**Scientia Marina** 72(2)
June 2008, 337-342, Barcelona (Spain)
ISSN: 0214-8358

# Incidental capture of sea turtles by longlines in the Gulf of Gabès (South Tunisia): A comparative study between bottom and surface longlines

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SUMMARY: Longlines are a fishing gear that have traditionally been used world-wide. Surface longlines are mainly used to fish swordfish, albacore, tuna and some species of sharks, while bottom longlines are used to fish large bottom-dwelling fish such as groupers. Longlines are widely known to interact with several species of sea turtles, and there is increasing concern about the impact of by-catch on these species. However, there is a paucity of data on sea turtle interactions with bottom longlines. In this paper we analyse the interaction of sea turtles with both bottom and surface longlines in the zone of Zarzis in the south of the gulf of Gabès, which is considered to be an important Mediterranean wintering and foraging area for the loggerhead turtle, *Caretta caretta*. Results show an important interaction with both types of longlines. Catch rates were estimated to be 0.823 per 1000 hooks for surface longline and 0.278 per 1000 hooks for bottom longline. Direct mortalities were estimated to be 0% (n=33 captures) and 12.5% (n=24 captures), respectively.

*Keywords*: longline, by-catch, catch rate, *Caretta caretta*, mortality, Gabès Gulf, Mediterranean.

RESUMEN: Captura incidental de tortugas marinas en palangres en el golfo de Gabès (Sur de Túnez): Un estudio comparativo entre palangres de superficie y profundidad. – Los palangres son un arte de pesca utilizado en todo el mundo. Los palangres de superficie son utilizados principalmente para pescar pez espada, albacora, atún y algunas especies de tiburones, mientras que los de fondo están dirigidos a especies que habitan cerca del fondo como los meros. Es ampliamente conocido que estas redes de pesca interaccionan con varias especies de tortugas marinas, y existe una creciente preocupación sobre el impacto de las capturas no dirigidas en estas especies. Hay una escasez de datos de las interacciones de las tortugas marinas con los palangres de fondo. En este trabajo analizamos las interacciones de las tortugas marinas con los palangres de fondo y superficie en la zona del Zarzis al sur del golfo de Gabès, que es considerada una importante zona donde pasa el invierno y se alimenta la tortuga boba, *Caretta caretta*. Los resultados muestran una importante interacción con ambos tipos de palangres. Las tasas de captura estimadas fueron de 0.823 por 1000 anzuelos para los palangres de superficie y 0.278 por 1000 anzuelos para los de fondo. Las mortalidades directas estimadas fueron de 0% (n=33 capturas) y 12.5% (n=24 capturas) respectivamente.

*Palabras clave*: palangre, capturas no dirigidas, tasa de captura, *Caretta caretta*, mortalidad, golfo de Gabès, Mediterráneo.

## INTRODUCTION

Sea turtles are recognised to be under increasing threat from humans world-wide (Márquez, 1990). A major source of this threat is the interaction with fisheries (Laurent *et al*., 2001; Lewison *et al*., 2004; Camiñas *et al*., 2006; Carranza *et al*., 2006; Gilman *et al*., 2006; Casale *et al.*, 2007a). In the Mediterranean, the loggerhead turtle *Caretta caretta* interacts with many fisheries in many countries (Laurent, 1990; Laurent *et al*., 1990; Bradai, 1992; Deflorio *et al*., 2005; Gerosa and Casale, 1999). In the western part

of the basin (Camiñas, 1988; Camiñas *et al*., 1992; Camiñas and de la Serna, 1995; Laurent *et al*., 2001; Camiñas *et al*., 2006) the surface longline appears to be the fishing method that accidentally catches marine turtles more than others (Gerosa and Casale, 1999; Laurent *et al*., 2001; Deflorio *et al*., 2005). By-catch is particularly important in the Mediterranean as the animals impacted are from both the Atlantic and the genetically isolated Mediterranean stocks (Laurent *et al*., 1993; Bowen *et al*., 1993; Laurent *et al*., 1998). Additionally, it has been proposed that, given the small regional population size (Broderick *et al*., 2002), the current levels of fishing-induced mortality probably cannot be counterbalanced by recruitment (Gerosa and Casale, 1999).

In Tunisia, and particularly in the Gulf of Gabès, which is considered to be a foraging zone and an important wintering area in the Mediterranean (Margaritoulis, 1988; Laurent *et al*., 1990; Argano *et al*., 1992; Laurent et Lescure, 1994; Gerosa and Casale, 1999; Margaritoulis *et al*., 2003), studies concerning marine turtle by-catch in commercial fisheries and its potential impact on the population are limited to the interaction with trawl fisheries (Bradai, 1992; Jribi, 2003; Jribi *et al*., 2007). Studies on impacts of other fishing gears are very scarce, despite the fact that the quantification of the incidental catch rate and turtle mortality by each fishery are necessary for formulating conservation and management strategies, as mandated by the Action Plan for the Conservation of Mediterranean Marine Turtles, drawn up in the framework of the UNEP Barcelona Convention (RAC/SPA, 2001).

The present work was therefore carried out in order to assess marine turtle by-catch in bottom and surface longlines along the southeast coast of Tunisia, an area where both types of fishing gear are known to be extensively used. In this paper we provide comparative data on sea turtle by-catch obtained on fishing trips on board commercial surface longline and bottom longline vessels and analyse the parameters related to these two fishing gears.

## MATERIALS AND METHODS

The Gulf of Gabès (Fig. 1) is one of the most important Tunisian longline fishing areas. Two types of gear are used; the surface longline (SLL), which mainly targets sharks, and the bottom longline (BLL), which mainly targets groupers. For

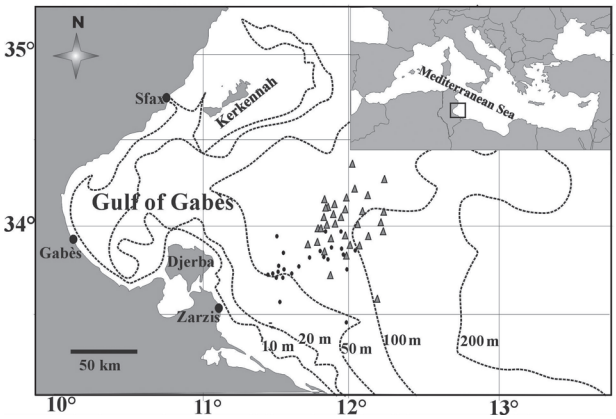


FIG. 1. – The Gulf of Gabès. Locations of sets with turtles caught by SLL (triangles) and BLL (dots).

this study, we cooperated with 8 commercial boats connected to the port of Zarzis. Data were collected by onboard observers of the INSTM (National Institute of Sea Sciences and Technologies) and the FSS (Sfax Faculty of Sciences, University of Sfax) during 80 fishing trips (47 with SLL and 33 with BLL). The trips took place from June to September in 2004 and 2005, encompassing the fishing season for both types of gear. In the remaining months, most fishermen change the longlines for others gears targeting other species, such as the gillnet targeting sharks and rays, longlines using small hooks targeting sparidae, and the Karoor, which is a traditional gear targeting octopus.

The differences between the two gears include the length of the mainline, the distance separating two successive branch lines and the number and size of hooks. The length of the SLL varied from 20 to 50 km and consisted of 500 to 2500 hooks (size 12/0 J hook: 111 mm length and 57 mm width and 11/0 J hook: 98 mm length and 51 mm width) attached to the branch lines separated by an average distance of 40 m. This fishing gear was initially used to target swordfish (*Xiphias gladius*), but the species' recent rarity has resulted in a shift in target to other species such as the sandbar shark (*Carcharhinus plumbeus*). The SLL was set horizontally stretched close to the surface using a buoy after every two hooks. The baits used were mackerel (*Scomber scombrus*), bogue (*Boops boops*) and horse mackerel (*Trachurus trachurus*). The setting and the hauling times were approximately one and three hours, respectively. Setting began around 18:00 h and hauling occurred around 07:00 h on the following day.

The BLL was set horizontally close to the bottom using attached ballast weights. This gear differs

from the SLL by its length which does not exceed 25km, by the size of its hooks (size 9/0 J hook: 78 mm length and 41 mm width) and the number of hooks which varied from 2000 to 3500. The distance between two successive branch lines was approximately 7 m. The targeted species were groupers such as the white grouper (*Epinephelus aeneus*) and the dusky grouper (*Epinephelus guaza*). The bait used was generally round sardinella (*Sardinella aurita*) or common cuttlefish (*Sepia officinalis*). The hauling lasted one to three hours and sometimes occurred immediately after setting at any time of day.

At the beginning and end of each set we recorded the date, coordinates, bottom depth and number of turtles captured. Individual data were recorded on all captured sea turtles which were brought on board by a dipnet after pulling them gently to the vessel by hand. Information recorded included the species, the Curved Carapace Length (CCLn-t) (Bolten, 1999) and the physical condition, which was classified as follows: Healthy (lively movements), Injured (healthy but with wounds), Comatose (dazed and apparently dead but eyes or cloaca responding to touch after a few hours), and Dead (no sign of breathing; eyes not responding to touch). Before the release of healthy or animals recovered from a comatose state, an attempt was made wherever possible to unhook the turtle. Otherwise the branch line was cut as close to the turtle as possible and the turtle was released with a hook inside the digestive tract.

In order to compare catch rates within and between studies, catch rate, $\hat{R}$ which is catch per unit of effort (CPUE), as number of caught specimens per 1000 hooks, was calculated and 95% confidence intervals (based on a Poisson distribution) were derived. To estimate total turtle catch from the total fishing effort, $H$ (available as fishing trips), another catch rate, $R$ (turtle/fishing trip), with a 95% confidence interval, was calculated. Annual total catch of marine turtles by SLL and BLL was estimated by applying catch rates, $R$ (turtle/fishing trip), to the total fishing effort, $H$ (number of trips), for the whole longline fleet operating in the zone of Zarzis. Annual total captures with a 95% confidence interval were calculated for both SLL and BLL. The direct mortality, $p$, is the proportion of turtles found dead on gear retrieval. Total direct mortality was calculated by applying total captures to $p$.

## RESULTS

A total of 126 336 hooks were deployed in 111 sets (62 with SLL and 49 with BLL) on 80 trips: 40 106 hooks on 47 trips for SLL and 86 230 on 33 trips for BLL. Altogether 57 loggerheads (*C. caretta*) were caught during this work: 33 by SLL, which constitutes a catch rate of 0.823 (95% C.I.: 0.568-1.158) turtles per 1000 hooks, and 24 by BLL, which constitutes a catch rate of 0.278 (95% C.I.: 0.1788-0.4152) turtles per 1000 hooks. Catch rates for SLL from other studies are shown in Table 1 for comparison. On all occasions, only a single turtle was captured in any given set. SLL sets occurred in water of depths ranging between 40 and 110 m but hooks were at shallower depths because the use of buoys while BLL sets occurred between 30 and 90 m which correspond to the depth of hooks. There was no apparent distinguishing feature in terms of location between the sets that did or did not catch turtles. Thus, sea turtles were captured throughout the entire study zone. Sea turtles were caught throughout the four months of the campaigns in the two-year study. The estimated average fishing efforts for the SLL and BLL fleet operating in the zone of Zarzis were respectively 693 trips/year and 1007.5 trips/year (Source DGPA: General Directorate of Fishing and Aquaculture). The total captures resulting from these fishing efforts were estimated respectively to be 486.48 (95% C.I.: 334.93-683.30) and 732.89 (95% C.I.: 469.50-1090.21).

The mean carapace length (CCLn-t) of caught loggerheads was 58.5 cm (SD=9.33; range=38-72; n=33) for SLL and 48.7 cm (SD=6.7; range=38.3-

TABLE 1. – Comparison of turtle catch rates from various longline fisheries in the Mediterranean.

| Fishing zone | Year | Catch rate (turtles per 1000 hooks) | Source |
|---|---|---|---|
| Spain (West Mediterranean) | 1999-2004 | 0.69-1.41 | Camiñas *et al*., 2006 |
| Spain (West Mediterranean) | 2000 | 1.15 | Laurent *et al*., 2001 |
| Italy - Ionian Sea | 1999-2000 | 0.27 | Deflorio *et al*., 2005 |
| Italy (Lampedusa island) | 2005 | 0.97 | Casale *et al*., 2007b |
| Greece | 2000 | 0.63 | Laurent *et al*., 2001 |
| Tunisia (Zone of Zarzis) | 2004-2005 | 0.82 | Present study |

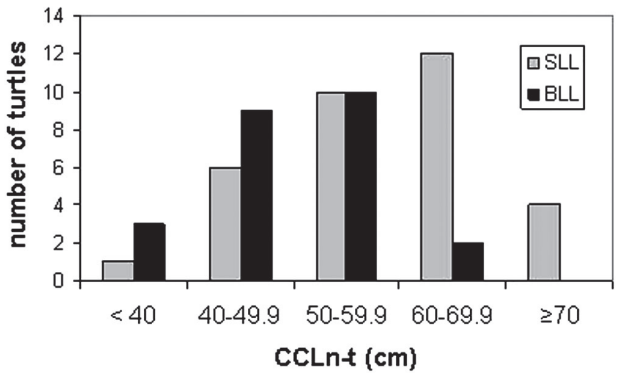


FIG. 2. – Distribution of Curved Carapace Length (CCLn-t) frequencies of loggerhead turtles caught in the study area by Surface longline (SLL) (N=33) and Bottom longline (BLL) (N=24).

61; n=24) for BLL (Fig. 2). On the basis of the size of adult females nesting in the Mediterranean (Margaritoulis *et al*., 2003), most of these turtles were juveniles. The SLL sample included larger specimens than the BLL one (Mann-Whitney U-test; $U$ =163 000; $p$<0.0001; $n$ =57)

Sea turtles were hooked or entangled in 51.4% of the sets. The majority of them were healthy (80.7%). Eight turtles were found in a comatose state (14.0%) and three were dead (5.3%). No injured turtles were observed. The physical condition of turtles captured by both types of longline is shown in Table 2.

For the SLL no turtles were found dead and 3 were in a coma, leading respectively to 0 and 9.1% (N=33) of direct and potential mortality (assuming that the comatose turtles would die). For BLL 3 turtles were found dead and 5 in a comatose state. The direct and potential mortality were respectively 12.5

TABLE 2. – Physical condition of turtles captured by SLL and BLL.

| Physical conditions | SLL | BLL | Total |
|---|---|---|---|
| Healthy | 30 | 16 | 46 |
| Comatose | 3 | 5 | 8 |
| Dead | 0 | 3 | 3 |

TABLE 3. – Capture mode of turtles in two types of longline (SLL and BLL) during the study in the zone of Zarzis.

| Interaction | SLL (n = 33) | | BLL (n = 24) | |
|---|---|---|---|---|
| | n | % | n | % |
| Hooked | 30 | 91 | 23 | 96 |
| in the mouth | 19 | 58 | 9 | 38 |
| deep in digestive tract | 11 | 33 | 14 | 58 |
| Entangled | 3 | 9 | 1 | 4 |
| on main line | 0 | 0 | 0 | 0 |
| on branch line | 3 | 9 | 1 | 4 |

and 33% (N=24). Consequently, the total direct and potential mortalities for the longline fleet operating in the zone of Zarzis were estimated respectively to be 00 and 44.27 (95% C.I: 30.48-62.18) turtles for SLL and 91.61 (95% C.I: 58.69-136.28) and 244.27 (95% C.I: 156.48-363.37) for BLL.

The way in which the marine turtles were captured is shown in Table 3. Considering the total catch obtained by the two types of longline, the results show that most turtles were captured by hook (91% for SLL and 96% for BLL), while the remainder were entangled in the lines.

The catches by SLL recorded in this study occurred in waters deeper than those recorded by BLL because the two gears have largely different distributions (Fig. 1).

## DISCUSSION AND CONCLUSION

The observed catch rate of sea turtles over two seasons in a two-year period indicates a substantial interaction with longline fisheries and a high density of marine turtles in this region. This high marine turtle density can be explained by the fact that the wider area of the Gulf of Gabès is an important wintering and foraging area for marine turtles in the Mediterranean (Margaritoulis, 1988; Laurent *et al*., 1990; Argano *et al*., 1992; Laurent and Lescure, 1994; Gerosa and Casale, 1999; Margaritoulis *et al*., 2003).

The recorded sea turtle catch rate coming from longline fishing activities in Zarzis during two years suggests that the catch rate of loggerheads by BLL was lower than by SLL. However, the total catch of BLL was higher because of the higher fishing effort in comparison with SLL.

The comparison of turtle catch rates between this study and other Mediterranean studies considers only the SLL since few or no data are available regarding the BLL in other areas. The turtle catch rate in the area of Zarzis is higher than those reported in Greece and Italy (other than Lampedusa) but lower than that reported in the western Mediterranean Sea. This is not surprising since it is known that the occurrence of a high concentration of sea turtles in the western basin of the Mediterranean Sea is due to the entrance of specimens from the Atlantic Ocean via the Straights of Gibraltar (Argano *et al*., 1992; Camiñas and de la Serna, 1995).

Concerning the depth of catches registered by SLL and BLL, it is known that the loggerhead (*C.*

*caretta*) mostly frequents bottoms at depths of less than 50 m, and is more rarely found in deeper waters (Gerosa and Casale, 1999). Consequently, the use of SLL, which have a higher catch rate, in shallow waters involves a high risk.

The analysis of sizes of specimens caught by SLL indicates that most of them were juveniles with CCLn-t ranging between 40 and 70 cm. The sizes of less than 40 cm or more than 70 cm represent respectively 3 and 12%. For the BLL, the majority of specimens caught had sizes ranging between 40 and 60 cm (79%). No large turtle (CCLn-t>70 cm) was caught by this longline gear. Sea turtles captured by SLL were larger than those captured by BLL. It is possible that this is largely due to the larger hook size used in SLL.

Unfortunately, post-release mortality is very difficult to investigate (Gerosa and Casale, 1999). Our study was limited to the evaluation of the direct mortality at gear retrieval. The results provided in this study clearly indicate that BLL has the potential to be much more harmful than SLL.

When the aim is to assess the impact of longline fishing activities in the Mediterranean Sea on sea turtle populations which seem to be genetically isolated from the Atlantic ones (Bowen *et al*., 1993; Laurent *et al*., 1993; Laurent *et al*., 1998), data concerning BLL should be considered, especially given the rarity of assessments on this specific gear's impact on sea turtles. In addition, mortality of turtles with hooks left in their digestive tract should be investigated as the injury caused by the hook is rarely fatal at first and the fishermen are in the habit of cutting the branch line and leaving the hook inside the turtle. At present, the best way to protect marine turtles is to conduct awareness campaigns aimed at fishermen. Such campaigns should explain how to treat captured turtles and how to apply recovery techniques to comatose turtles: if the turtle is too large to bring on board, fishermen can cut the line as close to the turtle's mouth as possible (Gerosa and Aureggi, 2001). If the turtle can be taken on board, fishermen can remove the hook if the animal was hooked externally or in the mouth and the whole shank of the hook is visible; otherwise they should cut the line as close to the mouth as possible if the hook is not visible. For comatose turtles, fishermen can reduce the mortality by leaving the turtle on board for a few hours before releasing it. In fact, a large part of the mortality is likely to be the result of turtles released in a comatose state, which drown soon afterwards because they are unable to swim. Fishermen can recognise the comatose state of turtles by a response of eyes or cloaca to touch after a few hours (Gerosa and Aureggi, 2001).

## ACKNOWLEDGEMENTS

We wish to thank all the fishermen who allowed us to operate on their boats, all the crews, as well as all the scientists and onboard observers who have participated in this work. Special thanks to Giulia Mo, Dimitris Margaritoulis and Brendan Godley for the critical reading of an earlier version of this manuscript.

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Scient. ed.: D. Oro.
Received May 2, 2007. Accepted January 14, 2008.
Published online April 14, 2008.