Chapter 5
Fish stock assessment of Lake Schulen, Flanders: a comparison between 1988 and 1999

I. SIMOENS*, J. BREINE, H. VERREYCKEN and C. BELPAIRE

Institute for Forestry and Game Management, Groenendaal-Hoeilaart, Belgium

Abstract

Lake Schulen, a shallow man-made lake (90 ha) in Flanders, Belgium, was excavated in the 1970s, as a flood storage reservoir for the neighbouring River Demer (Scheldt basin). In the autumns of 1988 and 1999 extensive fish stock assessments were carried out. To avoid selectivity of fishing gear, four fishing techniques (electric fishing, gill netting, fyke netting and seine netting) were used. The fish biomass was assessed by a multiple-mark–recapture method. Twenty-three fish species were captured in both surveys but five species found in 1988 were not caught in the recent survey, when five new species were collected. Important observations in 1999 were the occurrence of the non-indigenous Asian topmouth gudgeon, *Pseudorasbora parva* (Schlegel), which was reported for the first time in Flanders in 1992 and has now invaded most lakes and rivers, and the presence of 0+ specimens of the European catfish, *Silurus glanis* L., indicating the reproduction of this species in the lake. Shifts in the fish population structure and recruitment were observed not only between the two sampling periods, but also between different sampling zones in the lake. Based on the fish community, the biotic integrity of the lake was assessed with a multi-metric Index of Biotic Integrity developed for standing waters.

Keywords: Belgium, fish, stock assessment, Flanders, Index of Biotic Integrity.

5.1 Introduction

Extreme variation in abundance and/or species composition over space and time is a feature of fish communities in (larger) lakes, which necessitates assessment for lake management (Martin-Smith 1998). Of all the biological components of lakes, fish are the most difficult and time-consuming to sample as they are diverse and do not necessarily reflect local conditions in large lakes. To overcome the biases associated with sampling fishes in large lakes, the use of different gear types is recommended (EPA 1998). The trends in the fish population and community structure obtained from stock assessment exercise can indicate when and where action has to be taken. In temperate European shallow lakes, fish communities may be valuable for recreational fisheries

*Correspondence: Institute for Forestry and Game Management, Duboislaan 14, B-1560 Groenendaal-Hoeilaart, Belgium (email: Ilse.Simoens@lin.vlaanderen.be).

(Perrow, Jowitt & Gonzalez 1996). However, in Flanders (Belgium) few possibilities for lake angling exist. One exception is Lake Schulen, one of the larger lakes in Flanders, and has been the subject of intensive study to understand the ecosystem dynamics in an effort to help managers in the development of stock enhancement activities.

The objective of this chapter is to determine the changes in the fish community structure between 1988 (Belpaire, Verreyeken, Van Vlasselaer & Ollevier 1989) and 1999, and assess the implications for management of the fish stocks of the lake.

5.2 Materials and methods

Lake Schulen (N50°57′30″ E05°08′50″), a shallow man-made lake in Flanders (Belgium), was excavated in 1974 to act as a flood storage reservoir for the neighbouring River Demer (Scheldt basin). It has a surface area of 90 ha and an average depth of 5 m (about 4.5 million m^3 water volume). The lake has a sandy substratum with little vegetation. The lake was originally surveyed in 1988 when it was divided into five zones (A–E) (Fig. 5.1) covering a total of 42 ha, representing all the different habitats in the lake. In 1988 fish were collected over a 35-day period, between September and November. In 1999 fishing took place over 18 days in September and October. In both surveys the same four fishing techniques were used (electric fishing, gill netting, fyke netting and seine netting). The data were supplemented with information from anglers' questionnaires.

Electric fishing was carried out from a boat using two hand-held anodes powered from a 5-kW generator with an adjustable output voltage of 300–500 V (DC) and a

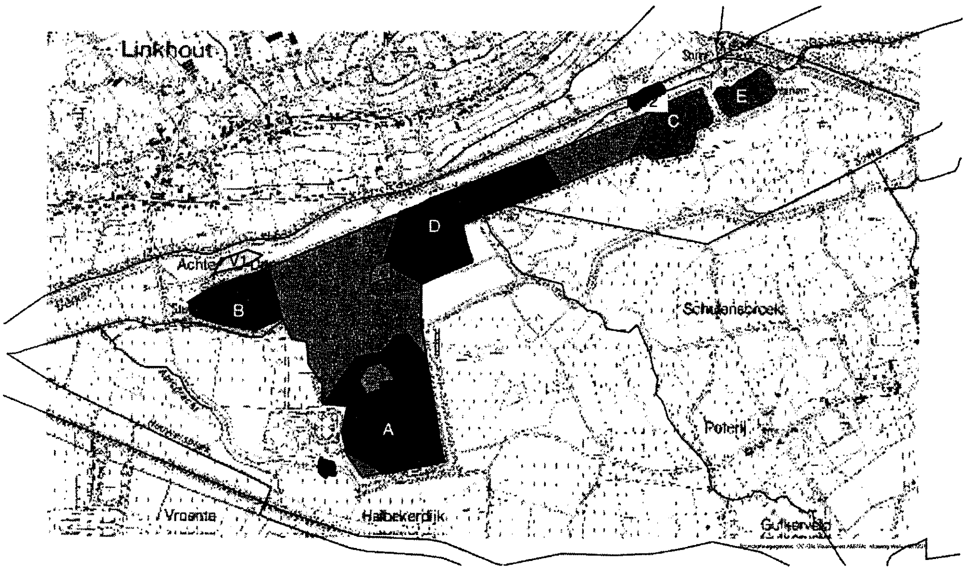

Figure 5.1 The different zones in Lake Schulen

Table 5.1 Number of samples of fish collected by each fishing method in each zone in 1988 and 1999

	1988				1999			
Zone	Electric fishing	Fyke nets	Gill nets	Seine nets	Electric fishing	Fyke nets	Gill nets	Seine nets
A	2	4	2	2	4	3	2	7
B	3	3	2	2	4	3	3	4
C	4	2	3	1	4	2	2	4
D	4	11	8	5	7	3	6	10
E	4	3	1	0	3	2	4	0

pulse frequency of 480 Hz. The fishing period was set at 1 h for each sample. The gill nets were 1.5 × 30 m and had knot-to-knot mesh sizes of 45, 50, 60 and 70 mm. For each sample, four nets were set for 2 h in the pelagic area of the target zone. The fykes were double fykes with each part 5 m long and a first hoop of 90 cm diameter; both parts were connected by a 12-m wing. They were placed randomly in groups of four in a particular zone and fished for 2 days. The seine nets were of variable size (from 30 up to 100 m long and 5 m deep). Details about the sampling frequency for the different fishing gears in each zone in 1988 and 1999 are given in Table 5.1.

Fish caught were identified, counted, and individually weighed (nearest g) and measured (total length (TL) up to 1 mm). Fish longer than 8 cm TL were marked by cutting part of the left pectoral fin and by freeze branding with liquid nitrogen (−196°C). For each zone a different mark was used. All fish captured were returned to their zone of origin.

Where possible, biomass (kg ha^{-1}) was calculated using a multiple-mark–recapture method (Robson & Spangler 1978). For each species for which marked fish were recaptured, the abundance (with a standard error) was estimated and multiplied by the mean weight of the species, to provide an estimate of standing crop.

The Kruskall–Wallis test was used to define the differences between fish assemblages in the entire lake and between the zones for the different years. Principal component analysis (PCA) and correspondence analysis (CA) were executed on the whole data set (log transformed data), to examine zonal effects and differences between the two sampling periods. Rare species (<1% of the population) were removed to reduce bias.

5.3 Results

5.3.1 *Inventory of the fish species of Lake Schulen*

In 1988 and 1999 respectively, 8483 and 10 693 specimens were caught (Table 5.2). Both surveys found 23 species, dominated by cyprinids. The fish species belong to the various trophic levels (piscivores, planktivores, invertivores and omnivores).

Table 5.2 Number of fish and proportion of 0+ fish in total catch (representing recruitment) collected in Lake Schulen in 1988 and 1999

	1988		1999	
Species	Total fish	% 0+ of catch species	Total fish	% 0+ of catch species
Abramis brama	336	11.9	524	25.5
Alburnus alburnus	3		1	
*Ameiurus nebulosus**	781	0.7	232	2.2
Anguilla anguilla	407		1722	
Barbatula barbatula	–		3	
Blicca bjoerkna	5		516	
Carassius auratus gibelio	7		270	18.3
Carassius carassius	4		–	
Cyprinus carpio	22		17	
Cobitis taenia	1		–	
Esox lucius	325	70.0	71	0.2
Gasterosteus aculeatus	4		–	
Gobio gobio	15		29	
Gymnocephalus cernuus	194	47.7	446	34.7
Lepomis gibbosus	123	1.8	222	0.6
Leuciscus cephalus	–		1	
Leuciscus idus	43	4.8	223	12.2
Misgurnus fossilis	–		1	
Perca fluviatilis	2401	30.6	1571	44.6
Pseudorasbora parva	–		104	0.5
Pungitius pungitius	6		–	
Rhodeus sericeus amarus	1		1	
Rutilus rutilus	3263	15.4	4385	49.2
Scardinius erythrophtalmus	241	13.3	71	43.0
Silurus glanis	–		8	100
Stizostedion lucioperca	102	16.7	214	95.2
Tinca tinca	198	72.2	61	6.9
Umbra pygmaea	1		–	
Total species	23		23	

*The black bullhead (*Ameiurus melas*) is probably also present in Lake Schulen. Due to the difficult determination in the field between the brown and the black bullhead, both species were treated as *Ameiurus nebolosus*.

Five species found in 1988 were not caught in 1999, whilst five new species were recorded in 1999. The newly recorded species in 1999 were topmouth gudgeon, *Pseudorasbora parva* (Schlegel), chub, *Leuciscus cephalus* (L.), stone-loach, *Barbatula barbatula* (L.), weatherfish, *Misgurnus fossilis* (L.) and wels, *Silurus glanis* L.

Umbra pygmea (DeKay) (striped or eastern mudminnow), *Carassius carassius* (L.) (crucian carp), *Cobitis taenia* (L.) (spined loach), *Pungitius pungitius* (L.) (ten-spined stickleback) and *Gasterosteus aculeatus* L. (three-spined stickleback) were five species present in 1988 but not caught in 1999. Only <10 specimens of these species were caught in 1988, so it is not clear whether these fish species are now extinct from the lake or whether they were just not caught in the 1999 survey. There is, however, no obvious reason why these species should in particular have disappeared since 1988.

In 1988 anglers caught five species only (perch, *Perca fluviatilis* L., roach, *Rutilus rutilus* (L.), bream, *Abramis brama* (L.), brown bullhead, *Ameiurus nebulosus* (Le Sueur) and pikeperch, *Stizostedion lucioperca* (L.)). Fourteen species (subtract brown bullhead and add silver bream *Blicca bjoerkna* (L.), gibel carp, *Carassius auratus gibelio* (L.), common carp, *Cyprinus carpio* L., crucian carp, eel, *Anguilla anguilla* (L.), rudd, *Scardinius erythrophtalmus* (L.), ruffe, *Gymnocephalus cernuus* L., pike *Esox lucius* L., ide, *Leuciscus idus* (L.), and tench, *Tinca tinca* (L.)) were captured in 1999 by anglers. These differences can largely be explained by the higher response by anglers to the questionnaire in 1999 compared with 1988. All of these species were also caught in the fish surveys.

5.3.2 *Species composition and population structure in 1988 and 1999*

Substantial differences in the species composition of catches were found between 1999 and 1988 (Table 5.2). The proportion of ruffe, bream and eel in the total catch was much higher in 1999, while the number of roach, perch and brown bullhead declined markedly. On both occasions, however, roach was the most abundant species.

A strong decline in relative abundance of pike (3.6–0.5%) and perch (27.7–13.1%) was recorded, but the contribution of pikeperch remained relatively stable (1.4–1.8%). The proportion of 0+ fish in the total catch per species (Table 5.2) revealed a shift in recruitment in the piscivorous trophic level from pike (70–0.2%) to pikeperch (strong increase from 16.7% to 95.2%).

A considerable increase in the average weight of pike was found in 1999 (915 g) compared with 1988 (257 g). Beside low recruitment, this could also be explained by enhanced cannibalism due to reduced habitat complexity (less macrophytes) and consequently loss of refuges (Grimm & Backx 1990).

The proportion of the bream and silver bream increased from 1988 to 1999 whilst roach decreased, although the contribution of 0+ roach in 1999 was higher than in 1988.

5.3.3 *Fish species distribution between different zones (1988–1999)*

Significant differences (PCA; $P < 0.01$) were observed in the fish assemblages between 1988 and 1999 (Fig. 5.2(a)) (48% of the variance was explained by the two first factors). The second axis in Fig. 5.2(b) explained the differences among the zones where two groups A–B–D and E–C can be distinguished.

CA on the same matrix, indicating the time and zone effects on the fish community, confirmed the differences (54% of the variance explained by the first two axes), but

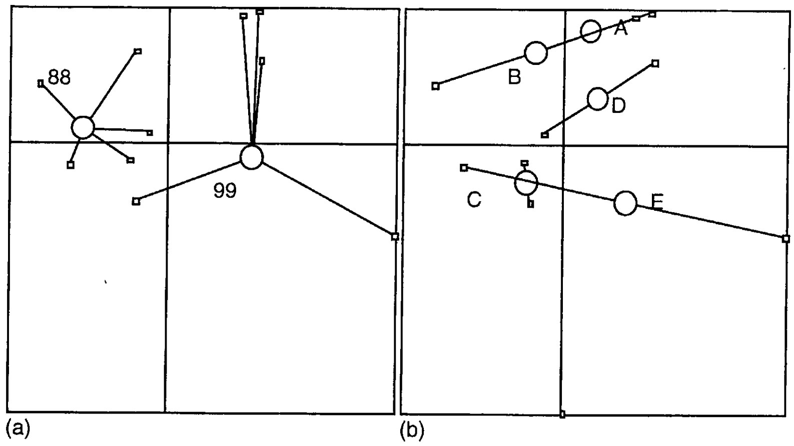

Figure 5.2 (a) and (b) PCA scatter plot for whole 1988 + 1999 data set, excluding rare (<1% of total catch) species

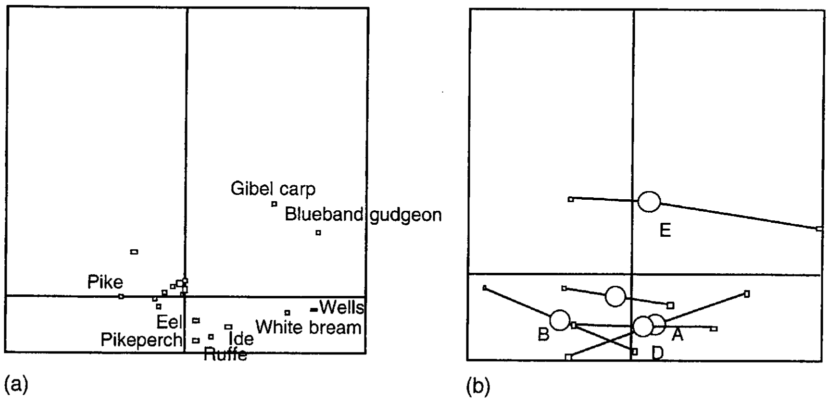

Figure 5.3 (a) and (b) FCA scatterplot on log transformed data (log $x + 1$) (x = % of total population in zones A–E) 1988 and 1999 excluding rare (<1%) species

zone E was distinct from the other zones (Fig. 5.3(b)). Zone E differs due to the higher density of topmouth gudgeon and gibel carp (Fig. 5.3(a)).The position of zone E is atypical since it receives water directly from the River Demer and acts as a sediment trap because of the narrow inlet to the rest of the lake.

When considering data from 1988 and 1999 separately, PCA revealed a difference between zones (Fig. 5.4(a) and (b)). In 1988 the zones were more heterogeneous than in 1999. In 1988 the abundance of brown bullhead in zone E accounted for its position in the plot. Zone C is differentiated from the other zones due to the presence of gibel

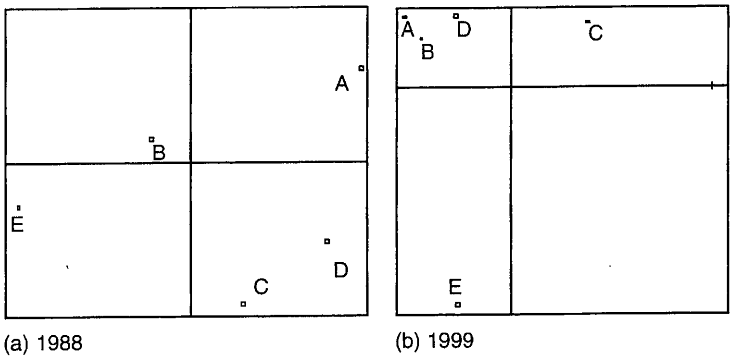

Figure 5.4 (a) and (b) nPCA scatterplot on log transformed data (log $x + 1$) (x = % of total population in zones A–E) 1988 and 1999 respectively excluding rare (<1%) species

Table 5.3 Recaptures of different species of fish in relation to zone of release

Species	Recaptured in same zone	Recaptured in different zone
Brown bullhead	7	24
Eel	44	4
Gibel carp	1	0
Ide	10	0
Perch	18	3
Pike	4	0
Pumpkinseed	5	0
Roach	4	0
Ruffe	1	0
Rudd	1	0

carp and bream. In 1999 zone E was distinct mainly because of the high density of *P. parva*, gudgeon and silver bream. Pike and roach densities explained the position of zone C in 1999.

From the recapture data (Table 5.3) most species appeared sedentary, except for bullhead, which was more actively moving and showed no home range specificity.

5.3.4 *Fish biomass assessment in Lake Schulen*

The standing stock (kg ha^{-1}) of each species for 1988 and 1999 (Table 5.4) was only estimated when there was at least one marked fish recaptured. These estimates should be treated as minimum estimates because few fish were recaptured, however, the shifts in biomass of each species between the two sampling periods reflect trends in

Table 5.4 Biomass ± standard error ($kg\,ha^{-1}$) of different fish species in Lake Schulen in 1988 and 1999

Species	1988	1999
Bream	167.8 ± 99.8	
Brown bullhead	5.4 ± 16.0	1.8 ± 15.1
Eel	45.0 ± 70.3	77.6 ± 15.0
Gibel carp		6.2 ± 98.8
Ide	0.4 ± 42.3	0.9 ± 29.4
Perch	278.0 ± 11.3	3.1 ± 10.4
Pike	4.7 ± 13.2	6.4 ± 54.2
Pikeperch	26.7 ± 98.4	
Pumpkinseed	0.3 ± 33.0	0.1 ± 40.3
Roach	160.5 ± 19.4	125.1 ± 56.0
Ruffe	1.1 ± 56.9	3.2 ± 57.3
Rudd	6.5 ± 36.0	0.8 ± 48.6
Tench	0.6 ± 67.4	
Total	447.1	225.2

abundance. The large difference in the total biomass can be explained by the lack of an estimate of bream in 1999. Bream were abundant in the catches but no marked specimen was captured.

5.3.5 *Biotic integrity*

The establishment of an Index of Biotic Integrity (IBI) for standing waters in Europe is relatively new. Belpaire, Smolders, Vanden Auweele, Ercken, Breine, Van Thuyne & Ollevier (2000) recently described a method for standing waters in Flanders. This index was used to calculate the integrity class for both sampling periods 1988 and 1999 (Table 5.5). The index showed no major shifts in scoring between the two periods, with the lake exhibiting a reasonable biotic integrity. This suggests that the lake ecosystem is relatively stable, despite a shift in the fish community.

5.4 Discussion

This study found a rich species diversity in Lake Schulen. Important shifts in the fish community structure occurred between 1988 and 1999. New species (of which the topmouth gudgeon and the wels were the most conspicuous) were caught while apparently other species disappeared.

The small Asian topmouth gudgeon was accidentally transported to Europe in the early 1960s with Chinese carps (first recorded in Romania in 1961). Over the last 40 years it has spread all over Europe and it was first recorded, in Flanders in 1992, in the

Table 5.5 The IBI score for each metric for the lake in 1988 and 1999

	1988		1999	
Parameter	Value	Score	Value	Score
Total number of species	16	5	23	5
Mean tolerance value	2.25	5	2.5	5
Total biomass (kg ha^{-1})	447.05	4	295.3*	5
Weight ratio piscivores/ non-piscivores	0.09	3	0.048	2
Type species	2.3	2	2.3	2
Pike recruitment and biomass (kg ha^{-1})	4.7 (recruitment)	3	6.4	3
Tench recruitment and biomass (kg ha^{-1})	0.69 (recruitment)	3		
Weight percentage of non-native species	7.24	2	21.4	1
Final score		3.38		3.29
Integrity class		4		4
Assessment		Reasonable		Reasonable

*Underestimated.

River Demer basin (De Charleroy & Beyens 1998). It is now common in almost all river and lentic systems of Flanders. The presence of large numbers of 0+ specimens as well as adult fish in the lake indicates that the population has naturalised. Its effect on the indigenous fish population is unclear, however, interaction with native species can be expected and should be monitored.

The appearance of chub and stoneloach in 1999 was based on one specimen of each. This was probably due to improvement in water quality in the River Demer over the last few years, and populations of both species now occur in the river (Breine, Van Thuyne, Belpaire, De Charleroy & Beyens 1999); the specimens in the lake probably entered from the river during flood periods.

Although some references show that the wels was an indigenous fish species in Western Europe and even in Flanders (found in archeological sites until the 12th century; Van Neer & Ervynck 1993), no natural populations of this species remain (Bruylants *et al.* 1989; De Nie 1996). In Lake Schulen a number of large wels were illegally stocked in the early 1990s by anglers and eight juvenile specimens (ranging from 8 to 14 cm) were caught in the 1999 survey. The presence of small specimens of wels is unique in Flanders. There is no indication that these small specimens were stocked suggesting this species is breeding in the lake. This is supported by some stretches in zone A corresponding to the habitat needed for the natural recruitment of wels, i.e. shallow with reed fringes and hanging tree roots (Huet 1970; De Nie 1996).

Only one specimen of *Misgurnus fossilis* was found in the lake. The weatherfish is very rare in Flanders and is protected by the Flemish Fisheries Law. *Misgurnus fossilis* was recorded in 1994 in a brook adjacent to the lake and other specimens were found in several locations in the Demer catchment in 1995 (De Charleroy & Beyens 1998) and 1998 (Breine *et al.* 1999). Due to cryptic habitats (often hiding in the mud) the weatherfish is difficult to catch using the methods applied, therefore the number of specimens present in a water body is often underestimated.

Reasons for the shift in community structure between 1988 and 1999 are varied and complex. In 1991 the lake had almost a complete fringe of emergent vegetation with some submerged species (Schoonjans, Belpaire, Podoor & Van Assche 1991). In 1999 barely any aquatic vegetation, needed for spawning of pike, rudd and tench, was present in the lake. This is probably the main reason for the low recruitment of these species in 1999.

Large roach and bream populations can cause a reduction of aquatic vegetation. In search for benthic food, these animals can increase turbidity by stirring up the sediment, which also enhances the nutrient flow in the water column. This brings unfavourable conditions for the development of submerged macrophytes and stimulates algal blooms (Scheffer 1998).

Persson, Diehl, Johansson, Andersson & Hamrin (1991) studied shifts in fish communities along the productivity gradient of 13 temperate lakes. They observed that a high biomass of percids was caused by different species depending on the productivity gradient of the lake. In mesotrophic systems this was due to a high biomass of perch, as opposed to pikeperch in eutrophic systems. In eutrophic systems, a higher abundance of ruffe was also present. A similar shift took place in Lake Schulen, although the pikeperch population did not increase in biomass but only in numbers. Also ruffe abundance increased in 1999 compared with 1988. This success of pikeperch and ruffe has been related to adaptations of these species to feed under poor light conditions prevalent in eutrophic systems (Ali, Ryder & Anctil 1977). Pikeperch may also take advantage of the presence of ruffe as a food source (Löffler 1998).

The decrease of perch is probably due to the competitive superiority of roach and bream in eutrophic, turbid waters, which is related to their efficient capture of zooplankton. Also green algae is an important food resource for roach (Johansson & Persson 1986) making this species more adaptable to eutrophic waters.

Eel is now very abundant in the lake. The main reasons for the expansion of this population are the yearly restockings with glass eels (4 kg glass eel year^{-1}) and the large ruffe population, which is probably a good food source for eel. The increasing food requirement of the present eel population could explain the decline in abundance of bullhead from 7.6% to 1.9%. The active movement pattern of bullhead in the lake could also be a sign of this lack of food.

The IBI for both sampling periods was nearly identical and classified the lake as having a moderate biotic integrity. Karr (1981) defined this as an ecosystem with a species richness somewhat below expectation (due to loss of intolerant forms), some species with less than optimal abundance or size distribution and with a trophic structure showing some signs of stress.

A multi-disciplinary research programme on the lake (water quality, plankton community, etc.) could provide additional data on the lake ecosystem, however, the present study has already provided much information for management of the lake fisheries.

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