

Distribution and Relative Abundance of the *Tursiops truncatus* in Lebanese Marine Waters (Eastern Mediterranean)

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Abstract: Data related to the presence of cetaceans and especially the bottlenose dolphin (*Tursiops truncatus*) in Lebanese marine waters (eastern Mediterranean) is almost non-existent. This article aims to delimit, for the first time, the areas of distribution and the relative abundance of *T. truncatus* along the Lebanese coasts in order to develop a strategy for the conservation of this species. Nine campaigns at sea, each lasting between 1 to 3 days, were conducted aboard the vessel “CANA” between September 2009 and August 2012 in Lebanese marine waters. A total of 1576 km in prospecting effort were covered along the Lebanese coast (220 km). Dolphins were mainly sighted in the central region of Lebanon (120 km) and 32 sightings and 91 individuals were recorded. The size of the groups ranged from a minimum of one individual and a maximum of 7 individuals. Relative abundance of *T. truncatus* for the whole studied region is 0.06 individuals·km⁻¹ in prospecting effort while it is 0.11 individuals·km⁻¹ in Beirut area that offers habitats sought by this species. The bathymetric distribution of this species is spread over a wide range from a depth of 35 m to 1300 m. More than half of the individuals have been observed in areas where bathymetry ranges between 300 and 600 m depths.

Key words: Bottlenose dolphin, areas of distribution, relative abundance, Lebanon, eastern Mediterranean.

1. Introduction

Marine mammals, especially cetaceans, are an important component of marine biodiversity. They are useful indicators of the state of health of the marine ecosystems. Since they are top-level predators in the marine environment, they are able to concentrate contaminants through bioaccumulation, the fact which makes them an important barometer of the health and the status of lower trophic levels [1]. They are also considered as umbrella species and actions to conserve them may have positive effects on other species [2]. The threats on this biodiversity and especially on the cetaceans are very obvious and urgent. This can mostly be related to human impact: fishing gear or fishing practices, habitat degradation,

boating and shipping, etc. [3-6]. Prey depletion resulting from fishery overexploitation may represent an important threat to Mediterranean cetaceans, and particularly to dolphins living in or near coastal waters [5, 7, 8]. Many studies highlighted the impact of pollution, especially toxic contaminants, on these marine mammals. Persistent organochlorine concentrations and heavy metals levels were studied in resident bottlenose dolphins in many areas in the world [9, 10]. Shoham-Frider et al. [11] found relatively high DDE/ΣDDT percentages and heavy metal concentrations in tissues of *Tursiops truncatus* collected from the Levantine Basin of the eastern Mediterranean.

Due to its strategic location in the middle of the coastal strip of the eastern basin of the Mediterranean, Lebanon is located at the crossroads of three

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continents Asia, Africa and Europe and three seas, the Mediterranean Sea, the Black Sea and the Red Sea where marine biodiversity is relatively important. In Lebanon, there is an almost absolute lack of information on cetacean species composition, ecology, distribution and population parameters.

The only little information available corresponds to some fishermen observations who think that bottlenose dolphins are the most regular species in coastal waters and their groups are composed of 3-5 individuals [12, 13]. On the other hand, some campaigns limited in time and space and conducted along the eastern basin of the Mediterranean have reported the presence of some dolphins in the Lebanese waters [14].

The acquisition of a scientific vessel CANA in 2009 donated by the Italian Government has allowed the Lebanese National Council for Scientific Research (NCSR) to elaborate a strategy composed of 5 tasks: coastal bathymetry, hydrobiology and biodiversity, fishery and mammals, coastal pollution, and management and awareness. Following the ratification of the "ACCOBAMS" agreement by the Lebanese Parliament in 2004 (Agreement on the Conservation of Cetaceans of the Black Sea, Mediterranean Sea and contiguous Atlantic Area) and the signing of a memorandum of understanding between the Lebanese NCSR and the secretariat of this agreement in 2009, the cetaceans, and especially *Tursiops truncatus* [15] currently constitute a fauna of growing interest to Lebanon. Moreover, among the 13 cases of stranding, recorded in Lebanon since 2002, 10 cases concern the bottlenose dolphin. This species' interactions with fishing gear were also reported in Lebanese waters [12, 16].

Tursiops truncatus is a cosmopolitan delphinidae [17]. Many factors influence its distribution; the inshore form frequents river mouths, bays, lagoons and other shallow coastal regions (depth between 0.5-20 m) [18]. The offshore form prefers productive areas.

According to Wells and Scott [19], bottlenose dolphins tend to inhabit waters with surface temperature ranging from about 10 °C to 32 °C. In other studies, a clear relationship was obtained between their distribution and depth, distance to shore, bottom oxygen, feeding events and submarine habitat characteristics [20, 21]. According to Sykes et al. [22], chlorophyll a and fish distribution (brill, cuttlefish, plaice, pollack, red and grey mullet, etc.) were the main factors influencing *Tursiops truncatus* distribution along the Dorset coast of England.

In the Mediterranean Sea, this species is heterogeneously distributed along the entire coastline from the Strait of Gibraltar until the Black Sea [6]. It appears to be scattered and fragmented into sub populations of small sizes. A recent estimate of the population of the Mediterranean has shown that this species has a relatively high abundance, suggesting that coastal waters provide an important habitat for it [23]. In the north-western Mediterranean waters, total abundance is estimated as 7.654 while the abundance in the central Spanish Mediterranean is 1.333. Nevertheless, the mean dolphin density in the Amvrakikos Gulf (western Greece) is 0.37 animal·km⁻² [24]. However, the northern Adriatic Sea is the only Mediterranean area with quantitative historical information regarding the distribution of *Tursiops truncatus* [6].

In fact, the bottlenose dolphin in the Mediterranean Sea has been classified in the last IUCN report on the Status of Cetaceans in the Mediterranean and Black Sea [6] as vulnerable. According to Bearzi and Fortuna [5], and Bearzi et al. [8], deliberate killing, overfishing (prey depletion), and habitat degradation may have caused a considerable decline of the bottlenose dolphin population all over the Mediterranean basin, with a current total population of less than 10,000 animals representing a decrease of about 30% in the last 60 years. These results should be taken as the best possible estimate considering the extreme data shortage in the Mediterranean Sea.

Since the information on the cetacean species occurring off Lebanon is extremely scarce and limited to a handful of stranding and sighting records, the primary aim of this study is to identify and quantify the presence, the distribution areas and the abundance of bottlenose dolphins in Lebanese marine waters.

2. Material and Methods

Nine missions at sea aboard the scientific vessel CANA, each lasting between 1 to 3 days, have been

executed in: September 2009 (15, 16 and 17), April 2010 (15 and 16), June 2010 (7, 9 and 10), October 2010 (25 and 26), April 2011 (7 and 8), June 2011 (2), December 2011 (7), March 2012 (19) and August 2012 (7 and 8) (Table 1).

The prospected zone covers the waters off the Lebanese coast, from the Lebanese-Syrian border in the North to the southern borders of Lebanon, on a length of 220 km (Fig. 1) and a 4,750 km² area.

The line transect method [25] was adopted in all of

Table 1 Characteristics of the data collected during the various missions at sea.

Mission	September 2009	April 2010	June 2010	October 2010	April 2011	June 2011	December 2011	March 2012	August 2012
Total km (in prospecting effort)	222	177	269	197	223	79	126	77	206
Number of sightings	4	10	6	0	6	2	4	0	0
Number of individuals	8	31	17	0	22	3	10	0	0
Mean distance of sightings from coastline (km)	6	7	9	15	11	7	10	10	12
Mean depth of sightings (m)	525	850	800	-	225	300	650	-	-
Sighting rate (sighting·km ⁻¹)	0.018	0.056	0.022	0	0.027	0.025	0.032	0	0
Relative abundance (individual·km ⁻¹)	0.036	0.175	0.063	0	0.099	0.038	0.079	0	0

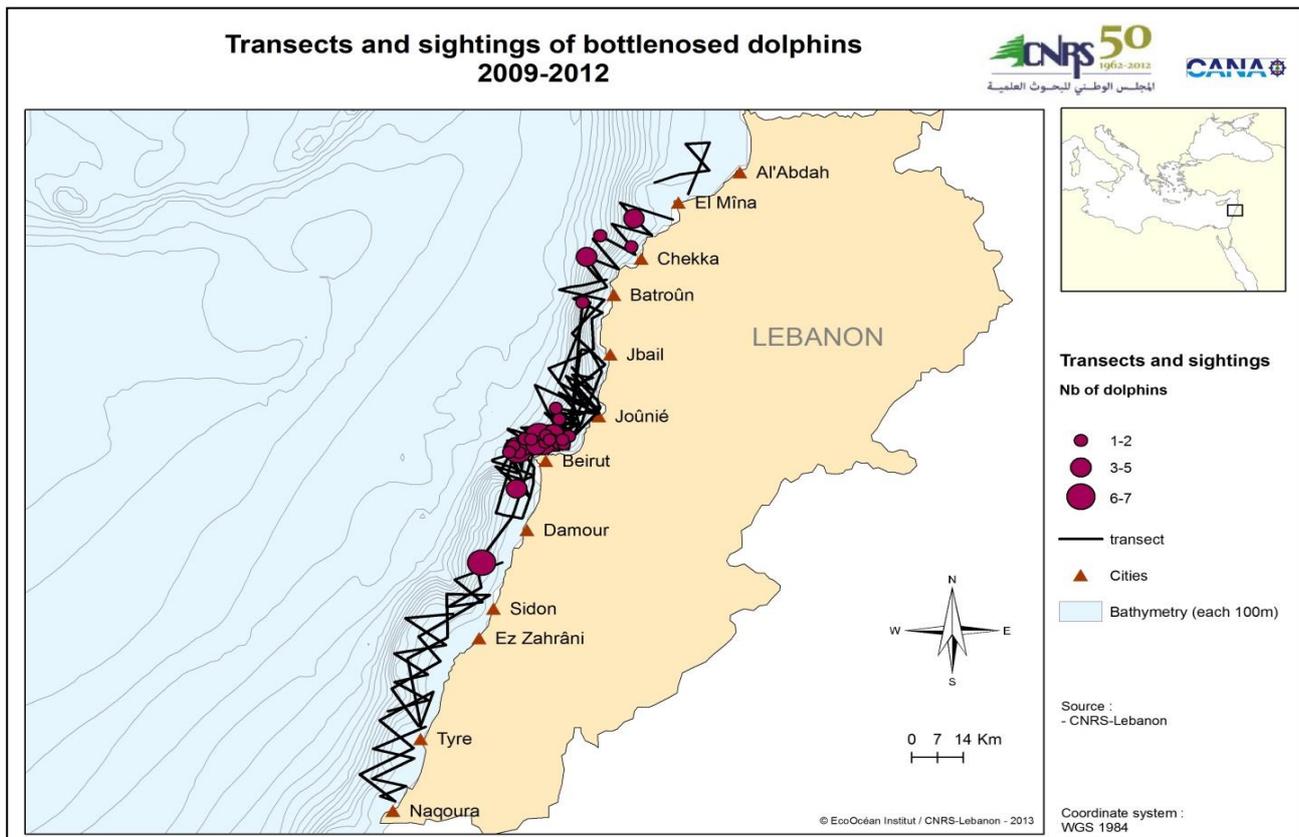


Fig. 1 Campaigns at sea between 2009 to 2012 off the coast of Lebanon, prospecting effort and sightings of bottlenose dolphins.

the campaigns. Three observers were on the deck at the front part of the boat at a height of 7 m from the sea level, permanently covering an angle of 180° of observation. 62 transects, with a length between 3 to 10 km each, sometimes reaching 15 km offshore, have been made, covering a total length of 1,576 km of which 558 km were located in the region of Beirut (Fig. 1). All campaigns were done in a sea state classified equal or less than 3 according to Beaufort scale. The vessel had a constant speed of 8 knots.

The position of the boat was regularly and automatically recorded through a computer connected to a GPS with the software “Max Sea”. Cetaceans were observed using naked eyes and for more precision a 7 × 50 “Nikon Action Ex” binoculars were used.

At each sighting, data concerning time, number of individuals and behavior of the species were recorded with other complementary environmental information. Microsoft excel® software was used to elaborate some descriptive statistical tests. A sighting was defined as a group of animals of the same species (*Tursiops truncatus* in our case) seen at the same time showing similar behavioral characteristics and at distance of less than 1,500 m from each other [26].

3. Results and Discussion

The Lebanese coast is frequented regularly by bottlenose dolphins. The total number of *T. truncatus*

observed during all the campaigns is 91 individuals in 32 sightings. The distribution of observed individuals of *T. truncatus* is presented in Fig. 1 where we can clearly see that bottlenose dolphins presence spreads in the central part of Lebanon, on a coastal length of 120 km, in the area limited by the cities of Sidon in the South and El Mîna in the North.

This distribution of bottlenose dolphins in the central part of Lebanon (Fig. 1) is probably due to the nature of the bottom which is mostly rocky and the continental shelf which is narrow (3 km on average) [27]. No individual was observed North of El Mîna and south of Sidon. In these two regions, the bottom is basically covered with soft sediments and the continental shelf is relatively wide (7 km) [27].

The size of the groups ranged between a minimum of one individual and a maximum of 7 individuals; however, the groups ranging from 1 to 3 individuals are the most frequent and constitute the 2/3 (24 sightings) of all the sightings (Fig. 2). The average group size is 2.84 (SD = 1.9) individuals. These groups' sizes were lower than those detected along the Tunisian coast and Sicily channel where observations indicated that the number of individuals can reach 14 and 20 individuals per group [28, 29]. However, the mean size of the groups 2.84 ± 1.9 is comparable with that observed in Sardinia (Asinara Island) [30] and lower than that observed in the western Mediterranean which is ranging between 7.4 and 10.2 [17, 31, 33].

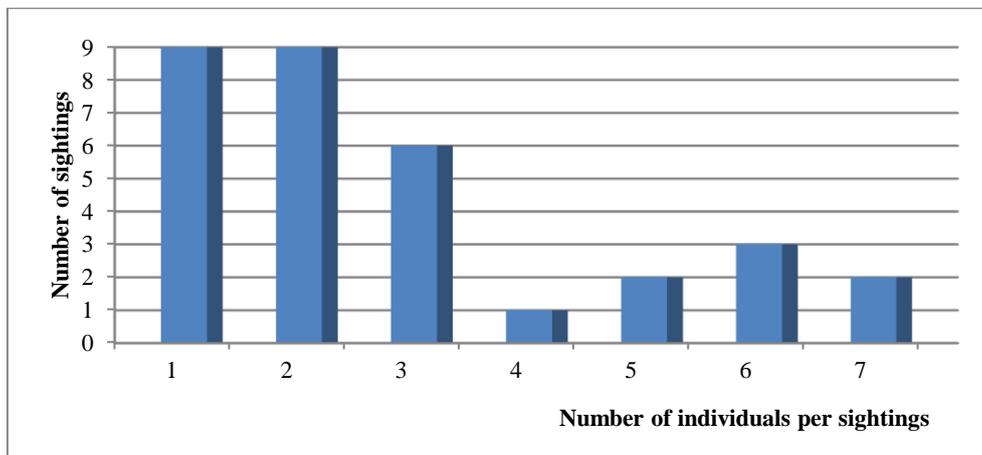


Fig. 2 Frequency of the size of the groups of *T. truncatus* sighted.

This dislocation of the groups in the marine waters of the eastern Mediterranean could be due to adaptation to the food resources that are weak and scattered in an area known for its oligotrophic state [34, 37].

The structure of the groups consisted of adult and young individuals with sizes ranging between 1.5 and 3.5 m. The number of young observed is estimated to be 1/3 of the total effective.

Most individuals had a social behavior; they approached the boat, played and swam in front of the bow for several minutes.

The individual's relative abundance and sighting rate are respectively 0.06 individuals·km⁻¹ and 0.020 sighting·km⁻¹ for the entire Lebanese coast, and 0.11 ind·km⁻¹ and 0.032 sighting·km⁻¹ for the region of Beirut where the observations were more frequent.

These relative abundances are similar to those observed in the Balearic Islands (0.085 ind·km⁻¹) and Catalonia in Spain (0.088 ind·km⁻¹) [23], but higher than those observed by Dede et al. [14] in the Turkish Mediterranean coasts (0.007 ind·km⁻¹), in the Syrian coasts (0.006 ind·km⁻¹) and in the Lebanese coasts (0.03 ind·km⁻¹).

The higher abundance in the Beirut area is

explained by the fact that the shelf and continental slope seem to provide favorable conditions for the presence, reproduction, and alimentation of this species [17, 38-40].

In fact, this region is characterized by the presence of i) submarine canyons which are topographic structures that interact with the hydrographic movements and generate production of biomass, thus forming a habitat sought by the bottlenose dolphin [41], ii) crustaceans and benthic fish (Merlucciidae) that are very important in the *T. truncatus* diet [42, 43] and iii) several navigation corridors for vessels in the destination of the big port of Beirut, which promotes the presence of dolphins who follow the boats [4].

T. truncatus has been observed in bathymetric depths that are spread over a wide range from 35 m to 1,300 m depth (Fig. 3). More than half of the individuals (57 individuals, 62%) were observed in a bathymetric area ranging between 300 and 600 m depth. The highest frequency (19 individuals) was observed at a depth of 550 m, followed by the 15, 14, and 12 individuals at 1,200, 400 and 300 m depths, respectively. Isolated individuals have been observed at a depth of 35, 270 and 850 m.

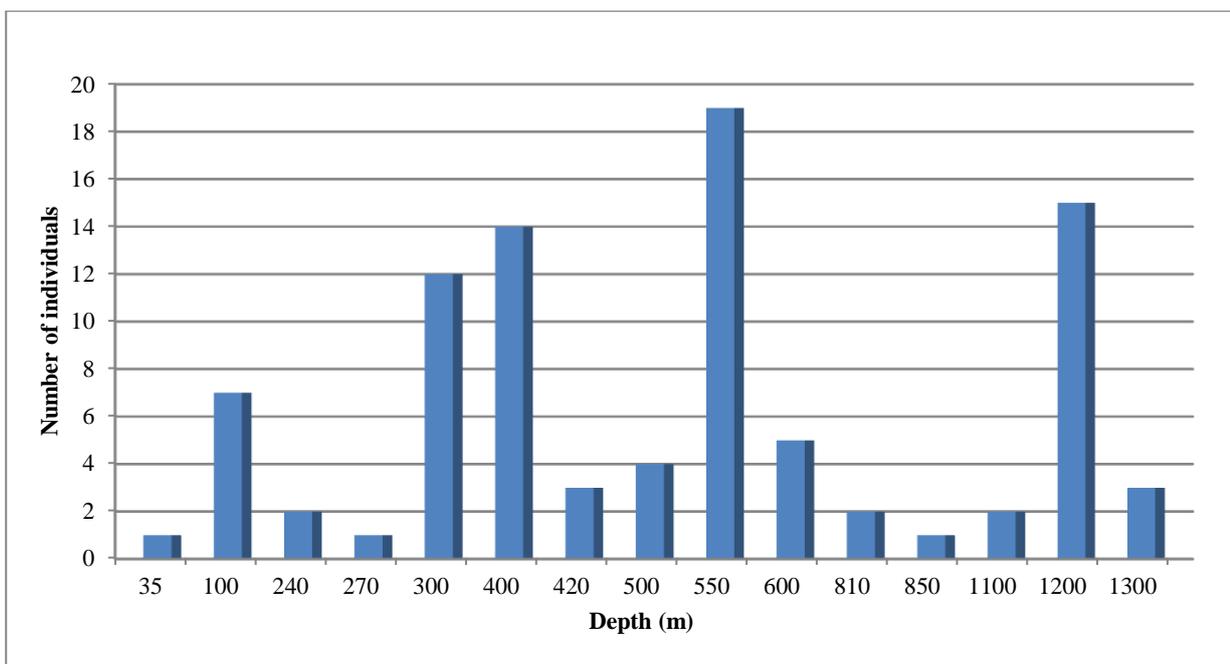


Fig. 3 Distribution of *T. truncatus* according to depth.

The bathymetric distribution is in accordance with that observed by Dede et al. [14] and it corresponds to habitats sought by this species, which is known to be coastal as well as pelagic [4, 31, 32].

However, compared to Mediterranean waters off southern Spain where the bottlenose dolphins are mostly present at a mean depth of 200 to 400 m [38], the distribution of this species in the Lebanese waters is spread over a wider range of depth with 80 individuals (88% of the total frequency) observed beyond the continental shelf (270 m), in depths ranging between 300 and 1,300 m (Fig. 3). These results show that *T. truncatus* in Lebanon as in other Mediterranean areas are more closely related to the offshore than to the inshore ecotype [44, 45]. This can be due to the fact that the continental shelf in Lebanon is narrow and the depth of 1,500 m in Beirut area can be reached at a distance of 1 km from the shoreline [27].

4. Conclusion

This study is the first attempt for monitoring the presence of cetaceans in Lebanese marine waters. The results highlight the regular presence of bottlenose dolphins in a central area of the Lebanese coast, adding a piece to the puzzle of the Mediterranean knowledge of this species' distribution. 91 individuals were detected in 32 sightings. The size of the groups ranged between a minimum of one individual and a maximum of 7 young and adult individuals. The individual's relative abundance and sighting rate are higher in Beirut area ($0.11 \text{ ind}\cdot\text{km}^{-1}$ and $0.032 \text{ sighting}\cdot\text{km}^{-1}$, respectively) compared to values obtained for the entire Lebanese coast. This relatively higher abundance in Beirut area can be related to the topographic structure of Beirut coast, the abundance of nutrition in these waters albeit the oligotrophic nature of the eastern Mediterranean waters and the presence of several navigation corridors created by the vessels in these waters. Noteworthy that this higher abundance in Beirut waters should motivate the

Lebanese government to identify this zone as an area of special interest for the conservation of this species in the Lebanese waters.

On the other hand, *T. truncatus* occur in higher numbers beyond the continental shelf, the fact which indicate that the bottlenose dolphins in the Lebanese waters belong to the offshore ecotype. More campaigns at sea should be engaged, in order to monitor this population and highlight its links with other dolphins of this species along coasts of other countries around Lebanon. Pictures of some of the dolphins sighted during these Lebanese campaigns at sea allow monitoring the animals through photo-identification. This will provide baseline data for the development of strategies and plans for the protection and conservation of these animals. These results also constitute a solid base to other research that can study the impact of anthropogenic factors on these species and evaluate their heavy metal and organic contaminant levels.

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