pp. 41-52

6. Monitoring the Great White Pelican (*Pelecanus onocrotalus* Linnaeus, 1758) breeding population using drones in 2016 - the Danube Delta (Romania)

MARINOV Mihai[1*], POGAN Tamiris[2], DOROȘENCU Alexandru[1], NICHERSU Iulian[1], ALEXE Vasile[1], TRIFANOV Cristian[1], BOZAGIEVICI Raluca[1], TOŠIĆ Katarina[1], KISS Janos Botond[1]

[1] Danube Delta National Institute for Research and Development - Tulcea, Babadag Street, no. 165, Tulcea 820112, Romania; e-mail: office@ddni.ro
[2] SC Aerocontrol UAV SRL, Bucharest, Romania; e-mail: tpogan@gmai.com

**Address of author responsible for correspondence: MARINOV Mihai, Danube Delta National Institute for Research and Development - Tulcea, Babadag Street, no. 165, Tulcea 820112, Romania; e-mail: mihai.marinov@ddni.ro*

Abstract: The Danube Delta colony of the Great White Pelican (*Pelecanus onocrotalus*) was evaluated in 2016 at 17,000 pairs, with a minimum of 15,000 and a maximum of 19,000 pairs. We used unmanned aerial vehicle (UAV) technology to count the number of nesting birds in the colony. The UAV-derived counts in 2016 show a 4 times higher number of pairs than the most recent estimates for Romania (4,100-4,500 pairs) and 3 times higher than for Europe (4,900 to 5,600 pairs). The possible causes of this increase are discussed. Preliminary analyses suggest that the remoteness and availability of nesting sites played a crucial role. This is supported by significant conversion of the reed bed to nesting units that started in the north-western part of the colony in 2014 and by 2016 there were already 17,076 pairs counted in this site alone. We put forth the hypothesis that Great White Pelicans play an important role in the expansion process of the open water areas from Hrecisca and Buhaiova Lakes to the detriment of floating reed beds. UAVs proved their ability to survey hard-to-reach locations and increase counting precision for the Great White Pelican colony in the Danube Delta. The results of our study suggest that UAV technology is a powerful tool for estimating Great White Pelican populations for research teams involved in precision monitoring and it provides up-to-date figures for management authorities. We highly recommend its application in further monitoring activities.

Keywords: UAV, colony, Great White Pelican, Danube Delta Biosphere Reserve, population, nesting pairs

INTRODUCTION

The Great White Pelican (*Pelecanus onocrotalus*) is the largest aquatic bird species, present in significant numbers from spring to autumn in the Danube Delta Biosphere Reserve. Out of the 362 species of wild birds that have been recorded in the Danube Delta Biosphere Reserve perimeter, the Great White Pelican is one with a major ecological and economical relevance for the area. The Great White Pelican has two distinct populations - one in Eastern Europe and Asia, the other in Africa - without forming separate taxonomic units. About half of the Palearctic population nests in Europe, with an estimated 4,900-5,600 pairs which equates to 9,700-11,100 mature individuals (*****, 2015a).

The largest known number of Great White Pelicans in Europe nests in Romania in the colony of Hrecisca-Buhaiova, from the Danube Delta Biosphere Reserve. This population is probably of crucial importance to the species in the Western Palearctic. Although there have been several evaluations since the 1950s, with varying degrees of accuracy, no more than 5,400 nesting pairs of Great White Pelican have been estimated in the Danube Delta. In the past 20 years, estimates were between 3,000 and 4,500 breeding pairs and led us to attribute this relative constancy to a lack of nesting sites. Autumn migration counts performed in Israel and Bulgaria have revealed very high numbers of Great White Pelicans since 90' (between 40,000 and 80,000 individuals in Israel) that do not match the breeding population reported for the Danube Delta and circumpontic region (Hatzofe, 2014; Iankov, 2014; Michev *et al*., 2011).

The Great White Pelican colony was assessed by drones instead of planes due to better coverage of the area, more accurate georeferencing of the images and a much lower degree of disturbance.

MATERIAL AND METHODS

The area assessed was the colony of Great White and Dalmatian pelicans settled around Lake Hrecisca and Lake Buhaiova of the Rosca Buhaiova strictly protected area (**Fig. 1, Appendix 1 & 2**) in the northern part of the Danube Delta Biosphere Reserve. Launching procedures of the UAV were carried out on Câmpul Chiliei. In the 2013-2016 period, several types of drones were used (rotary wing - helicopter, multi-copter and fixed wing / wing flying).

The aircraft used in 2016 was a Dragon – a forward-swept delta wing (**Fig. 4**), hand launched, with a 1.6 m wingspan, 4.5 kg weight, capable of 40 minutes endurance and a 25 km range. The aircraft was equipped with an APSC NX500 camera of 28Mp, with 20, 30 and 70mm lenses. Flights were conducted at heights between 70m-80m AGL and 270m AGL.

On May 24 a total of four flights were executed, between 2.30 p.m. and 6.30 p.m. Winds at mission flight altitudes were 4-6 m/s at 80m AGL, and over 8m/s at higher altitudes. Concerning the methodology used in compiling all the flight images of both lakes (Hrecisca and Buhaiova), several software packages were used in order to achieve the final result – a photomosaic of the entire area (**Appendix 1 & 2**). The processing included in the workflow described above takes time, depending on the PC performance. For example, a mid-high end computer, CPU i5, with 16 Gb of RAM and a VGA with 941Hz CPU, RAM 3Gb DDR5 and 2304 CUDA cores took approximately 12 hours for the final output, not counting all the trials and the product versions which lead to the final product (**Fig. 2**).

Finally, the photomosaic was used in GIS software to manually evaluate the Great White Pelican bre**e**ding area through simple and basic procedures. A point layer in ArcGis was used to count the Great White Pelicans on nests.

In order to minimize the risk of double counting, the final numerical evaluation of the Great White Pelican nesting population on Lakes Hrecisca and Buhaiova was performed on the images (photomosaic) taken at 3 p.m. The distribution of each nesting pair in the colony was represented by a point, so the number of points in the figure is equal to the number of Great White Pelican nesting pairs. For each bird we estimated whether it was on the nest or not (in other positions) – by expert judgment. Both were counted, the total number of Great White Pelicans and the total number of birds on nests.

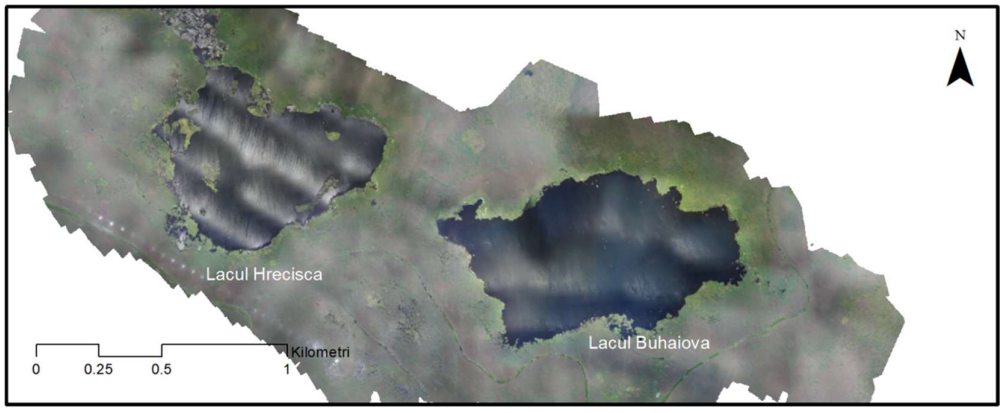


Figure1 The evaluated area, Hrecisca Lake and Buhaiova Lake - Danube Delta Biosphere Reserve - Romania (mosaic aerial image 2016 - (UAS-BIRD)

The software used for this step was Global Mapper and the vectorization of each individual was done manually using the provided tools (**Fig 2**). To increase the accuracy of the vectorization process, the orthomosaic's blending option was altered with other screen options such as: Color Dodge, Difference, Keep Red, Keep Green, Keep Blue, SPOT (Natural Color). The most accurate display of the orthomosaic is with the Difference view, as shown in **Fig. 3**.

Figure 2 Manual counting of the individual pelicans (nesting or not) on the orthophoto in visible support - the assessed area of Hrecisca Lake and Buhaiova Lake - Danube Delta Biosphere Reserve - Romania, May 2016

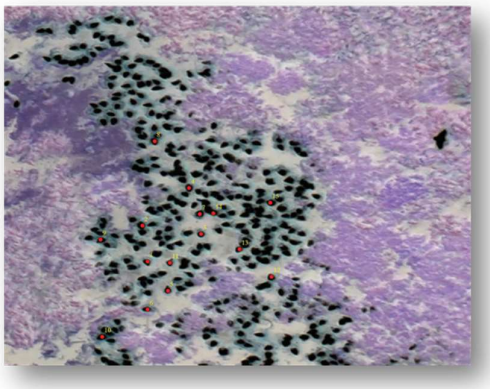


Figure 3 Method for improving manual counting of Great White Pelican individuals (nesting or not) on the orthophoto support by altering the visible spectrum in "Difference" - the assessed area of Hrecisca Lake and Buhaiova Lake - Danube Delta Biosphere Reserve - Romania, May 2016

Figure 4 Dragon – the forward-swept delta wing used to assess the colony of Great White pelicans (*Pelecanus onocrotalus*) within the Roșca – Buhaiova area, Danube Delta (May 2016)

RESULTS AND DISCUSSION

At the range level, the total population of Great White Pelicans is estimated at 265,000-295,000 individuals (*****, 2016) and the European population is estimated at 4,900-5,600 pairs (*****, 2015a). The largest breeding population of Great White Pelicans outside Africa nests in Romania, in a colony in the Danube Delta. Recent counts estimate it at approximately 3,560 – 4,160 pairs (Munteanu, 2009;

Papp & Fântână, 2008), and 4,100-4,500 pairs (aero evaluations of Romanian Ornithological Society - Catsadorakis *et al*., 2015; *****, 2015).

The first bibliographic reference regarding the current location of this colony of the Great White Pelican (*Pelecanus onocrotalus*) and smaller numbers of Dalmatian Pelicans (*Pelecanus crispus*) is from 1958 (Cătuneanu *et al*., 1978). The colony is located around the Hrecisca and Buhaiova lakes (**Fig. 1**). Pelicans use the floating reed beds as nesting platforms. The floating reed beds are fragmented and destroyed by weather (storms, ice, waves etc.) and by the pelican themselves. For this reason, the pelicans are forced to move on from Hrecisca Lake to Buhaiova Lake where they have been nesting for several years, up until damage of the floating reed bed, then returning to the other lake (Kiss, 2002). During the past 40 years, the shift of the colony from one lake to the other occurred five times. Currently, the colony is shifting from Lake Buhaiova to Lake Hrecisca (**Fig. 1**). In intermediate periods, for a year or two, the nesting Great White Pelicans have had relatively equal numerical distribution on both lakes.

The population of Great White Pelicans in the Danube Delta is completely migratory, like all other northern populations. Great White Pelicans in the Danube Delta migrate along the Black Sea through Bulgaria, then cross inland Turkey, east of the Mediterranean and then Egypt, wintering in Sudan, Kenya and other countries in equatorial Africa (Cătuneanu, 1999; Crivelli *et al*., 1991; Del Hozo *et al*., 1992; Iyhaki *et al*., 2002; Shmueli *et al*., 2014).

No projects devoted specifically to the study of Great White Pelicans in the Danube Delta have been granted thus far, and a series of gaps and oversights have been identified:

- lack of publications regarding recent surveys (recent publications are based on older assessments);
- assessments over a long series of years indicate only a slight increase in number of breeding pairs in the last two decades,
- discrepancies between the numbers in recent assessments of the Danube Delta and along migration routes (even after adding immature pelicans, there are still discrepancies - 40,000 ± 9,000 individuals in Israel - Hatzofe, 2014 and 51,000 in migration in Bulgaria, Iankov, 2014). Great White Pelican numbers migrating across Bulgaria total about 40,000 individuals in the period from 1979 to 2003, with an upward trend (Michev *et al*., 2011). Official data regarding European and West Asian populations of the Great White Pelican indicate about 20,000-33,000 individuals (*****, 2016).

The total number of Great White Pelicans counted on the photomosaic was 20,500 individuals on both lakes. These 20,500 individuals of Great White Pelican were counted from the photomosaic that was produced only from the images recorded during the 3 p.m. flight (to avoid double counting, we counted only by using the mosaic photo, with checks at some images with maximum density). However, flights at lower altitudes were finalized after 7 p.m., and thousands of other Great White Pelicans arrived in the meantime.

Of 20,500 individuals counted, all the flying and swimming pelicans were excluded. Only the individuals that appear to be on nests were considered. Finally we counted 19,155 nesting pelicans in total: 17,076 in the northwest part of Lake Hrecisca, 1,568 pelicans on the remaining shores of Lake Hrecisca and 621 on the shores of Lake Buhaiova - **Fig. 8, Annex 2**.

The most spectacular situation was the colonization of the northwestern part of Lake Hrecisca by the Great White Pelicans (**Fig. 7 & 8, Appendix 1 & 2**). The area was covered only by reed beds in 2011 and 2012 (**Fig. 5 & 6**) and 17,076 nesting Great White Pelicans were counted in 2016 in this location (**Fig. 8)**. Even if the counting method is precise, errors are possible in certain regions of the colony photomosaic, caused by the shooting angle and degree of light reflection, or misinterpretation of whether or not the pelican is on the nest.

In order to assess the maximum error percentage of our counting, the surface of the area that showed some degree of uncertainty on the photomosaic was calculated and resulted in a maximum of 20% of the colony. Considering a maximum possible counting error of 20%, the minimum number of nesting pairs is approximately 15,000 and the average would be about 17,000 pairs of Great White Pelicans in 2016 in the Danube Delta in Romania - **Appendix 2**.

This approximately quadruple increase (compared to the most recent assessments) of the breeding population of Great White Pelicans in the Danube Delta can be a numerical pulsation in the last two or three years (characteristic of the species when trophic abundance and availability of nesting areas increases) but it could be a longer process (with the possibility of inaccurate counting from the aero-photographic material obtained in previous assessments). Assuming that the increase of the number of Great White Pelican pairs recorded in 2016 was a slower, continuous process, then a number of situations may have caused this phenomenon. Firstly, we should consider the consequences of protecting regional wetlands and the implementation of appropriate management measures, including the establishment of the Danube Delta Biosphere Reserve. Another possibility is the reallocation, in the Danube Delta, of Great White Pelicans belonging of other circumpontic populations as a result of the damming of wetlands, direct persecution and other anthropogenic disturbances. Although unproven, we may also consider the arrival in Europe of Great White Pelican subadults from African resident populations along with migratory populations (Kiss, 1992).

Regarding the assessments of Great White Pelican in the Danube Delta, in the last five decades we have seen a pulsating numerical trend, a phenomenon noted previously (Cătuneanu, 1958). This phenomenon has also been reported in other areas of the species' range (Krivenko *et al*., 1994) and attributed to climate change (Doxa *et al*., 2012; Jiguet *et al*., 2008).

We aim to evaluate the nesting areas again in 2017 using drones in order to record whether this growth is continuous or only a pulse. Until the reassessment of the Great White Pelican breeding population in the Danube Delta, we have analyzed here the images of the studied area in the 2007-2014 period. Following the proven effectiveness of using UAV technology, its use is recommended for the monitoring of known colonies and the location of new ones.

Although during the breeding season the flock at Hrecisca-Buhaiova is made up of 19,000 pairs, this mass is composed of smaller units, each made up of several hundred, up to several thousand pairs, lying more or less together with little overlap from one group to the next (**Fig. 1, 7 & 8)**.

The images from 2011 and 2012 (**Fig. 5** and **6)** show that the northwestern area of Lake Hrecisca was much less colonized at that time (1,000 pairs were estimated, although many nests were deserted in June - enlarged view of **Fig. 5**). In 2014 several thousand pairs have been counted in northwestern part of Lake Hrecisca (**Fig. 7**) and 17,076 pairs in 2016 (**Fig. 8**). The large increase of nesting pair numbers in the last years started in 2013 or 2014 (**Fig. 7**). No reliable images are available for the 2013 breeding season yet so there is a gap in our data regarding the annual development of the colony.

The aerial photomosaic for 2014 is not complete, so only a partial count was possible using this method. Besides filling in the data gaps, the counting process based on this methodology has to be extended back in time as far back as aerial and satellite images are available for the area.

Besides the 2016 photomosaic, no precise and/or complete counts could be performed on the other available images. Even so, significant population size variations and location shifts are traceable.

The variations of breeding population size are mainly determined by the availability of trophic supply as well as of the nesting habitats (and also probably of other intrinsic and extrinsic factors) but we do not know if this variation is an interdependence between the two requirements and what their proportion is. The spectacular increase of the number of Great White Pelican nesting pairs should be directly related to an increase in fish stocks in the area. According to the results of annual fish stocks assessments, no large increase has been reported in the last six years.

The foraging medium-range during the nesting period for the Great White Pelican in the Danube Delta is about 40 kilometers (Platteuw *et al*., 2004). This comprises the main foraging sites. Nevertheless, it can reach to over 100 kilometers (Kiss & Nichersu, 2003). In this context it is worth mentioning the presence of large agglomerations of Great White Pelicans that have been observed fishing along the Black Sea shores from the Danube Delta Biosphere Reserve in the 2016 breeding season.

For a long time we have considered that the size of the Great White Pelican breeding population in the Danube Delta does not increase due to lack of nesting areas around the Buhaiova and Hrecisca Lakes, the only areas that provide sufficient possibilities for long-term nesting of this species in

Romania. The nests are located on the floating reed beds that are degraded relatively rapidly. As a direct consequence, after only a few years they need to relocate their nesting locations to other floating reed beds in the vicinity. In this regard, we mention that in 2002 we built several reed platforms consolidated with willow sticks, and all of them were occupied by Great White Pelicans in the same season (Kiss, 2002).

Since 2014 the shifting strategy in nest grouping, from parallel alignment along the lake shores (a thin strip of small cores of nests) to a vast core (the highest percentage of the nesting pairs is concentrated here) in the northwestern part of Hrecisca Lake, inside the compact reed bed. We do not know if the strategy shift in nest grouping (occupation of large areas within the region with compact reed beds in the northwestern part of Lake Hrecisca) beginning with 2014 and until 2016 (**Fig. 7 & 8**) was driven by growth in trophic supply, or was caused by the degradation of floating reed beds on Buhaiova and Hrecisca lakes, by insufficient nesting places (reported or not to a previous reproductive success followed by a high rate of immature survival) or some other extrinsic factor.

The colonization of the compact reed bed area from northwestern Hrecisca Lake, with a great density of pairs, and difficult /very difficult access to the pairs within the new nesting area, at least compared with the previous densities and configurations of the pelican colony, is a new phenomenon that has never before been seen within the Danube Delta.

Furthermore, by analyzing the images from the 2011-2016 period (**Fig. 5-8**), we found that Great White Pelicans have increased the water surface of the Hrecisca Lake. So far, we have considered the phenomenon only for slow expansion and circular or parallel with the lake shores, along with marginal degradation.

However, during the 2014-2016 period we recorded a spectacular expansion in size, irregular in relation to the lake shores. We put forth the hypothesis (that needs to be explore in future studies) that Great White Pelicans play an important role in the expansion process of the open water areas of Hrecisca and Buhaiova Lakes (and possibly other lakes in the Danube Delta) to the detriment of floating reed beds.

Figure 5 Ortophoto of Hrecisca and Buhaiova Lakes taken by plane (Matița – Merhei Aquatic Complex) - June 2011 (CARTODD project)

Figure 6 Satellite image of Hrecisca and Buhaiova Lakes (Matița - Merhei Aquatic Complex) - SPOT 2012

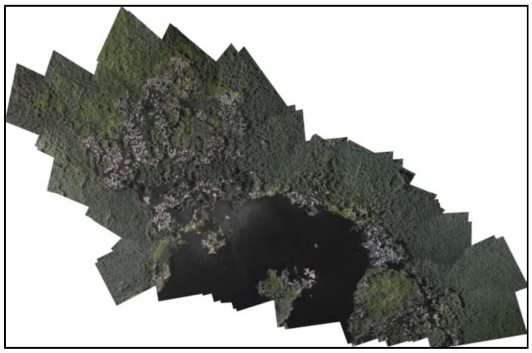


Figure 7 Photomosaic achieved by stitching together images taken by a drone in order to assess the colony of Great White Pelicans (*Pelecanus onocrotalus*) in the northwestern part of Lake Hrecisca (Matița – Merhei Aquatic Complex) - July 2, 2014 (UAS –BIRDD project)

Figure 8 Mosaic obtained by shooting pictures with a drone (270 m) in order to assess the colony of Great White Pelicans (*Pelecanus onocrotalus*) in the northwestern part of Lake Hrecisca (Matița – Merhei Aquatic Complex) – May 24, 2016 (UAS –BIRDD project)

CONCLUSIONS

Following aerial evaluations by drones in May 2016 at the Hrecisca - Buhaiova colony (Danube Delta, Romania) 19,155 nesting Great White Pelicans were counted (17,076 in the northwestern part of Hrecisca Lake, 1,568 on the remaining shores of Hrecisca Lake and 621 on Buhaiova Lake).

Considering a maximum possible counting error of 20%, the minimum number of nesting pairs is approximately 15,000 and the average would be about 17,000 pairs of Great White Pelicans in 2016 in the Romanian part of the Danube Delta.

This number of pairs of Great White Pelican in the Danube Delta recorded in 2016 is about 4 times higher than the most recent estimates for Romania (4,100-4,500 pairs) and more than 3 times higher than the breeding population estimated for all of Europe (4,900 to 5,600 pairs).

As a result of aerial photograph and satellite image analyses for the period 2007-2014 we found that in 2012 the colony was approximately at the level of previous years, whilst in 2014 the colony was already in consistent numerical and spatial expansion.

With no data on the colony from 2013, we can conclude that the number of nesting pairs of the Great White Pelican started to increase significantly in the Danube Delta in 2014. However, this might also have occurred in 2013.

We do not know the reasons for the quadruple increase in the number of pairs of Great White Pelican in the Danube Delta. There is no evidence of exponential growth in fish population size in the Danube Delta Biosphere Reserve. However, we noticed a change of strategy regarding the grouping of nests

(from circular grouping of small cores of nests), to one vast core (the highest percentage of nesting pairs is concentrated here) in the northwestern part of Hrecisca Lake, inside a compact reed bed.

An approximately four-fold increase in the breeding population of the Great White Pelican in the Danube Delta necessitates the application of a series of management measures, from new conservation and awareness actions to applying for compensation in the aquaculture sector through sEU funding instruments.

UAVs proved their ability to survey hard-to-reach locations and increased count precision for the Great White Pelican colony in the Danube Delta Biosphere Reserve. We highly recommend it for the monitoring of pelican colonies and other colonial aquatic bird species.

Special consideration is required to ensure the continuity and coherence of new dynamic UAV-derived data with data obtained by traditional methods.

The results of our study suggest that UAV technology is a powerful tool for estimating Great White Pelican populations for research teams involved in precision monitoring and it provides up-to-date figures for management authorities.

ACKNOWLEDGEMENTS

We thank Constantin Toma, Lazăr Constantin, Burlacu Mihai and Pogan Cecilia (Aerocontrol team) for supporting our field (drone operation) and office work (GIS and counting), as well as Munteanu Ion (Danube Delta Biosphere Reserve Authority), Ohad Hatzofe (Israel Nature & Parks Authority) and Giorgos Catsadorakis (Chairman of IUCN SSC Pelican Specialist Group) for providing relevant information. Field and office work were conducted mainly within the framework of project “UAS – BIRDD (UAS innovative survey and monitoring model for colonially breeding waterbird species from Danube Delta Biosphere Reserve)” - PN-II-PT-PCCA-2011-3.2-1215 - financed by the Romanian National Authority for Scientific Research. Office work was also done within the project “Starea actuala a coloniilor de păsări acvatice si a speciilor de păsări pentru care s-au desemnat situri NATURA 2000 în Rezervația Biosferei Delta Dunării / The current status of waterbird colonies and bird species for which Natura 2000 sites have been designated in the Danube Delta Biosphere Reserve” - PN 16 28 01 10 - financed by the Romanian National Research program Nucleus.

REFERENCES

Catsadorakis G., Onmuș O., Bugariu S., Gül O., Hatzilacou D., Hatzofe O., Malakou M., Michev T., Naziridis T., Nikolaou H., Rudenko A., Saveljic D., Shumka S., Siki M., Crivelli A.J., 2015. Current status of the Dalmatian pelican and the great white pelican populations of the Black Sea/Mediterranean flyway. IN: *Endangered Species Research*, vol. 27, pp. 119 – 130.

Cătuneanu I.I., 1958. Coloniile de cuibărit din Delta Dunării şi necesitatea creării unor rezervaţii ornitologice. IN: *Ocrotirea Naturii*, vol. 3, pp. 79 – 115.

Cătuneanu I.I., 1999. Istoricul cercetărilor efectuate pe teritoriul României asupra migraţiei păsărilor prin metoda inelărilor, până la înfiinţarea Centralei Ornitologice Române, şi fazele acesteia de dezvoltare în perioada 1939-1970. Publicaţiile Societăţii Ornitologice Române, vol. 8, nr. 32, pp. 56, 63.

Cătuneanu I.I., Korodi Gál I., Munteanu D., Paşcovschi S., Vespremeanu E., 1978. IN: *Fauna R.S.R. Aves*. Ed. Academiei R.S.R. Bucureşti, vol. 15, no. 1, pp. 267 – 275.

Crivelli A.J., Leshem Y., Mitchev T., Jerrentrup H., 1991. Where do palaearctic Great white pelicans (*Pelecanus onocrotalus*) presently overwinter? IN: *Revue d’Ecologie (La Terre et la Vie)*, vol. 46, pp. 145 - 171.

Doxa A., Robert A., Crivelli A., Catsadorakis G., Naziridis T., Nikolaou H., Jiguet F., Theodorou K., 2012. Shifts in breeding phenology as a response to population size and climatic change: a comparison between short- and long-distance migrant species. IN: *The Auk*, vol. 129, no. 4, pp. 753 - 762.

Hatzofe O., 2014. Pelicans and fisheries conflict management - lessons learned? Hula Valey, Pastoral Hotel, Kfar Blum, Israel 27-29 October 2014. Summary of the International Workshop. https://www.wetlands.org/wp-content/uploads/2015/11/pelican-Conference-summary_Final.pdf.

Iankov P., 2014. Pelicans (*Pelecanus onocrotalus* and *P. crispus*) and fisheries in Bulgaria. Hula Valey, Pastoral Hotel, Kfar Blum, Israel 27-29 October 2014. Summary of the International Workshop. https://www.wetlands.org/wp-content/uploads/2015/11/ pelican-Conference-summary_Final.pdf.

Izhaki I., Shmueli M., Arad Z., Steinberg Z., Crivelli A., 2002. Satellite Tracking of Migratory and Ranging Behavior of Immature Great White Pelicans. IN: *Waterbirds*, vol. 25, no. 3, pp. 295 - 304.

Jiguet F., Doxa A., Robert A., 2008. The origin of out-of-range pelicans in Europe: wild bird dispersal or zoo escapes? IN: *Ibis*, vol. 150, pp. 606 – 618.

Kiss J.B., 1992. Noi regăsiri de inele de pelicani comuni – *Pelecanus onocrotalus*. IN: *Buletin de Informare SOR*, nr. 2, p. 4.

Kiss J.B., 2002. Mesterséges fészkelőhelyek biztositása a rózsás gödények (*Pelecanus onocrotalus* L.) a Duna-Deltában. IN: *Múzeumi Fűzetek*, vol. 13, pp. 92 - 94.

Kiss J.B., Nichersu I., 2003. Satellite telemetry of birds route for automatic data logging of Pelicans deal behaviour. IN: Analele Stiinţifice, Scientific Annals 2002. INCDDD – Tulcea. Editura Technică, vol. 9, pp. 106 – 111.

Krivenko V.G., Crivelli A.J., Vinogradov V.G., 1994. Historical changes and present status of pelicans in the former URSS: a synthesis with recommandations for their conservation. In: *Pelicans in the former URSS*. IWRB Publication. Slimbridge, vol. 27, pp. 132 - 151.

Michev T., Profirov L., Nyagolov K., Dimitrov M., 2011. The autumn migration of soaring birds at Bourgas Bay, Bulgaria. IN *British Birds*, vol. 104, pp. 16 – 37.

Munteanu D., 2009. Păsări rare, vulnerabile şi periclitate în România. Editura Alma Mater. Cluj-Napoca. pp. 12-14.

Papp T., Fântână C. (editors), 2008. Important bird areas in Romania – published in cooperation by the Romanian Ornithological Association and association “Milvus Group”. Tg. Mureş, pp. 178-180.

Platteuw M., Kiss J.B., Sadoul N., Zhmud M.Y., 2004. Colonial waterbirds and their habitat use in the Danube Delta. RIZA Report 2004.002. ISBN 90.369.5658.7. Pp. 107 – 111.

Shmueli M., Arad Z., Izhaki I., 2014. Satellite tracking of the Great White Pelican migrating between Europe and Africa through Israel. Hula Valey, Pastoral Hotel, Kfar Blum, Israel 27-29 October 2014. Summary of the International Workshop. https:// www.wetlands.org/wp-content/uploads/2015/11/pelican-Conference-summary_ Final.pdf.

*****, 2015. Atlas al speciilor de păsări de interes comunitar din România. Proiect cofinanţat din Fondul European de Dezvoltare Regională. Fundaţia Centrul Naţional de pentru Dezvoltare Durabilă. Pp. 82-83.

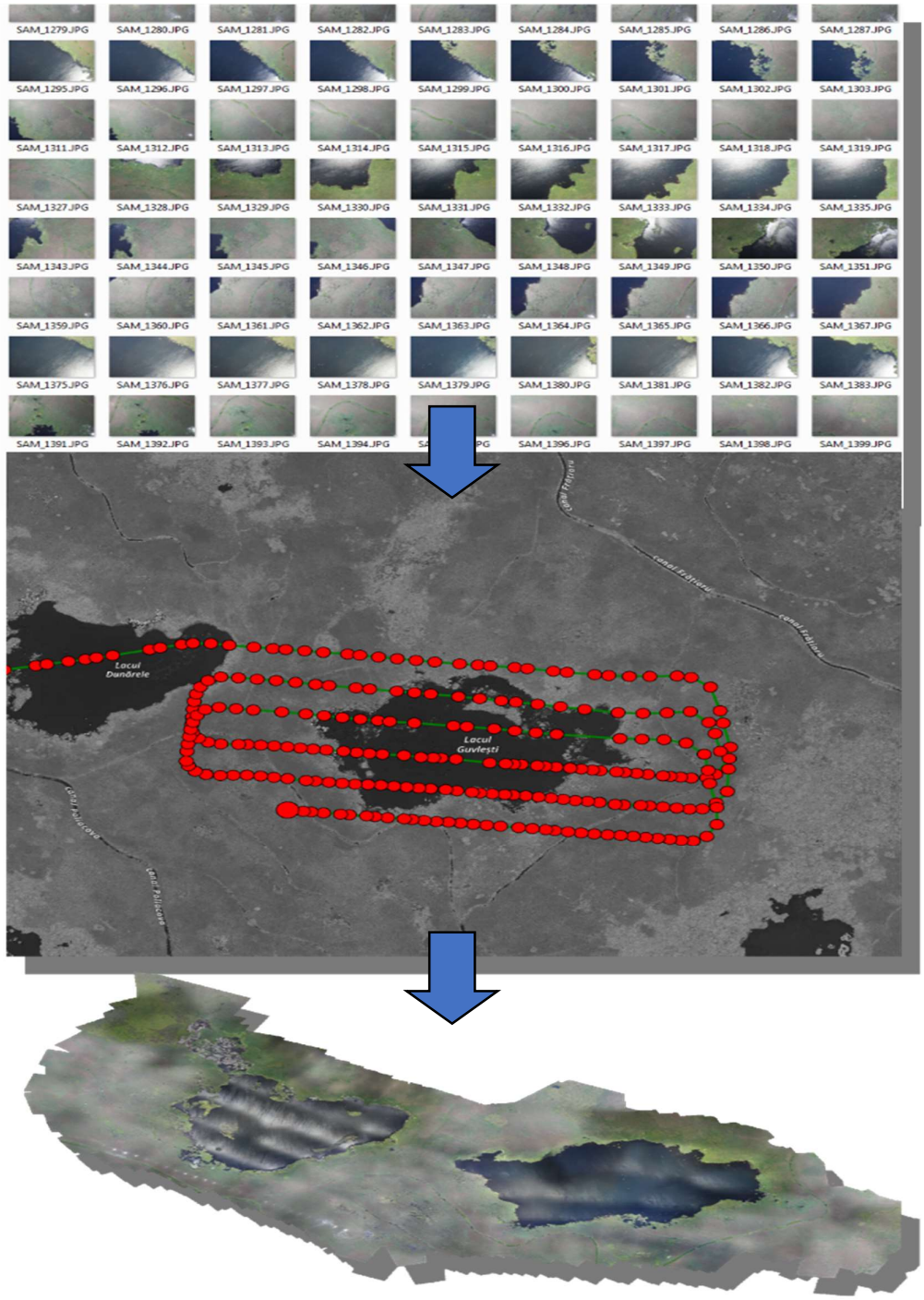
*****, 2015a. BirdLife International. European Red List of Birds. Office for Official Publications of the European Communities, Luxembourg.

*****, 2016. Wetlands International - Waterbird Population Estimates. http://wpe.wetlands.org/search?form%5Bspecies%5D=pelecanus+onocrotalus&form%5Bpopulation%5D=&form%5Bpublication%5D=5.

Received 7 March 2017
Revised 10 April 2017

APPENDIX

Appendix 1 Aerial image processing for obtaining a homogeneous result of "Mosaic" or "Ortophoto" through GIS applications - the assessed area of Hrecisca Lake and Buhaiova Lake - Danube Delta Biosphere Reserve - Romania, May 2016



Appendix 2 Assessment of the Great White Pelican colony (*Pelecanus onocrotalus*) Hrecisca and Buhaiova lakes (Matita – Merhei Aquatic Complex) - Danube Delta Biosphere Reserve - Romania, May 2016