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Differential distribution within longline transects of loggerhead turtles and swordfish captured by the Spanish Mediterranean surface longline fishery

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Surface longline targeting mainly swordfish is considered a major threat for loggerhead turtle populations in the western Mediterranean Sea. For this reason, it is necessary to analyse the relationship between the characteristics of longline sets and loggerhead turtle by-catch. The objective of this study is to look for differential spatial distribution of loggerhead turtle and swordfish captures along the longline to gain insights that might be useful to diminish unintended, incidental catch of turtles without affecting the captures of the target species.

Longlines are divided into transects separated by two consecutives buoys. During the 1999 fishing period of the traditional (without roller) Spanish surface drifting longline fleet (August to November), 59 technically homogeneous fishing operations, composed of 23 sections each, were observed. Chi-square test was used to compare loggerhead turtle and swordfish distributions among transects with those expected at random. Significant differences were obtained only for loggerhead turtles, with 93% of the specimens caught in the second half of the longline transects, which were retrieved from the sea during daytime. Significant differences were not found for the swordfish along the whole longline or for loggerhead turtle captures retrieved during daytime. We conclude that swordfish captures are independent of retrieval time whereas the incidental catch of loggerhead turtles occurs mainly during daytime, probably because loggerhead turtles use vision to locate baits.

The swordfish *Xiphias gladius* (L.) represents a valuable longline fishery resource in the western Mediterranean Sea, where juvenile and adult loggerhead turtles *Caretta caretta* (L.), a threatened species (www.redlist.org), find one of their main concentration areas. The Spanish surface longline fleet based in the western Mediterranean Sea targets mainly swordfish all year round and is considered the principal threat for the loggerhead turtle populations of this area (Lewison et al., 2004; Camiñas et al., in press), where incidental captures extend from spring to later autumn, with a maximum in summer. About 20,000 loggerhead turtle individuals are estimated to be caught annually in the western Mediterranean Sea (Laurent et al., 2001), so it is necessary to analyse the effects of fishing strategy and environmental conditions on loggerhead turtle by-catch with a view to better conserving its populations. The aim of this document is to analyse the spatial distribution of captured loggerhead turtles and swordfish along the longline, to infer from catch data the existence of differential capture patterns in these large pelagic species.

Vessel description

During August to November of 1999 a total of 141 fishing operations (sets) were observed onboard a commercial traditional Spanish drifting longline fishing boat without roller, representative of the Spanish Mediterranean fleet targeting swordfish, which consists of 105 vessels from 12 to 27 m in length (http://www.mapya.es). The boat was selected at random among the vessels of these characteristics based in Carboneras Port (Almería, southern Spain), where 80% of the surface longline Spanish fleet fishing in the south-western Mediterranean Sea are based. The boat was 23.62 m in length and had 52.24 Register Ton Gross and 136803 W of Potency (data origin http://www.mapya.es). This kind of boat can support rough sea conditions and usually spends between three and eight days at sea, keeping fish captures in the fridge, and being capable of operating in distant fishing grounds.

Fishing grounds and gear description

The fishing grounds included a large area of the western Mediterranean between 36° and 44°N and 02°W and 05°E. The most important fishing effort was carried out around the Balearic Islands and in the Ibiza Channel (Laurent et al., 2001; Valeiras & Camiñas, 2003).

The fishing gear was a traditional Spanish style monofilament polyamide longline divided into transects separated by buoys. Each transect consisted of floats and branch lines hanging from the main-line (see Laurent et al., 2001 for a detailed description). Captures in longlines composed of the same number of transects were analysed to diminish technical variability during the fishing operation. The hooks were 'J' shaped Mustad No. 1 and were mainly baited with Argentine squid and chub mackerel in

Table 1. *Mean and standard deviation (Std.) of loggerhead turtles and swordfish captured by the observation boat per longline transect.*

Transects	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Loggerhead turtle												
Mean	0	0	0	0	0.020	0	0	0	0.020	0.020	0	0.020
SD	0	0	0	0	0.140	0	0	0	0.140	0.140	0	0.140
Swordfish												
Mean	0.961	0.902	0.745	0.980	0.804	0.980	1.137	1.353	1.098	1.098	1.333	1.196
SD	0.799	0.900	0.891	1.140	1.040	0.948	1.217	1.354	1.188	1.100	1.438	1.371

SD, Standard deviation

Table 1. *(Continued.)*

Transects	XIII	XIV	XV	XVI	XVII	XVIII	XIX	XX	XXI	XXII	XXIII
Loggerhead turtle											
Mean	0.059	0.020	0.020	0.039	0.059	0.059	0.118	0.118	0.039	0.059	0.098
SD	0.238	0.140	0.140	0.196	0.238	0.238	0.382	0.475	0.196	0.238	0.361
Swordfish											
Mean	1.000	1.157	0.961	1.137	0.941	1.216	1.137	1.392	1.020	1.235	1.275
SD	1.442	1.138	1.095	1.167	1.156	1.172	1.096	1.744	1.393	1.570	1.415

SD, Standard deviation

combinatory series. Given that bait type may have a selective effect on the by-catch (Watson et al., 2005; Gilman et al., 2006), we focused on longline sets whose hooks were baited with identical consecutive combinatory series.

A fishing operation involves all the procedures performed from the wet of a longline set until the retrieval of all the gear, which is usually carried out in less than 20 h. Typically, the setting of the longline lasts from 1500 to 2000 h, the gear drifts in the open sea until 0230 h, and its retrieval takes from 0230 h to 1200 h.

Results and conclusions

Fifty-one fishing operations were observed in which longline sets were technically homogeneous. They were composed of 23 transects each, and Argentine squid and chub mackerel distribution within longline transects was identical. In these homogeneous sets, 44 loggerhead turtles (0.8 loggerhead turtles per fishing operation) and 1278 swordfish (25 swordfish per fishing operation) were captured. Chi-square test was used to compare loggerhead turtle and swordfish distributions among transects with the distributions expected at random. Significant difference was obtained for loggerhead turtles (χ^2=52.00, df=22, P=0.00031) but not for the swordfish (χ^2=30.05, df=22, non significant) (Figure 1). About 90% of the loggerhead turtles were caught in the second half of the longline transects. This is the last part of the gear recovered from the sea, normally in the morning. As the time required to retrieve a complete transect averaged about 25 min, we estimated that sunrise normally occurred when transect 12 was beginning to be retrieved. Significant differences between loggerhead turtle by-catch before and after dawn (χ^2=29.52, df=1, P=5.5E^{-8}) were found, whereas the distribution of loggerhead by-catch among transects retrieved after sunrise were not significantly different from that expected at random (χ^2=16.55, df=11, non significant). This implies that it is not that turtles take longer than swordfish to be attracted to baits, but that they

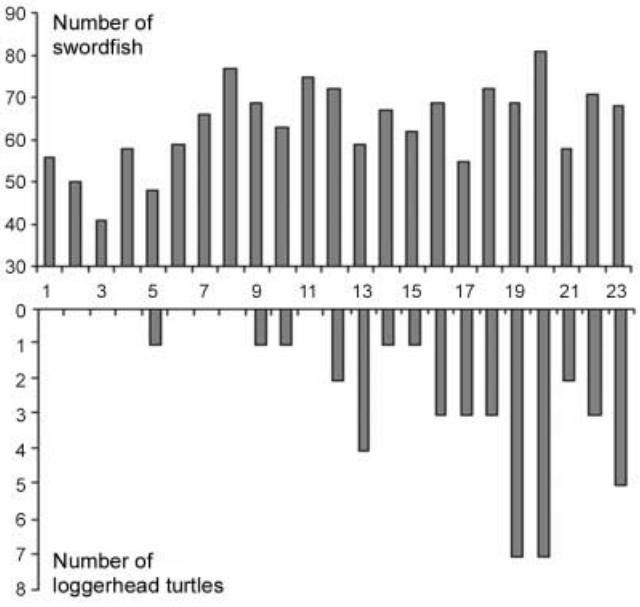

Figure 1. Frequencies of swordfish and loggerhead turtle by-catch in each longline transect.

are only attracted in the daytime. This highlights the important effect of daylight soak time over incidental catch of loggerhead turtles, in a way that the higher the number of longline transects retrieved after dawn the higher the number of loggerhead turtles captured.

These results imply that retrieving the gear before the morning, or at least reducing daylight soak time, could help diminish substantially loggerhead turtle by-catch. Watson et al. (2005) and Gilman et al. (2006) already proposed this management measure, but based on inconclusive results. Our results also show that swordfish captures would not be significantly affected by this measure, given the random distribution of swordfish catch within the set (see also Rey & Múñoz-Chápuli, 1992). The reason for the differential distribution of swordfish and loggerhead turtles along the longline could be that loggerhead turtles use vision to locate the baits, at least at short distance, while swordfish do not.

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