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The impact of hydrotechnical facilities on island avifauna: a case study of the middle Vistula River

Key words: middle Vistula River, riverine birds, river conservation, effects of hydrotechnical facilities, islands and shoals

Summary

The study was conducted in the years 1994-2006 at the middle of the Vistula River between Wróble and Kochów (416th – 418th km of the waterway). The presence of islands and steep banks makes it a key place for nesting avifauna, including a number of endangered species. The aim of this paper is to present the impact of hydrotechnical facilities (a diversion weir) on habitat changes, and consequently on the abundance and distribution of birds that inhabit this part of the river.

A cross-divider in the riverbed (weir) connecting the bank of the river with one of the islands increased the flow rate and pushed the current to the middle of the river, directing it towards the islands. The result of these changes was a sudden erosion of the sandy, high slope at the top of the island II, a partition of this island into two parts and

a slow erosion of the island located near the left bank (island IV, Fig. 1B). Lack of fixed, steady flow along the right bank resulted also in a considerably faster succession of vegetation on the island I and slow shallowing of the channel between the island and the bank. As a result, the area of sandy habitats, most valuable to nesting birds, decreased disproportionately faster than the area of the whole islands (Table 1). In the years 2001-2002 , when the island I was completely united with the right bank and the islands 0 and I were connected to each other, a width of the riverbed at this point decreased from 870 m to 710 m, i.e. by more than 20 % (Fig. 1).

The greatest effect was observed on the island I and III. The first of these islands started losing its isolation from the riverbank, and then it was completely transformed into the mainland. The second was quickly eroded by the current directed towards the center of the river, losing the most valuable habitat for nesting birds: steep slopes and sandy beaches (Fig. 1). Two years after the foundation of the weir, twice as few breeding species were recorded on these islands-, and after four years the number of breeding species was five times lower. Densities of nesting birds also drastically decreased (Table 2). On the other two islands of this complex (island II and IV), in addition to similarly drastic decline in nest density, a decrease in the number of breeding species by about one half was observed: from 21-26 to 10 -12 on the island II and from 10-15 to 5-7 on the island IV (Table 2).

Destructive changes that took place in the riverbed resulted in the devaluation of the importance of this place for birdlife. In the first half of 1990, more than 80% of black-headed gull pairs, about 40% of little tern pairs and not less than 20% of common gull, and ringed plover pairs of all breeding pairs of the Vistula River between Dęblin and Kozienice (km 393-426) nested within 417 and 418 kilometers of the river. In 1999, the same islands were the breeding ground for no more than 10% of bird species colonizing the riverbed between Dęblin and Kozienice (Table 3).

This example shows how sensitive to anthropogenic changes the habitats of river valleys are. The local hydrotechnical construction caused loss or destruction of breeding habitats important to birds within two kilometers of the riverbed. Protecting banks against flooding is necessary. However, having in mind the unique natural value of Vistula River, one should carefully choose the method of achieving objectives. There might be several solutions, other than weir construction, to protect riverbanks, including those, which influence animals disproportionately less than presented in the paper.

1. Introduction

Economic development over the past two centuries dramatically changed the function, and thus the appearance of rivers valleys in Europe. Transforming rivers from nature refuges into transport routes changed wide valleys, with meandering riverbeds and numerous islands and floodplain forests on the banks to systems of narrow waterways typical for most major European rivers (review in Czaya 1987, Jankowski and Świerkosz 1995). As a result, many species of animals that require unstable river habitats for living have disappeared forever. Particular exceptions among European rivers are Bug and Vistula, which still maintain their natural character in many locations (Gacka-Grzesikiewicz 1995, Dombrowski et al. 2002).

At its middle course, the Vistula River is a semi-natural braided river with a wide, meandering riverbed, numerous branches, islands and shoals in the stream and steep banks and a wide floodplain terrace. Most of the valley area is protected under the Natura 2000 as a bird refuge of international importance, locally also under reserve protection (Chylarecki and Sawicki 2003, Sidło et al. 2004, Wilk et al. 2010). Protection of this area, as well as active measures to protect selected species or assemblies of plants and animals (e.g. Nowicki and Sitnicki 2007, Bukaciński and Bukacińska 2008, Centrum Koordynacji Projektów Środowiskowych 2010) result from the exceptional importance of

the Middle Vistula Valley for the preservation of a unique nature of large valleys of natural lowland rivers. This unique value is associated primarily with two habitats: mature riparian forest (elm-ash-alder) and the riverbed with steep banks and islands (Tomiałojć and Dyrcz 1993, Gacka-Grzesikiewicz 1995). Breeding densities and species diversity of bird assemblages in mature riparian forests are among the highest of the forest environments in Europe (Imboden 1987, Wesołowski 1987). Nest densities of gulls, terns and plovers observed on the islands of the Vistula exceed sometimes even100-times that recorded at other large lowland rivers of Europe (Festics and Leisler 1970, Brugière et al. 1980, Bögli and Barbieri 1982, Wesołowski et al. 1984, Bukaciński et al. 1994, Kot et al. 2009). Middle Vistula River is also a key breeding site for a number of rare and endangered species. The riverbed of the middle Vistula is occupied by more than 80% of the national population of common gull (*Larus canus*), more than 70% of the population of little tern (*Sternula albifrons*) and depending on the year, 35-50% of the population of ringed plover (*Charadrius hiaticula*), oystercatcher (*Haematopus ostralegus*), Mediterranean gull (*Larus melanocephalus*) and common tern (*Sterna hirundo*) (Chylarecki et al. 1995, Bukaciński and Bukacińska 2008, Wilk et al. 2010). All of these species are included in the Polish Red Book of Animals (Głowaciński 2001), or in the annexes to the legislative acts and international agreements regulating the principles of conservation of wild bird populations in Europe (e.g. the Birds Directive, the Bonn Convention, the Bern Convention; Gromadzki 2004). Bearing in mind that birds are just one of many reasons for treating the Vistula River exceptionally (for review see e.g. Gacka-Grzesikiewicz 1995, Matyjasiak and Romanowski 2011) naturalists for many years have warned against the consequences of the implementation of complex hydrotechnical projects (e.g. Chylarecki et al 1994, Keller and Bukaciński 2000, Wawręty and Żelaziński 2007).

The aim of this work is to demonstrate by a particular example the vulnerability of a river to local hydrotechnical construction within a riverbed.

2. Study area and methods

The paper describes changes between 1994 and 2006 in (1) the appearance of islands in the Vistula riverbed between Wróble and Kochów (416th-418th km of waterway) and (2) numbers and distribution of the core riverbed avifauna nesting there.

The basis for determining the size, habitat structure and distribution of islands in the riverbed (Fig. 1, Table 1) were orthophotomaps and aerial photographs from resources of Główny Urząd Geodezji i Kartografii (the Central Office of Geodesy and Cartography), supplemented by measurements and descriptions of each island made by the authors every year (Buczyński et al. 2000, Buczyński, Bukaciński and Bukacińska, unpublished).

Table 1. Changes in the area and the contribution of different habitats on selected Vistula River islands in 1997, 1999 and 2006 (after Buczyński et al. 2000, modified and supplemented); islands I, II, III as in Fig. 1; X – since 2002 lack of an island (connected with the bank, see Fig.1)

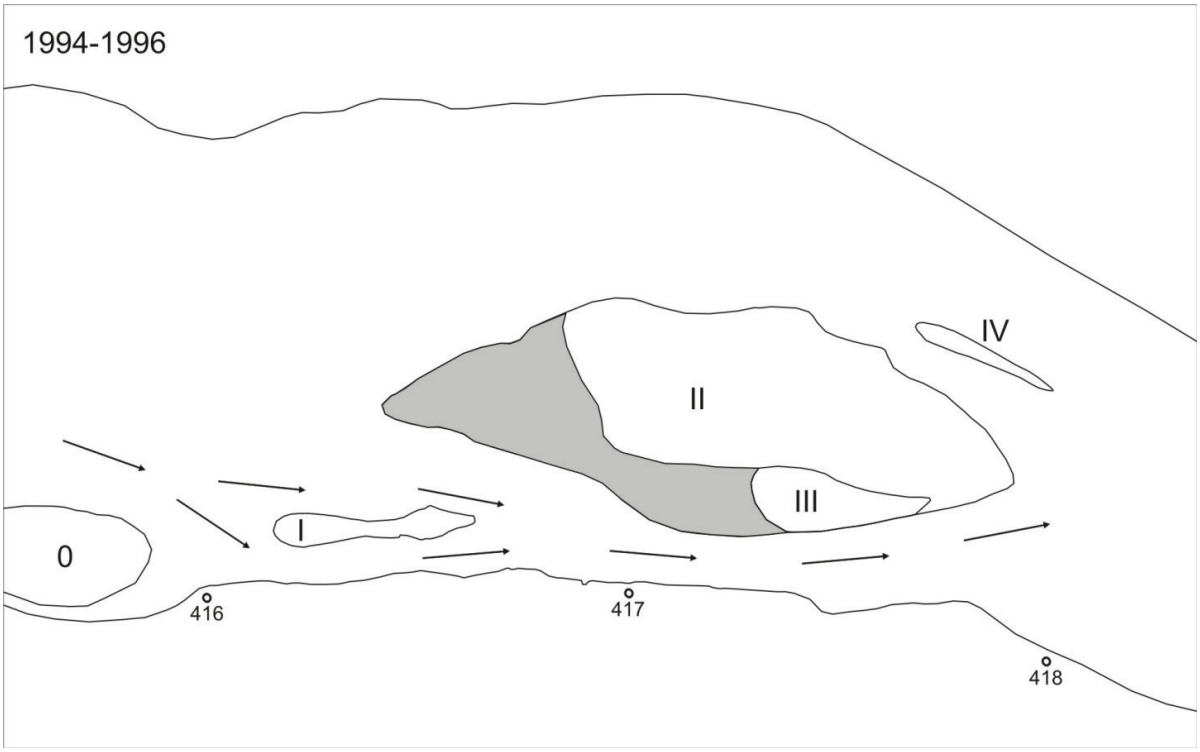
Islands	Area of the island (ha)			Contribution of different habitat (%)								
				Trees and shrubs			Herbaceous vegetation			Sand		
	1997	1999	2006	1997	1999	2006	1997	1999	2006	1997	1999	2006
The island at 411th-412th km	11.6	12,7	15,9	2	2	1	24	26	21	74	72	78
The island at 415th-416th km	4,4	3,9	4,3	68	72	69	16	11	12	16	17	19
The island at 415th-416th km	2,9	3	3,4	74	66	65	13	12	13	13	22	22
Island I	2,3	1,6	X	54	57	81	34	43	19	12	0	0
Island II	19,8	16,1	12,4	57	61	79	20	35	20	23	4	1
Island III	4,8	2,2	0,5	44	68	74	6	16	21	50	16	5

The ornithological inventory included all species of birds occupying islands and shoals in the stream. Particular attention was paid to the presence of those that are listed in Annex I of the Birds Directive, the Polish Red Book of Animals, and are considered as species important for designation in Natura 2000 Special Protection Areas (SPAs) in Poland (Głowaciński 2001 Gromadzki 2004). In this paper we present changes in numbers and distribution of the 12 most important species, which are the core of the riverbed avifauna (Table 2, Table 3). The data was collected in accordance with the method of monitoring riverbed avifauna, where at least two surveys (canoeing) are the standard (e.g. Wesołowski et al. 1984, Bukaciński et al. 1994, Keller et al. 2000). The surveys were made by an engine boat. Each island or shoal was inspected on foot to search for nests. Families with young, mating or anxious birds were also recorded. Only steep banks of the river were checked directly from the boat (nesting burrows were counted). Distribution of nests/birds was marked on topographic maps 1:10 000.

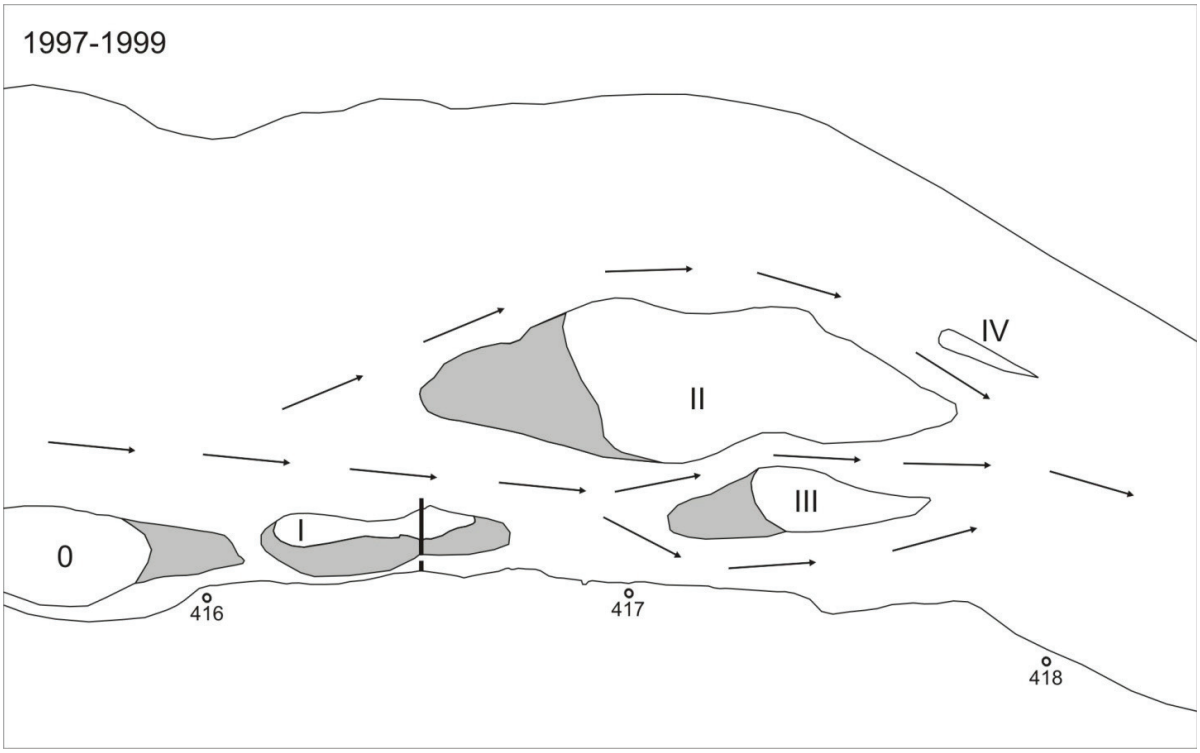
Surveys were conducted in the best possible period, taking into account the reproductive phenology of the species and the current dynamics of the river (water level). The first canoeing was usually performed in the first half of May, the second in the first or second decade of June. Repeated checks of all islands in April-July were an important supplement to the results of the canoeing. In situations where the exact numbers of the species was not known for certainty, a range with the minimum and maximum values was given.

Fig. 1. Changes in the riverbed of the fragment of the Vistula River in the years 1994-2006. 416, 417, 418 – kilometres of the waterway; 0, I, II, III, IV – particular islands of the complex (details in the text); in grey –sandy habitat on islands, in black – completely shallowed channel. On the island I the weir structure was marked. Arrows show the direction of river current

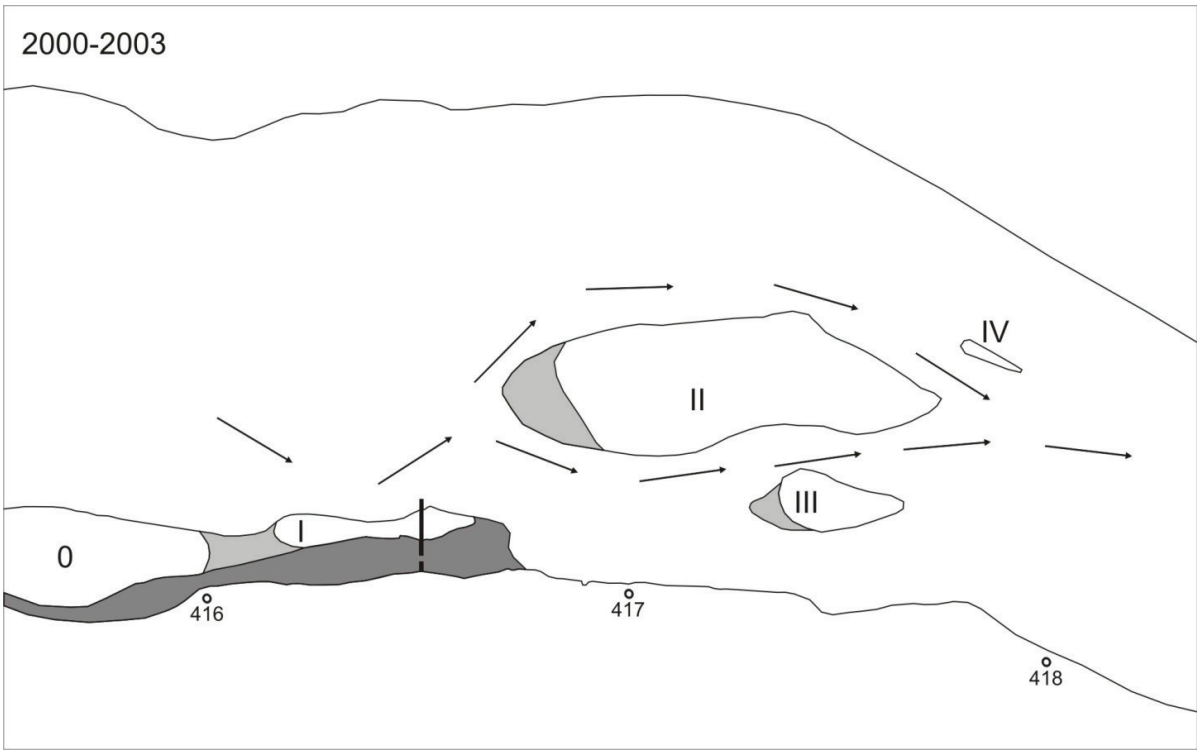
A.


1994-1996
IV
II
III
I
0
416
417
418

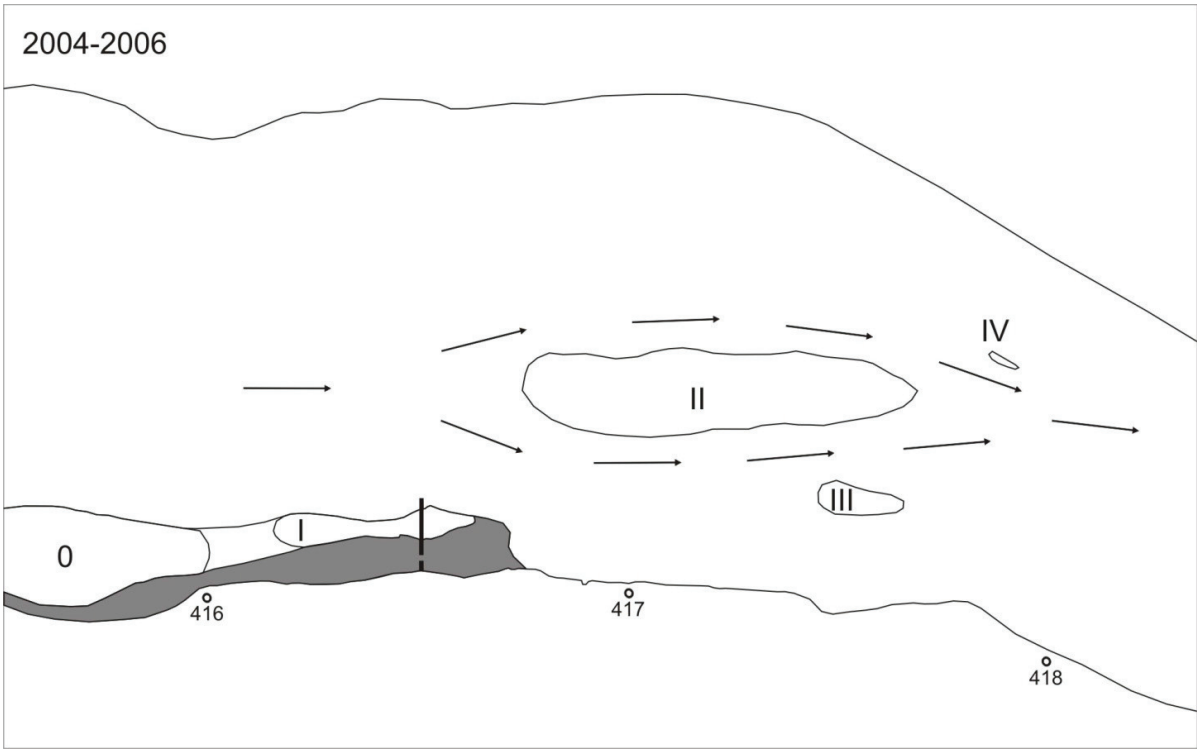
B.


1997-1999
IV
II
III
I
0
416
417
418

C.


2000-2003
IV
II
III
I
0
416
417
418

D.


2004-2006
IV
II
III
I
0
416
417
418

3. Results

3.1. Characteristics of the Vistula riverbed habitats and avifauna before the creation of a hydrotechnical facility

Until the mid-1990s, the width of the riverbed between 416 and 418 km of the river was 850-900 meters, with a complex of three islands (Fig. 1). The main current of the river was running (at least since the mid-1980s) along the right bank, putting sand shoals at the top and along the right edge of a large island (later this island was divided into islands II and III, Fig. 1A). This fragment of the river was one of the most valuable from the ornithological point of view and for many years it was planned to create an ornithological reserve there with the islands I-IV as its main part (Kot et al. 1988, Bukaciński et al. 1994, Kot et al 2009). An effective isolation from the land, and the presence of high, steep sandy banks allowed for the settlement of species nesting in bank slopes (e.g. sand martin *Riparia riparia*, common kingfisher *Alcedo atthis*) and sensitive to human disturbance (e.g. little tern, ringed plover, common gull, little bittern *Ixobrychus minutus*, northern shoveler *Anas clypeata*, ferruginous duck *Aythya nyroca*). A mosaic of habitats, covering a full spectrum of the subsequent stages of succession typical of the riverbeds of large lowland rivers including low sandy shoals, sand with clumped herbaceous vegetation, places overgrown by grass or bushy and woody willow and poplar (e.g. Gacka-Grzesikiewicz 1995) determined a remarkable species diversity, among which were both birds characteristic of rivers, as well as species typical of floodplains, old riverbeds, wetlands and riparian forest. The avifauna of riverbed alone consisted of, depending on the year, 25 to 30 species, and the nest densities of many of them were among the highest recorded along the Vistula River (Table 2, Bukaciński et al. 1994).

In autumn 1996, near the village of Kobylnica, the construction of a dam connecting the right bank with one of the islands of the complex (Fig. 1B) had begun. The work was completed in the spring of 1997.

The structure has a length of 65 m with partial passage in the middle of a depth of about 0.5 m and a width of 15 meters.

Table 2. Changes in numbers of some riverine bird species on islands located between 416th and 418th km of the Vistula River waterway in the years 1994-2003**.** The arrows show trends in the bird numbers in separate periods: ↓ decline, ↑ increase, — no change, X – fluctuations; A: 1994-1996, B: 1997-1999, C: 2000-2003; I, II, III, IV – island symbols as on fig. 1. Number of species – all species of the riverbed (ducks, waders)

Species		The numbers and trends							
		I		II		III		IV	
black-headed gull *Chroicocephalus ridibundus*	A	120-250	↑	200-2500	X	5-10	X	500-3500	↑
	B	0-10	↓	0		0		100-1000	↓
	C	0		0		0		500-1000	↓
common gull *Larus canus*	A	10-15	↑	85-110	X	17-31	↑	11-12	X
	B	1-8	↓	30-40	↓	11-26	↓	6-8	↓
	C	0-1	X	2-5	X	0		3-6	X
herring/caspian gull *Larus argentatus/ cachinnans*	A	0-1	X	1-2	X	0		0	
	B	0		0		0		0-1	X
	C	0		0		0		0	
Mediterranean gull *Larus melanocephalus*	A	1	—	1-2	X	0		0-1	X
	B	0		0-1	↓	0		1-2	X
	C	0		0		0		0	
common tern *Sterna hirundo*	A	15-25	X	15-30	X	3-10	↑	3-8	X
	B	10-15	↓	8-15	↓	0		0-3	↓
	C	0		0		0		0	
little tern *Sternula albifrons*	A	3-6	X	6-8	X	1-2	X	2-3	X
	B	0		0-4	↓	0		0	
	C	0		0		0		0	
little ringed plover *Charadrius dubius*	A	4-6	X	8-11	X	3-5	X	2-3	X
	B	0-1	↓	0-5	X	0-2	↓	1-2	X
	C	0-1	—	0-3	X	0-1	X	0-1	X

common ringed plover *Charadrius hiaticula*	A	2-3	X	4-6	X	2	—	1	—
	B	0		1-3	X	0		0-1	X
	C	0		1-2	X	0		0	
Eurasian oystercatcher *Haematopus ostralegus*	A	1	—	0-1	↑	1	—	0	
	B	0		0-1	X	0		0	
	C	0		0		0		0	
common sandpiper *Actitis hypoleucos*	A	2-3	↓	5-7	X	1-2	X	0-1	X
	B	0-1	X	3-4	X	0-1	X	0	
	C	0-1	X	2-3	↓	0		0	
common kingfisher *Alcedo atthis*	A	1	—	1-2	X	1-2	X	0	
	B	0-1	↓	1-2	X	0-1	↓	0	
	C	0		0		0		0	
sand martin *Riparia riparia*	A	0		10-15	X	0		35-60	X
	B	0		0		0		0	
	C	0		0		0		0	
Number of species	A	14-16	X	21-26	X	15-17	X	10-15	X
	B	7-9	↓	13-16	↓	7-9	X	8-9	X
	C	3-4	X	10-12	X	3-4	X	5-7	X

3.2 Changes in riverbed habitats and avifauna after 1996

Establishment of the weir considerably increased the flow rate and pushed the current to the middle of the river, directing it towards the islands (Fig. 1B). Changes in the avifauna after the construction of the transverse weir concerned both the island I which provided support to the structure as well as other islands of the complex situated two kilometers downstream (including island II, III and IV; Fig. 1). The greatest effect was observed on the island I and III (Table 2). As a result of building the weir, the first of these islands lost its isolation from the bank, and from 2000 was a part of the mainland (Fig. 1C-D). As a result, the width of the riverbed at this point decreased by more than 150 m (from 870 m to 710 m), i.e.

by more than 20% (Fig. 1C-D). The second island was quickly eroded by the current directed to the center of the river, first of all losing, like the island I, the habitats most valuable to the birds: steep slopes and sand beaches (Fig. 1, Table 1). Two years after the foundation of the weir there were twice as few, and after four years, five times less breeding species recorded on these islands, nesting in drastically lower densities (Table 2). Some years after 2000, only single pairs of some riverbed species, such as little ringed plovers (*Charadrius dubius*), common sandpipers (*Actitis hypoleucos*), and common gulls, were recorded (Table 2). On the other two islands of this complex which were also successively diffused by the current (island II and IV, Fig. 1, Table 1), in addition to a similar drastic decline in nest densities, a decrease in the number of breeding species by about one half was observed in the years 1996 -2000: from 21-26 to 10 -12 on the island II and from 10-15 to 5-7 on the island IV (Table 2).

At the same time habitat changes within the riverbed upstream of the weir followed. At the 411-412km and 415-416km up the waterway the islands' area changed only slightly, and the proportion of sand in the habitat structure remained the same or increased (Table 1). In an undisturbed natural river system, even if there is a dilution of one part of the island, sand is deposited in another location. As a result, the island may change its location but its size and the share of different habitats in a short time will change only slightly.

4. Discussion

Valleys of large lowland natural rivers are the specific environment of characteristic habitats both within riverbeds and on banks. The unstable environment, combining high dynamics of plant succession with frequent renewal of the habitat due to flooding is inhabited by unique bird assemblies adapted to such conditions. For many species, unregulated rivers are a key place for foraging and reproduction.

Table 3 illustrates changes of the importance of islands between 416 and 418km along the Vistula river for bird species which comprise the

core of the riverbed avifauna. It is worth noting that in the first half of 1990 these two kilometers of the river provided the nesting place for more than 80% of the black-headed gull (*Chroicocephalus ridibundus*) pairs, for about 40% of the little tern pairs and for not less than 20% of common gull pairs, and ringed plover pairs inhabiting more than a 30-kilometer section of the middle Vistula River between Dęblin and Kozienice (km 393-426). Destructive changes in habitats that occurred in the riverbed as a result of damming caused the devaluation of the importance of this place for birdlife. Although in micro-scale (km 415-420) these islands are still the primary nesting site for gulls, terns and plovers, when we consider that no more than 10% of breeding species was observed in the fragment of the Vistula river between Dęblin and Kozienice (Table 3).

Table 3. The importance of the fragment of the Vistula River between 417th and 418th km of the waterway for selected bird species expressed as a percentage of bird pairs breeding within this fragment relative to the larger fragments of the river: A – between Wróble and Maciejowice (415th-420th km of the river), B - between Dęblin and Kozienice power plant (393th-426th km) in the years 1993 and 1999-2006 (Bukaciński et al. 1994, Bukaciński 2009, Bukaciński unpubl.)

Species		% of pairs breeding at 417th and 418th km of the river relative to all breeding pairs at fragments A and B	
		1993	1999-2006
black-headed gull *Chroicocephalus ridibundus*	A	100	80-100
	B	83	4-6
common gull *Larus canus*	A	68	24-28
	B	26	6-10
Mediterranean gull *Larus melanocephalus*	A	100	33-67
	B	100	25-40
common tern *Sterna hirundo*	A	38	30-40
	B	8	3-5
little tern *Sternula albifrons*	A	80	27-35
	B	40	2-5

little ringed plover *Charadrius dubius*	A	74	40-55
	B	17	7-9
common ringed plover *Charadrius hiaticula*	A	82	35-45
	B	20	4-6

Protecting the banks against flooding is necessary. However, taking the unique natural value of this river into account, one should always consider the pros and cons when determining the methods of achieving this goal. Usually, there might be several possible solutions considering different locations and methods of riverbank protection (e.g. a riprap or a fascine lining of the bank). Unfortunately, frequently there are no serious ecological consultations or searches for alternative solutions. An ill-conceived decision led to the irreversible loss of the self-regulating system in the riverbed islands, which could have ensured breeding grounds suitable for a number of endangered species of birds. We cannot turn the clock back. This example, however, should be a warning to all those to whom the nature of middle Vistula valley matters. It is still an unusual environment of transnational importance with delightful landscapes, inhabited by unique species.

At present almost all large lowland rivers in Europe, such as the western (Loire, Seine, Rhine), southern (Rhone, Danube, Po), central (Elbe, Oder, Tisza) or eastern rivers (Volga, Don, Dniester) are almost devoid of birds during the breeding season (review in Gibbons et al. 1993, Tucker and Heath 1994, Hagemeijer and Blair 1997). In contrast, the over 200-km long middle section of the Vistula has still not lost its natural character, which is the reason for the presence of many riverine bird species. Natural flooding of the Vistula allows for the existence of mature riparian deciduous forest. The processes of erosion and sedimentation form steep banks and islands and shoals in the riverbed – key nesting habitats for plovers, terns and some species of gulls. Such sites should be treated as natural heritage. The only effective form of their protection is to prevent transformations caused by human activity.

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