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Long-term changes in the fish community of Neusiedler See (Burgenland, Austria)

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Summary. In the course of establishing the National Park Neusiedler See-Seewinkel, an investigation of the fish community of Neusiedler See on the Austrian/Hungarian border was carried out between 1990 and 1992.

According to the literature, 19 indigenous fish species occur in the lake. In addition another ten species have occasionally been found in the lake but they are usually confined to the small tributaries of the catchment area. Seven alien species were introduced by stocking to enhance the professional fisheries (e.g., *Anguilla anguilla, Ctenopharyngodon idella*) or by aquarists (e.g., *Lepomis gibbosus*). Comparing the results of the present study with those of investigations before 1960, marked changes in species composition and abundance can be observed: four indigenous species have disappeared completely (*Umbra krameri, Leucaspius delineatus, Misgurnus fossilis, Proterorhinus marmoratus*) and the abundance of several species has declined considerably (e.g., *Tinca tinca*) while others, especially planktivorous species (e.g., *Pelecus cultratus, Alburnus alburnus*), show a pronounced increase in population density.

The possible reasons for these changes are:
1. Human impact on the hydrology of the lake, especially water level regulations, has led to a loss of habitats within the reed belt due to drying out.
2. The eutrophication during the 1970s is probably responsible for the tremendous increase in abundance of the cyprinid populations, especially of the planktivorous species.
3. The introduction of alien species is the most direct way of disturbing the indigenous fauna. Stocking with *Ctenopharyngodon idella* led to the almost complete disappearance of the submerged macrophytes, resulting in the loss of an important spawning habitat for many species. Also since 1975 about 4000000 glass eels have been introduced annually. Competition and predation by *Anguilla anguilla* are most probably key factors in the disappearance of small species.

Introduction

The earliest information on the fish and the fisheries in Neusiedler See dates back to the 16th century (Löffler, 1974). Most of the publications before 1960 deal largely with faunistics. In some cases additional details such as maximum recorded length or weight of particular species (e.g., Herman, 1887; Haempel, 1926, 1929; Mika and Breuer, 1928) or the annual fishing yield (e.g., Varga and Mika, 1937; Sauerzopf and Hofbauer, 1959) are registered. Most of these sources do not give any information about methods used or locations of sampling so that a comparison of their results with those of the present study is rather difficult even from the faunistic point of view. As Hacker (1979) mentioned, uncritical acceptance of older species lists may lead to misinterpretations.

In the course of establishing a national park in the area of Neusiedler See-Seewinkel it was necessary to investigate the actual state of the fish community in order to define a management plan for fisheries in agreeement with the IUCN criteria for national parks.

Material and methods

The Neusiedler See is a shallow (mean depth about 1 m), alkaline lake situated on the Austrian/Hungarian border. Its surface area is 321 km^2, over half (about 180 km^2) being covered

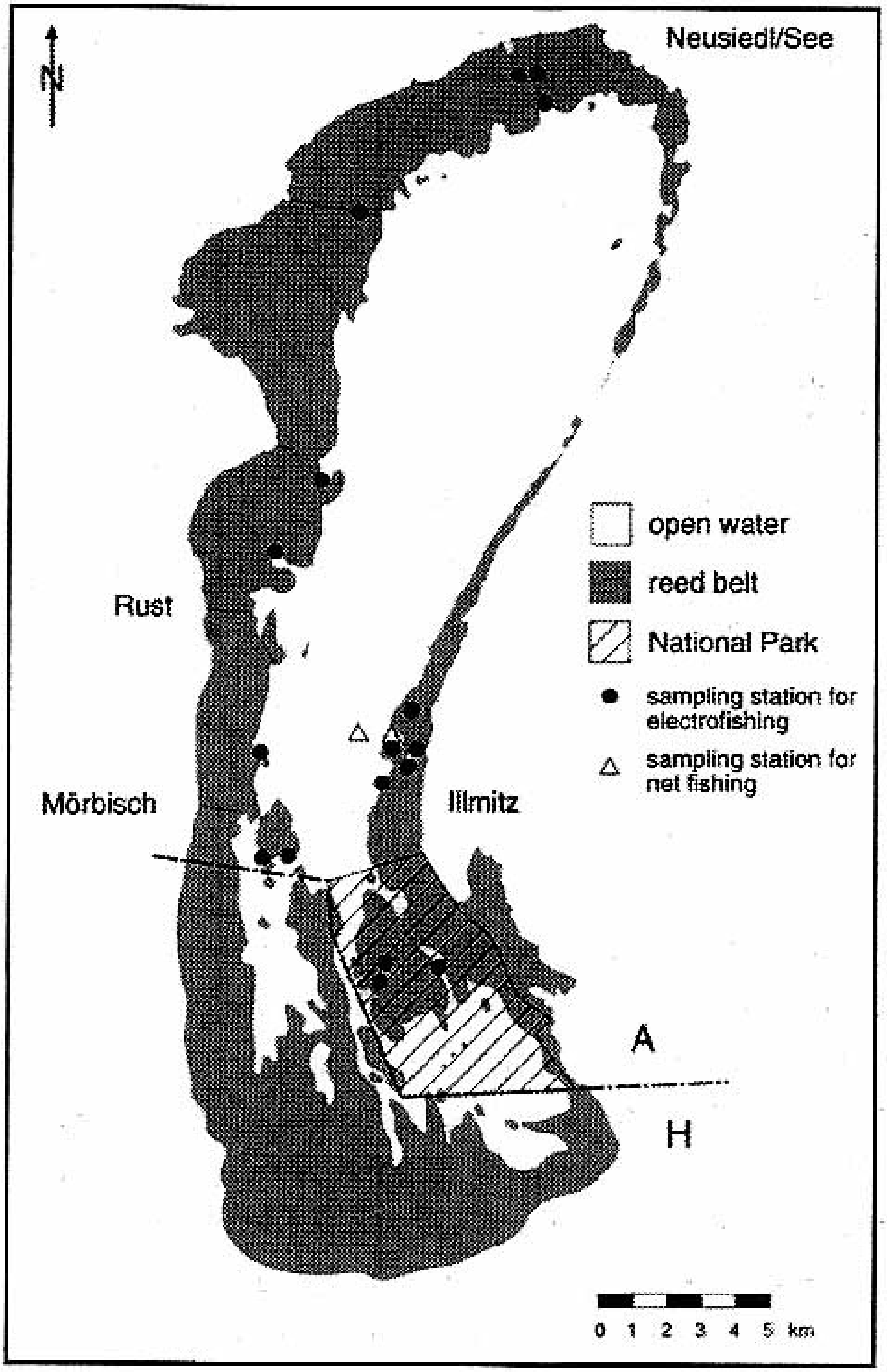

Figure 1. Map of Neusiedler See.

with reeds (*Phragmites australis*), which form a belt around the lake up to 3 km wide (for details see Löffler, 1979). Consequently two different habitats can be distinguished: the open lake and the reed belt. The present paper deals with the open water and the water-reed-ecotone including areas such as channels and pools within the reeds.

Between 1990 and 1992, 66 fish catches were made using monofilament gill nets (30 m long, 2 m high) of 10, 15, 20 and 30 mm bar mesh size. Due to the high fish densities, the gill nets were only exposed for 0.5 hours. The main sampling stations for the gill net fishery were located in the area of the bay of Illmitz. A total of 2600 fish were caught. Additional data was obtained by electrofishing (37 catches; DC, 8 kW, 200–300 V) at various stations around the lake (Fig. 1).

Results

A species list is given in Table 1, including the results of former investigations. A total of 20 species were found during the study. The most striking change during the last decades is the disappearance of some small species, i.e., *Umbra krameri, Misgurnus fossilis, Proterorhinus marmoratus* and *Leucaspius delineatus*. Of the remaining indigenous fish community, four species appear to be extremely endangered: *Aspius aspius* and *Silurus glanis* were not caught in the course of the present study and their scarcity has been confirmed by professional fishermen. Only one example of *Carassius carassius* and two specimens of *Tinca tinca* were caught during our fishing activities.

Another notable result of the recent investigations was the complete absence of species which can be classified as guests in the lake proper (Tab. 1). Species such as *Rhodeus sericeus amarus, Cobitis taenia* or *Barbatula barbatula* were assumed only to be present in low numbers and/or in restricted areas (Mika and Breuer, 1928; Varga and Mika, 1937) but their complete absence during the intensive sampling activities of this study was unexpected.

An important change in the species composition was due to the introduction of seven alien species: *Anguilla anguilla, Ctenopharyngodon idella, Hypophthalmichthys molitrix, Carassius auratus gibelio, Stizostedion volgensis, Lepomis gibbosus* and *Ictalurus melas*.

Apart from the faunistic changes mentioned above, a tremendous increase in population density of cyprinids could be observed. From 1975 to 1990/92 the catch per unit effort increased on average by a factor of 15 (Fig. 2), mainly due to the high abundance of *Pelecus cultratus*, but *Blicca bjoerkna* and *Abramis brama* also showed an increase in population density. Unfortunately, due to inefficient sampling methods, former investigations do not provide any information about *Alburnus alburnus* which is one of the most common species today.

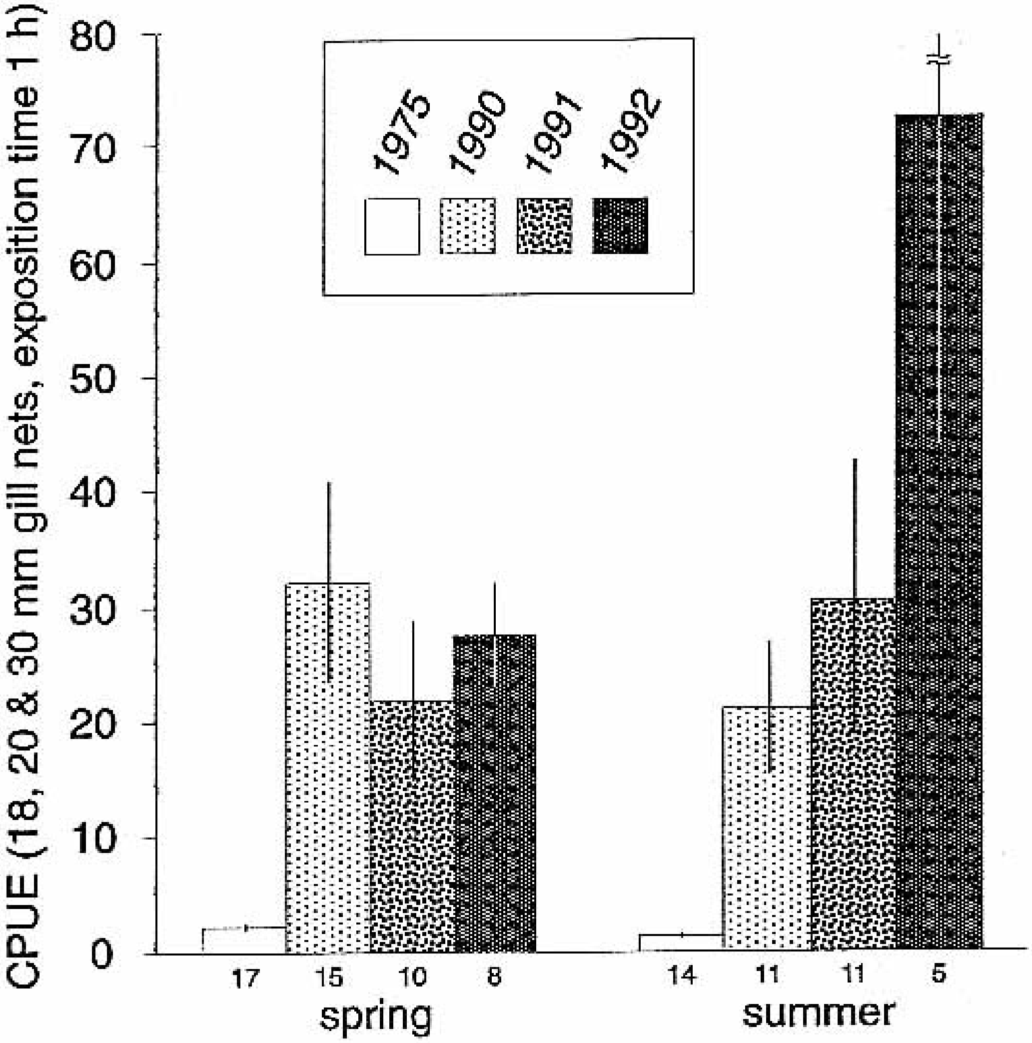

Figure 2. Catch per unit effort (fish numbers). Comparison of the results of 1975 with those of 1990/92. The figures below the abscissa indicate the number of fishing sets, the standard errors are shown as vertical lines.

Discussion

Neusiedler See is situated in the catchment area of the Danube, but direct connection to the Danube system is only possible during exceptional floods. At the beginning of the 20th century a drainage-channel (Hansag-Channel) was built; it is now an artificial outflow of the lake and a permanent connection to the Danube system. The fish community of Neusiedler See has always been rather similar to that of the Danube with the exception of the strictly rheophilic species, of which only a few have been occasionally found as guests in the lake (Tab. 1), usually confined to small tributaries of the lake.

Ecologically, Neusiedler See can be characterized as a rather unstable, dynamic system. Long term dynamics of hydrology and also seasonal water level fluctuations probably restrict the development of fish populations. In fact natural catastrophes (Varga and Mika, 1937), such as the complete drying out of the lake between 1865 and 1868 or the almost complete freezing of the waterbody during the winter 1928/29, led to a dramatic decrease in population densities. However, within a short period of time the population recovered by natural reproduction leading to the same species composition as before (Hacker, 1979). In contrast, human impact within the last decades has led to a marked change in the species composition and the abundance of the fish.

Table 1. Species composition of Neusiedler See

Family	Species	S	RL	1950/60	1992
Esocidae	*Esox lucius* L.	i	-	+	+
Umbridae	*Umbra krameri* Walb.	i	0	+	
Anguillidae	*Anguilla anguilla* (L.)	a		+	+
Cyprinidae	*Abramis ballerus* (L.)	g	3	+	
	Abramis brama (L.)	i	-	+	+
	Alburnus alburnus (L.)	i	-	+	+
	Aspius aspius (L.)	i	3	+	+
	Blicca bjoerkna (L.)	i	-	+	+
	Barbus barbus (L.)	g	-	+	
	Carassius carassius (L.)	i	-	+	+
	Ctenopharyngodon idella (Val.)	a			+
	Carassius auratus gibelio (Bloch)	a		+	+
	Cyprinus carpio (L.)	i	-	+	+
	Gobio gobio (L.)	g	-	+	
	Hypophthalmichthys molitrix (Val.)	a			+
	Leuciscus idus (L.)	g	4	+	
	Leucaspius delineatus (Heckel)	i	2	+	
	Pelecus cultratus (L.)	i	4	+	+
	Rhodeus amarus sericeus Bloch	g	3	+	
	Rutilus rutilus (L.)	i	-	+	+
	Scardinius erythrophthalmus (L.)	i	-	+	+
	Leuciscus cephalus (L.)	g	-	+	
	Tinca tinca (L.)	i	-	+	+
Cobitidae	*Barbatula barbatula* (L.)	g	-	+	
	Cobitis taenia L.	g	2	+	
	Misgurnus fossilis (L.)	i	2	+	
Siluridae	*Silurus glanis* L.	i	4	+	+
Gobiidae	*Proterorhinus marmoratus* (Pallas)	i	3	+	
Percidae	*Gymnocephalus cernuus* (L.)	i	-	+	+
	Stizostedion lucioperca (L.)	i	3	+	+
	Perca fluviatilis L.	i	-	+	+
	Stizostedion volgensis (Gmelin)	a		?	?
Centrachidae	*Lepomis gibbosus* (L.)	a			+
Cottidae	*Cottus gobio* (L.)	g	-	+	
Gadidae	*Lota lota* (L.)	g	3	+	
Ictaluridae	*Ictalurus melas* (Raf.)	a		+	?

S = Status of species (i = indigenous, g = indigenous in the region but only a guest in the lake, a = alien species), RL = classification according to the Red List of Austria (Herzig-Straschil, 1994) (- = not endangered), 1950/60 = status in the late 1950s according to Herzig-Straschil (1989), 1992 = results of the present study (+ = species found,? = occurrence uncertain).

Causes for change in fish community

Three main causes are probably responsible for the changes observed between 1950 and 1992 (Fig. 3):

Eutrophication

During the 1970s Neusiedler See became extremely eutrophic (Herzig, 1990). This led to two changes: Higher primary production provided an improved food supply for planktivorous (mainly *Pelecus cultratus, Alburnus alburnus*) and benthivorous (mainly *Abramis brama, Blicca bjoerkna*) cyprinids (Wais, 1993; Wolfram, 1993; Herzig, 1994; Herzig et al., 1994). *P. cultratus* was found only occasionally before the late of the 1960s (Herzig and Winkler, 1983); since then its abundance has increased dramatically (Fig. 2). Today *P. cultratus* is one of the most abundant fish species of Neusiedler See.

On the other hand, the high production resulted in an increase of organic matter which was deposited and decomposed within the reed belt, thus causing oxygen deficiency especially during summer. As a consequence, fish cannot inhabit large sections of the reed belt area today, a fact that could explain the dramatic decrease or even disappearence of species such as *Tinca tinca, Carassius carassius* and *Misgurnus fossilis. T. tinca* was an important commercial species until the 1960s (yield for 1968 in the Hungarian part of the lake: 4.2 tons; Pannonhalmi, personal communication).

Human impact on hydrology

In order to prevent floods and to drain wetlands for agricultural use an artificial outflow for the Neusiedler See was established at the beginning of this century. As a consequence the water level was stabilized which resulted in the loss of characteristic seasonal and long-term variations in the water regime.

Stabilization of the water level caused an expansion of the reed belt, both towards the open lake and outwards into the surrounding meadows. Earlier, these meadows were flooded regularly in spring providing the most important spawning habitat for *Esox lucius*. Over the last decades however they have become overgrown with *Phragmites australis*. The reduced reproductive success might have resulted in the observed decrease in the pike population density, which, in turn, faciliated the increase of cyprinids due to reduced predation pressure. Also, the expansion of reed beds by the tributary deltas may be responsible for the complete lack of so-called guest species.

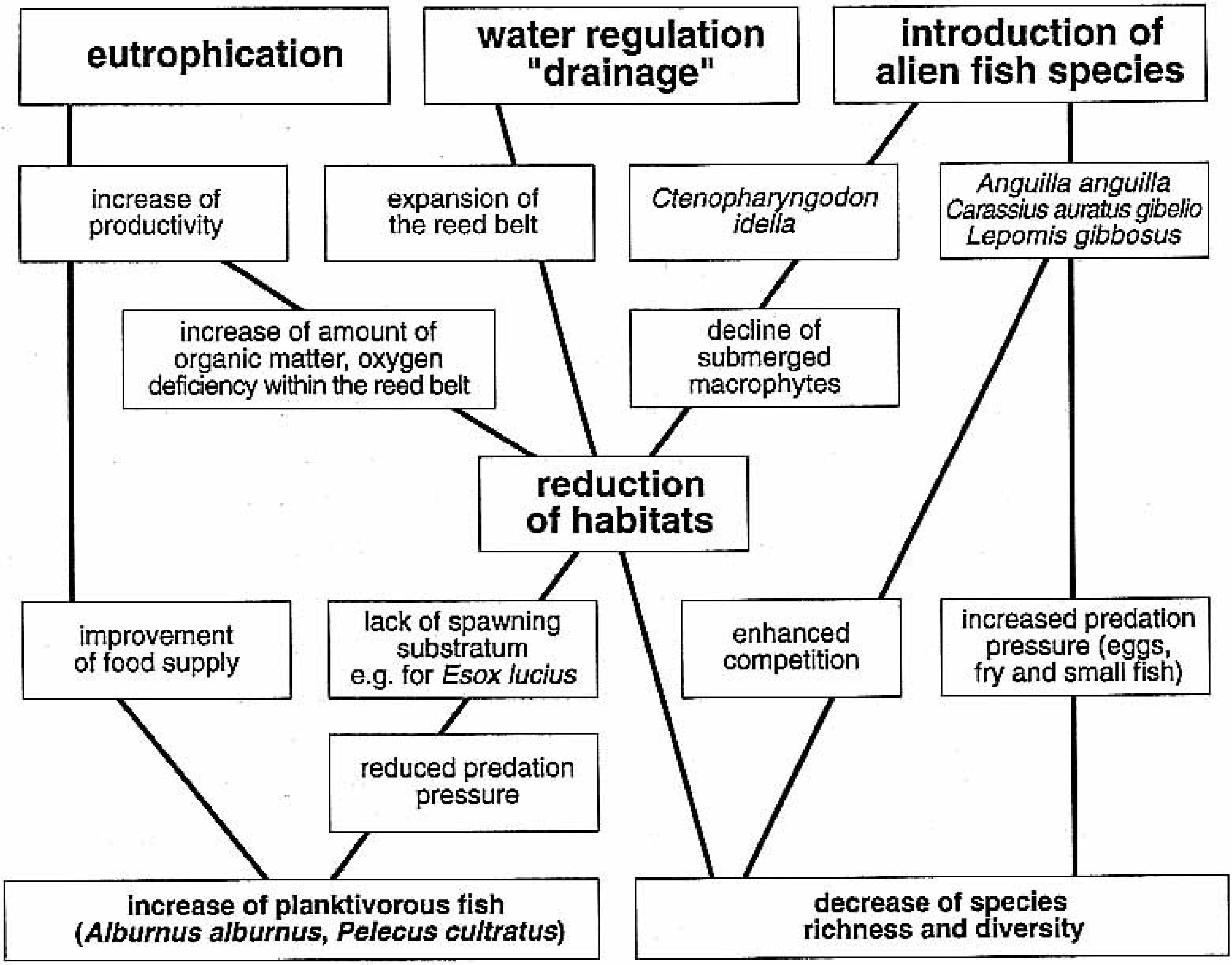

Figure 3. Changes of the fish community in Neusiedler See – causes and effects.

Introduction of alien species

Before the 1970s, the broad belt (about 24 km^2) of submerged macrophytes (namely *Potamogeton pectinatus* and *Mycrophyllum spicatum*) situated in front of the reed belt was characteristic for the Neusiedler See. The introduction of *Ctenopharyngodon idella* and *Hypophthalmichthys molitrix* during the 1970s resulted, within a few years, in the almost complete disappearance of the macrophytes which earlier formed on of the most important habitats for fish.

Anguilla anguilla was first introduced in 1958 to enhance the professional fishery and regular stocking on a large scale (up to 4 000 000 glass eels per year) also took place between 1974 and 1990. The presence of the eels increased predation pressure on small species which subsequently have disappeared over the last decades. *Proterorhinus marmoratus*, *Leucaspius delineatus*, *Misgurnus fossilis* and *Umbra krameri* are known to frequent the same type of habitat as *A. anguilla* (Kritscher, 1973). *U. krameri* was one of the most common species at the beginning of this century, living in the bogs and ditches around the lake. The last records of *U. krameri* from the Neusiedler See reed belt date back to the late 1950s (Lehmann, 1958). This species was also not found in the catches made by Wanzenböck and Keresztessy (1991) who investigated the fish community of the channels surrounding the lake.

During the present study, fish proved to be of only minor importance in *A. anguilla* nutrition, but there are strong indications that eel predation was a key factor in the disappearance of the small species: Waidbacher (1985) reported eels feeding on fish eggs during spawning activities. Löffler (1974) mentioned *Misgurnus fossilis* as an important prey fish for *A. anguilla*, and Wanzenböck and Keresztessy (1991) found that small species such as *M. fossilis, Leucaspius delineatus* and *Proterorhinus marmoratus* were missing from ditches and channels in the surroundings of the lake when *A. anguilla* was present even in rather low numbers. Also, according to Wais (1993), stocking with eels results in an increased food competition among indigenous benthivorous species in Neusiedler See.

Carassius auratus gibelio was probably introduced into the lake in the course of stocking with *Cyprinus carpio* (cf. Berg et al., 1989) and has now established a stable population. Its very first occurrence in Neusiedler See is unknown; older records cited by Hacker (1979) refer to synonyms of *Carassius carassius*. The role of *C. auratus gibelio* within the system is uncertain. Competition for benthic food has perhaps contributed to the decrease of *C. carassius* (Herzig et al., 1994).

Lepomis gibbosus was introduced into the lake by aquarists, and its abundance has increased tremendously within the last years. This species seems to influence the indigenous ichthyofauna by predation and competition (Guti et al., 1991).

Recommendations to future management

According to the IUCN report (cit. in Pavlov, 1993), the destruction of habitat and the influence of introduced species are the most important of the various anthropogenic factors. The results of our investigations support this statement. The establishment of a National Park will probably to be the best way to protect the indigenous fish community, but the fact that only a part of the lake has been declared a reserve (Fig. 1) causes problems in ichthyofauna management. According to Pavlov (1993) the protection of only sections in aquatic systems provides a rather low grade of preservation, especially for the total ecosystem approach which usually characterizes a National Park. Therefore, in our opinion, the fish fauna management of the of the National Park Neusiedler See-Seewinkel has to include the whole system. Our proposals are:

1. A stop to the stocking with alien species should lead to the disappearance of eel and grass carp, as both species are unable to reproduce in Neusiedler See.
2. The outflow *via* the Hansag channel is now an irreversible situation. But we propose in future a water regime management that simulates natural conditions as far as possible (especially a high water level in spring).
3. Finally, a reduction of external nutrient loading should lead to a decrease in production and consequently to a reversal of some undesirable changes discussed above (the oxygen situation within the reed belt, abundance of cyprinids etc.). In the last years, a first step in this direction has been made with the establisment of some waste water treatment plants and sewager-works.

These management proposals primarily aim at an improvement of the environment and should enable a natural recolonization of species from the surrounding areas. We do not recommend restocking these species with fish from other locations because this would alter the gene pool (Philipp et al., 1993; Skaala et al., 1989).

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