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Striped dolphin Home Ranges within the IMMA and Natura 2000 Area "Gulf of Corinth"(Greece)

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***Abstract* — The striped dolphin (*Stenella coeruleoalba*) is one of the most abundant cetaceans of the Mediterranean Sea, nevertheless it is recognised as a "Vulnerable" species for this basin, according to IUCN experts. The Gulf of Corinth is a Protected Area belonging to the European Network "Natura 2000". The Gulf of Corinth is also classified as an Important Marine Mammal Area (IMMA), for the presence in its waters, among others cetacean species, of striped dolphins. The Home Range is defined as the area occupied by an animal, or a group of animals, during daily activities. Estimating and identifying the Home Ranges of striped dolphins within the Gulf of Corinth would be essential for the conservation of this protected species in this Protected Area. The Photo-identification technique allows to recognise individuals and to investigate their level of site fidelity, following their movement through the geographical positions of different sightings. The photo-identification technique has been applied in the Gulf of Corinth to investigate striped dolphin population trends and to analyse individuals Home Ranges. 447 marked dolphins have been photo-identified and data of the individuals sighted at least 3 times have been used to determine Home Ranges. Photo-identification data have also been used to estimate the population of striped dolphins for the summers 2010-2011 and 2015-2016, showing an increasing in the number of individuals.**

I. INTRODUCTION

The striped dolphin, *Stenella coeruleoalba*, is a cosmopolitan species that can be found worldwide, in tropical and temperate pelagic waters [1]. It is considered the most abundant cetacean of the Mediterranean Sea [2]. In the 90's, an epizootic produced a massive die-off of striped dolphins in this basin [3], and now the species is classified "Vulnerable" in the Mediterranean Sea, by IUCN experts [4].

The Gulf of Corinth is a Protected Area that belongs to the European Network "Natura 2000" due the presence in its waters of: bottlenose dolphin (*Tursiops truncatus*), striped dolphin (*Stenella coeruleoalba*), common dolphin (*Delphinus delphis*), loggerhead sea turtle (*Caretta caretta*), green sea turtle (*Chelonia mydas*). Due to presence of highly vulnerable cetaceans the Gulf of Corinth is also classified as an Important Marine Mammal Area (IMMA) by IUCN Marine Mammal Protected Areas Task Force.

Home Range is defined as the area occupied by an animal, or a group of animals, during its daily activities [5], and its size may be influenced by many variables, such as feeding ecology, body size, group size, and habitat quality. There is a tendency for larger bodied animals and animals that live in larger groups to occupy larger areas, but this is not necessarily always the case [6]. There are many ways to determine the area used by a species: the grid cells method, kernel density estimation (KDE), low convex hull (LoCoH) and the minimum convex polygon (MCP).

The grid cell method consists of superimposing an imaginary grid on the study area, then estimating the area used by a species, basing on which grid cells the individuals or groups occupy. However, grid cell size can dramatically influence results.

KDE is the most commonly used method, and it involves a more complex, nonparametric analysis of home range data. It uses locational data to create what is called a utilization distribution, which describes the probability for an animal to be found in a given location. Multiple problems can arise with KDE in relation to smoothing parameter selection and overestimation of home range, among other variables.

LoCoH is basically a kernel method that uses minimum convex polygon construction, and it is useful because it

tends to account for areas that are unusable by animals, such as cliffs, water bodies, and unforested areas.
The minimum convex polygon (MCP) represents the approach employed in this study. It uses GPS coordinates registered following dolphins during boat surveys and photo-identification technique to define Home Ranges by connecting the point of "recapture" of the same animal over the area of study. It assumes animals use all the area within the home range equally, and increased weight is not given to areas used more frequently. As a result, a point used only once over the course of a year could extend the home range significantly and high-use areas cannot be differentiated. However, the MCP has been found to be preferred over other approaches because more accurate [6].
The identification of individuals Home Ranges within the Gulf of Corinth would allow identifying suitable strategies to protect the species in this Protected Area.

II. METHODS

A. *The area of study: the Gulf of Corinth*

The Gulf of Corinth (Figure 1) is a semi-closed basin of the Ionian Sea (Eastern Mediterranean), that separates Peloponnesus from northern Mainland Greece. It is linked to the Ionian Sea by the Gulf of Patras, and the artificial channel of Corinth allows the connection with the Saronic Gulf and the Aegean Sea. Thanks to the morphology of this environment, to its high mean depth (Figure 2), that increases rapidly to reach a maximum of 935 m centrally, to the slope, slight in the northern part and steep in the central-southern area, and to wind-generated upwelling currents [7], the Gulf of Corinth presents a rich marine biodiversity, offering the perfect conditions for the survival of striped dolphins. The bathymetry in figure 2 shows the neritic zone, with depth from 0 to 200m, with a light blue colour, and pelagic waters with darker shades of blue.

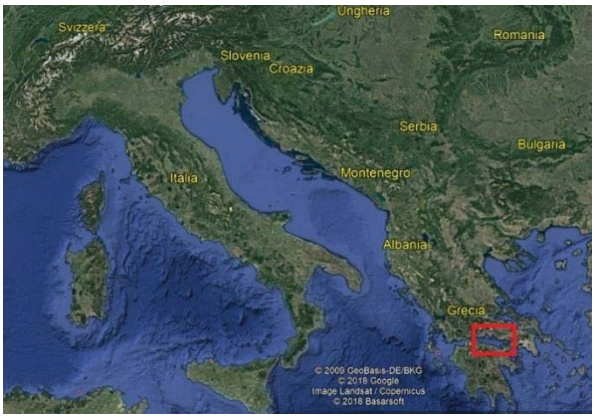

Figure 1: the red box shows the position of the Gulf of Corinth within the Eastern Mediterranean Sea

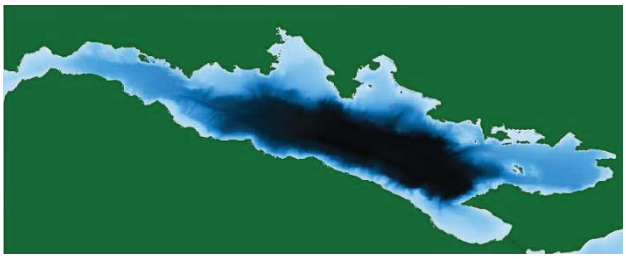

Figure 2: Gulf of Corinth's bathymetry

B. *Data collection*

The data analysed for the present study were collected during the summers of every year from 2009 to 2017. Monitoring activity was conducted from a sailing vessel (12m), in optimal weather conditions (Beaufort ≤ 3, Douglas ≤ 3, visibility ≥ 5 miles). When striped dolphins were sighted, the boat approached them, in the full respect of the animals' welfare. Photographs of dorsal fins were taken in order to capture an image of every individual.

C. *Photographs analysis and Home Range analysis*

At the end of each survey, high quality photos of dolphins were analysed for photo-identification purposes, and they were employed to create a catalogue of identified individuals. The software Mark was employed to analyse the population size for 2 periods of time spaced 5 years between them: 2010-2011 and 2015-2016, in order to evaluate if the consistency of the population is constant during the years. The coordinates of the sightings of the dolphins photo-identified at least three times were employed to determine the Home Ranges. The QGIS software allowed to define individuals Home Ranges, employing the geographical positions of each photo-identified individual, and linking them with Minimum Convex Polygon method (MCP).

III. RESULTS

During the summers from 2009 to 2017, 168 surveys were conducted. Monitoring activity was led along 5812 linear kilometres, and during 524 hours of survey. Tables 1 and 2 respectively report information about survey effort (number of surveys, km and time spent looking for striped dolphins) and monitoring results (number of sightings and mean sighting frequency).

year	n° surveys	monitoring time (hours)	km tot
2009	18	47,80	564,36
2010	27	46,67	445,86
2011	31	92,71	971,52
2012	23	69,70	685,6
2013	6	17,63	150,12
2014	12	41,33	557,05
2015	16	40,08	829,98
2016	23	105,58	940,19
2017	12	62,68	667,7

Table 1: number of surveys, monitoring time and distance covered per year

year	n° sightings	mean sightings frequency
2009	28	0,30
2010	18	0,47
2011	37	0,46
2012	29	0,43
2013	7	0,30
2014	13	0,26
2015	13	0,41
2016	24	0,69
2017	21	0,44

Table 2: number of sightings and mean sighting frequency

The years 2011 and 2016 are the ones with a greater effort, both in terms of time and km spent looking for striped dolphins. 194 sightings were realized in total. The number of sightings with photo-identification data is lower than the total number of sightings for the following reasons: 1) different sightings were realised when the boat was surveying employing the distance sampling technique, avoiding a closer approach to dolphins; 2) striped dolphins are very fast swimmer and it is not always possible to keep in touch with them for taking a pictures of their dorsal fin.

A. Photo-identification results

Analysing the pictures of all the 8 years of study, 447 individuals have been identified employing the photo-identification technique. They represent about one third of the sighted dolphins. The annual distribution of the frequency of photo-identified individuals with markers and without markers is shown in Figure 3. In 2011, the sum of individuals with and without markers, results higher than the one of other years. That may be due to a higher number of surveys carried out during 2011.

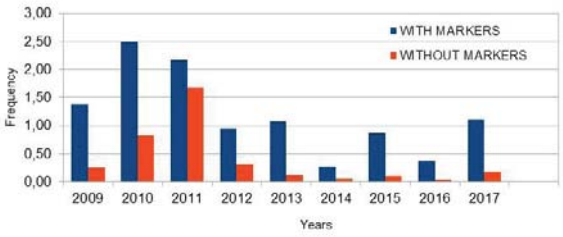

Figure 3: annual distribution of photo-identified individual with/without markers.

The cumulative curve of photo-identified individuals shows that their number increases every year (Figure 4), indicating the possibility that the investigated population is open and exposed to variations of its composition. The annual increasing is probably due to a higher number of sightings during the early summer.

Figure 4: cumulative curve of photo-identification

Employing the mark release recaptures technique to the photo-idenetification data of the summers 2010-2011 and 2015-2016, the software Mark allowed estimating a population of 960 individuals for the first period and of 1052 individuals for the second one, considering both, marked and unmarked animals. The number of individuals slowly increased in the area, in the considered 5 years interval. For conservation purpose a new analysis would be carried out for the following 5 years interval period (2020-2021).

B. Home Ranges Results

For the determination of the Home Ranges, all the photo-identification data from 2009 to 2017 have been used. The geographical positions of the individuals with well recognizable markers, sighted at least 3 times, therefore allowing the construction of the Minimum Convex Polygon, were employed. Over the 447 photo-identified individuals, 55 were then selected for the Home Range analysis. The software QGIS allowed drawing every

polygon. Three categories of Home Range were then highlighted with different colour (Figures 5, 6, 7, 8).

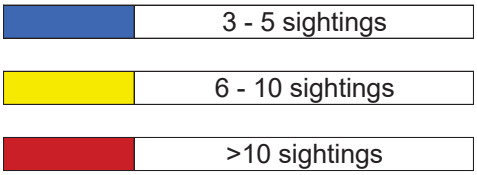

Figure 5: categories based on the numbers of sightings

Figure 6: the Home Ranges of the first category.

Figure 7: the Home Ranges of the second category.

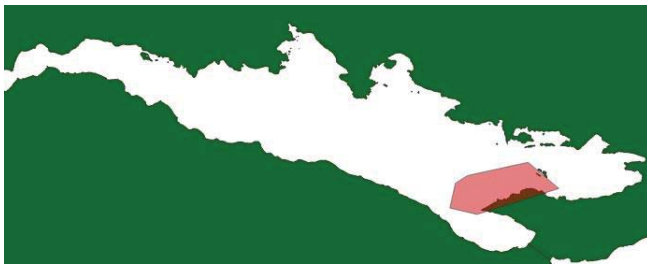

Figure 8: the Home Range of the third category.

The extension of each Home Range has been calculated, in order to obtain the average extension for each category of re-sighted individuals: the first category (3-5 sightings) shows a mean Home Range extension of 21.85 km^2; the second category (6-10 sightings) shows a mean Home Range extension of 46.93 km^2; the third category (>10 sightings) shows a mean Home Range extension of 208.11 km^2.

Subsequently, the areas obtained from the sum of all Home Ranges was calculated. The total area (Figure 9) of the polygon obtained by overlapping the Home Range of each individual is 490.14 km^2.

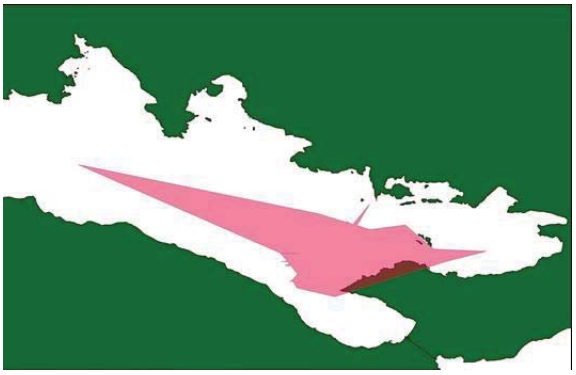

Figure 7: the overlapping of the Home Ranges

IV. DISCUSSION AND CONCLUSION

Photo-identification technique allowed to build a catalogue of 447 marked striped dolphins living in the Gulf of Corinth. The marked and photo-identified individuals represent about one third of the sighted ones. The present study highlights a presence of about 1000 individuals in the investigated area. 960 for the period 2010-2011 and 1052 for the period 2015-2016, that is in agreement with another study, that estimated for the Gulf of Corinth a population of about 1324 individuals for the period 2011-2015 [8].

55 photo-identified individuals allowed defining Home Ranges, highlighting that the area is regularly employed by striped dolphins.

The most re-sighted individuals show a wider mean extension of their Home Range. Nevertheless, their presence results limited to the Eastern Southern portion of the Gulf of Corinth, showing a high degree of site fidelity for this area. All their sightings fall in the same area and their Home Ranges overlap.

Contrary the less re-sighted individuals, even if showing a smaller extension of Home Range, occupy a wider latitudinal range, showing a smaller site fidelity. Their sightings in the western portion could indicate some movement across the Ionian Sea. More sightings would help to improve the precision of the defined Home Ranges for each individual.

The determination of the Home Ranges offers a great contribution for the conservation of this protected species in the Protected Area “Gulf of Corinth”. The analysis of Home Range allow highlighting which areas are the most important for the conservation of the individuals that show a higher degree of site fidelity and that are the ones more affected by local management plans.

REFERENCES

[1] Notarbartolo di Sciara G. (2002). Cetacean species occurring in the Mediterranean and Black Seas. A report to the ACCOBAMS Secretariat, Monaco, February 2002. Section 3, 17 p.

[2] Notarbartolo di Sciara G. (1993). Cetacei del Mediterraneo. Montepulciano, Editori del Grifo.

[3] Aguilar A. (2000). Population biology, conservation threats and status of Mediterranean striped dolphins (*Stenella coeruleoalba*). Journal of Cetacean Research and Management 2(1):17-26.

[4] Aguilar A., Gaspari, S. (2012). Stenella coeruleoalba (Mediterranean subpopulation). The IUCN Red List of Threatened Species 2012: e.T16674437A16674052.

[5] Burt W.H. (1943). Territoriality and home range as applied to mammals. Journal of Mammalogy 24:346–352.

[6] Gregory T. (2017). Home Range Estimation. The International Encyclopedia of Primatology. Edited by Agustín Fuentes. Published 2017 by JohnWiley & Sons, Inc.

[7] Lascaratos A., Salusti, E, Papageorgaki, G. (1989). Wind-induced upwellings and currents in the gulfs of Patras, Nafpaktos and Korinthos, Western Greece. Oceanonologica Acta 12(3):159 -164.

[8] Santostasi N.L., Bonizzoni S., Bearzi G., Eddy L., Gimenez O. 2016. A robust design capture-recapture analysis of abundance, survival and temporary emigration of three odontocete species in the Gulf of Corinth, Greece. PLoS ONE 11(12): e0166650.