Short-beaked common dolphins of Dilek Peninsula National Park, South Aegean Sea: Preliminary results on group structure, spatial distribution, behavioural patterns, whistle characteristics and behavioural context

AYLIN AKKAYA[1], TIM AWBERY[1,2], PATRICK LYNE[1], HANNAH SCHARTMANN[1], KAYLA NEASE[1], CAROLINE HASS[1], ANNE LE HENAFF[1], BETH MURRAY[1], LAURA RUDD[1] AND AYŞE ORUÇ[3]

Contact email: akkayaaylinn@gmail.com

ABSTRACT

Basic knowledge about populations of short-beaked common dolphins (*Delphinus delphis*) in the eastern part of the Mediterranean Sea is still lacking. Classified as 'Endangered' in an IUCN assessment released in 2022, it is necessary to gain baseline knowledge to understand the species' population status and develop impactful conservation measures. The current study conducted boat surveys, employing visual and acoustic techniques between January 2019 and July 2022 in the Dilek Peninsula National Park, central Aegean Sea. Results revealed the continuous coastal presence of common dolphins, with subadults recorded during every sighting in low group sizes. Travelling-related activities made up 58% of observed behaviour while resting comprised just 1%. Whistles were produced in the range of 1.83–48kHz with a peak frequency of 10.4kHz and median duration of 0.54s. Concave whistles were the most frequently recorded whistle type. Whistles were found to be generated when dolphins were interacting with boats and diving/travelling fast, forming 53% and 31% of whistle production respectively. The continuous presence of common dolphins, particularly subadults, emphasises the importance of the Dilek Peninsula. Whistle parameters show similarities with other common dolphin populations of the Mediterranean and Black Sea, albeit with shorter durations. The high whistle presence during boat interactions requires investigation to assess whether whistles carry avoidance or predatory messages, or whether there are potential consequences for the species' energy budget. The current study presents preliminary information on the behavioural context of acoustic patterns. Further research is essential to understand the click and whistle characteristics within the biological, environmental and anthropogenic variables of their surroundings.

KEYWORDS: COMMON DOLPHIN; AEGEAN SEA; ACOUSTICS; BEHAVIOUR; DISTRIBUTION; MEDITERRANEAN; VOCALISATION; PHOTO-ID

INTRODUCTION

Short-beaked common dolphins (*Delphinus delphis*) (hereafter 'common dolphins') are widely distributed around the globe (Hammond *et al*., 2008), including the Mediterranean Sea where they were once considered one of the most common cetaceans (Alan *et al*., 2018; Bearzi and Reeves, 2004; Bearzi *et al*., 2008). Since the 1960s,

[1] DMAD Marine Mammals Research Association, Kadikoy, Istanbul, Turkey
[2] Marine Mammals Research Team, Scottish Association for Marine Science, Scottish Marine Institute, Oban, UK
[3] Doğal Hayatı Koruma Vakfı, World Wildlife Fund (WWF)-Turkey, Istanbul, Turkey

the Mediterranean subpopulation has experienced an alarming decline, now showing only a patchy distribution throughout the basin (Bearzi *et al*., 2003; Cañadas and Hammond, 2008). This basin-wide decline is due to a variety of factors, including bycatch, prey depletion due to overfishing and habitat degradation, marine traffic, chemical and noise pollution, marine debris and outbreaks of disease (Aguilar *et al*., 1999; Bearzi *et al*., 2003; Costello *et al*., 2010; Harwood, 2001; Sutherland *et al*., 2010).

The steady decline of common dolphins in the Mediterranean Sea has led to the subpopulation being listed as 'Endangered' on the IUCN Red List of Threatened Species in 2003 (Bearzi, 2003). This 'Endangered' status was reiterated during a recent IUCN assessment of common dolphins in the inner Mediterranean with an estimated population of just 2,496 individuals considered to be in decline (Bearzi *et al*., 2021). As a result of this and the decline of other species, international agreements, including the Barcelona Convention (Annex II), the Convention on Biological Diversity and Agreement on the Conservation of Cetaceans of the Black Sea, Mediterranean Sea and Contiguous Atlantic Area (ACCOBAMS), have been put into place to monitor the population status of various marine species (ACCOBAMS, 2002; Pietroluongo *et al*., 2020). ACCOBAMS listed several research actions in 2002, including the need to conduct visual and acoustic surveys to determine the current distribution, abundance and habitat use of common dolphins in the Mediterranean (ACCOBAMS, 2002; Cañadas and Hammond, 2008). Despite the actions taken, there is still too little baseline data on the species to establish a robust population size estimate for the Mediterranean (Karamitros *et al*., 2020; Mussi *et al*., 2021; Pietroluongo *et al*., 2020). A better understanding of the common dolphin's critical habitats, behaviour and acoustic context, and residency and movement patterns, are vital for conservation efforts to ensure these habitats and connection corridors can be treated as a priority for research and management (Bearzi *et al*., 2004; Bräger *et al*., 2003; Cañadas *et al*., 2005; Condet and Dulau-Drouot, 2016; Hastie *et al*., 2003; 2004; Ingram and Rogan, 2002).

Common dolphins are known to show both coastal and offshore distributions within the Mediterranean Basin (Cañadas and Hammond, 2008; Gannier, 2005). While year-round presence has been recorded within the westernmost portion of the basin (Papale *et al*., 2020), there are also seasonal fluctuations in their distribution (Arcangeli *et al*., 2017; Evans and Hammond, 2004; Laran *et al*., 2017). Key habitats for behaviours such as foraging, resting and nursing are yet to be identified in the basin (Saintignan *et al*., 2020). The species is generally seen in large groups, ranging from 50–70 individuals (Notarbartolo di Sciara *et al*., 1993). The species is also known to be highly vocal (Caruso *et al*., 2017) with their vocal repertoire comprising tonal calls (whistles), clicks and burst pulse calls (Ansmann, 2005; Griffiths, 2009; Henderson *et al*., 2011). The whistles of Mediterranean common dolphins are characterised as frequency-modulated, long-duration tonal calls with an emitted frequency range of 2–18kHz; clicks are typically produced between 23–67kHz (Azzolin *et al*., 2014; 2019; Gannier *et al*., 2010; Papale *et al*., 2014). Furthermore, several studies have linked the role of behavioural context and vocalization type (Henderson *et al*., 2011; Petrella *et al*., 2012; Wiggins *et al*., 2013), but the limited number of acoustic studies on common dolphins in the Mediterranean and Black Sea restricts our understanding (Antichi *et al*., 2018).

While cetacean studies within the western and central Mediterranean Sea have been relatively thorough, the southern and eastern regions, including the Aegean Sea, are historically understudied and continue to be the least studied areas in the basin (Dede *et al*., 2012; Frantzis *et al*., 2003; Mannocci *et al*., 2018; Würtz, 2010). As a result of data deficiency in these regions, it would be challenging to monitor any conservation efforts as this requires baseline knowledge of species composition and habitat use (Dede *et al*., 2012). Nevertheless, previous studies indicate frequent sightings of common dolphins in the Aegean Sea (Dede and Öztürk, 2007; Frantzis *et al*., 2003; Öztürk and Öztürk, 1998).

The Dilek Peninsula falls under National Park protection status and was the first protected area to be declared in Turkey in 1966 (Kaboğlu *et al*., 2005). Our preliminary results identify the group structure and distribution of common dolphins in the National Park; investigate whistle types and characteristics; to help to analyse the link between behavioural context and vocal repertoire. The study aims to generate baseline knowledge for this endangered species and urge its inclusion in the current management plans for the Dilek Peninsula Protected Area.

METHODOLOGY

Survey Area

Surveys were conducted within the coastal waters of the Dilek Peninsula National Park, central Aegean Sea (Figure 1). The national park is 276.75km^2; the peninsula itself covers 110km^2 with 61km of coastline (Çelik *et al*., 2003; Kılıçaslan *et al*., 2011). The selected survey area covers 158.5km^2 and falls within both the protected area and adjacent waters. The area has multiple coastline habitats, such as sandy beaches, rocky shores, coastal lagoons and deltaic systems, all serving as hotspots for several species of flora and fauna (Altuğ *et al*., 2011; Coll *et al*., 2010; Katağan *et al*., 2015). Average water temperature ranges from 15–20°C with a salinity of approx. 38.5psu (Kucuksezgin *et al*., 2019).

Data Collection

Data were collected during the boat surveys between Winter 2019 and Summer 2022. A 17m wooden motorboat with 200hp was used. Surveys were conducted on average for six hours. The boat followed a random route with an average speed of four knots (Figure 1). A double platform technique was used during the surveys with a minimum of six researchers on board. Two researchers on the primary platform scanned the peninsula by naked eye up to 500m. A further two researchers on a second platform scanned the peninsula using binoculars, looking between 500m and the horizon. One data logger on the second platform ran the software *Logger 2010*, recording environmental parameters and the behavioural activity of dolphins, with a GPS device attached to log the spatial position of the research boat and focal group. The final researcher operated the acoustic station. While the position of the research boat was auto-recorded every 30s, the position of the focal group was calculated using the distance and bearing of the group from the research boat every minute throughout the encounter. Environmental conditions were either recorded every hour or when conditions changed. Environmental

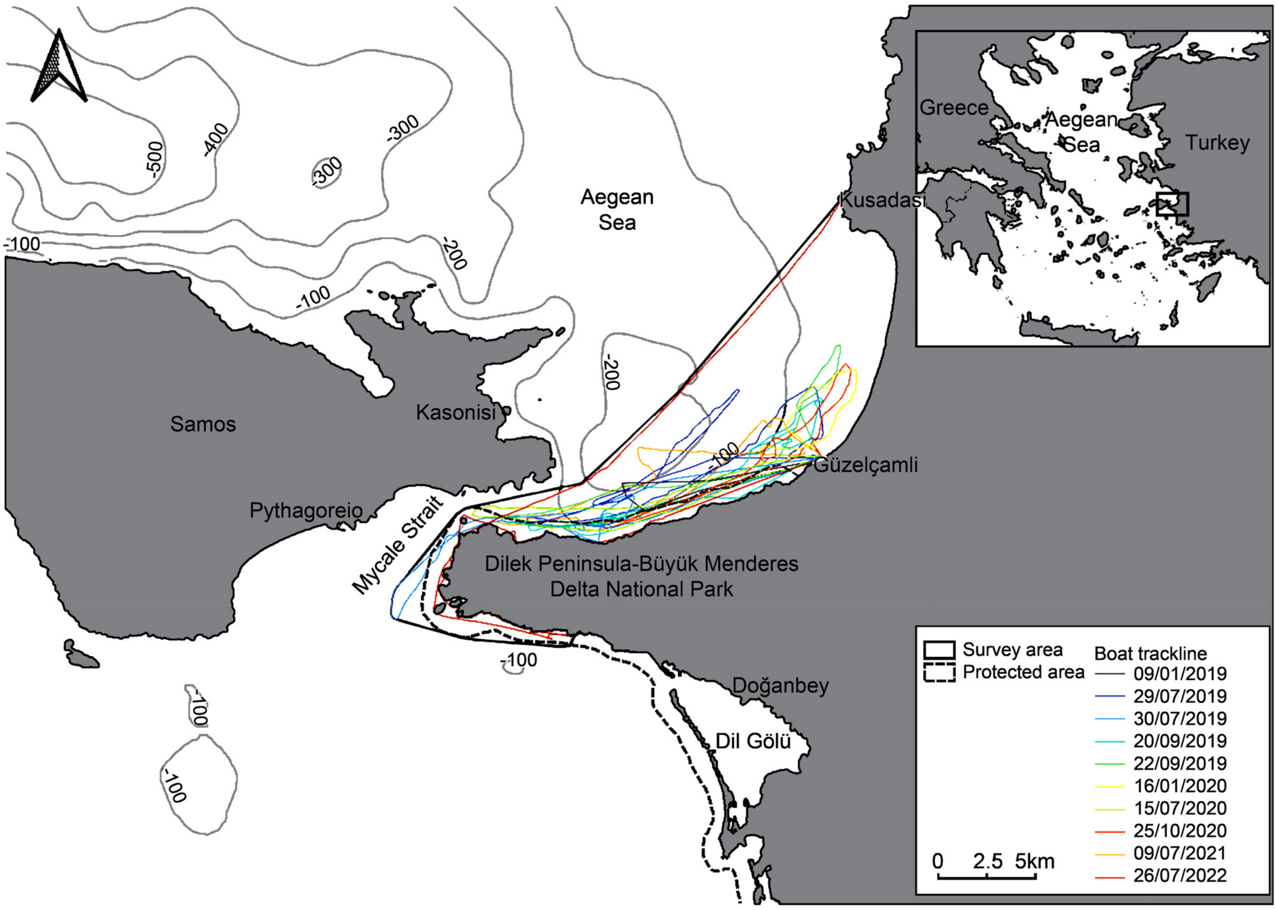

Fig. 1. Survey area and followed track lines throughout the surveys.

conditions recorded include: Beaufort sea state, wave and swell height, cloud cover, visibility, wind speed, wind direction, sun glare angle and intensity.

Once a species sighting occurred, the boat approached the focal group from the side or rear (with dolphins at 45 degrees to the vessel), with the engine idling when possible. The research boat remained at least 100m from the focal group, unless the group approached the boat. The focal group was followed for 20 minutes on average, with the duration ranging from five to 60 minutes. During this time, the behavioural activity of the group was recorded every five minutes through an instantaneous focal group scan-sampling method (Mann, 2000). The groups were identified using the 100m radius chain rule, where each individual within a single group must be within 100m of the next individual, with the dominant behavioural activity of the group remaining the same throughout. If the distance of an individual was greater than 100m, or the individual engaged in a different activity, the individual was assigned to a different group. During the behavioural sampling, one of 10 behavioural activities were assigned to the focal group (see Table 1). To identify group behaviour, the behaviour of each individual was first noted from the head to tail of the group, before a dominant behaviour, representing the activity of more than 50% of the focal group, was assigned to the group.

Table 1

Definition of identified behavioural activities during the surveys.

Behavioural activity	Definition
Travel (TR)	Dolphins move at least 200m in 1 minute. They move with a constant speed in a certain direction, with diving intervals between 3 and 5 seconds.
Travel Diving (TR-DV)	Dolphins swim underwater at least 400m from where they were originally spotted.
Travel Fast (TR-F)	Dolphins move more than 200m in 1 minute. They almost fly across the sea surface, spending very little time underwater.
Diving (DV)	Dolphins stay in a 100m radius within 1 minute. The majority of the time is spent underwater.
Surface Feeding (SU-FE)	Dolphins move with lots of splashes in the same area. There are likely to be birds and fish present.
Socialising (SOC)	Dolphins can have erratic movements. The presence of body contact and high surface-active behaviour is possible.
Milling (MI)	Dolphins linger close to one another. The group cohesion can vary but the position of the individuals does not particularly change.
Interacting (INT)	Dolphins swim on the bow, behind or at the sides of the boat.
Resting (RE)	Dolphins travel very slowly, less than 100m in 1 minute.
Undetermined (UND)	The behavioural activity is unknown to the researcher.

In addition, the group size (minimum and maximum), group cohesion, subadult presence, changes in swimming direction and marine traffic density surrounding the focal group (within 100m, 400m, 1,000m and more than 1,000m) were also recorded. Group cohesion was recorded as one of four categories: tight (individuals are less than 5m apart from each other), spread (individuals are more than 5m apart), mix (a combination of both tight and spread) or undetermined. Subadults (calves and juveniles) were identified using body length: i.e., if the individual was ≤ two-thirds' the length of the adult swimming in close proximity (Díaz López *et al*., 2010; Shane, 1990), with adults estimated to be longer than 2.5m (Lopez, 2006). Any changes in swimming direction of the focal group in relation to the closest marine vessel were identified as positive (swimming towards the boat), negative (swimming away from the boat), neutral (no directional changes) or undetermined.

Four omni-directional broadband hydrophone elements, with a frequency range of 0.01–192kHz, were deployed at the end of a 200m cable and towed from the back of the vessel. The acoustic signal was recorded with a *Behringer U-Phoria* UMC404HD sound card capable of sampling up to 192kHz. The hydrophone array was connected to a 12v laptop running *PamGuard* software for real-time monitoring. The acoustic operator was responsible for logging the acoustic detections and ensuring the system was continually running.

Data Analysis

Due to the relatively short nature of this study, descriptive statistics were used to describe the behavioural activities and the structure of sighted common dolphin groups. Spatial distribution of sighted groups was mapped in QGIS (version 3.22). Group and individual encounter rates were calculated first for each 500m × 500m grid cell and later mean-averaged across the survey area, following the formula ER = n/L, where n represents the number of group or individual encounters per cell, and L is the survey effort in kilometers travelled by the research vessel in the corresponding grid cell. When averaging across the survey area, only cells that contained survey effort greater than the diagonal of cell (707.11m) were included to avoid biases associated with low survey effort.

Acoustic recordings were played back on a personal computer and viewed as spectrograms using *Raven Pro* 1.6.1 (2019). A 1024-point Hann window with an FFT size of 512 points was used to plot the spectrograms. The spectrogram display was chosen within the frequency range of 0–48kHz. All acoustic data were displayed in 20s intervals with a display frame duration of 5s. A total of three vocalisation types were manually identified: clicks, pulsed calls and whistles. Only whistles that had the following criteria were considered for further analysis: a good signal to noise ratio (at least 10dB above the background noise), recognisable frequency contour from the start to the end of the signal, and independent of other signals with no overlaps or interference. Any signals that were either too faint, without a complete frequency contour or that overlapped with other signals were determined to be poor quality and discarded from the analysis. The quality of whistles was visually assessed.

The contour of each whistle was clipped to visually determine the whistle types (see Table 2; Figure 2). The whistle types were consistent with previous studies (Azevedo *et al*., 2007; Díaz López, 2011). Whistle types were also added to the analysis where they had a recognisable pattern which did not fall into previously identified whistle descriptions.

Six acoustic parameters were measured by visual inspection of each whistle: duration (s), lowest frequency (Hz), highest frequency (Hz), peak frequency (Hz), centre frequency (Hz) and inflection points. Inflection points were identified as a change in the slope of the whistle contour (Díaz López, 2011). Whistle types and acoustic parameters were recorded by date and time before later matching with the visual data, identifying the behavioural category, group size and group cohesion.

Table 2

Definition of the whistle types.

Upsweep	Ascending whistle with no inflection point. Shows an upsweep pattern.
Downsweep	Descending whistle with no inflection point. Shows a downsweep pattern.
Sine	Ascending-flat-ascending or descending-flat-descending whistle with no inflection point.
Multiloop	At least two inflection point with a sequence of ascending and descending patterns or vice versa.
Concave	Making a U shape with descending and ascending pattern with only one inflection point.
Concave-tail	Similar to the concave but with its tail skewed either to the left or right.
Convex	Ascending and descending with only one inflection point, it has an 'n' shape.
Flat	A horizontal whistle with no ascent or descent or inflection point.

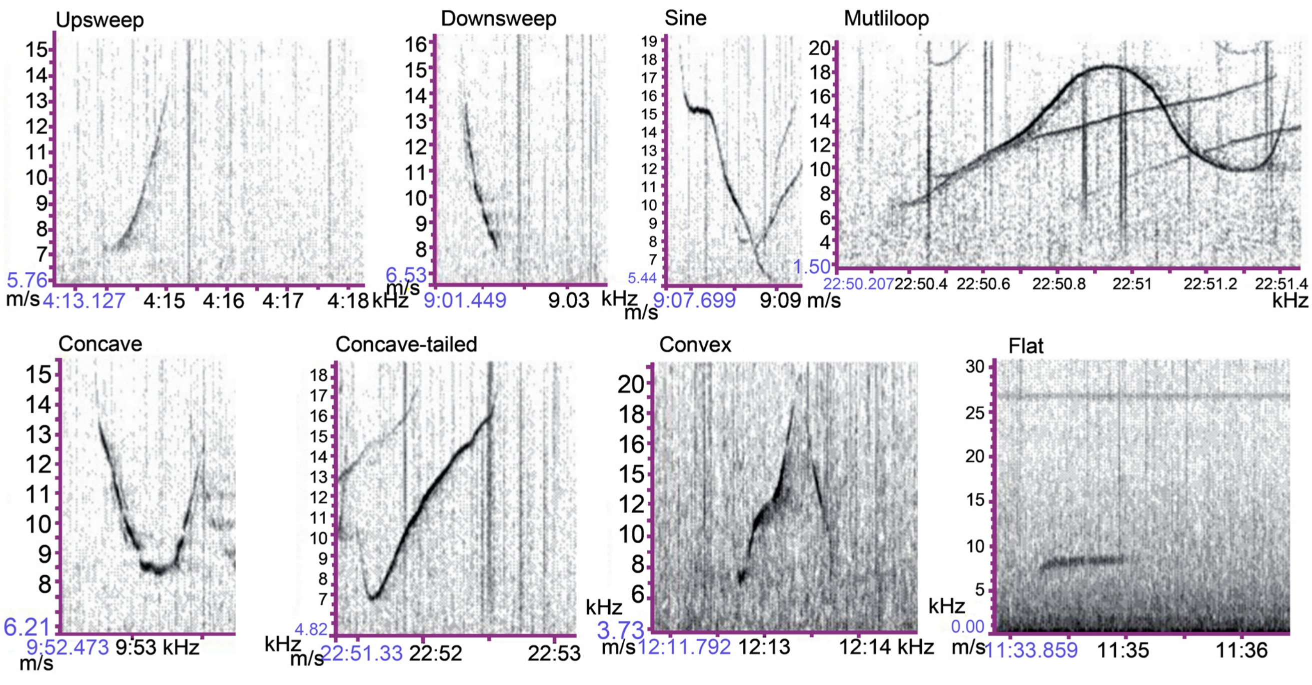

Fig. 2. Examples of each whistle type.

Kruskal Wallis tests were applied to test the equality of medians of the selected parameters between whistle types. The same test was used to assess the variation of selected acoustic parameters between the behavioural activities. If a significant inequality was detected, the post-hoc Dunn test was employed to understand where the variation arose. Statistical analyses were performed with the R software package version 3.6.1 (R Core Team, 2022).

RESULTS

Common dolphins were encountered on every survey undertaken with 22 groups recorded and followed for 8:08 hours of the total 55:37 hours of survey effort between 9 January 2019 and 26 July 2022. Group size varied from two to 18 individuals, with a median of six individuals. Subadult presence was recorded in each group, with a range of one to four and a median of one. Species mapping revealed the coastal distribution of common dolphins, not only within protected area zones, but also extending outside of its borders. Dolphin presence was recorded throughout the survey routes with no specific spatial variation (Figure 3).

The mean encounter rate was 0.16 groups per km and 1.26 individuals per km. Group and individual encounter rates were highest off the cost of Güzelcamlı. The highest number of individuals was also recorded in coastal cells (Figure 4).

Travel-related behaviour (TR, TR-DV, TR-F) formed 64% of the total behavioural sampling, followed by interaction and diving activities, each responsible for 14% of total recordings. Of the dolphins recorded as interacting with vessels, 73% interacted with the research vessel. Resting behaviour formed just 1% of recordings (Figures 5 and 6). While travelling behaviour was recorded throughout the survey routes, socialising and feeding-related behaviour (DV and SU-FE) were concentrated in the northern waters of our study area (Figure 5). Within the behavioural samples, 43% were recorded within 400m of a marine vessel. On 50% of these occasions, the

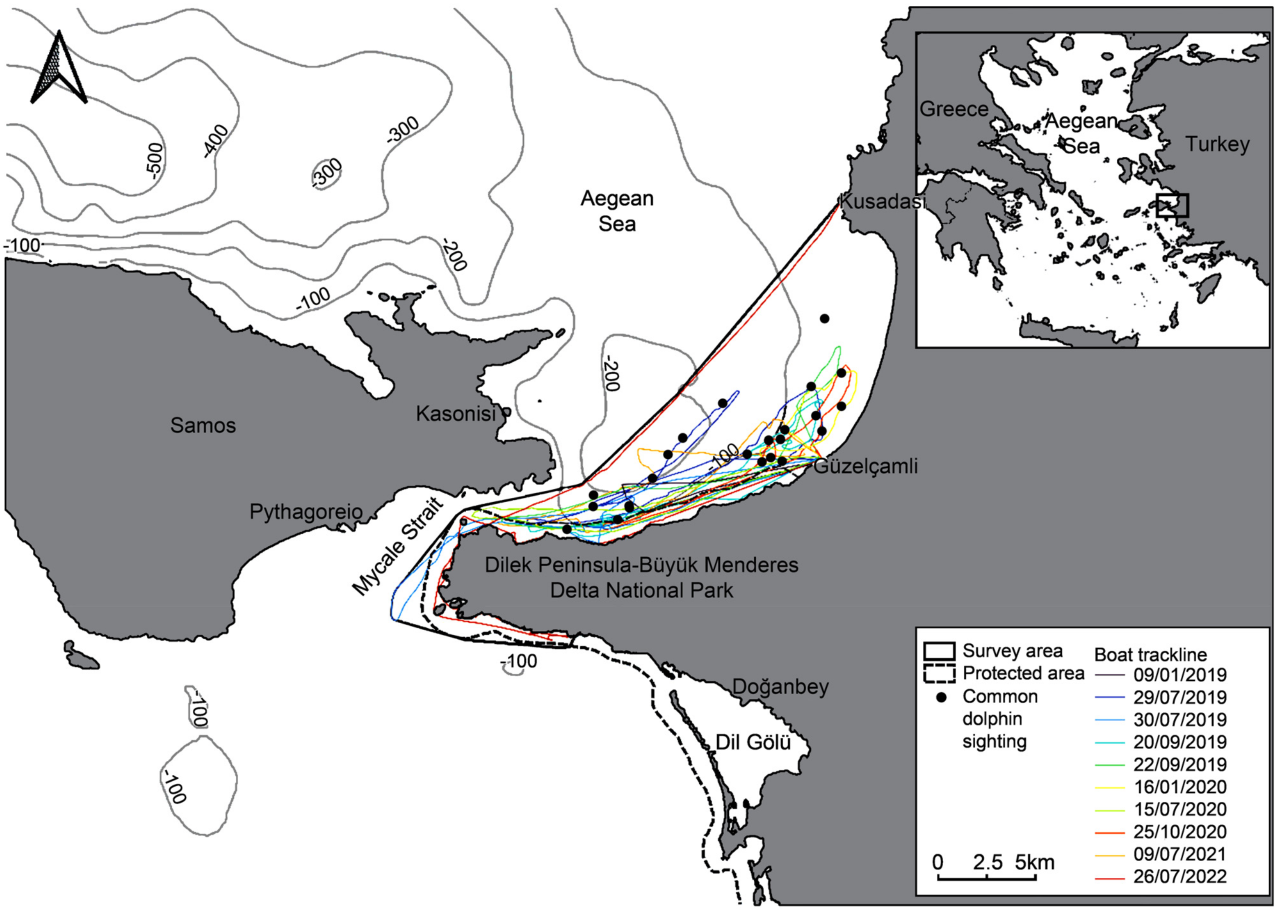

Fig. 3. Common dolphin sightings within the study area.

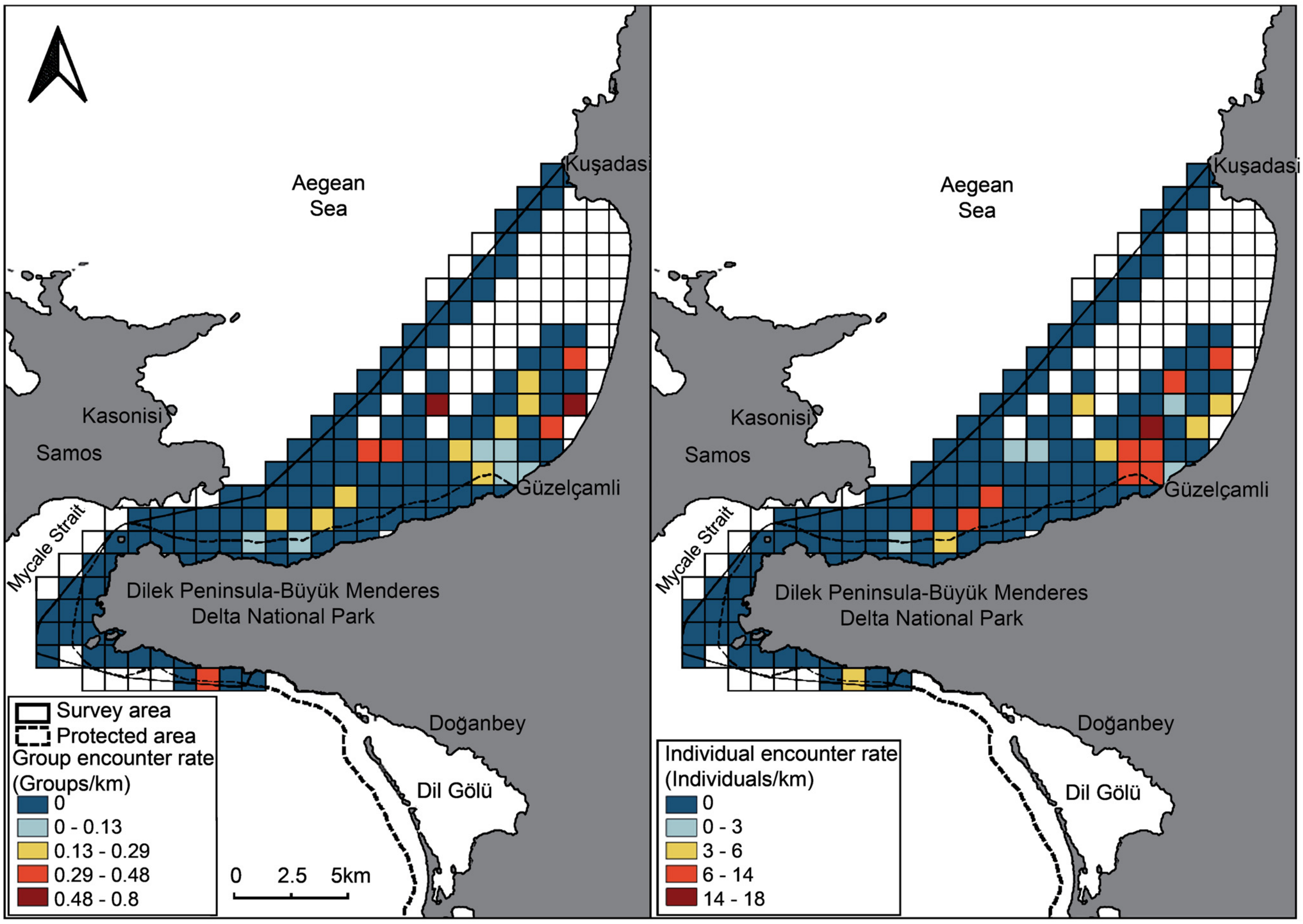

Fig. 4. Group and individual encounter rates of common dolphins within the study area with warmer cells indicating a higher encounter rate. Grey cells indicate no survey effort.

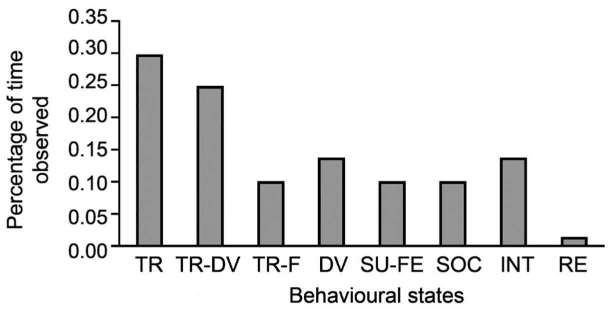

Fig. 5. Percentage of time each behavioural state was recorded throughout the surveys. TR = Travelling; TR-DV = Travel-Diving; TR-F = Travelling-Fast; DV = Diving; SU-FE = Surface-Feeding; SOC = Socialising; INT = Interacting with vessel; RE = Resting.

dolphins elicited a neutral response with infrequent negative responses (movement away from the vessel (7.5%)). The remainder of responses were positive (movement towards vessels (40%)) or undetermined (2.5%).

The hydrophone array was towed for a total of 28.42 hours. Ten groups of common dolphins had simultaneous visual and acoustic recording, generating five hours of acoustic data (Table 3). Click trains were present in 78% of the acoustic detections, while whistles and burst pulses respectively formed 41% and 32% of the detections. Overall, 696 whistles were cropped from the spectrogram; only 310 whistles were identified as good quality and therefore embedded in the further analysis. Whistles occurred in the frequency range of 1.83–47.97kHz, the median values of low and high frequencies respectively being 7.4 and 16.53kHz. Whistle duration varied from 0.14–2.10s with a median value of 0.54s. Both peak and centre frequency had a median frequency of around 10.4kHz (Table 4).

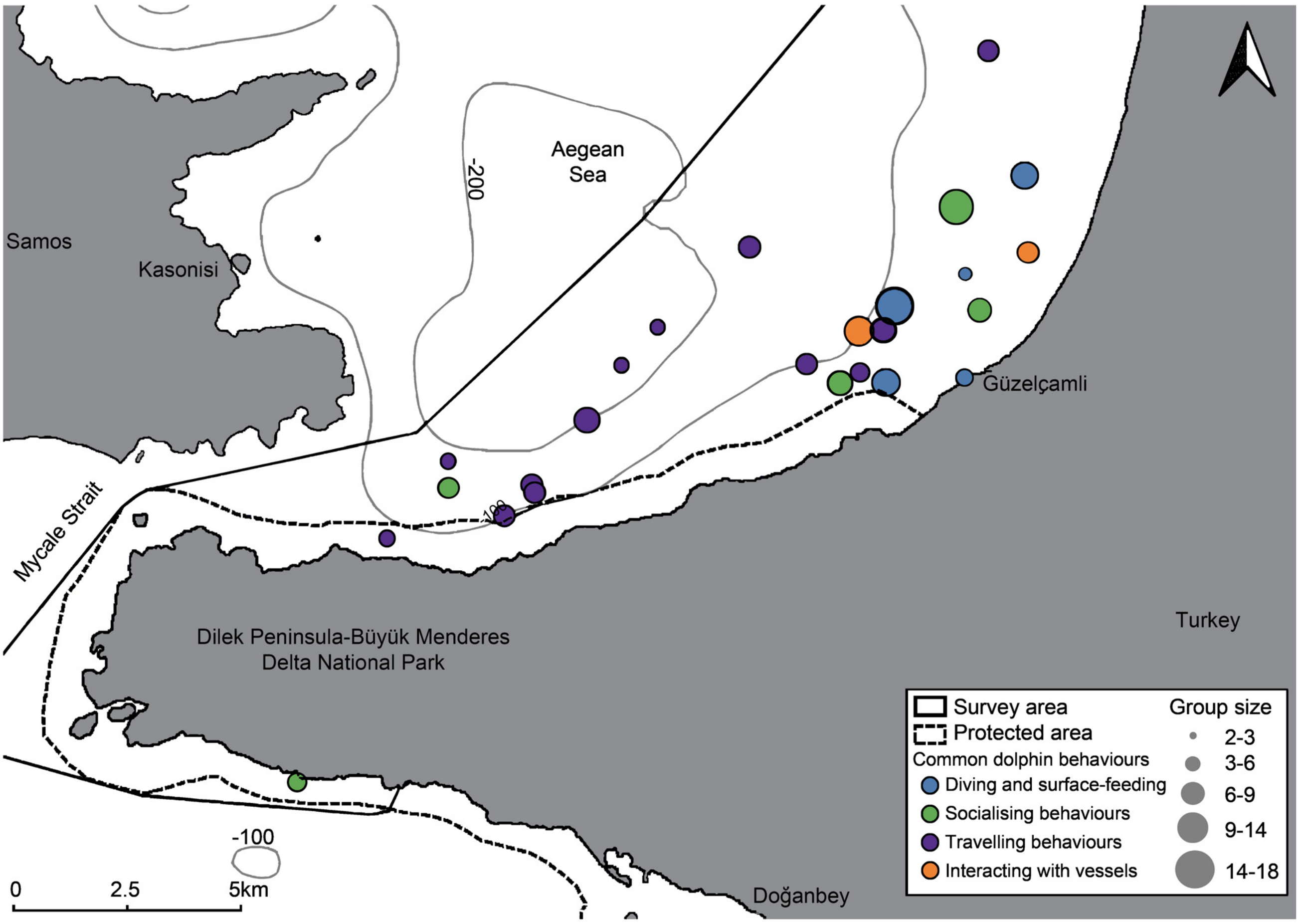

Fig. 6. Spatial distribution of observed behavioural states of common dolphins within the study area.

Table 3

Descriptive information on the encountered common dolphin groups in the Dilek Peninsula.

Date	Time	Encounter	Best group size	Pre-dominant activity	Acoustic recording
01/01/2019	08:20:00	1	5	Undetermined	Absence
09/01/2019	08:40:00	1	5	Undetermined	Absence
09/01/2019	11:35:00	2	5	Undetermined	Absence
29/07/2019	08:23:32	3	3	Travel-diving	Absence
29/07/2019	09:07:57	4	2	Travel	Absence
29/07/2019	09:18:55	5	2	Travel-diving	Presence
29/07/2019	09:43:15	6	6	Travel-diving	Absence
29/07/2019	13:27:11	7	6	Socialising	Absence
30/07/2019	12:23:00	8	6	Surface-feeding	Presence
20/09/2019	07:54:52	9	5	Travel-diving	Presence
20/09/2019	08:12:43	10	8	Diving	Presence
20/09/2019	11:20:39	11	3	Travel-diving	Presence
20/09/2019	13:04:31	12	6	Travel	Presence
22/09/2019	07:49:39	13	3	Diving	Absence
16/01/2020	12:15:00	14	7	Travel-diving	Presence
16/01/2020	12:57:00	15	5	Interaction	Presence
16/01/2020	13:25:00	16	8	Interaction	Presence
15/07/2020	09:43:00	17	5	Socialising	Absence
15/07/2020	10:20:00	18	9	Surface-feeding	Absence
25/10/2020	10:18:56	19	10	Travel	Presence
07/09/2021	09:13:00	20	18	Surface-feeding	Absence
07/09/2021	12:22:00	21	8	Travel	Absence
26/07/2022	10:20:00	22	4	Socialising	Absence

Table 4

Summary statistic of recorded whistles of common dolphins in the Dilek Peninsula.

	Min	Max	Mean ±SE	Median
Duration (s)	0.137	2.104	0.641 ±0.019	0.536
Low frequency (Hz)	1,828.6	35,114.3	8,872.3 ±312.3	7,397.3
High frequency (Hz)	9,438.6	47,967.1	18,706.4 ±458.4	16,525.0
Peak frequency (Hz)	4,150.4	42,000.0	12,446.3 ±395.9	10,405.3
Centre frequency (Hz)	4,394.5	38,531.3	12,316.2 ±394.7	10,406.3
Inflection point	0	3	1 ±0.05	1.0

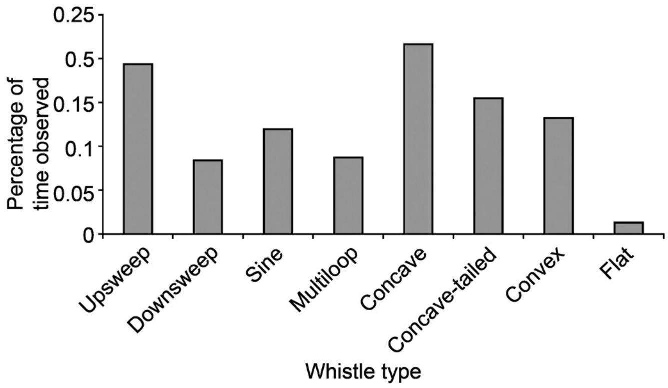

Fig. 7. Proportion of recorded whistle types of common dolphins.

Concave and Concave-tailed formed 37% of whistle types, followed by upsweep (19%), while the least recorded whistle was flat (1%) (Figure 7).

Whistle types showed significant variation between their acoustic specifications ($p < 0.0001$). Multiloop had a significantly higher duration of whistles (median = 1s) than the rest ($\chi^2 = 28.956$, df = 7, $p < 0.0002$). Regarding low frequency ranges, Convex, Flat and Upsweep had similar medians, ranging between 7–8kHz, while Sine had a significantly lower median low frequency range of 4kHz ($\chi^2 = 50.37$, df = 7, $p < 0.0001$). Convex had the highest median of high (22kHz), peak and central frequency (both 12kHz) (χ^2high = 104.34, df = 7, $p < 0.0001$; χ^2peak = 43.368, df = 7, $p < 0.0001$, χ^2central = 72.796, df = 7, $p < 0.0001$) (see Table 5).

Acoustic recordings were obtained simultaneously with five visually recorded behavioural states. 53% of whistle recordings were generated when individuals were interacting with a boat. Travel-diving and travel-fast held 31% of whistle production, whereas the lowest number of recordings occurred during diving and surface-feeding behaviours, respectively forming 2% and 4% of the recordings. There were no whistles collected simultaneously with visual observations of travelling, socialising or resting behaviour (Table 6). Furthermore, 56% of whistles were produced in cases when group cohesion was tight, compared with 18% when the group was dispersed.

The variation of acoustic structure was significantly different between the behaviours ($p < 0.0001$). The median low frequency had the highest values during travel-diving of 8kHz, but the lowest during diving of 6kHz ($\chi^2 = 26.64$, df = 4, $p < 0.0001$). Travel-diving also held the highest medians of high frequency of 21kHz ($\chi^2 = 74.41$, df = 4, $p < 0.0001$), peak frequency of 12kHz ($\chi^2 = 28.8$, df = 4, $p < 0.0001$) and centre frequency of 11kHz ($\chi^2 = 35.9$, df = 4, $p < 0.0001$). There were no significant differences in the length of whistles between different behaviours ($\chi^2 = 7.47$, df = 4, $p = 0.11$) (see Table 6).

Classified whistle types were assigned to a behavioural activity at the corresponding time. Upsweep was the dominant whistle type during diving and interaction behaviour making up 50% and 22%. Concave-shaped was the dominant whistle type during interaction, surface-feeding and travel-fast, forming 20%, 50% and 28% of total whistle types. Travel-diving had the most common convex whistle type, making up 24% of total whistle types. There were 31 acoustic cases where a behaviour couldn't be assigned to the whistle type (Table 7).

Table 5

Descriptive statistics of acoustic parameters considered in whistle types.

Whistle type	Descriptive	Duration (s)	Low frequency (Hz)	High frequency (Hz)	Peak frequency (Hz)	Centre frequency (Hz)	Inflections
Upsweep	Median	0.438	7,867	16,778	10,949	11,156	0
	Mean (SE)	0.531 (±0.036)	9,702 (±822)	18,667 (±1,063)	13,392 (±905)	13,145 (±941)	0
	Range	0.148–1.2489	4,731–32,451	9,835–45,199	7,313–37,031	7,875–38,531	0
Downsweep	Median	0.541	7,896	15,958	9,750	10,498	0
	Mean (SE)	0.559 (±0.036)	9,054 (±603)	17,364 (±928)	11,526 (±731)	11,500 (±644)	0
	Range	0.3097–0.95	5,667–18,322	10,724–28,028	8,156–20,156	8,344–19,125	0
Sine	Median	0.574	4,131	14,294	10,219	10,010	0
	Mean (SE)	0.595 (±0.042)	6,344 (±986)	16,691 (±1,186)	11,831 (±1,104)	11,005 (±1,044)	0
	Range	0.1804–1.4033	1,829–35,114	10,706–43,705	4,150–38,343	4,395–38,250	0
Multiloop	Median	1.03	6,611	18,479	10,010	10,742	3
	Mean (SE)	0.929 (±0.062)	7,885 (±801)	20,277 (±1,216)	11,778 (±1,213)	11,698 (±1,030)	3
	Range	0.325–1.5123	3,909–21,583	14,749–46,226	6,281–37,875	7,568–34,313	0
Concave	Median	0.508	7,046	13,544	8,789	8,719	1
	Mean (SE)	0.645 (±0.041)	7,562 (±210)	14,485 (±357)	9,681 (±312)	9,425 (±243)	1
	Range	0.1369–1.4165	5,491–14,494	10,327–23,531	6,375–17,090	6,844–16,846	0
Concave-tailed	Median	0.708	7,207	16,264	10,189	10,078	1
	Mean (SE)	0.73 (±0.059)	11,008 (±1,193)	20,933 (±1,620)	14,084 (1,424)	14,422 (±1,454)	1
	Range	0.1608–1.5184	5,100–32,958	11,044–47,967	7,031–42,000	7,500–38,156	0
Convex	Median	0.431	8,361	22,231	12,094	11,906	1
	Mean (SE)	0.613 (±0.606)	10,498 (±836)	25,641 (±1,351)	15,968 (±1,425)	16,196 (±1,409)	1
	Range	0.1848–2.1035	5,009–26,133	17,256–47,458	8,301–41,906	9,521–36,188	0
Flat	Median	0.621	7,731	9,808	8,391	8,484	0
	Mean (SE)	0.641 (±0.092)	7,159 (±587)	10,540 (±860)	8,834 (±651)	8,942 (±609)	0
	Range	0.479–0.8442	5,398–7,777	9,439–13,105	7,813–10,742	8,057–10,742	0

Table 6

The occurrence of behaviour under different whistle types.

Behaviour	Descriptive	Duration(s)	Low frequency (Hz)	High frequency (Hz)	Peak frequency (Hz)	Centre frequency (Hz)	Inflections	Total
DV	Median	0.892	6,171	13,722	10,594	9,375	0	6
	Mean (SE)	0.863±0.0858	6,122±412	15,398±1,917	11,530±1,766	10,185±797	0.5±0.342	
	Range	0.621–1.132	5,055–7,696	9,438–22,167	7,969–19,775	8,438–13,672	0–2	
INT	Median	0.565	7,789	17,294	10,715	10,969	1	166
	Mean (SE)	0.672±0.0269	8,930±370	19,223±546	12,326±458	12,246±465	0.97±0.0691	
	Range	0.15–2.11	3,858–35,114	11,056–47,967	6,592–38,344	7,324–38,250	0–3	
SU-–FE	Median	0.467	6,624	14,485	7,594	8,979	1	14
	Mean (SE)	0.667±0.0931	6,845±578	15,710±1,761	10,240±2,011	10,698±1,895	1±0.105	
	Range	0.254–1.240	3,533–13,739	10,836–36,919	7,031–35,889	7,406–34,912	0–2	
TR-DV	Median	0.446	7,891	21,393	12,375	11,250	1	52
	Mean (SE)	0.609±0.0562	12,421±1,179	25,079±1,529	16,743±1,484	16,756±1,459	1.1±0.124	
	Range	0.137–1.518	4,273–32,957	12,264–47,458	6,281–42,000	6,844–38,156	0–3	
TR-F	Median	0.5	6,927	12,789	8,812	8,812	1	47
	Mean (SE)	0.615±0.0389	8,035±633	14,388±908	10,638±849	10,526±852	0.787±0.121	
	Range	0.252–1.136	3,908–32,450	9,720–44,620	6,281–36,656	7,500–38,531	0–3	

Table 7

Count of behavioural states that were assigned to the whistle types.

Behaviour	Upsweep	Downsweep	Sine	Multiloop	Sine	Flat	Concave	Concave-tailed	Convex	Total
DV	3	0	1	0	1	1	0	1	0	6
INT	37	14	15	16	15	1	34	22	27	166
SU-FE	1	0	1	0	1	0	7	3	2	14
TR-DV	4	7	2	7	2	0	6	9	11	52
TR-F	12	4	0	4	0	2	13	11	1	47
UND	3	1	18	0	18	0	7	2	0	31
Total	60	26	37	27	37	4	67	48	41	316

DISCUSSION

Common dolphins, including subadults, were encountered in every single survey in the Dilek Peninsula and its surrounding waters. Their continuous presence highlights the importance of the Central Aegean Sea for this endangered species, though the recorded group sizes were relatively low and none of the sightings contained more than 20 individuals. Common dolphins are known to form larger groups in the Mediterranean Sea (Notarbartolo di Sciara *et al*., 1993). Further assessment is needed to understand the comparably low group sizes in this area. Common dolphins were abundant throughout the Mediterranean Sea until the 1960s, but since then have shown patchy and sparse distribution due to the cumulative impacts of various human pressures (Bearzi *et al*., 2003). Their habitat preference is largely linked to prey availability, environmental parameters and predator presence (Bearzi *et al*., 2005; Giannoulaki *et al*., 2017; Milani *et al*., 2017; Paradell *et al*., 2019), which suggests their movement patterns are impacted by these factors. Common dolphins are now known to be relatively abundant in the westernmost Mediterranean Sea, with the Aegean Sea suggested as one of the last strongholds within the eastern waters (Bearzi *et al*., 2003).

For common dolphins observed in this study, travelling-related behaviours were the most dominant (64%), whereas diving and surface-feeding together formed less than 25% of all behavioural recordings. The high occurrence of travelling could indicate dolphins chasing prey while foraging; however, observed feeding activity while travelling was only recorded in three out of 22 groups. Travelling behaviour is therefore more likely to be indicative of the species' movement patterns around the peninsula. Data collection has only been conducted during daytime hours. It is possible that dolphins may engage in feeding activity at night or prefer deeper waters for daytime foraging; dolphin preference for foraging during the night has already been documented in both the Mediterranean Sea (Caruso *et al*., 2017; Giorli *et al*., 2016) and outside of the basin (Au *et al*., 2013; Henderson *et al*., 2011; Wiggins *et al*., 2013). It remains unknown whether the limited amount of foraging observed in this study is simply a consequence of the species' diurnal activity patterns and habitat preference or a decline in prey availability. There is a clear need for further investigation, especially since prey depletion has been identified as the main reason for population decline in western Greece (Bearzi *et al*., 2008; Cañadas and Hammond, 2008; Gonzalvo *et al*., 2011; Piroddi *et al*., 2010). As Turkey holds a large fishing fleet (with 27% of the coastal fishing effort in the Aegean Sea) (FAO, 2020; Tokaç *et al*., 2010), the impact of continuous fishery pressure on prey availability should be considered.

Common dolphins show flexible feeding habits, with a preference for small epipelagic and mesopelagic fish (Birkun, 2002; Meynier *et al*., 2008; Santos *et al*., 2004). Stomach contents of common dolphins from the North Aegean Sea revealed sardinella, picarels, Cocco's lantern fish, European anchovies, bobtail squid, gobies and bogue are all part of the dolphin's diet (Bearzi *et al*., 2006; Giménez *et al*., 2018; Meynier *et al*., 2008; Milani *et al*., 2017). In the Dilek Peninsula, coastal fisheries mainly target saddled and gilthead seabream, red and common mullet, salema and black scorpionfish, which are also identified as part of the common dolphin diet (Akyol and Ertosluk, 2010; Bearzi *et al*., 2008). These fish migrate in search of food (Cockcroft *et al*., 1990; Škrivanić *et al*., 1973); it is believed that dolphins will move in accordance with the distribution of their prey to improve foraging success (Bearzi *et al*., 2006; Milani *et al*., 2012). There is a further need to understand if the documented movement of common dolphins during the current study is related to the foraging behaviour of the species.

The small group sizes reported in our study (maximum of 18 individuals per group) raises concerns since common dolphins tend to form larger aggregations of up to 70 individuals (Notarbartolo di Sciara *et al*., 1993). Group sizes reported in the Aegean Sea are typically lower, rarely exceeding 35 individuals (Alan *et al*., 2018; Milani *et al*., 2019; Pietroluongo *et al*., 2020). Variation in dolphin group sizes can be related to the animal's activities, prey availability, predator presence and habitat preference (Acevedo-Gutiérrez, 2002; Bearzi *et al*., 2003, 2005, 2008; Mann *et al*., 2000; Santos and Rosso, 2007). Previous studies report a tendency to encounter smaller groups within coastal protected waters, while dolphins may form larger aggregations in open waters to facilitate detection of patchy food sources within a vast area and increase protection from predators (Santos and Rosso, 2007; Würsig, 1986). Dolphins tend to form larger aggregations when travelling and socialising; group sizes can have more variation when foraging and feeding (Bearzi *et al*., 2003; Santos and Rosso, 2007; Würsig, 1986). While travelling was the dominant behaviour in our study, the groups encountered were small. These small group sizes may reflect the geography of the basin: the Aegean Sea is almost landlocked as coastal habitats dominate the area (Poulos *et al*., 2020; Velaoras and Lascaratos, 2005). It could also indicate some degree of disruption as previous studies within the Aegean Sea report larger group sizes (Alan *et al*., 2018; Milani *et al*., 2019; Pietroluongo *et al*., 2020). This potential development is of concern, especially as the species has shown a steady population decline in other regions, including the Alboran Sea, Malta, south-eastern Tyrrhenian Sea and Ionian Sea (Bearzi *et al*., 2003; 2005; 2008; Forcada and Hammond, 1998; Mussi *et al*., 2002; Stockin *et al*., 2004). Nevertheless, due to the lack of long-term data from this area, it is difficult to assess if the small group sizes reported in this study might be an indicator of common dolphin population decline in the Aegean Sea. Despite the small group sizes, the presence of subadults in each group highlights the importance of this area as a suitable nursing habitat. Nursing grounds are considered critical habitats crucial for species survival (Hall *et al*., 1997) and should be prioritised in research and management to ensure effective conservation (Bearzi *et al*., 2004).

The acoustic analyses of this study increased our understanding of the whistle characteristics of common dolphins around the Dilek Peninsula. The whistle frequency ranged between 1.8–47.9kHz with a duration of 0.14–2.10s (median 0.54s). While this is the first research effort on common dolphin whistles around the Dilek Peninsula, common dolphin whistles have been studied in other areas of the Mediterranean: the Alboran and Tyrrhenian Sea (Papale *et al*., 2014), Ionian Sea (Azzolin *et al*., 2019) and Black Sea (Panova *et al*., 2020). For example, whistle duration of common dolphins recorded in the Black Sea is longer with a median duration of 1.04s (Panova *et al*., 2020). However, direct comparisons of whistle parameters between different studies are often challenging due to variations in method, sample size and study area (Quick *et al*., 2008). Further, since delphinid communication is complex, slight variations in whistle characteristics between studies can be caused by a variety of factors, including ambient, natural and anthropogenic noise levels (Ding *et al*., 1995a; 1995b; Rendell *et al*., 1999).

Whistles were predominantly recorded when the focal group was interacting with vessels. This specific context requires further investigation, particularly given that most interactions were with the research boat. It could provide an explanation for the variation in whistle types, with 'concave' and 'concave-tailed' being the dominant patterns, compared with elsewhere in the Mediterranean where the 'Upsweep' whistle pattern is most commonly recorded (Azzolin *et al*., 2019; La Manna *et al*., 2020). Vessel noise (Gospić *et al*., 2016; Heiler *et al*., 2016) and behavioural context may impact whistle characteristics (Díaz López, 2011; La Manna *et al*., 2020). Whistles emitted in close proximity to a boat may function as a social defence mechanism against a threat and can be used to aid group cohesion. This is supported by the fact that 56% of whistle production recorded in this study occurred when the group was in tight cohesion. Studies of bottlenose dolphins have demonstrated that whistles are primarily communication signals, which can vary depending on behavioural and social context (Díaz López, 2011; La Manna *et al*., 2020), playing an important role in social interactions and maintaining group cohesion (Díaz López, 2011; Oswald *et al*., 2008). Therefore, the frequent production of whistles in close proximity to marine traffic could indicate the necessity to maintain social cohesion during disruption. This high whistle production also comes with a potential cost to the energy expenditure of the group (Heiler *et al*., 2016). Despite the Dilek Peninsula having notable marine traffic, interaction between common dolphins and boats was only recorded on 40 occasions which prevented further analysis of visual and acoustic alterations in behaviours. Further studies should consider the pressure of marine traffic on this endangered dolphin. As further data are collected in this region, analysis of how behaviour and whistle type are affected by the presence of marine traffic should be performed, as has already been done for other marine mammal species (e.g., Akkaya Baş *et al*., 2017; Christiansen *et al*., 2013; Clarkson *et al*., 2020; Luís *et al*., 2014; Rudd *et al*., 2022)

While travelling was the dominant behavioural activity of the observed groups, the presence of associated whistles was never recorded. Nevertheless, travel-fast and travel-diving were responsible for the second highest whistle emissions, outlining the need for group cohesion during this activity (Henderson *et al*., 2011), but not explanining the reasons behind the lack of whistles while travelling. It is important to bear in mind that the acoustic results presented here are preliminary in their nature since whistles were recorded from only 22 groups of dolphins. Further acoustic studies are required to develop our knowledge on vocal repertoire and its variation in relation to behavioural context. In addition, for logistical and financial reasons, the current study mainly targeted the northern part of the existing marine protected area, meaning there is a knowledge gap as to the southern boundaries. Extending the survey area to encompass this region should be a future research priority.

In conclusion, despite sparse research effort, the Aegean Sea has been proposed as one of the few remaining habitats to hold relatively abundant populations of common dolphins in the eastern Mediterranean (Bearzi *et al*., 2003; Dede and Öztürk, 2007; Frantzis *et al*., 2003; Milani *et al*., 2017; Öztürk and Öztürk, 1998). Since common dolphins have declined dramatically, urgent research and conservation actions are needed, specifically in locations where data is scarce, such as the eastern and southern Mediterranean (Reeves *et al*., 2003). Any identified stronghold of this endangered population must be protected. Little progress has been made in understanding the species' biological/ecological needs and the causes of its regional decline. This study presents preliminary results on common dolphins in a protected area within the Aegean Sea. The Dilek Peninsula National Park represents only a portion of the home range of these common dolphins. We therefore suggest the protected areas should be extended and further research/conservation measures are put in place to ensure effective management of the endangered short-beaked common dolphins within Turkey's oldest protected area.

ACKNOWLEDGEMENTS

The current study is a collaborative effort between WWF-Turkey and DMAD. We wish to thank Nestle Cereal Department for their financial support. The authors are grateful to all the students and volunteers for their help with fieldwork, specifically Cansu İlkılınç, Belen Yıldırım and Efe Sevim. Finally, we would like to extend our thanks to the reviewers for their helpful suggestions on drafts of this manuscript.

REFERENCES

ACCOBAMS, 2002. Proceedings of the First Session of the Meeting of the Parties of the Agreement on the Conservation of Cetaceans of the Black Sea, Mediterranean Sea and Contiguous Atlantic area. ACCOBAMS meeting report, Monaco, 28 February–2 March 2002. [Available from the Permanent Secretariat of ACCOBAMS, 16 bd de Suisse, MC98000 Monaco].

Acevedo-Gutiérrez, A., 2002. Interactions between marine predators: dolphin food intake is related to number of sharks. *Mar. Ecol. Prog. Ser.* 240: 267–271. [Available at: *https://doi.org/10.3354/meps240267*]

Aguilar, A., Borrell, A., Pastor, T., 1999. Biological factors affecting variability of persistent pollutant levels in cetaceans. *J. Cetacean Res. Manage.* 1(1): 83–116. [Available at: *https://doi.org/10.47536/jcrm.v1i1.264*]

Akkaya Baş, A., Christiansen, F., Öztürk, B., Öztürk, A. A., Erdoğan, M. A., Watson, L. J., 2017. Marine vessels alter the behaviour of bottlenose dolphins *Tursiops truncatus* in the Istanbul Strait, Turkey. *Endanger. Species. Res.* 34: 1–14. [Available at: *https://doi.org/10.3354/esr00836*]

Akyol, O. and Ertosluk, O., 2010. Fishing near sea-cage farms along the coast of the Turkish Aegean Sea. *J. Appl. Ichthyol.* 26(1): 11–15. [Available at: *https://doi.org/10.1111/j.1439-0426.2009.01348.x*]

Alan, V., Kaboğlu, G., Akçalı, B., Bengil, F., Ubay, B., Güçlüsoy, H. 2018. Sightings of small delphinids in the southern Çandarlı Bay (Aegean Sea) between 2015 and 2018. *J. Black Sea/Medit. Environ.* 24(3): 224–232.

Altuğ, G., Aktan, Y., Oral, M., Topaloɫlu, B., Dede, A., Keskin, Ç., Işinibilir, M., Çardak, M., Çiftçi, P. S., 2011. Biodiversity of the northern Aegean Sea and southern part of the Sea of Marmara, Turkey. *Mar. Biodivers. Rec.* 4: 1–17. [Available at: *https://doi.org/10.1017/S1755267211000662*]

Ansmann, I. C., 2005. The whistle repertoire and acoustic behaviour of short-beaked common dolphins, *Delphinus delphis*, around the British Isles, with applications for acoustic surveying. MSc thesis submitted to University of Wales, Bangor. 108pp.

Antichi, S., Ashok, K., Pietroluongo, G., Miliou, A., Tsimpidis, T., 2018. Acoustic characteristics of *Delphinus delphis* and *Stenella coeruleoalba* based on behavior and vessel presence in the Eastern Aegean Sea, Greece [Paper presentation]. 1st Conference of the African Bioacoustics Community, Cape Town, South Africa.

Arcangeli, A., Campana, I., Bologna, M. A., 2017. Influence of seasonality on cetacean diversity, abundance, distribution and habitat use in the western Mediterranean Sea: Implications for conservation. *Aquat. Conserv. Mar. Freshw. Ecosyst.* 27(5): 995–1010. [Available at: *https://doi.org/10.1002/aqc.2758*]

Au, W. W. L., Giorli, G., Chen, J., Copeland, A., Lammers, M., Richlen, M., Jarvis, S., Morrissey, R., Moretti, D., Klinck, H., 2013. Nighttime foraging by deep diving echolocating odontocetes off the Hawaiian islands of Kauai and Ni'ihau as determined by passive acoustic monitors. *J. Acoust. Soc. Am.* 133(5): 3119–3127. [Available at: *https://doi.org/10.1121/1.4798360*]

Azevedo, A. F., Oliveira, A. M., Rosa, L. D., Lailson-Brito, J., 2007. Characteristics of whistles from resident bottlenose dolphins (*Tursiops truncatus*) in southern Brazil. *J. Acoust. Soc. Am.* 121(5): 2978-83. [Available at: *https://doi.org/10.1121/1.2713726*]

Azzolin, M., Gannier, A., Lammers, M. O., Oswald, J. N., Papale, E., Buscaino, G., Buffa, G., Mazzola, S., Giacoma, C., 2014. Combining whistle acoustic parameters to discriminate Mediterranean odontocetes during passive acoustic monitoring. *J. Acoust. Soc. Am.* 135(1): 502–512. [Available at: *https://doi.org/10.1121/1.4845275*]

Azzolin, M., Gannier, A., Papale, E., Buscaino, G., Mussi, B., Ardizzone, G., Giacoma, C., Pace, D. S., 2019. Whistle variability of the Mediterranean short beak common dolphin. *Aquat. Conserv. Mar. Freshw. Ecosyst.* 31: 1–15. [Available at: *https://doi.org/10.1002/aqc.3168*]

Bearzi, G., 2003. Short-beaked common dolphin *Delphinus delphis* (Mediterranean subpopulation). IUCN Red List of Threatened Species 2008. [Available at: *https://dx.doi.org/10.2305/IUCN.UK.2021-3.RLTS.T189865869A189865884.en*]

Bearzi, G. and Reeves, R. R., 2004. Where did the Mediterranean's common dolphin go? *Ecol. Mediterr.* 30(2): 243–244.

Bearzi, G., Reeves, R. R., Notarbartolo di Sciara, G., Politi, E., Canadas, A., Frantzis, A., Mussi, B., 2003. Ecology, status and conservation of short-beaked common dolphins *Delphinus delphis* in the Mediterranean Sea. *Mamm. Rev.* 33(3–4): 224–52. [Available at: *https://doi.org/10.1046/j.1365-2907.2003.00032.x*]

Bearzi, G., Notarbartolo di Sciara, G., Reeves, R. R., Cañadas, A., Frantzis, A., 2004. *Conservation plan for short-beaked common dolphins in the Mediterranean Sea.* ACCOBAMS Agreement for the Conservation of Cetaceans in the Black Sea, Mediterranean Sea and Contiguous Atlantic Area. 90pp. *https://dx.doi.org/10.13140/RG.2.2.26236.64647*.

Bearzi, G., Politi, E., Agazzi, S., Bruno, S., Costa, M., Bonizzoni, S., 2005. Occurrence and present status of coastal dolphins (*Delphinus delphis* and *Tursiops truncatus*) in the eastern Ionian Sea. *Aquat. Conserv. Mar. Freshw. Ecosyst.* 15(3): 243–57. [Available at: *https://doi.org/10.1002/aqc.667*]

Bearzi, G., Politi, E., Agazzi, S., Azzellino, A. 2006. Prey depletion caused by overfishing and the decline of marine megafauna in eastern Ionian Sea coastal waters (central Mediterranean). *Biol. Conserv.* 127(4): 373–82. [Available at: *https://doi.org/10.1016/j.biocon.2005.08.017*]

Bearzi, G., Agazzi, S., Gonzalvo, J., Costa, M., Bonizzoni, S., Politi, E., Piroddi, C., Reeves, R. R., 2008. Overfishing and the disappearance of short-beaked common dolphins from western Greece. *Endanger. Species Res.* 5(1): 1–12. [Available at: *https://doi.org/10.3354/esr00103*]

Bearzi, G., Genov, T., Natoli, A., Gonzalvo, J., Pierce, G. J., 2021. *Delphinus delphis* (Inner Mediterranean subpopulation). IUCN Red List of Threatened Species 2021 [Available at: *https://dx.doi.org/10.2305/IUCN.UK.2021-3.RLTS.T189865869A189865884.en*]

Birkun, A. J., 2002. Interactions between cetaceans and fisheries in the Black Sea. (pp.78–97) In: G. Notarbartolo di Sciara (Ed.), *Cetaceans of the Mediterranean and Black Seas: State of Knowledge and Conservation Strategies.* ACCOBAMS, Monaco.

Bräger, S., Harraway, J. A., Manly, B. F. J., 2003. Habitat selection in a coastal dolphin species (*Cephalorhynchus hectori*). *Mar. Biol.* 143(2): 233–44. [Available at: *https://doi.org/10.1007/s00227-003-1068-x*]

Cañadas, A. and Hammond, P. S., 2008. Abundance and habitat preferences of the short-beaked common dolphin *Delphinus delphis* in the southwestern Mediterranean: Implications for conservation. *Endanger. Species Res.* 4(3): 309–31. [Available at: *https://doi.org/10.3354/esr00073*]

Cañadas, A., Sagarminaga, R., De Stephanis, R., Urquiola, E., Hammond, P. S., 2005. Habitat preference modelling as a conservation tool: Proposals for marine protected areas for cetaceans in southern Spanish waters. *Aquat. Conserv. Mar. Freshw. Ecosyst.* 15(5): 495–521. [Available at: *https://doi.org/10.1002/aqc.689*]

Caruso, F., Alonge, G., Bellia, G., De Domenico, E., Grammauta, R., Larosa, G., Mazzola, S., Riccobene, G., Pavan, G., Papale, E., Pellegrino, C., Pulvirenti, S., Sciacca, V., Simeone, F., Speziale, F., Viola, S., Buscaino, G., 2017. Long-term monitoring of dolphin biosonar activity in deep pelagic waters of the Mediterranean Sea. *Sci. Rep.* 7(1): 1–12. [Available at: *https://doi.org/10.1038/s41598-017-04608-6*]

Çelik, A., Baslar, S., Guvensen, A., Ozturk, M., 2003. Role of national parks in Turkey: A case study from Dilek peninsula-great Menderes Delta National Park. *Pak. J. Bot.* 35(5): 641–57.

Christiansen, F., Rasmussen, M., Lusseau, D., 2013. Whale watching disrupts feeding activities of minke whales on a feeding ground. *Mar. Ecol. Prog. Ser.* 478: 239–51. [Available at: *https://doi.org/10.3354/meps10163*]

Clarkson, J., Christiansen, F., Awbery, T., Abbiss, L., Nikpaljevic, N., Akkaya, A., 2020. Non-targeted tourism affects the behavioural budgets of bottlenose dolphins (*Tursiops truncatus*) in the South Adriatic (Montenegro). *Mar. Ecol. Prog. Ser.* 638: 165–76. [Available at: *https://doi.org/10.3354/meps13257*]

Cockcroft, V. G., Peddemors, V. M., 1990. Seasonal distribution and density of common dolphins *Delphinus delphis* off the south-east coast of Southern Africa. *S. Afr. J. Mar. Sci.* 9(1): 371–77. [Available at: *https://doi.org/10.2989/025776190784378853*]

Coll, M., Piroddi, C., Steenbeek, J., Kaschner, K., Lasram, F. B. R., Aguzzi, J., Ballesteros, E., Bianchi, C. N., Corbera, J., Dailianis, T., Danovaro, R., 2010. The biodiversity of the Mediterranean Sea: Estimates, patterns and threats. *PLoS One* 5(8): e11842. [Available at: *https://doi.org/10.1371/journal.pone.0011842*]

Condet, M. and Dulau-Drouot, V., 2016. Habitat selection of two island-associated dolphin species from the south-west Indian Ocean. *Cont. Shelf Res.* 125: 18–27. [Available at: *https://doi.org/10.1016/j.csr.2016.06.010*]

Costello M. J., Coll, M., Danovaro, R., Halpin, P., Ojaveer, H., Miloslavich, P., 2010. A census of marine biodiversity knowledge, resources, and future challenges. *PLoS One* 5(8): e12110. [Available at: *https://doi.org/10.1371/journal.pone.0012110*]

Dede, A. and Öztürk, B., 2007. Cetacean observations in the Marmara and Aegean Sea in spring season 2005. *Rapp. Comm. Int. Mer Médit*. 38: 455.

Dede, A., Saad, A., Fakhri, M., Öztürk, B., 2012. Cetacean sightings in the Eastern Mediterranean Sea during the cruise in summer 2008. *J. Black Sea/Medit.Environ.* 18(1): 49–57.

Díaz López, B., 2011. Whistle characteristics in free-ranging bottlenose dolphins (*Tursiops truncatus*) in the Mediterranean Sea: Influence of behaviour. *Mamm. Biol.* 76(2): 180–89. [Available at: *https://doi.org/10.1016/j.mambio.2010.06.006*]

Díaz López, B., Shirai, J. A. B., 2009. Mediterranean common bottlenose dolphin's repertoire and communication use. In: A. G., Pearce, L. M., Correa (Eds.), *Dolphins: Anatomy, Behavior and Threats* (pp.129–148). Nova Science Publishers, New York.

Ding, W., Wursig, B., Evans, W., 1995a. Whistles of bottlenose dolphins: comparisons among populations. *Aquat. Mamm.* 21(1): 65–77.

Ding, W., Wursig, B., Evans, W., 1995b. Comparisons of whistles among seven odontocete species. In: J. Thomas, P. Nachtigall (Eds.), *Sensory Systems of Aquatic Mammals* (pp.299–323). De Spil Publishers, Woerden.

Evans, P. G. H., Hammond, P. S., 2004. Monitoring cetaceans in European waters. *Mamm. Rev.* 34(1–2): 131–56.

FAO (Food and Agriculture Organization of the United Nations), 2020. The State of Mediterranean and Black Sea Fisheries 2020. General Fisheries Commission for the Mediterranean, FAO, Rome.

Forcada, J., and Hammond, P., 1998. Geographical variation in abundance of striped and common dolphins of the western Mediterranean. *J. Sea Res.* 39(3–4): 313–25. [Available at: *https://doi.org/10.1016/S1385-1101(97)00063-4*]

Frantzis, A., Alexiadou, P., Paximadis, G., Politi, E., Gannier, A., Corsini-Foka, M., 2003. Current knowledge of the cetacean fauna of the Greek Seas. *J. Cetacean Res. Manage.* 5(3): 219–32. [Available from the Office of this Journal]

Gannier, A., 2005. Summer distribution and relative abundance of delphinids in the Mediterranean Sea. *Rev. d'Ecologie* 60(3): 223–38. [Available at: *https://doi.org/10.3406/revec.2005.1267*]

Gannier, A., Fuchs, S., Quèbre, P., Oswald, J. N., 2010. Performance of a contour-based classification method for whistles of mediterranean delphinids. *Appl. Acoust.* 71(11): 1063–69. [Available at: *https://doi.org/10.1016/j.apacoust.2010.05.019*]

Giannoulaki, M., Markoglou, E., Valavanis, V. D., Alexiadou, P., Cucknell, A., Frantzis, A., 2017. Linking small pelagic fish and cetacean distribution to model suitable habitat for coastal dolphin species, *Delphinus delphis* and *Tursiops truncatus*, in the Greek Seas (Eastern Mediterranean). *Aquat. Conserv. Mar. Freshw. Ecosyst.* 27(2): 436–51. [Available at: *https://doi.org/10.1002/aqc.2669*]

Giménez, J., Marçalo, A., García-Polo, M., García-Barón, I., Castillo, J. J., Fernández-Maldonado, C., Saavedra, C., Santos, M. B., de Stephanis, R., 2018. Feeding ecology of Mediterranean common dolphins: The importance of mesopelagic fish in the diet of an endangered subpopulation. *Mar. Mammal Sci.* 34(1): 136–54. [Available at: *https://doi.org/10.1111/mms.12442*]

Giorli, G., Au, W. W. L., Neuheimer, A., 2016. Differences in foraging activity of deep sea diving odontocetes in the Ligurian Sea as determined by passive acoustic recorders. *Deep Sea Res. Part I Oceanogr. Res. Pap.* 107: 1–8. [Available at: *https://doi.org/10.1016/j.dsr.2015.10.002*]

Gonzalvo, J., Moutopoulos, D. K., Bearzi, G., Stergiou, K. I., 2011. Fisheries mismanagement in a Natura 2000 area in western Greece. *Fish. Manag. Ecol.* 18(1): 25–38. [Available at: *https://doi.org/10.1111/j.1365-2400.2010.00764.x*]

Gospić, N. R., Picciulin, M., 2016. Changes in whistle structure of resident bottlenose dolphins in relation to underwater noise and boat traffic. *Mar. Pollut. Bull.* 105(1): 193–98. [Available at: *https://doi.org/10.1016/j.marpolbul.2016.02.030*]

Griffiths, E. T., 2009. Whistle repertoire analysis of the short-beaked common dolphin, Delphinus delphis, from the Celtic Deep and the Eastern Tropical Pacific Ocean. MSc thesis, School of Ocean Sciences, Bangor University. [Available at: *http://www.seawatchfoundation.org.uk/wp-content/uploads/2012/08/Griffiths2009_SBCDwhistle-repertoire.pdf*]

Hall, L. S., Krausman, P. R., Morrison, M. L., 1997. The habitat concept and a plea for standard terminology. *Wildl. Soc. Bull.* 25(1): 173–82.

Hammond, P. S., Bearzi, G., Bjørge, A., Forney, K., Karczmarski, L., Kasuya, T., Perrin, W. F., Scott, M. D., Wang, J. Y., Wells, R. S., Wilson, B., 2008. *Delphinus delphis*. The IUCN Red List of Threatened Species 2008: e.T6336A12649851. [Available at: *https://doi.org/10.2305/IUCN.UK.2008.RLTS*]

Harwood, J., 2001. Marine mammals and their environment in the twenty-first century. *J. Mammal.* 82(3): 630–40. [Available at: *https://doi.org/10.1644/1545-1542(2001)082%3C0630:MMATEI%3E2.0.CO;2*]

Hastie, G. D., Wilson, B., Thompson, P. M., 2003. Fine-scale habitat selection by coastal bottlenose dolphins: Application of a new land-based video-montage technique. *Can. J. Zool.* 81(3): 469–78. [Available at: *https://doi.org/10.1139/z03-028*]

Hastie, G. D., Wilson, B., Wilson, L. J., Parsons, K. M., Thompson, P. M., 2004. Functional mechanisms underlying cetacean distribution patterns: Hotspots for bottlenose dolphins are linked to foraging. *Mar. Biol.* 144(2): 397–403. [Available at: *https://doi.org/10.1007/s00227-003-1195-4*]

Heiler, J., Elwen, S. H., Kriesell, H. J., Gridley, T., 2016. Changes in bottlenose dolphin whistle parameters related to vessel presence, surface behaviour and group composition. *Anim. Behav.* 117: 167–77. [Available at: *https://doi.org/10.1016/j.anbehav.2016.04.014*]

Henderson, E. E., Hildebrand, J. A., Smith, M. H., Falcone, E. A., 2011. The behavioral context of common dolphin (*Delphinus* sp.) vocalizations. *Mar. Mammal Sci.* 28(3): 439–60. [Available at: *https://doi.org/10.1111/j.1748-7692.2011.00498.x*]

Ingram, S. N. and Rogan, E., 2002. Identifying critical areas and habitat preferences of bottlenose dolphins *Tursiops truncatus*. *Mar. Ecol. Prog. Ser.* 244: 247–55. [Available at: *https://doi.org/10.3354/meps244247*]

Kaboğlu, G., Güçlüsoy, H., Bizsel, K. C., 2005. Marine protected areas in Turkey: History, current state and future prospects [Paper presentation]. INOC International Workshop on Marine and Coastal Protected Areas, 23–25 March 2005, Meknes, Morocco. 145pp.

Karamitros, G., Gkafas, G. A., Giantsis, I. A., Martsikalis, P., Kavouras, M., Exadactylos, A., 2020. Model-based distribution and abundance of three Delphinidae in the Mediterranean. *Animals*, 10(2): 260. [Available at: *https://doi.org/10.3390/ani10020260*]

Katağan, T., Tokac, A., Beşiktepe, Ş., Öztürk, B. (Eds.), 2015. *The Aegean Sea Marine Biodiversity, Fisheries, Conservation and Governance*. Turkish Marine Research Foundation.

Kılıçaslan, Ç., Deniz, B., Göktug, T.H., Kara, B., Kutsal, E., 2011. Evaluation of tourism alternatives in the national park of Dilek Peninsula Büyük Menderes delta. *Procedia Soc.* 19: 270–79. [Available at: *https://doi.org/10.1016/j.sbspro.2011.05.132*]

Kucuksezgin, F., Gonul, T., Pazi, I., Kacar, A., 2019. Assessment of seasonal and spatial variation of surface water quality: Recognition of environmental variables and fecal indicator bacteria of the coastal zones of Izmir Bay, Eastern Aegean. *Reg. Stud. Mar. Sci.* 28: 100554. [Available at: *https://doi.org/10.1016/j.rsma.2019.100554*]

La Manna, G., Rako-Gospić, N., Sarà, G., Gatti, F., Bonizzoni, S., Ceccherelli, G., 2020. Whistle variation in Mediterranean common bottlenose dolphin: The role of geographical, anthropogenic, social and behavioral factors. *Ecol. Evol.* 10(4): 1971–87. [Available at: *https://doi.org/10.1002/ece3.6029*]

Laran, S., Pettex, E., Authier, M., Blanck, A., David, L., Dorémus, G., Falchetto, H., Monestiez, P., Van Canneyt, O., Ridoux, V. 2017. Seasonal distribution and abundance of cetaceans within French waters – Part I: The North-Western Mediterranean, including the Pelagos sanctuary. *Deep Sea Res. Part II Top. Stud. Oceanogr.* 141: 20–30. [Available at: *https://doi.org/10.1016/j.dsr2.2016.12.011*]

López, B. D., 2006. Bottlenose dolphin (*Tursiops truncatus*) predation on a marine fin fish farm: some underwater observations. *Aquat. Mamm.* 32(3): 305. [Available at: *https://doi.org/10.1578/AM.32.3.2006.305*]

Luís, A. R., Couchinho, M. N., dos Santos, M. E., 2014. Changes in the acoustic behaviour of resident bottlenose dolphins near operating vessels. *Mar. Mamm. Sci.* 30(4): 1417–26. [Available at: *https://doi.org/10.1111/mms.12125*]

Mann, J., 2000. Unraveling the Dynamics of Social Life. (pp.45–64). In: J. Mann, R. C.Connor, P. L. Tyack and H. Whitehead, eds.*Cetacean Societies: Field Studies of Dolphins and Whales*. University of Chicago Press, Chicago, Il.

Mann, J., Connor, R. C., Barre, L. M., Heithaus, M. R., 2000. Female reproductive success in bottlenose dolphins (*Tursiops* sp.): Life history, habitat, provisioning and group-size effects. *Behav. Ecol.* 11(2): 210–19. [Available at: *https://doi.org/10.1093/beheco/11.2.210*]

Mannocci, L., Roberts, J. J., Halpin, P. N., Authier, M., Boisseau, O., Bradai, M. N., Canadas, A., Chicote, C., David, L., Di-Meglio, N., Fortuna, C. M., Frantzis, A., Gazo, M., Genov, T., Hammond, P. S., Holcer, D., Kaschner, K., Kerem, D., Lauriano, G., Lewis, T., Notarbartolo di Sciara, G., Panigada, S., Raga, J. A., Scheinin, A., Ridoux, V., Vella, A., Vella, J., 2018. Assessing cetacean surveys throughout the Mediterranean Sea: A gap analysis in environmental space. *Sci. Rep.* 8(1): 1–14. [Available at: *https://doi.org/10.1038/s41598-018-19842-9*]

Meynier, L., Pusineri, C., Spitz, J., Santos, M. B., Pierce, G. J., Ridoux, V., 2008. Intraspecific dietary variation in the short-beaked common dolphin *Delphinus delphis* in the Bay of Biscay: Importance of fat fish. *Mar. Ecol. Prog. Ser.* 354: 277–87. [Available at: *https://doi.org/10.3354/meps07246*]

Milani, C., Vella, A., Vidoris, P., Christidis, A., Kallianiotis, A., 2012. Dolphin species' diet, fisheries association and net damage in coastal fisheries of the North Aegean Sea (Greece) [Paper presentation]. 26th Conference of the European Cetacean Society, Galway, Ireland.

Milani, C., Vella, A., Vidoris, P., Christidis, A., Koutrakis, E., Sylaios, G., Kallianiotis, A., 2017. Encounter rate and relative abundance of bottlenose dolphins and distribution modelling of main cetacean species in the North Aegean Sea (Greece). *Black Sea/Medit. Environ.* 23(2): 101–20.

Milani, C., Vella, A., Vidoris, P., Christidis, A., Koutrakis, E., 2019. Abundance, distribution and diet of the common dolphin, *Delphinus delphis*, in the northern Aegean Sea (Greece). *Aquat. Conserv. Mar. Freshw. Ecosyst.* 31(Special Issue): 1–11. [Available at: *https://doi.org/10.1002/aqc.3081*]

Mussi, B, Miragliuolo, A., Bearzi, G., 2002. Short-beaked common dolphins around the islands of Ischia, Italy (southern Tyrrhenian Sea). *Eur. Res. Cetaceans*. 16(1): 15.

Mussi, B., Vivaldi, C., Zucchini, A., Miragliuolo, A., Pace, D. S., 2021. The decline of short-beaked common dolphin (*Delphinus delphis*) in the waters off the island of Ischia (Gulf of Naples, Italy). *Aquat. Conserv. Mar. Freshw. Ecosyst.* 1–14. [Available at: *https://doi.org/10.1002/aqc.3061*]

Notarbartolo di Sciara, G., Venturino, M. C., Zanardelli, M., Bearzi, G., Borsani, F. J., Cavalloni, B., 1993. Cetaceans in the central mediterranean sea: Distribution and sighting frequencies. *Bolletino di Zool.* 60(1): 131–38. [Available at: *https://doi.org/10.1080/11250009309355800*]

Oswald, J. N., Rankin, S., Barlow, J., 2008. To whistle or not to whistle? Geographic variation in the whistling behavior of small odontocetes. *Aquat. Mamm.* 34(3): 288–302. [Available at: *https://doi.org/10.1578/AM.34.3.2008.288*]

Öztürk, B. and Öztürk, A. A., 1998. Cetacean strandings in the Aegean and Mediterranean coasts of Turkey. *Rapp. Comm. Int. Mer Médit*. 35: 476–77.

Panova, E., Agafonov, A., Logominova, I., 2020. First description of whistles of Black Sea short-beaked common dolphins, *Delphinus delphis ponticus*. *Bioacoustics* 1–18. [Available at: *https://doi.org/10.1080/09524622.2020.1842245*]

Papale, E., Azzolin, M., Cascão, I., Gannier, A., Lammers, M. O., Martin, V. M., Oswald, J., Perez-Gil, M., Prieto, R., Silva, M. A., Giacoma, C., 2014. Macro- and micro-geographic variation of short-beaked common dolphins whistles in the mediterranean sea and atlantic ocean. *Ethol. Ecol. Evol.* 26(4): 392–404. [Available at: *https://doi.org/10.1080/03949370.2013.851122*]

Papale, E., Alonge, G., Grammauta, R., Ceraulo, M., Giacoma, C., Mazzola, S., Buscaino, G., 2020. Year-round acoustic patterns of dolphins and interaction with anthropogenic activities in the Sicily Strait, central Mediterranean Sea. *Ocean Coast. Manage.* 197: 105320. [Available at: *https://doi.org/10.1016/j.ocecoaman.2020.105320*]

Paradell, O. G., Díaz López, B., Methion, S., 2019. Modelling common dolphin (*Delphinus delphis*) coastal distribution and habitat use: Insights for conservation. *Ocean Coast. Manage.* 179: 104836. [Available at: *https://doi.org/10.1016/j.ocecoaman.2019.104836*]

Petrella, V., Martinez, E. Anderson, M. G., Stockin, K. A., 2012. Whistle characteristics of common dolphins (*Delphinus* sp.) in the Hauraki Gulf, New Zealand. *Mar. Mamm. Sci.* 28(3): 479–96. [Available at: *https://doi.org/10.1111/j.1748-7692.2011.00499.x*]

Pietroluongo, G., Cipriano, G., Ashok, K., Antichi, S., Carlier, H., Miliou, A., Maglietta, R., Fanizza, C., Carlucci, R., 2020. Density and abundance of *Delphinus delphis* in waters south of Samos Island, Greece (eastern Mediterranean Sea). *J. Mar. Sci.* 8(3): 218. [Available at: *https://doi.org/10.3390/jmse8030218*]

Piroddi, C., Giovanni, B., Villy, C., 2010. Effects of local fisheries and ocean productivity on the northeastern Ionian Sea ecosystem. *Ecol. Modell.* 221(11): 1526–44. [Available at: *https://doi.org/10.1016/j.ecolmodel.2010.03.002*]

Poulos, S., Kotinas, V., 2020. Physio-geographical characteristics of the marine regions and their catchment areas of the Mediterranean Sea and Black Sea marine system. *Phys. Geogr.* 1–37. [Available at: *https://doi.org/10.1080/02723646.2020.1762960*]

Quick, N. J., Janik, V. M., 2008. Whistle rates of wild bottlenose dolphins (*Tursiops truncatus*): influences of group size and behavior. *J. Comp. Psychol.* 122(3): 305–11. [Available at: *https://doi.org/10.1037/0735-7036.122.3.305*]

RavenPro, 2019. Raven Pro: Interactive sound analysis software 1.6.1.. K. Lisa Yang Center for Conservation Bioacoustics, Cornell Lab of Ornithology, Ithaca, NY 14850.

R Core Team, 2022. *R: A language and environment for statistical computing.* R Foundation for Statistical Computing, Vienna, Austria.

Reeves, R. R., Smith, B. D., Crespo, E. A., Notarbartolo di Sciara, G., 2003. *Dolphins, Whales and Porpoises: 2002–2010 Conservation Action Plan for the World's Cetaceans.* IUCN/SSC Cetacean Specialist Group. [Available at: *https://doi.org/10.2305/IUCN.CH.2003.SSC-AP.2.en*]

Rendell, L. E., Matthews, J. N., Gill, A., Gordon, J. C. D., Macdonald, D. W., 1999. Quantitative analysis of tonal calls from five odontocete species, examining interspecific and intraspecific variation. *J. Zool.* 249(4): 403–10. [Available at: *https://doi.org/10.1111/j.1469-7998.1999.tb01209.x*]

Rudd, L. E., Awbery, T., Waller, R., Crowe, M., Bauer, J., Jacquemart, A., Nikpaljevic, N., Akkaya, A., 2022. The effect of commercial and artisanal fishing practices on the behavioral budget of bottlenose dolphins off the coast of Montenegro, South Adriatic Sea. *Mar. Mamm. Sci*. 38: 990–1006. [Available at: *https://doi.org/10.1111/mms.12913*]

Saintignan, S., Costantino, M., Milou, A., Moscatelli, S., Pietroluongo, G., Azzolin, M., 2020. Habitat use of *Delphinus delphis* (Linnaeus, 1758) in the southern waters of Samos Island (Aegean Sea, Greece) [Paper presentation]. 2020 IMEKO TC-19 International Workshop on Metrology for the Sea, Naples, Italy.

Santos, M. C. O. and Rosso, S., 2007. Ecological aspects of marine tucuxi dolphins (*Sotalia guianensis*) based on group size and composition in the Cananéia Estuary, southeastern Brazil. *Lat. Am. J. Aquat. Mamm.* 6(1): 71–82. [Available at: *https://doi.org/10.5597/lajam00110*]

Santos, M. B., Pierce, A., Lopez, A., Martinez, J. A., Fernández, M. T., Ieno, E., Mente, E., Porteiro, P., Carrera, P. and Meixide, M. 2004. Variability in the diet of common dolphins (*Delphinus delphis*) in Galician waters 1991–2003 and relationship with prey abundance [Paper presentation]. ICES 2004 Annual Science Conference, Copenhagen, Denmark.

Shane, S. H., 1990. Behaviour and ecology of the bottlenose dolphin at Sanibel Island, Florida. In: Leatherwood, S., Reeves, R. R. (Eds.), *The Bottlenose Dolphin* (pp.245–265). Elsevier Press.

Škrivanić, A., Zavodnik, D., 1973. Migrations of the sardine (*Sardina pilchardus*) in relation to hydrographical conditions of the Adriatic Sea. *Neth. J. Sea Res.* 7: 7–18. [Available at: *https://doi.org/10.1016/0077-7579(73)90028-8*]

Stockin, K. A., Vella, A., Evans, P. G. H., 2004. Proceedings of the Workshop on Common Dolphins: Current Research, Threats and Issues, European Cetacean Society 18th Annual Conference, Kolmården Djurpark, Kolmården, Sweden, 1 April 2004. ECS Newsletter 45 – Special Issue. 44pp.

Sutherland, W. J., Clout, M., Côté, I. M., Daszak, P., Depledge, M. H., Fellman, L., Fleishman, E., Garthwaite, R., Gibbons, D. W., De Lurio, J., Impey, A. J., Lickorish, F., Lindenmayer, D., Madgwick, J., Margerison, C., Maynard, T., Peck, L. S., Pretty, J., Prior, S., Redford, K. H., Scharlemann, J. P. W., Spalding, M., Watkinson, A. R., 2010. A horizon scan of global conservation issues for 2010. *Trends Ecol. Evol.* 25(1): 1–7. [Available at: *https://doi.org/10.1016/j.tree.2009.10.003*]

Tokaç, A., Özbilgin, H. Ö., Kaykaç, H., 2010. Selectivity of conventional and alternative codend design for five fish species in the Aegean Sea. *J. Appl. Ichthyol.* 26(3): 403–09. [Available at: *https://doi.org/10.1111/j.1439-0426.2009.01379.x*]

Velaoras, D. and Lascaratos, A., 2005. Deep water mass characteristics and interannual variability in the North and Central Aegean Sea. *J. Mar. Sys.* 53(1–4): 59–85. [Available at: *https://doi.org/10.1016/j.jmarsys.2004.05.027*]

Wiggins, S. M., Frasier, K. E., Elizabeth Henderson, E., Hildebrand, J. A., 2013. Tracking dolphin whistles using an autonomous acoustic recorder array. *J. Acoust. Soc. Am.* 133(6): 3813–18. [Available at: *https://doi.org/10.1121/1.4802645*]

Würtz, M. 2010. Mediterranean pelagic habitat: oceanographic and biological processes, an overview. IUCN. Gland, Switzerland and Malaga, Spain: 90pp.

Würsig, B., 1986. Delphinid foraging strategies. In: R. J. Schusterman, J. A. Thomas, F. G. Woods (Eds.), *Dolphin Cognition and Behavior: A Comparative Approach* (pp.347–359). Lawerence Erlbaum Associates.