donnelly, 2007). This is probably an effect of the large fisheries pressures faced by turtles in the area.

15. East-Central Indian Ocean (Ei-East Centl IO)
Malaysia (Melaka) and Thailand (Andaman Coast) collectively hosts less than 100 nesting females per year (Mortimer and Donnelly, 2007) and has been described as depleted.

16. Western Australia (Ei-WA)
The Western Australian hawksbill population is one of the larger RMUs in the world, and the largest in the Indian Ocean. It is concluded to be of one genetic stock (Limpus, 2008c). The largest nesting congregation takes place on the Dampier Archipelago (Limpus, 2008c) with ~2000 nesting females per year (Mortimer and Donnelly, 2007), but the overall status and trends are not well documented. An estimate of survival probability was conducted for a small rookery on Varanus Island. This study indicated obligate skip-nesting by females (lowering the overall reproductive output) but with a high survival probability: 0.95 (Prince and Chaloupka, 2011). This suggests that the population is reasonably well protected despite the oil industry operations, but also that the population is vulnerable should pressures change for the worse (Prince and Chaloupka, 2011). The foraging area of these individuals include the Australian Indian Ocean Territories, i.e. Cocos (Keeling) and Christmas Islands (Limpus, 2008c), which suggest that they are energy-limited. There are no (known) records indicating hawksbill nesting on these islands. This RMU is thus rated as large.

Olive Ridley (*Lepidochelys olivacea*)

17. Western Indian Ocean (Lo-WIO)
Very little is known about the olive ridleys of the WIO as the nesting seems to take place over a large area with no significant densities of nesting recorded anywhere. The most consistent nesting events seem to take place along the west coast of India, Oman (Masirah Island) (Rees et al., 2012) and some nesting in the Maldives (www.SWOT.org). Kenya noted ~ 30 females.y^{-1} (in www.ioseaturtles .org). Nesting has also been reported in Madagascar but not quantified. Shanker and Andrews (2006) listed olive ridley nesting site in the province of Gujarat (at 732 nests), with less than 100 nests off Maharashtra and Goa coasts, and similar low level nesting in Kerala and Tamil Nadu (BoB) combined. The combined rookery therefore is small (estimated to be around ~300 nesting females.y^{-1}) but this is only a vague estimate as it is a Data Deficient RMU.

18. East Bay of Bengal (Lo-EBoB)
Olive rideleys in the bay of Bengal display both standard (unsynchronised) nesting behaviour and arribada style, mass synchronised nesting. Nesting takes place along the east coast of India, Sri Lanka (Rekawa beach <100 females.y^{-1} www.ioseaturtles.org), as well as Bangladesh. Orissa (India), a known arribada beach, is the largest (by several orders of magnitude) of these olive ridley rookeries. The number of females is estimated at 180 000 females.y^{-1} (Shanker et al., 2003). Limited information is available on the population genetics but it is reported to be an independent RMU (Shanker et al., 2003). Shanker et al., (2004) separated the East Indian rookeries from that of Sri Lanka (based on mtDNA gene flow) but with a restricted sample size. (For this assessment, these will be grouped due to spatial proximity and practicality). It is reported that the major threats to olive ridleys along this coast include trawl and gillnet fisheries with >90 000 individuals killed in 8 years (Shanker et al., 2003). This rookery may also be impacted by the constructions such as the Dhamra Port development.

19. East Indian Ocean (Lo-EIO)

The Lo-EIO RMU is defined from Myanmar, including the Nicobar-Andaman Islands (~ 1000 nests.y^{-1}), to the Gulf of Carpentaria (Northern Australia). Incidental nesting of olive ridleys in Western Australia has been reported on occasion (www.OBIS-SWOT.org) however it is the exception (Limpus, 2008a). More significant nesting is present on the western extend of the Northern Territories (Limpus, 2008a) (on the edge of the IOTC region). This rookery seems to host a 'few hundred' olive ridley nests per year and are genetically distinct from the other Indian and Pacific genetic stocks (Limpus, 2008a). Limpus (2008a) rated the Australian olive ridley stock as endangered due to the threats and the data deficiency as it has never been studied in significant detail. The combined number of females does not seem to exceed a 1000 females.y^{-1} so this rookery is thus rated as small.

Flatback turtles (*Natator depressus*)

20. South East Indian Ocean (Nd-SEIO)

Flatback turtles are unique to the continental waters of Australia. The entire north coast of Australia has flatback nesting but there seems to be two distinct RMUs (an east and west RMU) with overlap along the Northern Territories. Published information for the western shelf RMU (or Nd-SEIO), is scarce. The only (know) census beach with time series information is from Bare Sand Island (Limpus 2007) showing a slow decline. Whiting et al., (2009) evaluated the population at Cape Dormett and reported it to be larger than expected with >3000 individuals.y^{-1}. Nest success was reported to be low but not quantified as a result of a large number of beach predators, but hatching and emergence success was high (>80%)(Whiting et al., 2008). Collectively this stock is estimated to be 8000 females.y^{-1} and stable (M. Chaloupka, pers.com). Since 2005, over 4000 flatback turtles have been tagged at Barrow Island while an additional 3,800 have been tagged at Cowrie Beach on Mundabullangana Station in the Pilbara region of Western Australia. A large number of flatback (and other) turtles have been tagged with satellite transponders due to the booming oil and gas industry off this coast. The post-nesting distribution is therefore well mapped confirming the coastal/shelf distribution of flatback turtles.

Table S1.1 Biological data for 20 sea turtle RMUs in the IOTC region used to assess the population productivity of each of these turtle RMUs. Generation length and MaxAge= Data Deficient (DD) for all RMUs.

	Population TREND	RMU Size (#.females.y^{-1})	Generation length (y)	Age at Maturity (y)	Nest Survivorship HS% or ES%	#eggs.nest^{-1}	#nest.s^{-1}	RI	References
Cc-SWIO	Increase	Small	($36^{\%}$ + 20 years)	(36)	High (NS 89 ES 72)	106	3.7	3	(Nel et al., 2013, De Wet, 2012, Hughes, 1974)(Tucek, Unpublished data)
Cc-AG	Uncertain	Very Large		DD	DD		DD	4	(Baldwin et al., 2003)
Cc-BoB	Decline ±	DD	DD	DD	DD	DD	DD	DD	(Ekanayake et al., 2002)
Cc-SEIO	DD	Medium		29*	High (>70%)	$120\text{-}136^{\$}$	3.4*	3.82*	(Limpus, 2008d, Baldwin et al., 2003, Wallace et al., 2011) (S. Trocini, Unpublished Data, B. Prince Pers.com)
Cm-SWIO	Increase	Very Large		$33^{\#}$		124-142	3-3.5	3yrs	(Lauret-Stepler et al., 2007, Hughes, 1974)(S. Cicicione pers com)(MTSG, 2004).
Cm-AG	DD	Large		$33^{\#}$					(Wallace et al., 2011)(MTSG, 2004)
Cm-NEIO	Likely decline	±Medium		$33^{\#}$					(Ekanayake et al., 2002, MTSG, 2004)
Cm-SEIO	Stable	Very large		$33^{\#}$	DD	76-82	5.6*/6.2	5.78*	(Limpus, 2008b, MTSG, 2004) (B. Prince & K. Pendoley Pers.com)
Dc-SWIO	Stable	Small	$16^{\#}$+16	$16^{\#}$	High (NS 78 ES 73)	104	6.8	2.9	(Nel et al., 2013, De Wet, 2012, Hughes, 1974)
Dc-BoB	DD/Decline?	Medium ±		$16^{\#}$		100.5			(Shanker and Andrews, 2006)
Dc-SP	Decline	Medium	DD	$16^{\#}$	High	70-80	5.5±1.6	2-4	(Tapilatu et al., 2013)
Ei-SWIO	Decline	Very large		$>30^{\#}$		182	4	2.5	(Diamond, 1976, Mortimer and Bresson, 1999, Mortimer and

							Donnelly, 2007)
Ei-AG	DD	Very large	>30#	High	98.4 - 97		(Mobaraki, 2004, Ross, 1981)
Ei-BoB	DD/Decline	Medium	>30#				(Wallace et al., 2011)
Ei-EC IO	DD	Small	>30#				(Wallace et al., 2011)
Ei-WA	DD	Very Large	>30#		111 [14]		(Prince and Chaloupka, 2011)
Lo-WIO	Decline	Small?	13		100		(Zug et al., 2006)
Lo-EBoB	Decline	Very Large	13		100		(Zug et al., 2006, Shanker et al., 2003)
Lo-EIO	DD/Decline?	Small	13		100		(Zug et al., 2006)
Nd-SEIO	Stable	Large	21	NS Low but (HS = 88%), ES 80%	54	3.5	(Whiting et al., 2008) K. Pendoley Pers. com) (Chaloupka dn Limpus pers com).

* Data obtained from adjacent rookeries, RMUs or published values and applied where applicable.? Indicates uncertainty.

Estimating age to maturity for leatherback turtles (Jones et al., 2011). Hawksbills (Mortimer and Donnelly, 2007) green turtles (MTSG, 2004) and olive ridleys ((Zug et al., 2006)

% (Tucek unpublished data: Evaluating the recovery potential of loggerhead and leatherback turtles in KZN, South Africa).

$(Trocini unpublished data: "*Conservation of the endangered loggerhead turtle (Caretta caretta): Health assessment and hatching success of Western Australian populations;* the thesis is currently under review).

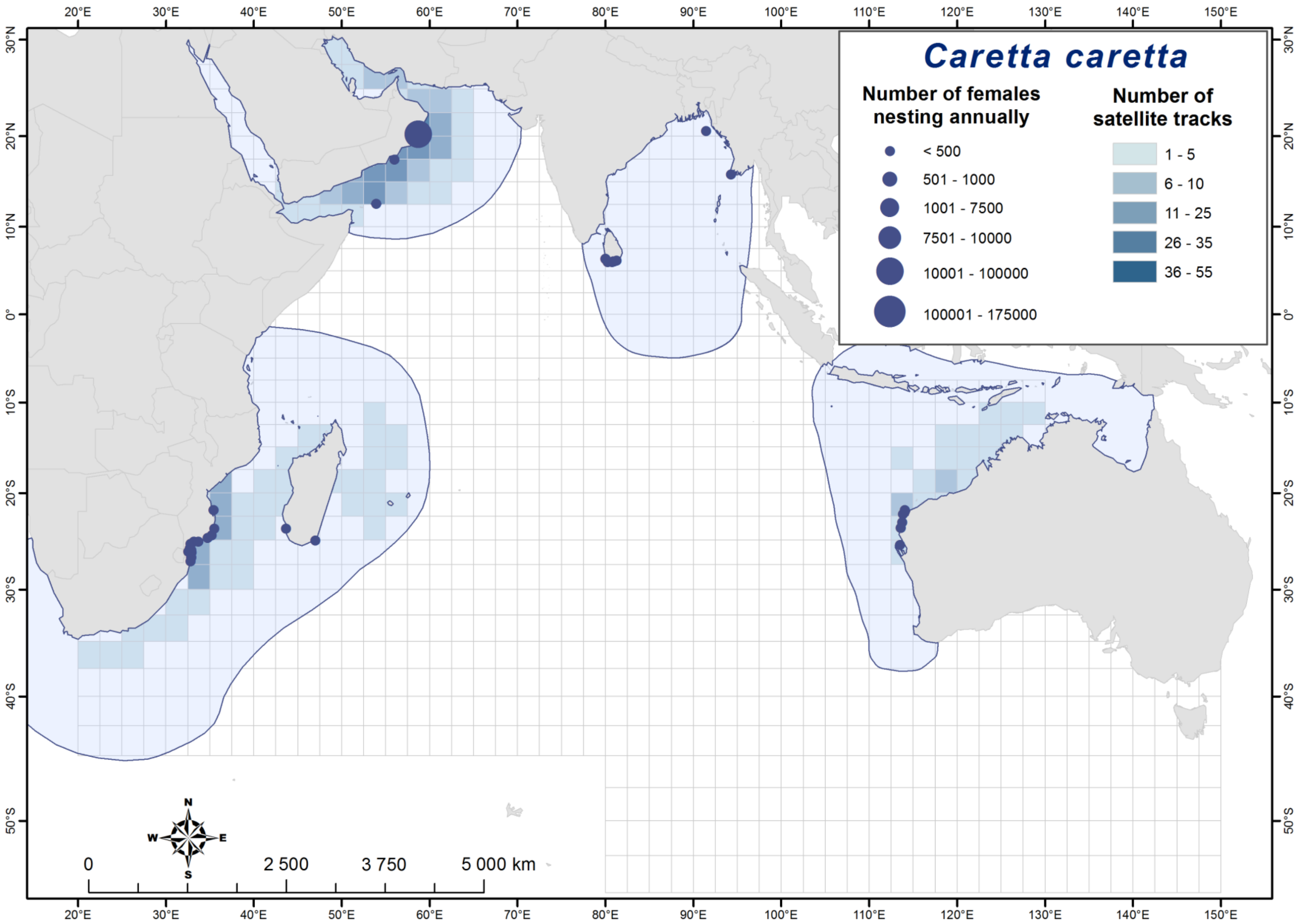

Figure S1.1 Distribution of loggerhead turtles (*Caretta caretta*, Cc) across the IOTC according to nesting sites (circles), RMUs (shaded areas) and distributions per satellite tracks (squares).

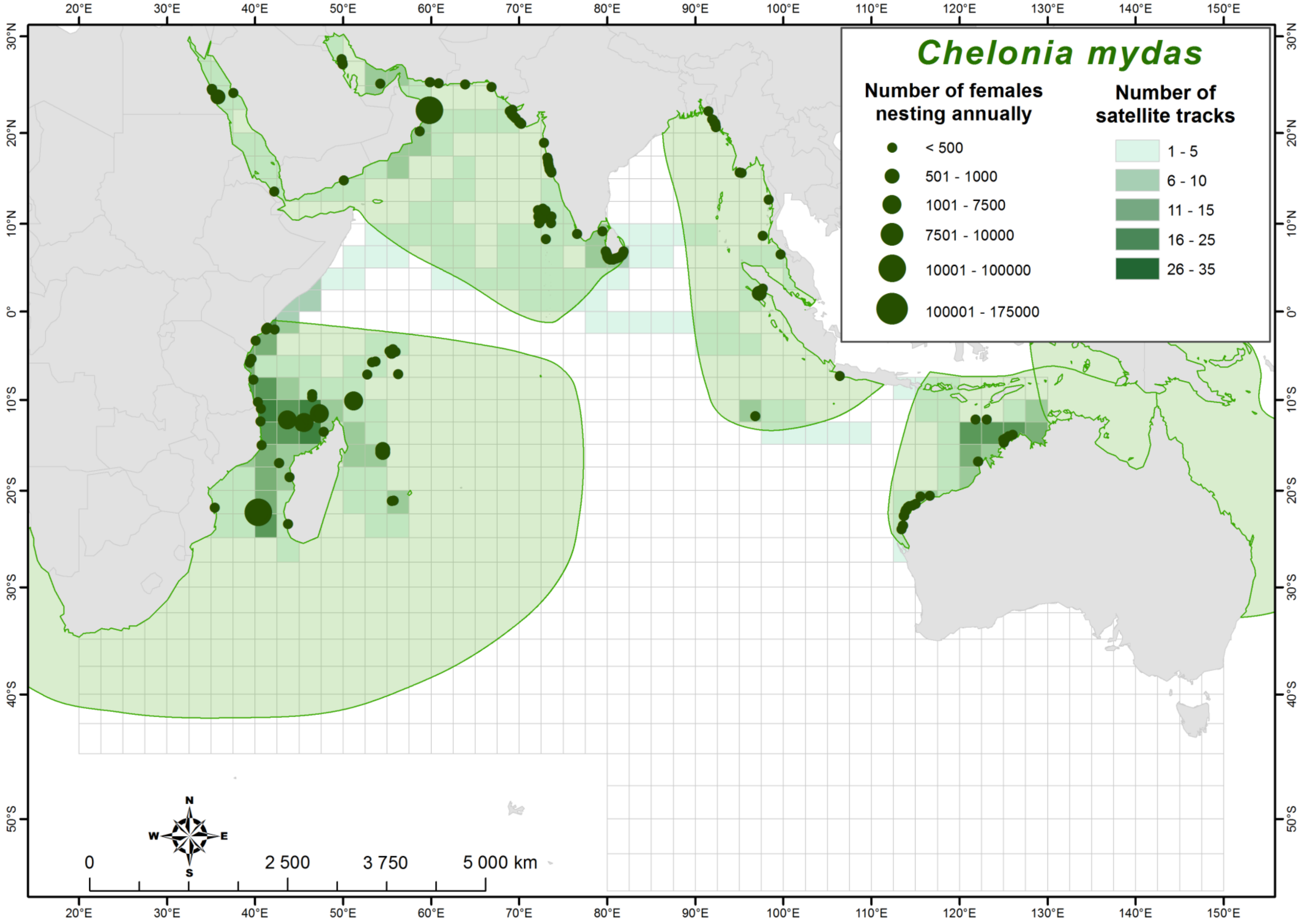

Figure S1.2 Distribution of green turtles (*Chelonia mydas*, Cm) across the IOTC according to nesting sites (circles), RMUs (shaded areas) and distributions per satellite tracks (squares).

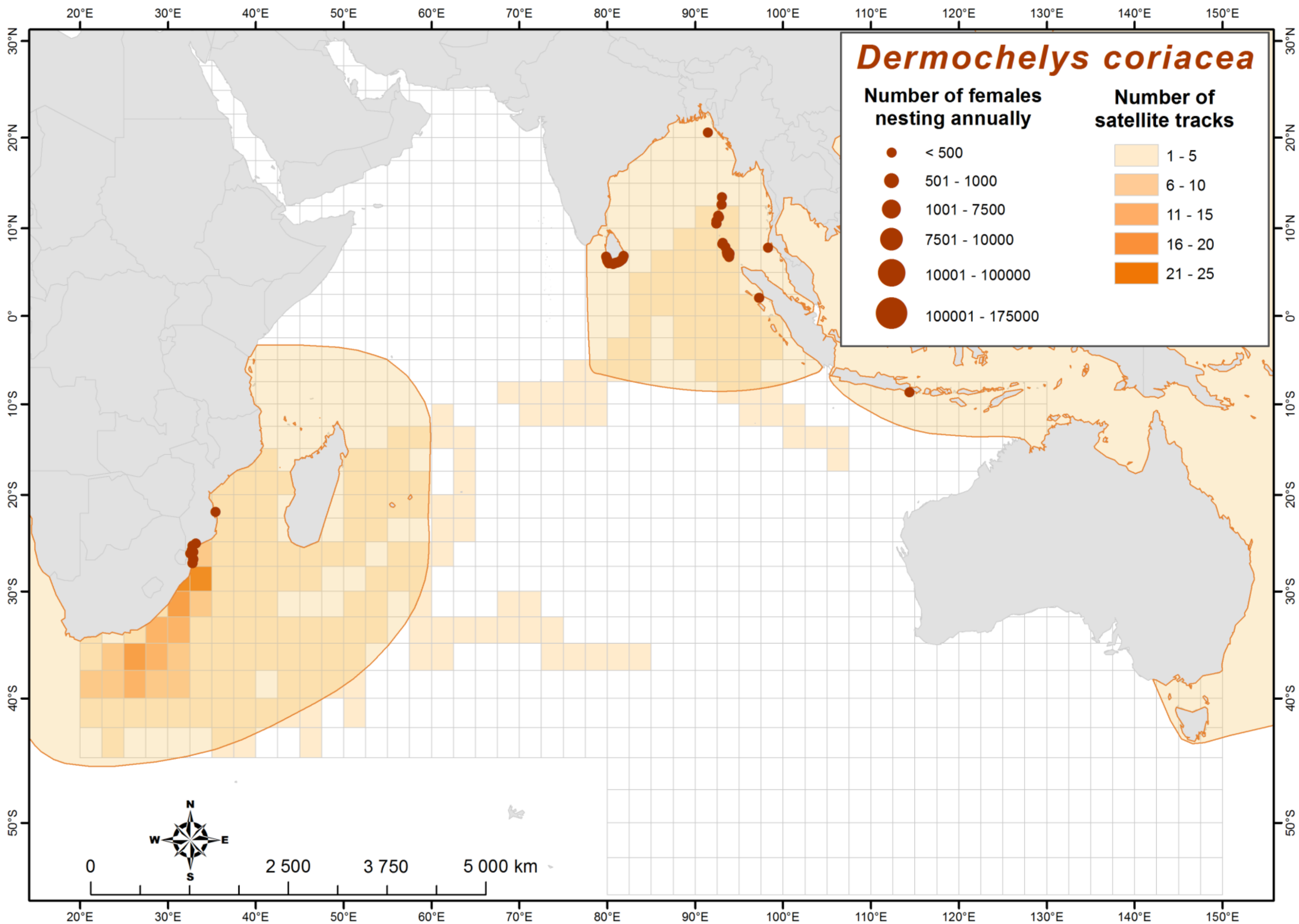

Figure S1.3 Distribution of leatherback turtles (*Dermochelys coriacea*, Dc) across the IOTC according to nesting sites (circles), RMUs (shaded areas) and distributions per satellite tracks (squares).

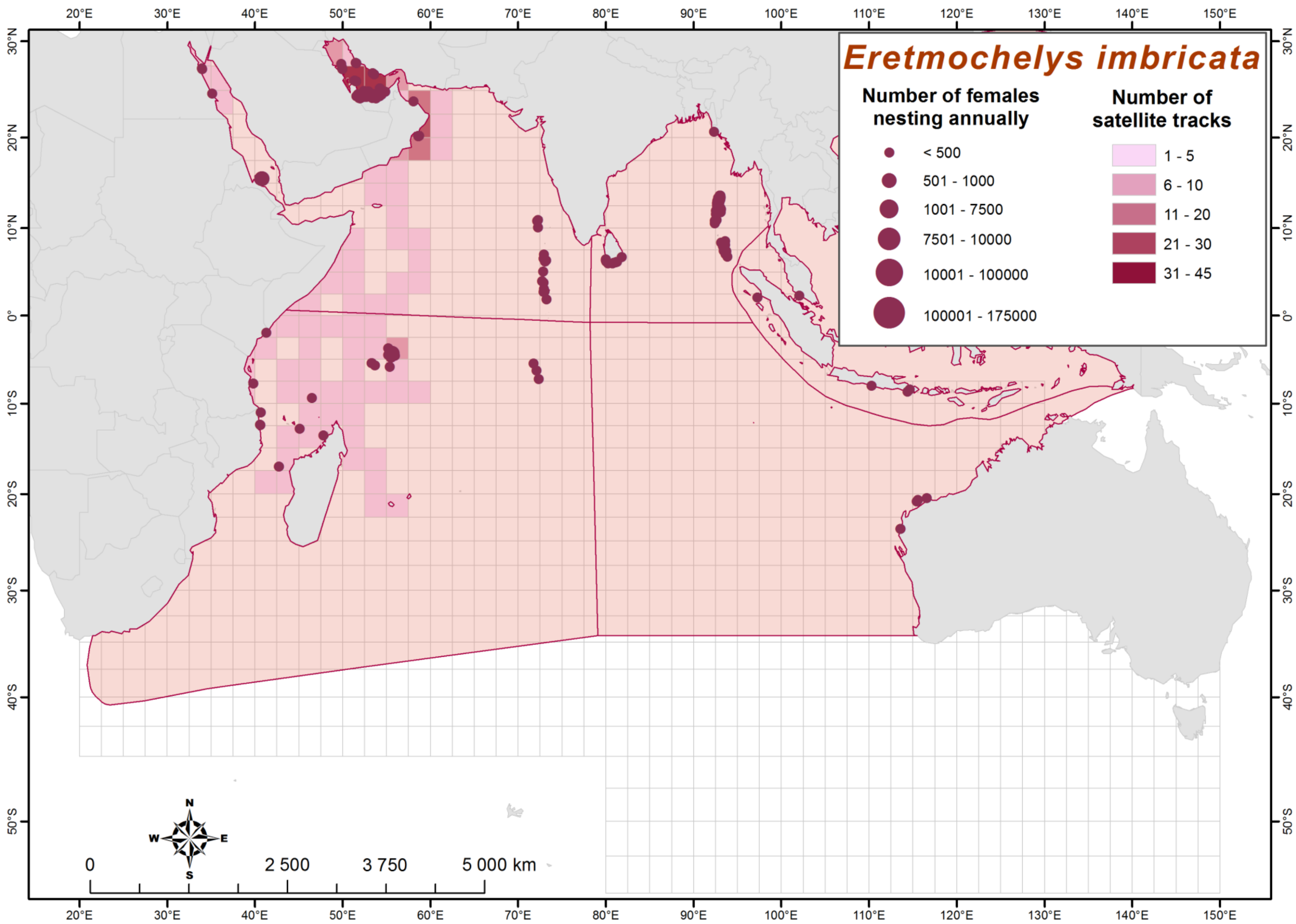

Figure S1.4 Distribution of hawksbill turtles (*Eretmochelys imbricata*, Ei) across the IOTC according to nesting sites (circles), RMUs (shaded areas) and distributions per satellite tracks (squares).

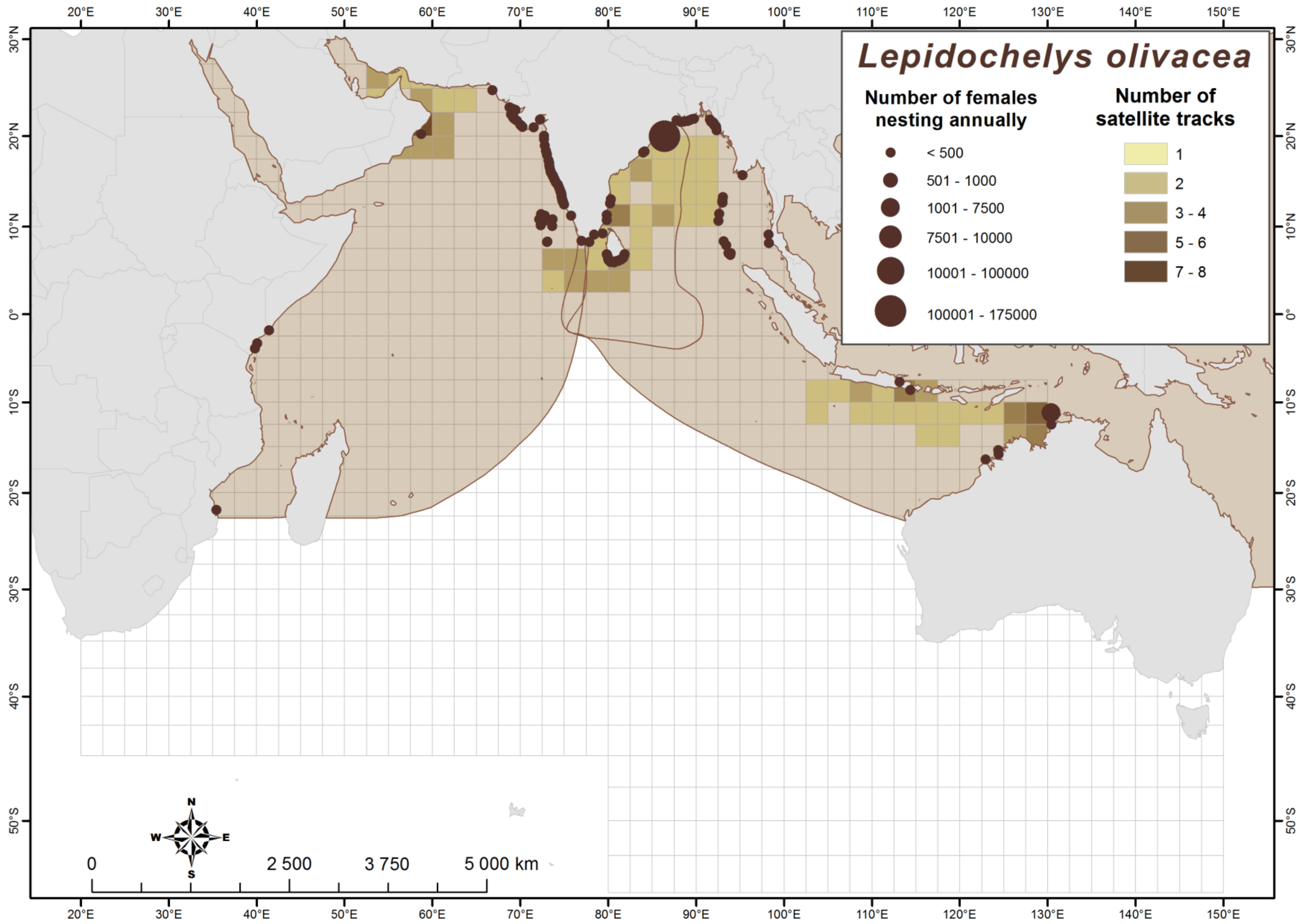

Figure S1.5 Distribution of olive ridley turtles (*Lepidochelys olivacea*, Lo) across the IOTC according to nesting sites (circles), RMUs (shaded areas) and distributions per satellite tracks (squares).

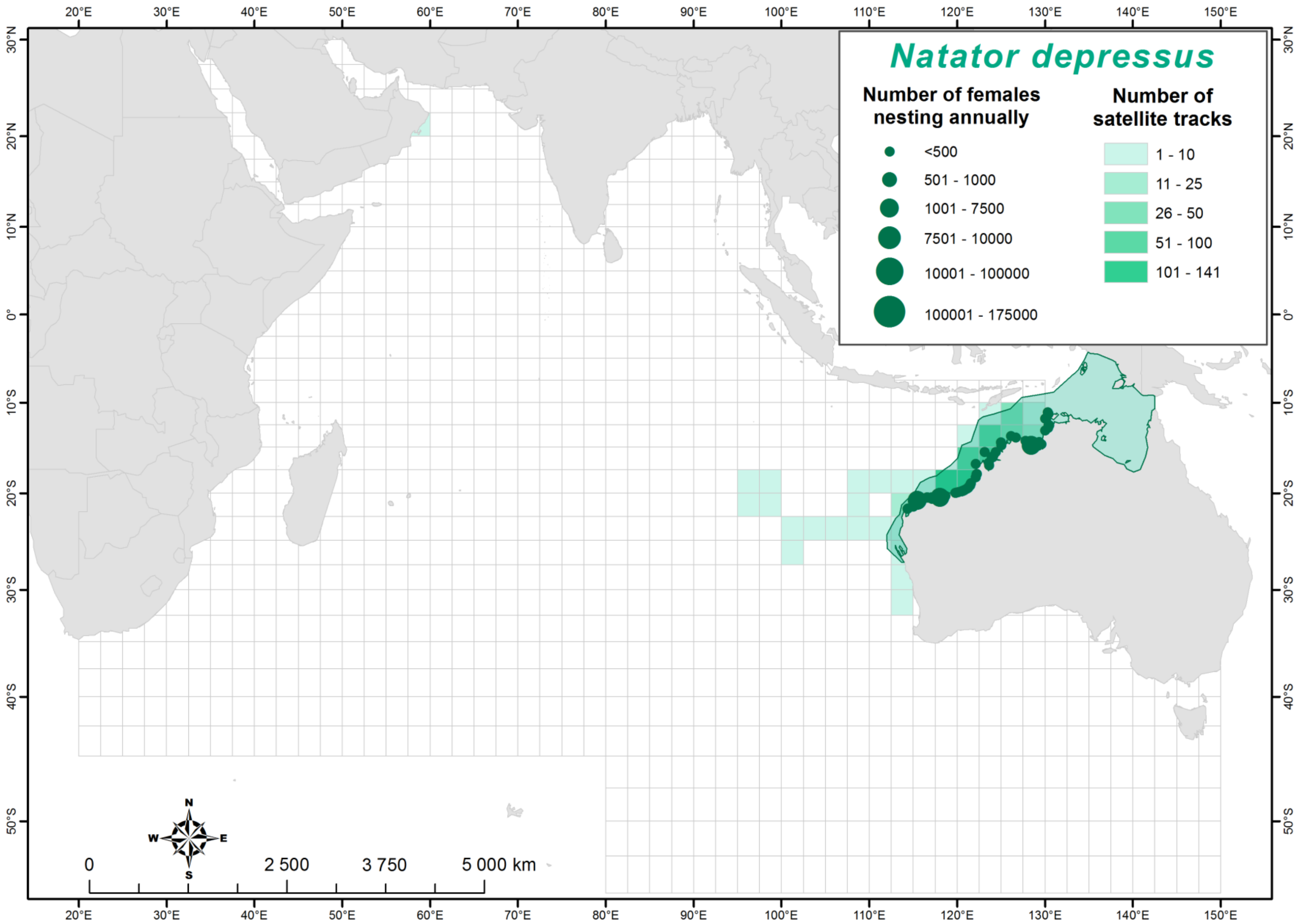

Figure S1.6 Distribution of flatback turtles (*Natator depressus* Nd) across the IOTC according to nesting sites (circles), RMUs (shaded areas) and distributions per satellite tracks (squares).

Table S1.1 Summary of satellite programmes reviewed to create turtle distributions.

Country	Project	URL	Species	No
Australia	Cocos (Keeling) Island	Whiting SD, Koch AU (2006) Mar Turtle Newsl 112:15–16	Ei	1
Australia	Cocos (Keeling) Islands- Nesting Green Turtles Biomarine International	www.seaturtle.org/tracking/index.shtml?project_id=123	Cm	6
Australia	Barrow Island Greens 2001-2003 West Australian Sea Turtle Satellite Tracking Project	www.seaturtle.org/tracking/index.shtml?project_id=40	Cm	8
Australia	Barrow Island flatback tracking 2005-2006 West Australian Sea Turtle Satellite Tracking Project	www.seaturtle.org/tracking/index.shtml?project_id=108	Nd	4
Australia	Mundabullangana Station flatbacks 2005-2006 West Australian Sea Turtle Satellite Tracking Project	www.seaturtle.org/tracking/index.shtml?project_id=112	Nd	2
Australia	Barrow Island Flatback tracking 2006-2007 West Australian Sea Turtle Satellite Tracking Project	www.seaturtle.org/tracking/index.shtml?project_id=194	Nd	3
Australia	Barrow Island Flatback tracking 2006-2007 West Australian Sea Turtle Satellite Tracking Project	www.seaturtle.org/tracking/index.shtml?project_id=194	Cm	1
Australia	Mundabullangana Station flatbacks 2006-2007 West Australian Sea Turtle Satellite Tracking Project	www.seaturtle.org/tracking/index.shtml?project_id=195	Nd	2
Australia	Barrow Island green trutles 2006-2007 West Australian Sea Turtle Satellite Tracking Project	www.seaturtle.org/tracking/?project_id=197	Cm	2
Australia	Ningaloo Turtle Program	www.seaturtle.org/tracking/index.shtml?project_id=265	Cm	9
Australia	Barrow Island flatback tracking 2007-2008 West Australian Sea Turtle Satellite Tracking Project	www.seaturtle.org/tracking/index.shtml?project_id=264	Nd	6
Australia	Barrow Island flatback tracking 2007-2008 West Australian Sea Turtle Satellite Tracking Project	www.seaturtle.org/tracking/index.shtml?project_id=264	Cm	1

Australia	Cemetery Beach Port Hedland Flatback Tracking Project 2008/2009	www.seaturtle.org/tracking/index.shtml?project_id=352	Nd	4
Australia	Barrow Island flatback tracking 2008-2009 West Australian Sea Turtle Tracking Project	www.seaturtle.org/tracking/?project_id=354	Nd	6
Australia	Barrow Island flatback tracking 2008-2009 West Australian Sea Turtle Tracking Project	www.seaturtle.org/tracking/?project_id=354	Cm	1
Australia	Flatback Turtles, Cape Dormett Western Australia	www.seaturtle.org/tracking/index.shtml?project_id=417	Nd	5
Australia	CVA-2009 Eco Beach Flatback Monitoring Program Conservation Volunteers Australia	www.seaturtle.org/tracking/?project_id=462	Nd	2
Australia	Cemetery Beach Port Hedland Flatback Tracking Project 2009/2010 West Australian Sea Turlte Satellite Tracking Project	www.seaturtle.org/tracking/?project_id=357	Nd	9
Australia	Barrow Island flatback tracking 2009-2010 West Australian Sea Turtle Satellite Tracking Project	www.seaturtle.org/tracking/?project_id=457	Nd	40
Australia	2009-2010-Woodside- Lacepede Islands turtle Tracking Program Woodside Energy Limited	www.seaturtle.org/tracking/?project_id=611	Nd	11
Australia	2009-2010-Woodside- Lacepede Islands turtle Tracking Program Woodside Energy Limited	www.seaturtle.org/tracking/?project_id=611	Cm	17
Australia	CVA-2010 Eco Beach Flatback Monitoring Program Conservation Volunteers Australia	www.seaturtle.org/tracking/?project_id=567	Nd	2
Australia	Cemetery Beach Port Hedland Flatback Tracking Project 2010-2011 West Australian Sea Turtle Satellite Tracking Project	www.seaturtle.org/tracking/?project_id=574	Nd	6
Australia	Barrow Island Flatback Tracking 2010-2011 West Australian Sea Turtle Satellite Tracking Project	www.seaturtle.org/tracking/?project_id=575	Nd	10

Australia	Cape Lambert Flatback Turtle Monitoring Program Rio Tinto	www.seaturtle.org/tracking/?project_id=579	Nd	70
Australia	2009-2010 Woodside Scott Reef Turtle Tracking Program	www.seaturtle.org/tracking/index.shtml?project_id=478	Cm	12
Australia	Flatback Turtles-2005-Gulf of Carpentaria WWF Australia	www.seaturtle.org/tracking/index.shtml?project_id=99	Nd	3
Australia	Crab Island Flatback Sea Turlte Research Project, Cape York Australia	www.seaturtle.org/tracking/?project_id=330	Nd	4
Australia	CVA-2011 Eco Beach Flatback Monitoring Program	www.seaturtle.org/tracking/?project_id=670	Nd	4
Australia	Cemetery Beach Port Hedland Flatback Tracking Project 2011-2012 Pendoley Environmental	www.seaturtle.org/tracking/?project_id=685	Nd	9
Australia	CVA-2011 Eight Mile Beach Flatback Monitoring Program Conservation Volunteers Australia	www.seaturtle.org/tracking/?project_id=689	Nd	6
Australia	Barrow Island Flatback Turtle Tracking 2011-2012 Pendoley Environmental Pty Ltd	www.seaturtle.org/tracking/?project_id=695	Nd	7
Australia	Hawksbill turtles in Torres Strait James Cook University	www.seaturtle.org/tracking/?project_id=511	Ei	2
Bangladesh	Bangladesh Sea Turtle Satellite Tacking Project MarineLife Alliance Bangladesh	www.seaturtle.org/tracking/?project_id=487	Lo	2
Egypt	Egypt red sea green turtle nesting migrations Indiana U SE(USA)/ WGNP (egypt)	www.seaturtle.org/tracking/?project_id=536	Cm	4
France	Mayotte Isalnd Green Turtles 2005 Islameta Group Dept of Biology Univerity of Pisa	www.seaturtle.org/tracking/index.shtml?project_id=28	Cm	19
France	Europa Island Green Turtles Islameta Group, Dept of Biology-University of Pisa	www.seaturtle.org/tracking/index.shtml?project_id=13	Cm	3
France	Jerome Bourjea (Pers Com)	IFREMER/Kelonia	Cc	6

India	Andaman and Nicobar Island Leatherbacks CES, Indian Istitute of Science	www.seaturtle.org/tracking/?project_id=584	Dc	9
India	Chennai India Olive Ridley Tracking Tree Foundation India	http://www.seaturtle.org/tracking/?project_id=477	Lo	2
India	Chennai India Olive Ridley Tracking Tree Foundation India	http://www.seaturtle.org/tracking/?project_id=477	Cm	1
India	Satellite Tracking of Olive Ridley sea turtles off Orissa coast in the Indian Ocean Wildlife Institute of India	www.seaturtle.org/tracking/index.shtml?project_id=399	Lo	67
India	Satellite Tracking of Olive Ridley sea turtles off Orissa coast in the Indian Ocean Wildlife Institute of India	www.seaturtle.org/tracking/index.shtml?project_id=400	Cm	1
Indonesia	Bali turtles Udayana University-WWF Joint Program	www.seaturtle.org/tracking/?project_id=390	Lo	1
Indonesia	Bali turtles Udayana University-WWF Joint Program	www.seaturtle.org/tracking/?project_id=390	Cm	1
Indonesia	Tracking on green sea turtle in South Misol Raja AMPAT_Papau, Indonesia Udayana University WWF Joint Program	www.seaturtle.org/tracking/?project_id=437	Cm	1
Indonesia	Tracking on Magnifying Olive Ridley Journey in Kaironi beach, Papau_Indonesia Udayana University of Bali	www.seaturtle.org/tracking/index.shtml?project_id=391	Lo	5
Indonesia	Crossing the tide Udayana University- WWF Joint Program	www.seaturtle.org/tracking/?project_id=348	Lo	2
Indonesia	Grren sea turtle tracking in sukamade, meru betiri national park east java Udayana University WWF Joint Program	www.seaturtle.org/tracking/index.shtml?project_id=275	Cm	4
Indonesia	Satellite tracking of Hawksbill Turtle in West Sumbawa Indonesia	www.seaturtle.org/tracking/index.shtml?project_id=266	Ei	1
Iran	Gulf Turtle Tracking Project 2011 Emirates Wildlife Society WWF MRF	www.seaturtle.org/tracking/?project_id=737	Ei	5

Iran	Gulf Turtle Tracking Project 2010 Emirates Wildlife Society WWF MRF	www.seaturtle.org/tracking/?project_id=658	Ei	5
Kenya	WWF/KWS Integrated Sea Turtle Conservation Project Kenya	www.seaturtle.org/tracking/?project_id=307	Cm	14
Kenya	WWF/KWS Integrated Sea Turtle Conservation Project Kenya	www.seaturtle.org/tracking/?project_id=307	Ei	1
Kuwait	Kuwait 2010: Hawksbill & Green Turtle Tracking KTCP-TOTAL Foundation	www.seaturtle.org/tracking/?project_id=503	Cm	4
Kuwait	Kuwait 2010: Hawksbill & Green Turtle Tracking KTCP-TOTAL Foundation	www.seaturtle.org/tracking/?project_id=503	EI	4
Maldives	Maldivian Sea Turtle Conservation Program Seamarc at Four Seasons Resorts	www.seaturtle.org/tracking/?project_id=750	LO	5
Maldives	Tracking headstarted green turtles from the Maldives Marine Research Foundation - Marine Turtle Programme	www.seaturtle.org/tracking/index.shtml?project_id=53	CM	4
Mozambique	Maluane/ZSL Turtle Conservation Project in Mozambique: Green Turtles Marine Turtle Research Group	www.seaturtle.org/tracking/index.shtml?project_id=204	Cm	4
Oman	Gulf Turtle Tracking Projhect 2011 Emirates Wildlife Society- WWF &MRF	www.seaturtle.org/tracking/?project_id=737	EI	7
Oman	Gulf Turtle Tacking Project 2010 Emirates Wildlife Society WWF MRF	www.seaturtle.org/tracking/?project_id=658	EI	5
Oman	Marine Turtle Conservation Project 2012 Emirates Wildlife Society WWF & MRF	www.seaturtle.org/tracking/?project_id=494	EI	12
Oman	2012 Inter-Nesting and Post-Nesting Movements of Loggerhead Turtles from Masirah Oman MECA and ESO	www.seaturtle.org/tracking/index.shtml?project_id=733	CC	12
Oman	2011 Inter-Nesting and Post-Nesting Movements of Loggerhead Turtles from Masirah Island Oman MECA and ESO	www.seaturtle.org/tracking/?project_id=618	CC	18

Oman	2010 Inter_Nesting and Poist_Nesting Movements of Loggerhead Turtles from Masirah Island Oman	www.seaturtle.org/tracking/?project_id=505	CC	4
Oman	Oman 2008: Green Turtles of Masirah Marine Turtle Research Group	www.seaturtle.org/tracking/index.shtml?project_id=310	CM	2
Oman	Oman 2008: Olive Ridley Turtles of Masirah Marine Turtle Research Group	www.seaturtle.org/tracking/index.shtml?project_id=278	LO	9
Oman	Post-Nesting Migrations of Green Turtles from Ras al Hadd Turtle Reserve, Sultanate of Oman	www.seaturtle.org/tracking/index.shtml?project_id=255	CM	3
Oman	Post-Nesting Migrations of Hawksbill Turtles from Daymaniyat Islands, Oman	www.seaturtle.org/tracking/index.shtml?project_id=214	EI	2
Oman	2006 Post-nesting Migrations of Logerhead Turtles from Masirah Island, Oman Environmental Society of Oman and Oman Ministry of Regional Municipalities	www.seaturtle.org/tracking/index.shtml?project_id=171	CC	10
Oman	Oman 2006: Loggerhead Turtles of Masirah Marine Turtle Research Group	www.seaturtle.org/tracking/index.shtml?project_id=145	CC	10
Qatar	Gulf Turtle Tracking Project 2011 Emirates Wildlife Society WWF MRF	www.seaturtle.org/tracking/?project_id=737	EI	5
Qatar	Gulf Turtle Tracking Project 2010 Emirate Wildlife Society WWF MRF	www.seaturtle.org/tracking/?project_id=658	EI	5
Qatar	Marine Turtle Conservation Project 2012 Emirates Wildlife Society WWF & MRF	www.seaturtle.org/tracking/?project_id=494	EI	7
Seychelles	Mahe Seychelles Hawksbill Project MCS_Seychelles	www.seaturtle.org/tracking/index.shtml?project_id=277	Ei	3
Seychelles	Aldabra Green Turtles Seychelles Island Foundation	www.seaturtle.org/tracking/index.shtml?project_id=712	Cm	2
South Africa	Luschi et al	S. Afr. J. Sci (2006) 102: 51-58	Dc	7
South Africa	DEA/Ezemvelo/NMMU Unpublished data		Dc	12
South Africa	DEA/Ezemvelo/NMMU Unpublished data		Cc	15

Sri Lanka	Turtle Track Sri Lanka 2006-07: Green Turtles Marine Turtle Research Group	www.seaturtle.org/tracking/?project_id=149	Cm	10
Tanzania	Post nesting migrations of green turtles nesting in Mafia Island Marine Prak, Tanzania Sea Sense	www.seaturtle.org/tracking/index.shtml?project_id=760	Cm	10
UAE	Gulf Turtle Tracking Project 2010 Emirates Wildlife Society WWF MRF	www.seaturtle.org/tracking/?project_id=658	EI	5
UAE	Gulf Turtle TrackingProject 2011 Emirates Wildlife Society WWF & MRF	www.seaturtle.org/tracking/?project_id=737	EI	7
UAE	Marine Turtle Conservation Project 2012 Emirates Wildlife Society WWF & MRF	www.seaturtle.org/tracking/?project_id=494	EI	14
UAE	Dubai Turtle Rehabilitation/Release Project	www.seaturtle.org/tracking/index.shtml?project_id=55	CM	4
UAE	Dubai Turtle Rehabilitation Project	www.seaturtle.org/tracking/index.shtml?project_id=687	CM	2
UAE	Dubai Turtle Rehabilitation Project	www.seaturtle.org/tracking/index.shtml?project_id=687	EI	1
UAE	Dubai Turtle Rehabilitation Project	www.seaturtle.org/tracking/index.shtml?project_id=687	CC	2

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Gillnet (bycatch) fishery information:

The impact of gillnet fishing on turtles in the IOTC area was derived from comparing catch statistics (as derived from global catch statistics; see Watson et al. (2006) for details) across gear types (longline:gillnet). The best available data were obtained from the Seas Around Us Project. Table S2.1 provides a comparison of the relative contribution of each gear type to the catch statistics of each large marine ecosystem and high seas region in IOTC region. From this comparison, it is clear that longlining is a highly selective fishery contributing less than 10% of the regional catches (in most instances). We assumed that bycatch would scale in the same proportions, which is conservative because gillnetting is non-selective. This comparison also indicated regions with high gillnet fishing pressure, particularly the Somali Current, the Arabian Gulf and Bay of Bengal, where 30 – 60% of total catches are attributed to gillnetting. A comparison of the total landings of gillnets (4,239,494 tonnes) to longlines (283,033 tonnes) indicate that gillnets land ~ 15x as many fish. Applying this relationship, it is possible that up to ~52 400 turtles (3,500 turtles X 15) are caught per annum in gillnets across the IO (with no information on the survival rates).

Other comparisons, e.g.Wallace et al. (2010) also suggest a gillnet turtle bycatch rate approximately one order of magnitude higher than the longline bycatch for the Indian Ocean. Wallace et al. 2010 reported 5,329 turtles caught in gillnets and 432 in longlines, a ratio of 12:1 (despite more data available for longlines). Using this ratio against the longline estimates for the current study yields an estimated 43,100 turtles caught per annum in the IOTC region using gillnets.

We used a second approach, taking data from the Seas Around Us database and following the approach of (Waugh et al., 2011) which calculated an unweighted exposure index (UEI; or gillnet fishing pressure)per EEZ and High Seas Areas. which is an indication of fisheries pressure (see Waugh et al. 2011 Table 37 for details). The subset of relevant unweighted exposure values for the IOTC per EEZ was selected. Listing the values in order of the lowest exposure values (e.g. BIOT) to the highest (India) suggested an exponential increase. In an attempt to translate the fisheries pressure as per the UEI to an estimate of turtles caught, available bycatch values obtained from the literature (as per this review) were modelled against the UEI (Fig S2.1). Two different extrapolations were obtained – one exponential and a linear estimate. These estimates were then applied per country to obtain a lower and upper estimate of gillnet catches (Table S2.2).

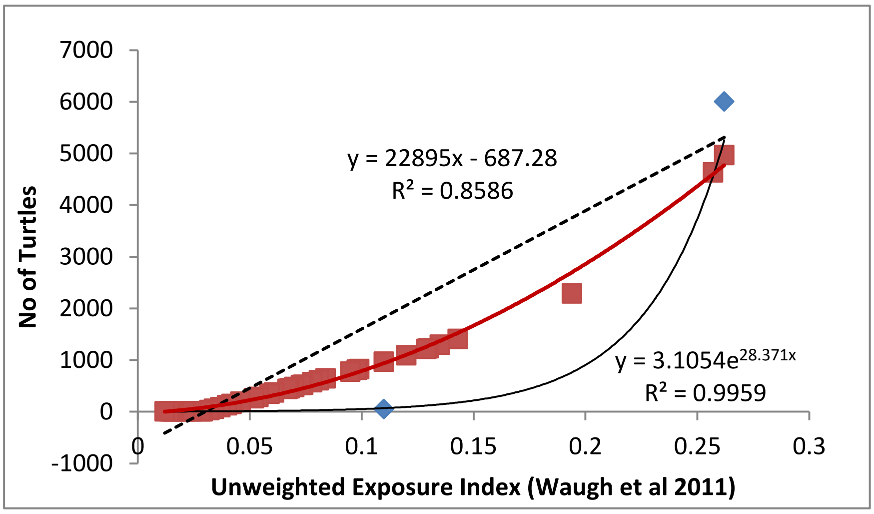

Figure S2.1 Linear (upper) and exponential (lower) extrapolation of the number of turtles caught (y-axis) per set unweighted exposure index for turtles in gillnets (as calculated by Waugh et al 2011). The mean of the two estimates are indicated in red.

Table S2.1A. Relative Fisheries catch (tons) ratings based on gear type (Data from Seas Around Us Project http://www.seaaroundus.org). Mean of catch (tons) estimate per gear type for landings between 2000 and 2006. **B.** Data normalised per surface area to indicate intensity (tons.km^{-2}). The contribution (tons.km^{-2}) then expressed as a % of the total catch to indicate relative success per gear type. E.g. 28% of the catch (per tons.km^{-2}) in the Agulhas LME were obtained from gillnets as opposed to 5% from longlines and 21% from purse seines.

A. LME	Surface Area (km^2)	Gillnets	Longline tuna	Purse seines	Driftnets	Set gillnets	Other
Agulhas LME	2,615,294	82788	14742	63497			137102
Somali LME	844,524	24702	2595	4167			15598
Red Sea	480,385	24723		5924			82871
Arabian Sea	3,950,421	970287		236783	91283		1860623
Bay of Bengal	3,657,502	2340138		165060	32542		1167320
North Australian Shelf	722,214	12092	282	5474			43243
North-west Australian Shelf	911,812	13374	783	3378		1986	28920
Western Central Shelf	543,577	4912	752	975		627	12510
South Australian Shelf	1,046,368	6833	2247	1963			21352
South-east Australian Shelf	1,199,787	4617	1579	1512			22375
WIO High Seas	17,027,045	130729	158000	248945			249286
EIO High Seas	22,176,590	624299	102053	106201			185720
		4,239,494	283,033				

B. LME	Gillnets_km^2	Longline tuna_km^2	Purse seines_km2	Driftnets_km2	Set gillnets_km2	Other
Agulhas LME	0.032 **(28%)**	0.006 (5%)	0.024 (21%)			0.052 (46%)
Somali LME	0.029 **(53%)**	0.003(5%)	0.005 (9%)			0.018 (33%)
Red Sea	0.051 (22%)		0.012 (5%)			0.173 (73%)
Arabian Sea	0.246 **(31%)**		0.060 (8%)	0.023 (3%)		0.471 (59%)
Bay of Bengal	0.640 **(63%)**		0.045 (4%)	0.009 (1%)		0.319 (31%)
North Australian Shelf	0.017 (20%)		0.008 (9%)			0.060 (71%)
North-west Australian Shelf	0.015 **(28%)**	0.001 (2%)	0.004 (7%)		0.002 (4%)	0.032 (59%)
Western Central Shelf	0.009 **(25%)**	0.001 (3%)	0.002 (6%)		0.001 (3%)	0.023 (64%)
South Australian Shelf	0.007 (23%)	0.002 (6%)	0.002 (6%)			0.020 (65%)
South-east Australian Shelf	0.004 (16%)	0.001 (4%)	0.001 (4%)			0.019 (76%)
WIO High Seas	0.008 (17%)	0.009 (19%)	0.015 **(32%)**			0.015 (32%)
EIO High Seas	0.028 **(61%)**	0.005 (11%)	0.005 (11%)			0.008 (17%)

Table S2.2 An estimate of the total number of turtles caught (per country) across the IOTC region based on an exponential or linear interpretation of catch data per unweighted exposure index (UEI).

Rating	Country	Region	UEI	Exponential	Linear	Mean Est
1	India		0.262	4617	5311	4964
2	Myanmar		0.257	4068	5197	4632
3	Indonesia	West	0.194	825	3754	2290
4	Thailand		0.143	227	2587	1407
5	Malaysia	West	0.135	185	2404	1294
6	IO East	High seas	0.13	163	2289	1226
7	Madagascar		0.129	159	2266	1213
8	Pakistan		0.12	127	2060	1093
9	South Africa		0.11	98	1831	965
10	Oman		0.099	74	1579	827
11	Iran		0.098	73	1556	814
12	Somalia		0.098	73	1556	814
13	Yemen		0.098	73	1556	814
14	IOW	High seas	0.095	67	1488	777
15	Australia		0.084	51	1236	643
16	UAE		0.081	47	1167	607
17	Saudi Arabia	Persian Gulf	0.078	44	1099	571
18	Andaman & Nicobar	(India)	0.074	39	1007	523
19	Tanzania		0.073	38	984	511
20	Saudi Arabia	Red Sea	0.07	36	915	476
21	Egypt		0.068	34	870	452
22	Sri Lanka		0.067	33	847	440
23	Bahrain		0.061	28	709	369
24	Maldives		0.059	27	664	345
25	Kuwait		0.054	24	549	286
26	Mozambique		0.052	23	503	263
27	Mayotte	(France)	0.046	19	366	193
28	Qatar		0.046	19	366	193
29	Eritrea		0.042	18	274	146
30	Mauritius		0.04	17	229	123
31	Kenya		0.037	15	160	88
32	Christmas Isl	(Australia)	0.034	14	91	53
33	Timor Leste		0.032	14	45	29
34	Comoros		0.029	13	0	6
35	Seychelles		0.028	12	0	6
36	Cocos Isl	(Australia)	0.024	11	0	6
37	Iraq		0.021	10	0	5
38	Moz. Channel Isl.	(France)	0.021	10	0	5
39	Tromelin	(France)	0.016	9	0	5
40	BIOT	(UK)	0.015	9	0	4
41	Jordan		0.014	9	0	4
42	Reunion	(France)	0.012	8	0	4
				11,460	**47,516**	**29,488**

This estimate indicates turtle bycatch values between ~11 000 - 47 000 (Table S2.2). An extrapolation per country should be treated cautiously as either the exponential or the linear estimate may be more appropriate. No trend could be obtained as to which of these the more appropriate estimate is. The mean of the two was therefore calculated. It is also expected that the values are probably less useful on a country basis and thus not be taken out of context. It is expected that the impact of non-purse seine net fisheries should be in this order of magnitude.

To estimate the relative contribution per species per region, values from reports were used. Where quantitative data were available these were translated into % values per country, and combined with estimates from interview surveys per country (Table S2.3).

Table S2.3 Relative contributions of each species to the turtle gillnet fisheries (summarised from available literature below).

	Caretta	*Chelonia*	*Dermochelys*	*Eretmochelys*	*Lepidochelys*	*Natator*
Comoros	20	50		30		
Madagascar	1.6	94.5	0.0	3.5	0.4	
Tanzania	0.4	91.3	0.4	6.0	2.0	
Zanzibar	65			10	8	
Seychelles						
Reunion						
Mauritius		30		70		
Kenya	13.0	65.2	4.3	13.0	4.3	
Mozambique	45	20		20	15	
Average %	**21**	**50**	**1**	**22**	**4**	**0**
Sri Lanka (%)	**30**	**20**	**6**	**6**	**37**	**0**
W.Australia (%)	9%	88%	0	2%	0	0
AVG Gillnets	**20%**	**53%**	**2%**	**10%**	**14%**	**1%**

Values in red were approximated.

Global patterns of marine bycatch:

Wallace et al. (2010) provides the best global comparison of bycatch specially comparing the effort and actual bycatch between gillnet and longline fisheries. However, from the regional overview (provided in the rest of this analysis), it is clear that this is an underestimate of bycatch (as recognised by the authors, Wallace et al. 2010, that suggested bycatch to be underestimated by two orders of magnitude). From the current review, it seems to be a reasonable premise as the data gathered in this review also suggest a large under-estimate particularly for gillnet bycatch.

It has been difficult to find useful data with regards to gillnetting for a number of reasons. Firstly, to distinguish between subsistence and artisanal, or artisanal and small-scale commercial fisheries is somewhat arbitrary. Further, no data tracking nor observer systems are in place for subsistence and artisanal fisheries and hence data are mostly anecdotal or through interviews. Secondly, interview-type data provide useful information to describe the fisheries in terms of gear used, seasonality of operations, and fractions of catches/bycatch per gear type. A clear shortcoming is incomplete effort record keeping (in terms of number of fishers, boats or gear types) across these fisheries. The data collection methods tend to be localised with little/no spatial or temporal replication. The third major confusion is around gear types; for example nets are sometimes referred to as gillnets, drift nets, anchored gillnets or mono-/multi-filament drift gillnets. For the sake of this report, these data were grouped as the impacts on turtles would be the same. The compilation of gillnet data in the current report was therefore aimed entirely to estimate the ratio of longline to gillnet bycatch, and the relative proportion of turtle bycatch per species, per region per fishery.

Wallace et al. (2010) compiled data from peer reviewed papers between 1990 and 2008. In addition they contacted agencies around the world in charge of collecting data on fisheries. A summary of the bycatch data are presented in Table 1. This compilation indicates that longline data are much more abundant and effort metrics are much more consistently reported. Based on all of the records, between 1990 and 2008, 85 000 marine turtles were taken as bycatch in gillnets, longlines, and trawls.

Table 1 Summary of reported bycatch records (i.e., bycatch rates and fishing effort) and total number of unique fishing effort and bycatch rate metrics reported in published literature. A record was entered in the database if it contained bycatch rate data, observed fishing effort data, and/or number of turtles taken.

Gear type	Total no. records	Total no. Effort records	No. unique effort metrics reported	Total no. BPUE records	No. unique BPUE metrics reported
Gillnets	251	185	17	156	21
Longlines	554	492	10	482	16
Trawls	128	83	10	91	14
Total	933	760	37	729	51

BPUE = bycatch per unit effort.

From Wallace et al. (2010).

Table 2 Summary of reported sea turtle bycatch and fishing effort in gillnets, longlines, and trawls worldwide. All data shown are based on reported data, not estimates or extrapolations. "Weighted median BPUE" was calculated by accounting for the proportion of total effort observed per record to derive a bycatch rate per unit effort (BPUE); BPUEs with no reported effort were not included in calculation of the weighted median BPUEs, and no weighted median BPUE was calculated for region–gear combinations with only one record (see text for details on calculations). "Weighted median BPUEs" and "median observed fishing effort" values presented with minimum and maximum values in parentheses. Effort units reflect converted values to standardized "sets" relative to gear type and region (see text for details on methodology). "No. of records" represents the number of records used to calculate the weighted median BPUEs (i.e., those reporting both a BPUE and fishing effort); the total number of records of bycatch, including those reporting number of turtles taken, for that region–gear stratum in parentheses. "Total observed effort" is the sum of all observed fishing effort reported for each region–gear stratum.

Region	No. turtles taken	Weighted median BPUE	No. of records	Median observed effort	Total observed effort
Gillnets (effort expressed in number of sets)					
Caribbean	5,971	0.0119 (0.0000–0.1700)	28 (35)	82 (52–68,355)	105,724
Eastern Indian	5,251	0.1904 (0.0313–0.3496)	2 (3)	13,760	13,760
Eastern Pacific	353	0.0392 (0.0032–0.2212)	5 (5)	312 (90–312)	458
Mediterranean	177	0.0772 (0.0000–2.2169)	9 (9)	54 (27–369)	912
Northeast Atlantic	6	0.0135 (0.0080–0.0190)	2 (2)	193 (125–261)	386
North Pacific	475	0.0000 (0.0000–0.0157)	51 (51)	587 (178–2,695)	17,859
Northwest Atlantic	18	0.0000 (0.0000–0.0506)	18 (18)	111 (99–291)	1,002
Oceania	300	NA	0 (2)	NA	NA
Southwest Atlantic	394	0.1315 (0.0153–1.3700)	13 (13)	27 (1–523)	1,024
West Indian	78	NA	0 (1)	NA	NA
GN Total	13,023		129 (139)		141,125

Longlines (effort expressed per 1,000 hooks)					
Caribbean	1,384	0.0042 (0.0004–0.1657)	14 (14)	90 (2–3,139)	4,427
Eastern Indian	26	0.0190 (0.0000–0.3200)	8 (8)	221 (14–539)	994
Eastern Pacific	2,040	0.2138 (0.0005–19.3000)	47 (47)	51 (1–10,604)	14,870
Mediterranean	28,071	0.2740 (0.0000–7.1411)	69 (75)	291 (12 – 22,594)	85,741
Northeast Atlantic	1,366	0.0367 (0.0070–4.5450)	37 (37)	32 (16–427)	1,878
North Pacific	624	0.0134 (0.0000–2.5000)	18 (35)	95 (33–1,329)	4,347
Northwest Atlantic	6,719	0.5954 (0.0100–4.6000)	29 (29)	283 (14–11,604)	73,040
Northwest Atlantic/Caribbean	4,546	0.0050 (0.0000–0.5207)	70 (70)	422 (181 – 4,450)	11,006
Oceania	466	0.0014 (0.0000–0.2000)	18 (20)	1,272 (16 – 68,000)	107,032
Southwest Atlantic	9,916	0.2240 (0.0000–11.6129)	96 (96)	79 (8–20,263)	24,499
West Africa	397	0.0356 (0.0000–0.5140)	21 (27)	272 (33–520)	2,362
Western Indian	409	0.0080 (0.0112–0.1000)	9 (11)	1,380 (44–6,725)	15,306
LL total	55,964		436 (469)		345,502

From Wallace et al (2010). A total of 5,329 turtles were reported to be caught in gillnets and 435 for longlines combining the eastern and western Indian Ocean regions (not scaled to effort).

Each of the countries/regions in the IOTC region will described (below) to review the available gillnetting information.

Agulhas LME

Comoros

Fishing is exclusively artisanal (Poonian et al., 2008). **Traditional canoes and motorized fiberglass** boats are used. Many different fishing gears are used including beach seines, fish traps, gillnets, lines and purse seines) (Kiszka et al., 2008). Shark gillnets of up to 270 m and 2 m wide with a mesh size of 30 cm. **Fishing activities tend to be seasonal**. Artisanal fishers in the Comoros reported 3403 *galawas* (traditional canoe) and 924 *vedettes* (motorized boat) and approximately 8500 fishers.

Table S2.4 Surveys used to gather data from artisanal fisheries (Moore et al., 2010). (Data adapted from Moore et al. (2010). Number of boats and fishers for each geographic area.)

Country:	Geographic Area:	No. Boats:	No. of Fishers:
Comoros	Grand Comoro	2299	4500
	Moheli	348	1100
	Anjuan	1680	2400

- For the Comoros the sea turtles reportedly caught by the artisanal fishers include green, hawksbill and loggerhead turtles (Moore et al., 2010).

Madagascar

Fisheries are the main source of income in coastal communities (Kiszka et al., 2008). There are three types of fisheries in Madagascar defined by the power of the crafts used: (i) commercial fishery (>50hp), (ii) artisanal fishery (<50hp) and (iii) traditional fishery (non-motorized) (Kiszka et al., 2008).
Trawling (a commercial fishery) occurs within two miles off the coast of Madagascar in shallow water. Artisanal fishery within 12 miles offshore with **gillnets as the principal gear used.** The **traditional fishery targets a range of species including turtles** (Kiszka et al., 2008).

In 2001- 2004: A small shark fishery that was developing in northern Madagascar was evaluated by surveying ports/villages. Nets used were baited, bottom set gillnets (usually operating in less than 100m), 7-8m vertical height and 400 – 700 m length. Soak times were typically a 24hr day, serviced in the mornings and reset (Robinson and Sauer, 2011).

- The turtle bycatch in this shark fishery consisted mainly of green turtles, olive ridley and hawksbills. One leatherback was also caught (Robinson and Sauer, 2011)
- On average **3 turtles per 10 days fishing was caught, all dead.**

Looking at the effectiveness of interview method for tracking the number of marine turtles bycatch and fishery in Madagascar (Humber et al., 2010). Interviews were done between October to December of 2007 (Humber et al., 2010). 68% of the turtles recorded were caught using *Jarifa* (a 12 – 25cm mesh gillnet). 8 – 10cm mesh gill net was recorded in 5 % of landings. Community members revealed that the austral summer **(Nov – Feb), cited as the best season to catch turtles**, this is also the period most susceptible to bad weather, which also reduces the fishing intensity.

Walker and Roberts (2005) conducted interviews in 2002 across 8 subsistence villages in Madagascar. Catch statistics varied widely with catches reported of 300 turtles (mostly green turtles) per month from just one village.

Table S2.5 Number of turtles caught in a year from a subsistence fisheries gear (other) vs the *jarifa* (gillnet) in one year (2007) (From (Humber et al., 2010)).

Species	Total catch	*Jarifa* catch no	Size CCL	Size range
Caretta	11	9	74.4±20.2	40-98
Chelonia	654	451	74.4±22.1	21-120
Eretmochelys	24	7	50.6±15.5	31-89
Lepidochelys	3	1	66.0±14.7	57-83
Unidentified	7	3	NA	NA
Total	**709**	**471**		

Table S2.6 Previous studies on bycatch in Madagascar provide an index of turtles caught (not specific to the gear type) (From Humber et al 2011).

	Region:	Est. No. Trtl. Caught.	Reference:
A	Nosy Hara	101 - 200	Sodomara 2003 (in Andrameca et al. 2006).
B	Radama	201 - 500	Montell et al. 2007.
C	Barren	26 - 50	Gerard Leroux pers. Comm.
D	Study Area	501 - 1000	Humber et al 2011
E	South Western Madagascar	51 - 100	Residoener (unpublished data).
F	South Western Madagascar	101 - 200	Rakotonirina & Cooke 1994
G	South Western Madagascar	501 - 1000	Walter & Roberts 2005
H	South Eastern Madagascar	51 - 100	Gladstone et al. 2003

- The conclusion from this paper was **that 10 000 to 16 000 turtles** are caught per annum in the artisanal fisheries around Madagascar.

Mayotte (France)

No mention of gillnet fishery in artisanal fishing methods (Kiszka et al., 2008). Off Mayotte

(2009-2010), four loggerhead turtles were caught alive (**0.28 turtles per 1,000 hooks**), and released alive (Kiszka et al., 2010) on 29 longline sets of 500 hooks (Kiszka, 2012).

Mozambique

60% of the coastal population in Mozambique are dependent on the marine resources. Fisheries constitute many gear types, but principally gillnetting (Kiszka et al., 2008).

In Louro et al. (2006), Gove et al. (2001) estimated that between 1932 and 5436 marine turtles were accidentally caught every year on the Sofala Bank during the prawn fishery season, most caught are killed for meat or market.

- Currently the practice of capturing marine turtles for food and sale of its carapace is becoming a common practice in the coastal zone of the country. **Turtles are 'accidentally' caught in trawling or gillnets** (Louro et al., 2006).
- A total than **240-420 turtles are caught per annum in gillnets of which ¾ are green turtles**. (Louro 2006 in Kizka 2012).

From (Kiszka, 2012) the following catches per gear type were reported:

<u>Beach seines:</u>

Mean length: 232m (range = 9 – 480m). Mesh size (mean -= 4.53cm). 44% of Fishers declared having caught turtles. Four Species caught: Loggerhead (38%), olive ridley (21%), hawksbill (20%) and green (14%). 53% of fishers declare catching 1 – 3 turtles last year. 17% caught 4 -10 individuals and 6% caught more than 20 individuals. Remaining fishers could not specify any number of turtles as bycatch.

<u>Bottom Set Gill nets:</u>

Mean length = 348m (range 30 – 900m). Mesh size ranges from 5.1 – 11.4cm.
34% of fishers declared turtles as bycatch. Four species caught were:

- Loggerhead (45%),
- Green (20%),
- Hawksbill (20%) and
- Olive rildley (15%).

More than 83% of the fishers declared that they had caught 1-3 individuals in the previous year, whereas 4 -10 individuals were caught by 17% of fishers.

<u>Monofilament drift gillnet:</u>

Length ranges from 50 to 650m (mostly 600m; modal size). Mesh size 1.3 to 5.1cm.

<u>Multifilament drift gillnets:</u>

Limited data were collected. Mean length 302m (range = 230 – 600). Mesh Size varies from 2.3 – 3.8cm.

Bycatch data are for both drift net types. Due to under sampling of monofilament drift gillnet. 8% of fishers declared turtle bycatch. Four species of turtle identified:

- Olive Ridley, Loggerhead, Green and Leatherback. **All fishers stated they had caught between 4 and 5 turtles last year.**

<u>Handline:</u>

Mostly a single hook used. 4% declared turtles as bycatch. Three species caught: Loggerhead (50%), Green (25%), Hawksbill (25%). Only 33% of fishers provided an estimate as to number of turtles caught the previous year, of which they suggest 1 – 3 individuals caught last year.

- Overall turtle bycatch:
    - Loggerhead (41%).
    - Olive Ridley (22%).
    - Hawksbill (20%).
    - Green (16%).
    - Leatherback (1%).

Bycatch incidence:
Number of turtles caught per gear time in a year (2006) (N/boat/year) Monofilament: 0.286 (n=94)

- **Drift Gillnets: 0.33**
- **Bottom-set gillnets: 0.743**
- Beach seine: 1.56
- Handline: 0.09

92% of fishers stated that turtle is released alive when caught, remaining percentage stated they ate the animal.

Tanzania

Marine fisheries in the country are mostly artisanal, which include the use of drift and set gillnets (Kiszka et al., 2008). Most threatening of the fishing gear and drift set nets for large fish, and bottom set nets for demersal species (Kiszka et al., 2008). **Drift nets** are approximately 500 – 900 m in length, with mesh sizes from 7 – 20 cm. The **bottom-set nets** targeting sharks and rays vary in length of approximately 450 m, mesh size ranging from 20 – 40 cm. The bottom set nets are very close to the shore (Kiszka et al., 2008).

Table S2.7 summarized from (Moore et al., 2010): Number of fishers and boats, and sampling effort in different geographic areas of each country (study period 2007 to 2008).

Geographic stratum:	No. of Boats:	No. of Fishers:
Tanga	1391	7756
Coast	2726	12 984
Dar es Salaam	1039	4887
Lindi	1117	5014
Mtwara	1069	5606

- Turtle species documented as bycatch by the artisanal fishers (Moore et al., 2010)
  - Green.
  - Hawksbill.
  - Loggerhead.
  - Olive Ridley.

Tanzania: (Zanzibar and Pemba Island)

Bottom Set Gillnets:
Mean length of nets are 307m (with a range of 14 – 900m). Mesh size was variable (4 to 22.9cm).
4 to 7 days of the week spent at sea (Kiszka, 2012).

Multifilament Drift Gillnets:
Mean length of 443m (range: 30 – 1600m). Mesh size varied from 3 to 17.8cm. 3 to 7 day spent at sea.

Monofilament drift gillnet:
Ranged from 20 to 900m in length. Mesh size varied from 5 to 15.2cm. 4 to 7 days of the week spent at sea. Overall the gillnet mesh size larger than Kenya.

Purse seine:
Small mesh size 5.2cm, ranging from 30 to 1500m long. 3 to 7 days per week spent at sea.

Longline fishery:
6 to 500 hooks per line. 2 to 7 days spent at sea.

HandLine:
1 to 150 hooks used. 2 to 7 day s spent at sea.

Fishing effort was generally stable throughout the year off both Zanzibar and Pemba.

- Overall bycatch for the artisanal fisheries for the following five turtle species:
  - Loggerhead (most common)
  - Hawksbill (21%)
  - Olive ridley (11%).
  - Leatherback
  - Green

Monofilament drift gillnets:
7% of fishers declared turtle bycatch. Only the olive ridley turtle was identified as bycatch.
Number of turtles caught last year between 1 and 3 turtles.

Multifilament drift gillnets:
38% of fishers declared turtle bycatch. Five species caught with the three most commonly caught being loggerhead, hawksbill, olive ridley. Only 6% of fishers declared they did not catch a sea turtle last year, 24% declared catching 1 – 3 turtles last year.

Bottom Set Gillnets:
39% fishers declared turtles as bycatch. The three most commonly caught turtles are:

- Loggerhead (65%).
- Hawksbill (10%).
- Olive ridley (8%).

Green turtles also caught by but only on rare occasions. 75% of fishers declared catching 1 – 3 turtles last year; 10% claimed 4 – 10 individuals and 5% at least 20 turtles caught last year.

Purse seine:
24% of fishers declared turtle bycatch. Loggerhead turtles are the most common species caught.
Hawksbill cited as a secondary species caught, rare events. 87% of fishers declared 1 – 3 individuals caught last year, 13% of fishers declared at least 20 individuals caught last year.

Longline Bycatch:
27% of fishers declared turtles as bycatch. Three species were identified as bycatch; these being loggerhead, hawksbill and green turtles. 60% of fishers declared 1 – 3 individuals caught; 17% declared 11 – 20 individuals caught and 15% declared no sea turtles caught last year.

Handline Bycatch:
13% of fishers reported turtle bycatch. The turtle species caught were loggerhead (70%), hawksbill (20%) and olive ridley (10%). 70% of fishers declared 1 – 3 individuals caught last year; 10% caught between 4 and 10 individuals. 10% of the fishers could not provide a number for bycatch last year.

Total Bycatch incidence:

- Number of turtles caught per gear type in a year (2006) (N/boat/year):
  - Monofilament: 0.143
  - Multifilament: 0.949
  - **Bottom-set gillnets: 1.275**
  - Purse seine: 0.75
  - **Longline: 0.59**
  - Handline: 0.313

53% of fishers declared releasing the turtles alive. 42% either ate, sold or discarded the carcase. Perceptions of fishers indicate they believe there to be a significant decline in the turtles.

Seychelles

The use of gillnets (formely targeting reef sharks) has been recently prohibited in Seychelles territorial waters (Kiszka et al., 2008).

Reunion Island

Longline (offshore and pelagic) and the hand line fishery (coastal). Made up of about 30 boats (Kiszka et al., 2008). Around 300 boats have been registered around the island (IFREMER data), targeting game fish and large pelagic fish.

Mauritius

Data were collected using interviews and questionnaires. Therefore numbers presented as the number of times a species were mentioned as bycatch by fishers or where percentages of fishers answering set questions (Kiszka, 2012).

Main artisanal fisheries:

- Beach seines
- **Bottom set gillnets.**
- Longlines/hook line around FAD's (Fish Aggregating Devices).
- Handlines in coastal areas (mostly using one hook).

All the fishing methods use a fishing vessel called *pirogues* (50% fiberglass, 5-% wood), seven metres in length and motorized. Only 20% of the fishers declared they actively fished year round, and fishing effort is concentrated between March and September.

- Overall **green and hawksbill turtles were mentioned** as regular bycatch but bycatch composition was variable among the fisheries/gear types.
- Hawksbill turtles were caught in all the artisanal fisheries; in order from most accounts of bycatch to the least: beach seine, bottom set gillnet, handline and longline with FAD's.
- Green turtles where caught in beach seine, handline and bottom set gillnet.

Table S2.8. Bycatch incidence (bycatch/year/boat) calculated for each fishery and taxonomic group in Mauritius. Data are extrapolated at the fishery level as the counts for each boat are available (for 2010 – 2011).

Gear type	n/boat/year	Extrapolated n/year
Beach seine	6.74	283.08
Bottom set gillnets	3.38	15.52
Lines under FADs	0.17	30.94
Handlines	0.44	241

The results (from Table 7) suggest net fisheries (particularly beach seines) have the highest impact for sea turtles. Of these catches, 69% of fishers confirm releasing the turtle alive when caught, while the rest either discarded or used the carcase. 55% of fishers noted that sea turtle bycatch is decreasing around Mauritius, while 5% believe it to be increasing.

Beach Seine

Beach seines are conducted with nets that are 500 m long with a 9 cm mesh size (Kiszka 2012). The time spent at sea ranges 4 to 5 days per week.

94% of fishers interviewed noted green and hawksbill turtles as bycatch, with hawksbill being most common.

- 40% of fishers indicated catches of 1 – 3 turtle caught,

- 40% indicated catches of 4 – 10 turtles and
- 20% of fishers interviewed indicated 11 – 20 caught in the previous fishing year (Kiszka 2012).

Beach seine bycatch showed no peak in the number of turtles caught during autumn/winter (Match to September) "fishing period".

Bottom-set Gillnet

Bottom set gillnets 250 m in length and mesh size of 11cm are used (Kiszka 2012). Between 2 to 7 days per week are spent at sea for the bottom-set gillnet fishery (between Feb and Oct.).

Bycatch of turtles was declared by 100% of the fishers interviewed, with hawksbill being the most common and green being the other species caught.

- 60% of the fishers reported <3 turtles pa,
- 20% indicated catching 4 – 20 turtles pa, and
- 20% indicated catching 11 – 20 turtles pa.

Longline with FAD's

Longline/hook line methods varied between 1 and 8 for the number of hooks. Fishing effort is greatest during the rainy season (October to April). **Hawksbill was the only turtle species caught, and was declared by only 8% of the respondents.**

- Turtle bycatch is rare in this fishery (around one catch per year).

Handline Bycatch

The handline fishery used on one hook and effort is 4 -7 days spent fishing.

44% of respondents declared bycatch of sea turtles.

- Green (50%) and hawskbill (30%) are the two species comprising the bycatch of Mauritius, (although 20% of fishers could not identify the turtles to species level). All respondents indicated <3 turtles caught pa. The fishing effort was more intense around the trade wind periods (Nov – Apr).

The effort is unevenly distributed among these gear types: in 2006 it was reported that there are 183 longliners, 43 purse seiners, 2 mid-water trawlers and among the artisanal fisheries using a range of gear types by about 1852 boats (Kiszka et al., 2008).

Kenya

Higher effort was dedicated to sample handline and gillnet fisheries by (Kiszka, 2012). The analysis is focussed on bycatch taken in the gillnets (mono- and multi-filament, bottom set gillnet), longline and handline fisheries. Gear characteristics differed greatly among the fishers, net mesh and hook size were significantly different among the fishers and were not linked to geographic locality.

Gillnets are bottom set with a mean length of 267m. Mesh size was variable, ranging from 1.5 to 4.5cm. Two to seven days out of the week are spent fishing. 44% of fishers declared turtles as bycatch.

- Green turtle is the most commonly caught species (~80%, n=15). Other species present as bycatch are hawksbill (n=3), loggerhead (n=3), olive ridley (n=1) and leatherback (n=1).
- 60% of fishers indicated 1 – 3 turtles caught pa; 20% indicated 4 – 10 turtles pa; 20% of fishers indicate 11 – 20 turtles pa. For the bottom set gillnets the occurrence of bycatch was highly correlated to the reported fishing effort. (Lower bycatch rates were reported during the austral winter when fishing effort was lower).

Beach seine length (mean = 89m, range = 10 – 400m) and mesh size (mean = 2cm, Range = 0.5 – 4.5cm). Two to seven days out of the week are spent fishing. 50% of fishers declared sea turtles as bycatch. Green turtle most common species (53%), other bycatch species include hawksbill, loggerhead and olive ridley. Only 48% of the fishers could provide a number of bycatch sea turtles in the last year, all declaring 1 – 3 individuals.

Multi-filament drift gillnets: mean net length of 383m and a range = 15 – 1500m. The mesh size varied from 1.5 to 8cm. Three to seven days out of the week are spent fishing. 28% of fishers reported turtle bycatch, these being green, olive ridley and hawksbill turtles. The number of turtles caught in the previous year ranged from 1 to >20.

Mono-filament drift gillnets with a mean net length of 468m, while they range from 8 – 1300m in length. The mesh size ranged from 2 – 6cm in mesh size (mean = 2.9). Three to seven days out of the week are spent fishing. 33% of fishers reported turtle bycatch. All five of the turtle species were identified within the monofilament bycatch. Number of turtles caught ranges between 1 to 10 for last year.

Longline fishery had a variable number of hooks per line, ranging from 2 to 300 hooks. Four to seven days out of the week are spent fishing. Only 10 interviews were conducted for longlines. 30% of fishers declared turtles as bycatch

- **Hawksbill, loggerhead and green turtles**. The turtle bycatch was considered **rare by most of the fishers**

The **Handline fishery** number of hooks ranged from 2 to 20. Four to seven days out of the week are spent fishing. 13% of fishers declared sea turtle bycatch. Species caught were: green (53%), loggerhead (21%), hawksbill (13%) and olive ridley (13%). Estimated 73% of fishers declared category 1 for last year bycatch; 18% declared category 3.

The handline and drift gillnet fisheries effort increased from January to April. For all the fisheries, the lowest effort was reported during the trade wind season from June to August.

- Five species of sea turtle are present in the **overall bycatch.**
  - Green (57% - dominant in net fisheries)
  - Hawksbill (19%)
  - Loggerhead (17%)
  - Olive Ridley
  - Leatherback

- Number of turtles caught per gear time in a year (2006) (N/boat/year) with a total number of boats (although the total number of boats were not reported to scale up. Assuming that each of the 330 interviews count for one boat the total number of turtles will be as follows)
  - Monofilament: 0.286 (n=94)
  - Multifilament: 1.37 (n=452)
  - Bottom-set gillnets: 2.53 (n=834)
  - Beach seine: 1.33 (n=438)
  - Longline: 1.1 (n=363)
  - Handline: 0.374 (n=123)

- Results for bycatch incidence show that net fisheries capture the highest number of sea turtles. For sea turtles, bottom set gillnets, multifilament drift gillnets and beach seine have the highest bycatch rates. **69% of the fishers declared they had released the turtle alive**, 15% used turtle as a food source, 10% discarded the turtles and 6% sell the meat.

South Africa:

Gillnets are infrequently used in South Africa with the exception of the bather protection nets along the eastern seaboard. These nets consistent turtle catches reported are along the north-east coast of the country with 27km of permanently installed gillnets in the water, acting as bather protection nets against dangerous sharks. (Brazier et al., 2012) reviewed the impacts of these nets with the following results:

- Loggerheads ~41 per annum (1.11 km.net^{-1}.y^{-1})
- Green turtles: ~ 12 per annum (0.32 km.net^{-1}.y^{-1})
- Leatherback turtles: ~5per annum (0.14 km.net^{-1}.y^{-1})
- Hawksbill turtles: 1.93 per annum
- Olive ridley: 0.6 per annum

Arabian Gulf

Islamic Republic of Iran:

Gillnets are extensively used in the Gulf including by Iran but use of purse seines seems to be increasing. Analysis of the levels of turtle bycatch attributed to gillnet fisheries in Iran was not possible. (Baldwin and Cockcroft, 1997) reviewed dugong bycatch but also reported on other bycatch including turtles. Exact numbers are not available. The gear type used include drifting gillnets, >60m in length and a mesh size of 14 -18cm. The 2012 bycatch report recognised the extensive use of gillnets with **no turtles reported in the bycatch** (Shahifar, 2012).

Oman:

Gillnets are extensively used in Oman and are the tenth highest catches reported (by CPCs) to IOTC.
In regards to bycatch, Oman's EEZ was found by Waugh et al. (2011) to be **the second highest density of gillnet fishing after India of anywhere in the Indian Ocean**.

Bay of Bengal

India

47% of India's catches for the last five years (2006 – 2010) are attributed to gillnets (MRAG, 2012).
Bycatch for IOTC is low, but gillnets account for 50% of india's bycatch. Number of gillnet vessels in India's fleet ranges from 2400 to 3700. (This data were however was inconsistent, and had to be extrapolated from data originating from Iran and Pakistan). Total Number of vessel operating in India 243 939, the types of vessels range from traditional non-mechanised vessels through to mechanised vessels.

Majority of the mechanised vessels are present on the west coast of India, but greater number of vessels in total in the eastern coastline (Fig. 4, From MRAG 012). Therefore the east coastline more fishing is practiced in the near-shore, while the west offshore fishing is more intense.

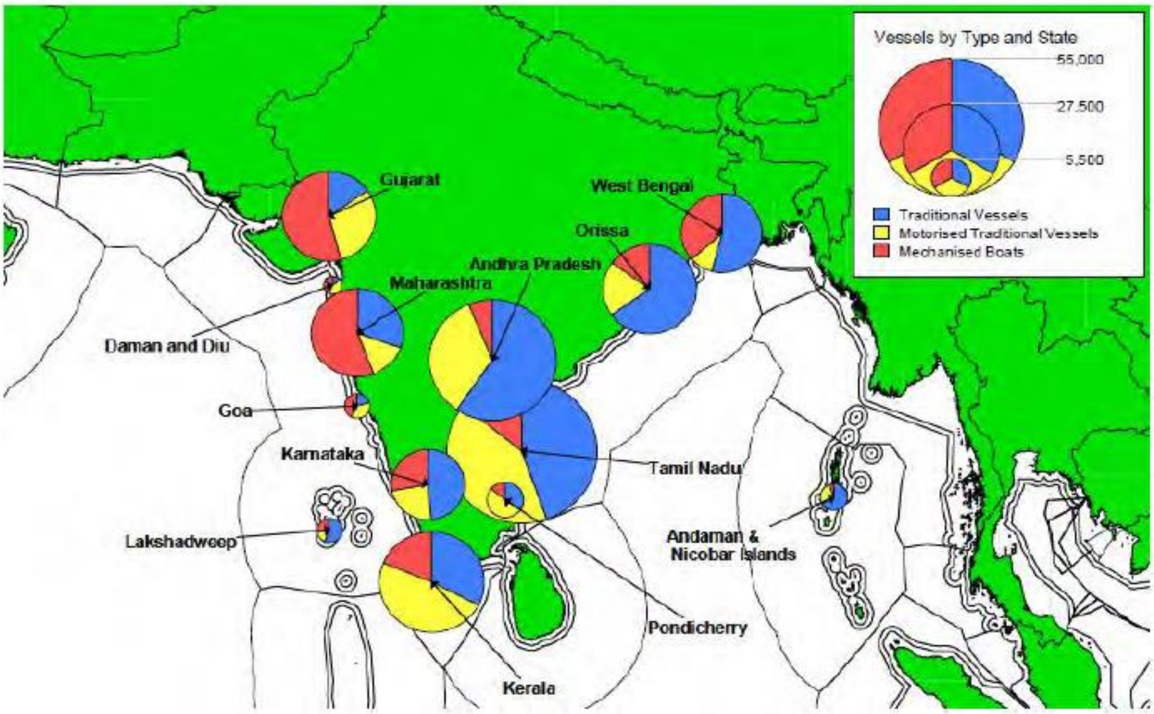

Figure 4 **Distribution of fishing vessels in India. Red indicates the most technologically advanced vessels (highly mechanised); yellow represents less complex mechanised vessels and blue those that are not mechanised. (Source: Ministry of Agriculture, India, 2010).**

No IOTC data were available for cetaceans, turtles and seabirds (MRAG 2012). Sea turtles of India, hold extensive data relating to turtle bycatch levels, but did not make these data available. The IOTC working party on ecosystem and bycatch, not able to conduct an assessment of turtle bycatch. Wallace et al. (2011) showed that India bycatch via gillnet at 5,251 turtles, second in the world.

Gillnets are the main gear attributed to the bycatch of turtles. Estimate suggests that they accounted for 76.8% and 60% of turtle bycatch between 1985 – 95 and 1997 – 98, respectively. India's east coast contributed 93% of turtle bycatch in the country. An estimate suggests a mortality attributed to bycatch is between 1994 – 2004. Tamil Nadu catch rate for turtles 0.24 $vessels^{-1}.year^{-1}$ and in Goa 1.83 $vessels^{-1}.year^{-1}$.

Drift gillnet fishery in GOA as per Kemparaju (1994). Drift gillnet fishing is carried out mainly by plank built canoes, without rigger(odi, size 7 to 10m long) motorized, 8 – 11HP. Drift gillnets are 500 – 700m long, mesh size 8 to 14cm. Nets are set between 20 to 60m depth zone off the coast soaking time is around 4 hrs, haul taking 1 to 2 hrs. Fishing starts between 1600 and 1800hrs, units return to the base the following morning at between 0700 and 1000hrs. Drift gillnet fishery starts in the first week of September through to February; peak fishing season (October to November). 4 to 5 fishers are engaged in the drift gillnet fishery practice. Turtles are noted as bycatch, numbers not given. **Their abundance insignificant.**

Below "Table 1: Earlier reports of accidental catches of different species of sea turtles in India" (Pillai, 1998). Among the reported in incidental catches 45% of the turtles were caught in trawlers , while gillnet accounted for 20%.

TABLE 1. *Reported incidental catch of turtles in different states (in nos and %)*

Place	No. of turtle	Percentage
Tamil Nadu		
Pamban	14	66.6
Rameswaram	2	9.5
Mandapam	1	4.8
Thondi	1	4.8
Madras	1	4.8
Kanyakumari	2	9.5
Maharashtra		
Ratnagiri	11	68.5
Bombay	3	19.0
Malvan	2	12.5
West Bengal		
Digha	2	66.3
Mohana	1	33.3

The region covered in this study includes the Eastern coastal states of Orissa, Andhra Pradesh and Tamil Nadu (MRAG, 2012). Total marine fishing fleet is estimated at 233, 500. Of which 47 000 are fully mechanized, 36 500 are traditional craft (motorized) and 150 000 are traditional non-motorized boats.

Table 3: Percentage of bycatch caused by gear type on the east coast of India, 1997-1998. Data Source: Rajagopalan et al, 2002.

State	Trawl	Gillnet	Seine	Other
West Bengal	0.0	0.0	0.0	100.0
Orissa	13.9	64.7	0.0	0.0
Andhra Pradesh	27.5	34.7	32.1	21.4
Tamil Nadu	2.8	72.5	1.7	5.5

Mortality of thousands of *Lepidochelys olivacea* in the nesting area due to incidental catch in fishing gears has also been reported (MRAG, 2012). Study was done over a 50km stretch of beach, from December 2000 to April 2001. This has resulted in a decline in the population, as the mature individuals and their eggs will be lost forever. This study's geographic study site is along the Nagapattinam coast, Tamil Nadu, southeast Coast of India, and outlines measures to conserve them.
205 carcasses of turtles were recorded in 50km stretch of the beach. 199 olive ridleys and 5 green.

Sex identification was only possible in 94 of the olive ridley turtles, females dominated. Turtles caught in the nets are known to be either clubbed on the head or flippers removed. Highest number of deaths was during January, possibly due to the aggregation of turtles in the shallow waters for courtship and mating.

Bangladesh

Artisanal fishery contributes 95% of total marine production, and this sector has been growing faster than the industrial sector (Islam, 2003). At present (2003) 14 014 non-mechanized and 3317 mechanized boats are operating in marine and coastal artisanal fishing activities.

Sri Lanka

Gillnets are normally used by the following vessel types (MRAG, 2012):

- Motorized traditional canoe.
- 17- 22 ft crafts with outboard motor.
- 3.5t inboard (28 – 32') multipurpose vessels (industrial sector).

Total of 46138 vessels, 9% of which can undertake offshore fishing operations. Coastal artisanal fleet is mostly comprised of non-motorized traditional craft and fibre reinforced plastic boats, fitted with an outboard motor which make up 47% and 44% of this sector respectively. Sri Lanka has over 3000 vessels registered longline vessels permitted to fish outside the countries EEZ. Sri Lanka is revising its fisheries legislation, introducing logbooks of improving bycatch reporting, and introducing a vessel monitoring system.

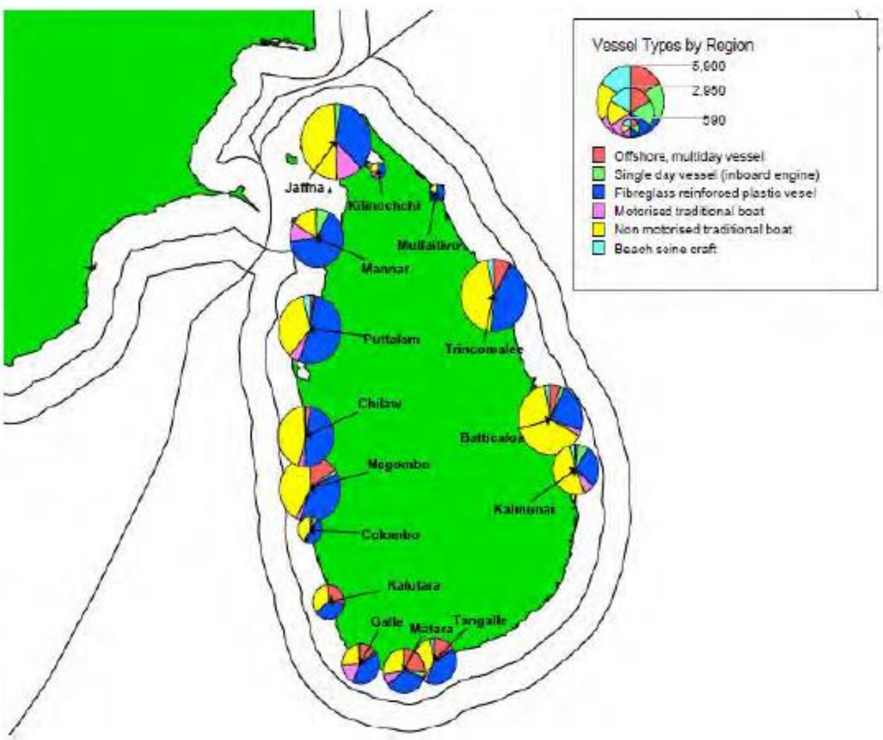

Figure 5 **Distribution of fishing vessels in Sri Lanka. Source: Ministry of Fisheries and Aquatic Resources, 2010.**

Gillnets main gear deployed in coastal and offshore fisheries of Sri Lanka, and are responsible for capture of nearly 80% of the coastal fish catch and 85 to 90% of the offshore fish catch. Gillnets account for 100% of the bycatch of non-tuna like species and elasmobranchs.

Annually 13000 turtles bycatch in Sri Lanka. Main gear responsible for bycatch, gillnets and longlines.
Turtles conservation programme in Sri Lanka found between November and June 2000 recorded 5241 turtles caught as bycatch. 20% of which were dead or killed and sold by the fishers, remaining 80% were release alive. Bycatch is dominated by olive ridleys (37%), loggerheads (30%), green (20%) and remaining 3% classed as unidentified. Turtle bycatch has increased, 4000 (1970's) to 13000 (2000). Attributed to the growth of the gillnet fishery fleet.

Indonesia

Of all the IOTC CPC's, Indonesia landed the most fish across all gears. When just gillnet gear, it ranked third in the world.

Thailand

Number of registered fishing gear in Thailand (1996) 17 950, Fish gillnet comprising 4.9% (872) of the total (Vibunpant et al., 2003).

Australia

Both tables below are from (Hobsbawn and Wilson, 2010)).

Table 3: Numbers of vessels fishing and catch (kg live weight) in Western Australian state fisheries by method.

Year	Dropline		Gillnet		Line (mainly handline)		Trawl		Troll	
	Catch (kg)	Vessels	Catch (kg)	Vessels	Catch (kg)	Vessels	Catch (kg)	Vessels	Catch (kg)	Vessels
2004	581	7	2 706	9	36 787	46	3 413	14	435 062	34
2005	42	6	2 617	8	46 348	30	4 989	4	310 445	22
2006	-	-	903	6	*10 600	30	23 357	10	283 641	18
2007	101	5	1 189	8	23 559	24	-	-	317 830	18
2008	-	-	5 010	9	12 632	22	-	-	333 614	26
2009	-	-	1 259	7	12 076	17	-	-	285 614	16

* total includes dropline catches for this year as individual method data could not be presented for state jurisdictional confidentiality reasons (i.e. < 5 active vessels using each method).

Purse seine fleet has fluctuated from 5 – 14 vessels since 1998. These vessels vary from 20 to 45m in length. There was a reported 11 sea turtles (4 leatherback, 4 loggerhead, 2 green and 1 olive ridley) during the monitoring that accounted for four percent of the total effort in the fishery . All were release alive.

Table 9: Observed annual estimated captures of species of special interest (seabird, turtle and marine mammals) for the Australian longline fleet, in the IOTC Convention Area, for 2005 to 2009 (source: AFMA scientific observer data).

Group	Common name	Scientific name	2003-2006	2007	2008	2009
Seabirds	Yellow nosed albatross	*Thalassarche chlororhynchos*	0	0	0	1
	Flesh footed shearwater	*Puffinus carneipes*	12	0	0	1
Marine turtles	Loggerhead turtle	*Caretta caretta*	4	1	2	1
	Hawksbill turtle	*Eretmochelys imbricata*	0	0	0	2
	Leatherback turtle	*Dermochelys coriacea*	4	0	2	4
	Green turtle	*Chelonia mydas*	2	0	0	0
	Olive Ridley turtle	*Lepidochelys olivacea*	1	0	0	0

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Survival probabilities of sea turtles in different ocean basins:

Loggerheads on the Great Barrier Reef = 0.87 (Chaloupka and Limpus, 2002)
Including immature transients change this to = 0.91 (Chaloupka and Limpus, 2002)

Loggerheads in the Mediterranean (mostly juveniles) = 0.73 (Casale et al., 2007)

Loggerheads in North Carolina (adult females) = 0.85 (Monk et al., 2010)

Immature **green turtles** in the Bahamas (accounting for confounding factors) = 0.891, but declined to 0.761 due to human induced pressure (Bjorndal et al., 2003)

Nicaragua greens (artisanal green turtle fishery off Tortuguero) = 0.55 (Campbell and Lagueux, 2005) but adult females from the nesting beach (foraging in the Caribbean) =0.82

Costa Rican (Tortoguero) green turtles = 0.85 (Troëng and Chaloupka, 2007).

Leatherbacks in PNG Houn Coast = 0.85 (Pilcher and Chaloupka, 2013)

Leatherbacks in French Guiana = 0.91 (Rivalan et al., 2005)

Leatherbacks in Playa Grande, Costa Rica = 0.78 (Santidrián-Tomillo, 2007)

Hawksbills in Varanus Island, WA =0.947 (Prince and Chaloupka, 2011)

Based on these values it is estimated that populations can grow if the total fisheries catch rate (including all size and sex classes) is <30% of the adult female spawner biomass, stable at 100% of spawner biomass, and experience declines at >100 % of the female spawner biomass. This assumes that adult females represents ~ 5% of the total population (=1/10 of the population x 1/2 to account for males and females).

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State of implementation of sea turtle mitigation measures across RFMOs.

An inspection of the most recent turtle mitigation resolution for other tRFMOs are summarise in Table 1. This summary provide the mitigation measures as stated in the resolutions and the level of implementation required, by each member states, of each item as either Mandatory, Optional or Recommended. The resolutions consulted are:

- WCPFC: Western Central Pacific Fisheries Commission 2005. Conservation and Management of Sea Turtles. Conservation and Management Measure 2008-03, Fifth Regular Session, Busan, Korea.
- IATTC: Inter-American Tropical Tuna Commission 2007. Resolution to mitigate the impact of tuna fishing vessels on sea turtles. Resolution C-07-03, 75th Meeting, Cancun, Mexico
- ICCAT: International Commission for the Conservation of Atlantic Tunas 2010. Recommendation by ICCAT on the by-catch of sea turtles in the ICCAT fisheries.
- IOTC: Indian Ocean tuna Commission 2012. On the conservation of marine turtles. Resolution 21/04 IOTC.

Table 1 *Comparison of management measures recommended for the mitigation of marine turtle bycatch across tRFMOs. M = Mandatory, O = Optional, NR = Not Recommended*

	IOTC 2012	ICCAT 2011	IATTC 2007	WCPFC 2005
General				
Estimate total mortality	M	NR	NR	NR
Estimate catch rate	NR	M	NR	NR
Bring onboard and foster recovery of any captured marine turtle	O	NR	O	O
Ensure that fishermen are aware of and use proper mitigation, identification, handling and de-hooking techniques	M	NR	NR	O
Carry onboard all necessary equipment for safe release of marine turtles	M	M	O	O
Gillnet vessels				
Carry onboard all necessary equipment for safe release of marine turtles	NR	NR	NR	NR
Longline vessels				
Carry onboard all necessary equipment for safe release of marine turtles	M	M	M	M
Use of circle hooks	O	NR	NR	NR
Use of finfish bait	O	NR	NR	NR
Purse seine vessels				
Carry onboard all necessary equipment for safe release of marine turtles	M	NR	NR	NR
Avoid encirclement	O	O	O	O
If encircled or entangled (innet/FAD), take measures to safely release any incidentally caught marine turtle	O	O	M	O
If a marine turtle is entangled in the net, stop net roll, disentangle and assist in its recovery before returning it to the water	M	NR	NR	M
Use FAD designs that reduce the incidence of entanglement	O	NR	O	NR

State of implementation of Resolution 12/04 under the IOTC.

We looked at the level of implementation of the resolution by IOTC's Contracting Parties and Cooperating non-Contracting Parties (CPCs) by scanning each CPCs national reports since 2006 to 2011. We provide here a summary of their level and progress of implementation; we also include turtle bycatch data reported. No information could be found for the level of implementation of the resolution by other bodies fishing in the Indian Ocean.

Resolution 12/04 (On the conservation of marine turtles) requires that CPCs undertake the following:

General

- Collect and report all interactions with marine turtles from logbook or observer data, and estimate total mortality of marine turtles incidentally caught in their fisheries.
- Report on progress of implementation of the FAO Guidelines and this Resolution.
- Fishermen are required to bring aboard, if practicable, any captured marine turtle that is comatose or inactive as soon as possible and foster its recovery.
- Fishermen must use proper mitigation, identification, handling and de-hooking techniques and keep on board all necessary equipment for the release of marine turtles.
- Undertake and report on research into minimising fisheries interactions with turtles
- Record turtle interactions in logbooks and report these to the appropriate authorities of the CPC.

CPCs with Gillnet vessels

- No specific measures

CPCs with Longline vessels

- Operators must carry line cutters and de-hookers.
- Use of whole finfish bait whenever possible

CPCs with purse seine vessels

- Avoid encirclement of marine turtles, and if a marine turtle is encircled or entangled, release it safely.
- Release all marine turtles observed entangled in fish aggregating devices (FADs) or other fishing gear.
- If a marine turtle is entangled in the net, stop net roll as soon as the turtle comes out of the
- water; disentangle the turtle without injuring it before resuming the net roll; and to the extent
- practicable assist the recovery of the turtle before returning it to the water.
- Carry and employ dip nets to handle marine turtles.
- Encourage such vessels to adopt FAD designs that reduce the incidence of entanglement of marine turtles according to international standards.

CPC's reporting on 12/04 resolution to the IOTC

Australia - Longline fishery fleets (Western Tuna and Billfish Fishery – WTBF; Eastern Tuna and Billfish Fishery – ETBF), purse seine fisheries – (Southern Bluefin Tuna Fishery – SBTF) and Skipjack Fishery.

2006 – 2007

- Australia provides regular observer data from longline vessels fishing in the Eastern Indian Ocean to monitor catch and effort reporting, bycatch and wildlife interactions to the IOTC.
- Catches of sea turtles have been reported in Southern and Western Tuna and Billfish Fishery (SWTBF) logbooks and during interviews with operators.
- Catches of sea turtles have been reported in Western Tuna and Billfish Fishery (WTBF) logbooks and during interviews with operators.

2008

- Research into the use of Circle hooks has been undertaken.
- Circle hooks are not mandatory on Australian longliners.

2009

- Implementation of Marine Turtle Mitigation Strategy to minimize bycatch in Australian longline fisheries which includes an education program for skippers and crew on safe handling and resuscitation techniques to employ should sea turtle interactions occur.
- Australia will implement 10 nm longline exclusion zones around known rookery sites.
- Research into the use of circle hooks has not yet been determined.

2010

- Carrying line cutters and de-hooking devices for the safe release of marine turtles is compulsory for the ETBF in 2010.

2011

- Carrying line cutters and de-hooking devices for the safe release of marine turtles is compulsory for all tuna longline vessels in the IOTC area.

<u>Turtle interaction data reported by the Australian fishery</u>

<u>Turtle interactions (SWTBF)</u>:

- 2003–04 - reported low catch rates of marine turtles.

<u>Turtle interactions (ETBF)</u>:

- Majority of interactions with marine turtle are with **green and leatherback turtles**.
- 2006 - 16 interactions were observed, with 13 released alive.
- 2007 - 17 interactions observed, with 15 released alive.
- 2008, 2009, 2010 - No interactions observed in the IOTC area.

<u>Turtle interactions (WTBF)</u>:

- Low levels of interaction with marine turtle interactions, during the years 2005-2006 due to the low levels of effort in the fishery.
- 2003 – 2006 (pilot monitoring programme – 4%of fishing effort) – **4 leatherback turtles, 4 loggerhead turtles, 2 green turtles and 1 olive ridley turtle**) were observed, with all released alive
- 2007 - (1.42% fishing effort) **1 loggerhead turtle** reported and released alive.
- 2008 (12.72% of fishing effort) – **2 loggerhead turtles, 2 leatherback turtles**. 1 dead 3 released alive. No information is available on the survivorship of these released sea turtles.
- 2009 (8.48% of fishing effort) - **1 loggerhead turtle, 2 hawksbill turtles and 4 leatherback turtles hooked**, with all released alive.
- 2010 – **1 leatherback turtle interaction** reported and released alive

Number of marine turtles caught by the Australian WTBF fishery							
Common name	Species name	2003 -2006	2007	2008	2009	2010	Total
Loggerhead	*Caretta caretta*	4	1	2	1	0	8
Hawksbill	*Eretmochelys imbricata*	0	0	0	2	0	2
Leatherback	*Dermochelys coriacea*	4	0	2	4	1	11
Green	*Chelonia mydas*	2	0	0	0	0	2
Olive Ridley	*Lepidochelys olivacea*	1	0	0	0	0	1

Belize– Longline fishery fleet

2011

- Belize by-catch procedure is determined based on the scientific committee's recommendations and in compliance with resolutions and reporting obligations for marine turtles.
- Fishing vessels operators are encouraged to implement a catch and release system sea turtles.
- Longline vessels are required to:
    1. Use circle hooks.
    2. Carry on board and employ the necessary de-hookers, line cutters, and scoop nets for the prompt release of incidentally caught sea turtles.
    3. Continue to improve fishing techniques that mitigate turtle bycatch, such as appropriate combinations of circle hooks and bait, setting depth.
    4. Crew members are required to adopt measures aimed at ensuring that sea turtles captured and released alive, during longline operations.
    5. Required to report any interactions with marine turtles.

No turtle interaction data were reported by the Belize fishery.

China - Longline fishing fleet

2006

Fisheries management policies adopted include:

- conduct scientific research around the application of mitigation measures, such as using the circle hook and tori lines aimed at preventing or reducing the incidental catch of marine turtles, sharks and sea birds.
- encouraging scientific research around the incidental catch of sea turtles and sea birds.
- request fishing companies to report incidental catch of sea turtles.
- running training courses on data formulation and collection for fisheries management and technical information related conservation of sea turtles and sharks.

2007 – 2008

- Request fishing companies to report situation on incidental catch of sea turtles and sea birds from 2008.

2009 - 2010

- All Chinese longline vessels have been equipped with de-hooking devices to reduce sea turtle mortality.
- All vessels required to replace j-hooks with circle hooks.

2011

- The observer is responsible for recording species-specific interactions of marine turtles in longline fisheries, including number of caught, fate, and release status.
- **There is no national plan of action for marine turtles.**

Turtle interaction data reported by the Chinese fishery (non-raised observer data)

- In 2008 observer reports only one turtle caught no information on whether it was alive or dead.

Marine turtle bycatch on Ice longliners:

2006 – 2010

Species unknown – nil catches

Marine turtle bycatch on Deep freezing longliners :

2006 – 2010

Species unknown – nil catches

Taiwan, Province of China – Longline fishery fleet

2009

- Observer programme in place

- Observers are required to record bycatch species such as turtles.

2010-2011 no reports

No turtle interaction data were reported by the Taiwanese fishery.

European Union – Purse seine and longline fishery fleets

Portuguese EU – Longline fishery fleet

2009 – 2011:

- All IOTC Resolutions and Recommendations concerning Sharks, Seabirds and Marine Turtles are broadly publicized among fishermen operating in the area.
- Guidelines on how to safely handle and release marine turtles has been provided.
- Fishermen are encouraged to release marine turtles accidentally caught, after gear removal.
- All vessels have/keep on board the necessary equipment for the release of live turtles.
- A new system has been implemented to improve data reporting interaction with marine turtles by fishing vessels operating in the area.

Turtle interaction data is reported since 2011 by the Portuguese fishery.

Spain EU – Purse seine and longline fishery fleet

2006 - 2008

- Research around FAD's to find a prototype that will result in fewer entanglements of turtles without reducing target catch.
- Research around hooks and bait type aimed at reducing marine turtle by-catch

2009 - 2011

- Rates of interaction between turtles and longliners is being collected and reported.
- Spain collects data though the observer programme.

Turtle interaction data reported by the Spanish fishery

Turtle interactions and mortality rate for 1,724,840 hooks from 2006-2009

	Interaction rate	Mortality rate
2006	1.23E-05	1.540E-06
2007	2.174E-05	0
2008	0.00042	0.000102
2009	0	0

2010 –NIL interactions observed during 106,620 total hooks set.

2011 – NIL interaction with turtles reported.

France EU and territories - Purse seine and longline fishery fleet

2010 - 2011

- There is no national plan of action for turtle bycatch for French Overseas Territories and French EZZ in the Indian Ocean.
- France has ratified the IOSEA regional convention for the conservation of marine turtles.
- Research into alternative FAD's that minimizes turtle entanglement.
- There is an observer programme in place for purse seiners and longliners (over 10m) that provides more that the 5% coverage required by IOTC.
- Identification cards are being distributed to the fishery.
- Catch rates and mortality of marine turtles are recorded by the fishery.

Turtle interaction data reported by the French fishery

2007-2009 **Three marine turtles** were caught after the launching of the observer programme in 2007, all where released alive (see table).

2010 **Seven marine turtles** were caught all released alive but one dead loggerhead.

Number and rate of marine turtles interaction reported by observers on French fishery

Common name	Species name	2007 -2009	CPUE (*1000)	2010	CPUE (*1000)	Mortality rate (*1000)
Loggerhead	*Caretta caretta*	2	0.012	4		0.008
Hawksbill	*Eretmochelys imbricata*			1	0.058	0.008
Leatherback	*Dermochelys coriacea*	1	0.006	1	0.058	0.008
Green	*Chelonia mydas*			1	0.058	0.008
Olive Ridley	*Lepidochelys olivacea*					

India - Longline fishery fleet

2006 – 2007

- Information on incidental catches including turtles are being collected in national and international projects being implemented in the Indian EEZ.

2008 – no national report submitted.

2009 – 2010

- The introduction of logbooks which advise the reporting on the occurrence of turtles and other bycatch is being proposed for the longline fishery.
- Awareness campaigns for the conservation of marine turtles under the Wildlife Protection Act, have been implemented.

2011

- Indian longline vessels are advised to carry de-hooking devices and line cutters while on fishing operations and pamphlets on safe release of sea turtles have been distributed.
- An observer programme is being considered

Turtle interaction data reported from research vessels

Studies conducted by Fishery Survey of India showed that, the observed hooking rate of sea turtles in the longline fishery in the Indian EEZ during 2005-2008 was 0.108 turtle/1000hooks (Varghese et al., 2010).

[Varghese, S. P. Varghese, S. and Somvanshi V. S. 2010. Impact of tuna longline fishery on sea turtles of Indian seas. Current Science 98(10): 1378-1384.]

No turtle interaction data were reported by the Indian fishery.

Indonesia– Longline fishery fleet

2008-2010

- No mention of turtle by-catch, mitigation measures, research or reporting thereof.
- Observer program in place since 2005

2011

- No national plan of action has been drafted, however efforts to reduce turtle bycatch are being implemented through WWF-Indonesia and the observer programme
- Observers have captured turtle bycatch data since 2005.

Turtle interaction data reported by the Indonesian fishery.

2005 – 2010

- A total of **51 marine turtles** were caught with dead **14 and 37** released alive.

  5 species were recorded:

  Leatherback turtle

  Olive Ridley turtle – the most common species encountered

  Loggerhead turtle

  Hawksbill turtle

  Green turtle

2011

- **Leatherback turtle** was recorded in July 2011 (130 40.234” S and 1170 04.284” E)
- **Olive ridley turtles were recorded several times**, March, July, and November 2010 and June 2011.

Iran– Purse seine and longline fishery fleets

2010 - 2011

- Training courses and information brochures have been provided by the Iranian Fisheries Organization on bycatch issues, including marine turtles.
- Iran has implemented an observer programme.
- No data on turtle bycatch are available.

No turtle interaction data were reported by the Iranian fishery.

Japan – Longline fishery fleet

2006

Japan launched programs to reduce fishery interactions and to conserve nesting populations of sea turtles, through the following actions:

- the collection of scientific data, including observer data whenever feasible;
- the development and implementation of practical measures for monitoring incidental catch including, among others, the introduction of electronic observer techniques;
- the development and use of technology to reduce incidental catch and improve post-release survival rates for sea turtles;
- vigorously promote the immediate use of appropriate combinations of circle hooks and squid bait, including their use on a trial basis, to reduce sea turtle incidental catch and improve post-release survival rate;
- The preparation of the drafting of the national plan of action on sea turtle conservation and fisheries is underway;
- Research into use of circle hooks and bait combinations to reduce marine turtle bycatch in the longline fishery;
- Observer programme implemented

2007 - 2008

- No information on turtle by-catch provided

2009

- Japan committed to collected information on turtle catches.

2010

- Bycatch is photographed and the photos are returned to Japan for expert identification, which generates delays in the data availability

2011

- Japan has been taking actions in accordance with the FAO Guidelines on sea turtle by-catch. Specific actions are not specified.

Turtle interaction data reported by the Japanese fishery (non-raised observer data)

July 2010 – January 2011 – observations from 6 Longline vessels

Common name	Species name	2010 – 2011
Leatherback	*Dermochelys coriacea*	1
Loggerhead	*Caretta caretta*	1
Olive ridley	*Lepidochelys olivacea*	12

Kenya – Purse seine and longline fishery fleets

2007

- No mention of turtle by-catch, mitigation measures, research or reporting thereof.

2008

- A National action plan for turtles and seabirds as well as an observer programme is being discussed by authorities.

2009

- Funds for the preparation of the national plan of action for the sharks, turtles, sea birds and marine mammals will be set aside during the next financial year in order to execute requirement by IOTC.
- Observer programme and port monitoring, training courses will take place during 2009/2010 which will allow the collection of by-catch data.

2010

- Longline observers have not been able to board due to piracy threat. Port sampling programme operational since 2008 had only four purse seine vessels call in 2009 due to piracy, with no bycatch being reported.

2011

- The national conservation strategy and action plan for sea turtles 2010- 2014 was completed. It aims to reduce and mitigate the threats to marine turtles and enhance ecological, social, and cultural benefits of marine turtles.

No turtle interaction data were reported by the Kenyan fishery.

Korea - Longline fishing fleet

2006 – 2008

- No mention of turtle by-catch, mitigation measures, research or reporting thereof.

2009

- Observer turtle bycatch reported for 2006- 2009.

2010

- Information on turtle bycatch is to be captured on logsheet from 2011.
- Species identification guides were made available for by-catch species identification.
- Initiation of an observer programme

- No turtle bycatch reported

2011

- Korean National Action Plan for the Conservation and Management of Marine turtles will be drafted by 2012.
- Interaction and mortality of marine turtles has been collected through the national observer program. But **fishermen** are requested to record them from 2011 onwards.
- No research on turtle bycatch mitigation measures is being carried out in the IOTC area.
- No turtle bycatch reported

Turtle interaction data reported by the Korean fishery (non-raised observer data)

Observed annual catches of marine turtles

Common name	Species name	2006	2007	2008	2009	2010	2011
Loggerhead	*Caretta caretta*	0	0	NA*	7	ND	ND
Olive Ridley	*Lepidochelys olivacea*	0	0	NA*	29	ND	ND

*No observers deployed during 2008; ND – No data reported.

Mauritius – Longline fishery fleets operate in the Indian Ocean as well as a coastal FAD associated fishery and sports fishery.

2008 – 2009

- No mention of turtle by-catch, mitigation measures, research or reporting thereof.

2010

- Mauritius reports that it is implementing all the recommendations of the Scientific Committee. No mention of how or what specific recommendations are being implemented.
- No mention of turtle by-catch, mitigation measures, research or reporting protocols for turtles.

2011

- The Mauritian Fisheries and Marine Resources Act 1998 (FMRA) provides the necessary legal framework for the protection of any marine turtles.
- Operators of all longline vessels have to carry line cutters and de-hookers in order to facilitate the appropriate handling and prompt release of marine turtles caught or entangled.

No turtle interactions data were reported by the Mauritian fishery.

Philippines – Longline fishery fleet

No national reports available/submitted

- There is no national observer programme in place

Turtle interactions data reported by the Philippine fishery

2008-2011 Interactions with marine turtles reported to be nil.

Seychelles – Purse seine and longline fishery fleets

2007 – 2008- 2009

- No mention of turtle by-catch, mitigation measures, research or reporting thereof.

2010

- Assurance from the government that the fishery is in compliance with IOTC conservation and management measures and IOTC Scientific Committee' s recommendations, regarding bycatch species including marine turtles. No mention of what specific measures are in place.
- No information on any record of turtle bycatch is given.

2011

- Steps have been taken to implement a National Scientific Observer Programme.
- Research projects focusing on bycatch mitigation measures, include promoting the use of ecological and biodegradable FAD's in the purse seine fishery, and setting strategies for longline vessels.

No turtle interactions data were reported by the Seychelles fishery.

Sri Lanka – Small scale gillnets and longline fishery fleet

2007

- The nature of the fleet and lack of resources has not enabled by-catch data to be collected.

2008 - 2010 No national reports submitted.

- No data on turtle by-catch or mitigation measures.

2011

- No more purse seine fishing permits will be granted in the neritic or oceanic waters.
- Government are running incentive schemes to induce gillnetters to change over to longline fishing and thus minimize negative impacts to marine turtles and other bycatch species.
- Awareness programs urging fishermen to release marine turtle when accidentally caught by fishing gear are being run by conservation agencies.
- There is no observer programme in place

No turtle interactions data were reported by the Sri Lanka fishery.

South Africa - Longline fishery fleet

2007 - 2011

- South African government has educated skippers on release procedures for turtles.
- The use of circle hooks are encouraged as stated in the permit conditions.

- Information on turtle interaction is provided to the IOTC.
- South Africa is using the observer data collected since 1998 to assess the impact of longline fisheries on seabirds, turtles and sharks and to investigate various mitigation and management measures.
- De-hooking devices and line cutters are mandatory on all longline vessels.
- Research into impacts of longline fishing on marine turtles.
- South Africa collects data though the observer programme.

Turtle interaction data reported by the South African fishery

Turtle catch rates 2000 – 2003: Average 0.05 turtles.1000 hooks^{-1}

The most common turtle caught was the **loggerhead (39%)** followed by the **leatherback (23%).** Green and hawksbill turtles were also recorded but in small numbers. A large number of turtles (32%) were unidentified by the observer.

Number of turtles caught between 2006 – 2010.

Common name	Species name	2006	2007	2008	2009	2010	Total	%
Green	*Chelonia mydas*			1		1	2	2
Leatherback	*Dermochelys coriacea*	1	14	5	2	17	39	40
Loggerhead	*Caretta caretta*	1	13	5	4	2	25	26
Olive Ridley	*Lepidochelys olivacea*	-	6	2	1	-	9	9
Unidentified		1	9	2	6	4	22	23

Thailand – Purse seine and longline fishery fleet

2006 – 2007 - 2009 – 2010

- Landing surveys are conducted where information on by-catch species is collected. There is no mention of which by-catch species are caught.
- No mention of turtle by-catch, mitigation measures, research or reporting protocols for turtles.

2011

- Thailand active involvement in turtle conservation as stated in its Fisheries Act 1974, which prohibits fishing of turtle. Any turtle accidentally caught alive during fishing activity, has to be released.
- There are no available records of the number of accidentally caught turtles by the Thai fishery.
- No observer programme in place.
- Port sampling is carried out by Andaman Sea Fishery Research and Development Center (AFRDEC) and collects by-catch species information. No mention of what bycatch species information is collected or how it is reported.

No turtle interactions data were reported by the Thai fishery.

Vanatu – Longline fishery fleet

2008 - 2010

- No turtle by-catch reported

2011

- Vessels conducting fishing activities in all areas are required to observe the management regulations developed by related RFMOs on protecting the health of ecosystem.
- Operators are encouraged to implement a catch and release system for seabirds and sea turtles, such as using weighted branch lines and night setting with minimum deck lighting.
- Use of circle hooks is encouraged.
- No observer programme in place

Turtle interactions data reported by the Vanuatu fishery

2010 and 2011 Nil turtle bycatch reported.

CPC's that have submitted no reports on 12/04 resolution to the IOTC

Eritrea, Guinea, Indonesia, Madagascar, Maldives, Malaysia, Oman, Pakistan, Sierra Leone, Comoros, Sudan, Tanzania, Yemen, Mozambique 2010 and thereafter.

CPC's exempt to reports on 12/04 resolution to the IOTC

United Kingdom BIOT has no active fleet, Senegal is a non contracting party and has had no activity since 2007, Mozambique is a non contracting party and the resolution has not applied 'till 2009, but is applicable thereafter.

Recommendations

1) Amend the National Report template so that CPCs report against the prescribed mitigation measures (by fishery) according to the conservation measure in force.

2) Require that each CPC submits to the Secretariat, possibly as an annex to the National Reports, a full copy of the fishing permit conditions for the period of the report.

3) All observer reports and national reports should make clear how many turtles (by species) were captured and released alive and how many were dead or died before release.

4) Bycatch numbers should be converted to a rate per observed effort and raised to total fishing effort (by fishery). Alternatively, catch and mortality rates should be calculated and total fishing effort, and proportion of effort observed (to indicate level of confidence in calculations) should be reported.

List of National reports consulted

- **Australia** IOTC-2006-SC-INF17, IOTC-2007-SC-INF13, IOTC-2008-SC-INF09, IOTC-2009-SC-INF01, IOTC-2010-SC-Inf01, IOTC-2011-SC14-NR01
- **Belize** IOTC-2011-SC14-NR02
- **China** IOTC-2006-SC-INF16, IOTC-2007-SC-INF12, IOTC-2008-SC-INF21, IOTC-2009-SC-INF19, IOTC-2010-SC-Int07, IOTC-2011-SC14-NR03
- **Comoros** IOTC-2010-SC-Inf04 – not a relevant fishery
- **EU-France** IOTC-2007-SC-INF05, IOTC-2008-SC-INF11, 2009 part of EU report,
- **EU-Spain** IOTC-2007-SC-INF04, IOTC-2008-SC-INF07, 2009 part of EU report,
- **European Union** IOTC-2009-SC-INF02, IOTC-2010-SC-Inf05, IOTC-2011-SC14-NR06
- **France Territories** (IOTC-2007-SC-INF10)
- **India** IOTC-2006-SC-INF21, IOTC-2007-SC-INF19, IOTC-2009-SC-INF05, IOTC-2010-SC-Inf12, IOTC-2011-SC14-NR09
- **Iran** IOTC-2010- SC-Inf09, IOTC-2011-SC14-NR11
- **Japan** IOTC-2006-SC-INF08, IOTC-2007-SC-INF09, IOTC-2008-SC-INF19, IOTC-2009-SC-INF07, IOTC-2010-SC-Inf11, IOTC-2011-SC14-NR12 Rev_1
- **Kenya** IOTC-2007-SC-INF20, IOTC-2008-SC-INF22, IOTC-2009-SC-INF09, IOTC-2010-SC-Inf06, IOTC-2011-SC14-NR13
- **Korea** IOTC-2007-SC-INF07, IOTC-2008-SC-INF20, IOTC-2009-SC-INF16, IOTC-2010-SC-Inf14), IOTC-2011-SC14-NR14 - R.O.
- **Madagascar** IOTC-2009-SC-INF04, IOTC-2010-SC-Inf10, IOTC-2011-SC14-NR15
- **Maldives** IOTC-2010-SC-Inf15,
- **Mauritius** IOTC-2008-SC-INF18, IOTC-2009-SC-INF17, IOTC-2010-SC-Inf08, IOTC-2011-SC14-NR18
- **Malaysia** IOTC-2011-SC14-NR16
- **Mozambique** IOTC-2011-SC14-NR30
- **Senegal** IOTC-2011-SC14-NR31
- **Seychelles** IOTC-2007-SC-INF11,(IOTC- 2008-SC-INF16, IOTC-2009-SC-INF21, IOTC-2010-SC-Inf19, IOTC-2011-SC14-NR22
- **Sri Lanka** IOTC-2007-SC-INF18, IOTC-2011-SC14-NR24
- **South Africa** IOTC-2007-SC-INF14, IOTC-2008-SC-INF17, IOTC-2009-SC-INF12, IOTC-2010-SC-Inf16, IOTC–2011–SC14–NR32
- **Taiwan** IOTC-2009-SC-INF25
- **Thailand** IOTC-2007- SC-INF15, IOTC-2008-SC-26, IOTC-2009-SC-INF20, IOTC-2010-SC-Inf13 IOTC-2011-SC14-NR27 Rev_1
- **United Kingdom** IOTC-2007-SC-INF06, IOTC-2008-SC-INF12, IOTC-2009-SC-INF08, IOTC-2010-SC-INF03, IOTC-2011-SC14-NR28
- **Vanatu** IOTC-2011-SC14-NR29