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THE INFLUENCE OF SPRING FLOOD WATER LEVELS ON THE DISTRIBUTION AND NUMBERS OF TERNS (ON THE EXAMPLE OF THE LOWER DESNA RIVER)

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Influence of Spring Flood's Water Level on the Distribution and Numbers of Terns (on Example of Lower Desna River). Atamas', N. S., Tomchenko, O. V. — The floodplain reservoirs of the lower Desna River are known to represent suitable breeding habitats for the Black Tern (*Chlidonias niger*) and the White-winged Tern (*Chlidonias leucoptera*), while the Common Tern (*Sterna hirundo*) and the Little Tern (*Sterna albifrons*) nest on sandy islands and river spits at the river bed. We combined analysis of Landsat 8 satellite images and the breeding abundance of the lower Desna River resident terns to investigate if the levels of the floodplain inundation affect the terns' distribution and numbers. Under the high flood conditions of 2013, we observed a significant decrease in the numbers of colonies and nesting pairs of the Common and Little Terns, which was probably caused by the delayed exposure of their breeding habitats at the river bed. In contrast, in the low water conditions of 2014, areas of sandy islands and river spits increase in the form of temporary sandbanks. Under low-water conditions, we observed a marked increase of the number of colonies and nesting pairs of the Little Tern, while the White-winged Tern disappeared from nesting sites and the Black Tern decreased in numbers.

Key words: *Chlidonias niger*, *Chlidonias leucoptera*, *Sterna hirundo*, *Sterna albifrons*, nesting, spring flooding, numbers, Lower Desna River.

Влияние степени затопления поймы на распределение и численность крачек на примере нижней Десны. Атамась Н. С., Томченко О. В. — Пойменные водоемы нижней Десны образуют подходящие гнездовые стации для черной (*Chlidonias niger*) и белокрылой крачки (*Chlidonias leucoptera*), а в русловой части на песчаных островах и косах гнездятся речная (*Sterna hirundo*) и малая крачки (*Sterna albifrons*). С помощью анализа спутниковых снимков Landsat 8 установлена степень затопления поймы в условиях крайне высокого и крайне низкого половодья в 2013 и 2014 гг. В условиях высокого половодья значительно снижается количество колоний и гнездовых пар речной и малой крачек в связи с поздним обнажением из-под воды гнездовых биотопов в русловой части реки. В условиях низкого половодья площади песчаных островов и кос значительно возрастают за счет превращения многих отмелей во временные песчаные острова. Это приводит к росту численности колоний и гнездовых пар малой крачки. Черная крачка в условиях раннего схода воды и сухой поймы резко снижает свою численность, белокрылая крачка исчезает с гнездования.

Ключевые слова: *Chlidonias niger*, *Chlidonias leucoptera*, *Sterna hirundo*, *Sterna albifrons*, гнездование, весеннее половодье, численность, нижняя Десна.

Introduction

In the course of the 20th century, most Ukrainian large rivers became regulated and meliorated by hydraulic engineering, channel straightening, and construction of fishing ponds in order to meet agricultural or power needs (Nature…, 1987). All these processes influenced the hydrological characteristics of reservoirs and consequently the plant and animal life of floodplain and riverbed ecosystems. For this reason, the least altered or intact aquatic landscapes are particularly interesting. One of such examples is the Desna River, a large

tributary of the Dnipro and one of the last hydrologically relatively undisturbed lowland rivers. The Desna River valley is minimally plowed and mostly consists of various flooded meadows. Due to the unaltered natural state of Desna's floodplain, it harbors high biodiversity. Spring floods are typically high and cover most of the Desna river valley, followed by usually low water in summer (Desna…, 2010). Regular seasonal fluctuations of the water level have a significant impact on the resident animal life, particularly the populations of wetland birds.

Therefore, the Desna's unique situation (compared with other large Ukrainian rivers) allows studying the distribution, numbers and phenology of birds that inhabit the river valley in the context of natural annual changes in water levels during the spring flood and low water. The impact of flooding on aquatic landscapes' overall biodiversity and wetlands birds in particular has been addressed in a number of studies, but mostly they concentrated on processes induced by human activities in artificial or vastly transformed ecosystems (Bijlsma et al., 2010). The Desna's floodplain complex of habitats includes the feeding and breeding biotopes of many wetland birds, but it is especially intriguing to understand how natural hydrological regimes shape the colonies, their distribution and fluctuations in numbers of the Sterna terns, such as *Sterna hirundo* (L., 1758), *Sterna albifrons* (Pallas, 1764), and the marsh terns, such as *Chlidonias niger* (L., 1758) and *Chlidonias leucopter* (Temminck, 1815). *Sterna albifrons* is an endangered species protected by the Red Data Book of Ukraine (Red Data…, 2009). *Chlidonias leucoptera* and *Chlidonias niger* are species with rapidly decreasing numbers in Europe for the reasons including degradation of their habitat — the natural floodplain ecosystems (European…, 2000; Hötker et al., 2005; Meier-Peithmann, 2005; van der Winden et al., 2004). The aim of our research was to assess the influence of the natural flooding regime on the breeding groups of these species on a model area on the Lower Desna River.

Material and methods

The largest part of the Desna's floodplain area studied was the 211 km stretch between Chernihiv and Kyiv, where fieldwork was performed on June 20–27, 2013 and July 7–13, 2014. Previously, on July 3–7, 2012, fieldwork was performed on the Lower Desna's floodplain between Krekhayev village (Kyiv Region) and Kyiv. All colonies of wetland bird species on the floodplain and river bed of the Desna were counted and mapped. Total counts of clutches and/or nestlings were performed and their breeding habitats were recorded. To assess the spatial distribution of water during flooding in the spring and summer of 2013 and 2014, we used Landsat 8 satellite images taken by the OLI (Operational Land Imager) sensor in two shooting modes, VNIR (Visible and Near Infrared) and SWIR (Short wave Infrared) with the resolution of 30 m. Images taken on May 18, 2013, July 05, 2013, June 06, 2014, and July 08, 2014 were most suitable for analysis. Also, these images were best matched chronologically with our colony count field trips on the river. Images taken in May and June were used to estimate the water surface area during the spring flood (fig. 1). Images taken in July allowed us to assess the dynamics of sandy bars, spits and islands at the Desna's river bed. Thresholding satellite images for isolation of water surface area was done using normalized water index (NWI), calculated as normalized ratio of green to mean infrared channels (Gao, 1996). To calibrate for sand identification, the Landsat 8 red channel of 0.630–0.680 μm was used.

Results

The nesting biotopes of terns. The Desna River is snow-fed, thus the flood depends on the preceding snow levels. During the spring inundation, high water covers the floodplain for a long time, filling numerous small reservoirs. These habitats are preferred by the marsh terns *Chlidonias niger* and *Chlidonias leucoptera* for nesting on the Desna River.

The main breeding habitats of *Chlidonias niger* are larger and deep (natural lakes, oxbow lakes and lagoons). After the flood, these reservoirs become overgrown with floating-leaved plant communities dominated by *Nuphar lutea*, *Sagittaria sagittifolia* and *Potamogeton* sp. or by emergent vegetation. Such reservoirs usually are 1–1.5 m in depth (or deeper) and the deepest of them do not dry completely even during the most arid summers.

The breeding habitats of *Chlidonias leucoptera* are shallow pools, 0.3–1 m in depth, ephemeral and subject to complete drying. They quickly become overgrown with wetland or meadow-marsh plant species (*Stratiotes aloides, Butomus umbellatus, Polygonum amphibium, Alisma plantago-aquatica, Rumex hydrolapathum* and *Oenanthe aquatica*). The area and existence of *Chlidonias leucoptera* breeding habitats directly depend on the spring flood water levels (namely the duration of inundations and the amount of water on floodplains). Thus, *Chlidonias leucoptera* almost never colonize valleys of rivers with disturbed flood system. Because of that, Desna's floodplain is among the most significant areas where its colonies can exist.

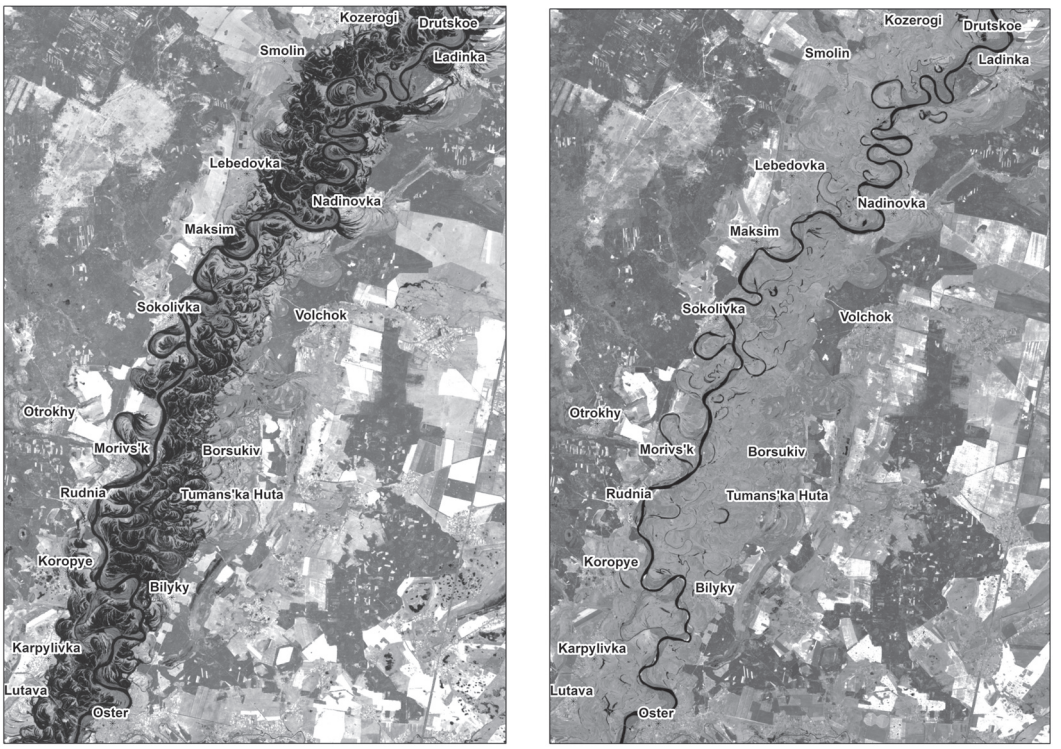

Fig. 1. The dynamics of spring flood according to Landsat 8 satellite images (*A* — a fragment of Landsat 8 SI as of May 18, 2013; *B* — a fragment of Landsat 8 SI as of June 6, 2014).

On the Desna's floodplain, these marsh terns sometimes may form mixed-species colonies on small, shallow natural lakes. These colonies are especially numerous on the Middle Desna River, for example in Mezynsky National Nature Park.

Main biotopes of *Sterna* on inland reservoirs are sandy and rocky beaches, reclaimed islands and spits, and artificial hydrological structures. The Desna's river bed retains its natural profile. There are many meanders, especially in the lower parts of the river, and diverse sandy bars and reclaimed spits become the main breeding habitats for *Sterna hirundo* and *Sterna albifrons*.

The water levels and intensity of the flood affect the advance of mean water and thus the ensuing emergence of these habitats. Consequently, they become suitable for nesting at different times during the breeding season, influencing the number and localization of colonies and numbers of breeding birds.

Therefore, the characteristics of *Chlidonias* breeding habitats on the Desna's floodplain, as well as the dependence of those habitats on water levels during the spring flood, determine the numbers and distribution of the species' colonies in the years of high or low water floods.

The numbers of colonies and birds in the years with floods of high and low water. In 2013, the spring flood on Desna was especially severe. In mid-May 2013, almost 40 % of the Lower Desna's floodplain total area between Chernigiv and Kyiv were flooded (table 1). Water receded only in mid-June. According to satellite images taken on June 19, the floodplain was devoid of water, except for many natural lakes and small pools.

In the third decade of June, 2013, in 12 of 13 observed colonies marsh terns had begun to lay eggs.

Table 1. Water levels at the Lower Desna River between Chernihiv and Kyiv at different times of the annual water level cycle, according to Landsat 8 satellite images

Areas of floodplain	2013		2014	
	18.05	05.07	06.06	08.07
Area of sandy spits, km²	0	1.23	1.52	2.0
Floodplain area under water, km²	302.37	0	63.7	0
Total floodplain area, km²	798.57			

The 2014 year was extremely arid with a remarkably low spring flood. The SIs revealed that at the beginning of June, 2014, no more than 8 % of the total floodplain area was under water (table 1). Many small reservoirs and natural lakes had not filled. This adversely affected the numbers and localization of colonies of both the unstably nesting *Chlidonias leucoptera* and the more conservative *Chlidonias niger* (fig. 2).

In 2014, *Chlidonias leucoptera* colonies disappeared altogether. One of the three detected colonies of *Chlidonias niger* was located at the Desna's river bed (fig. 3), which is not typical of this species in river ecosystems.

Nest groups of *Sterna* on the Desna River are tightly associated with both large stable reclaimed sandy islands and smaller unstable spits and beaches exposed if the water level is sufficient during mean water.

Data from SI revealed that in 2013, due to high flood, sandy spits started to be exposed in the second half of June. For example, on June 19 the floodplain was completely dry and the water only remained in the river bed. By that time, *Sterna* terns had started their colonies in the area and the earliest eggs were found in their clutches.

In the arid 2014 with low flood, significant areas of reclaimed sandy spits and islands were exposed as early as at the beginning of June and were almost twice the areas of 2013 (table 1). Also, the numbers of *Sterna albifrons* increased significantly (fig. 2).

Low water and increase in sandy areas affected the distribution of *Sterna albifrons* and *Sterna hirundo* as well (fig. 3). Thus, the early recession of the water level in 2014 on the Lower Desna lead to the emergence of numerous small sandy islands that otherwise in higher mean water would have been shallows (as in 2012 and 2013). Aside from the regular colonies on repeatedly populated (according to surveys in 2012–2014) large sandy islands and spits (near Oster town, Zhukiv village and the confluence of the Lubytch branch with the Desna River), there were numerous other small and supposedly unstable colonies in 2014.

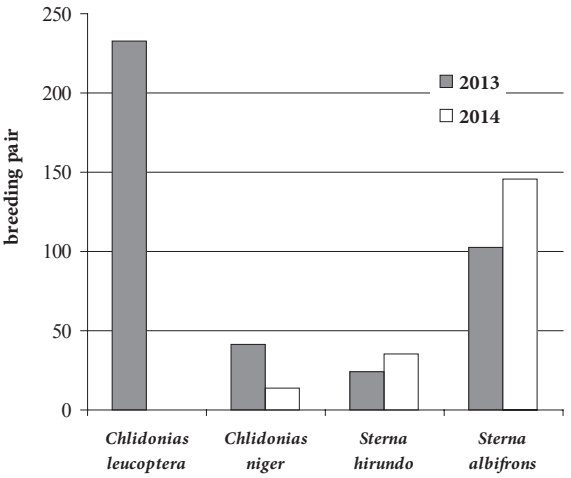

Fig. 2. The numbers of tern colonies on the Lower Desna in the years of high water (2013) and low water (2014) during the spring flood.

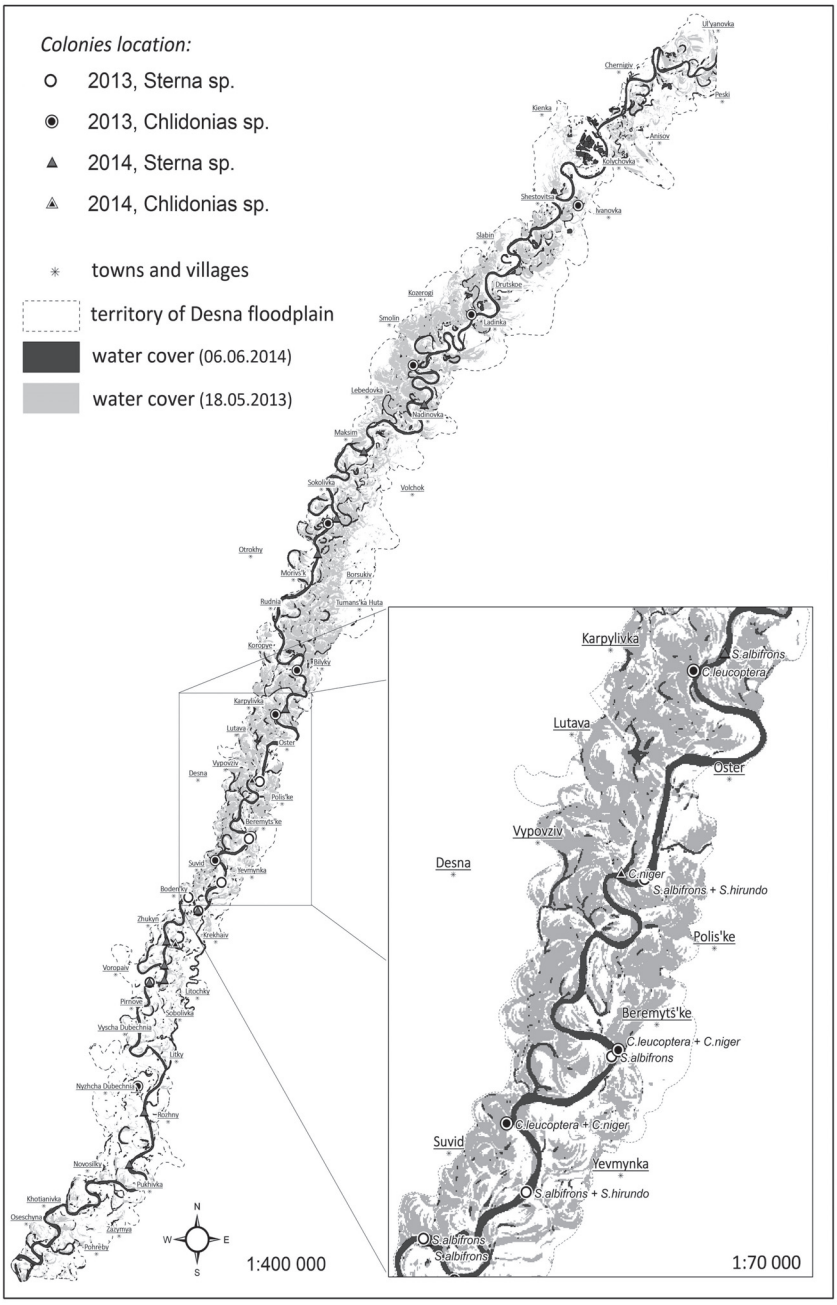

Fig. 3. Distribution of tern colonies on the Lower Desna in 2013–2014.

Discussion

Chlidonias and *Sterna* terns have significant differences regarding their ecology. *Sterna* terns breed not only in riverine inland ecosystems, but also at seashores. The marsh terns are strictly bound to inland reservoirs including rivers, eutrophic inlets and chains of reservoirs in river deltas, natural and artificial marshy ponds etc. (Birds…, 1988). They also differ in diet. *Sterna* terns are fish-eaters, the marsh terns are mostly insectivores (Borodulina, 1960). This discrepancy means that *Sterna* terns are capable of long-distance foraging

flights (especially in cases of sea ecosystems with irregularly occurring prey), while *Chlidonias* terns do not forage farther than 1–2 km from their colonies (Cabot, Nisbet, 2013).

The transformation of natural feeding and breeding habitats in river ecosystems in Ukraine and Europe, caused by both seasonal factors and human activity, strongly influences the numbers and distribution of *Chlidonias* terns' colonies (Beintema et al., 2010; Dzyubenko, 2005).

Analysis of the numbers of breeding pairs of *Sterna* and *Chlidonias* terns on the Lower Desna reveals an upward trend in the numbers of breeding marsh terns, and an opposite tendency for *Sterna* terns in the years of high continuous floods ($\chi^2 = 234.7$ df = 1 $p < 0.0001$; $\chi^2 = 9.5$ df = 1 $p < 0.01$) (fig. 4).

The marsh terns have much stricter preferences for the nesting substrate and breeding habitats. Thus, one of the key problems of protecting *Chlidonias niger* nesting groups in several European countries is supposed to be the reduced variation of breeding habitat due to agricultural and hydrological developments (Beintema et al., 2010). Another problem is instability of breeding habitats, e. g. changes in the floating-leaved plant communities or in aspects of their vegetation caused by a variety of factors. For example, the dense floating mats of *Stratiotes aloides* are among the most significant nesting substrates in artificial and natural reservoirs in Europe and Western Ukraine. The loss of such aquatic vegetation due to human activity has often been considered a major factor contributing to the decline marsh tern populations (Dzyubenko, 2005; van der Winden, 2005). However, in the conditions of Dnipro reservoirs, *Chlidonias niger* establish stable colonies on other plant substrates. The colonies rarely relocate and the numbers of breeding pairs steadily increase (Atamas', 2011).

In contrast, *Chlidonias leucoptera* do not tend to breed on carp ponds or other artificial reservoirs (Birds…, 1988). The species' preferences are defined by a reservoir's capacity more than by aquatic vegetation (Kapocsy, 1979). Low flood and hot summer promote rapid disappearance of the necessary biotopes (as it was in 2014) and the tern's numbers drop to zero. Thus, natural hydrological regime and seasonal fluctuations of water levels during spring inundation are among the major factor limiting the increase of nesting groups of marsh terns in natural marginally transformed landscapes.

In the conditions of high and low flood, the numbers of *Sterna albifrons* varied more than the numbers of ecologically similar *Sterna hirundo*. The latter usually breed on river

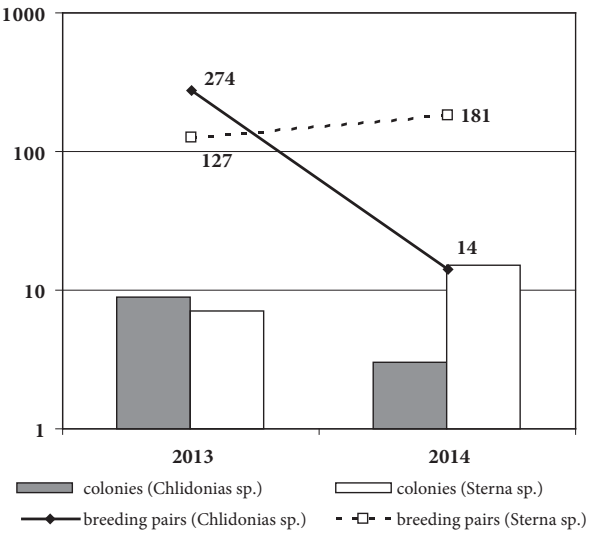

Fig. 4. Changes in numbers of breeding pairs and colonies of *Chlidonias* and *Sterna* terns on the Lower Desna in 2013–2014.

landscapes of the Lower Desna in mixed-species colonies as a satellite species, while *Sterna albifrons* is able to form monospecific colonies in those habitats. The most unstable colonies of *Sterna albifrons* in 2014 on exposed shallows were monospecific. Thus, the numbers of *Sterna albifrons* on the Lower Desna River fluctuate more than the numbers of *Sterna hirundo*, in accordance with water level during inundation and the area of sandy breeding habitats. This confirms the findings by V. T. Afanas'yev et al. (1992) for the entire Desna River.

In general, the distribution of colonies and numbers of *Sterna* terns in natural riverine ecosystems appear to be more stable than those of marsh terns due to the relative stability of their breeding habitats. But in cases of anthropogenic transformation of aquatic ecosystems, e. g. Dnipro reservoirs, *Sterna* terns prefer the man-made structures to flood-affected sandy spits. Thus, the numbers of *Sterna albifrons* on reservoirs may fluctuate somewhat from year to year but the numbers and distribution of their colonies remain steady, constrained by the availability of breeding biotopes. But if the flood is low, the numbers of birds and their colonies in natural floodplains may significantly increase owing to new breeding habitats (fig. 3).

Thus, the fluctuations of water levels during the spring flood have drastically different results for *Sterna* and *Chlidonias* terns. High flood is likely to be the most important factor limiting the nesting of *Chlidonias leucoptera* and increase in breeding pairs of *Chlidonias niger*. Low flood causes decreased numbers and distribution of *Chlidonias* terns and may lead to discontinued nesting of *Chlidonias leucoptera*. At the same time, the numbers of *Sterna* sp. increase in stable colonies on early exposed breeding biotopes, and new colonies arise on islands originating from former shallows.

The Lower Desna's floodplain remains one of the most important refuges for *Chlidonias leucoptera* breeding that heavily depends on natural shallow reservoirs (ponds). At the same time this territory is of great importance for the conservation of *Sterna albifrons* breeding group on Dnipro. Desna's role in sustaining the *Chlidonias niger* population of the Middle Dnipro basin directly depends on spring flood levels and the area of submerged floodplain, but this question needs further research and more data.

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References

Afanas'yev, V. T., Gavris', G. G., Klestov. N. L. 1992. Avifauna of Desna floodplain and its conservation. Kyiv, 1–57 (Preprint NAS of Ukraine, Schmalhausen Institute of Zoology; 92.7) [In Russian].

Atamas' N. S. 2011. Changes in community structure of *Chlidonias* terns in connection with macrophyte communities transformation on water reservoirs of Middle Dnieper river. *Birds ecology: species, communities, interrelations* (Proceeding of the meeting commemorating the 150th anniversary of the birth of Nikolay N. Somov (1861–1923), 1–4 Desember 2011, Kharkov, Ukraine), Kharkov, 1, part 1, 301–315 [In Russian].

Beintema, A. J., van der Winden, J., Baarspul, T. at al. 2010. Black Tern Chlidonias niger and their dietary problems in Dutch wetlands. *Ardea*, **98** (3), 365–372.

Bijlsma, R. G., Platteeuw, M., van Eerden, M. R. 2010. Wetlands and birds: expected and unexpected changes in the birdscape. *Ardea*, **98** (3), 259–263.

Birds of USSR. Laridae. 1988. Ilyichev, V. D., Zubakin,V. A., eds. Nauka, Moscow, 157–169 [In Russian].

Borodulina, T. L. 1960. The biology and importance of Larid birds in southern waters of USSR. *Trudy Instituta Morphologii Zhivotnych im. A. N. Severtzova*, **32**, 3–98 [In Russian].

Cabot, D., Nisbet, I. 2013. *Terns*. Collins, UK,1–235.

Desna river ecological corridor. 2010. Kostyushin, V., Prekhrasna, E., eds. Kyiv, 67–70 [In Ukrainian].

Dzyubenko, N. V. 2005. Peculiarities of the temporal structure of Tern settlement in the Upper Dniester basin. *Proc. of the State Nat. Hist. Museum (Lviv)*, **21**, 65–76 [In Ukrainian].

European bird population: estimates and trends. 2000. Cambridge, UK (BirdLife Conservation. Ser. No. 10), 1–160.

Gao, B. 1996. NDWI — a normalized difference water index for remote sensing of vegetation liquid water from space. *Remote Sensing of Environment*, **58**, 257–266.

Hötker, H., van der Winden, J. 2005. Bestand, Verbreitung und Schutz der Trauerseeschwalbe *Chlidonias niger* in Deutschland 1990–2003 mit Vergleichen zu den Niederlanden. *Vogelwelt*, **126**, 179–186.
Kapocsy, G. 1979. *Weißbart- und weißflügelseeschwalbe*. A. Ziemsen Verlag, Lutherstadt Wittenberg, 36–37.
Meier-Peithmann, W. 2005. Die Trauerseeschwalbe *Chlidonias niger* in der Elbaue des Hannoverschen wendlandes. *Vogelwelt*, **126**, 219–225.
Nature of USSR. 1987. The seas and inland water reservoirs. Romanenko, V. D., ed. Kyiv, 137–140 [In Russian].
Red Data Book of Ukraine. Animals. 2009. Akimov, I. A., ed. Kyiv, 1–578 [In Ukrainian].
van der Winden, J. 2005. Black Tern *Chlidonias niger* conservation in the Netherlands — a review. *Vogelwelt*, **126**, 187–193.
van der Winden, J., Beintema, A. J., Heemskerk, L. 2004. Habitat-related Black Tern *Chlidonias niger* breeding success in the Netherlands. *Ardea*, **92** (1), 53–62.

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