02.08 Fish Fauna (2014 Edition)

Overview

Berlin's waterscape was formed during the second, the so-called Brandenburg Stage of the Weichselian Glaciation, which ended about 10,300 years ago. The **Berlin Glacial Spillway** is part of the Glogau-Baruth Glacial Spillway, which extends along the Weichselian end moraines of the Brandenburg Stage. It starts at the mouth of the Prosna, where that river empties into the Warta in western Poland, and proceeds along the Obra to the Oder, along the Oder from Nowa Sól to the Bobr and the Neisse, and then from Forst across to the Spree around Lübben, over to Luckenwalde and Tangermünde, and finally to Brandenburg-on-the-Havel and down the lower Havel to the Elbe.

At the end of Weichselian Glaciation, the waters of the Vistula (Ger.: Weichsel), Warta and Oder, flowing northward from periglacial areas, were dammed by the inland ice and drained away toward the west, to where the Oder is today, and further toward the Havel and Elbe. Moreover, at all inland-ice protrusions as far west as the Ruhr District, there were connections between the Rhine, Weser and Elbe systems which were passable for aquatic organisms (Hantke 1993).

This postglacial waterway network made it possible for three lamprey species and 33 fish species to populate the bodies of water of what is today the state of Berlin (Wolter et al. 2003). These species are considered the original or **indigenous fish fauna of Berlin**.

Due to their low gradient, the lowland rivers were early the object of **hydraulic engineering impairments** such as dams, weirs or canal connections between different river watersheds, which reached an initial climax during the Middle Ages. Once, the hydrodynamics of the Spree and the Havel characterized Berlin's water network; later, these rivers were increasingly dammed and regulated. The **construction of dam facilities** along river and creek courses began during the early days of the Askanian dynasty, which founded the Markgravate of Brandenburg in the 1^{0th} century (Driescher 1969). In Berlin, dam construction for the operation of mills can be traced back at least to the 13th century. The first documentary mention of a mill dam is in 1261 at Spandau. In 1285, there was a water-mill in Berlin, and the Berlin Mühlendamm ("mill dam")(Uhlemann 1994) is certified for October 28th 1298. However, a 1232 document indicates that a dam facility already existed in Spandau at that time (Natzschka 1971, Driescher 1974).

Many dam facilities are moreover probably considerably older than their first documentary mention would have us suspect. In 1180 for example, Spandau Castle and its castle town were moved about 1.5 km up the Havel, to today's Old Town Island, due to a disastrous rise in the water level of the Havel caused by a mill dam at the city of Brandenburg, which already existed earlier than 1180 (Müller 1995).

In addition to mill dams, other dam facilities for the regulation of the water level and the promotion of navigation were also built. The **straightening of single river sections** already began during the 17th century. The lower Havel - for fish, the main colonization pathway into the Berlin waters - was regulated comprehensively for the first time between 1875 and 1881. In the context of the "Melioration of Receiving-Stream and Navigation Conditions on the Lower Havel" of 1907-1913, not only new breakthroughs and cross-section enlargements, but also three additional dam facilities were built at Grütz, Gartz (both 1911) and Bahnitz (1912).

By 1914, the **Havel was fully channelized as far as Spandau**, with a channel depth of at least 2 m ensured, even at low water levels. This regulation led to a dramatic **collapse of the fish populations**, and thus almost to the death of the Havel fishing industry. At that time, 1100 fishermen lost their livelihoods on an 80-km stretch of the Havel, and sued for compensation (Kotzde 1914). It was now no longer possible for migrating fish to overcome the weirs, even at high water levels, and to reach the Berlin area. The dam facilities not only interrupted vitally necessary migration routes, but also destroyed valuable habitat structures in the streams, as well as the flooding areas necessary for many fish species. The flow speed was cut, so that fine-grained material was deposited in the sediment, causing the coarse-grained sediments to be overlain with mud. Oxygen-consuming degradation processes in the stream-beds became predominant. For fish species which prefer a gravelly substratum rich in oxygen, there were no longer suitable spawning grounds and habitats, and no possibility of carrying out compensatory migration, so that e.g. the barbel, a typical river fish which had formerly been the dominant fish species, became extinct in the lower and middle Spree. By the end of the 19th century, the waters of the **Spree** in Berlin changed their character from that of a **classic barbel area** to that of a **bream area** (Wolter et al. 2002).

In addition to these permanent impairments caused by waterway melioration, immissions of all kinds had an effect on long-term aquatic conditions. Even before the turn of the century, the pollution of the Spree and the Havel by industrial and municipal wastes and from excrement was so heavy that fish death was common, and fishing was seriously impaired. For instance, due to the poor oxygen supply of the water, it became impossible to transport living fish to Berlin (i.e., today's central Berlin) in the water from the Lower Havel in so-called drebels, i.e. boats with open, flow-through fish boxes; they died on the way. The establishment of city sewage farms provided only limited remedy of the water quality situation. Pollution was particularly dramatic in the Spree, which received so much sewage immission on its way through Berlin that all animal life on the river bed was eliminated below the Charlottenburg sluice (Lehmann 1925). These anthropogenic effects caused additional **impoverishment of the Berlin fish fauna**. In addition to the migrating lampreys and fish species and the barbel, other species which required fast-flowing and oxygen-rich water, such as the pond lamprey and vimba bream, died out in Berlin waters. The eutrophication caused or promoted by nutrient immissions favoured euryecoid (environmentally tolerant) fish species, whose increase often concealed the decline of more demanding species.

These effects of the historical impairment of the bodies of water in Berlin on the fish fauna were summarizing in 1993 in the first complete Berlin edition of the Environmental Atlas (edition 1993), and in supplementary booklets (Vilcinskas & Wolter 1993, 1994 and Wolter et al. 2003).

In the 2014 Edition, unlike previous editions, the bodies of water are no longer to be evaluated on the basis of the number of verified fish species by water body type. With the entry into force of the European Water Framework Directive (WFD) in 2000, the goal is the good ecological condition and/or the good ecological potential of all surface bodies of water. Since 2004, in accordance with the WFD, bodies of water are to be evaluated not on the basis of the number of fish species which occur in them, but rather on the basis of the stock of species or ecological guilds, species frequency, gild distribution, age structure, migration patterns, fish regions and dominant species (SenStadt 2004).

In the 2014 Edition, the catch data of the Fishing Agency have for the first time been linked with the bodies of water in the Directory of Water Bodies. In addition to the fish species verified by water body during the period 2003 through 2013, the water body types (river lakes, streams, standing bodies of water), and the measurement points in bodies of water are shown. The fish species are shaded in accordance with their degree of endangerment under the Berlin Red Data Book (2013), and identified as neozoa if appropriate.

In addition to the evaluation of the fishing statistics of the Berlin Fishing Agency, which are referenced to the particular bodies of water, the current species referenced evaluation was published as a brochure in 2013.

Tab 1: Occurrence and endangerment of attested fish species, 1993, 2003, 2013										
		Occurrence 1993		Occurrence 2003		Occurrence 2013		Threat category as per Berlin Red Data Book 2013	Threat category as per nationwide Red Data Book	Habitat Directive Annex
Number of bodies of water investigated		151		170		153				
Fish species		Number of bodies of water with occurrence	Proportion of of bodies of water with occurrence [%]	Number of bodies of water with occurrence	Proportion of of bodies of water with occurrence [%]	Number of bodies of water with occurrence	Proportion of of bodies of water with occurrence [%]			
Asp	Aspius aspius (Linnaeus, 1758)	34	22,5	36,0	21,2	32,0	20,9	Least concern (*)	Least concern (*)	II, V
Bitterling	Rhodeus amarus (Bloch, 1782)	10	6,6	2,0	1,2	17,0	11,1	Vulnerable (3)	Least concern (*)	II
Bleak	Alburnus alburnus (Linnaeus, 1758)	61	40,4	75,0	44,1	56,0	36,6	Least concern (*)	Least concern (*)	-
Bream	Abramis brama (Linnaeus, 1758)	88	58,3	96,0	56,5	72,0	47,1	Least concern (*)	Least concern (*)	-
Brook trout	Salvelinus fontinalis (Mitchill, 1814)					1,0	0,7	Neozoa		
Brusque	Perca fluviatilis Linnaeus, 1758	100	66,2	115,0	67,6	103,0	67,3	Least concern (*)	Least concern (*)	-
Bullhead	Ameiurus nebulosus (LeSueur, 1819)	3	2,0	3,0	1,8	2,0	1,3	Neozoa		
Burbot	Lota lota (Linnaeus, 1758)	20	13,2	21,0	12,4	12,0	7,8	Vulnerable (3)	Near threatened (V)	-
Carp	Cyprinus carpio Linnaeus, 1758	75	49,7	77,0	45,3	25,0	16,3	Least concern (*)	Least concern (*)	-
Catfish	Silurus glanis Linnaeus, 1758	18	11,9	28,0	16,5	10,0	6,5	Least concern (*)	Least concern (*)	-
Chub	Leuciscus cephalus (Linnaeus, 1758)	15	9,9	7,0	4,1	7,0	4,6	Vulnerable (3)	Least concern (*)	-
Crucian	Carassius carassius (Linnaeus, 1758)	85	56,3	69,0	40,6	52,0	34,0	Endangered (2)	Endangered (2)	-
Dace	Leuciscus leuciscus (Linnaeus, 1758)	12	7,9	12,0	7,1	12,0	7,8	Vulnerable (3)	Least concern (*)	-
Eel	Anguilla anguilla (Linnaeus, 1758)	86	57,0	99,0	58,2	76,0	49,7	Not evaluated	Not evaluated	-
Gibel carp	Carassius gibelio (Bloch, 1782)	63	41,7	66	38,8	52	34,0	Least concern (*)	Least concern (*)	-
Gold orfe	Leuciscus idus auratus (Bade, 1901)					1	0,7	Neozoa		
Goldfish	Carassius auratus (Linnaeus, 1758)	10	6,6	9	5,3	9	5,9	Neozoa		
Grass carp	Ctenopharyngodon idella (Valenciennes, 1844)	18	11,9	6	3,5	3	2,0	Neozoa		
Gudgeon	Gobio gobio (Linnaeus, 1758)	48	31,8	47	27,6	49	32,0	Near threatened (V)	Least concern (*)	-
Ide	Leuciscus idus (Linnaeus, 1758)	32	21,2	43	25,3	38	24,8	Least concern (*)	Least concern (*)	-
Loach	Cobitis taenia Linnaeus, 1758	3	2,0	10	5,9	13	8,5	Near threatened (V)	Least concern (*)	II
Marble carp	Hypophthalmichthys nobilis (Richardson, 1845)			4	2,4	1	0,7	Neozoa		
Moderlieschen	Leucaspius delineatus (Heckel, 1843)	41	27,2	47	27,6	48	31,4	Least concern (*)	Near threatened (V)	-

Nine-spined stickleback	Pungitius pungitius (Linnaeus, 1758)	19	12,6	19	11,2	13	8,5	Near threatened (V)	Least concern (*)	-
Pike	Esox lucius Linnaeus, 1758	84	55,6	98	57,6	104	68,0	Least concern (*)	Least concern (*)	-
Pike-perch	Sander lucioperca (Linnaeus, 1758)	60	39,7	60	35,3	32	20,9	Least concern (*)	Least concern (*)	-
Pumpkinseed	Lepomis gibbosus (Linnaeus, 1758)					5	3,3	Neozoa		
Rainbow trout	Oncorhynchus mykiss (Walbaum, 1792)	17	11,3	4	2,4			Neozoa		
Roach	Rutilus rutilus (Linnaeus, 1758)	102	67,5	116	68,2	111	72,5	Least concern (*)	Least concern (*)	-
Rudd	Scardinius erythrophthalmus (Linnaeus, 1758)	78	51,7	93	54,7	93	60,8	Least concern (*)	Least concern (*)	-
Ruffe	Gymnocephalus cernuus (Linnaeus, 1758)	60	39,7	71	41,8	42	27,5	Least concern (*)	Least concern (*)	-
Silver carp	Hypophthalmichthys molitrix (Valenciennes, 1844)	15	9,9	7	4,1	4	2,6	Neozoa		
Smelt	Osmerus eperlanus (Linnaeus, 1758)	13	8,6	10	5,9	15	9,8	Near threatened (V)	Near threatened (V)	-
Stone loach	Barbatula barbatula (Linnaeus, 1758)					1	0,7	Extremely rare (R)	Least concern (*)	-
Stone moroko	Pseudorasbora parva (Temminck & Schlegel, 1846)					2	1,3	Neozoa		
Tench	Tinca tinca (Linnaeus, 1758)	80	53,0	95	55,9	89	58,2	Least concern (*)	Least concern (*)	-
Three-spined stickleback	Gasterosteus aculeatus Linnaeus, 1758	58	38,4	59	34,7	28	18,3	Least concern (*)	Least concern (*)	-
Weatherfish	Misgurnus fossilis (Linnaeus, 1758)	8	5,3	5	2,9	13	8,5	Endangered (2)	Endangered (2)	II
White bream	Abramis bjoerkna (Linnaeus, 1758)	74	49,0	79	46,5	47	30,7	Least concern (*)	Least concern (*)	-

Tab. 1: Occurrences and endangerment of verified fish species in Berlin 1993, 2003, 2013

The numbers for the Berlin/nationwide Red Data Book reflect the German categories, which provide information on the national or regional, as opposed to the worldwide, status of a species. In some cases, these are designated with the same names as the German translations of the international categories in English, and these English terms are then given here. The term "Extremely rare" is a purely German category. The term translated here as "Near threatened" (an international Red Data Book category) is however a German category, "Vorwarnliste", or "Preliminary warning list".

The implementation of Directives of the Council of the European Union places in some cases very far-reaching requirements on the quality of fish stock data and recording. Thus for example, Council Directive 92/43/EEC of May 21st 1992 Concerning the Preservation of Natural Habitats as well as Wild Fauna and Natural Flora (Abl. L 206) - the "**Habitat Directive**", for short - includes an Appendix II "Animal and Plant Species of Community Interest, for the Preservation of which Special Reserves Must Be Certified" (as amended by Directive 206/105/EC of November 20, 2006). This Appendix II of the EC Directive also lists four of the species of fish currently occurring in Berlin: the **bitterling, asp, weatherfish and loach**.

With the European Water Framework Directive (EC-WFD) of October 23rd 2000, fish fauna for the first time were adopted into the European statutory framework as a biological quality component for the ecological condition of bodies of water. On the basis of the **species inventory, frequency (abundance) and age structure of the fish fauna**, as well as of the existence of type- specifically disturbance-sensitive species of fish, the ecological condition of lakes and streams is to be assessed. The goal of the EC-WFD is to achieve a **good ecological condition** in all surface bodies of water, and of good ecological potential in all artificial and strongly anthropogenically affected bodies of water, by 2015. If these ecological conditions cannot be achieved by 2015, it will be possible to extend the deadline twice until 2027. The results from the monitoring operations under the Habitat Directive and the Water Framework Directive will be incorporated into the Environmental Atlas.

Statistical Base

The present map shows an overview of the current state of knowledge of the fish populations of the Berlin bodies of water through **December 2013**. After 2003 (02.08 edition 2004), the recording process of the fish population continued consistently in the Berlin waters. Between 2003 and 2013, numerous recording data were updated and new bodies of water, particularly small streams, examined (SenStadtUm 2013a). For the presentation of the current stock situation of the Berlin fish fauna, **over 900 catch data from 153 bodies of water** were evaluated. The stock-taking is **representative**, since it contains all major streams and lakes in Berlin, as well as more than fifty of a wide variety of smaller bodies of water. During the **recording time period through December 2013**, each smaller body of water was fished at least once, and each major one repeatedly, in some cases annually, in some cases at different seasons. All bodies of water were electrically fished. In addition, in the larger bodies of water, fixed nets, fish traps, dragline nets and trawl nets were also used.

By means of the combined use of different types of equipment, the difference in the catch selectivities of the various measurement methods is compensated, which increases the recording precision of the fish population. Particularly in canals and in places with artificial bank reinforcements, the combination of electro-fishing and stationary nets has proven itself; in lake-like river widenings and in areas with unspoiled shore structures, trawl nets are most useful (Doetinchem & Wolter 2003).

The **fishing procedure** has been carried out according to the usual good practice. Wadable trenches and small bodies of water were fished with a portable DC-powered impulse device, while for larger and deeper bodies of water, a boat with a DC-power unit and partial multi-mesh gillnets are used. The shoreline was sampled with electrofishing device in each case, depending on the breadth of the body of water, the structural variety and the catch success, with the goal of verifying the species spectrum as completely as possible.

Electric fishing is the most efficient of all catch methods, especially for bed substrata such as large rocks, rocky deposits or plant formations. Used correctly, it is also the **least disruptive method** for recording a fish population, since the fish have the least contact with net material, etc., and thus show hardly any injuries to their scales or mucous membranes. With the aid of a DC-power unit, an electrical field is produced in the water. Fish situated within it receive various voltages, depending on their length and position relative to the lines of force. Depending on the voltage they receive, their reactions range from flight through positive electrotaxis (swimming toward the anode) to electronarcosis. The effective radius of the catch electrode is approx. 2 m, so that pelagic (free-water-living) species and large, shy individuals of all species are under-represented in the catch, due to their greater flight distance. Moreover, the selectivity of electric fishing is altogether far lower than that of other methods, given comparable work and time expenditure.

For the **catch evaluation**, the species were determined and the individuals counted and measured, and also weighed on a sample basis. Fish larvae and young fish of the same age are for the most part not considered in determining species frequencies, since they have not been included representatively using the chosen fishing methods and the sample size. However, they were registered for species and reproduction verification.

Methodology

Fish are comparatively long-living, mobile organisms which represent several trophic levels (levels in the food chain) and are dependent on various, different water habitats in the course of their development or their life cycle. Due to their distinctive habitat requirements, fish have been included in the EC-WFD as **biological indicators for the structural variety of the surface bodies of water**. **High diversity of indigenous (local) species** of fish typical for the body of water indicates the **good ecological quality** of that water, according to the **EC-WFD**, i.e. the intactness of a water ecosystem and thus also its value for species and biotope protection.

It must be taken into account that only with the verification of **natural reproduction** is the existence of a population verified. As a rule, the proof of a **high number of species** of fish is the basis for a positive assessment, since this – provided it is not caused by stocking measures – indicates the existence of a variety of available habitats and resources, and hence of great structural variety.

The existence of stable populations of **threatened species** of fish is also grounds for a positive assessment. As a rule, they make the greatest demands upon their habitats, and therefore are affected most strongly by negative factors. As a result, the **threat level of a species** in the current Red Data Book is suitable as an indicator for the protection-worthiness of a habitat.

By contrast with previous editions, the 2014 Edition has undertaken no ichthyological assessment of the bodies of water based on the relationship between attested fish species and the average number of species per body of water type. However, the **type assessment** of the bodies of water and the numbers of fish species in each has been retained.

Also retained was the **level of threat**, according to the current Berlin Red Data Book (2013).

In the first version, **nine types** had been established (Wolter & Vilcinskas 1993), based on the factors genesis of the bodies of water, surface-area, networking, type and continuity of water supply, and settlement possibilities for fish species, and since these have proven useful, they have been retained. They are:

- streams
- river lakes
- natural inland lakes
- artificial inland lakes
- retention basins
- canals
- trenches
- sewage-treatment plant discharge channels

Artificial lakes and rain retention basins constitute an ichthyologically independent type of body of water, since their fish occurrences are at least initially, and as a rule continually, based on stocking, and thus reflect neither a settlement history nor a body-of-water specific population development.

Sewage-treatment-plant discharge channels and rain retention basins are the bodies of water, flowing and standing respectively, with the highest level of melioration. Moreover, the former differ from the other types by a water level which remains relatively constant over the course of the year, while comparable creeks and trenches regularly dry out.

The category of **small bodies of water** includes all standing ponds, tarns, meres, kettle-holes and the like with an area of up to one hectare. All other categories are self-explanatory.

Map Description

During the recording period of 2003-2013, **38 species of fish** were verified in the state of Berlin, including nine non-local species. Compared with 2003, the species inventory was expanded by five more species, of which four are neozoans (foreign species). These include the brook trout, the stone moroko, the pumpkinseed and the gold orfe. Moreover, the native stone loach, a species which had disappeared from the territory of the state of Berlin since 1920, was attested again for the first time in 2010 in the Berlin segment of the Neuenhagen Millstream (Erpe).

On the other hand, one non-indigenous species, the rainbow trout, can no longer be ascertained.

As in the 2004 edition, the systematics of European freshwater fish by Kottelat (1997) has been used here. Also used in the definition of non-indigenous species. As a result, the scientific species names of several fish species have been changed, by comparison with the last edition of the map. Besides this editorial change, the view of a species as not local (non-indigenous, neozoans) has been fundamentally changed. As the result of an international working group on Neozoans/ Neophytes, **the year 1492**, the official discovery of the "New World" by Columbus, has been established as the threshold year for the determination of a **species as non-indigenous**, since after this, the exchange processes of goods, commodities and also biota increased immensely between the continents. Species of fish naturalized after 1492 are regarded as non-indigenous, not local (Kinzelbach 1996, Kowarik 2003).

In contradiction to this, the **Berlin State Fishing Regulation** (LFischO Berlin) has, for purposes of simplification of economic stocking measures of the fish industry (abolition of approval requirements), established all species of fish naturalized since **1900** as native. With reference to finish stocking regulations, stocking of native fish species is legally subject to notification, and for non-native and nonindigenous species, authorization is required from the Subordinate Fishing Authority. The species carp and gibel carp, which are economically significant in Berlin, particularly for fishermen, are no longer viewed as non-indigenous, as they were in the 1993 Edition, since they demonstrably settled the Elbe watershed area, including the Havel and Spree, between 530 and 1100 (Hoffmann 1994).

Tab. 2: Number of Berlin bodies of water with occurrences of attested fish species

No. on Map	Fish species	Type of body of water									Total
		River lakes	Inland lakes		Retention basis	Small waters	Streams	Canals	Ditches	Sewage plant channels	
			nat.	artif.							
		Number of bodies of water investigated									
		15	32	9	1	48	13	13	20	2	153
01	Crucian	5	16	2		18	7		3	1	52
02	Weatherfish	2				2	4		5		13
03	Burbot	7		1			2	2			12
04	Bitterling	1	7	3		3	2			1	17
05	Chub	4					2			1	7
06	Dace	6					2	2	1	1	12
07	Stone loach									1	1
08	Smelt	11	1				3				15
09	Gudgeon	12	14	1		3	10	4	3	2	49
10	Loach	6	2	1					3	1	13
11	Nine-spined stickleback		1				7		5		13
12	Ide	11	2	1			6	11	6	1	38
13	Brusque	15	26	8	1	19	13	13	6	2	103
14	Bream	15	18	5	1	9	8	9	5	2	72
15	Three-spined stickleback	6	2			3	9	2	5	1	28
16	Gibel carp	10	6	4		17	9	2	3	1	52

17	White bream	12	15	1		4	6	6	3		47
18	Pike	12	28	8	1	22	13	10	9	1	104
19	Carp	5	9	3		4	3	1			25
20	Ruffe	15	5	1		1	5	9	5	1	42
21	Moderlieschen	4	16	2		17	7	1		1	48
22	Roach	15	29	9	1	23	13	13	6	2	111
23	Asp	12	1	1			5	9	4		32
24	Rudd	12	26	8		23	12	8	3	1	93
25	Tench	8	28	6		23	10	5	8	1	89
26	Bleak	13	15	3		3	7	8	5	2	56
27	Catfish	6	2	1			1				10
28	Pike-perch	14	3	1		1	5	7		1	32
29	Eel	15	18	7		3	11	13	7	2	76
30	Brook trout									1	1
31	Stone moroko					1	1				2
32	Goldfish		4			4				1	9
33	Gold orfe					1					1
34	Grass carp	2				1					3
35	Marble carp	1									1
36	Silver carp	4									4
37	Pumpkinseed	2		1		1				1	5
38	Bullhead					1	1				2
Total		31	25	23	4	25	29	20	20	24	38

Tab. 2: Number of Berlin bodies of water with verified presence of fish species

The most frequent species of fish in Berlin bodies of water are still the **roach, brusque** and, for the first time in 2013, also the **pike**. These three species are followed closely by **eel, bream, tench and rudd**, all of which show different development tendencies (Tab. 1).

The current Red Data Book of fish and cyclostomata in Berlin shows a positive development tendencies compared with the Red Data Book of 2005. A total of eleven species were assigned a lower threat level, i.e., their populations have developed positively, and twenty-three species have remained unchanged. For not one single species has the categorization, and hence the assessment of threat level, become worse (cf. Tab. 1, SenStadtUm 2013a).

The most dramatic population decline involved the **crucian**, with 16 eliminated occurrences over the past ten years, for which reason this species is still classified as endangered in the current Red Data Book. Under the most recent amendment to the Berlin State Fisheries Regulation (LFischO) in 2012, a year-round protection period for the crucian was introduced.

The decline in occurrences of the neozoans the **grass carp, marble carp and silver carp** was comparably dramatic, albeit from a conservationist viewpoint not undesirable. These species cannot reproduce naturally in Berlin waters, and may no longer be stocked.

Two other Habitat-Directive species, the **loach** and the **weatherfish**, also showed a strong increases in Berlin.

Since Berlin's bodies of water have hardly changed at all structurally – the degradation of the Spree has even increased in the government district construction area – the **increase in fish species** can particularly be explained by an **improvement in water quality**. One reflection of this is the relatively high number of species moved to **lower-threat categories in the Red Data Book**, and also that the "mass fish problem," widely discussed in 1993, is now a thing of the past. Today, the so-called white fish show good to very good individual growth, which is particularly also due to good white fish management.
Here, the use of phosphate-free detergents, the full-scale introduction of phosphate elimination or precipitation in sewage treatment plants, as well as reduced agricultural fertilizer use in the Spree and Havel watershed areas have had a positive effect on the **reduction of the nutrient burden** in the bodies of water. How considerably the phosphate load has been reduced can e.g. be seen from the

fact that the estimation of per capita daily use has been corrected from 4.2 g of phosphorus per day (g P/d) to 1.8 g P/d, as a result of the widespread availability of phosphate-free detergents and efficient phosphate elimination in sewage-treatment plants (Behrendt et al. 1999). Moreover, the ongoing measures for the rehabilitation of the Berlin **mixed-water sewage system** are contributing to further relief for the bodies of water. Mixed-water overflows, during which untreated sewage water and polluted rain water during heavy rainfalls flow directly into the bodies of water, may lead to fish kills. In the water, bacteria immediately decompose the organic material, consuming oxygen in the process. During heavy rainfall and the accompanying massive mixed-water overflows, the consumption of oxygen is so high that whole sections of waters are free of oxygen. **Fish kills** are unavoidable. Due to extensive measures during recent years, the mixed-water overflows have already been reduced considerably, so that situations critical for fish are significantly less common than has been the case in the past. The rehabilitation measures will last through 2020. Moreover, the Berlin Senate operates an **aerating ship**, which provide artificial input of oxygen if the values drop during the summer. The regular monitoring of summertime oxygen conditions are carried out by **stationary online-measuring probes supplemented by longitudinal profile cruises during critical weather periods**.

In addition to these direct measures for the improvement of water quality and oxygen conditions, the fish have also profited from the Berlin **reed-bed protection programme**, the efforts to plant and service **pike-spawning meadows**, e.g. in the Tiefwerder meadows, and the carp, tench and pike **stocking measures** financed by all licensed fishing people through the sale of fishing tickets. In addition restocking with the European eel are carried out within the framework of an EU-funded project.

Brief Characteristics of Selected Berlin Bodies of Water

River Lakes

Some 30 km of the **Havel** and its lake-like expansions are located in the Berlin municipal area. The Spandau barrage weir, which has existed since before 1232, separated the **upper Havel**, including Nieder-Neuendorf and Tegel Lakes, from the **lower Havel**, including the Scharfe Lanke, Stössen Lake, Jungfern Lake and Great Wannsee. The **Little Wannsee chain** lies in an ancillary ice-age spillway, and includes the Little Wannsee and Pohle and Stölpchen Lakes. These bodies of water are similar both morphologically and hydrologically, and can be considered outflow or river lakes. The total area of the Havel lakes is more than 2000 ha, with Pohle and Stölpchen Lakes the smallest with 10 ha each, and Tegel Lake the largest with about 400 ha. All bodies of water mentioned were tested in the course of the Berlin ichthyological survey. The Havel lakes are among the **Berlin bodies of water with the highest number of species of fish**, with up to 24 species in some waters on the lower Havel, and a total of **31 fish species altogether**. The large number of fish species in the river lakes has a number of **causes**. On the one hand, as mentioned above, there are **both flowing and still water areas**, so that in addition to the ubiquitously present eurytopic species, both lentic species (preferring still water) and lotic species (preferring flowing water) can find suitable living conditions. Moreover, despite major anthropogenic impairments, relatively **variegated shore structures** can still be found.

Apart from widespread structures of every kind (bung walls, footbridges, moorings etc.), there are also flat, weeded bays and reed-beds, which serve the fish as spawning grounds and their brood as growth areas.

In addition, eel, pike and carp are regularly **stocked**. The Havel waters are a **waterway of the first order**, i.e. they are used by professional navigation. Moreover, they are heavily used by professional and sports fishermen as well as by water-sports enthusiasts and relaxation seekers.

In addition to the Havel, the **Spree and Dahme** also have lake-like expansions. Along the Dahme are the **Langer and Zeuthen Lakes and the Great Krampe**. Seddin Lake is fed with Spree water through the Gosen Canal; the Spree flows through all the other bodies of water examined (**Rummelsburg Lake, the Great and Little Müggel Lakes, Dämeritz Lake and the Bänke**). The last-named lakes occupy an area of 952 hectares together, with their size ranging between 15.8 hectares (**Little Müggel Lake**) and 770 hectares (**Great Müggel Lake**). A total of **31 species of fish** have been verified; the single bodies of water had counts ranging from six species (Rummelsburg Lake) to 30 species (Great Müggel Lake).

The **bitterling** has largely disappeared from these bodies of water; it has been attested only in the Great Müggel Lake. The strong occurrences of the Habitat-Directive species **loach and asp** in the Great Müggel Lake particularly deserve mention. For both species, the **Great Müggel Lake is the main spawning area** in Berlin. These species are particularly numerous here, and from here they also settle other inner-city bodies of water, such as the Spree. The river lakes located at the south-eastern edge of the city stand out for their variegated habitats. They still have extensive floating foliate plant zones (the Bänke), broad non-reinforced, near-natural shorelines (the southern and western shores of the Great Müggel Lake), and relatively extensive reed-bed belts (eastern shore of the Seddin lakes). The use of these bodies of water is analogous to that of the Havel lakes, although the burden due to sports boats is considerably lower. The Dahme till Schmöckwitz is part of the Spree-Oder waterway, and is used by professional navigation.

The species-poorest river lake between 2003 and 2013 was **Rummelsburg Lake**, where only **six species of fish** were attested.

Inland Lakes

The category of **inland lakes** includes closed, standing bodies of water with areas greater than one hectare. Depending on their type of genesis, the distinction is made between natural lakes (created by the Weichselian Glaciation), and artificial lakes (pits, gravel or clay quarries, peat cuts, etc.).

Natural Lakes

Thirty-one of the sampled lakes were assigned to this category. Their sizes ranged from 1.2 ha (Möwen Lake) to 70 ha (Gross-Glienicke Lake). A total of **25 species of fish** were verified in them, with the number of species per lake ranging from two (Schwarzwasser Lake) to 15 (Koenig Lake).

The land-forming, flat, polytrophic **Bogen Lake** in the Buch Forest has an extensive reed-bed belt. The sewage-farm operation near the lake, which continued into the mid-'80s, led to heavy nutrient immissions, causing it to silt up. In summer, the oxygen content of the water often reaches values critical for fish. From the south shore of the lake, there is a pipe connection to the Buch ponds. The lake appears very unspoiled.

The **Grunewald, Hundekehl, Nikolas and Schlachten Lakes and the Krumme Lanke form the Great Grunewald lake chain**. They are located in an ancillary postglacial spillway off the Havel lakes. The shores of these long bodies of water are overgrown with trees almost throughout their entire length. With the exception of Nikolas Lake, which has extensive herbaceous areas of flat water and reed-beds, the mentioned bodies of water have scanty reed-beds in only a few places. The **Little Grunewald lake chain includes the Hertha, Halen, Diana, Hubertus and Koenig Lakes**. Like the Great Grunewald lakes, they are located in an ancillary postglacial spillway off the Havel lakes. Their shores are lined with bushes and trees, and to some extent reinforced with wooden fascines. These bodies of water all have reed-beds and flat herbaceous areas. Their shores are accessible to the public only at a few locations. Like most Berlin lakes, they are also fishing areas, and as such are regularly restocked with fish.

With an area of 70 ha, **Gross-Glienicke Lake** is Berlin's biggest inland lake. It is a stratified, eutrophic to hypertrophic lake. Its earlier, temporary connection to Sacrow Lake no longer exists, so that migration of fish via this path has ceased. Fish-stocking is carried out mainly with pike, tench, carp and eel; a total of **eight species of fish** have been verified. Due to a chemical phosphate precipitation project carried out in 1992-'93, the summertime view depth has improved considerably in the lake, which has also favoured the settlement of sub-aquatic plants and led to a rise of the structural variety of the lake.

The long-drawn **Hermsdorf Lake** is located in the north of Berlin. It is drained by Tegel Creek. Like Heiligen Lake, its flow is too slight for it to count as a river lake. Its shore vegetation is variously structured; some areas are overgrown with reed-beds, others with bushes and trees. Flat, herbaceous areas which can serve the fish and their brood as spawning grounds and shelters are found in the water. The lakebed is muddy. **Fourteen verified species** have been attested in Hermsdorf Lake

The hypertrophic **Malchow Lake** is located in the north of Berlin. It is used for fishing. Its maximum depth is only 6.5 m; its view depth is only a few centimetres. The lakeside is partly lined with thick willow bushes (eastern shore) and trees (northern and north-western shores). Higher aquatic plants are largely lacking, due to the nutrient entry from the surrounding area; the western part of the lake is particularly strongly silted. Here, thick mud deposits extend to just below the water surface (10-20 cm). No fish kills have been observed during the past twenty years, as had repeatedly been the case between 1974 and 1988. The lake is managed and stocked with fish by the Berlin State Fishermen's Association which belongs to the German Fishermen's Association e.V (DAV). They have stocked catfish successfully, as could be impressively seen, among other things, by the catch of a 1.20 m long fish in the summer of 2003. However, only **12 species of fish** are currently attested, compared with 14 to 1993 and 11 to 2003.

The hypertrophic **Ober Lake** in Hohenschönhausen is a park lake. The lake structure is poor except for an island, with monotonous concrete shorelines which offer fish neither shelter nor spawning grounds. From 2011 to 2014, an extensive lake rehabilitation project was carried out, including mud removal, shoreline rehabilitation and the installation of a lake filter. The goal of the measure is the considerable improvement of water quality. The lake is also managed by the Berlin state branch of the German Fishermen's Association (DAV). The fish population has changed considerably compared with the period before 1993. At that time, crucian, gibel carp, tench and carp were frequent; by 2003, brusque and moderlieschen predominated, as they still do today. Particularly brusque have a much lower tolerance for oxygen scarcity than the cyprinids mentioned above. The number of fish species has **declined to nine**, compared with 14 in 1993 and ten to 2003.

Neighboring eutrophic **Oranke Lake** is also a park lake used for fishing; on its northern shore, there is also a heavily frequented public swimming area. The lakesides were reinforced with steel bung walls and concrete honeycomb plates, until these were removed in 2012 in the course of a shoreline renaturalization project. Extensive curltop growth, which provides the fish with spawning grounds and shelter, is still found in the lake, while the bathing beach provides sand-spawning (psammophilic) species of fish like the gudgeon with a suitable spawning refuge. The lake is fed from a submerged spring, is considerably less silted than neighbouring Ober Lake, and has a better water quality despite heavier frequentation by bathers.

Plötzen Lake in Wedding is also used for public swimming. The lake is also used for fishing. The Plötzen Lake has predominantly non-reinforced shores; the tree stands reach the water. The only non-wooded shore is in the area of the public bathing area. Every year, large quantities of leaves from the shore vegetation fall into the water, causing nutrients to be released and oxygen deficiency to appear in the hypolimnion. At the time of the full circulation in October 2000, an **eel kill** occurred, so that in the fall of the same year, **chemical methods were used intensively for nutrient fixing in the sediment**. An examination of the consequences for the ichthyo-fauna carried out in subsequent year verified a total of 15 fish species (Fredrich & Wolter, not published) as opposed to 10 species to 1993. As of 2013, **13 species** could be attested, including the eel.

Before the termination of fish farming in the **Müggelheim Teufel Lake**, it was stocked with fish by the DAV Berlin Branch. The species of fish verifiable at present are primarily the result of that programme. Like Plötzen Lake, the shores are largely tree-lined. The leaf entry caused by this has led to the polytrophic lake having a mud floor, with an up to 20 m thick layer of fine sediment.

The **Teufel Lake in Wilmersdorf** is located in a nature reserve. Its shores are lined with trees and to some extent with reeds. The result is a variegated structure and a near-natural appearance. The lake has a self-reproducing population of **bitterling**, one of very few in Berlin.

The shores of the **Hermsdorf Wald Lake** have thick stands of trees. There are flat herbaceous areas which are suitable habitats for broods and young fish and spawning grounds for fish which require aquatic vegetation. The lake appears very natural. A total of **nine fish species** are attested.

The **Zehlendorf Wald Lake** is not open to the public and also appears quite natural. The shores are thick with trees, with stabilized walkways in some places. Submerged aquatic vegetation is rich. Compared with 11 fish species in 1993, and eight in 2003, **only seven** were attested in 2013.

The hypertrophic **Weisse Lake (in Weißensee)** is a park lake managed by the DAV Berlin Branch, with a monotonous shoreline of old facines and few structures. Cyprinide species (carp) have hardly any spawning substrate, because strong eutrophication hinders higher water plants. The lake bottom is very muddy, except for the bathing area on the east shore. The water fountain in the middle of the lake introduces much oxygen in the summer months and is therefore to be seen as positive. After numerous fish kills between 1993 and 1996, **only seven fish species** were attested in 2003 and also in 2013, compared with 18 in 1993.

The **drop in the numbers of species compared with 1993** in many inland lakes, seemingly so dramatic, can often be explained by the fact that the users, **mostly fishing organizations**, today apparently plan and carry out **fish-stocking measures more responsibly**. The species which are now missing in the lakes are almost exclusively those which were stocked in the past, although they were unsuitable for the particular body-of-water type. These included primarily rainbow trout, but also pike-perch, asp, chub etc., which are now disappearing once again, since the stocking measures have evidently been terminated. In the 900 fishing samples taken between 2003 in 2013 in Berlin, the rainbow trout was no longer found.

Artificial Lakes

This category **includes nine of the lakes sampled**. Their size varies between 0.5 hectares (Körner Lake) and 15 hectares (Habermann Lake). In them, a total of **23 species of fish** were verified; each lake had at least four (Lasszins Lake), and at most 11 (Butz Lake, Fauler Lake, Neuer Lake). The high numbers of fish species can be explained by **stocking**.

The **BUGA bodies of water** on the terrain of the former Federal Horticultural Exhibition (BUGA), the Eastern Lake, the Main Lake, the Southern Lake and the Iris Lake, were created for the scenic design of the park. They are artificially fed. Their water is relatively low in nutrients, and clear. Parts of the shore region have been near-naturally designed and planted, and are home to a large number of plant species. Thick growths of submersed makrophytes grow in the water. Although numerous species of fish, including bitterlings, were stocked in these bodies of water, **only eight** are attested. The bitterlings have not taken hold.

In the **Great Tiergarten**, there are a number of **park bodies of water** which are in some cases interconnected by trenches, of which two, Faule Lake and Neue Lake, are classed as artificial lakes due to their size. Their water is supplied from the Spree, but this connection is not passable for fish, so that the still very high number of fish species, **11**, compared with 18 until 1993 and 15 until 2013, is **still largely due to stocking**. A connection passable for fish from the Tiergarten bodies of water to the Spree, proposed by Wolter & Vilcinskas in 1993 has not been realized to date.

The **Kaulsdorf Lakes**, located in the borough of Hellersdorf, are a very recently created recreation area containing 5 manmade lakes, of which **Butz and Habermann Lakes** are the two oldest. The latter was built in 1942 in connection with the construction of the Reich Railway's Wuhlheide detour track. The Kies ("gravel") Lake was not excavated until 1970; with a depth of 1-2 m it has a very shallow connection with Habermann Lake. A total of **13 species of fish** are attested in the Kaulsdorf Lakes. **Pike** still find suitable conditions for natural reproduction in the lakes. Since, as a result of the loss of spawning grounds and thus restricted possibilities for its preservation, this species is largely present in Berlin due to stocking, so that the few remaining spawning grounds are particularly protection-worthy.

The former gravel pit **Lasszins Lake** is a near-natural body of water, protected and fenced in due to its significance for birdlife. The shore structure consists of a broad reed-bed belt and trees. A thick growth of submersed macrophytes exists in the clear, relatively low-nutrient water. Here, too, particularly the pike has suitable living and reproduction conditions.

Retention Basins

Retention basins are artificially created bodies of water. As their name implies, they serve as catchment, collection and sedimentation basins for rain and surface water. The run-off from roofs, courts, streets and other sources collected in these basins is **heavily contaminated by nutrients and pollutants**, particularly PCBs. The toxic sediments washed in do not reach the open bodies of water, so that rain retention basins contribute to the often demanded reduction of various nutrient and pollutant immissions into other surface bodies of water; they were conceived and designed for this purpose.
Due to the pollution of the water and the sediments which accumulate in the fish, **these bodies of water may not be fished**.Since retention basins can of course not be settled by fish either, they should actually be fish-free. The opposite is the case. For example, four fish species were attested in the Krötenteich ("toad pond") in Rahnsdorf.

Unlike the other retention basins, the **Krötenteich** was built as a survival pit for the fish from the Fredersdorf Mill Stream, the lower stretches of which periodically dry out. More than 14,000 fish from 11 species were counted in the mass fishing of approx. 250 sqm area survival pit carried out a 1999 (Fredrich & Wolter. unpublished). This included one single stocked catfish, for which both the basin and the stream itself are completely unsuitable as a habitat.

Small Bodies of Water (ponds, tarns, meres, kettle-holes and the like)

Ponds are artificial, dischargeable bodies of water. The other bodies of water were usually naturally created as a result of landscape processes during the Ice Age, including "dead-ice" lakes, and kettle-holes, or as abandoned clay or gravel quarries, or peat cuts. These bodies of water are different from ponds due to the fact that they are generally not drainable. Since no pond management is carried out in Berlin and therefore the ponds are drained only in the course of rehabilitation work, both forms have been categorized together. No further distinctions of the small bodies of water are required, either, from an ichthyological point of view in the examination area.

Their quality of inflow waters, anthropogenic impairments (mainly by fish stocking), and their areas (usually less than 1 ha) are all similar and make them comparable. In a total of **48 small bodies of water** examined in **Berlin**, a total of **24 species of fish** were attested, 18 of them indigenous. The average number of species per small body of water is four, which is very high, considering their small sizes. Only a few examples of these bodies of water are to be introduced briefly in the following:

With **13 fish species**, **Jungfernheide Pond** is the small body of water which is richest in species. All fish species present here are indigenous.

Four of the small bodies of water examined had **no fish species** whatever. These are the **Enten Pool** and **Sperling Lake** in the Borough of Mitte, the **Small Torfstich** (peat dig) in **Hermsdorf and the Röte Pool** in Marienfelde

Eckern Pool is in the middle of a park in Tempelhof. Its shore structures are monotonous, regularly-formed reinforcements. **Two species of fish** were verified here - in 2003, there were five - all of them euryecoid species.

The **Karow ponds** are four hypertrophic former fish ponds in the fields of the discontinued Buch sewage farms. The ponds, interconnected by pipes, were used for fish farming until 1990, and are today a nature protection area. Their very unspoiled shores are lined with extensive reed-bed stands. Between 2003 and 2013, fish sampling was carried out in the Insel Pond and the Weiden Pond, and a total of **six species** were attested.

Streams

This category covers **the Spree River** in Berlin, **small tributaries of the Havel and Spree**, and the **tributaries of the large lakes**, all in all ten bodies of water which have however been listed as 13 water body segments for purposes of observation. All still show at least rudimentarily the near-natural habitat structures characteristic for streams, such as **pools, meanders, back currents, turbulences, and various bottom sediments**. Particularly overflow areas, coarse-grained sediment and meanders, all near-natural structural elements, have been removed almost everywhere by hydrological construction measures. This has led to a major elimination of those stream-dwellers which were tied to these structures. The strict protection of still-existing stream habitats as well as the restoration of some of those destroyed would constitute a very valuable contribution to fish-species protection. Other streams have changed markedly in their character, and have been heavily polluted by the discharges of sewage treatment plants. They are described under the category sewage-treatment plant discharge channels.

A total of 29 fish species occur in Berlin streams, including the **crucian and the weatherfish**, which are classed as "endangered" in the Berlin Red Data Book, and the burbot, bitterling, chub and dace. Only two of these species verified as occurring in streams are neozoa: the bullhead and the gudgeon.

The Berlin streams are home to **an average of 14 different fish species**. The **pike and the roach** occur in all waters investigated. The largest number of species was ascertained in Tegel Creek, with twenty 21 occurrences, all of them native. Below average numbers of species were found in the Fließgraben (13), the New Wuhle (11), and in the Kuhlake, the Lietzen Ditch and the Laake, each with ten species.

The feeding of mechanically cleaned Havel water into the **Kuhlake** has enabled the resettlement of submerged macrophytes, e.g., water-starworts and water milfoils, and also the water violet. The dense stands of plants favour the natural reproduction of the **rudd and the pike**.

The source of the **Lietzen Ditch** is located in the state of Brandenburg, west of the village of Schönow, near Bernau. The Lietzen Ditch drains the old sewage fields near Hobrechtsfelde, flows west past the Bogen chain of lakes, and empties into the Panke near the Karow ponds.

The **Old Wuhle** has its source in the state of Brandenburg near Ahrensfelde, and the **New Wuhle** at the former sewage treatment plant; these two branches flow together north of Cecilienstraße and then empty into the Spree near the old forestry station in Köpenick. The fish sampling operation was carried out in three ichthyological segments: First, in the New Wuhle, second in the Wuhle between Cecilienstraße and the "Wuhleblase" (**the Wuhle above the drop structure**), and finally between the Wuhleblase and the Spree (**the Wuhle below the drop structure**). After the shutdown of the Falkenberg Sewage Treatment Plant in 2003, extensive renaturalization measures were carried out in the Wuhle between 2006 and 2008. In addition to restructuring measures for weirs appropriate to fish and small animals, concrete and steel piling structures were replaced with near-natural stone row fish passages, and approx. 50,000 t of polluted mud were removed from the Wuhle and the Kaulsdorf Ponds. Moreover, the floor of the bodies of water was raised by up to 1 m, in order to counteract the often low level of the water in the Wuhle, and to attain groundwater stabilization. Other measures are planned (SenStadtUm 2013b). In der New Wuhle, a total of **12 species**, 11 of them native, including the weatherfish, have been verified. In the two segments of the Wuhle, **16 native species**, including the crucian in both cases, were likewise verified. In the section above the Wuhleblase, the weatherfish was also verified.

Canals

Canals are **artificial waterways** with monotonous, reinforced shores (ripraps, concrete or steel bung walls), largely constant breadth and depth, and usually with a mostly trapezoidal profile. **Berlin has more than 100 km of canals**, if the canal-like structures of the Spree River in the inner city areas are included. Fish make are present here only on seasonal visits or in **migrations**, because of the **lack of structures** important for them, such as spawning, shelter and feeding areas. The number of fish species present is thus affected by the fauna in the still bodies of water with which they are connected. In order to realize the good ecological potential in the Berlin canals in accordance with the EC WFD, it was required that 16 characteristic fish species occur (Pottgiesser et al. 2008). However, this good ecological potential was not achieved in any of the canals investigated. Currently, an average of **only 10 species** are verified in the Berlin canals.

The **Gosen Canal**, completed in 1936, connects Dämeritz Lake and Seddin Lake. Its shores consist largely of ripraps. Its mean depth is 3 m, its width 35 m. Aquatic plants are very rare in the canal; shore reinforcement measures as well as the impact of waves caused by ships are the assumed reason for that. Currently, **10 species of fish** are verified in the Gosen Canal.

The canals in the **city centre**, such as the **Landwehr Canal and the Kupfergraben**, have been developed even more monotonously. For reasons of space, the shores are perpendicular here, and are solidly sealed. Thus, unlike the ripraps of other canals, they are not even usable as spawning substrata by hard-substrate spawners like the perch or the ruffe. **A total of 20 species of fish** were verified in the canals; the canal with the **largest number of species** was the **Teltow Canal, the southern connection between the Spree and the Havel**, which showed **16 fish species**.

Trenches, Melioration Trenches

This category consists of small, hardly structured, largely straight artificial streams. They were mainly built as **inflow and outflow trenches for the sewage farms**, but also for **drainage**, e.g. of the Gosen Meadows in Köpenick. Their profile is trapezoidal or rectangular. While the outflow channels of the sewage farms are heavily contaminated by nutrients and pollutants, the pure melioration trenches, i.e. the irrigation or drainage trenches, are typically only polluted if their surrounding countryside is or was intensively agriculturally used. The abandonment of sewage dissemination and the drop of the ground-water table caused **many of the trenches in the north of Berlin (the former Buch sewage farms) to dry out**. A total of 20 trenches and melioration trenches were investigated between 2003 and 2013.

The **Western Withdrawal Ditch** (Westlicher Abzugsgraben) branches off from the Citadel Moat via a weir, and empties into the Havel below the Spandau Lock. There is a relatively strong current below the weir, and the sediment is sandy and gravelly. Further downstream, in areas of weaker currents, the floor is muddy. The banks appear near-natural, and are tree-lined almost throughout their entire length. A total of **nine fish species** have been verified. Without a doubt, the Western Withdrawal Ditch is a favourite spawning area for the fish of the Havel, especially for rheophilic species.

The **Great Sprint Ditch** is a strongly weed-clogged melioration trench connected with the Lübars pond. Both species of stickleback and the weatherfish were verified in it. With regard to ichthyological value and protection, it should be treated as equivalent to the sewage-farm trenches (see below). Maintenance measures may be necessary to prevent the overgrowth and hence the disappearance of this trench.

There are many **discharge trenches** around the discontinued **Buch sewage farms**, remainders of 100 years of such use. They are today dry during the summer because of the lowering of the groundwater table. **Both stickleback species** were found in almost all sewage farm trenches. They are the species most adapted to this kind of extreme biotope and find their last refuge areas here. Since the remained small trenches have been preserved, the populations of sticklebacks has during the last few years stabilized at a level which is low in comparison with the habitat supply prior to the extensive groundwater lowering, for which reason the endangerment level of both species has been

reduced in the current Red Data Book (Wolter et al. 2003). In the Berlin Red Data Book for 2013, the nine-spined stickleback is on the "Preliminary Warning List" (a German category roughly equivalent to the international "near threatened" status), and the three-spined stickleback is non-threatened. Little trenches are typically only settled by **two or three fish species**. This number can, however, increase considerably if the **trenches are connected with rivers or lakes** and are used as spawning and breeding areas by the species inhabiting the latter.

Sewage-Treatment-Plant Discharge Channels

In the 2014 Edition, only the Neuenhagen Mill Stream (Erpe) is listed as a sewage treatment plant discharge channel. Since the shutdown of the Falkenberg Sewage Treatment Plant in 2003, the Wuhle, which had served as a discharge channel there, has, in later editions been listed as a stream.

With **23 species**, including 20 native ones, the **Neuenhagen Mill Stream (Erpe)** has a very high number of species. These include such endangered species as the bitterling and the chub, as well as the loach, which is classified is extremely rare in Berlin. In 2010, it was verified in the state of Berlin for the first time since 1920.

Seven native species, including the crucian, occur in the **Neuenhagen Mill Stream (the segment in Bellevue Park, the old Erpe)**.

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