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Seasonal encounter rates and residency patterns of an unstudied population of bottlenose dolphin (*Tursiops truncatus*) in the northwestern Levantine Sea, Turkey

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Abstract

Insufficient data regarding abundance, distribution and movement patterns of bottlenose dolphins has contributed to lack of effective conservation strategies within the Levantine Sea. It has been inferred that the bottlenose dolphin population has decreased by 30 % in the last 60 years, thus a basin wide research effort on the population is an urgent priority. We present the preliminary results of the first bottlenose dolphin photo-identification study in the northwestern Levantine Sea. 32 boat surveys were conducted from March 2015 to July 2016, totalling 1433 km of survey effort. Current study reported an uneven distribution, high seasonal encounters and varied residency patterns of bottlenose dolphins within the northwestern Levantine Sea. We propose that the northwestern Levantine Sea, specifically the coastal waters of Antalya Bay, indeed is an important bottlenose dolphin habitat and adjacent waters may be of similar significance. Of the 56 individuals catalogued, 13 were re-sighted in both years. Encounter rates varied seasonally, with a peak in spring of 12 groups and 100 individuals per 100 km. Dolphin presence was not detected during autumn and winter. While seasonal, visitor and transient dolphins were reported, no year-round residency was documented. Incidental observations of visible starvation signs and skin parasites suggested individual dolphins in this region could be under anthropogenic stressors. The results reported here highlight the importance of baseline information on encounter rate, distribution and residency pattern as they have a key role on the assessment of population statues and the threats they are facing. Future studies with annual survey effort, have to be continued in the northwestern Levantine Sea and its adjacent waters.

Keywords: bottlenose dolphins, encounter rates, residency patterns, seasonality, photo-identification, conservation strategies, important habitat, Levantine Sea

INTRODUCTION

The common bottlenose dolphin (*Tursiops truncatus* MONTAGU, 1821) is a cosmopolitan Delphinid, which has a coastal distribution in both tropical and temperate waters (PILLERI & GIHR, 1969, NOTARBARTOLO DI SCIARA & DEMMA, 1994, BEARZI & FORTUNA, 2006). Once widely distributed, the population in the Mediterranean Sea, is now assumed to

be less than 10,000 individuals (BEARZI ET AL., 2012) as a result of a decline of approximately 30 % within the last 60 years (BEARZI ET AL., 2008). According to the IUCN Red List of Threatened Species (HAMMOND ET AL., 2012), the Mediterranean subpopulation of bottlenose dolphins is classified as 'vulnerable' (VU) under A2cde categories. The species is also listed in the Annex II of the Habitats Directive as a species of "community interest". Although there is no specific national protection status of Mediterranean bottlenose dolphins, all 12 cetacean species recorded in Turkish waters have been under protection by law since 1983 (ÖZTÜRK, 1996, GÜÇLÜSOY ET AL., 2014).

A range of anthropogenic activities has had major detrimental effects on the bottlenose dolphin population due to overlap in use of coastal habitats. Historical intentional killing, incidental mortality during fishery practices, prey depletion and habitat degradation are the leading causes of the population decline (BEARZI ET AL., 2012). The low productivity and extreme oligotrophy of the Levantine Basin amplifies the severity of the aforementioned threats, causing an increase in the rate of regional population declines (BEARZI ET AL., 2006) on Mediterranean bottlenose dolphins in this area. Unfortunately, despite the proven decline of their population in recent decades, there is still a lack of knowledge regarding their population status within the Levantine Sea.

Bottlenose dolphin presence throughout the Turkish territorial waters has been documented over a long period of time (MARCHESSAUX, 1980, ÇELIKKALE ET AL., 1988, ÖZTÜRK & ÖZTÜRK, 1997, DEDE, 1999, DEDE & ÖZTÜRK, 2007, DEDE ET AL., 2008, DEDE & TONAY, 2010, DEDE ET AL., 2012, BAŞ, 2014). While various studies have reported the overall encounter rates of cetaceans within Turkish waters, few refer specifically to bottlenose dolphins; however there have been limited attempts to understand their residency, site fidelity and movement patterns (DEDE, 1999, BAŞ, 2014).

The Turkish Black Sea subpopulation of bottlenose dolphin was estimated at 11,213 individuals with an overall cetacean encounter rate of 1.08 individuals per km^2 in 1987 (ÇELIKKALE ET AL., 1988), however these results were subject to some criticism due to the methodology used (IWC, 1992, BIRKUN, 2002).

The Turkish Strait System had an estimated population size of 468 bottlenose dolphins in 1998 (DEDE, 1999). In the Istanbul Strait the overall encounter rate of cetaceans was estimated at 0.143 groups per nautical mile (Nm) in 2008 (ÖZTÜRK ET AL., 2009). BAŞ ET AL. (2015) reported 51 % of sighting success in the Istanbul Strait and catalogued 44 resident individuals between 2011 and 2013.

The encounter rates of bottlenose dolphins for the Marmara and North Aegean Seas were estimated at 2.7 groups and 2.34 groups per 100 km respectively in 2007 (ALTUĞ ET AL., 2011). In contrast, the overall encounter rate of cetaceans was reported to be 0.02 groups per Nm throughout the Turkish waters of the Aegean Sea in 2008 (ÖZTÜRK ET AL., 2009). Lastly, RYAN ET AL. (2014) conducted encounter rate estimations for bottlenose dolphins within the Aegean Sea and reported 0.077 groups per hour.

Finally, the overall encounter rate of cetaceans within the eastern Mediterranean Sea was approximately 0.18 sightings per 10 Nm in 2008 (DEDE ET AL., 2012), whereas the bottlenose dolphin encounter rate was estimated to be 0.006 groups per hour in 2013 (RYAN ET AL., 2014).

In regards to bottlenose dolphin encounter rates within the western and central Mediterranean basin, there were 0.54 groups per 100 km reported in the Pelagos Sanctuary (GNONE ET AL., 2011), 0.61 groups per 100 km in the eastern Ionian Sea (BEARZI ET AL., 2005) and 1.6 groups per 100 km in the northeastern Adriatic Sea (FORTUNA, 2007), however in the Amvrakikos Gulf, Greece, the encounter rate peaked at 7.3 groups per 100 km (BEARZI ET AL., 2008). Additionally, bottlenose

dolphins were sighted on 98% of surveys carried out in Kelibia, Tunisia (BENMESSAOUD ET AL., 2012).

Due to the missing knowledge on the encounter rates, residency and movement patterns of bottlenose dolphins in the Levantine Sea, the current study conducted the first multiyear dedicated surveys in the northwestern Levantine and employed a photo-identification technique and assessed bottlenose dolphin sighting data collected between 2015 and 2016. The project aimed to identify the seasonal encounter rates, as well as to clarify the distribution and residency patterns of bottlenose dolphins within the northwestern Levantine Sea.

MATERIALS AND METHODS

Study Area

In order to collect the desired data, three different sites were selected to represent the northwestern Levantine Sea (Figure 1). Surveys within the basin were carried out in various coastal zones, continental shelves and deep-sea canyons. Pre-determined transects and random routes, accumulating to up to 2000 m isobath, were followed to collect data during the surveys. Pre-determined transects were designed in accordance with principles of distance/line transect sampling and were generated by DISTANCE software. Minus sampling has been used for effort allocation. Truncation distance was selected as 2 km. Coverage probability throughout the study area was evaluated through a grid of equally spaced points with 4 km of grid spacing. Equally spaced zigzag lines were selected for the survey design. While six transects were generated for our survey design with 10 km spacing between lines in Antalya Bay, five transects were followed with 5 km spacing between lines in Fethiye. The total combined transect length covered 1433 km.

Survey Design

Boat surveys were conducted for a minimum duration of seven hours each month between 1st March 2015 and 30th July 2016 (Figure 1). GPS points of both the research vessel and dolphin groups were recorded using the software Logger 2010, Version 5. A 'group' was defined if the distance between the individuals was less than 50 m while engaging in similar behaviour.

Figure 1. The survey tracks that followed between 2015 and 2016.

Photographs of the dolphin groups were taken using Nikon D80 and Canon 500D digital SLR cameras equipped with 70-300 mm lenses. In an attempt to photograph all the individuals in the group, numerous photographs of both sides of the animals were obtained, with care to avoid bias towards distinctive individuals. A blank picture was taken between focal groups so that the photographs of the individuals could later be assigned to their respective group. Individual dolphins were identified using unique markings on their dorsal fin, such as nicks, notches and scars, along with unique fin shapes and other bodily deformities. The photographed individuals were subsequently catalogued in relation to the dominant features on their dorsal fins using IMatch Database, Version 4©. To avoid misidentifications, calves and individuals without distinctive marks were not

included in the analysis. Group size, location and time of the sighting were recorded for each encounter.

Data analysis

Distribution pattern

To visualise survey efforts and bottlenose dolphin sightings, Esri ArcGIS software version 9.3 was used. The kernel density function was employed to map the aggregation of dolphin sightings within a circular neighbourhood for each raster grid cell of 300 m, with a radius of 3000 m. Kernel density data was processed by mask extraction.

Encounter rates

Overall and seasonal encounter rates of bottlenose dolphins were computed in the northwestern Levantine Sea. Encounter rate calculations were carried out as per BEARZI ET AL. (2008). Specifically, dolphin encounter rates per km were calculated as n per L, where n is the total number of sightings and L is the total number of km travelled (BEARZI ET AL., 2008). Prior to the analyses, the study area was divided into cells of 3 km x 3 km to avoid bias which can arise from uneven survey distributions. Cells with a survey effort lower than the cell's diagonal (4243 m) were then excluded from the analysis. As several cells contained variable proportions of land, encounter rates of individual cells that included areas of land were weighted on the relative proportion of land within the cell as weight = sea area within cell per total area cell. Weighted estimators were then used in each step for all cells.

Residency patterns

Residency pattern analyses were carried out to assess the tendency of individuals to remain in or return to the study area. The analysis was carried out for Antalya and Finike Bay, while the individuals identified in Fethiye Bay were discarded from the dataset due to the small sample size. The monthly residency rate (the number of months a dolphin was sighted as a proportion of the total number of months surveyed) and the seasonal residency rate (the number of seasons a dolphin was sighted as a proportion of the total number of seasons surveyed) were calculated, in addition to the overall residency rate (the ratio between the number of re-sightings and number of survey days from individual's first sighting to its last re-sighting) (DALY ET AL., 2014, ZANARDO, 2016). An overall residency index value of 1 would indicate that the dolphin was photographed on every survey day, while 0 means that dolphin was never re-sighted during the surveys.

An agglomerative hierarchical cluster analysis was performed via XLStat V 5.01 (Addinsoft, Addinsoft Deutschland, Andernach, Germany) in order to distinguish groups of individuals with a similar degree of monthly residency, seasonal residency and overall residency as it was detailed in DALY ET AL. (2014) AND ZANARDO (2016). Euclidean distance for the dissimilarity measure and Ward's method as the clustering algorithm was chosen (ZANARDO, 2016). Automatic truncation was selected for the dissimilarity threshold, and results were displayed as a dendrogram. To check the validity of the dendrogram, the cophenetic correlation coefficient (CCC) was calculated using StatistiXL V 1.11 (StatistiXL, Nedlands, Western Australia) (ZANARDO, 2016).

RESULTS

Boat surveys were conducted on 32 days totalling 212.43 hours and covering 1643 km. Bottlenose dolphins were encountered on 17 of the 32 days, within which 890 min was spent following 25 focal groups. Group size ranged from 1 to 25 individuals with an average of 7.35 ±4.95.

Distribution pattern

Bottlenose dolphin sightings were concentrated within the coastal zones of northwestern Levantine Sea, with no sightings recorded beyond the 500 m isobath (Figure 2). 65 % of the sightings took place between 0 and 200 m isobaths and sightings rapidly dropped after 300 m isobath. While Antalya Bay, specifically coastal waters of Lara cliff, hold a comparably higher bottlenose dolphin sighting rate, Finike and Fethiye Bay showed lesser degree of species presence.

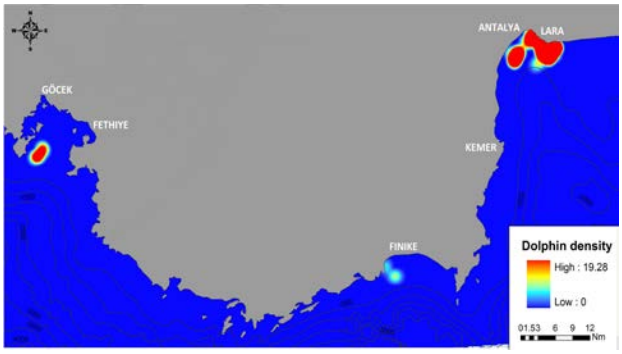

Figure 2. Density of bottlenose dolphins within the northwestern Levantine Sea

Encounter rates

Of the 173 grid cells in the survey area, 103 were discarded from the dataset due to their limited survey effort. The overall encounter rate in the northwestern Levantine Sea was on average 3.3 groups and 25 individuals per 100 km. Spring had the highest encounter rate with 11.6 groups and 100 individuals per 100 km, while in summer 3.17 groups and 16.9 individuals were sighted per 100 km. The encounter rate was zero for both autumn and winter.

Photo-identification

A total of 6324 digital photographs were taken during the surveys, resulting in 45 catalogued individuals in Antalya and Finike Bay and six individuals from Fethiye Bay (Table 1). The median interval between re-sightings was 61 days, while the mean was 142.5 ± 28.6 days, with a range from 10 to 425 days. The majority of the re-sightings were in close proximity to each other and the minimum linear distance between the re-sightings was 0 m. Nonetheless, on one occasion the linear distance of the re-sighting was 126 km from the location of the original observation.

Of the 56 individuals catalogued, 20 were seen on more than one occasion and 13 individuals were photographed both in 2015 and 2016 (Table 1).

The bottlenose dolphins were sighted up to seven months and four seasons throughout the study in Antalya and Finike Bay. While the overall residency index ranged from 0 to 0.6, their monthly residency rate ranged from 0.09 to 0.55 and seasonal residency rate from 0.2 to 0.8. Hierarchical cluster analysis indicated that three main groups of residency patterns were present in the study sites and the related dendrogram represents a reasonable distribution of residency patterns as CCC was 0.50 (Figure 3).

Table 1: Residency pattern of 56 catalogued individuals in the northwestern Levantine Sea (Lighter shade = one day encounter, darker shade = two days encounter, ID = individual ID, TOTAL = Photographed number of individual)

ID	2015										2016							
	MAR.	APR.	MAY	JUNE	JULY	AGUST	SEP.	OCT.	NOV.	DEC.	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	CAPTURED
1																		3
36																		1
3																		1
4																		2
37																		1
6																		7
7																		3
8																		3
9																		4
10																		4
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13																		3
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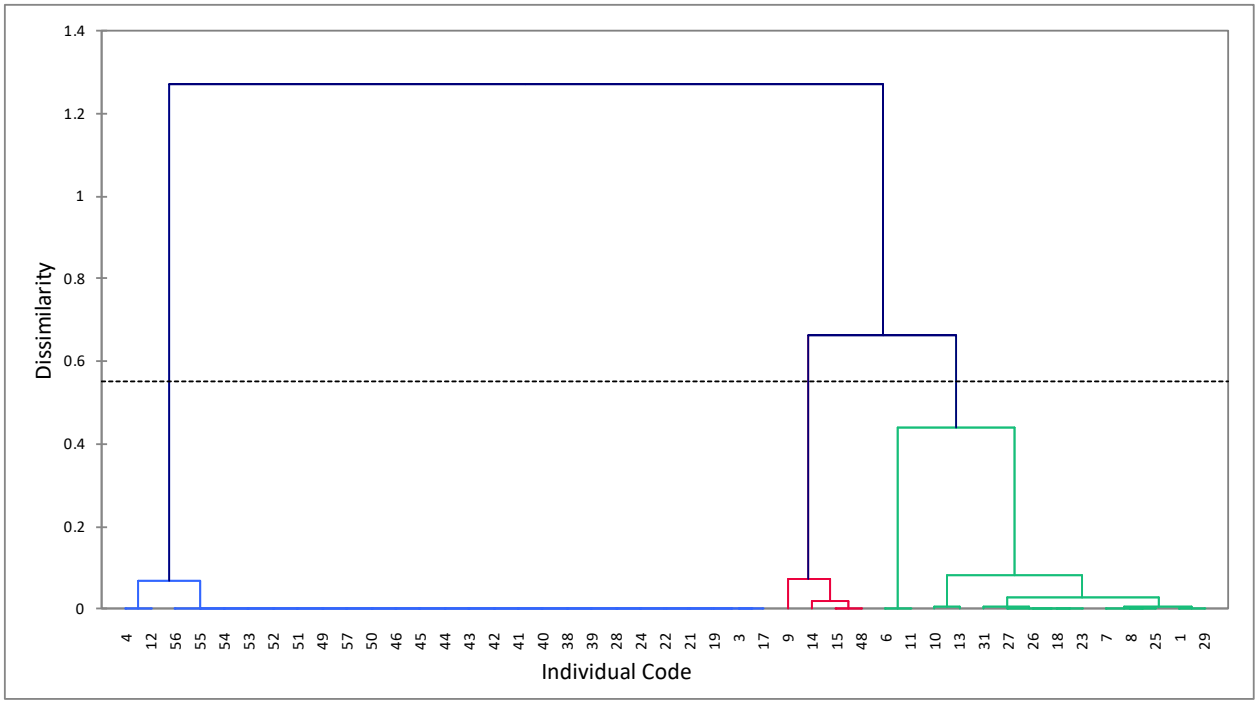

Figure 3. Clusters of residency patterns according to the dendrogram of the agglomerative hierarchical clustering analysis; group 1: seasonal, group 2: transient, group 3: visitor

Group 1 consisted of 14 individuals, which were categorised under seasonal residents. Seasonal individuals were sighted between two and seven occasions, over multiple years with periods of high seasonal residency (between two to four seasons, mean index of 0.49) and a long presence (at least two months per season) (Figure 3). Such individuals showed intermediate monthly and overall residency indexes (mean = 0.29 and 0.14 respectively). Group 2 comprised of 27 individuals and classified as transient. Transient individuals were sighted either once or twice within a single season throughout the study, with low monthly residency (mean = 0.1) and low overall residency (mean = 0.01). Group 3 consisted of four individuals and were categorised as visitors; they showed intermediate monthly index (mean = 0.16) but high overall residency (mean = 0.5). However, these individuals were captured only within a single season in a year (Table 2). Lastly, none of the photographed individuals fell under year round residency (Table 2).

Table 2: Mean monthly, seasonally and overall residency indices of the dolphin groups, as determined by agglomerative hierarchical cluster.

Group	Monthly	Seasonal	Overall Residency
Group 1	0.29 (±0.12)	0.49 (±0.15)	0.14 (±0.08)
Group 2	0.1 (±0.02)	0.2 (±0)	0.01 (±0.04)
Group 3	0.16 (±0.14)	0.2 (±0)	0.48 (±0.11)

DISCUSSION

Baseline knowledge on the overall and seasonal encounter rates, distribution and residency patterns provide information on the population status and allows the assessment of anthropogenic impacts on the target species. Thus, this information is essential for the application of conservation and management efforts.

Here, we report the first estimate of seasonal encounter rates, distribution maps and residency patterns of bottlenose dolphins within the northwestern Levantine Sea, the most heavily used habitat, via tourism activities and urban development, of northern Levantine Sea. The results of this study pointed out that bottlenose dolphins show uneven distribution patterns, high seasonal encounter rates and varying levels of residency patterns within the northwestern Levantine Sea, defining the area as an important habitat for bottlenose dolphins, within their home range. Antalya Bay identified with high presence of bottlenose dolphins, compared to the Finike and Fethiye Bay. Moreover, during the current study autumn and winter sightings of bottlenose dolphins were reported from the northeastern Levantine Sea by the local fishermen. Therefore, the low residency pattern of some dolphins and no recorded year round residencies suggest that bottlenose dolphins range beyond the study site and adjacent waters, specifically the northeastern Levantine Sea, which may also hold important bottlenose dolphin habitats.

The current study reported a concentrated presence of bottlenose dolphins between the 0 to 200 m depth zones, even though the survey effort covered depth zones over 2000 m. This result is in line with previous studies in the Mediterranean Sea (BEARZI ET AL., 2011, GNONE ET AL., 2011, BENMESSAOUD ET AL., 2012). Therefore, it can be inferred that the bottlenose dolphins preferred coastal zones in the northwestern Levantine Sea.

Reported encounter rates (both overall and seasonal) were considerably higher than those presented in the limited number of previous studies conducted in the Levantine Sea. Comparision of encounter rates of the same species in different habitats should be considered with caution, given differences in habitat characteristics, study year, sampling protocols and analysis techniques. RYAN ET AL. (2014) surveyed the coastal and international waters between Rhodes and Cyprus and estimated 0.05 groups of bottlenose dolphins per 100 km. DEDE ET AL. (2009) studied the northern Levantine Sea and reported an overall cetacean encounter rate of around 1 group per 100 km. Both studies reported much lower rates than the current one, which has an overall encounter rate of 3.3 groups (25 individuals) per 100 km and peaked in spring with 12 groups (100 individuals) per 100 km. Both of the previous studies consisted of a single survey conducted during the summer months, whereas the current study comprised of year-round surveys with monthly survey effort. Thus, the current study underlines the importance of annual surveys as it has not only updated the information on the bottlenose dolphin encounters, but also provides seasonal bottlenose dolphin encounter rates for the northwestern Levantine Sea.

The increase in spring sightings, in contrary to the lack of winter and autumn sightings can be an effect of biotic and abiotic factors resulting in predictable shifts of seasonal species distribution (HOLT, 2003). One of many reasons behind this could be the link between the extreme oligotrophic nature of the basin and the limited food sources of Eastern Mediterranean Sea (COLL ET AL., 2010), which may force individuals to travel different habitats in search of prey. The prey availability and predator relationship should be covered in future studies for an accurate conclusion behind the seasonal shifts.

Varying degrees of residency patterns were reported for bottlenose dolphins during the current study, while there were a large number of transients, seasonal residents and a considerable number of occasional visitors, year round residency was never recorded. The gap in knowledge of the residency patterns in the Levantine Sea does not allow for the comparison with previous studies in the same habitat. However, varying degrees of residency patterns were reported from the waters of the United States, New Zealand and Australia with similar classification, except that year round presence was also recorded in the named study sites (ZOLMAN, 2002,

LUSSEAU, 2005, BALMER ET AL., 2008, HENDERSON ET AL., 2013, ZANARDO ET AL., 2016). The large number of seasonal and transient dolphins within northwestern Levantine waters while underlining the seasonal importance of the northwestern Levantine Sea, specifically Antalya Bay, the above information also highlights that bottlenose dolphins indeed inhabit the areas beyond the study sites. This hypothesis is supported by the considerably large re-sighting distance of identified dolphins, with individuals recorded over 100 km away from their initial sighting area. It is known that bottlenose dolphins have relatively large home ranges (WILSON, 1995, WILSON ET AL., 1997, 2004). BEARZI ET AL. (2010) reported that the movements of photo-identified dolphins were up to 265 km off western Greece. It could therefore be argued that the home ranges of individuals are much greater than the results presented here. However, it is important to note that, given the two years of survey effort and number of unidentified individuals (those which were neither distinctly marked nor close enough to the boat to be photographed), the residency pattern found here might not be entirely representative of the bottlenose dolphins. Thus, this information needs to be considered carefully, as it would underestimate the number of dolphins regularly returning to the area. Future studies should consider increasing the survey effort in each study site to assess whether the estimated residency patterns are actually representative of the population over time.

The coastal areas of the northwestern Levantine Sea is intensively used by fishing fleets and recreational boating and the distribution of bottlenose dolphins appeared to overlap with human activities throughout the study sites (UNPUBLISHED DATA). The negative impacts of humans on dolphins have long been demonstrated by various studies (LEMON ET AL., 2006, LUSSEAU, 2006, BAŞ ET AL., 2014). During the current study, we continuously recorded erratic diving behaviour when dolphins were subjected to the presence of marine vessels. Moreover, almost half of the photographed individuals showed distinctive starvation signs and skin parasites (Figure 4). It is likely that human activities in the northwestern Levantine Sea may take it's toll on bottlenose dolphin populations. It should be noted that there are limited established marine protected areas within this region, none of which have conservation strategies specific to cetaceans (HOYT, 2012).

Figure 4. Example of bottlenose dolphin with a starvation sign

The preliminary results of current multi-year surveys in the northwestern Levantine Sea not only confirms concentrated bottlenose dolphin presence and high seasonal encounters, but also reports several residency patterns of bottlenose dolphins. It should also be noted that the presence of calves throughout the

surveys suggest that the study area can be and/or in close proximity to an important calving and/or nursery ground. Our results propose that the northwestern Levantine Sea, specifically the coastal waters of Antalya Bay, is an important bottlenose dolphin habitat and adjacent waters may be of similar significance.

In conclusion, long term dedicated and systematic studies with similar methodologies but wider survey coverage are both necessary and important in detecting possible changes in the encounter rates, distribution and residency patterns over time, which will also serve as the main tool in assessing the human impacts on the population. We urge future research, conservation and management efforts to be carried out and not be limited to the northwestern Levantine Sea, but to also take into account the adjacent waters, in order to improve our understanding of the population status and major threats of bottlenose dolphins in the Levantine Basin. Only with these profound research gaps filled, can we begin to create effective conservation and protection measures, which are currently missing and urgently needed in the area.

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