HYDROLOGICAL AND ECOLOGICAL INVESTIGATIONS FOR THE RESTORATION OF THE ECOSYSTEM COMPLEX OF FUNDU MARE ISLAND

Nicolae Onea, Peggy Zinke, Tudor Ionescu, Daniela Gheorghe, Anders Foldvik, Jan Ove Gjershaug, Muriel Brückner, Jochen Aberle, Florin Nedelcuț

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Abstract: Fundu Mare Island in the Natural Park Small Wetland of Brăila (Romania) is one of the few islands of the Lower Danube System that is in a nearly natural state and hence an important nature-protection area. During the last few years a massive willow encroachment has been observed in some formerly open habitats. It was found that the areas of willow development can be related to elevation zones that are affected by changes in the water level of the Danube. Data and recent observations of fish fauna and aquatic birds at Fundu Mare Island have confirmed the close inter-relationship between the Danube water level regime and wildlife. It has been suggested to increase the period of inundation of the island by installing weirs to regulate the water flow from island lakes to the Danube. The optimal operation of such a wiers has to balance effects on vegetation, avifauna and ichthyofauna.

Keywords: aquatic birds, ecological restoration, fish, hydrology, vegetation, willow

Nicolae Onea:
Museum of Brăila "Carol I"
Department of Natural Sciences
Aleea Parcului , 810296 Brăila, România
e-mail: oneanicolae@yahoo.com

Peggy Zinke:
Water Resources Research Group
Sintef Energy Research, Sem Sælands vei 11
NO-7465 Trondheim, Norway
e-mail: peggy.zinke@ntnu.no

Tudor Ionescu:
"Dunărea de Jos" University of Galați
Research and Development Centre for Sturgeon
Aquatic Habitats and Biodiversity
Str. Domnească 47, 800008 Galaţi, România
e-mail: tionescu@ugal.ro

Daniela Gheorghe:
"Dunărea de Jos" University of Galati
Department of Aquaculture, Environmental
Science and Cadastral Measurements
Str. Domnească 47, 800008 Galaţi, România
e-mail: Daniela.Gheorghe@ugal.ro

Anders Foldvik and
Jan Ove Gjershaug:
Norwegian Institute for Nature Research - NINA
P.O. Box 5685 Sluppen,
NO-7485 Trondheim, Norway
e-mail (Anders Foldvik):
anders.foldvik@nina.no
e-mail (Jan Ove Gjershaug):
jan.gjershaug@nina.no

Muriel Brückner and
Jochen Aberle:
Norwegian University of Science and
Technology, Department of Civil and
Environmental Engineering
S.P. Andersens vei 5, 7049 Trondheim, Norway
e-mail (Muriel Brückner):
m.z.m.bruckner@uu.nl
e-mail (Jochen Aberle): jochen.aberle@ntnu.no

Florin Nedelcuț:
"Dunărea de Jos" University of Galaţi
Engineering and Agronomy Faculty of Brăila
Calea Călărașilor 29, 810017 Brăila, România
e-mail: Florin.Nedelcut@ugal.ro

Introduction:

Ecological restoration is regarded as a major strategy for reversing biodiversity losses as well as for increasing the provision of ecosystem services (Bullock et al. 2011). Restoration actions focusing only on a particular part of the biodiversity could lead to negative impacts on other parts. It is therefore important to find a trade-off to solve this problem.

Large river-floodplains are shaped by the dynamic interaction between water, sediments and land; this interaction is important in shaping the ecology and abundance of species inhabiting these systems (Bayley 1995). The effects of flooding - on biota has been summarized in the flood - pulse concept (Bayley 1995; Junk et al. 1989). This concept interprets the predictable advance and retraction of the water on the floodplain as the principal agent controlling adaptations of most of the biota and not as a disturbance. As the water rises, dry areas become inundated with the littoral zone traversing the floodplain. This moving littoral zone will affect availability of nutrients both for the dry and wet season, by dissolving mineralized nutrients and by deposition of suspended sediments. The moving littoral zone is associated with high primary production and decomposition rates, and provides excellent spawning habitat and nursery ground for fish (Bayley 1995; Górski et al. 2010).

Large river-floodplains have to a large extent been impacted by river regulations, construction of side levees for flood protection and creation of farmland etc. These measures have affected flood plains both in terms of sedimentation and erosion processes and also the extent of flooded areas. Restoration towards completely natural conditions is however seldom realistic due to economic feasibility and conflict with other human needs. Restoration measures will often be cheaper “best of a bad situation” actions within a limited area of the river. Ecological restoration of large rivers should according to Schiemer et al. (1999), build on the following principles: (1) restoration should be based on theoretical concepts of river ecology, (2) restoration should be process - and ecosystem - orientated instead of species - focused, and (3) restoration should foster the hydrological and geomorphological function of the river.

The Natural Park Small Wetland of Brăila (SWB) in SE Romania is one of few nearly natural areas of the Lower Danube System, a 840 km long river reach between the Iron Gate II dam and the Black Sea, which has been heavily affected by human activities during the last centuries. SWB, which was declared as natural reserve in 1994, is an internationally important bird protection area due to the quality of its habitats and its location on the migration routes between northern Europe and Africa.

Fundu Mare Island is the northernmost of the seven islands in SWB covering an area of 1945 ha (see Fig. 1). About 50% of the area is regarded as aquatic habitat provided mainly by the two shallow lakes Chiriloaia (300 ha) and Misăilă (630 ha) (see Fig. 2 for details) connected by channels which were built for fisheries before 1989. The lakes are usually flooded in spring during periods of increased discharge in the Danube. Following the flooding period, the lake water levels drop depending on the Danube hydrograph. In recent years it has been observed that the lakes fell completely dry in summer. This has negative consequences for fish and birds, and can result in accelerated vegetation encroachment on formerly open areas. During the last few years a massive willow development has been observed in some former aquatic habitats.

The interdisciplinary project “Restoration of the aquatic and terrestrial ecosystem complex of Fundu Mare Island” (hereafter called RFM Project) has aimed to improve the hydrological situation by investigating and implementing appropriate restoration measures. It was a Romanian-Norwegian cooperation project funded by the EEA Grants, with a duration from May 2015 to April 2017. The RFM Project was coordinated by the Romsilva National

Forestry Park Administration (SWB) and included two Romanian and three Norwegian institutions. The project was divided into seven work packages including direct and remote sensing field measurements, hydrodynamic modelling, monitoring of aquatic birds and collecting available fish data from the area. The main aim of the project was to suggest and implement suitable measures for the ecological restoration. Preliminary results of the project have been published in a conference paper (Zinke et al. 2016) and a technical report (Zinke et al. 2017).

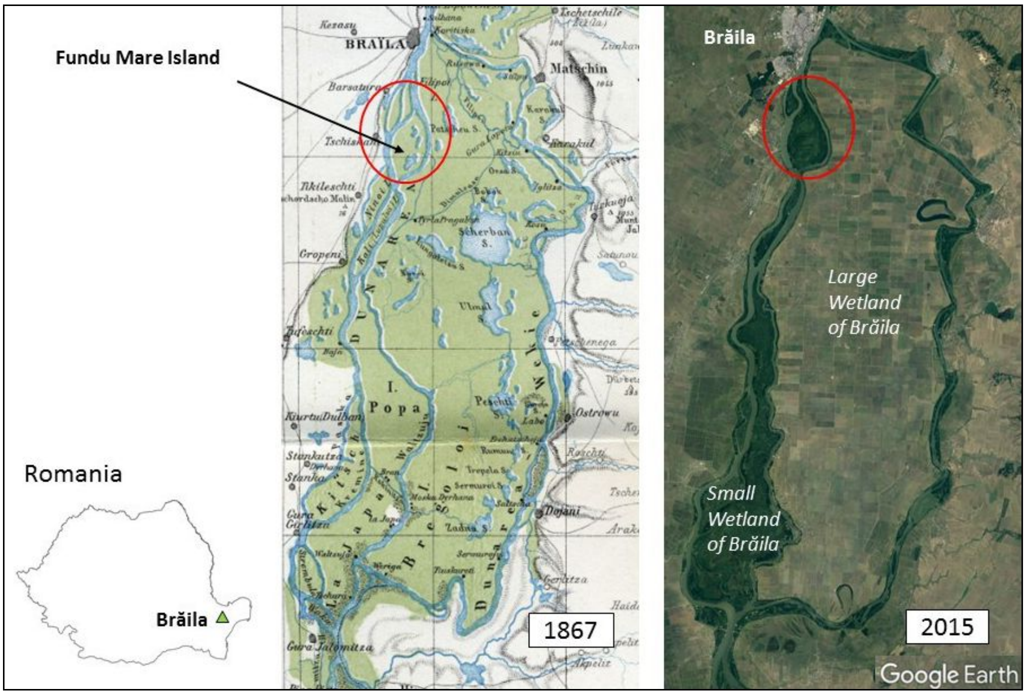
In the present paper we summarize the project's results by discussing how restoration on Fundu Mare Island is to be obtained to prevent willow development hence allowing for improved conditions for fish and birds. For this purpose data on hydrology, willow encroachment, fish fauna and bird fauna will be presented in a first step.

Materials and methods:

Study site

SWB and the project site are located in the south-eastern part of România, in the Lower Danube System (Fig. 1). The Danube is 2857 km long and flows from the Black Forest Mountains in Germany to the Black Sea, being the second largest river in Europe and amongst the largest river systems globally with a catchment area of 807,827 km^2. The Danube and its tributaries have been progressively influenced by measures for flood protection, navigation, and hydropower. It was estimated that, compared to the 19^{th} century, less than 19% of the former floodplain areas remains functional in the entire basin (Habersack et al. 2016).

Figure no. 1 Transformation of the area on the regional level from 1887 to 2015. Data sources: Kiepert (1867), Google Earth (2015)



In addition to the changes occurred at regional or river basin level, local human-induced changes have taken place at Fundu Mare Island over the last decades, such as the excavation of the connecting channels between the lakes, the blocking of the Păioasa channel or the construction of weirs. Previous restoration studies proposed that these measures together with the alterations of the hydrological and sediment regime of the Danube led to a trapping of sediment in the lakes and channels, which reduced their depths.

The new LIFE Channel (see Fig. 2) in the south-eastern part of the island was excavated in 2010, as part of a planned channel route that was supposed to flush out accumulated sediments (Bodescu and Iordache 2010). The new channel connects the Danube River with the inner parts of the island at higher water levels. The water level in the Hogioaia channel is partly regulated by a weir located at a distance of approximately 500 m away from the river (Fig. 3).

Figure no. 2 Habitat distribution within Fundu Mare Island and position of measurement sites. The habitat data was provided by SWB (2015) and modified including the lake near Logger 2. Logger-positions are indicated by the black numbers

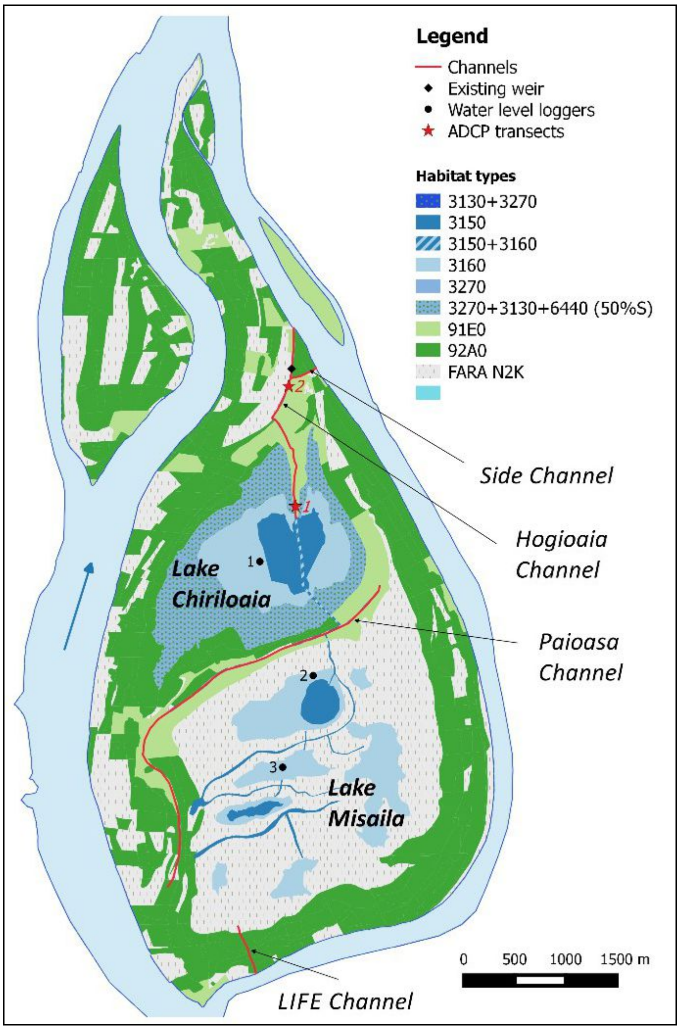


Figure no. 3 Weir in the Hogioaia channel

Figure 2 and Table 1 provide an overview of the study site and the habitat types, respectively. The corresponding data stem from digital maps of the nature types according to the EU Habitat Directive (EU-HAB 2013) which were extracted from the SWB data-base (SWB 2015). According to these maps, the dominant habitat types of Fundu Mare Island include the riparian species *Salix alba* and *Populus alba* [Type 92A0], natural eutrophic lakes with Magnopotamion or Hydrocharition-type vegetation [3150], natural dystrophic lakes and ponds [3160], and rivers with muddy banks with Chenopodion rubri p.p. and Bidention p.p. vegetation [3270].

Table no. 1 Habitat types according to EU-HAB (2013)

Code	Description
3130	Oligotrophic to mesotrophic standing waters with vegetation of the Litorelletea uniflorae and/or Isoeto-Nanojuncetea
3150	Natural eutrophic lakes with Magnopotamion or Hydrocharition - type vegetation
3160	Natural dystrophic lakes and ponds
3270	Rivers with muddy banks with Chenopodion rubri p.p. and Bidention p.p. vegetation
6440	Alluvial meadows of river valleys of the Cnidion dubii
91 E0	Alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior* (Alno-padion, Alnion incanae, Salicion albae)
92 A0	*Salix alba* and *Populus alba* galleries

Hydrology and vegetation

The water levels of the Danube at Brăila (river: km 170) from 1970 to 2015 were provided as mean daily values by the River Administration of the Lower Danube in Galaţi (AFDJ), together with the gauge datum referenced to Black Sea Sulina (MNS). These data were used to determine water level duration lines and hydrological indices at the study site.

A field survey was carried out in-between 13th-16th July, 2015, to enhance understanding of the water balance and flow processes at the island. Water depths ranging between 0.7 and 1.5 m were manually measured at selected locations in the densely vegetated lakes from a vessel using a folding ruler. These data complemented data from three water-level loggers recording the lake water levels in summer 2015. The available information was correlated with the observed vegetation type so as to allow for a rough estimation of the water depths associated with a given vegetation type for the date of the observation.

In addition, the status of the vegetation was documented during a remote sensing survey using a professional survey-grade mapping Unmanned Aerial Vehicle (UAV; Parrot SenseFly eBee) at the end of September 2015.

A digital model of the terrain surface and bathymetry of Fundu Mare Island was prepared using data of a laser-scan in 2007 (2 m resolution, provided by the Danube Delta National Institute), and a data set with bathymetry data of the Danube from 2008, in combination with available information on the depths of the lakes and channels on the island. The digital terrain model (DTM) from 2007 contained only information on water surface elevations of the Danube, whilst the island water level elevation during the flight period was unknown. In order to implement the bathymetry of the lakes and channels, the lake water level during the 2007 flight was estimated based on available aerial images and compared with the water level during the field campaign in July 2015. For more details of the model, see the description in Zinke et al. (2016).

Fish fauna

Fish fauna data for Fundu Mare Island and the nearby Danube River was available from Industrial catches during 1952-1962 in Brăila-Călăraşi area (Buşniţă 1967), Industrial catches recorded in the official statistics (Florea 1998), and scientific fishing in the period 2006 – 2009 (Gheorghe et al. 2010) and 2008 – 2011 (Geru et al. 2011).

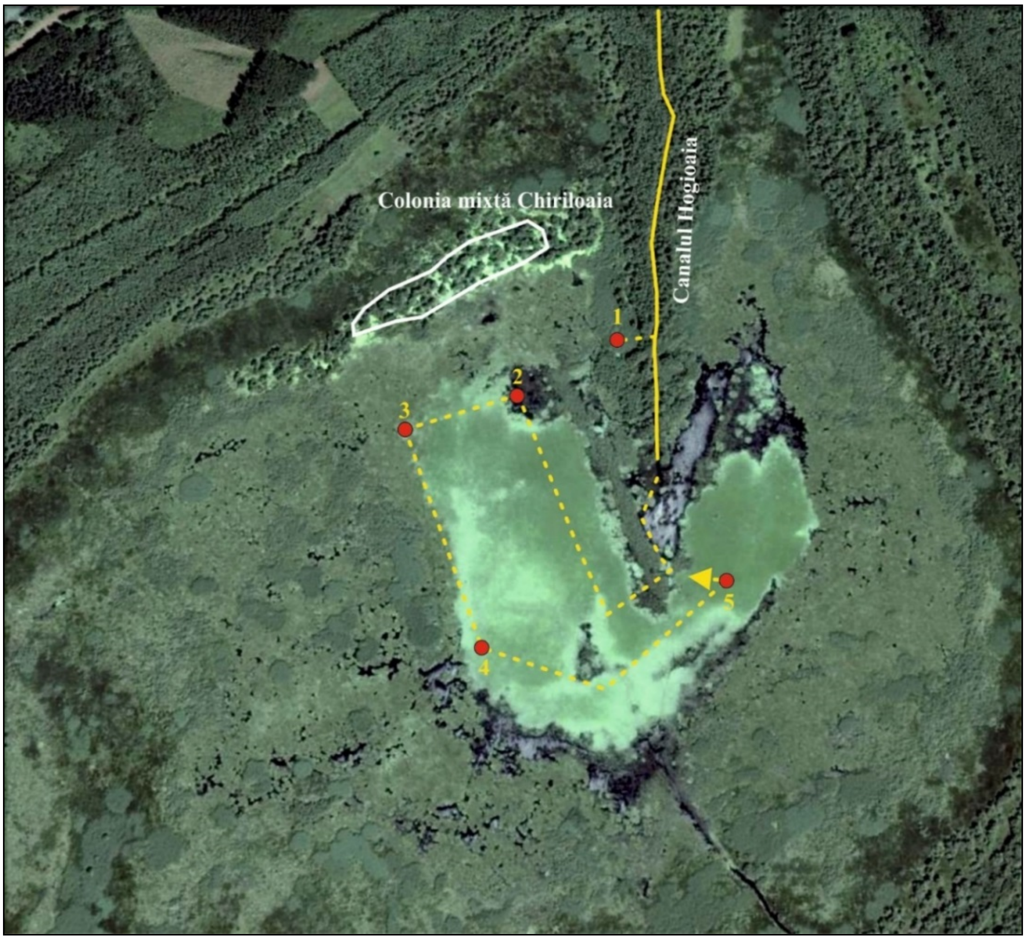
Bird fauna

Starting in the second half of the last century and the turn of the 21st century, many studies focused on research of the birds featuring the Small Wetland of Brăila. Năstăsescu and Ceaușescu (1981) published a first list of aquatic nesting bird species pertaining to the Small Wetland of Brăila. Subsequently, further studies contributed to new knowledge with regard to the biology and ecology of the birds in this area (Albu 1993; Petre 1996; Onea 1995, 1996, 2001a, 2001b, 2002).

The monitoring of the aquatic bird species of Chiriloaia wetland zone in this project was carried out over two years throughout the period of 2015-2016. In order to obtain a more complex outline of the aquatic birds' dynamics over a longer time span, both the existing data in the literature, and the data from the direct observations in the area (though not published; Onea, unpubl. data) were employed.

The selection of spots/routes of observation accounted for areas with a large concentration of bird species (Chiriloaia colony) and access ways towards these areas. Five observation spots were established (Fig. 4), out of which one was set at the birdwatching tower nearby Chiriloaia colony (spot 1 en route). The other observations were undertaken from a vessel at the established spots for which the location was known using the Global Positioning System (GPS).

Figure no. 4 Bird observation points in Chiriloaia Lake



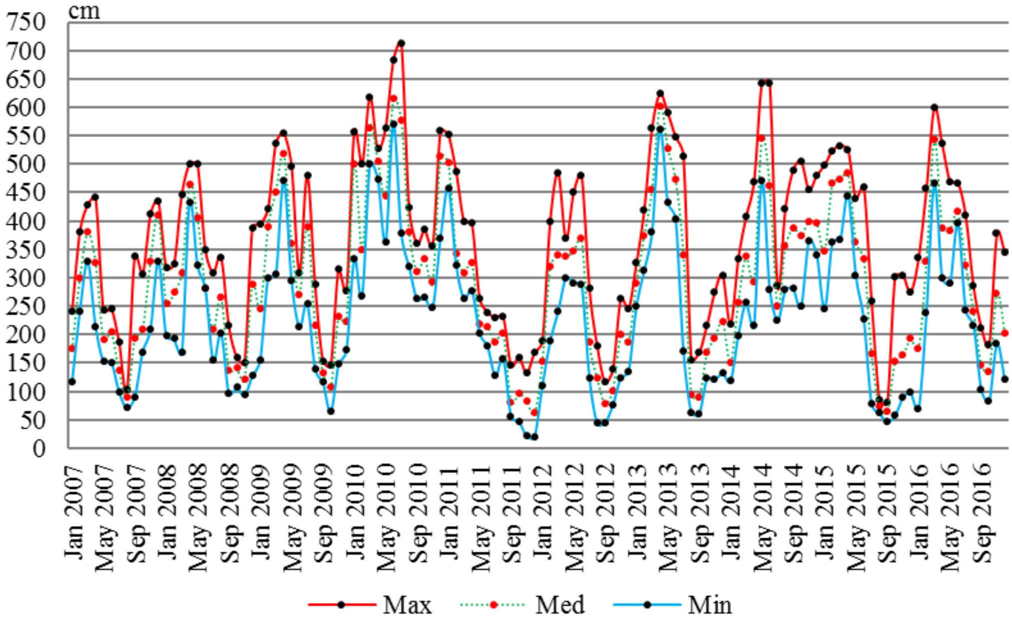
The birds in Chiriloaia colony were monitored from the spots 1-3. For the aquatic bird species depending on the water and aquatic vegetation of Chiriloaia wetland, observations were carried out from spots 2-5 (by vessel). The observation conditions, mainly those from vessel, resulted in recordings of individuals from the foreground areas. It is worth mentioning that the relative profusion typical of each species represents an estimate under the real level of the populations dwelling in this wetland and Chiriloaia colony. The errors of observation from distance, especially in case of a colony, are customary.

Results and discussion:

Hydrological conditions and vegetation

The biodiversity of Fundu Mare Island is directly affected by the Danube water levels displayed in Figure 5, showing the maximum, medium and lowest water levels over a period of 10 years (2007-2016). As a yearly feature, the water level rises commonly in the period from April to May (the spring high flood), followed by a drop in water levels. In autumn flooding can also occur as a result of seasonal rainfall but to a much lesser extent than in spring. Moreover, autumn flooding does not show an annual cyclical pattern.

Figure no. 5 The water level in Danube river in the period 2007-2016. Data from Romanian Waters National Administration Brăila Branch, unpubl.



The level of the Danube River affects Chiriloaia wetland. However, for Chiriloaia (likewise for the entire inland wetlands of the Natural Park of the Small Wetland of Brăila) no official measurements of monthly or annual water levels exist. Based on field observations in the period 2007-2016, an empirical assessment of the water level in Chiriloaia wetland was carried out (Fig. 6). For this purpose, a rank of 0 - 1, with 0.25-intervals was used, in which the maximum value of 1 corresponds to an optimum water level in the wetland, while a zero value means total drainage of the aquatic ecosystem. The optimum water level in the wetland corresponds to bankfull conditions in the Hogioaia channel after spring high flood when the banks are accessible on foot. As indicated by Figure 5, the highest water level within the wetland occurs in May during the spring flood. The following gradual decrease of the Danube results in decreasing water levels of Chiriloaia wetland, and autumn flooding has a limited influence on the wetland's water levels.

The weir construction in the Hogioaia channel has influenced the water level in the lakes. An early version of the weir consisted of wood and stones (see Fig. 3). In 2015 and 2016, the weir was sealed using plastic sheets, such that the leakages could be reduced. It is still an imperfect construction without possibilities for precise water level regulation.

In particular during the years with drought, large parts of the lake areas fall dry (for instance, 2007, 2012 and 2013 - see Fig. 5 and Fig. 7), or there merely remain tiny ponds and puddles of water. In years with normal temperatures during the warm season and in correlation with a better preservation of the existing weir regulating the water levels in the Hogioaia channel, a minimum water level within the wetland is maintained. In this case certain areas in the wetland will still preserve water (in August), while others will be completely drained.

Figure no. 6 Suitability assessment for the water level of Chiriloaia Wetland in-between 2007-2016

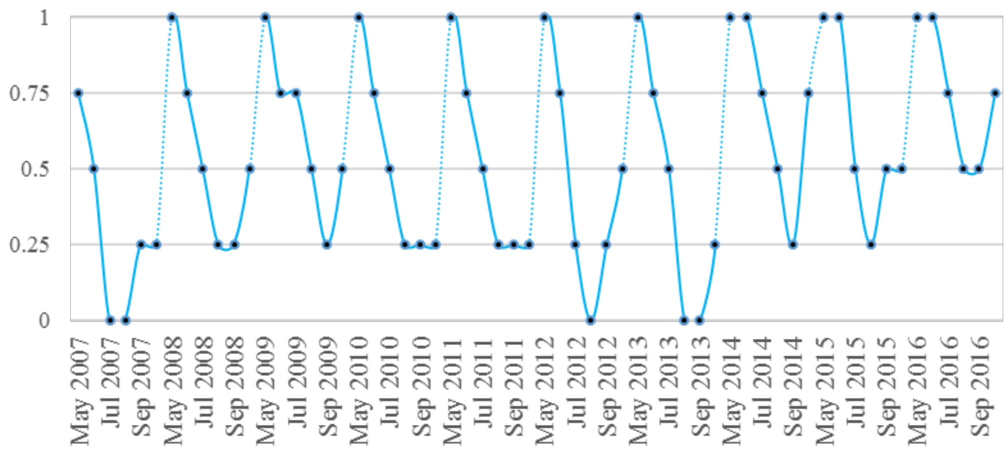
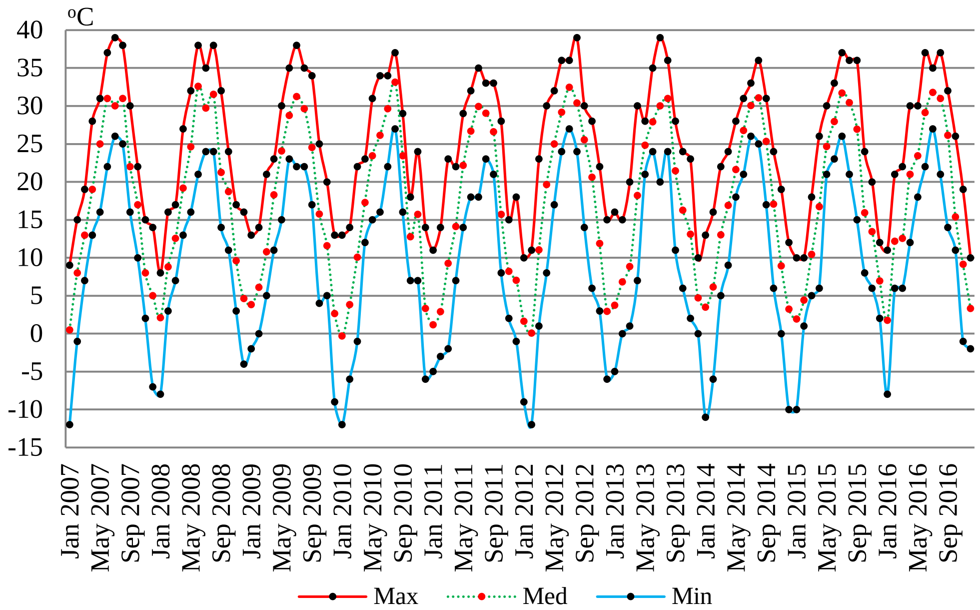


Figure no. 7 Complete drainage of the lake Chiriloaia and development of a specific vegetation in the year 2007 (July)

Figure 8 illustrates air temperature dynamics in Brăila for the period 2007-2016. The maximum values of 38-39 °C recorded for the years 2007, 2012 and 2013 led to a high evaporation and decrease of the water level in Chiriloaia wetland and total drainage of the aquatic basin. According to the developed DTM, Fundu Mare Island has a median elevation of about 4.6 MNS with large areas being characterized by elevations ranging from 4.4 to 4.8 MNS. Along the shoreline there exists a higher fringe of natural levees with an elevation between 6.5 and 7.5 MNS. Smaller levees occur along the Păioasa channel crossing the island in a direction from SW to NE (see Fig. 2 and Fig. 9). The minimum bed levels of the deepest lakes are about 3.2 MNS.

Figure no. 8 Air temperature in Brăila in-between 2007-2016. Data from Branch Distribution of Electricity Brăila, unpubl.



The flooding of Fundu Mare Island during a flood wave starts from NNE. Water from the Danube first enters through the Hogioaia channel, and for further rising water levels also over the lower levees of the floodplain in the northern part of the island. Island water level changes within the range of 4.4 and 4.8 MNS result in a high change of flooded area, as illustrated in Figure 9. The highest natural levees in the southern part of the island are only inundated if the Danube water level exceeds 7.2-7.5 MNS.

Figure 10 shows the mean seasonal water levels (10 days moving average) for the decades after 1970. Between 1970 and 1989, the maximum water level occurred on average at the end of May. More recently, the maximum water level was observed at the end of April or beginning of May. The high water subsides in summer. For the two decades, the Danube water level fell below 4.4-4.6 MNS in the second half of summer, while this happened about one month earlier between 1990 and 2009.

Figure 11 (a) shows the water level duration curve of the Danube River at Brăila together with characteristic flooding durations for hardwood floodplain forest (HWF) and softwood floodplain forest (SWF), the latter including also willow shrubs. The arrows indicate the differences between selected decades for the 41% exceedance percentile, which is the maximum flooding duration for the lower SWF according to Peper et al. (2012). For the decade between 1970 and 1979, only the floodplain zones in Brăila with an elevation higher than 4.6 MNS (about 4.7 MNS at Fundu Mare Island, taking into consideration the gradient) were characterized by inundation durations suitable for the development of riparian forests or willow shrubs. For the decade between 1990 and 1999, however, the hydrological conditions were suitable for the development of forest communities at elevations down to 4.2 MNS in Brăila (ca. 4.3 MNS at Fundu Mare Island). Inundation duration changes within this elevation range will affect large areas of Fundu Mare Island.

Figure no. 9 Flooded area at Fundu Mare Island for a water level of 4.4 MNS (left), 4.8 MNS (middle) and 6.8-7.2 MNS (right)

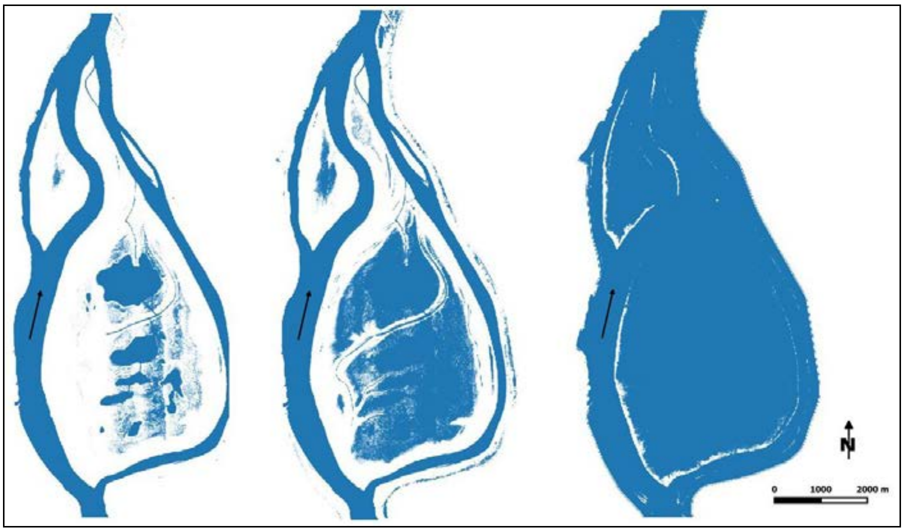


Figure no. 10 Seasonal water levels of the Danube at Brăila (10 days moving average of the mean daily value) for the decades after 1970. Measurement data from AFDJ

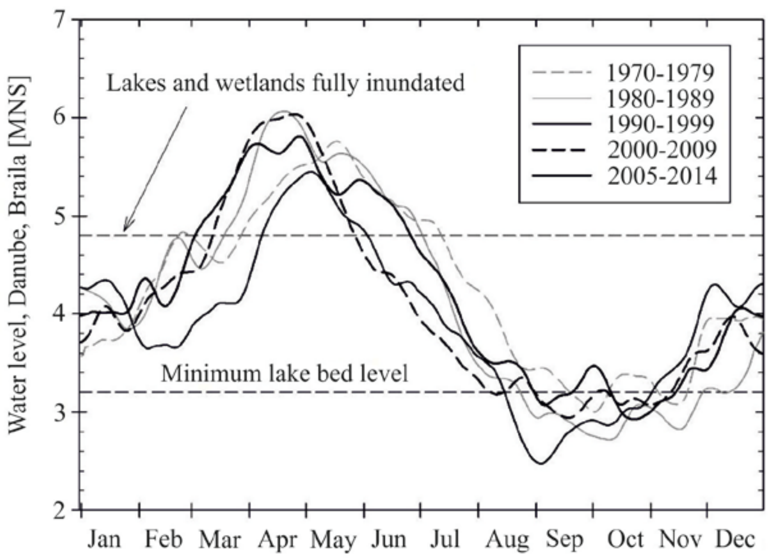
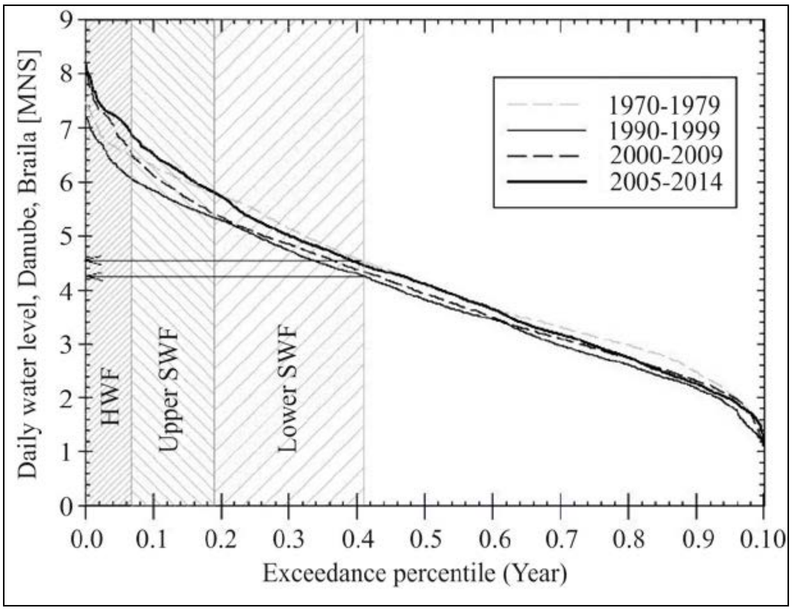
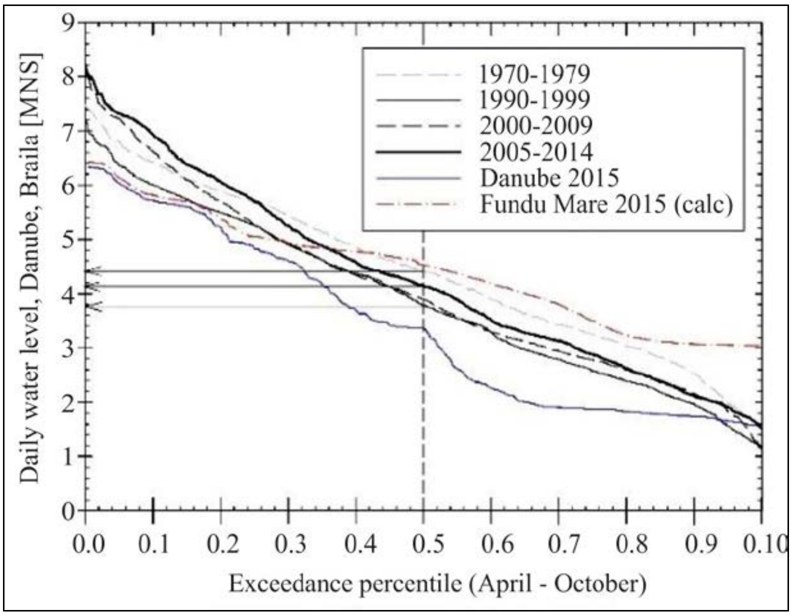


Figure no. 11 Water level duration curves for the Danube at Brăila for selected decades, based on mean daily values for the entire year (a) and for the growing season ranging from April to October (b). The hatched areas on the left side indicate typical inundation durations for hard - and softwood floodplain forests according to Peper et al. 2012



(a)



(b)

The differences of inundation duration between the investigated decades are more pronounced for the growing season (April to October). The mean water level of the Danube in Brăila during the growing season (i.e. the 50% exceedance percentile) for the decade 1970-79 was approximately 0.5 m higher than that recorded in-between the decades 1990 and 2009.

The reasons for the observed changes of the water level duration curve of the Danube River in Brăila are complex. The Lower

Danube between the Iron Gates and the Danube Delta is one of the few remaining free flowing sections of the Danube, but the sediment deficit from upstream (caused by hydropower development) and the modifications for flood protection have led to river bed erosion, frequent morphological changes, and a change of the flow distribution between the Danube branches (Bondar 2008; Andronache 2009; Habersack et al. 2016). An on-going project aims to improve the conditions for navigation between Călărași and Brăila (rkm 375-175) by a series of hydraulic structures including a sill, in order to increase the discharge in the main channel (Habersack et al. 2014). The hydrograph of the Lower Danube is affected by the water regulations at the Iron Gate dams, which can lead to unnatural smaller flood peaks throughout the year.

These pressures are overlaid by climate change. The observed seasonal changes of the Danube flood peaks and the higher maximum flood peaks are in agreement with other findings (e.g. Nesterenko et al. 2014) that climate change affects the floodplain water balance and habitats directly. There is a general warming signal over Romania, the number of summer days is significantly increasing, and annual temperature in the south-east of Romania has increased more than in other parts of the country (Croitoru et al. 2012; Dumitrescu et al. 2014). Actual prognoses foresee, among other effects, higher average annual, maximum and minimum temperatures, more droughts, higher evaporation, longer warm periods, and aridization – with problems related to eutrophication, water level changes, silting, ground water level decline and species loss for the relevant habitat types 3150, 3160, 91F0 and 92A0 (Doroftei et al. 2013).

The habitat types of Fundu Mare Island show a zoning according to the elevations and respective hydrological conditions (cp. Fig. 2 and Fig. 9). Habitat type 3150 is restricted to the island areas with the lowest elevations (3.6 to 4.0 MNS), type 3160 occurs mainly between 4.0 and 4.4 MNS, and the floodplain forests (type 91E0 and 92A0) dominate at elevations above 5.2 MNS. Habitats with a high percentage of willows (”50% S”; Salix) were mapped at elevations between 4.4 and 4.8 MNS. The habitat map (see Fig. 2) shows a zone around the lake near Logger 1 (“3270+3130+6440 (50% S)”) where willow encroachment was reported in the SWB database.

Figure 12 shows water depths measured for different habitat types during the field survey in July 2015, at lake stage 4.65 MNS. Both the 2015 aerial images and the field investigations showed that in recent years willows have started to grow also in areas formerly dominated by aquatic or semi-aquatic vegetation. For example, approximately 2 to 5 year old willows were observed in zones that are classified as types 3160 in the habitat map (cp. Fig. 2, Fig. 13 and Fig. 14).

The present analysis suggests that the changes in the water level duration curve of the Danube (lower water levels of the 41% percentile for the decades 1990-2009, compared to 1970-1979) may have contributed to the encroachment of willows in the elevation range 4.4 to 4.8 MNS, which was documented earlier in the SWB habitat maps. Recent investigations in other parts of the world indicate that flooding exerts primary control over soils, nutrient dynamics and vegetation only for the zones which are inundated >~40% of the growing season (De Jager et al. 2012).

More research is required to explain the newly documented encroachment of willows in the zones that were earlier mapped as aquatic habitats (e.g. type 3160). The average water levels of the Danube River for the period between 2005 and 2014 were higher than those of the decades between 1990 and 2009 (see Fig. 10 and Fig. 11), which is largely due to the wet years 2005/2006 and 2010. The low estimated age of the willows in these areas (about 2-5, locally 7-10 years in 2015) suggests that they may have been established during the dry years 2007/2008 and 2011/2013.

The variance of the mean, minimun and maximum water levels seems to have increased during the last ten years. In addition, it is very likely that the LIFE-channel built in 2010 had a negative effect on the inundation duration on the island as it may act as a drain.

Figure no. 12 Sketch of the typical water depths that were measured for different habitat types and plant communities during the field survey on 14 July 2015, at Lake stage 4.65 MNS

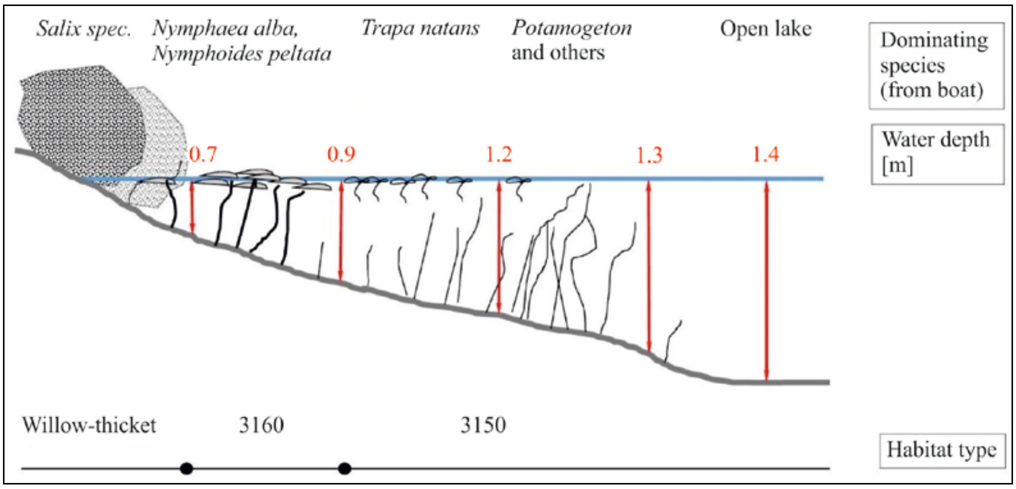


Figure no. 13 Willow encroachment in an area classified as ”Natural dystrophic lakes and ponds” (type 3160) by SWB. Photo taken in July 2015

Figure no. 14 Willow encroachment in aquatic and semi-aquatic vegetation types near Logger 1; overview (a) and detail (b). Aerial photos taken by UAV in September 2015, provided by UGAL

(a)

(b)

Riparian vegetation composition, structure and vigour responds rapidly to flow regime changes, as well as to the indirect hydrological consequences of river channel changes resulting from channel incision and floodplain sedimentation (Loheide and Booth 2011). Moreover, young willows (Salicaceae) produce above - and below - ground biomass rapidly and can act as ”ecosystem engineers” that enhance the accumulation of sediments and shape the habitat (Gurnell 2014).

Fish fauna. Overview of fish in the Danube River

The Danube is the river with the highest number of fish species in Europe, with a total number of species within the entire river exceeding 100 (Schiemer et al. 2004; Kováč 2015). Historical studies of the Danube ichthyofauna were conducted as early as the 18th century by Marsilius (1726) and in the 19th century by Heckel and Kner (1858). In România fishing has historically been an important means of livelihood for people along the Danube and in the Danube Delta.

According to Schiemer et al. (2004) the ichthyofauna of the Romanian parts of the Danube consists of 73 species including 6 non-naturally occurring species. 5 species that used to occur in the Danube are now extinct and of the remaining ones, 7 are critically endangered, while 15 are listed as vulnerable (Schiemer et al. 2004). The IUCN Red List of Threatened Species (http://www.iucnredlist.org/) has classified 4 of the species as critically endangered and 3 as vulnerable (Tab. 2, Annexes). According to Ciolac (2004) there are 69 species in the main channel of Lower Danube while, according to Bănărescu (1964) the ichtyofauna consists of about 80 species with another 10 to 15 species entering occasionally at high water levels. Some of the discrepancies between reported numbers might result from differences in nomenclature and taxonomic division, some from differences in inclusion criteria, while others are conflicting reports. For example, *Sander volgensis* is listed as extinct in România by Schiemer et al. (2004) while reported as being caught during the Joint Danube Survey 2 (JDS2) (Kováč 2015). Also both *Perccottus glenii* and *Ameiurus nebulosus* are listed as not occurring in România in Schiemer et al. (2004), while again reported during JDS2 (Kováč 2015).

Over the last century the ichtyofauna has undergone both significant quantitative and qualitative changes. Some of these changes could have occurred as associated with natural processes, but human activity such as embankments, river regulation with dams, navigation enhancement (dredging), industrial waste water discharge and other pollution, increase in fishing pressure and introduction of non-native species of fish clearly had negative impacts.

Seasonal migration of fishes in the Romanian Danube differs among species both to a temporal and spatial extent, but it is closely linked to water temperature and hydrological regime of the Danube (Ciolac 2004). The main migration for the non-anadromous species stretches from the main river to the flooded areas for spawning, where the offspring will either follow the retreating water and enter the main channel, or stay in waterbodies disconnected from the Danube until the next flood (Ciolac 2004). During dry summers, such water bodies potentially cause high mortality of fry due to their drying out or by oxygen deficiency caused by high decomposition of organic matter. Juveniles of species that spawn in the main river often utilize the floodplains and inshore habitat meaning that these areas are important also for the recruitment of these species. Reduction in connectivity between habitats and the total available area of floodplains have been suggested as some of the main drivers of the decline in the Lower Danube fisheries over the past years (Ciolac 2004; Schiemer et al. 2004). Recent findings of female *C. carpio* in the Danube nearby Galați (T. Ionescu 2014, unpub. data) together with high amounts of eggs in August long after regular spawning has been completed could be an indication of this species having a lack of suitable spawning areas in this part of the Danube.

Fish fauna at Fundu Mare Island

The extent of the aquatic habitat of Fundu Mare Island is dynamic and seasonal. The island is almost completely flooded during spring, and as the water resides, it creates a network of shallow lakes and channels. The water levels in these lakes and canals drop after the flood, depending on the amount of precipitation and water discharge in the Danube. In recent years the lakes have fallen completely dry during summer due to changes in seasonal water levels in the Danube. This had a likely negative impact upon the fish fauna.

Data in the area of Fundu Mare Island is available on behalf of professional fisheries reported in the periods 1952-1962 (Buşniţă 1967) and 1972-1986 (Florea 1998) and of scientific fishing in 2006-2008 (Liška et al. 2008; Gheorghe et al. 2010) and 2009-2010 (Geru et al. 2011; Sandu et al. 2013). These reports highlight the presence of a maximum of 44 species belonging to 12 families and 6 orders in and around Fundu Mare Island (Tab. 2, Annexes).

The lower number of species in the first two periods can be explained by the fact that the taxonomic structure was determined based on industrial catches. Industrial fishing targets species that are valuable economically, whereas small-sized species, insignificant from an economic point of view (but with high ecological value) are in the official records registered as either ”other species” or “small freshwater fish”. Also, in the earliest period (1952 - 1962) the three species of Asian Cyprinidae: grass carp, silver carp and bighead carp were not recorded. These species were imported to România for aquaculture in the 1960s (Manea 1985). Escapees of these species from aquaculture have reached the Danube and its tributaries and are now a common part of the river fish fauna. These three species of Asian Cyprinidae now potentially form naturally reproducing populations in the Lower Danube (Gavriloaie 2003).

The only species that was recorded during this period (1952-1962) and no longer appears in the later three periods of observation is the European eel (*Anguilla anguilla*). However, the European eel (*Anguilla anguilla*) has always been a rare species in România and has been fished in very small quantities. Eels in the Danube are likely to originate from stocking of juvenile eel, mainly common in the upper German part of the Danube Basin (Liška et al. 2008).

Of the 44 species caught in and around the Fundu Mare Island area, 12 were found in the lake on the island. Of these, nine were species preferring stagnant water and species without specialized affinity to current velocity. The last three species mainly live in lotic habitats but make seasonal habitat shifts between the river and backwaters. These species prefer spawning in aquatic vegetation. It is expected that 15 of the species found in the Danube (Tab. 2, Annexes) are eurytopic, limnophilic and rheophilic B and/or prefer spawning on or in aquatic vegetation on Fundu Mare floodplains (Fig. 15).

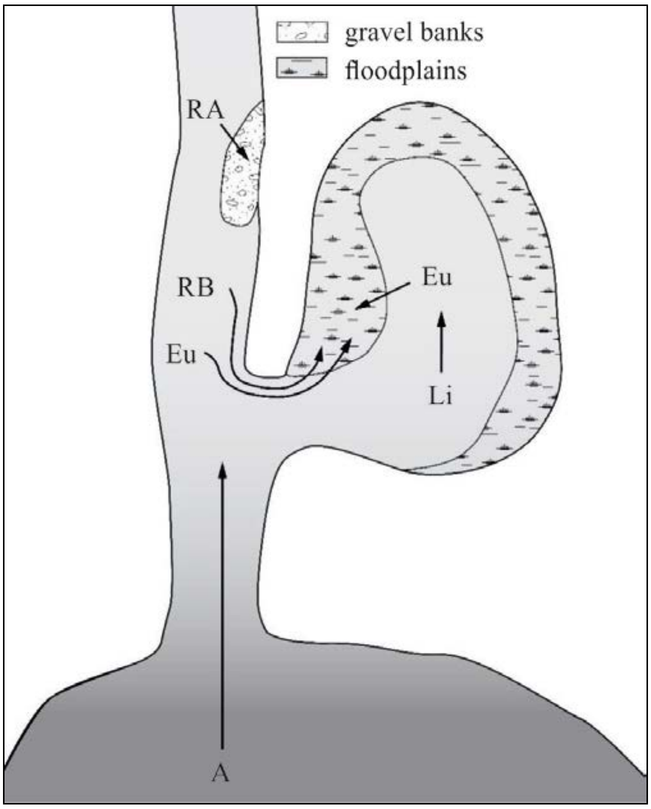
It is important to also beware of the numbers of species from the scientific fishing which are minimum estimates, as the choice of fishing methods and time of sampling influence the chance of catching various species. Of the species found in the surrounding waters, but not in the lakes of Fundu Mare Island, 15 have habitat preferences as well as spawning preferences that indicate that they potentially use the floodplains of Fundu Mare Island.

In order to ensure successful restoration of the Fundu Mare Island with regard to fish, one must ensure:

- hydrological conditions on the island to enable the inflow of water and fish during the spring flood;
- timing and duration of the flood to coincide with the optimum period of reproduction;
- connectivity to the Danube from the island lakes, allowing passage for

both spawning adults and the resulting juvenile fish.

Figure no. 15 Schematic presentation of habitat use of six fish guilds. RA: Rheophilic A, RB: Rheophilic B, EU: Eurytopic, Li: Stagnophilic, A: Anadromous species (adapded from Schiemer et al. 2004)



Bird fauna on Fundu Mare Island

In the period 2015-2016 a total of 114 species of birds were observed in the Chiriloaia area (Tab. 3, Annexes). Out of the total of the observed species, 59 are aquatic, of which 17 were monitored.

Aquatic species which do nest in the Chiriloaia mixt colony

Eight species from three different families nested in the mixt colony of Chiriloaia in the period 2015-2016: Phalacrocoracidae: *Phalacrocorax carbo* (Great Cormorant), *Microcarbo pygmaeus* (Pygmy Cormorant); Ardeidae: *Nycticorax nycticorax* (Night Heron), *Ardeola ralloides* (Squacco Heron), *Egretta garzetta* (Little Egret), *Ardea alba* (Great White Egret), *Ardea cinerea* (Grey Heron) and Threskiornithidae: *Plegadis falcinellus* (Glossy Ibis).

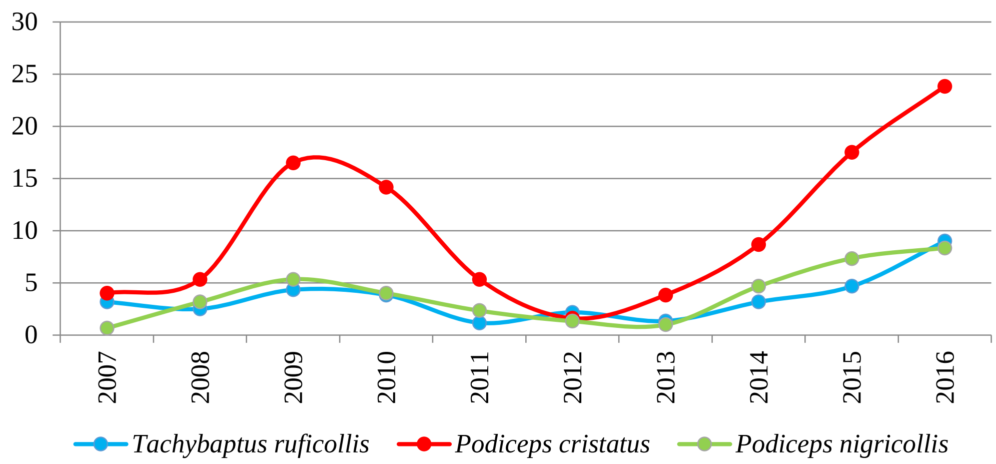
Except for the cormorants, which is a partially migratory species, all other are summer guests for Fundu Mare Island (Cătuneanu et al. 1978; Linția 1955; Onea 2011, 2015). In the milder winters, Great White Egret, Grey Heron and sometimes Pygmy Cormorant may be present in the area of Chiriloaia wetland or along the Danube's bank. The colony is formed even from the second half of March and is fully occupied in April, when all species are present (Onea 2011).

Our observations of the dynamics of the bird species in Chiriloaia wetland (Fundu Mare Island) show a depletion of aquatic nesting bird species starting in July-August, whereas some species continue and enhance their presence in the first autumn months. This phenomenon is caused mainly by the decrease of the water level in Chiriloaia wetland, which is in tight connection with the decrease of Danube water level and of the enhanced evaporation due to the high temperatures in summer time. This phenomenon was diminished as a consequence of the measures of blocking the flow of water out of the wetland at the level of the Hogioaia channel barrage. Therefore, for both 2015 and mainly 2016 the water of Chiriloaia wetland had a minimum to moderate level throughout the summer months and autumn (winter).

Allbeit the conditions in the 2015-2016 period illustrate an ordinary situation of life for the monitored aquatic species (and in general for all species present in the area in Chiriloaia wetland), the same cannot be said for the former period of time (2007-2014).

Our former observations (Onea 1995, 1996, 2001a, 2001b, 2002, 2007, 2009, 2011, 2014, 2015, as well as the unpub. data) indicate a huge variety of the dynamics of monitored bird species (Figs. 16, 17, 18, 19 and 20). During 2007-2008 and 2012-2013 for almost all species there was recorded a sharp depletion of their abundance as a consequence of the decrease in water level in Chiriloaia wetland up to total drainage of the aquatic basin.

Figure no. 16 Annual means for grebe species during 2007-2016



In some years, such as 2007 and 2008, high temperature with prolonged drought during the summer months led to a rapid drying of the Chiriloaia Lake, with only scattered small marshy areas remaining. The climatic conditions in these two years had a great impact on the population dynamics of all the aquatic bird species nesting in the lake. For example, the population of Great Cormorant dwindled from 320 pairs in 2007 to only 51 pairs in 2008 (Onea 2011).

In 2015-2016 there was managed a cease of the flow out of Chiriloaia wetland by means of certain makeshift works at the Hogioaia channel weir. This had as positive effect not only maintaining a minimum level of the water, but as well to preserve all monitored aquatic bird species in the region of the wetland.

Figure no. 17 Annual means for cormorant species during 2007-2016

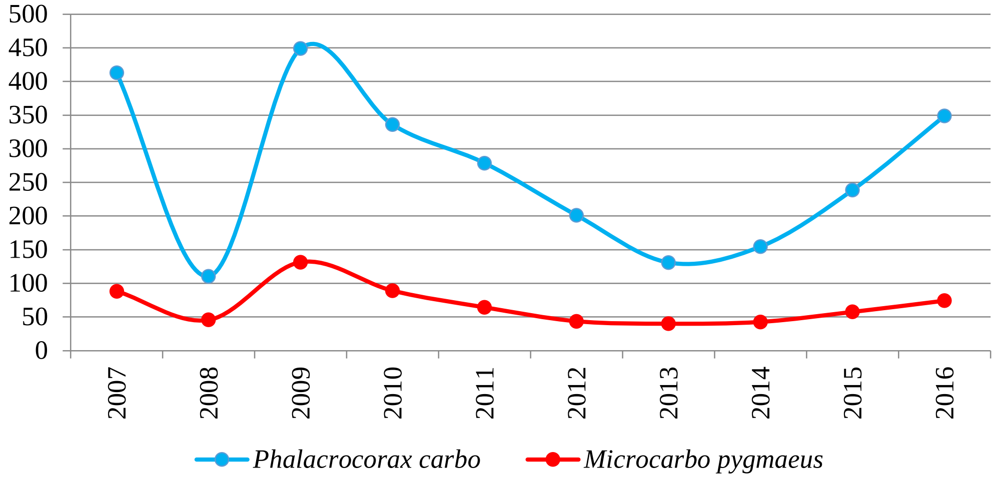
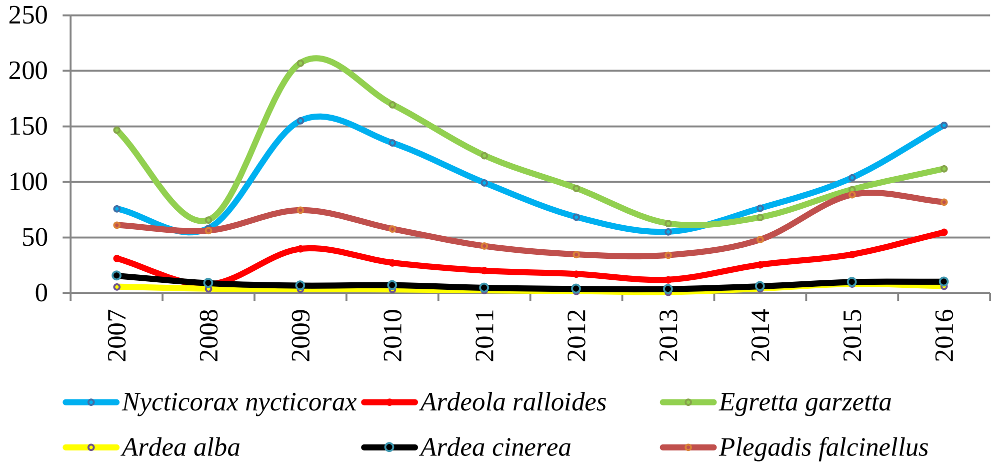


Figure no. 18 Annual means for heron species and Glossy Ibis during 2007-2016



For all species that breed in the aquatic vegetation of Chiriloaia wetland, the abundance of their populations is clearly higher during the two study years of monitoring compared to the former years. An exception is the species that nest in the mixt colony for which the maximum numbers recorded for 2007-2016 were higher in 2007 and 2009. See Zinke et al. (2017) for more details on the bird population dynamics in Chiriloaia Lake.

It is quite likely that, given the conditions of maintaining an optimum (medium) level of the water in Chiriloaia wetland, it might not be possible to witness significant variations of the effects on the aquatic bird populations, but a steadiness of these around some values which are to be optimized only by the weather conditions and their intra - and inter-specific relationships.

Figure no. 19 Annual means for Mute Swan and duck species during 2007-2016

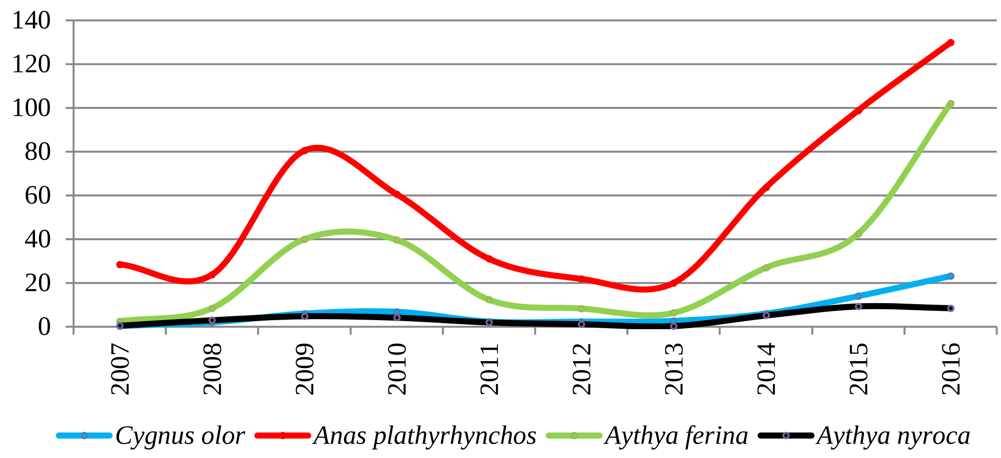
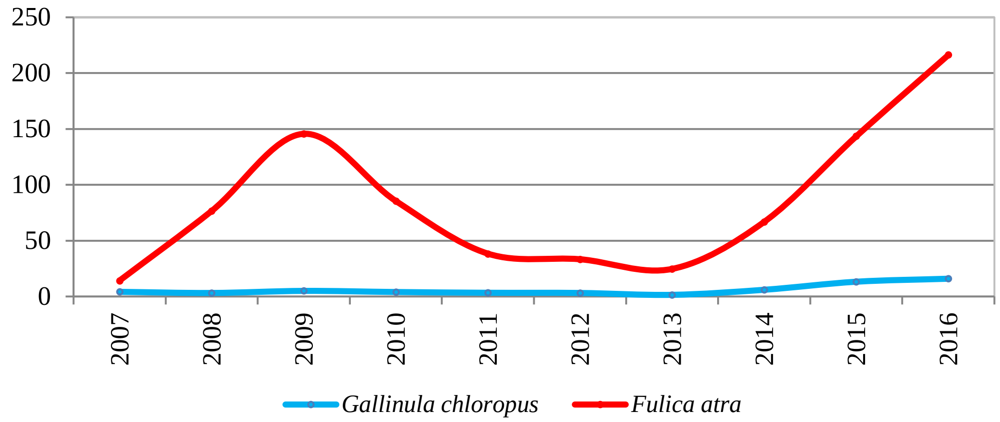


Figure no. 20 Annual means for Rallidae species during 2007-2016



Conclusions:

The interdisciplinary project investigated the ecological status of Fundu Mare Island and the potential measures for ecosystem restoration.

The on-going vegetation changes were analyzed by comparing nature types that have been mapped earlier with recent observations. It was found that the areas of massive willow development can be related to elevation zones that are affected by changes in the water level duration curve of the Danube.

The results suggest that changes in the flow regime of the Danube throughout the growing season play an important role for the vegetation changes on Fundu Mare Island, together with other influence factors. Recent observations of the fish fauna and birds of Fundu Mare Island have confirmed a close relationship between the Danube water level regime and wildlife.

The specific requirements of biota and the interaction between wetland vegetation, bird and fish were discussed during a project workshop in May 2016 in Trondheim (Norway), in which a group of 17 experts (9 of them from UGAL/România) including engineers, biologists, ecologists and administrative staff participated. The transdisciplinary expert group recommended building a moveable weir or a sluice in the Hogioaia channel in order to regulate the water in the wetland. The use of a moveable weir can allow for the adjustments to changing hydrological conditions and the needs of fish and birds. It is possible to try different regulation regimes for the weir and monitoring the effects on fish and birds to find the optimal solution. It was also recommended to control the discharges through the LIFE channel.

The installation of a movable weir in the LIFE Channel (instead of closing it) could have some advantages with respect to the unsteady flow processes during flooding. If the maximum water level of the spring flood is below (or just slightly above) the threshold levee elevation of about 5.6 MNS, the water entering the island has to advance through the channels, and it takes some time until the lakes are filled. With a movable weir in the LIFE-channel, this weir could be opened during the rising of the flood, so that the total discharge into the island would increase and the lakes fill up faster. The weir needs to be closed, however, during the falling limb of the flood, so that the water be stored in the lakes. This would require an advanced weir regulation facility that is automatically linked to the water level in the Danube, in combination with a monitoring of the island water levels.

There are still many open questions, particularly when it comes to sediment and water quality issues. For the practical implementation of the measures, the results of the short-term investigations within this project need to be combined with the detailed and long-term local knowledge and experience of the SWB Natural Park Administration, in order to find sustainable solutions. For a better understanding in the future of the interactions between the Danube and the ecological conditions on the island it is crucial to continue to update and improve the quality of the digital terrain model as well as to monitor the water levels, water temperature, sediment, vegetation, and biota at the island over longer time periods.

Rezumat:

IVESTIGAȚII HIDROLOGICE ȘI ECOLOGICE ÎN VEDEREA RESTAURĂRII COMPLEXULUI DE ECOSISTEME DIN INSULA FUNDU MARE

Insula Fundu Mare din Parcul Natural Balta Mică a Brăilei (România) este una dintre puținele insule din Sistemul Dunării de Jos, care se află într-o stare aproape naturală și prin urmare o importantă arie naturală protejată. În ultimii ani a fost observată o invazie masivă de salcie în câteva habitate care mai înainte au fost neocupate. S-a ajuns la concluzia că zonele în care a avut loc dezvoltarea sălciilor pot fi în strânsă legătură cu înălțimea terenului, care este influențată de schimbările survenite la nivelul apelor Dunării. Date și observații recente privind fauna de pești și păsările acvatice din Insula Fundu Mare au confirmat strânsa legătură dintre nivelul apelor Dunării și viața acestor animale. S-a sugerat o mărire a perioadei de inundație a insulei prin instalarea unor stăvilare pentru a regla scurgerea apei din lacurile insulei spre Dunăre. Funcționarea optimă a unor astfel de stăvilare ar trebui să echilibreze efectele asupra vegetației, avifaunei și ihtiofaunei.

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Annexes:

Table no. 2 Ichtyofauna taxonomic structure at different periods

No.	Scientific name / Family	Common name	CS (IUCN)	Frequence 1952-1962 A	1972-1986 B	2006-2009 C	2008-2011 D	Habitat preference	Reproductive guild
	Clupeidae								
1	*Alosa immaculata*	Danube shad	VU	+	+++	++	++	A	NA
2	*Alosa tanaica*	Black Sea shad	LC	-	-	+	+	A	NA
	Acipenseridae								
3	*Acipenser guldenstaedti*	Russian sturgeon	CR	+	+	+	+	A	A.1.2
4	*Acipenser stellatus*	Starry sturgeon	CR	+	+	+	+	A	A.1.2
5	*Huso huso*	Beluga sturgeon	CR	+	+	+	-	A	A.1.2
6	*Acipenser ruthenus*	Sterlet	VU	+	+	+	+	RA	A.1.2
	Cyprinidae								
7	*Cyprinus carpio*	Carp	VU	++++	+++	+++ (P)	+++	EU	A.1.5
8	*Leuciscus idus*	Ide	LC	+++	+	++ (Po)		RB	A.1.4
9	*Abramis brama*	Bream	LC	+++	++	++ (P)	++	RB	A.1.4
10	*Aspius aspius*	Asp	LC	+	+	++	+	RB	A.1.3
11	*Chalchalburnus chalcoides*	Danube bleak	NE	-	-	++	+	RA	A.1.3
12	*Abramis sapa*	White-eye bream	NE	-	-	++	++	RA	A.1.3
13	*Abramis ballerus*	Blue bream	NE	+	-	++	++	RB	A.1.4
14	*Carassius gibelio*	Gibel carp	NE	++	++++	+++ (Po)	++++	EU	A.1.5
15	*Carassius carassius*	Crucian carp	LC	+	-	1 ex (P)	-	LI	A.1.5
16	*Rutilus rutilus*	Roach	LC	++	+++	++ (P)	+	EU	A.1.4
17	*Tinca tinca*	Doctor fish	LC	+	-	. (P)	+	LI	A.1.5
18	*Scardinius erythrophthalmus*	Common rudd	LC	+	-	++ (P)	+	LI	A.1.5
19	*Alburnus alburnus*	Bleak	LC	+	++	++ (Po)	++	EU	A.1.4
20	*Blicca bjöerkna*	White bream	LC	++	++	++ (P)	++	RB	A1.5
21	*Vimba vimba*	Vimba bream	LC	+	-	++	+	RB	A.1.3
22	*Barbus barbus*	Common barbel	LC	++	+	++	+++	RA	A.1.3
23	*Ctenopharyngodon idella*	Grass carp	NE	-	+	++ (Po)	+	EU	A.1.1
24	*Hypophthalmichthys molitrix*	Silver carp	NE	-	+	++ (Po)	+++	LI	A.1.1
25	*Aristichthys nobilis*	Bighead carp	NE	-	-	+ (Po)	+	EU	A.1.1
26	*Pelecus cultratus*	Sichel	LC	+	+	+ (Po)	+	EU	A.1.1

27	*Chondrostoma nasus*	Common nase	LC	-	-	++	+	RA	A.1.3
28	*Squalius cephalus*	Chub	LC	-	-	++ (Po)	-	EU	A.1.3
	Siluridae								
29	*Silurus glanis*	Wels catfish	LC	++++	+++	++ (P)	+++	EU	B.1.4
	Percidae								
30	*Sander lucioperca*	Zander	LC	++	+	++ (P)	+	RB	B.2.5
31	*Sander volgense*	Volga zander	LC	-	-	++ (Po)	+	RB	B.2.5
32	*Gymnocephalus cernuus*	Eurasian ruffe	NE	+	+	++ (Po)	+	RB	A.1.4
33	*Perca fluviatilis*	European perch	LC	+	+	++ (P)	+	EU	A.1.4
34	*Gymnocephalus schraetser*	Schraetzer	LC	-	-	++	+	RA	A.1.4
35	*Zingel zingel*	Common zingel	LC	-	-	++	+	RA	A.2.3
36	*Zingel streber*	Streber	LC	+	-	++	+	RA	A.2.3
	Esocidae								
37	*Esox lucius*	Northern pike	LC	++	+	++ (P)	++	EU	A.1.5
	Gadidae								
38	*Lota lota*	Burbot	LC	+	-	+	-	RB	A.1.2
	Anguillidae								
39	*Anguilla anguilla*	European eel	CR	+	-	- (Po)	-	PA	NA
	Salmonidae								
40	*Salmo trutta*	Brown trout	LC	-	-	+	-	RA	B.2.3
	Gobiidae								
41	*Ponticola kessleri*	Bighead goby	LC	-	-	- (Po)	+	RB	B.1.3
42	*Neogobius fluviatilis*	Monkey goby	LC	-	-	- (Po)	+	RB	B.1.3
	Cobitidae								
43	*Misgurnus fossilis*	European weatherfish	LC	-	-	- (Po)	+	LI	A.1.5
	Centrarchidae								
44	*Lepomis gibbosus*	Pumpkinseed	LC	-	-	- (Po)	+	LI	B.2.2

Note: A-Industrial catches during 1952-1962 in Brăila-Călăraşi area (Buşniţă 1967); B-Industrial catches recorded in the official statistics (Florea 1998); C-Scientific fishing 2006-2009 (Gheorghe et al. 2010); D-Scientific fishing 2008-2011 (Geru et al. 2011); • Species reported as fished in the sector (NAFA official records): CS-conservation status: NE-not evaluated; LC-least concern; VU-vulnerable; CR-critically endangered; Percentage of catch: +: 0 - 2%; ++: 2-6%; +++: 6-15%; ++++: > 15%; P-present in Fundu Mare Island; Po-potentially in Fundu Mare Island.

Table no. 3 List of bird species observed on Fundu Mare Island (Chiriloaia wetland) during 2015-2016

			Ab%		F%		W%	
No.	Scientific name	Common name	2015	2016	2015	2016	2015	2016
1	*Tachybaptus ruficollis*	Little Grebe	0.23	0.37	66.67	83.33	0.15	0.31
2	*Podiceps cristatus*	Great Crested Grebe	0.89	0.99	83.33	100	0.82	0.99
3	*Podiceps nigricollis*	Black-necked Grebe	0.39	0.34	83.33	100	0.33	0.34
4	*Phalacrocorax carbo*	Great Cormorant	11.28	14.30	100	100	11.28	14.30
5	*Microcarbo pygmaeus*	Pygmy Cormorant	2.09	2.74	100	100	2.09	2.74
6	*Pelecanus onocrotalus*	Great White Pelican	1.96	1.82	66.67	50	1.31	0.91
7	*Ixobrychus minutus*	Common Little Bittern	0.10	0.08	66.67	83.33	0.06	0.06
8	*Nycticorax nycticorax*	Black-crowned Night-heron	5.24	6.24	100	100	4.80	5.20
9	*Ardeola ralloides*	Squacco Heron	1.77	2.29	83.33	83.33	1.48	1.91
10	*Egretta garzetta*	Little Egret	3.66	4.66	83.33	100	3.36	4.64
11	*Ardea alba*	Great White Egret	0.37	0.26	100	100	0.37	0.26
12	*Ardea cinerea*	Grey Heron	0.56	0.34	100	100	0.56	0.34
13	*Ardea purpurea*	Purple Heron	0.03	0.02	33.33	50	0.01	0,01
14	*Plegadis falcinellus*	Glossy Ibis	4.48	4.51	83.33	83.33	4.10	3.75
15	*Platalea leucorodia*	Eurasian Spoonbill	0.83	0.14	33.33	16.67	0.76	0.02
16	*Ciconia nigra*	Black Stork	0.03	0.01	16.67	16.67	0.01	0.01
17	*Ciconia ciconia*	White Stork	4.33	1.02	75	66.67	3.25	0.68
18	*Cygnus olor*	Mute Swan	0.60	0.64	100	100	0.55	0.64
19	*Anser albifrons*	Greater White-fronted Goose	1.50	6.61	8.33	16.67	0.12	1.10
20	*Anser anser*	Greylag Goose	0.03	0.06	8.33	16.67	0.01	0.01
21	*Branta ruficollis*	Red-breasted Goose		0.02		8.33		0.01
22	*Tadorna tadorna*	Common Shelduck	0.08	1.18	41.67	50	0.03	0.09
23	*Mareca strepera*	Gadwall	0.23	0.02	58.33	50	0.13	0.01
24	*Anas crecca*	Common Teal	0.07	0.12	33.33	50	0.02	0.06
25	*Anas platyrhynchos*	Mallard	4.06	4.40	100	100	4.06	4.40
26	*Spatula querquedula*	Garganey	0.09	0.08	25	33.33	0.02	0.02

27	*Spatula clypeata*	Northern Shoveler	0.04		25		0.01	
28	*Netta rufina*	Red-crested Pochard		0.01		16.67		0.01
29	*Aythya ferina*	Common Pochard	2.09	3.32	100	100	2.09	3.32
30	*Aythya nyroca*	Ferruginous Duck	0.50	0.35	83.33	83.33	0.42	0.29
31	*Haliaeetus albicilla*	White-tailed Sea-eagle	0.03	0.03	66.67	66.67	0.01	0.02
32	*Circus aeruginosus*	Western Marsh-harrier	0.03	0.03	58.33	66.67	0.02	0.02
33	*Circus cyaneus*	Hen Harrier		0.01		16.67		0.01
34	*Accipiter nisus*	Eurasian Sparrowhawk		0.01		16.67		0.01
35	*Buteo buteo*	Eurasian Buzzard	0.04	0.03	58.33	83.33	0.02	0.02
36	*Falco tinnunculus*	Common Kestrel	0.01	0.02	33.33	50	0.01	0.01
37	*Falco subbuteo*	Eurasian Hobby	0.07	0.03	83.33	66.67	0.05	0.02
38	*Falco peregrinus*	Peregrine Falcon	0.01	0.01	16.67	16.67	0.01	0.01
39	*Phasianus colchicus*	Common Pheasant	0.06	0.04	41.67	50	0.02	0.02
40	*Rallus aquaticus*	Western Water Rail	0.09	0.06	75	66.67	0.07	0.04
41	*Porzana porzana*	Spotted Crake	0.02	0.02	25	33.33	0.01	0.01
42	*Gallinula chloropus*	Common Moorhen	0.66	0.46	83.33	88.33	0.54	0.38
43	*Fulica atra*	Common Coot	6.87	7.55	100	100	6.87	7.55
44	*Himantopus himantopus*	Black-winged Stilt	0.02		8.33		0.01	
45	*Recurvirostra avosetta*	Pied Avocet	0.01		8.33		0.01	
46	*Charadrius dubius*	Little Ringed Plover	0.15	0.19	33.33	33.33	0.05	0.06
47	*Vanellus vanellus*	Northern Lapwing	0.10	0.09	58.33	50	0.06	0.04
48	*Calidris alba*	Sanderling	0.07		25		0.02	
49	*Limosa limosa*	Black-tailed Godwit	0.38	0.55	41.67	66.67	0.16	0.37
50	*Tringa totanus*	Common Redshank	0.04		16.67		0.01	
51	*Tringa stagnatilis*	Marsh Sandpiper	0.21	0.10	50	50	0.10	0.05
52	*Actitis hypoleucos*	Common Sandpiper	0.23	0.06	50	50	0.11	0.03
53	*Larus ridibundus*	Black-headed Gull	1.47	1.80	100	100	1.47	1.80
54	*Larus cachinnans*	Caspian Gull	1.16	1.10	100	100	1.16	1.10
55	*Chlidonias hybrida*	Whiskered Tern	1.41	0.87	83.33	66.67	1.29	0.58
56	*Chlidonias leucopterus*	White-winged Tern	0.01		8.33		0.01	

57	*Chlidonias niger*	Black Tern		0.02		16.66		0.01
58	*Sterna hirundo*	Common Tern	0.01	0.02	16.67	33.33	0.01	0.01
59	*Columba oenas*	Stock Dove	0.03		33.33		0.01	
60	*Columba palumbus*	Common Woodpigeon	0.05	0.04	66.67	83.33	0.03	0.08
61	*Cuculus canorus*	Common Cuckoo	0.16	0.12	66.67	66.67	0.10	0.08
62	*Alcedo atthis*	Common Kingfisher	0.42	0.50	91.67	100	0.39	0.50
63	*Merops apiaster*	European Bee-eater	1.33	1.39	25	16.67	0.33	0.23
64	*Coracias garrulus*	European Roller	0.01		16.67		0.01	
65	*Upupa epops*	Common Hoopoe	0.01	0.02	25	50	0.01	0.01
66	*Jynx torquilla*	Eurasian Wryneck	0.01		8.33		0.01	
67	*Picus canus*	Grey-faced Woodpecker	0.08	0.04	91.67	83.33	0.01	0.03
68	*Picus viridis*	Eurasian Green Woodpecker	0.06	0.02	75	66.67	0.04	0.01
69	*Dryocopus martius*	Black Woodpecker	0.06	0.04	75	100	0.04	0.04
70	*Dendrocopos major*	Great Spotted Woodpecker	0.13	0.07	100	100	0.13	0.07
71	*Dryobates minor*	Lesser Spotted Woodpecker		0.01		16.67		0.01
72	*Riparia riparia*	Sand Martin	0.67		8.33		0.05	
73	*Hirundo rustica*	Barn Swallow	2.05	1.34	83.33	66.67	1.71	0.89
74	*Delichon urbicum*	Northern House-martin	0.67		8.33		0.06	
75	*Motacilla flava flava*	Yellow Wagtail	0.22	0.07	58.33	66.67	0.13	0.05
76	*Motacilla alba*	White Wagtail	0.03	0.01	16.67	16.67	0.01	0.01
77	*Troglodytes troglodytes*	Winter Wren	0.04	0.01	41.67	33.33	0.02	0.01
78	*Erithacus rubecula*	European Robin	0.02	0.02	16.67	16.67	0.01	0.01
79	*Luscinia megarhynchos*	Common Nightingale		0.01		16.67		0.01
80	*Phoenicurus phoenicurus*	Common Redstart	0.26	0.10	66.67	66.67	0.17	0.06
81	*Ficedula hypoleuca*	European Pied Flycatcher	0.01	0.01	16.67	16.67	0.01	0.01
82	*Turdus pilaris*	Fieldfare	0.02		8.33		0.01	
83	*Locustella fluviatilis*	Eurasian River Warbler		0.01		16.67		0.01
84	*Locustella luscinioides*	Savi's Warbler	0.02	0.01	25	16.67	0.01	0.01
85	*Acrocephalus schoenobaenus*	Sedge Warbler	0.25	0.22	75	66.67	0.18	0.14
86	*Acrocephalus scirpaceus*	Eurasian Reed-warbler	0.50	0.46	83.33	66.67	0.41	0.30

87	*Acrocephalus arundinaceus*	Great Reed-warbler	1.94	0.10	91.67	83.33	1.78	0.66
88	*Hippolais pallida*	Eastern Olivaceous Warbler	0.02	0.01	25	16.67	0.01	0.01
89	*Sylvia curruca*	Lesser Whitethroat	0.40	0.16	83.33	66.67	0.33	0.10
90	*Sylvia communis*	Common Whitethroat	0.80	0.35	91.67	66.67	0.73	0.23
91	*Sylvia atricapilla*	Blackcap	0.22	0.16	66.67	66.67	0.14	0.10
92	*Phylloscopus collybita*	Common Chiffchaff	0.06	0.06	25	33.33	0.01	0.02
93	*Phylloscopus trochilus*	Willow Warbler	0.04	0.01	16.67	16.67	0.01	0.01
94	*Panurus biarmicus*	Bearded Parrotbill	0.02		25		0.01	
95	*Parus caeruleus*	Blue Tit	0.76	0.59	100	100	0.76	0.59
96	*Parus major*	Great Tit	1.96	1.35	100	100	1.96	1.35
97	*Sitta europaea*	Wood Nuthatch	0.04	0.03	50	66.67	0.02	0.02
98	*Certhia familiaris*	Eurasian Treecreeper	0.01		8.33		0.01	
99	*Oriolus oriolus*	Eurasian Golden Oriole	0.01		8.33		0.01	
100	*Lanius collurio*	Red-backed Shrike	0.72	0.63	66.67	66.67	0.48	0.42
101	*Garrulus glandarius*	Eurasian Jay	0.01		25		0.01	
102	*Pica pica*	Black-billed Magpie	0.12	0.17	75	100	0.09	
103	*Corvus frugilegus*	Rook	0.35	3.79	58.33	66.67	0.20	2.53
104	*Corvus corone cornix*	Hooded Crow	0.39	0.64	100	100	0.39	0.64
105	*Sturnus vulgaris*	Common Starling	4.70	3.19	100	83.33	4.70	2.66
106	*Passer domesticus*	House Sparrow	11.52	9.03	100	100	11.52	9.03
107	*Passer montanus*	Eurasian Tree Sparrow	3.51	3.90	83.33	100	2.93	3.90
108	*Fringilla coelebs*	Eurasian Chaffinch	0.67	0.31	100	100	0.66	0.31
109	*Carduelis chloris*	European Greenfinch	0.01		8.33		0.01	
110	*Carduelis carduelis*	European Goldfinch	0.18	0.14	75	100	0.14	0.14
111	*Carduelis cannabina*	Eurasian Linnet	0.01		8.33		0.01	
112	*Coccothraustes coccothraustes*	Hawfinch	0.01		8.33		0.01	
113	*Pyrrhula pyrrhula*	Eurasian Bullfinch		0.01		16.67		0.01
114	*Emberiza schoeniclus*	Reed Bunting	0.63	1.06	83.33	100	0.53	1.06

Note: Ab%= abundance; F%= frequency; W%= index of ecological significance (Dzuba index).