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RESEARCH ARTICLE

Cetaceans in the coastal waters of southern Romania: initial assessment of abundance, distribution, and seasonal trends

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Abstract

This paper presents the results of two vessel surveys in 2017 (spring and summer) in order to estimate cetacean abundance and distribution in Romanian Black Sea waters following distance sampling methods. Eight transects, from east to west, perpendicular on the shore line with a total length of 211.95 km, were designed and executed in sea conditions ≤ Beaufort 4 in an area of 1063 $km^2$with coverage of 39.6%. In total there were 275 sightings of bottlenose dolphin (*Tursiops truncatus ponticus*), common dolphin (*Delphinus delphis ponticus*) and harbour porpoise (*Phocoena phocoena relicta*) recorded. Both European Union (EU) Marine Strategy Framework Directive and Habitats Directive require Member States to monitor and maintain at favourable conservation status those species identified to be in need of protection, including all cetaceans. This study provides the baseline data on the Black Sea cetaceans in Romanian waters.

Keywords: Black Sea, cetaceans, abundance, distribution, line transect sampling, vessel survey

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Introduction

Reliable abundance estimates are critical for conservation of coastal small cetaceans. This is particularly important in countries where coastal human populations are increasing, the impacts of anthropogenic activities are often unknown, and the resources necessary to assess coastal cetaceans are limited (Dick and Hines 2011). We adapted the ship-based line transect method (Hiby and Hammond 1989) to small vessel surveys with a single platform to estimate the abundance of the three cetacean subspecies inhabiting the Romanian Black Sea waters: common dolphin (*Delphinus delphis ponticus*), bottlenose dolphin (*Tursiops truncatus ponticus*) and harbour porpoise (*Phocoena phocoena relicta*). The chosen study area was between Constanta and Vama Veche, covering the 12 nm territorial waters.

All three cetacean species are listed in the Red Book of vertebrates in Romania (Murariu 2005) and protected by national legislation as Environmental Ministry Order 374/2004 that approves the Action Plan for Cetacean Conservation (Ministry Order 374/2004)[1]. The Action Plan was developed under the project Life00NAT/RO/007194 in which Mare Nostrum NGO was a partner; Government Ordinance 57/2007 where two species are listed in annex 3 (*T.truncatus* and *P. phocoena*) and one in annex 4B (*D. delphis*).

The European Union (EU) Marine Strategy Framework Directive (MSFD Directive 2008/56/EC) states the need to establish a framework for community actions in the field of marine environmental policy to achieve the "Good Environmental Status" (GES) by 2020 across Europe's marine regions. In this context, the EU member States shall establish coordinated monitoring programmes aimed at "a description of the population dynamics, natural and actual range and status of species of marine mammals". Actions which are found also in the plans of the Agreement on the Conservation of Cetaceans of the Black Sea, Mediterranean Sea and Contiguous Atlantic Area (ACCOBAMS), in the Specially Protected Areas (SPA), Bucharest Convention, and Biodiversity Protocol under the Barcelona Convention, all ratified by Romania. The Black Sea bottlenose dolphins and harbour porpoises are listed in Annex II and IV of Directive 92/43/EEC, in view of threats to certain types of habitat and species, defined as having priority to favour the early implementation of measures to conserve them.

Cetacean distribution and abundance studies are scarce in Romanian waters (Radu *et al.* 2013; Paiu *et al.* 2017). To fill this gap, in July 2013, a survey for the western Black Sea was carried out including Bulgarian, Romanian and Ukrainian EEZ (Birkun *et al.* 2014). This is one of the few studies related to cetacean abundance in Romanian waters.

In December 2016, the first training on distance sampling methods was organized in Romania for the Black Sea scientists with the overall objective to

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[1] Ministry Order 374/2004 for approving the National Action Plan for cetacean conservation in the Romanian Black Sea waters, available at shorturl.at/mGK68 (accessed on 26 Dec. 2019).

increase capacity and encourage the use of common protocols in the area. In the following spring and summer in 2017, two surveys were performed as pilot studies on the abundance and distribution of the three cetacean species in Romanian waters. Here we report the results of these first dedicated surveys for identifying potential hotspots of these cetacean populations in the Vama Veche and its adjoining area.

Materials and Methods

Survey design and data collection

The study area was designed as a single stratum (Figure 1), following a 12 NM distance from the shore line to the open sea. A total of 8 equally-spaced parallel line transects, 5 km apart, over a 1063 km^2 area, with a random start point were determined using Distance version 7.0 (Thomas *et al.* 2010), to allow a homogeneous coverage probability over the selected area using line transect sampling approach adopted according to Buckland *et al.* (2001). Transects were oriented east-west, perpendicularly on the coast line, and overlapping several protected areas of Natura 2000: ROSCI0197, ROSCI0273, ROSCI0293, ROSCI0281, ROSCI0269 (Figure 1).

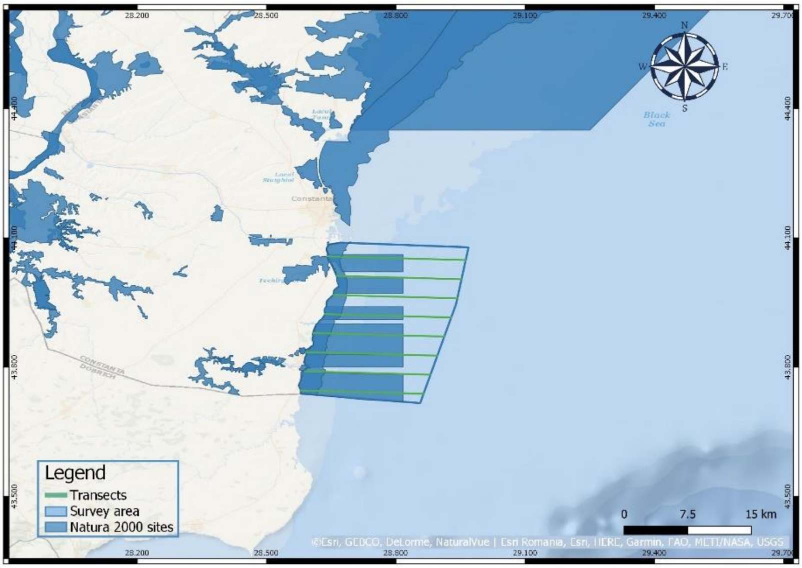

Figure 1. Survey area, green lines represent the transect on which the survey was performed – designed by Distance; with Natura 2000 sites in blue

The first survey was done between 7 and 29 March and the second between 26 and 28 June, 2017. The time of surveys was chosen in order to acquire data on the density, abundance and distribution of cetaceans before and after the peak of the reproduction season, which is in May-June, for the harbour porpoise and bottlenose dolphin (Birkun *et al.* 2008), to assess the status of the area and to identify if the area contains a potential critical habitat for cetaceans. Moreover, the period is important in assessing the migration of cetacean species from east to northwest (Reeves *et al.* 2006; Gladilina *et al.* 2018) in spring-summer seasons.

The surveys were conducted using a 10.5 m motor yacht, at a speed between 7 and 9 knots (12.96 – 16.66 km/h). Three observers were engaged for observation at the same time, one acting as a data recorder and the other two observers sharing the 180 degrees angle from port to starboard. At the beginning of a new transect the observers changed the positions within the platform. Data collection protocol was based on the one used for the vessel survey component of the Adverse Fisheries Impacts on Cetacean Populations in the Black Sea Project (Birkun *et al.* 2014) and Buckland *et al*. (2001).

Angle to a sighting was measured with fixed angle-boards and distance to sighted animals were measured using measuring sticks prepared individually for each of the observers according to Birkun *et al.* (2014) and Heinemann (1981). The radial distance to the sighted animal was calculated using the height of platform, eye height and arm length from observer's eye to the stick. Species were assessed if necessary with the help of 7x50 WPC-CF Fujinon Mariner Binoculars. Environmental conditions (sea state, glare, cloud cover, turbidity and a subjective assessment of overall conditions) were recorded at the beginning of each transect and whenever a change occurred. On the trackline under proper conditions (sea state <4 on the Beaufort scale), the observers searched a 110° arc from abeam to ahead. When a sighting was made, the following data were recorded: angle to the sighting when it was observed, distance, species, group size, initial cue, estimated swim direction, behaviour, and the name of the observer making that sighting.

The cetacean heat maps were generated using Kernel Density tool from ARCGIS 10.3.1 (ESRI 2019).

Data analysis

All the analysis was performed with the help of Distance software as described by Thomas et al. (2010). Abundance was estimated using both conventional distance sampling (CDS) and multiple covariates distance sampling (MCDS) as sea state and glare. The latter incorporated covariates, in addition to perpendicular distance, were used in the estimation of a detection function. Detailed by Buckland *et al.* (2001) and Panigada *et al.* (2011) the Conventional Distance Sampling, animal abundance is estimated by:

$$\hat{N} = A \frac{n}{2L\hat{\mu}} \hat{E}[s]$$

where for each stratum A is the area; L is the total search effort; n is the number of sightings; $\hat{\mu}$ is the estimated effective strip half-width (*esw*); Ê[s] is the estimate of mean group size. A variance estimates for $\hat{N}$ is obtained by combining the variance estimates of the three components, encounter rate, detection function and group size, using the delta method. The encounter rate variance is obtained using the R2 (Fewster *et al*. 2009) estimator. In MCDS, covariates other than perpendicular distance are included in the detection function and hence the *esw* becomes a function of the covariates, *z*. Abundance is estimated using a Horvitz-Thompson-like estimator: where $\hat{P}_a$= estimated probability of detecting the object within w of the transect line and z_i=covariates.

$$\hat{N} = \frac{A}{2L\hat{\mu}}\hat{E}[s]\sum_{i=1}^{n}\frac{1}{\hat{P}_a(z_i)}$$

The variance of this Horvitz-Thompson-like estimator is obtained using formulae described in Marques and Buckland (2003) and log-normal 95% Confidence Interval are obtained as for CDS.

The minimum value of the Akaike Information Criterion or AIC (Buckland *et al.* 2001; Akaike 1974), was used to choose between models and the hazard rate model was the most appropriate. The analyses as the designed were performed using Distance 7 software (Thomas *et al*. 2010).

The species density maps were derived using Kernel Density interpolator in ArcGIS 10.3.1, which calculates the density of sightings with a spatial distribution, considering their neighbourhood, using Silverman formula (Silverman 1998). It evaluates the number of dolphins that have been spot during the sea trips. Every point represents a spot where dolphins were numbered. Each point has a number of counted dolphins. These numbers were used in the analysis. Once calculated, the density is then multiplied with the sum of the point's values (each point represents the number of dolphins that were counted at each spot). The formula below applies for each cell centre of the output raster (ESRI 2019).The tool calculates (according to the formula) the density of points on a radius, starting from point "*i*". This radius is not fixed. Is evaluated by the tool considering the total number of the points that were recorded, thus resulting the density raster.

Density$= \frac{1}{(radius)^2}\sum_{i=1}^{n}\left[\frac{3}{\pi}\cdot pop_i\left(1-\left(\frac{dist_i}{radius}\right)^2\right)^2\right]$ For $dist_i < radius$

where:

i = 1,…,n are the input points, pop_i is the population field value of point i; $dist_i$ is the distance between point i and the (x, y) location., which represents the distance between the point where dolphins were numbered (i) and other point (x, y location) where there is probability that the same number of dolphins must have been (ESRI 2019).

Results

During the two surveys carried out, we recorded 275 sightings of cetaceans in the studied area. In spring, we observed 137 animals, both harbour porpoises and bottlenose dolphins, in 59 sightings. In summer we observed 340 animals, of all the three cetacean species, in 216 sightings as showed below in Table 1.

Table 1. Observation effort, number of cetacean sightings and number of animals recorded during the survey in the 12-mile area of southern Romanian Black Sea for spring and summer 2017

Season	Survey area in km^2	Sighting					
		Harbour porpoise		Common dolphin		Bottlenose dolphin	
		Sightings	*Indiv.	Sightings	*Indiv.	Sightings	*Indiv.
Spring	1063	36	73	0	0	23	64
Summer	1063	183	281	7	9	26	50

*Indiv. – the number of counted individuals
Sightings – the number of sightings

The analysis of the cetacean abundance showed a clear difference between spring and summer seasons for porpoises and common dolphins but not for the bottlenose dolphins as showed below in Table 2.

Table 2. Density (D) and abundance (N) of harbour porpoises, bottlenose dolphins and common dolphins in spring and summer 2017, for the surveyed area

Species	Density (ind./km^2)		Abundance		
	D	95% CI	N	95% CI	N CV%
Spring					
Harbour porpoise	0.337	0.119-0.955	359	127-1015	50.87
Bottlenose dolphin	0.627	0.201-1.957	667	214-2080	59.92
Common dolphin	-	-	-	-	-
Summer					
Harbour porpoise	5.359	2.821-10.183	5697	2999-10824	28.64
Bottlenose dolphin	0.424	0.194-0.927	451	207-986	38.75
Common dolphin	0.153	0.0491-0.480	163	52-510	56.94

Along the 8 transects surveyed, in March, no recordings were made on transect number 4 and only one sighting on each of the transects 1, 2 and 3 (one with single animal and two groups of three individuals) (Figure 2).

In spring, 36 sightings of harbour porpoise revealed a higher encounter rate in the southern part of the surveyed area (Figure 3 left). Assessing the size of harbour porpoise groups we conclude that the sightings were mostly single animals (13 sightings; 36% of the total) or pairs (12 sightings; 34% of the total). The largest groups having 4 individuals (3 sightings; 8 % of the total).

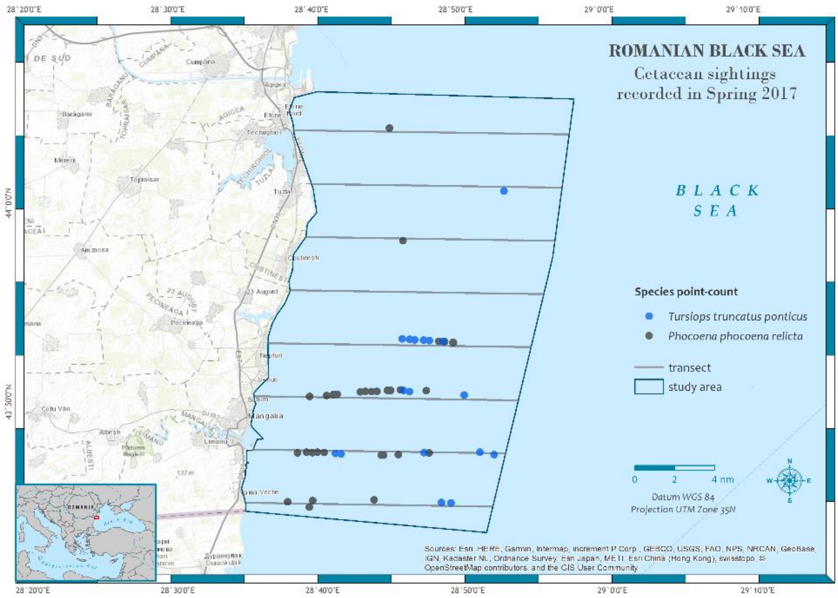

Figure 2. Cetacean sightings during the vessel-based survey in spring (March 2017)in the surveyed area (black dots – harbour porpoises; blue dots – bottlenose dolphins)

The 23 sightings of bottlenose dolphins collected revealed also a higher encounter rate in the southern part of the surveyed area, similar with harbour porpoises (Figure 3 right). Assessing the size of groups we conclude that the sightings were mostly solitary animals (6 sightings; 26% of the total) or pairs (7 sightings; 31% of the total), the largest groups having 8 individuals (3 sightings; 4 % of the total).

When it comes to the second survey in summer, all the three cetacean species were recorded: 26 sightings of bottlenose dolphin, 7 sightings of common dolphin and 183 sightings of harbour porpoise (Figure 4).

Among the 183 harbour porpoise sightings recorded, in summer, (Figure 5 left)133 sightings (72.68% of the total) were single animals, 31 sightings (16.94%) pairs and the largest group was composed of 12 animals (1 sighting; 0.55%).

In case of bottlenose dolphins, among the 26 sightings (50 animals) recorded (Figure 5 middle) 13 were single animals (50% of the total), 9 pairs (34%), and the largest group in a single sighting was composed of 8 animals (1 sighting; 4 %).

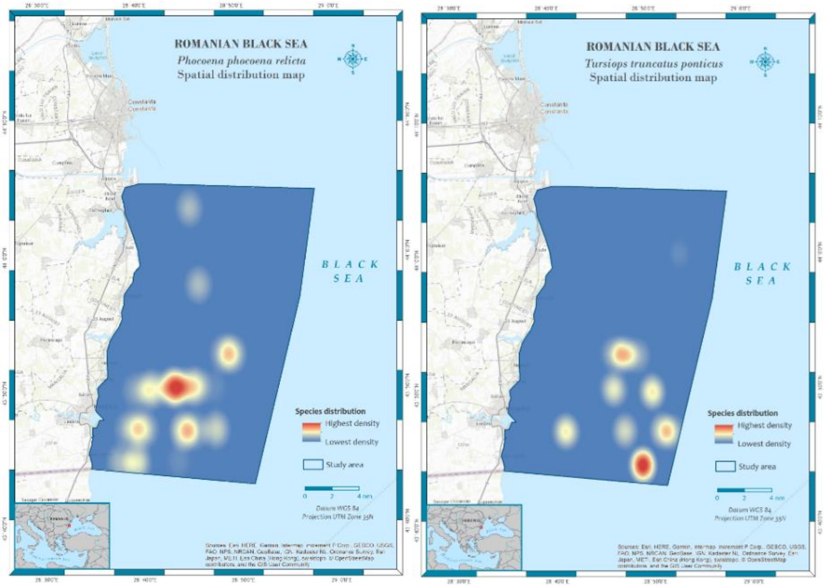

Figure 3. Cetacean distribution in spring (March, 2017)
left - harbour porpoises and right - bottlenose dolphins

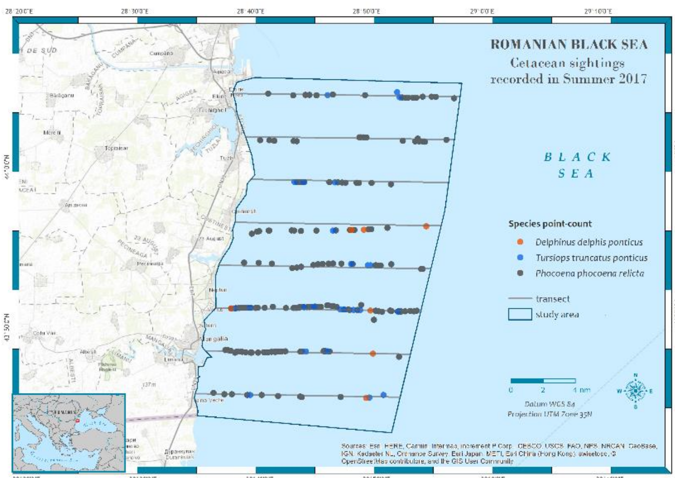

Figure 4. Cetacean sightings during the vessel-based survey in summer (June 2017) in the surveyed area (black dots – harbour porpoises; red dots – common dolphins; blue dots – bottlenose dolphins)

Finally common dolphins were sighted 7 times (9 animals) (Figure 5 right). The data recorded show that encountered common dolphins were single animals in 5 cases (83% of the total) and twice in pair (17%).

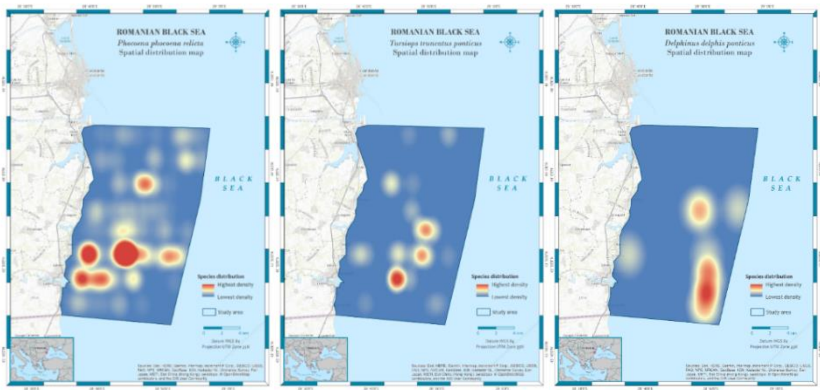

Figure 5. Cetacean distribution in summer (June, 2017)
left - harbour porpoise, middle - bottlenose dolphin, right - common dolphin

Discussion

Cetacean abundance, distribution and seasonal trend information are some of the most important population parameters which allow the assessments of species status and the anthropogenic impacts over these marine mammals. Having in mind the lack of physical or hydrological barriers the stock examined in the proposed area is not limited by the southern Romanian waters. Romanian shoreline is lacking in natural estuaries or sheltered areas, therefore not the most suitable area for accommodating a resident group of cetaceans. The abundance of bottlenose dolphins was similar in both study periods, with a decrease in the estimated abundance for summer, which could be related to the improved CV% (38.75 from 59.92) but at the same time it can be due to human disturbance (summer season – tourism increases) or movement to the north due to overpopulation (increased numbers of harbour porpoises) and prey availability in the area (Radu *et al.* 2013).

The gap in knowledge for cetaceans in the studied area and adjacent region prior to this study does not allow comparison due to the different methods for data collection, analysis and reporting. One of the few studies that can be used is Birkun *et al.*(2014) for the NW Black Sea, but only for the summer period. The absolute abundance estimates by our study were similar to the values reported for Romanian marine waters by Birkun *et al.* (2014) for harbour porpoise (8059: CV = 47.24; 95% CI = 3159 – 20563), but lower than those for common dolphins (5447: CV = 38.76; 95% CI = 2530 – 11731) and bottlenose dolphins (6413: CV = 31.75; 95% CI = 3402 – 12091). The differences could be due to different month for the survey (June and July), size of the surveyed areas (1063 km^2 versus 5871 km^2), observers bias, and not least prey availability (Kleinnenberg 1956; Tzalkin 1940) and environmental conditions, which were not assessed yet in the present study.

The distribution maps revealed hotspots in the southern Romanian waters, as previously mentioned by Birkun *et al.*(2014), Radu *et al.* (2013), Paiu *et al.* (2019), and a lower concentration in the northern area. Harbour porpoise being the main species with increased abundances, for summer, more than 15 times, with an estimated absolute abundance of 5697 individuals.

When it comes to compare the results between two seasons, there is an increase in abundance and density for harbour porpoises and common dolphins in summer from spring. This could be related to migration. Observations of calves, both *in situ* and strandings, are frequent in this season (Paiu 2012; Paiu *et al.* 2017). Together with the present study, it can be suggested that the Romanian waters are an important area for breeding and calving (Paiu and Mirea-Candea 2016; Paiu *et al.* 2017; Tonay *et al.* 2012; Vishnyakova and Gol`din 2014). As Birkun *et al.* (2014) mentioned, cetaceans start regularly appearing in February-April in the southern area and their migration route is to the north west; in autumn they take on return migration to the south within the same close range to the shore (Birkun *et al.* 2014). Information collected from Georgia indicates a displacement of cetaceans from the Georgian waters as mentioned by Kopaliani *et al.* (2015). For harbour porpoises, the estimate decreases from 18000 individuals in winter to 5000 individuals in spring and to 500 individuals in summer, and for common dolphins, from 16000 individuals in winter to 3000-6000 individuals in spring and summer.

Common dolphins were assessed only in summer due to the lack of sightings during the spring survey. The only records, in spring, were made off effort, twice, single animals. It is clear that the common dolphins are inhabiting mainly the offshore area (Radu *et al*. 2013; Murariu 2005), but making short trips to the coastal waters, mainly in summer (Birkun *et al.* 2014; Paiu 2016).

Conclusions

Our study presents new data regarding abundance estimate for the three cetacean species, of conservation concern, in a region where such estimations are scarce, for early spring and summer.

Both bottlenose dolphins and harbour porpoises were found almost exclusively in the southern half of the surveyed area in both survey periods, either due to food availability, anthropogenic disturbance or migration pattern.

According to the values shown in Table 2, the bottlenose dolphin was the most abundant cetacean in the surveyed area in spring. Its density and absolute number exceeded those of the harbour porpoise. Situation changed in summer when harbour porpoise abundance increased up to 15 times, which placed them as a dominant species within the study area.

It is necessary to underline that our estimations are valid for the periods (early-spring and early-summer) when the vessel surveys were conducted. It could be supposed that these periods concur with annual migration of cetaceans towards the north-western Black Sea, mass migration of cetaceans to the north at least in the case of harbour porpoises.

Based on present study, Mare Nostrum NGO studies and Birkun *et al.* (2014), together with the historical records of the other Black Sea studies, cetaceans in the Black Sea follow a yearly migratory pattern. We can support the positive answer, at least for the harbour porpoise population, at the question, "is the summer density of cetaceans really higher for Romanian waters mainly and NW Black Sea region altogether?".

Further studies on the relation to anthropogenic and environmental factors are needed in order to conclude which are the suppressive factors for the presence of dolphins and porpoises mainly in the southern part of the studied area.

The assessment results of the two surveys, executed in 2017, stress the need for an effective photo-identification program to be implemented, in the area, targeting the bottlenose dolphins, in order to understand the population structure and movement.

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References

Akaike, H. (1974) A new look at the statistical model identification. *IEEE Transactions on Automatic Control* 19(6): 716-723.

Birkun, A. (2008) The state of cetacean populations. In: State of Environment Report 2001-2006/7, 2008-3 (ed. T. Oguz), Publication of the Commission on the Protection of the Black Sea against Pollution, Istanbul, pp.365-395.

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, Belgium, 348 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. Oxford University Press, Oxford, U.K.

Dick, D.M., Hines, E.M. (2011) Using distance sampling techniques to estimate bottlenose dolphin (*Tursiops truncatus*) abundance at Turneffe Atoll, Belize. *Marine Mammal Science* 27: 606-621.

ESRI (2019) How Kernel Density works. Available at: https://pro.arcgis.com/en/pro-app/tool-reference/spatial-analyst/how-kernel-density-works.htm. (accessed 4 Jul. 2019).

Fewster, R.M., Buckland, S.T., Burnham, K.P., Borchers, D.L., Jupp, P.E., Laake, J.L., Thomas, L. (2009) Estimating the encounter rate variance in distance sampling. *Biometrics* 65: 225-236.

Gladilina, E., Shpak, O., Serbin, V., Kryukova, A., Glazov, D., Gol'din, P. (2018) Individual movements between local coastal populations of bottlenose dolphins (*Tursiops truncatus*) in the northern and eastern Black Sea. *Journal of the Marine Biological Association of the United Kingdom* 98(2): 223-229.

Heinemann, D. (1981) A rangefinder for pelagic bird censusing. *Journal of Wildlife Management* 45: 489-493.

Hiby, R., Hammond, P.S. (1989) Survey techniques for estimating the abundance of cetaceans. *Reports of the International Whaling Commission* 11: 47-80.

Kleinenberg, S.E. (1956) Mammals of the Black and Azov Seas: Research Experience for Biology and Hunting. USSR Academy of Science Publish House, Moscow, Russia, 288 p. (in Russian).

Kopaliani, N., Gurielidze, Z., Devidze, N., Ninua, L., Dekanoidze, D., Javakhishvili, Z., Paposhvili, N., Qerdikoshvili, N. (2015) Monitoring of Black Sea Cetacean in Georgian Waters. A report available at https://chm.cbd.int/database/record?documentID=241761 (accessed on 20 May 2019).

Marques, F.F.C., Buckland, S.T. (2003) Incorporating covariates into standard line transect analysis. *Biometrics* 59: 924-935.

Murariu, D. (2005) Mammalia. In: Cartearoșie a Vertebratelor din România. (eds., Botnariuc, N., Tatole, V.) National Natural History Museum “GrigoreAntipa”, *Curtea Veche Trading SRL*, Bucharest, Romania, pp. 59-61 (in Romanian).

Paiu, R.M. (2012) Annual Report of the Monitoring and Conservation of Black Sea Cetacean Program. Mare Nostrum NGO, Constanta, Romania (in Romanian).

Paiu, R.M. (2016) Annual Report of the Monitoring and Conservation of Black Sea Cetacean Program. Mare Nostrum NGO, Constanta, Romania (in Romanian).

Paiu, R.M. (2017) Annual Report of the Monitoring and Conservation of Black Sea Cetacean Program. Mare Nostrum NGO, Constanta, Romania (in Romanian).

Paiu, R.M., Fujioka, E., Paiu, A.I., Mirea-Cândea, M.E., Gheorghe, A.M., Timofte, C. (2019) Integration of cetacean monitoring data into databases such as obis-seamap, to advance spatially-explicit ecological assessments. Marina RRI-SIS Conference (in press).

Paiu, R.M., Mirea-Cândea, M.E. (2016) Correlation of cetacean stranding events between 2010-2014 at the Romanian coast. *Recherche Marine* 46: 144-155.

Paiu, R.M., Paiu, A.I., Mirea-Cândea, M.E., Gheorghe, A.M. (2017) Cetacean strandings between 2010-2016 at the coast of Romania. *Recherche Marine* 47: 222-231.

Panigada, S., Lauriano, G., Burt, L., Pierantonio, N., Donovan, G. (2011) Monitoring winter and summer abundance of cetaceans in the Pelagos Sanctuary (Northwestern Mediterranean Sea) through aerial surveys. *PLOS ONE* 6(7): e22878.

Radu, G., Anton, E., Nenciu, M., Spînu, A.D. (2013) Distribution and abundance of cetaceans in the Romanian marine area. *Recherche Marine* 43: 320-341.

Reeves, R., Notarbartolo di Sciara, G. (2006) The Status and Distribution of Cetaceans in the Black Sea and Mediterranean Sea. IUCN Centre for Mediterranean Cooperation, Malaga, Spain, 137 p.

Silverman, B.W. (1998) Density Estimation for Statistics and Data Analysis Vol 26. Chapman and Hall/CRC, London, U.K.

Thomas, L., Laake, J.L., Rexstad, E., Strindberg, S., Marques, F.F.C., Buckland, S.T., Borchers, D.L., Anderson, D.R., Burnham, K.P., Burt, M.L., Hedley, S.L., Pollard, J.H., Bishop, J.R.B., Marques, T.A. (2010) Distance 7.0. Release 1, Research Unit for Wildlife Population Assessment, University of St. Andrews, UK. http://www.ruwpa.st-and.ac.uk/distance/, 2010 (accessed on 18 Jan. 2017).

Tonay, M., Dede, A., Öztürk, A.A., Demircan, M.D., Fernández, A. (2012) Unusual mass mortality of cetaceans on the coast of the Turkish Western Black Sea in Summer 2009. *J. Black Sea/Mediterranean Environment* 18(1): 67-75.

Tzalkin, V.I. (1940) The data on biology of the Azov and Black Sea harbour porpoise (*Phocaena phocaena relicta* Abel). *Zoologichesky Zhurnal* 19(1): 160-171 (in Russian).

Vishnyakova, K., Gol'din, P. (2014) Seasonality of strandings and bycatch of harbour porpoises in the Sea of Azov: The effects of fisheries, weather conditions, and life history. *ICES Journal of Marine Science* 73(3): 981-991.