SCRS/2014/064 Collect. Vol. Sci. Pap. ICCAT, 71(6): 2862-2877 (2015)

MARINE TURTLE ENCOUNTERS IN THE SURFACE LONGLINE FISHERY IN NORTH ATLANTIC AREAS: 10º-30º N / 15º-35º W

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SUMMARY

*This paper describes encounters of five species of marine turtles (*C. caretta, D. coriacea, L. olivacea, L. kempii, C. mydas*) observed during surface longline fishery in North Atlantic areas (10º-30º N / 15º-35º W) in the 1997-2012 period. A total of 544982 hooks were analyzed; 7.5% came from an experimental cruise which had purposely selected this zone to test the effect of different hook and bait types on by-catch rates of marine turtles. The remainder observations were obtained during routine commercial fishing operations. A total of 438 encounters with marine turtles were recorded over the course of these years, either because the animals bit the bait-hook or because they became entangled in the branchlines. Of these, 89% were released alive. The interaction and mortality rates for species, areas and years combined were 8.0e-04 and 9.0e-05 individuals per hook, respectively. These rates were, however, lower when only recordings from regular commercial fishing were considered. It should not be assumed that the resulting rates are representative of or can be extrapolated to other fishing zones.*

RÉSUMÉ

*Le présent document décrit les interactions avec cinq espèces de tortues marines (*C. caretta, D. coriacea, L. olivacea, L. kempii, C. mydas*) observées dans le cadre de la pêcherie de surface palangrière opérant dans des zones de l'Atlantique Nord (10º-30º N / 15º-35º W) entre 1997 et 2012. Un total de 544.982 hameçons a été analysé, 7,5% d'entre eux provenaient d'une sortie expérimentale qui avait intentionnellement sélectionné cette zone afin de tester l'effet de différents types d'hameçons et d'appâts sur les taux de prise accessoire des tortues marines. Le reste des observations a été obtenu pendant des opérations routinières de pêche commerciale. Un total de 438 rencontres avec des tortues marines a été consigné tout au long de ces années, soit car les animaux avaient mordu aux hameçons appâtés ou bien car ils s'étaient emmêlés dans les avançons. Parmi ceux-ci, 89% des tortues ont été remises à l'eau à l'état vivant. Les taux d'interaction et de mortalité pour les espèces, zones et années combinées s'élevaient à 8,0E-04 et 9,0E-05 spécimens par hameçon respectivement. Ces taux étaient toutefois très faibles lorsque seules les données de la pêche commerciale étaient prises en considération. On ne saurait donc supposer que les taux obtenus sont représentatifs ou peuvent être extrapolés à d'autres zones de pêche.*

RESUMEN

Se describen los encuentros de 5 especies de tortugas marinas (C. caretta, D. coriacea, L. olivacea, L. kempii, C. mydas) *observados en las actividades de pesca con palangre de superficie en áreas del Atlántico Norte (10º-30º N / 15º-35º W) durante el período 1997-2012. Un total de 544982 anzuelos fueron analizados de los cuales el 7.5% proceden de una campaña experimental que seleccionó premeditadamente esta zona para testar el efecto de diferentes tipos de anzuelos-cebos sobre las tasas de captura incidental de tortugas marinas y el resto pertenecen a observaciones obtenidas durante pesca comercial regular. En total se registraron 438 encuentros con tortugas marinas durante esos años, bien por mordedura del cebo-anzuelo o por enredos con las brazoladas, de las cuales el 89% se correspondieron a individuos liberados vivos. Las tasas de interacción y mortalidad para especies, áreas y años combinados fueron respectivamente de* $8.0E^{-04}$ *y* $9.0E^{-05}$ *individuos por anzuelo. Sin embargo estas tasas fueron menores cuando solamente se consideraron aquellos registros procedentes de la pesca comercial regular. Las tasas obtenidas no deben ser asumidas como representativas ni extrapolables a otras áreas de pesca.*

KEYWORDS

Marine turtles, Longline, Interaction, By-catch, Atlantic

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Introduction

Marine turtles show nest-site fidelity between years and during this stage of life they must face a wide variety of threats. However, these species also suffer impacts in the marine environment where they spend most of their lives. Some of the most widely known anthropogenic threats affecting the different stages of their life cycle are: the degradation or destruction of their nesting beaches owing to urban development and tourism, the artificial regeneration of beaches or changes in currents caused by coastal construction (marinas, breakwaters, etc.), the destruction of nests by vehicles or dredging, the collection of eggs for human consumption in some coastal communities, newborn sea turtles disoriented by lights from the coast, the use of shells as souvenirs and turtle meat as food, the ingestion by marine turtles of plastic and other floating debris, collision with boats, spills of oil and other pollutants.

Incidental capture during oceanic fishery operations may also be a source of interaction and mortality, since turtles may occasionally become trapped as bycatch in some of the fisheries carried out in their distribution and migration zones (Plotkin 1995, Hays *et al.* 2006). However, in many regions coastal artisanal fishery may be one of the major causes of interaction and mortality on these species, although its impact is not widely known (Moore *et al*. 2010).

Bycatch species are unwanted by the fleets, as they usually cause operational problems during the fishing operations and put the crew at risk when they attempt to release these specimens. Moreover, there is usually little correlation between the distribution of the target species and bycatch, which makes it difficult to obtain reliable and representative estimates on these interactions (Wallace *et al.* 2008). It is necessary to characterize the different fishery activities in order to design protocols and obtain reliable estimates on the level of impact on bycatch species. In some cases, these estimates are not very realistic since standardized methods are not used to obtain them (Lucchetti and Sala 2010). Therefore, it is advisable to lay down general *ad-hoc* strategies to minimize these encounters, such as avoiding areas and time periods when concentrations are high in favor of alternative fishing grounds offering similar yields; making technical changes to the fishing gear; promoting release; developing and sharing educational information on how to reduce bycatch; offering assessment on the careful handling of specimens to foment their release and survival, etc. Offering incentives to the fleet is an effective way to encourage the application of mitigation measures as well as the development of fishing methods and fishing gear configurations that have been properly tested and aimed at significantly decreasing incidental or accidental captures. In general, the technical measures implemented to protect bycatch species are usually accepted by the fishermen, as long as they are reasonable, if the effectiveness has been tested by those affected and if these methods are explained and discussed and can, in fact, be applied without causing any substantial economic impact or danger to the crew. In this way, the fishermen themselves often become the most avid promoters and allies of these protection measures.

Conventions, laws, decrees and Action Plans envisage measures for the protection of marine turtles, such as the Bonn Convention, Annex I; the Bern Convention, Annex II; CITES 1, Law 3/88 March 4, 1988 of Catalonia, Annex II and Decree 151/2001 August 1, 2001 of the Canary Islands, among others (Aguilar 2010). Many studies have been designed on the basis of these and other international and national recommendations (i.e. Aguilar *et al.* 2011, Álvarez de Quevedo *et al*. 2013, Báez *et al.* 2007[a, b], 2010[a, b], 2013; Camiñas *et al.* 2006, Carranza *et al.* 2006, Casale 2011, Lucchetti and Sala 2010, Moore *et al.* 2010, Wallace *et al.* 2008) with the aim of proposing conservation priorities for these species (Wallace *et al.* 2011). While some countries have already implemented actions for the protection of marine turtles, ICCAT has recently started recommending that the Contracting Parties conduct studies on the interactions between the fisheries in their convention areas and sea turtles, with a view to shed light on the impact of these fisheries and their relative importance versus other sources of impact unrelated to these fishery activities. On the basis of preliminary analyses, ICCAT has implemented specific recommendations (i.e. Rec. 10-09, Rec. 03-11) in order to improve our knowledge on these interactions in the respective fisheries of tuna and tuna-like species in their convention area.

Several studies have pointed out that encounters with sea turtles usually take place in specific areas and times, and more intensely with surface fishing gears like drift gillnets, pelagic-semipelagic trawl fishing, purse-seine and surface longline, among others. The Autonomous Community of Andalusia has addressed this problem in the Red Book of Vertebrates in Andalusia (Pleguezuelos *et al*. 2002) in which trawl nets are identified as a threat to the conservation of marine turtles. Other authors blame drift gillnets as being the cause of the high mortality of turtles through drowning after they become entangled (Lucchetti and Sala 2010). The European Union’s LIFE Program developed a study on the “Conservation of cetaceans and turtles in Murcia and Andalusia (2002-2006)” to assess the effects of longline fishing on these species (Anguita 2003).

Surface longline fishing has been identified as a potentially significant factor in the dwindling populations of some marine turtles since the animals may get caught in the hooks or entangled in the fishing gear in some zones. Generally, hard-shell turtles get hooked when trying to bite the bait, whereas soft-shell turtles tend to become hooked externally and/or tangled in the gear by chance. Moreover, factors specific to each individual turtle such as size, a predisposition to feed in certain areas rather than others, vital signs, etc. may affect capture and survival. Fishing areas with high rates of turtle sightings do not necessarily show the highest rates of interaction with fishing activities, probably due to differences in their behaviour (Dalleau *et al*. 2014).

In addition to spatial and temporal factors, there are others related to longline operations that could affect the interaction and survival of turtles, such as hook type and size, depth and soak time, distance from the coast, bait type and size, oceanographic and meteorological conditions, etc. All of this information along with data on interaction rates, the position affected by the hook and where mortality occurs, must be compared with the yields of the target species to develop management plans tailored to each individual case in order to minimize unwanted impacts. When turtles are caught with a hook in their mouths, it is known that immediate mortality is usually low. However, barring certain exceptions, there is very little knowledge on medium and long term mortality and/or on the type of hook used. Moreover, very few studies have focused on mortality due to hook ingestion which may also entail the swallowing of a section of the remaining branchline after release. In this regard, experiments carried out with pop-up tags estimated a "post-release" mortality of around 30% under certain circumstances during the following three months (Álvarez de Quevedo *et al.* 2013). Nevertheless, recent studies performed in captivity using X-rays and considering different hook types and other factors have led to the adoption of the recent recommendations on protocols to achieve a higher post-release survival rate in these species.

The main conclusion of the Working Group SGRST-SGFEN-05-01of the EU SETCF (Anon. 2005) indicated that hook type/design/size affected the bycatch of soft-shell turtles as leatherbacks. However, hard-shell turtles like the loggerhead seemed to be more affected by hook size and particularly the type and size of bait used. Although some countries have encouraged the use of different devices like certain types of circular hooks, many experiments have found that bait type is the most significant factor able to explain the interaction and mortality rates of sea turtles, owing either to individual preferences for different types of bait or, what is more likely, to the greater or lesser ability to bite and swallow some bait types versus others. In this sense, the "squid" bait type, and the ingestion of the remaining section of the branchline after the release of the turtle have been described as the main factors that cause the highest rates of interaction and post-release mortality in the sea turtles (Lucchetti and Sala 2010).

In keeping with the above, during the 2002-2008 period, the IEO developed several projects related to the interaction between large pelagic fisheries and marine turtles. The Project "The reduction of the impact of loggerhead turtle bycatch on surface longlines" (LIFE02NAT/E/8610) was carried out from 2002-2006. In 2005 a Pilot Program was designed using surface longline targeting swordfish in the Mediterranean to study the effect of different factors (hook type and size, hook soaking depth, bait type and size) as a means to reduce or eliminate the capture of juvenile swordfish (*Xiphias gladius*) and to reduce the incidental capture of sea turtles (i.e. *Caretta caretta*) (De la Serna *et al.* 2007). In 2005 another experiment with surface longline was conducted in the Southwest Indian Ocean (Ariz *et al.* 2005, 2006) to test alternative hooks and different bait types for the purpose of minimizing marine turtle bycatch and to study their impact on commercial catches. Similar experiments were carried out in 2005 and 2006 using the surface longline gear in the North and South Atlantic to study the effect on both target and bycatch species, including turtles and seabirds (Mejuto *et al.* 2008). The conclusions drawn were highly consistent among all these projects as well in another study carried out via consulting and supported by DG Mare-EU (Mejuto *et al*. 2006, 2008; García-Cortés *et al.* 2009, Anon. 2008). The use of squid as bait seems to produce a significant increase in the hooking rates of sea turtles, regardless of the hook type used. Additionally, in the Mediterranean Sea where the interaction with sea turtles was found to be higher than in other areas surveyed, factors other than hook type were significant and clearly much more important in terms of reducing the interaction of the fishing activities with marine turtles and swordfish juveniles, such as the longline style and the bait type used (De la Serna *et al.* 2007, 2008, Báez *et al.* 2010[a]).

In November 2006 the Secretary General of Maritime Affairs (EU-Spain) implemented a Project called "Technologies for the reduction of the impact of the incidental capture of threatened marine species in fisheries" (Sagarminaga 2008). The efforts focused on the design of an effective fishing line cutter which was distributed among the fleet with the instruction manual designed by the CRAM, to improve the handling of turtles on the basis of past experience. It highlighted the importance of several factors to attain a higher survival rate in the turtles caught and released live: a) minimum possible turtle handling, b) avoiding traction on the line and hook, c) the importance of cutting the remaining section of the line as short as possible and as close as possible to the hook, d) release of the turtle, if possible, without hauling it on board. Moreover, actions have been carried out in the framework of different research projects dealing with the study of interactions with the fishery of tuna and tuna-like species and marine turtles (Mejuto *et al.* 2006) under which monitoring programs have been set up to release marine turtles captured live. Measures have also been proposed to reduce their capture and to ensure careful handling leading to release and survival.

It has sometimes been possible to obtain bycatch estimates from the vessel-areas where monitoring programs existed. However, according to current data (o.c.) only a limited number of projects were carried out on bycatch (including marine turtles) in the different fisheries, and most of them were conducted in the Mediterranean regions where the highest rates have been reported. In addition, some studies related to the importance of the nesting zones have been carried out in the intertropical and subtropical NE Atlantic zones (Carranza *et al.* 2006, Marco *et al.* 2011, 2012).

The activity of a considerable part of the Spanish surface longline fleet is targeting swordfish (*Xiphias gladius*) by means of night-time sets. This fleet underwent major expansion in the Atlantic and Mediterranean starting in the 1970s with operations aimed basically at coastal areas. The fleet gradually increased its fishing pressure to the North Atlantic, expanding geographically to more temperate oceanic zones. Later on it spread from the temperate zone to warmer waters and in the mid 1980s it branched out to the South Atlantic and in 1990 some of its vessels started heading towards other oceans. The fishing gear used by the Spanish surface longline vessels targeting swordfish from the beginning of their activity in the Atlantic Ocean until the end of last century was the “traditional longline” style, equipped with plurifilament main line with “J” or derivative hook shapes, soaked at night, with the predominant bait being mackerel. However, at the end of last century most boats shifted to the “American” style, a modified version of the original “Florida style” longline (Hoey *et al*. 1988). The most recent use of the mechanized surface monofilament longline has also introduced or combined squid as a frequent bait type, along with some changes in hook types and gear configuration (Mejuto *et al.* 2011). The shift from the traditional longline style to the new imported one took place very quickly, especially in some geographical regions. The use of squid in some cases in the new longline style instead of mackerel has likely produced a higher rate of interactions on the marine turtles.

The leatherback turtle (*Dermochelys coriacea*) and the loggerhead turtle (*Caretta caretta*) are the species most frequently observed, followed by the green turtle (*Chelonia mydas*) and the olive ridley turtle (*Lepidochelys olivacea*). Marine turtles are reptiles and therefore their metabolism is affected by the temperature of the environment. The loggerhead turtle has a temperature preference of around 18ºC. The geographic boundaries of the green turtles are usually within the 20ºC isotherm. Therefore, their migratory movements are carried out within these temperature preferences and, in some areas, depending on the season of the year. The leatherback turtle, however, owing to its large size, is able to tolerate lower temperatures than other species. Thus, an important aspect would be to acquire greater knowledge on the migrations of these species (Hays *et al.* 2006), to determine the areas and time periods having the greatest incidence with fishing gear on the different species of turtles and to understand the associated environmental factors since they are key elements in the study and protection of these species.

This paper presents a summary of the observation of encounters involving 5 species of marine turtles using the surface longline gear targeting swordfish in a specifically selected restricted zone of the North Atlantic, close to the archipelagos of the Canarias and Cabo Verde Islands. It does not, however, analyze the incidence and mortality by bait type used. These results have already been reported in previous papers.

Material and methods

The records were taken from commercial surface longline vessels and analyzed for the 1997-2012 period. However, it was not possible to obtain observations for years 2000, 2005, 2007, 2008, 2011 and 2012. From 2005-2006 a test was carried out to study the effect of different hooks and baits on the interaction and mortality rates of marine turtles (Mejuto *et al.* 2008). This test included the selection of areas in which high encounter rates were likely to be found based on the migratory routes described for these species and sea surface temperature (SST) ranges which would favor their presence a priori. A total of 56 sets performed during this test (7.5% of the total effort analyzed) were included in this analysis. The depth intervals at which the longline operated during this test ranged between 13 and 135 meters. The remainder of the hooks observed (92.5%) belonged to regular commercial activity.

The spatial window selected ranged from 10º-30º N / 15º-35º W, with a total of 16 squares 5ºx5º. The nomenclature was defined by 2 digits for latitude and 3 for longitude according to the criterion of ICCAT to name the squares by their lower left-hand vertex for the areas of the NW quadrant (Miyake 1990). The encounters with turtles and the total number of hooks observed were summarized by square and years combined. SST data were also compiled from the sets observed.

The encounter rates were expressed as number of turtles per number of hooks set. However, to facilitate the comparison of these results with those reported by other authors, data were also expressed as "*bycatch per unit of effort*" (BPUE) –number of encounters per thousand hooks – for the zone, for each square, species and species combined. The number of dead discards recorded was divided by the total number of hooks in the zone and in each square in order to obtain the respective mortality rates.

Results and discussion

A total of 544982 hooks were observed over the course of ten years (1997-1999, 2001-2004, 2006 and 2009-2010) in which 438 encounters with sea turtles were found. Of the sixteen 5ºx5º squares selected, thirteen were subject to fishing effort (**Figure 1**). A total of 5 species of marine turtles were identified. In square 25025NW, where fishing intensity was the lowest (5040 hooks), no encounters with turtles were reported. In the remaining 12 squares, encounters took place with the species *Caretta caretta* (CC) and *Dermochelys coriacea* (DC). However, encounters with *Lepidochelys kempii* (LK) only occurred in squares 10020NW and 15020NW. Encounters with *Lepidochelys olivacea* (LO) were observed in squares 10020NW, 10025NW and 15020NW. The only encounter with *Chelonias mydas* (CM) took place in square 15020NW (**Table 1**).

The overall rate of encounters for the whole zone analyzed and species combined was 8.0E^{-04} turtles per hook. Species DC exhibited the highest rate, followed by species CC with much lower rates reported for the other species (**Figure 2**). The highest encounter rates for species combined were found in squares 10020NW (2.1E^{-03}) and 15020NW (1.9E^{-03}) (**Figure 3**).

Table 2 shows the total number of hooks observed, the total number of encounters, the number of dead discards, as well as the encounter and mortality rates for each 5ºx5º square and for the whole zone analyzed. Fifty out of the 438 turtles observed were dead (11.4%) and the resulting mortality rate was 9.0E^{-05} turtles per hook. The highest mortality rates per hook were found in squares 15020NW (2.5E^{-04}), 10020NW (2.0E^{-04}) and 15030NW (1.9E^{-04}) (**Figure 3**). The rest of the turtles (88.6%) were released alive in good condition.

Table 3 shows the number of encounters with marine turtles by species and squares, as well as the number of dead discards and their respective mortality rates per hook. The highest mortality rate for the whole zone analyzed was exhibited by species CC (4.9E^{-05}), followed by DC (3.5E^{-05}), LK (3.7E^{-06}) and species LO and CM (1.8E^{-06}) (**Figure 4**). The highest mortality rate for species CC was found in square 10020NW (1.4E^{-04}), followed by squares 15020NW and 15030NW (1.3E^{-04}). Species DC showed the highest mortality rate in square 10025NW (8.7E^{-05}), followed by square 10030NW (7.8E^{-05}). The mortality rate of LK in square 15020NW was 3.8E^{-05} and species LO had a mortality rate of 2.2E^{-05} in square 10025NW. The only specimen of CM was found in square 15020NW, with a mortality rate of 1.9E^{-05} (**Figures 5 and 6**).

The rate expressed as BPUE for all the species combined was 0.804 individuals per thousand hooks set. The highest BPUEs for all the species were obtained in squares 10020NW and 15020NW with values of 2.104 and 1.900 individuals per thousand hooks, respectively (**Table 4, Figure 7**). The highest BPUE for the whole zone analyzed was for species DC (0.448), followed by CC (0.316). The BPUE of species LK and LO were roughly 0.020 for both species and 0.002 for species CM. The data by square indicate that species CC reached a maximum BPUE in square 15020NW (1.216), while DC did so in square 10025NW (1.683) (**Table 4, Figure 8**). If BPUE data are analyzed by month, it can be seen that the highest rates for the zone as a whole were reached between January and July (**Figure 9**). In January the BPUE of all the species of turtles combined (1.580) was affected by the high encounter rate with species CC and DC. However, the total BPUE in May (0.988) was primarily due to encounters with species CC. During the periods from February-April and June-July the BPUE was mainly affected by encounters with species DC (**Figure 10**).

The SST interval found during all the sets observed (with or without interaction) ranged between 18º-29ºC. Most of the sets, however, were carried out within interval 23º-27ºC and particularly at 25ºC (**Figure 11**). There were no encounters with marine turtles in squares 10020-10025NW during the months of July and September when the SST reached 29ºC. Encounters with marine turtles took place at SST interval 19º-28ºC, although most of the encounters occurred within interval 23º-27ºC (**Fgure 12**). Considering the SST interval where encounters with marine turtles were found, it was observed that the SST begins to reach 25º and 26ºC starting in May and lasts until December. SSTs of 27ºC were recorded between June and November, reaching 28ºC between July and September (**Figure 13**).

Upon examination of the encounter data for each species with regard to SST, it was found that encounters with species CC occurred at a broad-ranging SST (19º-27ºC), but the highest prevalence (56%) was recorded at interval 23º-24ºC corresponding to the time period from May to December. The highest level of encounters with species DC (29%) was found at 27ºC between June and August, although the interval was 19º-28ºC. Encounters with specimens of LK were reported at interval 22º-23ºC from March to June and species LO mostly (78%) between 23º-27ºC in June and July. The sole sample of CM was reported at 24ºC in August (**Figures 14** and **15**).

Samples assumed to be representative are commonly used to predict interaction with low prevalence bycatch species and to estimate the impact of the fishery as a whole. However, the migratory behavior of these species is not usually similar between years (Hays *et al.* 2006), nor is the behavior of the fleets in the pursuit of the target species. Therefore, interaction tends to be highly variable between the fishery and species with low prevalence rates. The rates obtained from an experiment should not be generalized or extended to other regions, not even to those with apparently similar environmental conditions. The lack of correlation between the distribution and abundance of the target species and the low prevalence of these bycatch species makes it difficult to obtain reliable estimates or predictions of overall rates. Moreover, estimations based on models supported by scantly field data generally yield variable results that are highly dependent on preliminary assumptions and premises.

Most of the available observations in this study come from areas that were selected intentionally. This intentional selection has a markedly greater effect on the data from the experimental cruise carried out to test hooks and baits, which yielded a substantial part of the total encounters observed. The results of the rates obtained during this experimental cruise differ from the rates obtained during regular commercial activity, the latter showing lower values. The regular commercial fishing had encounter and mortality rates of 7.82E^{-04} and 8.93E^{-05} individuals per hook, respectively, for all species combined; versus the higher encounter and mortality rates of 1.07E^{-03} and 1.21E^{-04}, respectively, found during the experimental cruise for testing hooks and bait types.

Despite the fact that the data are not widely representative, since they come from a restricted area, the results may be used to shed light on the presence-absence and prevalence of the different species in this zone and to understand associated environmental factors such as SST which tends to be essential when determining the presence and migration of these species. Finally, it is important to emphasize the fact that the information included here cannot be extrapolated or used to calculate the number of marine turtles that may interact with this fishery.

Acknowledgements

We are grateful to the Spanish surface longline fleet for their continuing collaboration and their willingness to handle and release marine turtles in the appropriate conditions.

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Table 1. Number of marine turtle encounters by species, 5ºx5º square and total.

Square	CC	DC	LK	LO	CM	total
10015	1	2	0	0	0	3
10020	23	43	4	5	0	75
10025	3	76	0	3	0	82
10030	2	32	0	0	0	34
15020	64	26	8	1	1	100
15025	1	11	0	0	0	12
15030	9	15	0	0	0	24
20015	17	3	0	0	0	20
20020	12	31	0	0	0	43
20025	3	1	0	0	0	4
25015	24	1	0	0	0	25
25020	13	3	0	0	0	16
25025	0	0	0	0	0	0
Total	172	244	12	9	1	438

Table 2. Total number of hooks observed, total number of marine turtle encounters, encounter rate, number of dead discards, percentage of dead discards and mortality rate per hook, by square 5ºx5º.

Square	Hooks#	Turtles#	Encounter rate	Dead#	% Dead	Mortality rate
10015	14400	3	0.00021	0	0	0
10020	35643	75	0.00210	7	9.3	0.00020
10025	45157	82	0.00182	7	8.5	0.00016
10030	25554	34	0.00133	3	8.8	0.00012
15020	52643	100	0.00190	13	13.0	0.00025
15025	37258	12	0.00032	1	8.3	0.00003
15030	68723	24	0.00035	13	54.2	0.00019
20015	96444	20	0.00021	0	0	0
20020	69364	43	0.00062	3	7.0	0.00004
20025	16646	4	0.00024	0	0	0
25015	41810	25	0.00060	3	12	0.00007
25020	36300	16	0.00044	0	0	0
25025	5040	0	0	0	0	0
Total	**544982**	**438**	**0.00080**	**50**	**11.4**	**0.00009**

Table 3. Total number of marine turtle encounters, total number of dead discards, rate of mortality, by species, 5ºx5º square and total.

	Total					Dead discards					Mortality Rate				
Square	CC#	DC#	LK#	LO#	CM#	CC#	DC#	LK#	LO#	CM#	CC	DC	LK	LO	CM
10015	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0
10020	23	43	4	5	0	5	2	0	0	0	$1.40E^{-04}$	$5.61E^{-05}$	0	0	0
10025	3	76	0	3	0	2	4	0	1	0	$4.43E^{-05}$	$8.86E^{-05}$	0	$2.21E^{-05}$	0
10030	2	32	0	0	0	1	2	0	0	0	$3.91E^{-05}$	$7.83E^{-05}$	0	0	0
15020	64	26	8	1	1	7	3	2	0	1	$1.33E^{-04}$	$5.70E^{-05}$	$3.80E^{-05}$	0	$1.90E^{-05}$
15025	1	11	0	0	0	0	1	0	0	0	0	$2.68E^{-05}$	0	0	0
15030	9	15	0	0	0	9	4	0	0	0	$1.31E^{-04}$	$5.82E^{-05}$	0	0	0
20015	17	3	0	0	0	0	0	0	0	0	0	0	0	0	0
20020	12	31	0	0	0	1	2	0	0	0	$1.44E^{-05}$	$2.88E^{-05}$	0	0	0
20025	3	1	0	0	0	0	0	0	0	0	0	0	0	0	0
25015	24	1	0	0	0	2	1	0	0	0	$4.78E^{-05}$	$2.39E^{-05}$	0	0	0
25020	13	3	0	0	0	0	0	0	0	0	0	0	0	0	0
25025	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	172	244	12	9	1	27	19	2	1	1	$4.954E^{-05}$	$3.49E^{-05}$	$3.7E^{-06}$	$1.8E^{-06}$	$1.8E^{-06}$

Table 4. By-catch rate (BPUE) in number of encounters by fishing effort (thousand hooks) for species of marine turtles by 5ºx5º square and total.

Square	CC	DC	LK	LO	CM	Total
10015	0.069	0.139	0	0	0	0.208
10020	0.645	1.206	0.112	0.140	0	2.104
10025	0.066	1.683	0	0.066	0	1.816
10030	0.078	1.252	0	0	0	1.331
15020	1.216	0.494	0.152	0.019	0.019	1.900
15025	0.027	0.295	0	0	0	0.322
15030	0.131	0.218	0	0	0	0.349
20015	0.176	0.031	0	0	0	0.207
20020	0.173	0.447	0	0	0	0.620
20025	0.180	0.060	0	0	0	0.240
25015	0.574	0.024	0	0	0	0.598
25020	0.358	0.083	0	0	0	0.441
25025	0	0	0	0	0	0
BPUE	0.316	0.448	0.022	0.017	0.002	0.804

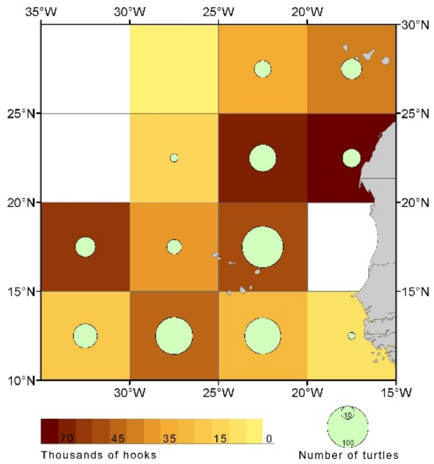

Figure 1. Map of the overall zone and 5ºx5º squares selected from the North Atlantic, fishing effort observed (thousands of hooks) and number of marine turtle encounters by 5ºx5º square.

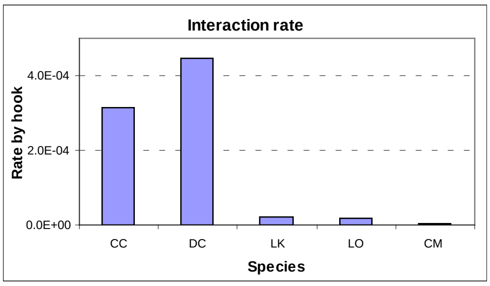

Figure 2. Overall encounter rate per hook for the five species of marine turtles.

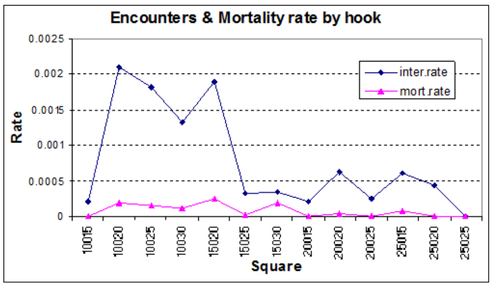

Figure 3. Encounter and mortality rates per hook for all marine turtles combined by 5ºx5º square.

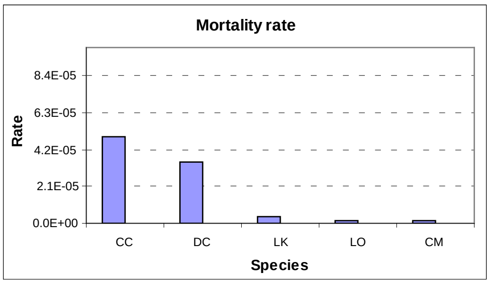

Figure 4. Mortality rate by marine turtle species for the whole zone analyzed.

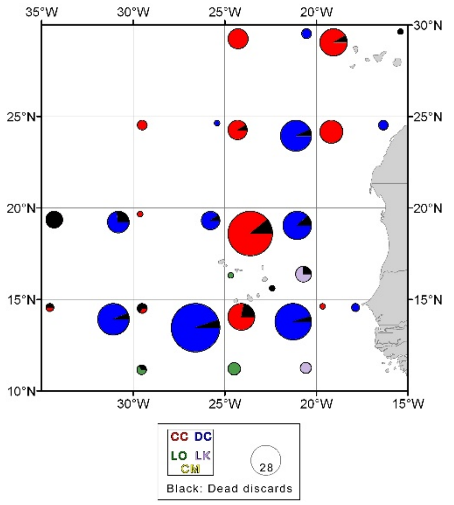

Figure 5. Level of marine turtles species encounters and dead discards (black colour) by 5ºx5º square.

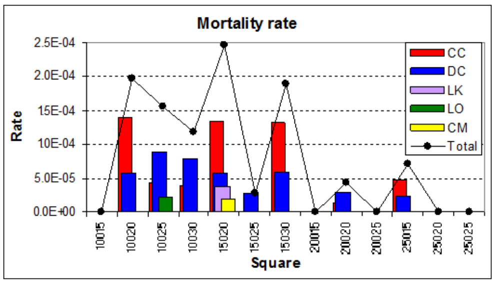

Figure 6. Mortality rate for each marine turtle species and species combined, by 5ºx5º square.

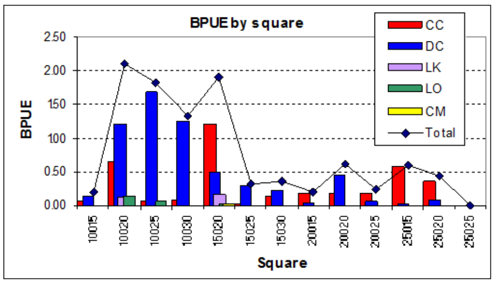

Figure 7. Bycatch per thousand hooks (BPUE) obtained for marine turtle species and total, by 5ºx5º square.

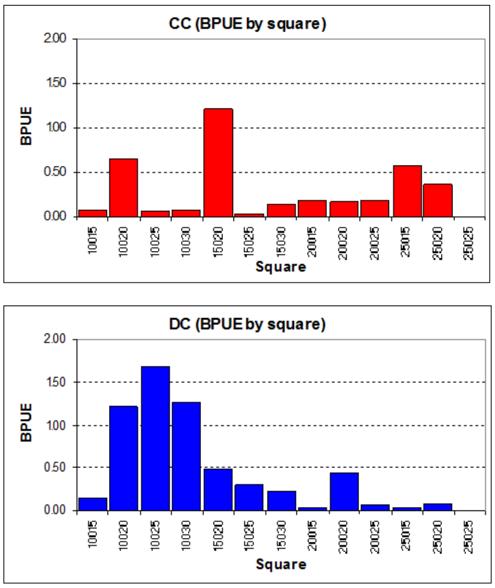

Figure 8. Bycatch per thousand hooks (BPUE) obtained for *C. Caretta* (CC) and *D. coriacea* (DC), by 5ºx5º square.

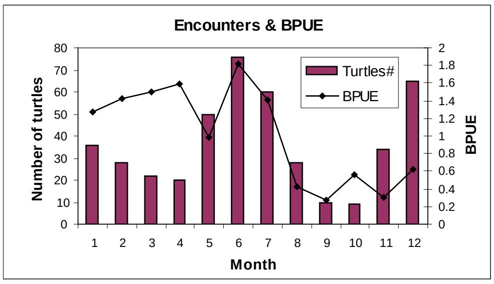

Figure 9. Number of marine turtle encounters and bycatch per thousand hooks (BPUE) for all marine turtles species combined and by month.

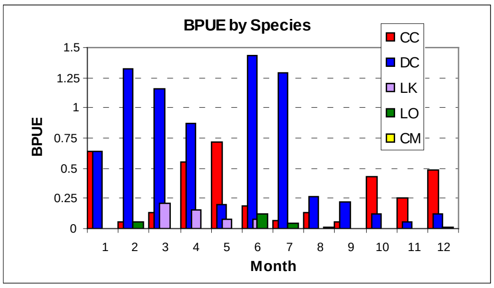

Figure 10. Bycatch per thousand hooks (BPUE) of the five species observed of marine turtles and month.

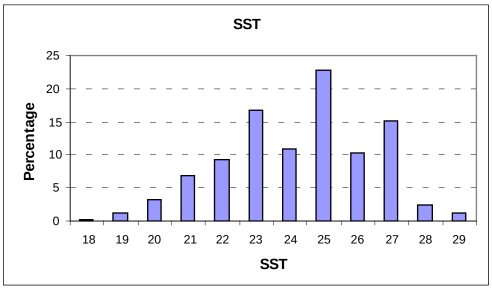

Figure 11. SST ranges and percentage of observations for all sets observed in the zone (with or without the occurrence of turtle encounters), for the period 2007-2012.

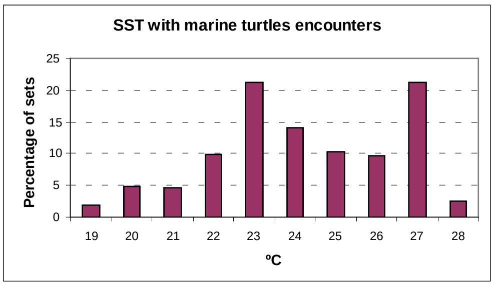

Figure 12. SST ranges and percentage corresponding to the total sets studied in the zone in which encounters with marine turtles took place, during the period 2007-2012.

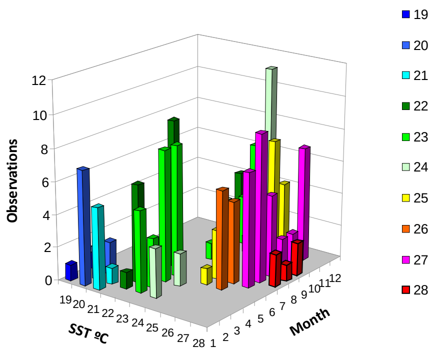

Figure 13. Marine turtle encounters by SST (ºC) range and month of the selected zone.

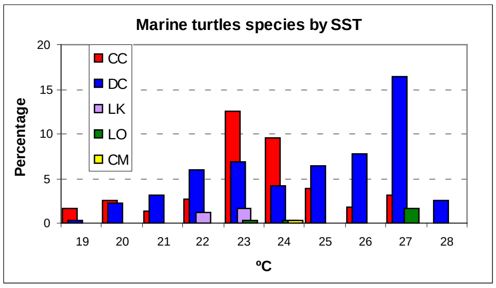

Figure 14. Percentage of occurrences of marine turtle species by SST (ºC)

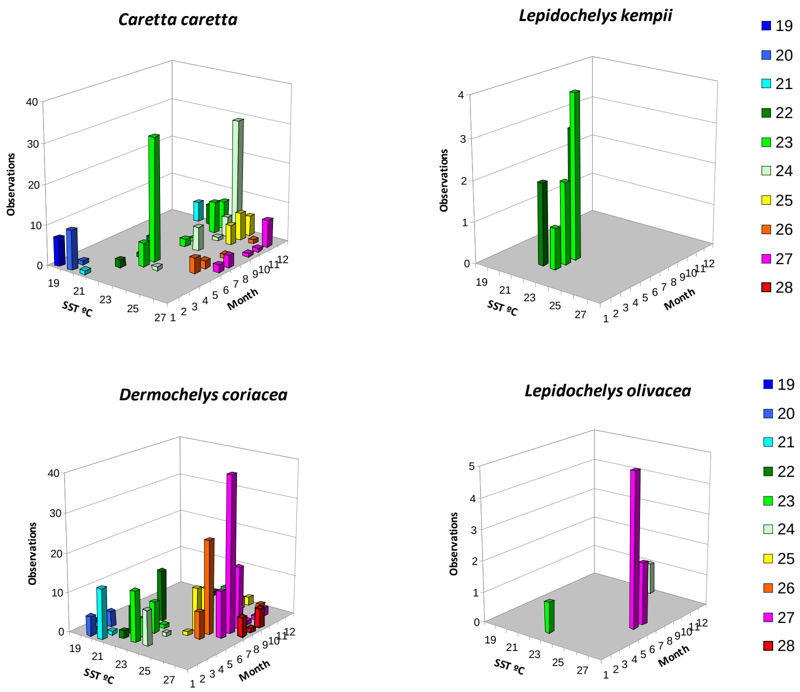

Figure 15. Overall plot of marine turtle encounters by species, month and SST(ºC) in the selected zone.