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LINEAR TRANSECT SURVEYS OF ABUNDANCE AND DENSITY OF CETACEANS IN THE AREA NEAR THE DZHARYLGACH ISLAND IN THE NORTH-WESTERN BLACK SEA

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Linear Transect Surveys of Abundance and Density of Cetaceans in the Area near the Dzharylgach Island in the North-Western Black Sea. Gladilina, E. V., Vishnyakova, K. A., Neprokin, O. O., Ivanchikova, Yu. F., Derkacheva, T. A., Kryukova, A. A., Savenko, O. V., Gol'din, P. E. — The first assessment of cetacean density and abundance by linear transect survey was conducted in 2016 and 2017 in the shallowest coastal area of the Ukrainian sector of the north-western Black Sea, in the Dzharylgach Gulf and the northern Karkinit Gulf, total area up to 259 km^2. Three cetacean species were found present in the area in summer, and the harbour porpoise was the most abundant species with the abundance of at least a few hundred animals (estimated as 175 individuals in the Dzharylgach Gulf), whereas the common dolphins (59) and bottlenose dolphins (31) were present in lesser numbers. Common and bottlenose dolphins showed the clearest patterns of habitat preferences, being restricted respectively to the Dzharylgach and the northern Karkinit Gulf; an unusual trait is the preference of the shallowest habitat by common dolphins. Recorded density of harbour porpoises in the Dzharylgach Gulf is among the highest in the whole Black Sea. Thus, the studied area may be an important summer habitat for cetaceans.
Key words: cetaceans, *Phocoena*, *Delphinus*, *Tursiops*, survey, abundance, distribution, Black Sea.

Introduction

The Ukrainian sector of the north-western part of the Black Sea, on the northern edge of which the Dzharylgach Island is situated, is a shallow area which is less than 50 m deep, often covered by ice in winter and influenced by inflow of freshwater from the greatest rivers of the region: Danube, Dniester, Southern Bug (Pivdennyi Buh) and Dnipro. This part of the Black Sea was generally considered as marginal for distribution of the Black Sea cetaceans, the harbour porpoise *Phocoena phocoena* (Linnaeus, 1758), the common dolphin *Delphinus delphis* Linnaeus, 1758, and the common bottlenose dolphin *Tursiops truncatus* (Montagu, 1821) (Salnikov, 1967; Bushuyev, 2000; Mikhalev, 2005; Birkun, 2006): all of them are protected species, which

status is assessed as vulnerable or even endangered due to food resource instability and biological invasions (Bushuyev, 2000). Meanwhile, admitting data deficiency, Birkun (2006) indicated possibly high seasonal (summer) abundance of cetaceans in that region. Also, extremely shallow gulfs and estuaries of this area, including the Dnipro, Yagorlytsky, Tendra and Dzharylgach (Jarilgac) gulfs, were historically known as localities frequently visited by cetaceans during the warm season (Tsemsh, 1941; Salnikov, 1967; Biodiversity of Dzharylgach, 2000). Nevertheless, few cetacean surveys have been conducted in these coastal gulf waters due to indented coastline: the Dzharylgach Gulf was included in large-scale boat surveys as a single transect line only in 2003 (Birkun and Krivokhizhin, 2003) and 2013 (Birkun et al., 2014), which showed presence of cetacean aggregations. Therefore, despite its small area, this relatively isolated water body could be an important habitat for cetaceans, and, thus, special research of these coastal waters seemed to be promising in terms of identification of habitats and abundance of summer groupings which is necessary for planning conservation measures for cetaceans.

The present study reports the results of boat linear transect surveys of cetacean density and abundance in the waters of the Dzharylgach Island uncovering general features of cetacean summer presence in the area. This is the first survey specially dedicated to the shallowest gulf area in the Ukrainian sector of the north-western Black Sea.

Table 1. General characteristics of linear transect surveys in the Dzharylgach area in 2016 and 2017

Date	Number of transect lines	Distance, km	Area, km^2	Locality
2016–09–02	5	21.0	71	Dzharylgach Gulf
2016–09–02	6	22.8	91	Karkinit Gulf
2017–06–26	7	49.4	143	Karkinit Gulf
2017–06–27	4	24.78	116	Dzharylgach Gulf
2017–06–28	3	19.1		

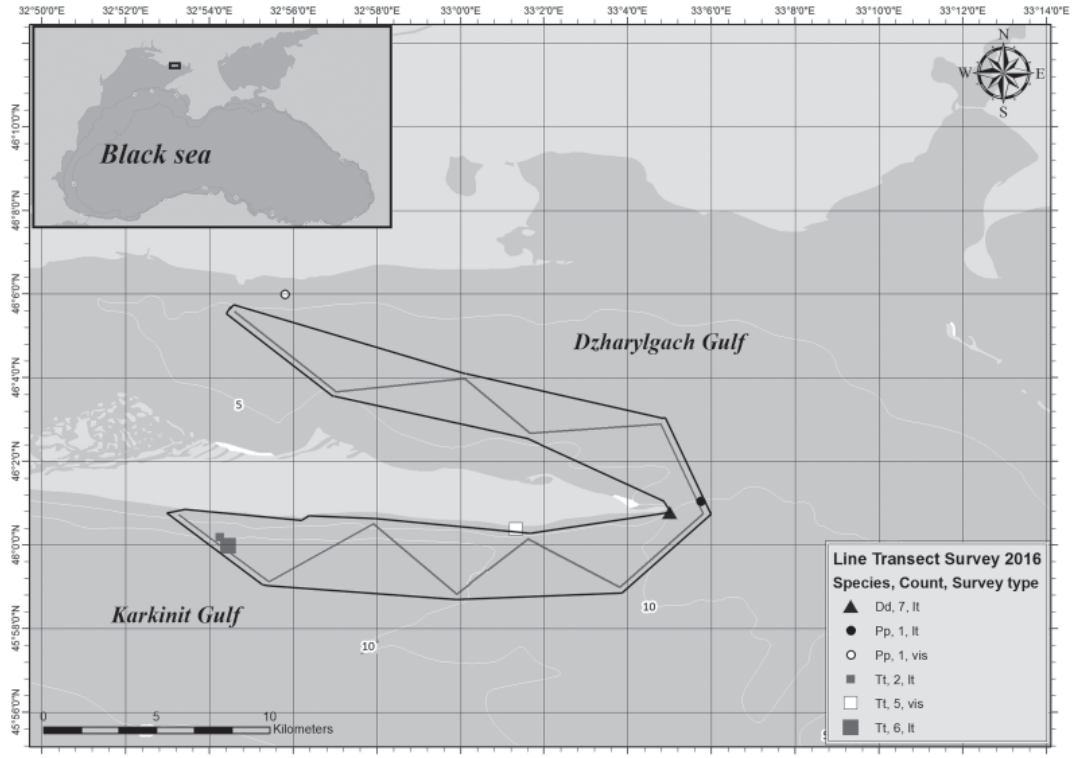

Fig. 1. Linear transect survey of cetaceans near the Dzharylgach Island in 2016 (lt, linear transect survey encounters; vis, additional visual observations).

Material and methods

The linear transect survey (LTS) was designed according to standard principles of distance sampling (Buckland, 2004; Buckland et al., 2001). The surveys were conducted near the Dzharylgach Island in two water bodies, namely in the Dzharylgach Gulf and the northern portion of the Karkinit Gulf, i. e. to the north and to the south of the island, in summer 2016 and 2017 (table 1; fig. 1, 2). These areas, which were identified as two independently processed strata, substantially differ in physical and ecological characteristics: the Dzharylgach Gulf is an extremely shallow, less than 8 m deep, semi-enclosed, highly productive water area, whereas the Karkinit Gulf is a deeper, by 30 m in the middle part, open gulf of the Black Sea. The surveys were conducted in the areas 5–8 m deep in the Dzharylgach Gulf (the greatest survey area in 2017 was 116 km^2) and 5–14 m deep in the Karkinit Gulf (the greatest area of 143 km^2), and the results were separately calculated for each stratum.

The survey platform was the yacht 8.8 m long; two pairs of observers, equipped by binoculars (10 x 40 and 10 x 50), changed after 30 minutes, and a dedicated operator recorded the data. The survey was conducted under good weather conditions (sea state less than 2 points of the Beaufort scale, visibility more than 5 km, zero precipitation). Boat speed was on average 9.5 km/h, at maximum 11 km/h. The observer eye height was 2.5 m. Tracks and coordinates were recorded, using the GPS navigator Garmin eTrex 30. Protocols of effort and registrations were filled in during the surveys.

Species, group size, distance and angle from the moving boat were recorded at each encounter. In addition, behaviour types were recorded: fast movement, normal movement, feeding, etc., as well as behaviour in relation to the boat: avoiding, attraction or neutral.

Density and abundance, cluster (group) density were estimated by analytical tools based on detection probability functions for distance sampling (Buckland et al., 2001), using Distance 7.0 software (Thomas et al., 2010). Encounter rate was defined as a number of group observations per km. Population density was estimated as a number of individuals per square kilometer. Type of spatial distribution (random, uniform or patchy) was estimated from the coefficient of variation for group density (Caughley, 1977). Only encounters on transect lines were used for density and abundance estimations: all the other records on the way to transect lines were only used as referring to cetacean presence in the area.

Results

All the three cetacean species inhabiting the Black Sea, the harbour porpoise, *Phocoena phocoena,* the short-beaked common dolphin, *Delphinus delphis,* and the common bottlenose dolphin, *Tursiops truncatus*, were recorded during the linear transect survey (fig 1 and 2, table 2). The most of encounters were recorded in areas 5 to 12 m deep. Spatial distribution of groups of all the species was random (CV = 45–85 %). Although the survey in the Dzharylgach Gulf was conducted during two consecutive days, there were no repeated encounters of cetaceans between two days: the harbour porpoises were recorded only during Day 1, while the common dolphins were recorded only on Day 2 (fig. 2).

Harbour porpoise. On September 2, 2016, a single animal was recorded north to the tip of the Dzharylgach Island. In 2017 porpoises were encountered both in the Karkinit (2 encounters by single animals) and in the Dzharylgach Gulf: 8 encounters of 14 specimens, single animals and groups of 2 or 3 animals, group size on average in the Dzharylgach Gulf 1.75 individuals, median value 2 individuals. Also, two groups were recorded on the way to the transect line (4 specimens) and a single animal was recorded after the survey, near the port of Skadovsk: therefore, all the records on the way were in the northern part of the Dzharylgach Gulf. Thus, the harbour porpoise, not only the most abundant but also the most widespread species in the area of study, was recorded throughout all the area; however, it mostly tended to the Dzharylgach Gulf. The encounter rate in the Dzharylgach Gulf in 2017 was 0.18 per km (CV = 49 %) (table 2).

Common dolphin. In 2016 a single group containing 7 individuals was encountered near the eastern tip of the Dzharylgach Island. In 2017 common dolphins were encountered near the eastern entrance to the Dzharylgach Gulf and in its eastern part, 5 encounters of 11 specimens, groups of 2 or 3 individuals, group size on average 2.2, median 2. Another group of 7 individuals was recorded in the Dzharylgach Gulf on the way to the LTS transect. After the survey 11 dolphins were recorded in groups by 2 or 3 in each and one more single dolphin. The encounter rate in the Dzharylgach Gulf in 2017 was 0.11 per km (CV = 67 %) (table 2).

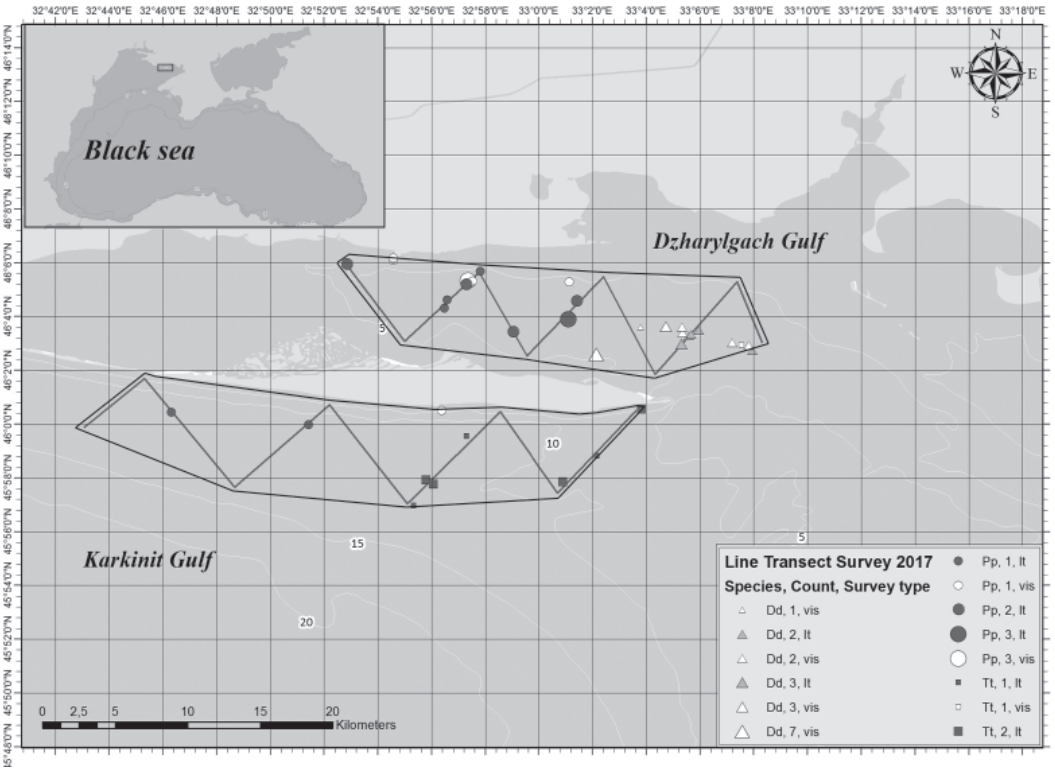

Fig. 2. Linear transect survey of cetaceans near the Dzharylgach Island in 2017 (lt, linear transect survey encounters; vis, additional visual observations).

Bottlenose dolphin. In 2016 there were 2 groups of 6 and 2 individuals encountered in the Karkinit Gulf near the southern coast of the Dzharylgach Island. In 2017 there were 7 encounters of 11 individuals, single and pair sightings, all in the Karkinit Gulf, 3–7 km south to the Dzharylgach Island. The average group size was 1.43, median 2. No bottlenose dolphins were recorded in the Dzharylgach Gulf during the LTS, and the only exception was a single dolphin recorded north to the tip of the island after the LTS on June 28, 2017. The encounter rate in the Karkinit Gulf was 0.09 per km (CV = 101 %) in 2016 and 0.14 per km (CV= 64 %) in 2017 (table 2).

Table 2. Results of estimation of cetacean abundance in the waters of the Dzharylgach Island, linear transect surveys 2016–2017

Species	Year	Region	n	Encounter rate (groups per km)		Mean group size		Effective strip width, m		Density (specimens per km^2)		Abundance				Group density (groups per km^2)		AIC
				Est.	CV, %	Est.	CV, %	Est., m	CV, %	Est.	CV, %	Est.	CV, %	95 % CI		Est.	CV, %	
Tt	2016	K	2	0.09	101	4,0	50	200	110	0,88	121	n/a				2,5	45	133,42
Tt	2017	K	7	0.14	64	1,4	14	470	37	0,22	75	31	75	7	137	0,15	74	88,93
Dd	2017	J	5	0.11	67	2,2	9	259	53	0,51	86	59	86	11	313	0,22	85	71,71
Pp	2017	J	8	0.18	49	1,7	14	107	29	1,51	59	175	59	53	583	0,86	57	76,63

Note. Species (Sp.): Tt — bottlenose dolphins, *Tursiops truncatus*, Dd — common dolphin, *Delphinus delphis*, Pp — harbour porpoise, *Phocoena phocoena*; Region: K — Karkinit Gulf, J — Dzharylgach Gulf; n — number of detected groups; Est. — estimate; CI, 95 % — confidence interval; CV — coefficient of variation, %; AIC — Akaike information criterion.

Density and abundance by species. Due to limited number of observations of each species all the estimates of density and abundance are of low precision, and they characterize only the order of values (table 2). As for 2016, final abundance estimates were not presented here because of extremely high variance of estimates. Besides, all the estimates are uncorrected by detection probability g (0), i. e. they do not involve differences in species detection rates: e. g., bottlenose dolphins are encountered during such a survey within an effective strip width at ideal weather conditions with the probability near 1; on the contrary, harbour porpoises spending much time underwater can be severely underestimated (Teilmann et al., 2013). However, it is clear that the harbour porpoise in the Dzharylgach Gulf is characterized by the highest density among all the encountered species in the area of study: its density is significantly higher than any one for the other species ($p < 0.05$). Based on these data, it is seen that the abundance of harbour porpoises in the Dzharylgach is at least of a few hundred animals, whereas the abundance of bottlenose and common dolphins is around some tens animals each.

Discussion

There were all the three species of the Black Sea cetaceans recorded during both surveys in 2016 and 2017 in the area of study which confirms their summer presence in the waters of the Dzharylgach.

The surveys in 2016 and 2017 showed great differences in occurrence and distribution between cetacean species in the Dzharylgach and Karkinit gulfs. Bottlenose dolphins were encountered exclusively in the Karkinit Gulf and near the tip of the Dzharylgach Island. Meanwhile, common dolphins were observed in the Dzharylgach Gulf and near the tip of the island, and harbour porpoises were encountered throughout the area but with strong prevalence to the Dzharylgach Gulf. Thus, each species has its specific habitat preferences within the local area. In this regard, notable is the presence of aggregations of common dolphins in the shallowest Dzharylgach waters. Such a shallow inshore habitat is unusual for *Delphinus*, which prefer deeper waters worldwide, but this kind of behavior has been already recorded for common dolphins in the north-western Black Sea which come close to the shoreline and even enter some estuaries (Savenko et al., 2016, and refs therein).

Encounter rate for each species in the strata where it could be calculated was within 0.09–0.18 per km (table 2). These values are lesser than those from the coastal waters of the south-eastern Crimea (Krivokhizhin et al., 2012; Gladilina and Gol'din, 2016) and somewhat less than average values for coastal Ukrainian waters as a whole, as well as Romanian and Bulgarian coastal waters (Birkun et al., 2014). However, as seen from this survey and previous locally based studies at coastal Black Sea sites (Zatevakhin, 1987; Birkun et al., 2006; Selyunina et al., 2006; Krivokhizhin et al., 2012; Gladilina and Gol'din, 2016), each species shows patterns or fluctuations of local density which can differ from overall region-wide trends. For example, the harbour porpoise is characterized by notably high density and encounter rate, nearly the greatest values across the Black Sea region which only can be compared to winter distribution in the waters of Georgia (Birkun et al., 2006, 2014) which are known for extremely large aggregations of porpoises. Possibly, the Dzharylgach Gulf is among the greatest summer hotspots for this species, although it is unclear how regular and stable is their summer presence. Notably, only a single specimen was encountered in 2016, indicating that large porpoise aggregations stay in the gulf for a relatively short time period or even occasionally visit the area.

On the contrary, two dolphin species are characterized by modest densities which are in contrast with their high visibility near the coast (see, e. g., Selyunina et al., 2006). In 2017 the encounter rate for bottlenose dolphins was 0.14 per km, at the average group

size of 1.4 and density of 0.22 per km^2. Meanwhile, in the area near Sudak in the north-eastern Black Sea the survey in 2012, which covered an area similar by size, showed similar average group size (1.64) almost twice higher encounter rate (0.26) and far greater density (4.3 per km^2) (Gladilina and Gol'din, 2016). In a result, the tentative abundance of Dzharylgach bottlenose dolphins of a few tens animals is lower in an order than that one near Sudak (n = 604) (Gladilina and Gol'din, 2016), at the same area size (respectively, 143 and 140 km^2), and significantly less than near Karadag in summer (n = 267) (Krivokhizhin et al., 2012). A higher concentration of bottlenose dolphins has also been noticed in the southern Karkinit Gulf, north to the coast of the Tarkhankut Peninsula. During a boat survey in September 2003 Birkun (2006) encountered 48 dolphins in 19 groups at 40 km (ER = 0.47), group size on average 2.5. Notably, bottlenose dolphins visit the northern Karkinit Gulf only during the warm season and are present there only from April to September (Selyunina, 1996; Selyunina, 2001; Selyunina et al., 2003; Tarina et al., 2003; Mikhalev, 2005; Birkun, 2006). Birkun (2006) suggested that bottlenose dolphins from the Tendra and Dzharylgach are locally wandering groups of a local population with the centre of distribution and density located at the south, near the Tarkhankut. However, local surveys near the Tarkhankut coast, although 30 years ago, showed density similar to that recorded in this study (0.13 per km^2 in May) (Zatevakhin, 1987), and maximum group size near the Tendra, up to 80 individuals in May (Selyunina et al., 2006), is at least the same as near the Tarkhankut (Zatevakhin, 1987; Mikhalev, 2005). Thus, contrary to the statement by Birkun (2006), bottlenose dolphins near the Tendra and Dzharylgach can equally represent a relatively separate, distinct summer grouping which is comparable in abundance and similar in density to the local stock near the Tarkhankut. This idea, as well as the tentative estimate of abundance presented here, is to be confirmed by photo-identification studies.

Relatively low density of coastal dolphin groupings in the north-western Black Sea, as seen from previous studies and this survey, is compliant with the hypothesis by Bushuyev (2000) who indicated that the modern cetacean abundance in the Black Sea and especially in its north-western part is generally limited by scarce, depleted prey fish resources. From this perspective, even expansion of cetacean ranges could be partly explained as dispersal driven by lack of prey pushing dolphins for search of new habitats.

Conclusions

All the three cetacean species are present near the Dzharylgach Island in summer. The harbour porpoise is fairly abundant, up to a few hundred individuals at certain moments, whereas the common and bottlenose dolphins can be represented by nearly a few tens individuals.

Common and bottlenose dolphins show the clearest patterns of habitat preferences restricting respectively to the Dzharylgach and the Karkinit Gulf. The harbour porpoise is less selective but also tends to the Dzharylgach Gulf. Notable is the presence of aggregations of common dolphins in extremely shallow coastal waters that is unusual for this species but earlier was recorded in the north-western Black Sea.

Density of harbour porpoises in the Dzharylgach Gulf, even if being an occasional record, is among the highest in the whole Black Sea. Density of common and bottlenose dolphins is lower than in earlier studied local coastal areas of north-eastern Black Sea. Population structure of common and bottlenose dolphins in the Dzharylgach waters, as well as more precise abundance estimates, are to be uncovered by future photo-identification studies.

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