



## Pilot Line-transect Surveys of Cetaceans in a Bulgarian Marine Protected Area: BG0001007 Strandzha Site of Community Importance

**Dimitar V. Popov<sup>1,2</sup>, Galina D. Meshkova<sup>1</sup>, Polina D. Hristova<sup>1</sup>, Antonia N. Miteva<sup>1</sup>, Teodora A. Ilieva<sup>1</sup> & Hristo A. Dimitrov<sup>2</sup>**

<sup>1</sup> Green Balkans NGO, 1 Skopie Street, 4004 Plovdiv, Bulgaria; [www.greenbalkans.org](http://www.greenbalkans.org); E-mail: [dpopov@greenbalkans.org](mailto:dpopov@greenbalkans.org)

<sup>2</sup> Zoology Department, Faculty of Biology, Plovdiv University, 2 Todor Samodumov Street, 4000 Plovdiv, Bulgaria; [bio.uni-plovdiv.bg/en/zoology](http://bio.uni-plovdiv.bg/en/zoology); E-mail: [hr\\_dim@abv.bg](mailto:hr_dim@abv.bg)

**Abstract:** Three cetacean species, each represented by an endemic subspecies, inhabit the Black Sea: Black Sea harbour porpoise *Phocoena phocoena relicta*, Black Sea bottlenose dolphin *Tursiops truncatus ponticus* and Black Sea common dolphin *Delphinus delphis ponticus*. This article presents the first effort for estimation of the cetacean distribution, density and abundance in the marine area of BG0001007 Strandzha Site of Community Importance. Two line-transect distance sampling surveys were conducted in April and May 2016, using a motor sailing yacht as a platform. In May, all three Black Sea cetacean species have been observed, while in April only the harbour porpoise and the bottlenose dolphin have been detected. In both surveys, the most abundant was the Black Sea harbour porpoise with estimated density of 0.871 ind.km<sup>-2</sup> in April and 0.369 in May and abundance in April 328 (CV=33.8%) and in May 139 (CV=50%). The abundance and density of the other two species of dolphins were: 275 (106-714, CV=41.8%) and 0.73 in April and 40 (9-171, CV=56.09%) and 0.107 in May for the bottlenose dolphin, and 24 (5-108, CV=58.72%) and 0.063 in May for the common dolphin. Encounter rates (sightings per kilometre of effort) during the surveys were as follows: harbour porpoise – 0.25 in April and 0.14 in May; bottlenose dolphin – 0.1 in April and 0.02 in May; common dolphin – 0.02 in May.

**Key words:** Black Sea cetaceans, *Phocoena phocoena relicta*, *Delphinus delphis ponticus*, *Tursiops truncatus ponticus*, distance-sampling, abundance.

### Introduction

The three cetacean species occurring in the Black Sea, each represented by an endemic subspecies, are listed in the IUCN Red List of Endangered species. The Black Sea harbour porpoise *Phocoena phocoena relicta* Abel, 1905 and the Black Sea bottlenose dolphin *Tursiops truncatus ponticus* Barabash-Nikiforov, 1940 have been recognised as Endangered (EN) while the Black Sea common dolphin *Delphinus delphis ponticus* Barabash-

Nikiforov, 1935 has been classified as Vulnerable (VU). The first two taxa are listed in Annex II of the EU Habitats Directive 92/43/EEC, meaning that member states must protect their key habitats by designating them as Sites of Community Importance (SCIs) included in the Natura 2000 network. Bulgaria has designated 13 SCIs for the conservation of marine mammals in the Bulgarian sector of the Black Sea but data on abundance, density and distribution of cetaceans in these sites are missing. No management bodies have been assigned and,

consequently, until now no regular monitoring and surveys have been conducted. That is an obstacle for establishing a baseline and reference values for cetaceans' abundance in any of the Bulgarian Natura 2000 sites, which is an essential precondition for defining any conservation measures. Lack of data prevents the identification of key habitats for cetaceans in the sites designated for their conservation. All that, combined with the generally scarce data on the abundance, density and distribution cetaceans in Bulgarian waters of the Black Sea, hinders defining trends in the development of their populations. The most recent dedicated survey on cetaceans along the North-Western Black Sea was conducted by an international team in July 2013. It included a vessel survey for territorial waters and an aerial survey for the rest of the Exclusive Economic Zones of Bulgaria, Romania and a part of Ukraine (BIRKUN et al. 2014). A pilot study combined visual and acoustic surveys for the purpose of testing national cetaceans' monitoring program under the EU Marine Strategy Framework Directive 2008/56/EC was conducted by the Institute of Oceanology of the Bulgarian Academy of Sciences in November 2015 (PANAYOTOVA et al. 2017) in the central sector of the Bulgarian shelf in the Black Sea between the Cape Galata and the Cape Emine. That study area included BG0001501 Emona SCI but still the derived abundance and density estimations were for the entire area and not specifically for the SCI.

This article presents the results from a pilot study dedicated to line-transect distance sampling surveys on abundance and density of cetaceans in the marine area of a Natura 2000 site in Bulgaria, BG0001007 Strandzha SCI.

## Materials and Methods

Marine area of the zone BG0001007 Strandzha SCI (376.18 km<sup>2</sup>) consists of a mosaic of rocky reefs, sandbanks and fields of fine sediment (silt). Various seabed profiles provide depths and conditions suitable for habitation (0–75 m). Sea currents bring to the surface cold waters rich in oxygen, minerals and nutrients in balanced proportions. Clean surface water is heated by the high solar radiation. Two subspecies of cetaceans – the Black Sea harbour porpoise and the bottlenose dolphin, are listed among the site's conservation objectives in the Natura 2000 Standard Data Form where these cetaceans are recorded in the categories "Rare" and "Common", respectively. Nevertheless, data quality is poor for both subspecies and no abundance estimates or reference values are provided.

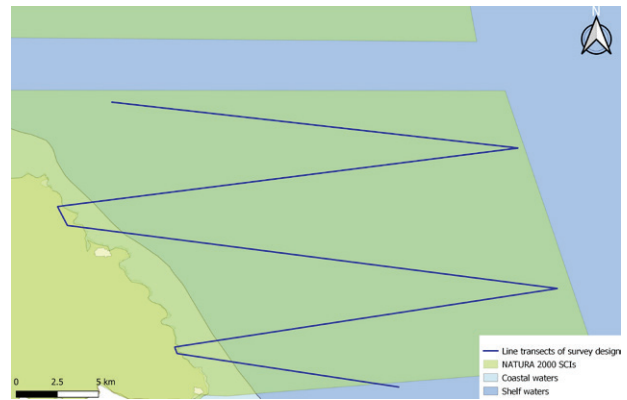


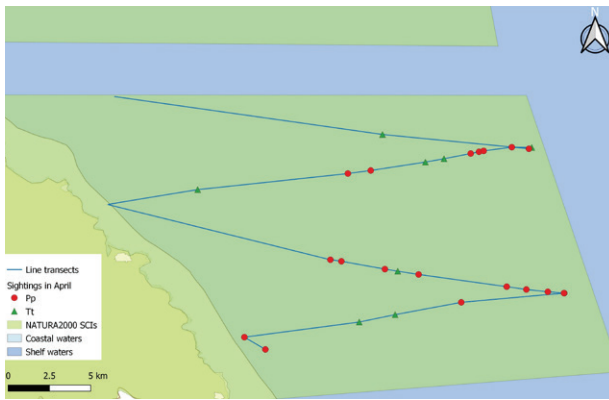
Fig. 1. Map of the survey design

The time of the surveys was selected to be in spring when the reproduction season starts. Standard line-transect distance sampling (BUCKLAND 2004, BUCKLAND et al. 2001) methodology was used deploying a single platform (with two observers and one data recorder). The survey design was made using Distance 6.0 package and included five transect lines with total length of 89.3 km, thus assuring coverage of 19% and an equal coverage probability (Fig. 1). The survey design followed a zigzag shape and was with east-west orientation, perpendicular to the coast.

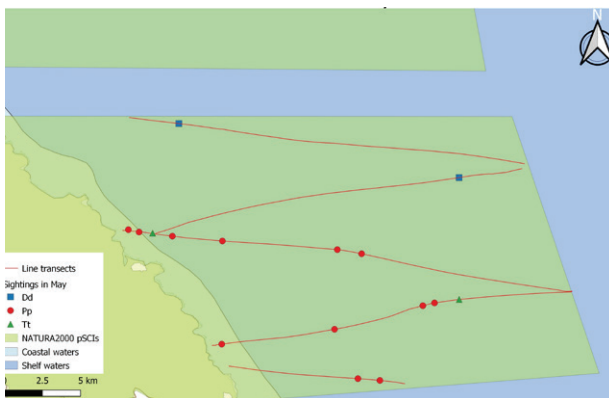
Data were collected during two surveys in April (3<sup>rd</sup> and 4<sup>th</sup>) and in May (9<sup>th</sup> and 10<sup>th</sup>) 2016, using a 12.8 m motor sailing yacht as a platform. Observer's height of eyesight was approximately 2.5 m above the sea level. The effort during the two surveys varied (77.1 km in April and 86.9 in May) due to navigational issues. The average speed was 4–5 knots. The surveys were conducted during appropriate weather conditions (sea state less than 4 by Beaufort scale and good visibility, i.e. more than 5 km). Data on environmental conditions and effort were also recorded during the surveys at the beginning of each transect, rotation of observers or if change in weather conditions occurred.

Species, group size, distance and angle of observation, behaviour and presence of calves were recorded for each sighting. Distance and direction of observation were measured using PENTAX Marine 7x50 reticle binoculars with built-in compass. Distances were recalculated using an online app (<https://graywizard.shinyapps.io/DataProducts>). Geographic coordinates of sightings and tracks of surveys were recorded using a GPS (Garmin GPS-Map 64st).

Abundance and density of individuals and groups were estimated using analytical tools based on detection probability functions for distance



**Fig. 2.** Map of the conducted surveys and the recorded sightings in April



**Fig. 3.** Map of the conducted surveys and the recorded sightings in May

sampling (BUCKLAND et al. 2001) in Distance 7.3 software (THOMAS et al. 2010). Encounter rate was defined as a number of sightings per kilometre of effort. Population density was estimated as a number of individuals per square kilometre. Only sightings per effort along transects were used in the analysis. Conventional distance sampling (CDS) engine of Distance 7.3 was used for the performed analysis. The minimum value of the Akaike Information Criterion or AIC (BUCKLAND et al. 2001, AKAIKE 1974) was used to choose between models.

## Results

During these pilot surveys, a total of 43 sightings were recorded. Twenty-seven sightings were in April (63 %) and 16 (37 %) were in May. In May, all three Black Sea cetacean subspecies have been observed while, in April, only the harbour porpoise and the bottlenose dolphin have been detected (Figs. 2 and 3). During the two surveys, the highest was the encounter rate for the Black Sea harbour porpoise. Two of the subspecies encountered during

both surveys, the Black Sea harbour porpoise and the bottlenose dolphin, were observed more often in April than in May.

The Black Sea harbour porpoise was the most frequently encountered subspecies during both surveys. In April, mostly single animals were observed (eight sightings, 42%), followed by groups of two (six sightings, 32%), while the maximum group size was three (five sightings, 26%). In May, only single animals (eight sightings, 67%) and groups of two (4 sightings, 33%) were observed. In both months, more sightings were recorded in the southern sector of the site with virtually zero sightings for the northern lines in May. The encounter rate (sightings per km of effort) was 0.25 (CV=30.45%) in April and 0.14 (CV=46.94%) in May. Three models of key function were used plus different series expansions. On basis of the lowest AIC, the best model was a uniform key function with cosine series expansion for both surveys. The results for the encounter rate, mean group size, effective strip width, abundance, density of individuals and groups by different key functions are shown in Table 1.

The Black Sea bottlenose dolphin was encountered during both surveys on ten occasions – eight in April and only two in May. In April, more than half of the sightings were of single animals and groups of two, while four animals were encountered once (12.5%) and in two of the sightings the group had a size of three (25%). In May, only single dolphins were encountered. In April, the spatial distribution was relatively even, while in May it was in the central part of site. The encounter rate was 0.1 (CV=36.03%) in April and 0.02 (CV=56.09%) in May, which suggested a five-fold decrease. Three models of key function were used to analyse data from both surveys but only two provided results for the May data, the uniform and the half-normal. Based on the values of the AIC, the best models for both months were those calculated using the uniform key function plus the cosine series expansion, as was the case for the harbour porpoise. Results for encounter rate, mean group size, effective strip width, abundance, density of individuals and groups by different key functions are shown in Table 2.

The Black Sea common dolphin was the rarest cetacean species for both conducted surveys and was encountered only twice with single animals in May. Its encounter rate in May was 0.02 (CV=58.72%). In the analysis, all three key functions were tested but only two provided results: the uniform and half-normal key functions. The lowest was the AIC for the uniform plus cosine series extensions key functions, similarly to the estimations of the other two

**Table 1.** Estimations of the abundance and the density of the Black Sea harbour porpoise *Phocoena phocoena relicta*.

Parameters Key function	April			May		
	Uniform	Half-normal	Hazard-rate	Uniform	Half-normal	Hazard-rate
AIC	<b>218.96</b>	219.37	220.18	<b>138.44</b>	139.08	140.12
Encounter rate, groups per km	<b>0.24643</b>	0.24643	0.24643	<b>0.13809</b>	0.13809	0.13809
Coefficient of variation (CV), %	30.45	30.45	30.45	<b>46.94</b>	46.94	46.94
Mean group size	<b>1.842</b>	1.842	1.4933	<b>1.3333</b>	1.0986	1.0986
Coefficient of variation (CV), %	<b>10.39</b>	10.39	11.79	<b>10.66</b>	10.45	10.45
Effective strip width, m	<b>211.17</b>	194.12	185.27	<b>205.73</b>	198.49	182.15
Coefficient of variation (CV), %	<b>8.87</b>	15.02	26.59	<b>13.53</b>	18.61	34.77
Density, ind. km <sup>-2</sup>	<b>0.871</b>	0.94787	0.99312	<b>0.369</b>	0.38213	0.41643
95% CI	<b>0.39-1.95</b>	0.42134- 2.1324	0.4143- 2.3804	<b>0.11047- 1.2305</b>	0.11512- 1.2685	0.12048- 1.4393
Coefficient of variation (CV), %	<b>33.84</b>	35.64	42.11	<b>49.96</b>	51.57	59.34
Group density, groups per km <sup>2</sup>	<b>0.583</b>	0.63475	0.66505	<b>0.336</b>	0.34785	0.37906
Coefficient of variation (CV), %	<b>31.7</b>	33.96	40.43	<b>48.9</b>	50.49	58.41
Abundance, ind.	<b>328</b>	357	374	<b>139</b>	144	157
95% CI	<b>147-732</b>	158-802	156-895	<b>42-463</b>	43-477	45-541
Coefficient of variation (CV), %	<b>33.8</b>	35.94	42.11	<b>50</b>	51.57	59.34

**Table 2.** Estimations of the abundance and the density of the Black Sea bottlenose dolphin *Tursiops truncatus ponticus*.

Parameters Key function	April			May	
	Uniform	Half-normal	Hazard-rate	Uniform	Half-normal
AIC	<b>79.3</b>	80.42	81.43	<b>18.73</b>	20.73
Encounter rate, groups per km	<b>0.10376</b>	0.10376	0.10376	<b>0.023</b>	0.023
Coefficient of variation (CV), %	<b>36.03</b>	36.03	36.03	<b>56.09</b>	56.09
Mean group size	<b>2</b>	2	2	<b>1</b>	1
Coefficient of variation (CV), %	<b>21.13</b>	21.13	21.13		
Effective strip width, m	<b>142.1</b>	100.31	64.506	<b>108</b>	107.98
Coefficient of variation (CV), %		25.92	84.33		45.18
Density, ind. km <sup>-2</sup>	<b>0.73</b>	1.0344	1.6086	<b>0.107</b>	0.107
95% CI	<b>0.281-1.897</b>	0.37298-2.8688	0.26411-9.7967	<b>0.0249-0.4552</b>	0.01786- 0.63568
Coefficient of variation (CV), %	<b>41.77</b>	49.16	94.1	<b>56.09</b>	72.03
Group density, groups per km <sup>2</sup>	<b>0.365</b>	0.51721	0.80428	<b>0.107</b>	0.107
Coefficient of variation (CV), %	<b>36.03</b>	44.38	91.7	<b>56.09</b>	72.03
Abundance, ind.	<b>275</b>	389	605	<b>40</b>	40
95% CI	<b>106-714</b>	140-1079	99-3685	<b>9-171</b>	7-239
Coefficient of variation (CV), %	<b>41.8</b>	49.16	94.1	<b>56.09</b>	72.03

subspecies, suggesting that the collected data fitted best with this model. Results for encounter rate, mean group size, effective strip width, abundance, density of individuals and groups by different key functions are shown in Table 3.

The estimated abundance for both dolphin species in May was based on only two sightings for each of them, thus resulting in low precision. Therefore, these results should be accepted cautiously.

## Discussion

Abundance, distribution, seasonal variation and trend are among the most important parameters for the assessment of the status of populations for species of conservation concern such as cetaceans. Combined with threats that derive mainly from human activities, these provide basis for the identification of the needed measures to assure conservation.

**Table 3.** Estimations of the abundance and the density of the Black Sea common dolphin *Delphinus delphis ponticus*.

Parameters	May	
	Uniform	Half-normal
Key function		
AIC	<b>20.81</b>	22.81
Encounter rate, groups per km	<b>0.023</b>	0.023
Coefficient of variation (CV), %	<b>58.72</b>	58.72
Mean group size	<b>1</b>	1
Coefficient of variation (CV), %		
Effective strip width, m	<b>181.5</b>	181.47
Coefficient of variation (CV), %		44.71
Density, ind. km <sup>-2</sup>	0.063	0.063
95% CI	<b>0.013989- 0.28736</b>	0.010608- 0.37905
Coefficient of variation (CV), %	<b>58.72</b>	73.8
Group density, groups per km	<b>0.063</b>	0.063
Coefficient of variation (CV), %	<b>58.72</b>	73.8
Abundance, ind.	<b>24</b>	24
95% CI	<b>5-108</b>	4-143
Coefficient of variation (CV), %	<b>58.72</b>	73.8

The EU Habitats Directive 92/43/EEC, that is the basis for Natura 2000 establishment, requires member states to undertake positive management measures to ensure populations of species listed in Annex II are maintained at, or restored to, a favourable conservation status throughout their natural range in the EU. In the case of BG0001007 Strandzha SCI, the first stage will be to establish a baseline for the cetacean abundance and then through a regular monitoring to assess the conservation status and trends in the development of populations at the site.

These pilot surveys have shown the presence of two target species for the site in spring: the harbour porpoise and the bottlenose dolphin. We recorded varying occurrence between months but clear decrease from April to May. Since there are no available data from previous surveys in the region, the obtained estimates can be compared only with results from similar surveys in other parts of the coastal Black Sea waters. These are available for territorial waters of Bulgaria, Romania and Ukraine. According to earlier studies, the density of the Black Sea harbour porpoise was 0.871 ind. km<sup>-2</sup> in April and 0.369 ind. km<sup>-2</sup> in May, higher than in Bulgarian territorial waters in July 2013 where it was 0.144 ind. km<sup>-2</sup> (BIRKUN et al. 2014) and the central Bulgarian sector in November 2015 where it was 0.150 ind. km<sup>-2</sup> (PANAYOTOVA et al. 2017). However, it was lower than in the Dzharylgach area in Ukraine in June 2017 where it was 1.51 ind. km<sup>-2</sup> (GLADILINA et al. 2017) and in the coastal waters of South-eastern

Crimea it was 4.86 ind. km<sup>-2</sup> in April 2011 and 1.67 ind. km<sup>-2</sup> in November the same year (KRIVOKHIZHIN et al. 2012).

The density of the Black Sea bottlenose dolphin was 0.73 ind. km<sup>-2</sup> in April and 0.107 ind. km<sup>-2</sup> in May while it was 0.696 ind. km<sup>-2</sup> for Bulgarian territorial waters in July 2013 and 0.323 ind. km<sup>-2</sup> in the central Bulgarian sector in November 2015. In the Dzharylgach area in Ukraine, it was 0.22 ind. km<sup>-2</sup> in June 2017; in coastal waters of South-eastern Crimea, it was 1.47 ind. km<sup>-2</sup> in April 2011 and 2.54 ind. km<sup>-2</sup> in June 2011 (KRIVOKHIZHIN et al. 2012).

## Conclusions

This study establishes a baseline in terms of approach and methodology for conducting distance-sampling surveys for assessment of the abundance, density and distribution of cetaceans in marine protected areas in Bulgarian waters of the Black Sea. The collected data represent contemporary information on the abundance and density of the three Black Sea cetacean subspecies that require conservation in a region where that kind of data are missing or scarce. In April, we observed an overlap in habitats of the harbour porpoise and the bottlenose dolphin. The common dolphin was encountered only in May at the northern part of the site. Line-transect surveys are an effective and relatively cheap tool for monitoring of cetaceans in marine NATURA 2000 sites. In order to obtain reliable data for estimation of the reference numbers of the target species, studies should be conducted during different seasons. Our results of these two pilot surveys have shown that for improvement in data collection, a better platform is required (higher speed – min. 6 knots). The obtained abundance estimations show large fluctuations between months but, during both months, the most abundant is the harbour porpoise with populations exceeding 100 ind. The common and the bottlenose dolphins are recorded with tens of specimens in May, with the latter being in hundreds in April.

**Acknowledgements:** This paper is a result of the efforts made within different projects. Data were collected within the project „Citizens’ support for the study of the Black Sea cetaceans along the Bulgarian coast“, funded through Program BG03 in Bulgaria of FM of EEA 2009–2014. The analysis of data was made with the support by ACCOBAMS Secretariat, EC (CeNoBS project) and OceanCare. We are grateful to all the volunteers who participated in the pilot surveys and Professor Phil Hammond, Sea Mammal Research Unit, University of St Andrews, for the training in distance sampling.

## References

- AKAIKE H. 1974. A new look at the statistical model identification. *System identification and time-series analysis*, IEEE Trans Automatic Control AC 19: 716–723.
- BIRKUN JR. A., NORTHRIDGE S.P., WILLSTEED E.A., JAMES F.A., KILGOUR C., LANDER M. & FITZGERALD G.D. 2014. Studies for carrying out the Common Fisheries Policy: adverse fisheries impacts on cetacean populations in the Black Sea. Final report to the European Commission. Brussels, 347 p.
- BUCKLAND S.T. 2004. *Advanced distance sampling: estimating abundance of biological populations*. New York: Oxford University Press, 416 p.
- BUCKLAND S.T., ANDERSON D.R., BURNHAM K.P., LAAKE J.L., BORCHERS D.L. & THOMAS L. 2001. *Introduction to distance sampling: estimating abundance of biological populations* (New edition). Oxford and New York: Oxford University Press, 448 p.
- GLADILINA E., VISHNYAKOVA K., NEPROKIN O., IVANCHIKOVA Y., DERKACHEVA T., KRYUKOVA A., SAVENKO O. & GOLDIN P. 2017. Linear transect surveys of abundance and density of cetaceans in the area near the Dzhaylgach Island in the North-Western Black Sea. *Vestnik Zoologii* 51 (4): 335–342.
- KRIVOKHIZHIN S., BIRKUN JR. A. & RADYGIN G. 2012. Seasonal variations in distribution and abundance of cetaceans along the coast of south-eastern Crimea. In: *Contemporary fishing and ecological problems in Azov–Black Sea Region*. Proceedings of 7<sup>th</sup> International Conference, Kerch, 20–23 June 2012. YugNIRO, pp. 115–119.
- PANAYOTOVA M., MARINOVA V., SLAVOVA K. & POPOV D. 2017. Studying of the distribution and abundance of marine mammals in the Bulgarian Black Sea area by combination of visual and acoustic observations. *Proceedings of the Institute of Fishing Resources, Varna, Bulgaria* 28: 34–41.
- THOMAS L., BUCKLAND S.T., REXSTAD E.A., LAAKE J.L., STRINDBERG S., HEDLEY S.L., BISHOP J.R.B., MARQUES T.A. & BURNHAM K.P. 2010. Distance software: design and analysis of distance sampling surveys for estimating population size. *Journal of Applied Ecology* 47: 5–14.