# DATA REGARDING FLUCTUATIONS IN THE GREAT WHITE PELICAN (*Pelecanus onocrotalus* LINNAEUS 1758) POPULATION IN THE DANUBE DELTA (ROMANIA) BETWEEN THE 1950-2016

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**Abstract.** The paper presents the numerical fluctuation of the populations of common pelican (*Pelecanus onocrotalus* Linnaeus 1758) during the last seven decades in the Danube Delta, Romania. Pelicans have been protected in Romania since 1933. Their only nesting ground in Romania, the largest in Europe, is situated in the northern part of the Delta in an isolated area that is extremely difficult to approach. As a result of their protected status the population had increased tenfold by the year 2000 compared to the 1930s. While population assessments historically were performed from rowboats and occasionally based on aerial photography, new, high tech methods have shown an apparent increase in the population trend. In 2016 the estimated number of nesting Great White Pelican pairs was 17,000. We postulate that hydrographical changes constitute an important factor in the positive population trend by creating new roosting grounds for pairs previously unable to nest. The increase could also be a result of the relocation of smaller pelican colonies from around the Black Sea. The use of drone photography and GPS localization was pivotal in determining current population figures, allowing the appraisal of areas previously inaccessible by boat. The unexpected increase in the pelican population warrants a revaluation of the management policy of the Danube Delta Biosphere Reserve Authority, and demonstrates the necessity of adopting equipment for future population monitoring.

**Keywords:** Romania, great white pelican, population trend.

**Rezumat. Date privind fluctuația numerică a populatiilor de pelican comun (*Pelecanus onocrotalus* Linnaeus 1758) în Delta Dunării (România) în perioada 1950-2016.** Lucrarea prezintă fluctuația numerică a populațiilor de pelican comun (*Pelecanus onocrotalus* Linnaeus 1758), în ultimele șapte decenii, din Delta Dunării. In România, pelicanii sunt păsări protejate din 1933. Singura lor colonie din țară, care este și cea mai mare în Europa, se află în partea de nord a deltei, într-o zonă extrem de greu accesibilă. După ce au fost declarați drept protejați, numărul pelicanilor a început încet să crească, înzecindu-se până la sfârșitul secolului trecut față de anii '30. Evalările efectivelor au avut loc din bărci, uneori cu mijloace avio, dar în a doua decadă al secolului nostru cu aplicarea metodelor de high-tech s-a constatat un salt calitativ, populațiile au fost apreciate la aprox. 17.000 perechi cuibăritoare. Considerăm că o importantă cauză a acestei creșteri o reprezintă schimbările hidrodinamice în jurul coloniei, care au generat noi spații de nidificare pentru perechile de pelicani care, în lipsă de locuri adecvate, nu au avut posibilități de cuibărit. Un motiv al creșterii poate să fie și transferarea aici a altor mici populații circumpontice. Dar, factorul principal care a făcut posibil monitorizarea completă și a zonelor inaccesibile pentru bărci, a fost utilizarea dronelor și localizarea păsărilor cu ajutorul GPS-ului. Creșterea neașteptată a efectivelor de pelicani solicită reconsiderarea politicilor de management a Rezervației Biosferei Delta Dunării și demonstrează necesitatea utilizării a high-tech în monitorizarea efectivelor de pelicani.

**Cuvinte cheie:** Romania, pelican comun, fluctuații populationale.

## INTRODUCTION

The Great White Pelican (*Pelecanus onocrotalus* Linnaeus 1758; hereafter referred to as GWP) is one of the most well-known out of the 362 listed bird species in the Danube Delta. Like pelicans in general, GWP is a popular and charismatic bird (BOWKER & DOWNS, 2008); it is also a heraldic charge and a symbol for the Danube Delta. At the same time GWPs play an extremely important ecological and end economical role because of the trophic pressure they exert on the fish population. Therefore, it is paradoxical that our knowledge of GWP population sizes and their trends still are so deficient.

Pelicans were considered common until the end of the 19th century and lived in millions in the lower Danube region from Călăraşi to the Black Sea. The drainage of wetlands led to the systematic destruction of their living habitats, and anthropic pressure increased because of their substantial consumption of fish. This leads to rapidly declining populations. As pelicans are particularly sensitive towards man-made disturbances and aggression, over the 20th century they retreated from the lower Danube region to the remotest areas of the actual Delta. (CĂTUNEANU, 1950, 1958; CRIVELLI et al., 1991; CIOCHIA, 2001; LINȚIA, 1955; ROSETTI-BĂLĂNESCU, 1957). In practice, this meant that by 1937 nesting GWPs and Dalmatian Pelicans (*Pelecanus crispus*) had disappeared completely from areas outside of the Danube estuaries (CĂTUNEANU, 1958) (Fig. 1).

But not even the vastness of the Danube Delta could provide adequate protection for the pelicans. The decline of the population is only partially explained by the fragmentation of the living environment, the construction of canals, the motorization of shipping, the burning of massive areas of reed and the poaching of birds and harvesting of eggs for various reasons (CĂTUNEANU, 1958, 1999; KISS, 1988). The main reason is "*a merciless campaign of eradication against fish-eating bird species, whether they are harmful or not. In the spring of 1949 Compesca initiated an unwarranted war against such birds, which between 1950 and 1955 was perpetuated together with agencies of the Ministry of Food Industries in close collaboration with local fishermen – with the purpose of destroying all birds suspected of eating fish. Thus, the nesting grounds of pelicans, grey herons, glossy ibises, egrets etc. were obliterated; eggs were destroyed by their tens of thousands, and chicks found in the nests were killed. In 1955 the Ministry of Food Industries planned the extermination of 75,000 fish-eating birds…"* (CĂTUNEANU, 1958).

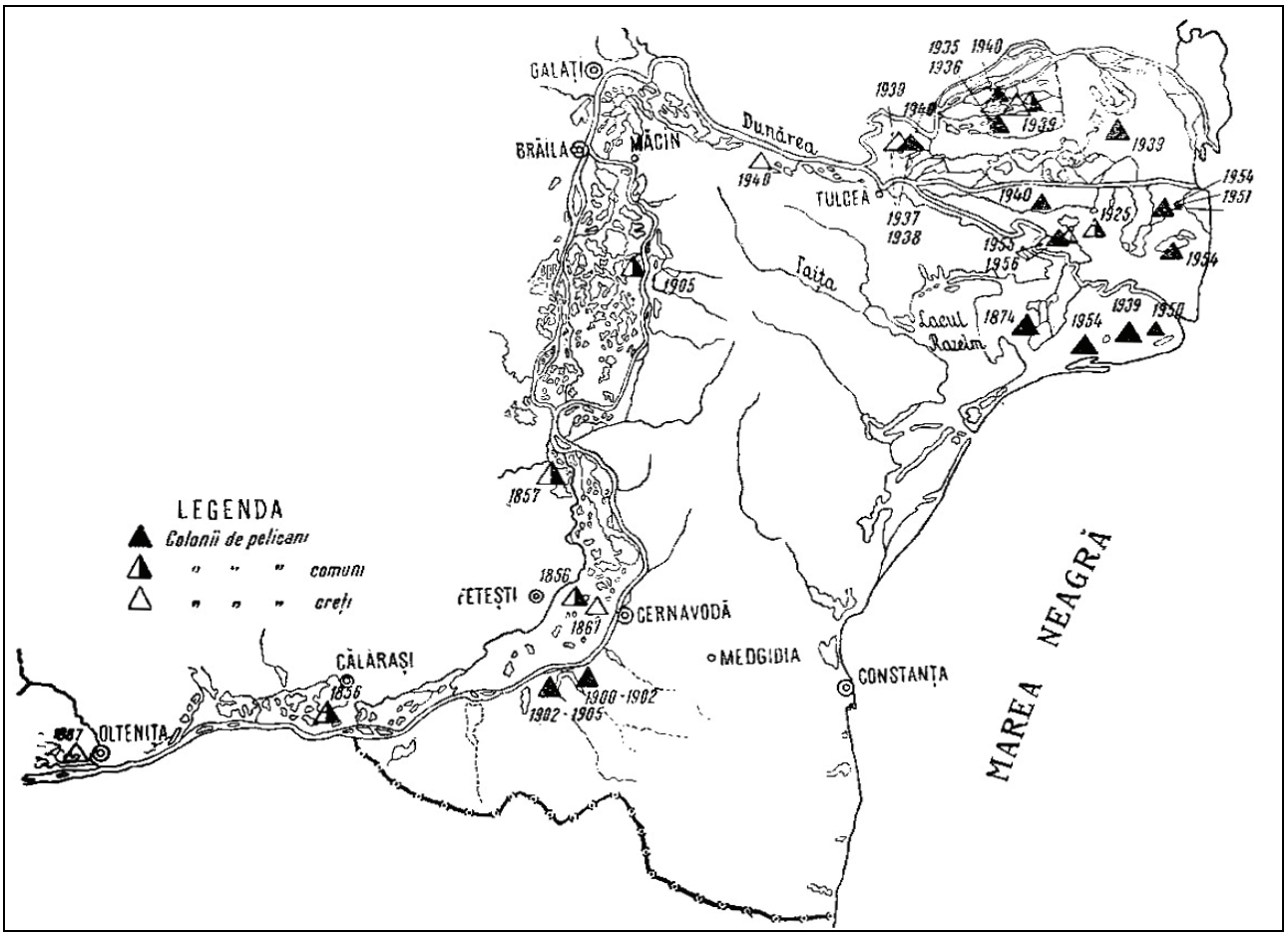


Figure 1. The retreat of pelican (*Pelecanus ssp.*) nesting areas between 1896-1954 in the Romanian lower Danube region (from CĂTUNEANU, 1958).

The population collapse of colonial water birds – among them the two species of pelican, whose numbers were reduced from around a million to a few hundred (DRAGOMIR & STARAȘ, 1992) – prompted the introduction of certain protective measures that materialized in the form of new legislation.

Thus, the Decision of the Council of Ministers 600/1933 declared GWPs and three other species protected, and Decision 645/1938 dictated the formation of a 14600 ha reserve in the Roşca – Buhaiova - Hrecişca lake-complex, which still serves as an annual nesting ground for pelicans. This was followed by Decision 961/1950, prohibiting the hunting of pelicans and destruction of their nests and eggs. Decision 458, coming into effect in April 1954 was of special importance, in that it declared the two species of pelican and certain other species as natural monuments, granting them the highest level of protection at the time (CĂTUNEANU, 1958, 1999; KISS, 1988). Following this, all official aggression against bird colonies was suspended (CĂTUNEANU, 1958; MUNTEANU, 1960; RUDESCU, 1955) which, however, did not preclude unlawful violations.

Following the political changes of the late 1980s and early 1990s the Danube Delta Biosphere Reserve was formed (***. 1993a; ***. 1994); Romania signed the international treaties on wetlands and bird protection (***. 1991; ***. 1993; ***. 1998); ratified the Agreement protecting the migratory birds of Africa and Eurasia - including the GWP (***. 2000); accepted the 79/409/CEE Birds Directive (***. 2006) and legislated the establishment a national network for the protected areas (***. 2001; ***. 2007a, b; ***. 2007c; ***. 2008). According to current wildlife-protective legislation, the killing of a GWP carries a penalty of 1350 € (***. 2018), corresponding to three months minimum wage in. However, the antagonism towards pelicans has not disappeared, it has just become more obscured. The illegal shooting and killing of pelicans near fish ponds and fishing equipment is ongoing (Fig. 2.), especially because no legislation exists regarding indemnities for damages to fisheries and piscicultures caused by fish-eating birds.

Figure 2. Great white pelican (*Pelecanus onocrotalus*), crucified adjacent to fishing equipment, Danube Delta, August 8, 2010 (Photo: Alexe Vasile).

The conflict between commercial and wildlife-protective interests is in dire need of a resolution. For example, the president of the Federated Fisheries of the Danube Delta has requested indemnities for 18,995 pelicans, which each eat 25 kg (!!!) of fish daily from the fisheries (SMOLII, 2017).

Despite all this, since 1933 (when the protection of pelicans was initiated), not a single official, institute-lead research project has been undertaken to evaluate pelican population trends, studies of migratory habits, or quantification of their impact on the fish stock. Population sizes were only inferred through indicators derived from collateral projects, through point-data collected in conjunction with banding (KISS, 1992; KISS & CONDAC, 1992), and through individual observations. While in later years several NGO studies have been conducted and findings have in part been reported (*** 2015; ***. 2016), a long-term project led by the institute and benefitting from international planning and participation is still needed.

The scope of the current paper is a meta-analysis of historical literature regarding GWP populations, an account of our own research and population estimates, and a presentation of the population trend. We also compare population estimates obtained through traditional methods with those acquired through the use of current technology, highlighting the need to adopt high tech monitoring systems.

**Research location**

In contrast to sub-Saharan GWP populations, which usually roost on skerries, and sometimes on mountain peaks (BROWN & URBAN, 1969), west-Palearctic GWPs typically nest in dense reed and sometimes on sand-islets. The colony assessed by us is situated in the north-eastern part of the Danube Delta Biosphere Reserve in the 9625 ha, rigorously protected Roşca-Buhaiova reserve. (Fig. 3)

The Delta itself was declared a UNESCO World Heritage Site in March 2000. Currently Roşca-Buhaiova holds the Delta's only GWP colony, the largest in Europe. The area itself is a system of lakes – two small and one large lakes, and a large number of lakelets – enclosed not by land but by extremely dense reeds. The tangled reed-rhizomes form a dense structure which, as a result from gases released by decomposition, rises to the surface in the summer. Thus, floating islands (locally called *plaur*) that move with the watercourses are formed. Trees are absent in favour of sparse thickets of grey willow (*Salix cinerea*). The area is intersected by several disused, silt-filled canals. The colony itself is situated on the lakes Buhaiova and Hrecisca, and the surrounding small lakelets (KISS, 2002; PLATTEUW et al., 2004). It is not approachable by canal, road or track; the closest settlement is at a distance of 11 km, and the closest building is a ranger hut located some 3.5 km from the colony. No other part of the Delta is as remote and isolated. The lake Mikiri Prespa in Greece, a nesting ground for Dalmatian Pelicans, is somewhat similar, but significantly smaller (CATSADORAKIS & CRIVELLI, 2001) (Fig. 4).

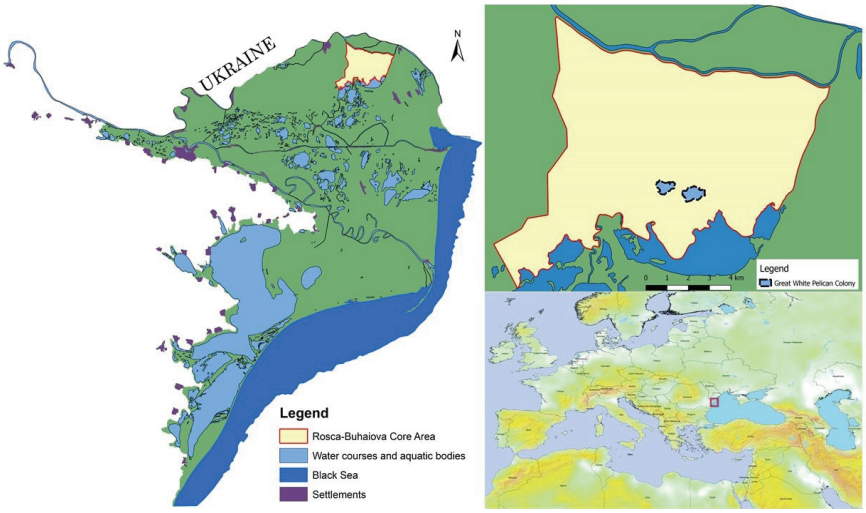


Figure 3. The lakes Buhaiova and Hrecisca in the rigorously protected Roșca-Buhaiova in the Danube Delta – Romania (Graphic: Doroșencu C. Alexandru).

Figure 4. Fragment of the largest nesting ground for Great White Pelicans (*Pelecanus onocrotalus*) in Europe in the rigorously protected Roșca-Buhaiova reserve located in the Danube Delta Biosphere Reserve - Romania (Photo: Kiss J. B.).

Nesting pelicans are extremely sensitive towards human-caused disturbances (CARNEY & SYDEMAN, 1999). Romanian literature also records multiple instances where pelicans have abandoned their colonies, especially if the disturbance occurred before the hatching of eggs (CĂTUNEANU, 1958; RADU, 1957; ***, own observations).

Pelicans are more tolerant towards syntopic natural enemies. For example, during a 1985 survey we observed a wild boar (*Sus scrofa*) in the vicinity of the pelican colony that each morning systematically killed and consumed two pelican chicks without significantly alarming the colony in general. We observe the presence of wild boar or fresh tracks on every control visit to Roșca-Buhaiova. Nonetheless, it is almost certain that only a few individuals actively hunt for pelicans. During nesting season, the colony is inaccessible to all other mammalian land predators. White-tailed eagles (*Haliaeetus albicilla*) are also frequently observed around the colony, and 2-3 pairs have a total of 7 nests at an average distance of 4.7 km from the colony (ALEXE et al., 2018). We have no direct indication of attacks against adult pelicans, but we have on several occasions observed white-tailed eagles feeding on young pelican cadavers. We could not establish whether these were predatory kills or the acts of scavenging.

Small, strictly isolated groups of Dalmatian Pelicans nest adjacent to the GWPs, but their colonies can also be found on rocky or sandy islets (KISS, 1976; KISS et al., 2016; MARINOV et al., 2016c). Cormorants (*Phalacrocorax carbo*) also nest here. GWP nests are simple depressions in the dry undergrowth, with very little deposited nesting material. Publications referring to oversize GWP nests (DOMBROWSKI, 1912; LINȚIA, 1955; CĂTUNEANU et al. 1978) have most likely confused them with those of syntopic Dalmatian Pelicans. The nests are usually found at the edges of floating reed islands, adjacent to, and in direct communication with the water. Gradually, this contact surface erodes away. The uric acid in the birds' faeces destroys the rhizomes – a process that is facilitated by the trampling of the 10-12 kg birds themselves. Waves also promote this erosion. Because of the eroding nesting grounds, large numbers of pelicans are forced to relocate from Lake Hreciska to Buhaiova or to other adjacent lakelets (or vice versa), and

return a few years later to nesting grounds that have since regenerated. We have observed such migrations on at least five occasions between 1969 and 2016 (KISS, 2002; CEICO, 2003).

Methods for numerical estimations of pelican colony sizes were set down in the 1990s (ZHATKANBAEV, 1994), but in the given circumstances these were only partially applicable. The difficulties of approaching the colonies, exacerbated by the need to disturb the birds as little as possible, probably meant that the colony was never appraised in its entirety. This is likely the chief objective reason for individual researchers publishing divergent population data, since each could only assess a limited and often disparate part of the vastly dispersed colony. Similarly, airplane-based photogrammetry methods can also introduce errors in counting. Things are further obscured by natural fluctuations in the number of nesting birds, and subjective errors introduced by the assessor. However, neither of these can fully explain the recent, extraordinary population increase detected using drones and other high-tech equipment.

## MATERIALS AND METHODS

To determine pelican population trends, we assessed the available relevant literature and supplemented it with our own findings. Little historical information of value survives regarding pelican populations; in most cases the sources refer solely to "pelicans" without elaborating whether GWPs or Dalmatian Pelicans are referenced. With few exceptions, reliable information is only available from ca. 1950 onwards. This study compiles population data spanning the last 70 years, without claiming completeness of the data. Regrettably, some of these sources are also variable, and it is sometimes difficult to establish the validity of original sources.

The data is complemented with estimations based on our own observations, conducted from dinghies using binoculars. Dinghies were operated using poles, and typically carried two observers and an oarsman. Colonies were approached to the limit of tolerance, around 120-150 m (the tolerated range being inversely proportional to the stage of nesting). This distance is based on our local experience; in literature, this critical range (100-600 m) has only been set down for brown pelicans (*Pelecanus occidentalis*; CARNEY & SYDEMAN, 1999). Considering the extremely dispersed nature of the colony our observations were typically centred on the one of the two lakes that currently harboured the majority of the population – plus surrounding lakelets. The sizes of more remote enclaves could only be estimated through counting of birds in flight. A break-through was caused by the advent of GPS and drone technology. The aircraft used in 2016 was a Dragon – a forward-swept delta wing, 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. Regarding the methodology used in compiling all the flight images of both lakes, several software packages were used in order to achieve the final result – a photomosaic of the entire area. The software used for this step was Global Mapper and the vectorization of each individual was done manually using the provided tools. To increase the accuracy of the vectorization process, the orthomosaic 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.

The photomosaic was used in the GIS software to manually evaluate the Great White Pelican breeding area through simple and basic procedures. A point layer in ArcGis was used to count the Great White Pelicans on nests. (MARINOV et al. 2016a, b). Using this technology, the entirety of the colony could be photographed without the need for overflights in an airplane, which carried the risk of collisions with pelicans (LESHEM, 2014).

## DISCUSSION

Two distinct GWP populations are known; one such population nests in Eastern Europe and Asia, the other in Central- and South-Saharan Africa (CRIVELLI & SCHREIBER, 1984). The African population is sedentary and dispersive; the Palearctic population migrates long distances. Approximately half of the western Palearctic population nests in the republics of the former Soviet Union, estimated at the turn of the century to comprise 3,120-6,550 nesting pairs (KRIVENKO et al., 1994). Other sources estimated the numbers to 3,070-4,300 nesting pairs (CRIVELLI et al., 1991). The total Palearctic population was estimated at 7,345-10,500 pairs (CRIVELLI, 1994; CRIVELLI et al., 2000; CRIVELLI et al., 1992; HAGEMEJER & BLAIR, 1997). Smaller, independent populations are known in Greece and Turkey (CRIVELLI et al., 2000).

During autumn the western palearctic population migrates, following the coastlines of Eastern Europe and Asia Minor, reaching Africa at the south-eastern part of the Mediterranean. Their African wintering grounds are not fully identified, but there is evidence that they reach the marshes of southern Sudan – including a confirmed report of a Romanian ring. (CĂTUNEANU, 1999). From here they follow the course of the Nile southwards, and later the lakes of Rift Valley all the way to Equatorial Africa (CATSADORAKIS, 2002; CHEGE, 2014; CRIVELLI et al., 1991a; CRIVELLI et al., 1992; IZHAKI et al., 2002; KISS, 2018; SHMUELI et al., 2014).

In Israel, GWP tagged with satellite transponders were recorded to cross Lake Nasser and Jebel Aula Dam on the White Nile and subsequently the Sudd marshland in southern Sudan, touching down by Lake Roseires on the Blue Nile and continuing through Ethiopia to Lake Rudolf (Turkana) in Kenya. In winter quarters the western Palearctic population uses the same habitats as the sedentary and dispersive African population (IZHAKI et al., 2002).

In the last few decades GWPs – especially younger individuals – have developed a behaviour where they do not migrate to their traditional wintering grounds in Africa. Instead they winter in the Balkans or the eastern parts of the Mediterranean, in Turkey (ONMUȘ, 2014) and especially in Israel, where they roam without following the established migratory routes (HATZOFE, 2014; IZHAKI, 1994; IZHAKI et al. 2002; LESHEM & YOM-TOV, 1996; SHMUELI et al. 2000 and 2000a, 2002, 2002a).

According to the population estimate in 2011-2012, the GWP population in south-eastern Europe and Turkey amounted to about 4,702-5,175 pairs (CATSADORAKIS, et al. 2015; CATSADORAKIS, 2016). From a nesting point of view the most significant GWP colony is the one in the Danube Delta (BEZZEL, 1985; BURFIELD & BOMMEL, 2004; GLUTZ & BAUER, 1987; CIOCHIA, 1992; CATSADORAKIS et al. in: CRAMP et al., 1998; CRIVELLI et al., 1991, 1997; CRIVELLI et al., 1992; DEL HOYO et al., 1997; GRIMETT & JONES, 1989; HAGEMEIJER & BLAIR, 1997; HEATH et al., 2000; HEATH & EVANS, 2000; KISS & CONDAC, 1992; ROSETTI-BĂLĂNESCU, 1957; SCHOGOLEV et al., 2005; TUCKER et al., 1994; ***. 1957, 2015); data in Table 1.

Table 1 details population estimates in the Romanian Danube Delta spanning the last 70 years, albeit at irregular intervals. Some assessments were based on aerial surveys or photography; these are marked by *. We have omitted data estimating counts of individuals and only included data on nesting pairs.

Despite fluctuations in the population (known since the mid-20$^{th}$ century (CĂTUNEANU, 1958), and irregular intervals between assessments, a trend of slow growth is observable, with a spectacular leap in 2016. Data from other countries indicate significantly larger GWP populations than can be reconciled with the numbers above. In the Bourgas bay in Bulgaria the approximate number of migratory individuals was 40,000 birds every year between 1979-2003, displaying a slowly growing trend (MICHEV et al., 2011). Likewise, by the sea of Marmara, following the Pontic migration route, the number of passing individuals grew from 40,000 to 50,000 within a few years (IANKOV, 2014). In Israel – a hub for key migratory routes – more GWPs have been tallied than the total estimate of the European and western-Asian population, reaching a record 70,000-80,000 individuals (CRIVELLI et al., 1991a; IZHAKI, 1994; LESHAM & YOM-TOV, 1996; SHMUELI, 2000, 2000a). In the 1990s the number of GWPs migrating through Israel was 37,000 (ALON et al., 2004), and more recently 40,000±9,000 (HADZOFE, 2014).

Table 1. Great White Pelican (*Pelecanus onocrotalus* L.) nesting pairs in the Danube Delta (Romania) between 1950-2016.

| Crt. nr . | Year | Number of pairs | Source or publication |
|---|---|---|---|
| 1 | 1950 | 300 | CĂTUNEANU, 1958* |
| 2 | 1955 | 600-650 | CĂTUNEANU, 1958 |
| 3 | 1956 | 2,000 | GLUTZ & BAUER, 1987; |
| 4 | 1957 | 1,500 | ROSETTI-BĂLĂNESCU, 1957 |
| 5 | 1961 | 4,800-5,400 | GLUTZ & BAUER, 1987 |
| 6 | 1961 | 4,000 | BEZZEL, 1985 |
| 7 | 1964/1965 | 1,000 | BEZZEL, 1985 |
| 8 | 1965 | 2,000-2,500 | CIOCHIA, 2001* |
| 9 | 1969 | 1,700 | BEZZEL, 1985 |
| 10 | 1971 | 1,200 | CATSADORAKIS et al in: CRAMP et al., 1998 |
| 11 | 1972 | 2, 000 | CIOCHIA, 2001* |
| 12 | 1980/1981 | 2,500 | BEZZEL, 1985 |
| 13 | 1989 | 2,500 | GRIMETT & JONES, 1989 |
| 14 | 1989-1993 | 3,000-3,500 | HEATH et al., 2000 |
| 15 | 1991 | 2,620 | CIOCHIA, 2001* |
| 16 | 1991 | 3.000-3.500 | CRIVELLI et al., 1991 |
| 17 | 1992 | 2,500-3,000 | KISS 1992; KISS & CONDAC, 1992 |
| 18 | 1992 | 2,000-2,500 | CIOCHIA, 1992 |
| 19 | 1992 | 3,000-3,500 | CRIVELLI et al., 1992 |
| 20 | 1994 | 3,000-3,500 | TUCKER et al., 1994 |
| 21 | 1994 | 3,000-3,500 | CRIVELLI, 1994 |
| 22 | 1996 | 1,100 | CRIVELLI et al., 1997 |
| 23 | 1996 | 1,800 | SCHOGOLEV et al., 2004 |
| 24 | 1997 | 2,000 ± 300 | SCHOGOLEV et al., 2004 |
| 25 | 1997 | 3,500 | HAGEMEIJER & BLAIR, 1997 |
| 26 | 1998 | 3,000 | HEATH & EVANS, 2000 |
| 27 | 1999 | 460 ± 30 | SCHOGOLEV et al., 2005 |
| 28 | 1980-1990 | 2,500-3,000 | CRIVELLI et al., 1997 |
| 29 | 1990-2002 | 3,500-4,000 | BURFIELD & BOMMEL, 2004 |
| 30 | 2000 | 3,000-3,500 | HEATH et al., 2000 |
| 31 | 2001 | 3,500 | PLATTEUW et al., 2002* |
| 32 | 2001 | 1,700 ± 150 | SCHOGOLEV et al., 2005 |
| 33 | 2002 | 3,590-4,160 | PLATTEUW et al., 2004* |
| 34 | 2002 | 2,900-3,000 | MUNTEANU (coord.), 2002 |
| 35 | 2001-2002 | 3,590−4,160 | CATSADORAKIS et al., 2015 |
| 36 | 2004 | 3,500 | MUNTEANU (coord.), 2004 |

| | | | |
|---|---|---|---|
| 37 | 2005 | 3,000-3,500 | MUNTEANU in: BOTNARIUC & TATOLE, 2005 |
| 38 | 2005 | 3,900 | Our data |
| 39 | 2008 | 3,560-4,160 | PAPP & FÂNTÂNĂ, 2008 |
| 40 | 2008 | 3,500 | Our data |
| 41 | 2009 | 3,600 | MUNTEANU, 2009 |
| 42 | 2009 | 4,100-4,480 | Data from the Romanian Ornithol. Society, 2009* |
| 43 | 2009 | 3,595 | Our data |
| 44 | 2010 | 1,900 | Our data |
| 45 | 2012 | 4,100−4,480 | CATSADORAKIS, 2016 |
| 46 | 2012 | 3,000−3,500 | CATSADORAKIS et al., 2015 |
| 47 | 2013 | 4,600 | Our data |
| 48 | 2,014 | 3,600-4,500 | KISS et al., 2014 |
| 49 | 2015 | 4,100-4,500 | *** Atlas specii comunitare, 2015 |
| 50 | 2016 | 17,000 | Our data* 2016, 2016a |

There are several possible explanations for the discrepancies between the numbers of observed migrating individuals and tallied nesting pairs. For example, other non-documented nesting grounds might exist, whose inhabitants only are counted when migrating through Israel. This phenomenon has been reported in the former Soviet Union (KRIVENKO et al., 1994). Discrepancies could also result from the general climate (DOXA et al., 2012; JIGUET et al., 2008). Satellite tracking has detected the springtime return northward in Europe of young, tagged specimens (IZHAKI et al., 2002). However, a young specimen tagged in Israel the previous winter was observed in Hungary in the summer of 2019 (*in lit*. Ohad Hadzofe).

The integration of immature African GWPs into returning West-Palearctic GWP flocks is still just an unproven hypothesis (KISS, 1992; KISS & CONDAC, 1992; MICHEV et al., 2018). A substantial project involving ringing and satellite tracking, plus genetic sequencing undertaken at the nesting and wintering sites, respectively, would be needed for confirmation. It is an established fact that the impact of individuals escaped from captivity is insignificant. (DOXA et al., 2012; JIGUET et al., 2008). It is of note that in the 90s rapid GWP population growth was reported from the Western Cape area in South Africa that could not be explained solely by successful breeding programs (CRAWFORD et al., 1995).

So far the number of GWPs, especially young specimens, who eschew the traditional migration routes to Africa in favour of roaming the eastern coasts of the Mediterranean – but who return to nest in south-eastern Europe remains unknown (CRIVELLI et al., 1991a; IZHAKI et al., 2002; LESHEM & YOM-TOV. 1996; SHMUELI et al. 2000, 2014). Even should GWPs worldwide experience a general, positive growth trend this cannot, on its own, adequately explain the rapid local population increase in the Danube Delta. However, a general, positive growth trend could be a direct result of a global effort towards protection of waterways, and of appropriate management measures – concretely, in the Danube Delta, the formation of the Danube Delta Biosphere Reserve, and the limitation of artificial disturbances.

Another possible reason for the abrupt increase is the relocation of other circumpontic GWP populations, escaping drainage of wetlands or other human interference. Such was the case for 500-1,500 GWP pairs from Turkey (ONMUȘ, 2014). Older data in the literature indicates a remarkably wide area of movement for adult GWPs during the mating season (GLUTZ & BAUER, 1987), also supported by satellite tracking data (KISS & NICHERSU, 2002).

We postulate that the determining factor for maintaining local (Danube Delta) GWP populations at the pre-2016 levels (Table 1.) were limited nesting grounds around Hrecisca-Buhaiova – the only area remaining in the Danube Delta suitable for GWP nesting. Though a description exists about how GWPs prepare their nesting grounds by landing on them (CĂTUNEANU et al., 1978), we have so far been unable to observe this behaviour. Nonetheless, we have through our own experiments been able to establish the importance of expanded nesting grounds. This was achieved by creating artificial nesting platforms, which were quickly occupied by arriving GWPs (KISS, 2002; CEICO, 2003). We here note that platforms made from locally available building material were previously also tried in the Volga Delta (SZPANDENBERG, 1958).

Our drone-based monitoring of GWP colonies at Hrecisca-Buhaiova commenced in 2014. Aerial and ground-based observations have shown an increased fragmentation of reed islands in later years, which has enabled the formation of a stretch of open water spanning 55,000 m² in the north-western part of Hrecisca. Surrounded by reed islets, this area is ideal as a GWP nesting ground. Increasingly regular storms and hurricane-strength winds further fragment reed islands. According to an estimate, 20-50% of local adult GWPs do not nest (SCHOGOLEV et al., 2005). Our working theory therefore postulates that mature GWPs who until now were unable to find suitable spots for nesting have now occupied the recently formed areas, supplementing a nesting colony that were estimated at approximately 17,000 nesting pairs in 2016. (Other sources also cite unusually large numbers of individual GWPs in the region, without reporting the number of nesting pairs (***. 2016; ALEXANDROU, et al. 2016).

Our current report improves the data on GWP population statistics and simultaneously proves the significance of adopting high tech for population studies, while inviting its use in in the study of other species.

We are convinced that increasingly accurate population estimates pertaining to fish-eating bird species (especially GWPs) will have a crucial impact on management processes advocated by the Danube Delta Biosphere

Reserve Authority. Such management is unambiguously important in the face of decreasing fish populations and an ever-growing tourist industry. This includes the management of fishing and fisheries, the issuing of permits for various economic enterprises within the protected area, the planning and management of tourist routes and of modes of transport, etc.

GWP population estimates will also play a key role in the determination of prospective indemnities for damages caused by protected species within the Biosphere Reservation. For all these reasons detailed studies of this ecologically and economically significant species remain a priority.

## CONCLUSIONS

- Although the local Great White Pelican population has fluctuated between 1950 and 2016, the general population trend has been positive, especially following the creation of the Danube Delta Biosphere Reserve.
- Previous population estimates were significantly limited by the shortcomings of available technical options: *in situ* observations and conventional aerial photogrammetry.
- The employment of high-tech methods such as drones, GPS, and data analysis programs brought unexpected results, indicating a population size three to four times larger than previously known.
- We theorize that the main reason for the progressive population growth and the expansion of the GWP colony are hydrographical changes that created new nesting grounds, thus providing nesting opportunities for individuals previously unable to find one.
- Other possible reasons include cross-migration of other circumpontic populations who have been disturbed in, or lost their home habitats; accelerated phenological changes; young specimens from African GWP-populations joining, west-Palearctic flocks in their northern migration, etc.
- Going forward, high tech methods for monitoring GWPs and other fish-eating species will be of key importance.

## ACKNOWLEDGEMENTS

The authors would like to thank Dr. Ohad Hatzofe (Israel Nature & Parks Authority), Dr. Giorgos Catsadorakis (Chairman of IUCN SSC Pelican Specialist Group) for supplementing relevant information, and Dr. N. B. Kiss for translation, proof-reading and his valuable comments.

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Received: April 15, 2019
Accepted: August 23, 2019