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ABUNDANCE AND SUMMER DISTRIBUTION OF A LOCAL STOCK OF BLACK SEA BOTTLENOSE DOLPHINS, *TURSIOPS TRUNCATUS* (CETACEA, DELPHINIDAE), IN COASTAL WATERS NEAR SUDAK (UKRAINE, CRIMEA)

E. V. Gladilina, P. E. Gol'din

Schmalhausen Institute of Zoology, NAS of Ukraine
vul. B. Khmelnytskogo, 15, Kiev, 01030 Ukraine
E-mail: el.gladilina@gmail.com; pavelgoldin412@gmail.com

Abundance and Summer Distribution of a Local Stock of Black Sea Bottlenose Dolphins, *Tursiops truncatus* (Cetacea, Delphinidae), in Coastal Waters near Sudak (Ukraina, Crimea). Gladilina, E. V., Gol'din, P. E. — The first assessment of abundance of a local population of bottlenose dolphins in the Black Sea (near the Sudak coast) in 2011–2012 has been conducted: the results of a mark-recapture study of photo identified animals were complemented by a vessel line transect survey. The overall abundance of a population was estimated at between 621 ± 198 and 715 ± 267 animals (Chapman and Petersen estimates), and the majority of members of the population were recorded in the surveyed area. The summer range covered the area of a few hundred square kilometers, similar to migrating coastal stocks in other world regions. The greatest density of distribution was observed in August in sea 45–60 m deep; in addition, frequent approaches to the coastline are usual for dolphins of this stock. These trends in distribution may be partly explained by distribution of prey. Interaction with sprat trawling fisheries can be a factor shaping the local population structure. Coastal waters of Sudak and adjoining sea areas are an important habitat for bottlenose dolphins in the northern Black Sea, significant for their conservation.

K e y w o r d s: *Tursiops*, photo-identification, mark-recapture, line transect survey, coastal migrating stock.

Introduction

The Black Sea is a margin area in distribution range of common bottlenose dolphins *Tursiops truncatus* (Montagu, 1821). Bottlenose dolphins in that region are considered as an endangered species by some authors (Birkun, 2012). Bottlenose dolphins occur across all the Black Sea area; however, their regional distribution is patchy and variable (Mikhalev, 2005), and some kind of differentiation in body size and life history is seen within the Black Sea (Gol'din and Gladilina, 2015), as well as genetic heterogeneity (Moura et al., 2013) that raises the problem of stock identification and assessment. There are a few local coastal stocks, which are possibly local populations, in the northern part of the Black Sea (Gladilina et al., 2013). One of these, inhabiting coastal waters near Sudak in the south-eastern Crimea, during warm season appears as some groups frequently approaching the coastline (Gladilina, 2012). This stock is relatively isolated from neighbouring ones (Gladilina, 2013). A remarkable feature of this stock, as well as some others in the Black Sea (Bushuev, Savusin, 2004) is that its members actively feed near trawlers taking sprat near Novy Svet (Gladilina et al., 2012).

Here we report the estimates of abundance and data on summer distribution for the local stock of bottlenose dolphins near Sudak which have been obtained from mark-recapture analysis of data of photo-identification research and complemented by a vessel survey of population density (Williams et al., 1993; Wilson et al., 1999; Read et al., 2003). This is the first integrative assessment conducted for a local cetacean stock in the Black Sea.

Material and methods

Area of study and data collection. The research was conducted in the coastal waters between the Choban-Kule and Meganom Capes (between 44°48′N, 34°44′E and 44°47′N, 35°02′E) (fig. 1, 2).

In 2011–2012, during warm season between July and September, 19 mark-recapture photo-identification surveys were conducted from small boats (5 m or less) near sprat trawling seine vessels. The greatest distance from the coastline was 10 km (depth 80 m), but the most of dolphin schools were observed near 5 km from the coastline (depth ca. 50 m).

For each observation, date and time, geographic coordinates, weather conditions, group size and composition, presence and number of neonates and calves, natural markings on dorsal fins or body, and behavioural aspects were recorded.

Density survey. Line transect boat survey was conducted on August 4, 2012, in the area between the Choban-Kule and Alchak Capes (between 44°48′ N, 34°44′ E and 44°47′ N, 35°02′ E) (fig. 2). The area of survey was 140 km^2. A 4.5 m motorized boat was used as a survey platform; observer eye height was 2 m above sea level. Two switching pairs of observers recorded cetaceans on the left and right sides and changed every hour; other members of the team took written records and photos. The survey was carried out at the sea state with Beaufort number between 1 and 2, visibility between 6 and 10 km, clear sky, no precipitation. In total, there were six transects from 7.4 to 10.3 km. Boat speed was between 15 and 17 km / h (15.9 on average).

Photo-identification. For photo-identification, the boat slowly approached dolphins in parallel to their course. Whenever possible, all individuals in a group have been photographed from both sides. Identified individuals were entered in a database by categories, according to presence and character of natural markings on body or dorsal fin (Würsig and Jefferson 1990; Urian et al., 2015). Dolphins with permanent markings (deep notches on dorsal fin margins or skin depigmentation) were categorized as Marked Animals (fig. 3, *a–d*). Dolphins with intact fin margins but temporary markings (scars, scratches, temporary patches) were categorized as Unmarked Left (fig. 3, *e*) and Unmarked Right (fig. 3, *f*). New individuals were entered to the catalogue only if there were high-quality photographs with fins from a perpendicular view.

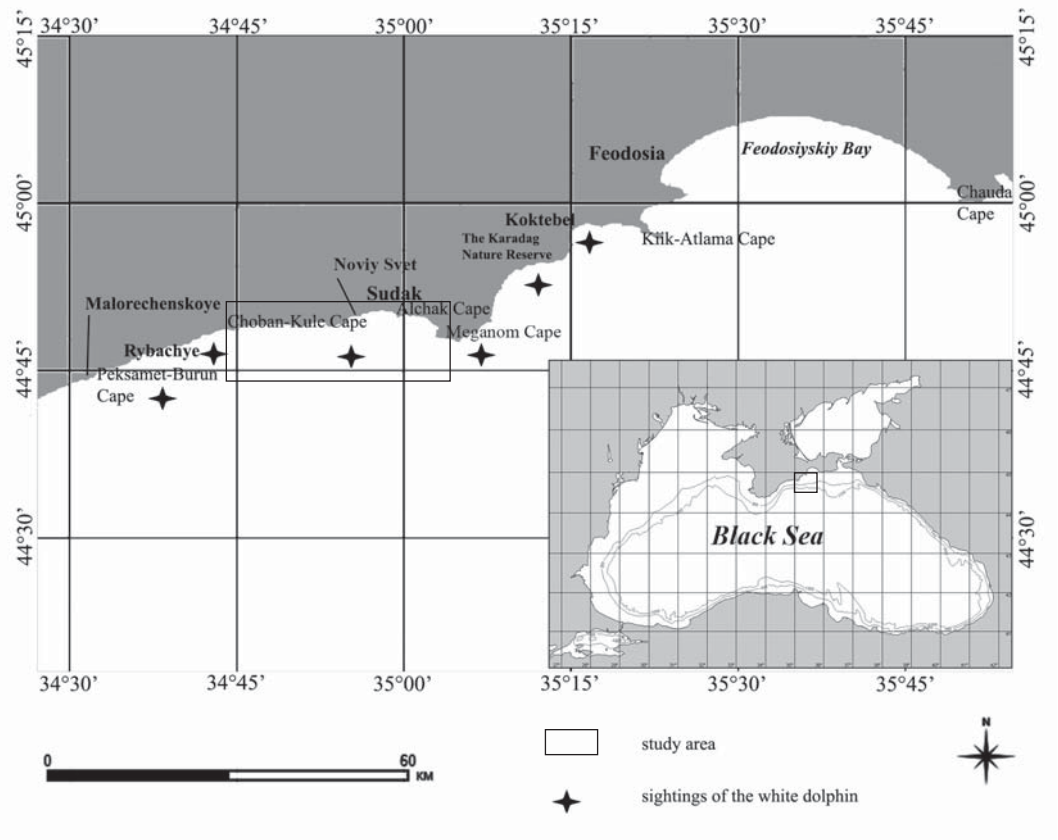

Fig. 1. Area of study in the northern Black Sea.

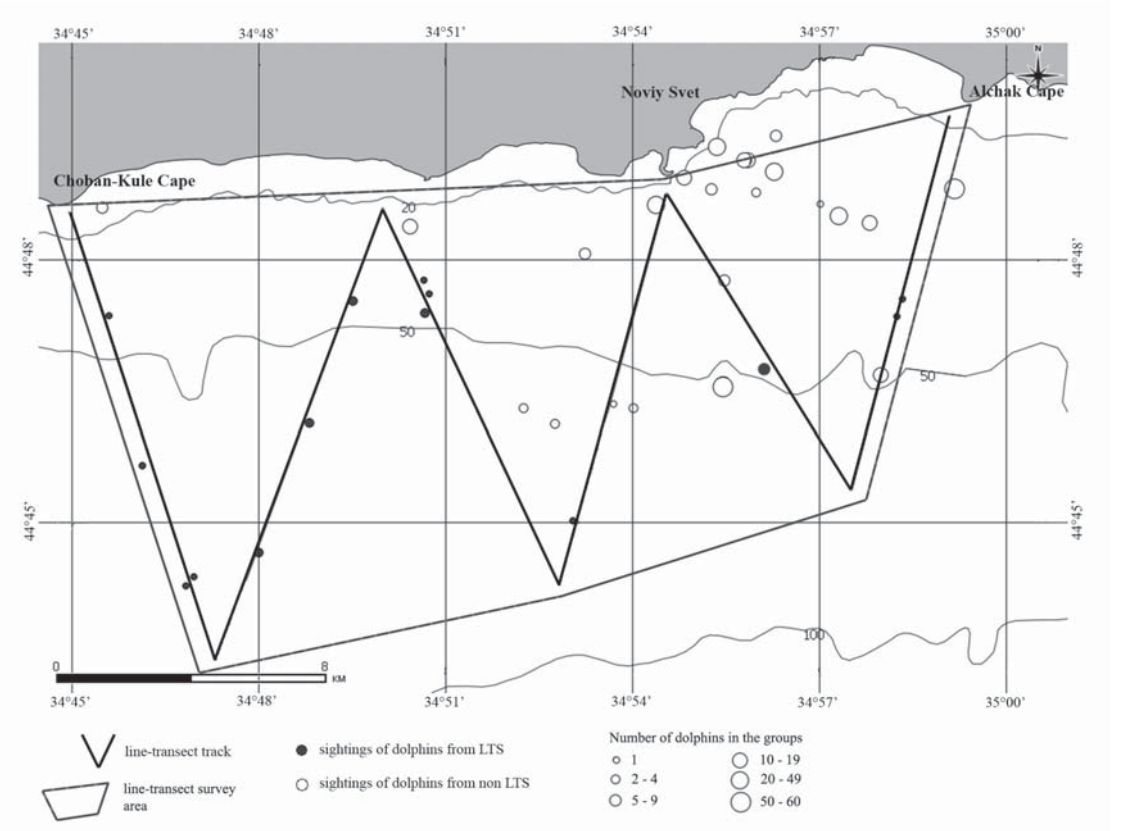

Fig. 2. Sightings of bottlenose dolphins near Sudak in 2011–2012. Sightings are indicated by circles of different size, depending on the group size category; sightings during the line transect survey (LTS) on August 4, 2012, are marked as filled circles, and other sightings (non LTS) are marked as empty circles. The LTS transects are shown as a zigzag line, and the LTS area is bordered by a contour line.

Analysis of data. The catalogue of photo-identified dolphins was independently examined by two researchers for resightings ("recaptures"). Resightings were considered only if there was consensus in identification between two experts. Only animals with permanent markings (Marked Animals) were used in all calculations.

Abundance assessment for the Sudak stock was obtained as a mark-recapture estimate. A "capture" was the first registration of an individual dolphin with the catalogue entry. Resightings were considered as "recaptures". Petersen and Chapman models were used for abundance estimates for Marked Animals in the populations (Caughley, 1977). Estimates of abundance for each model were obtained by division of the Marked Animals estimate by an average portion of marked animals (Williams et al., 1993; Wilson et al., 1999).

Data on density and abundance of dolphins from the line transect survey were calculated using the Distance software, following the procedure of Conventional Distance Sampling (Buckland et al., 2001). Random character of spatial distribution was estimated as the value of the coefficient of variation of density.

For each day of observations, percentage of marked animals (individuals with permanent markings) was calculated. An average portion of marked animals, $\overline{m}$, was calculated as a weighted mean value for all days of observations, as follows:

$$\overline{m} = \Sigma m_i / \Sigma n_{i,},$$

where m_i is the number of marked animals at each observation i, and n_i is the number of observed animals at each observation i.

Results

Occurrence. In 2011–2012, during 19 photo identification surveys near sprat trawling vessels we recorded 23 encounters of 343 bottlenose dolphins. Group size varied from 1 to 60 animals (fig. 4). Mean group size was 14.9 animals, and the median size was 10.

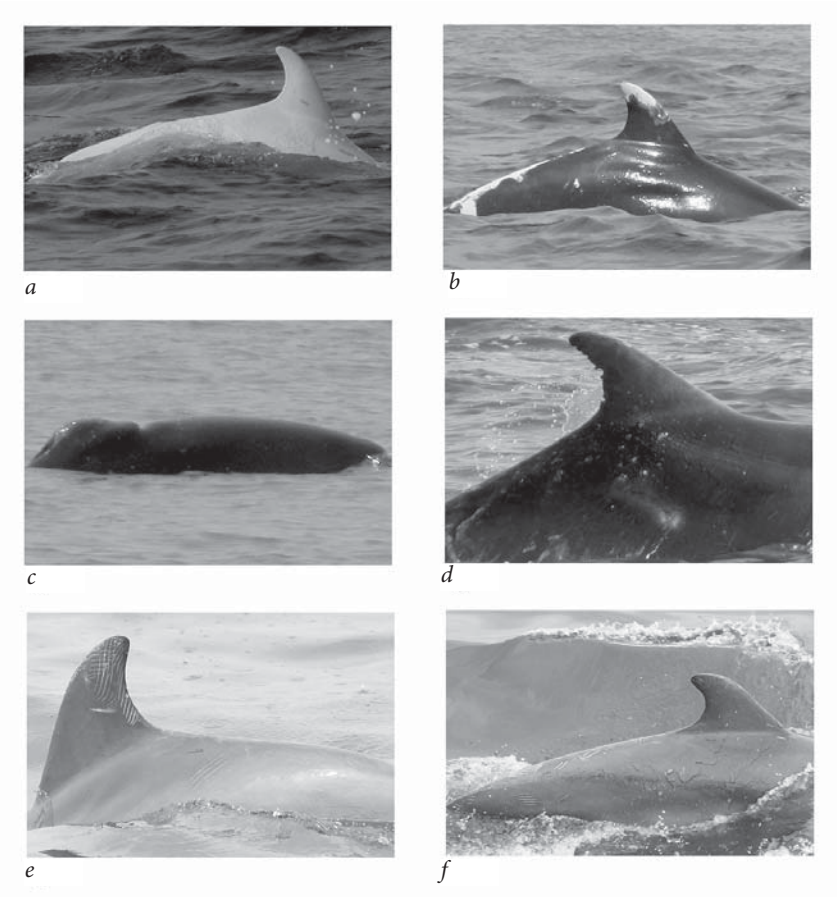

Fig. 3. Categories of dorsal fins for photo-identification(*a– d*, marked; *e, f,* unmarked).

There were neither records of interactions with the observer, nor cases of escaping or attraction to the boat or other behavioural changes due to observer activity; therefore, no differences in catchability were detected.

The results of survey: Density of distribution and abundance estimate. On the 53.6 km route there were 14 encounters of bottlenose dolphins numbering 23 animals. Mean group size was 1.6 (the median was 1). Mean density in surveyed area was 4.3 dolphins per square km (95% CI = 1.6–11.2; CV = 0.48); therefore,

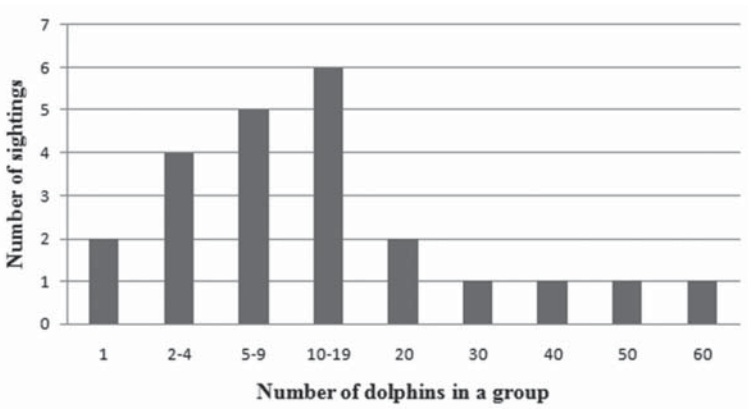

Fig. 4. Group size in bottlenose dolphins in the Sudak area.

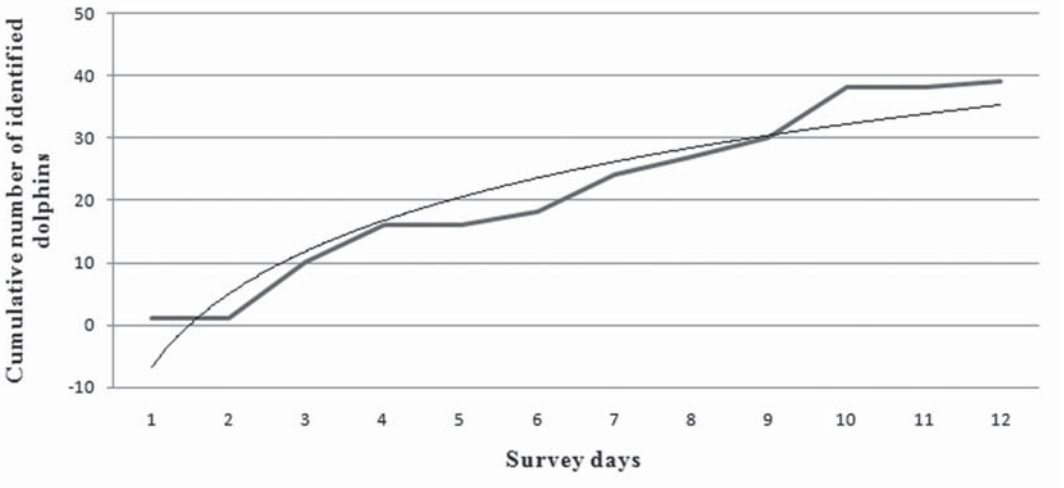

Fig. 5. Discovery curve as cumulative number of identified dolphins vs. duration of study.

minimum estimated abundance without adjustment to detection probability, g (0), was 604 dolphins (95 % CI = 231–1570). As during the photo identification cruises, there were no records of behavioural changes due to observer activity.

As seen from the CV value, dolphins were randomly distributed across the area of survey. However, there was a significant trend towards a strip in a certain depth range: 72 % of encounters and 74 % of individuals were recorded at a distance of 2–6 km from the shoreline, in waters 45–60 m deep.

Photo-identification. In total, 1,100 photographs taken in 2011–2012 have been analysed. From them, 43 individuals were identified, and among them 39 (91 %) were classified as Marked Animals. Majority of marked animals, 32, were recorded only once for the period of study. Four individuals were resighted between 2011 and 2012 years. Among animals with permanent markings, there was an unusually high portion of animals with white patches and partially white animals (18 %), one of which was a completely white dolphin (fig. 3, *a*).

The curve of growth of number of photo-identified specimens during the survey period (discovery curve) approached to the asymptotic value (fig. 5), which suggests good coverage of population (Williams et al., 1993).

Mark-recapture estimates using Petersen and Chapman models gave the following results: respectively, 113 ± 42 and 98 ± 31 marked specimens. An average portion of marked specimens in the Sudak area (weighted mean) was estimated as 15.7 %. Thus, overall abundance of the local population of bottlenose dolphins in the Sudak waters in 2011–2012 was between 621 ± 198 and 715 ± 267 animals. Concluding from results of the vessel survey, on August 4, 2012 there was the majority of members of the population (n = 604) in the surveyed area.

Discussion

Range and summer distribution of bottlenose dolphins near the south-eastern Crimea. The sea area near Sudak is not bordered by clear physical or hydrological barriers, and the range of the stock examined here surely cannot be limited by the Sudak waters. For example, during 2008–2013 there were numerous records of movements of dolphins around the Meganom Cape (EG, personal data). The white bottlenose dolphin, a highly distinct member of the Sudak stock, was frequently recorded in 2007–2012 in coastal waters between Rybachye (Tuak) and Koktebel (fig. 1). Simultaneously with this study, there were two other independent assessments of distribution, density and group

size of bottlenose dolphins in a neighbouring sea area between the Meganom and Kiik-Atlama capes, near the Karadag coast. First, Gladilina (2012), based on land observations in 2010, concluded that in 2.5 km coastal zone near the Karadag Nature Reserve mean group size in summer rose up to 4.1 animals (median = 2), the biggest group size was up to 18 animals, and occurrence in the 0.5 km coastal zone (shallower than 20–25 m) was greater than at 0.5–2.5 km from the shoreline (20–40 m deep). Second, Krivokhizhin et al. (2012) conducted a boat survey in the 3.5 km coastal zone (depth 0–45 m) in 2011 and showed the density of 2.5 animals per sq. km, mean group size of 2.6 animals and occurrence mainly within 1 km coastal zone. Therefore, there is a strong difference between size of groups recorded in sea or near the shoreline (mean size = 1.6–4.1) and aggregations near the trawling ships (mean size = 14.9). Meanwhile, there is also some variation in group size across local areas, as well as across summer months, due to uncertain factors (see also: Gladilina, 2012).

As seen from the comparison with the data of this study, the population density near Sudak was almost twice higher than near the Karadag Nature Reserve (4.3 per sq. km in this study vs. 2.5. reported by Krivokhizhin et al. (2012)) and dolphins mainly concentrated in deeper areas, at 45–60 m, which are closer to the shoreline than near the Karadag. The group size at these depths varied within broad range covering all the variation observed in shallow waters; however, relatively big aggregations were observed only near the trawling vessels. Notably, on the day of survey, August 4, 2012, the sea to the east of the Meganom was affected by relatively high concentration of phytoplankton; while the survey area was clear (NASA..., 2014). It is possible that dolphins preferred the clearer sea near Sudak; this can be also generally true for summertime.

Specific depth preferences can be explained by foraging behaviour of dolphins: in summer, the sea 50–60 m deep is a habitat for a broad range of prey fishes (Gladilina and Gol'din, 2014). A highly important species in the diet of bottlenose dolphins in the northern Black Sea is whiting *Merlangius merlangus* (Linnaeus, 1758) tending to cool deep waters, as well as sprat *Sprattus sprattus* (Linnaeus, 1758); picarel *Spicara flexuosa* Rafinesque, 1810 is often found at the same depth, near 50 m; thornback rays, *Raja clavata*, prefer sea floor down to 60 m with pebble grounds; finally, horse mackerels *Trachurus mediterraneus* (Steindachner, 1868) and red mullets *Mullus barbatus* Linnaeus, 1758 spawn in pelagic waters in this area (State of Biological Resources, 1995). Therefore, an opportunistic feeder like the bottlenose dolphin easily finds diverse prey both in pelagic and benthic habitats in that area.

Bottlenose dolphins near Sudak and east to the Meganom were frequently observed interacting with sprat trawling fisheries (Gladilina et al., 2012). Notably, in 2012 in the adjoining area west to the Peksamet-Burun Cape, near Malorechenskoye (Kuchuk-Uzen), bottlenose dolphins occurred significantly rarer than near Sudak (despite the same observation effort, as near Sudak) and did not interact with trawling fisheries, despite usual presence of the trawling vessels (Grachev and Gladilina, 2013). It can be suggested that in summer 2012 dolphins from the Sudak stock did not approached as far west as that area. However, dolphins might also rarer occur in the western area if there was lower fish concentration: it cannot be verified because of the absence of the fishery report.

Finally, the most obvious explanation for the high density of bottlenose dolphins which was observed during the line transect survey is the possible influence of sprat aggregations and trawling vessels which were present in adjoining sea areas. It can be suggested that all the stock may concentrate in the same local area during the trawling operations, and thus sprat fisheries is the element shaping the spatiotemporal stock structure at certain time intervals.

Possibly, the distribution of the Sudak stock can vary across years, as well as the seasons. For example, Mikhalev (2005) observed bottlenose dolphins near the Meganom during all the warm season; however, he recorded the greatest aggregations as more distant

from the coast, near the depth of 200 m. Thus, we suggest the overall summer range of the Sudak stock as dynamic and occupying at least a few hundred square kilometers of coastal waters between the Peksamet and Kiik-Atlama capes. A unit of such size and range is similar to migrating coastal stocks in the Gulf of Mexico and south-eastern USA waters (Speakman et al., 2010; Tyson et al., 2011). Meanwhile, the Sudak area is the locality with the highest observed density of the population where the overall stock may concentrate at some moments. Therefore, this area, a possible hotspot, is clearly important for the conservation of this stock.

Concluding remarks

1. In summer 2011–2012 there was high concentration of a local population of bottlenose dolphins near Sudak; its overall abundance, according to data of mark-recapture analysis, was near a few hundred animals, and the summer range covered the area of a few hundred square kilometers. A unit of such size and range is similar to migrating coastal stocks in other world regions.

2. The greatest population density was observed in August in sea 45–60 m deep; in addition, frequent approaches to the coastline are usual for dolphins of this stock. These trends in distribution can be at least partly explained by foraging behaviour.

3. An important factor influencing aggregations of dolphins of the Sudak stock is the interaction with sprat trawling fisheries. It also partly explains its summer distribution. Therefore, fisheries may be one of the factors shaping the local population structure.

4. Coastal waters of Sudak and adjoining sea areas are an important habitat for bottlenose dolphins in the northern Black Sea, significant for their conservation.

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