Waterplants in the New Danube: The Influence of Floods on the Spectrum of Species.

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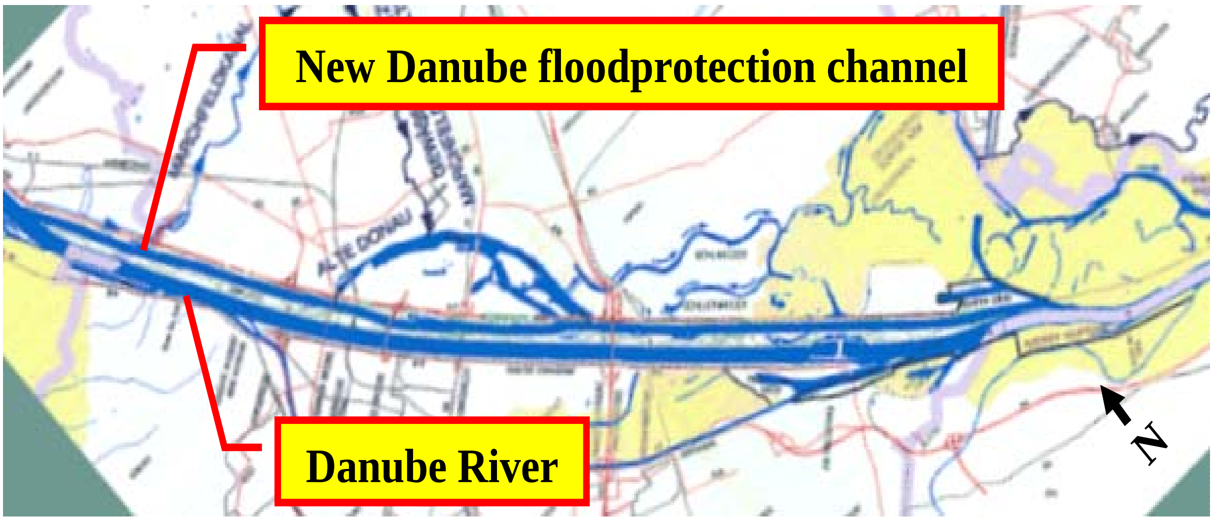
Keywords: flood protection channel, submerged macrophytes, number of species, floods

Introduction

The New Danube is a man-made flood protection channel within the boundaries of the City of Vienna which runs in parallel to the River Danube over a total length of 21km (Fig. 1). An intake gate upstream and two weirs downstream separate the system into two reservoirs of 11 km (Upper Impoundment) and 10 km (Lower Impoundment), respectively. Possible flood hazards for the central part of the City of Vienna are virtually eliminated by the possibility to divert water masses from the city center into this flood protection system. Since completion of the New Danube the area has also become an important recreational area, and as a consequence its water quality is of great importance to the municipal government. Submerged macrophytes that established quickly after construction are an essential enhancement of the ecology of the New Danube system, and also water quality.

In this study the influence of floods on macrophyte development was investigated in the Lower Impoundment, where the aquatic vegetation is more stable, is found in the entire reservoir, and intermittent disturbances are less frequent. Throughout each year the New Danube is characterized by still water conditions over long periods of time. During floods, however, the environment changes completely for about periods of approximately one week, characterised by high current velocities and a high load of suspended solids. Out of an 18 years observation period, four years with floods causing severe damage to the macrophyte populations are taken as general examples.

Figure 1: Location of the Danube River and the New Danube in Vienna



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Methods

Macrophyte surveys were based on estimates of plant abundance (Kohler & Janauer 1995; submerged plant assessment by SCUBA diving, 10 transect groups per impoundment), in accordance with European Standard EN 14184 (2003), hydroacoustic transects and species specific plant biomass assays (harvesting of squares, Janauer 1997). The accuracy of the method was adjusted to the conditions of the channel (Wychera & Janauer 1998). Species abundance was ranked according to a five-level estimator scale (Kohler et al. 1971, EN 14184 2003). Each year examinations were conducted at least three times within the vegetation period.

Results

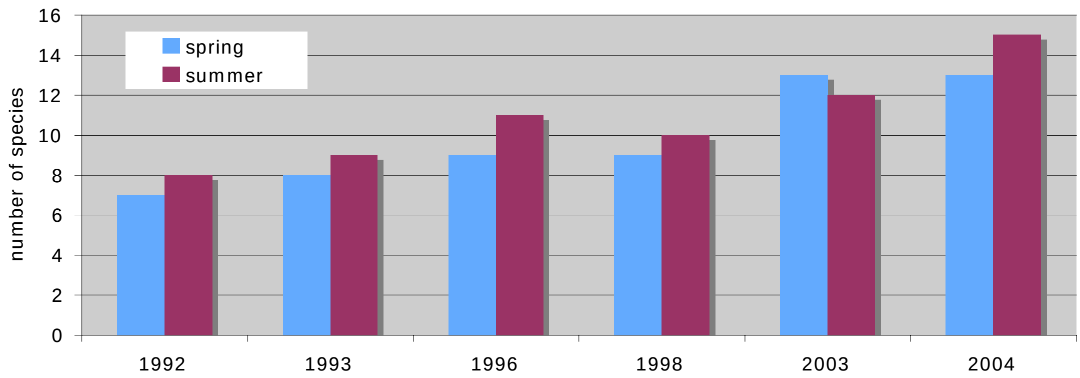
In the Lower Impoundment of the New Danube submerged macrophytes were established within a few weeks after completion of the channels construction in 1987. Already then seven macrophyte species could be observed, and the number of aquatic species increased to 15 in summer 2004 (Tab.1).

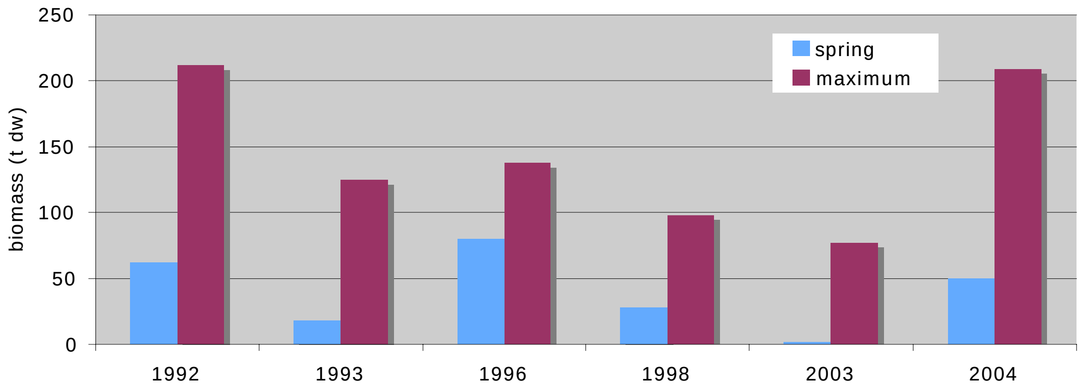
Tab. 1. Submerged species in the Lower impoundment of the New Danube in the years 1987 to 2005

	87	88	89	90	91	92	93	94	95	96	97	98	99	00	01	02	03	04	05
Ceratophyllum demersum L.	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Chara sp. L.					x	x			x				x				x	x	
Elodea nuttallii (Planchon) St. John	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Myriophyllum spicatum L.	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Najas marina L.		x	x	x	x	x	x	x		x		x	x			x	x	x	x
Najas minor Allioni																	x		
Nitella mucronata (A. Braun) Miquel										x						x	x	x	x
Nitellopsis obtusa (Desv.) J. Groves		x	x				x	x		x		x	x	x	x	x	x	x	x
Potamgeton crispus L.	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Potamogeton lucens L.	x	x	x	x	x	x	x	x		x								x	x
Potamogeton mucronatus Schrad. ex Sond.				x		x	x	x	x	x	x	x	x	x	x	x	x	x	x
Potamogeton natans L.																		x	
Potamogeton pectinatus L.	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Potamogeton perfoliatus L.		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Potamogeton pusillus L. sec Dand. & Tay.								x				x	x					x	x
Potamogeton trichoides Cham.et Schlecht.		x																	
Ranunculus aquatilis L.																			x
Ranunculus circinatus Sibthorp	x				x		x	x										x	x
Zannichellia palustris L.		x				x			x										
Number of species	7	11	9	9	10	11	11	12	9	11	7	10	11	8	8	10	12	15	14

Beyond the number of species also the biomass increased in years without floods. High macrophyte biomasses and an increasing number of species during the vegetation period are thus general features of years without flooding (Fig. 2).

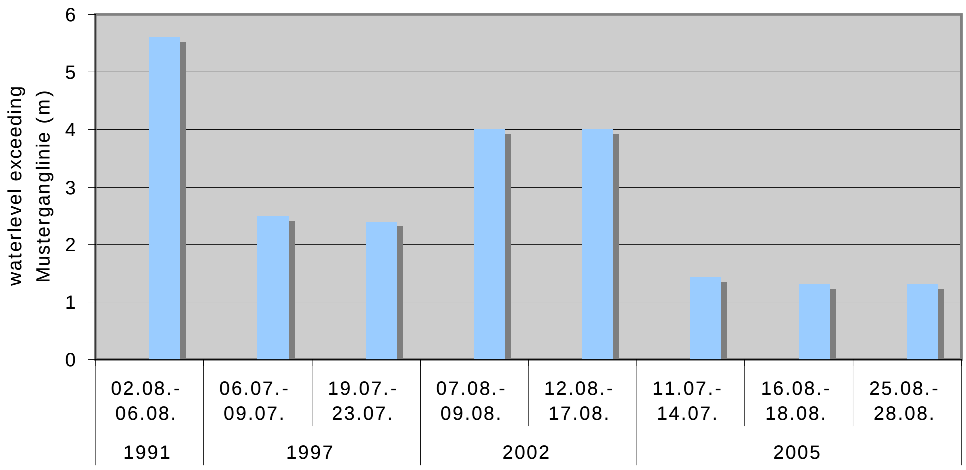
Figure 2. Number of species in spring and summer and standing crop biomass in spring and the maximum biomass in summer or autumn in years without floods





During the vegetation period 1991 a major flood reduced the aquatic vegetation in the New Danube for the first time in the existence of the channel. The observed water level was 5.6 m higher than the normal level. In 1997, two separate floods occurred in close succession, with measured heights of 2.5, and 2.4 m above normal water level. In 2002 again two floods influenced the growth of water plants, with a water level increase of up to 4.0 m above normal level in August and the expected destruction of the macrophyte biomass. In 2005, three smaller floods in July and August (water level increase: 1.4, and 1.3 m) reduced the biomass again.

Figure 3. Waterlevels exceeding the normal water level.



In 1991, nine species of submerged macrophytes were detected all over the Lower Impoundment. The severe flood in that year almost eliminated the macrophyte population, with only three species observed later in the year. In 1997, the two minor floods reduced the number of macrophytes species from seven to six. Also, the two floods in August 2002 reduced the species of macrophytes from ten to five, and the three minor floods during the summer of 2005 resulted in a decrease of species from 12 to eight (Tab. 2)

The total macrophyte biomass in the New Danube had increased from 100 t dw in 1987 to a maximum of over 500 t dw in 1989. The first severe flood in August 1991 reduced the standing crop from 485 t dw by 90%, to 53 t dw. Since that flood the plant mass in the Lower Impoundment of the New Danube has never again reached more than 300 t dw. In June 1997 62 t dw were measured, and two subsequent floods led to a further reduction of biomass to 33 t dw by the end of July of that year.

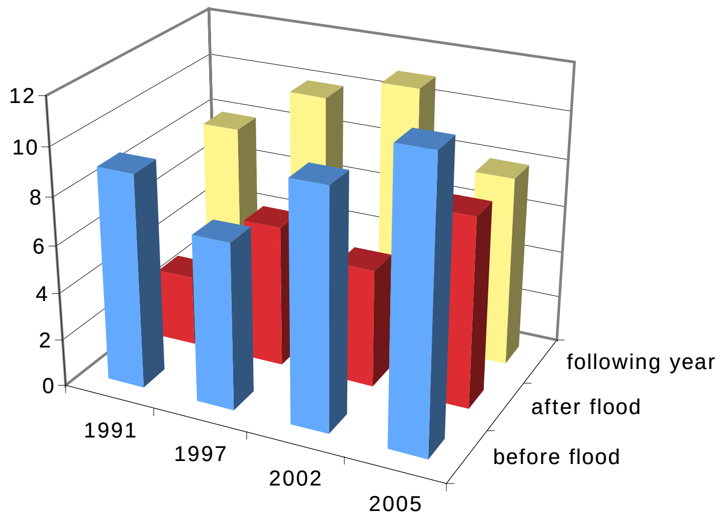
Unfavourable habitat conditions with a flood already in March 2002 caused a reduction of plant mass at the beginning of the vegetation period. As a consequence only 4 t dw could be determined in June. The maximum biomass of 9 t dw was measured in July of that year. Two severe floods in August virtually exterminated the biomass that had existed earlier in the year. However, two subsequent years without any flood impact caused an increase of plant mass in the New Danube, and 118 t dw were measured again by June of 2005. Three separate floods in July and August of that year again reduced the biomass to only 45 t dw by the end of August of this year (Tab. 2).

Table 2. Number of species and standing crop biomass (t dw) before and after severe floods.

	number of species		biomass (t dw)	
	before flood	after flood	before flood	after flood
1991	9	3	485	53
1997	7	6	62	33
2002	10	5	9	0
2005	12	8	118	45

The resilience potential as expressed by recovery of macrophyte species in number is also well established by our results. In years following a flood impact the number of species reaches levels close to those observed during periods prior to floods (Fig. 4).

Figure 4. The recovery of submerged species after an impact of floods



Comparing the four flood years, *E. nuttallii* was only washed away in two years, 1991 and 2002, respectively, when the water level raised over 4 m above normal. Also the non rooting species *C. demersum* was reduced considerably. But both these species do occur in quite similar amounts directly after floods with a lesser raise of the water level. In these years with lesser flood impact the broad leaved *P. lucens* and the alga *N. mucronata*, both typical still water species, are most susceptible and get uprooted completely.

Conclusion

Macrophytes in the New Danube are the key competitive species for phytoplankton. Any potential threat to the continual existence of macrophytes raises the danger of switching the ecosystem into an alternative stable state, dominated by plankton (Blindow et al. 1998). This would be unacceptable for the intended recreational use of the water body. This study shows that most macrophyte species persist, albeit at lower plant masses, even after many floods. Only severe floods significantly reduce the number of species. Yet, the resilience potential and power of recovery of the aquatic vegetation is high, and the aquatic vegetation re-establishes quickly and retains a macrophytes-dominated state. This in turn guarantees a good water quality. Importantly, this study also shows that natural variations in aquatic plant species composition and abundance do occur to an extent that must not be neglected when assessing the ecological status according to the regulations of the European Water Framework Directive.

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