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THE COMPOSITION OF THE FISH AND CRUSTACEAN COMMUNITY OF THE ZEESCHELDE ESTUARY (BELGIUM)

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Abstract. Fykes were used to monitor the fish and crustacean fauna of the mudflats of the Zeeschelde between April 1995 and December 1996. Overall 38 species were recorded; the number of species was greater in the brackish water part than in the fresh water part probably due to reduced oxygen concentrations in the upper reaches of the river. In terms of wet weight, just 6 species accounted for more than 96 % of the total annual catch. These species are shore crab, eel, flounder, common shrimp, sole and bass. Clear seasonal patterns in the community structure were not identified. It is argued that the selectivity of the fishing gear is mainly responsible for the dominance of a few species and the lack of a temporal structure.

Keywords: spatial distribution, fish, Crustacea, fykes, Zeeschelde estuary.

INTRODUCTION

The Zeeschelde is situated in Belgium and stretches from Gent to the Belgian/Dutch border. It is divided in a fresh water part (the Upper Zeeschelde) and a brackish water part (the Lower Zeeschelde) that is connected to the Westerschelde (CLAESSENS, 1988). Although the Zeeschelde is characterised by very poor water quality, a complete salinity gradient is present (HEIP, 1989). In addition, strong tidal incursion creates intertidal areas such as mudflats and salt marshes. These mudflats are important nurseries and feeding grounds for fishes and macrocrustaceans (BOESCH & TURNER, 1984). Field experiments even emphasise the role these mobile epibenthic predators play in determining estuarine mudflat prey densities (GEE *et al.*, 1985; RAFFAELLI *et al.*, 1989).

Most research on the intertidal areas of the Schelde estuary deals with the vegetation (*e.g.* MEIRE & KUIJKEN, 1988) and benthic fauna (*e.g.* YSEBAERT *et al.*, 1993; SOETAERT *et al.*, 1994) or concerns nutrient fluxes between the intertidal and subtidal sectors (*e.g.* HEMMINGA *et al.*, 1993). Little effort has been undertaken to study fish and macrocrustaceans entering these narrow mudflats. Recently CATTRIJSSE *et al.* (1994) investigated the utilisation of a brackish intertidal creek of the Westerschelde by estuarine nekton. They concluded that

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the marsh is a nursery for juveniles of common shrimp, flounder, common goby, bass and shore crab. Adults of these species possibly use these areas as feeding ground.

This paper presents and discusses results from fyke catches on the intertidal mudflats of the Zeeschelde. These data are the first since POLL (1945) on the spatial distribution of fish and larger crustaceans in the estuary of the Zeeschelde. The aim of this study is to inventory the fish and crustacean species occurring in these mudflats and to evaluate the fishing method as a tool to monitor the Zeeschelde ecosystem.

MATERIAL AND METHODS

Nine sampling sites, all situated in the Zeeschelde, were selected to collect samples of fish and crustaceans. Five stations (A-E) cover the Lower Zeeschelde between Antwerpen and Bath (on the Belgian/Dutch border), four locations (F-I) are situated in the Upper Zeeschelde between Schelle and Antwerpen (Fig. 1). Fish and crustaceans were sampled at each location using double fyke nets containing two fykes both connected by a longitudinal net. The overall length of the entire set-up is 26.4 m; stretched mesh size of the nets is 8 mm. All fyke nets were set at the low-water line and checked for fish and crustaceans every 3 days. Sampling at stations A, B and C was carried out between April 1995 and December 1995. All other stations were sampled in August and November 1995. Minimum and maximum salinity and oxygen concentration as well as temperature recorded in 1995 are given in Table 1. Both salinity and oxygen concentration increase in the downstream direction.

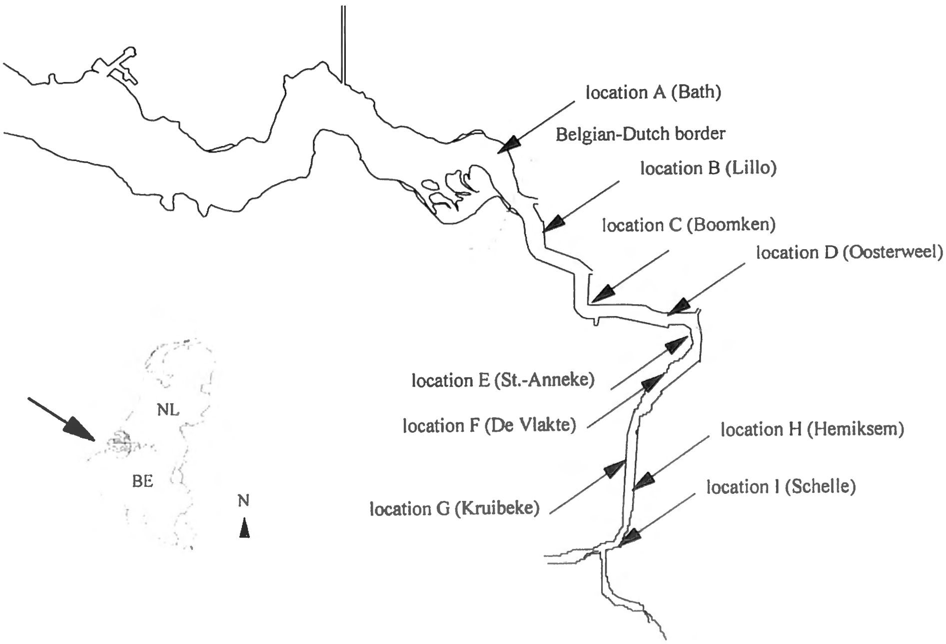


Fig. 1. – Map of the Schelde estuary with indications of the sampling sites. BE = Belgium; NL = the Netherlands.

TABLE 1

Minimum (m) and Maximum (M) salinity (g/l), oxygen concentration (mg/l) and temperature (°C) recorded in 1995 (based on monthly samples) for the sampling locations (the code of the sampling sites is the same as presented in Fig. 1). Data indicated with (*) originate from the environmental database of the Flemish Environment Agency.

sampling sites	salinity (g/l)		O_2 -concentration (mg/l)		temperature (°C)	
	m	M	m	M	m	M
A (*)	2.3	15.9	2.0	7.0	5.3	24.9
B	2.1	15.3	2.2	6.9	5.8	25.0
C	2.0	11.0	0.1	5.8	6.0	24.1
D-E	1.2	8.0	0.2	4.1	5.6	24.7
F	0.3	6.5	0.3	5.5	5.8	24.6
G (*)	0.1	0.6	0.6	6.5	6.0	24.4
H (*)	0.1	1.3	0.9	3.8	4.8	24.6
I	0.1	0.5	0.0	3.1	6.5	25.3

Fish and crustacean species were identified according to WHEELER (1992) and HOLTHUIS & HEEREBOUT (1986) respectively. For each species data are expressed either as densities (monthly average numbers per fyke per day) or as wet weights (monthly average wet weight (g) per fyke per day). Temporal patterns in the community were analysed by means of cluster analysis on densities and on wet weights (Ward's Method, Euclidean distances). This method uses an analysis of variance approach to evaluate distances between clusters and attempts to minimise the sum of squares of any two clusters that can be formed at each step (WARD, 1963). Prior to the statistical analysis the data were log (x + 1) transformed (FIELD *et al.*, 1982).

RESULTS AND DISCUSSION

Fyke netting yielded 38 fish species and 7 crustacean species (Table 2). Of all fish species recorded 23 species are marine (MA) with no strict estuarine requirements; 12 species are identified as fresh water species (FW); eel (*Anguilla anguilla*) is the only catadromous species (CA) and 2 species are anadromous (AN) namely the river lamprey *Lampetra fluviatilis* and the sea trout *Salmo trutta*. All crustacean species are marine species except the noble crayfish *Astacus astacus* which prefers a fresh water habitat. VAN DAMME *et al.* (1994) recently inventoried the fish species occurring in the cooling water of the Nuclear Power Station Doel which is situated near location B. They listed 32 fish species in the Lower Zeeschelde. If the first 3 sampling sites alone are considered, fyke netting recovered 36 fish species. In this case both studies have 26 species in common.

In terms of numbers, 4 species alone represented more than 96 % of the total annual catch. The samples were dominated by the common shrimp *Crangon crangon* (67.6 %)

and the shore crab *Carcinas maenas* (23.7 %). Flounder (*Pleuronectes flesus*) and the palaemonid shrimp *Palaemonetes varians* contributed each 2.7 % of the total numbers. In terms of wet weight 6 species represented more than 92 % of the total annual catch over the 9 sampling sites. Shore crab, eel (*Anguilla anguilla*) and flounder each represented 27.5 % of the total annual catch. The relative proportion of the common shrimp was 4.5 % whereas sole (*Solea solea*) and bass (*Dicentrarchus labrax*) both contributed 4 % and 1.3 % respectively. Other studies confirm indeed the dominant position of a small number of species in estuarine fish and crustacean communities (CLARIDGE *et al.*, 1986; ELLIOT & TAYLOR, 1989; HENDERSON, 1989). The major reason however, that a few species contributed more than 92 % of the annual catch may be the selective catch efficiency of the fishing gear used. Fykes almost only sample benthic or demersal species excluding pelagic species such as clupeids. In addition gobies and pipefish are able to escape through the meshes of the fykes used. These later species as well as clupeids are by contrast regularly sampled in the cooling water system of Nuclear Power Station Doel (VAN DAMME *et al.*, 1994). It is therefore most likely that the relative abundance of shrimps is underestimated. All dominant species recorded in this study were adult individuals of either benthic or demersal species probably using the intertidal as a feeding ground.

TABLE 2

Fish and crustacean species occurring in the intertidal mudflats of the Zeeschelde (the code of the mudflats is the same as presented in Fig. 1).
+++ = >1 individuals per fyke per day, ++ = <1 individual per fyke per day, + only 1 record.
For abbreviations of ecological type (E.T.) see text.

Fish species	**E. T.**	**brackish water part**					**fresh water part**			
		A	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**
Carassius auratus (L.)	FW	+								
Raniceps raninus (L.)	MA	+								
Atherina presbyter Cuvier, 1827	MA	++								
Gymnocephalus cernuus (L.)	FW	++								
Myoxocephalus scorpius (L.)	MA	++								
Pomatoschistus lozanoi (de Buen, 1923)	MA	++								
Zoarces viviparus (L.)	MA	++								
Pomatoschistus microps (Krøyer, 1838)	MA	+++								
Ciliata mustela (L.)	MA	+	+							
Salmo trutta L.	AN	+	+							
Trigla lucerna (L.)	MA	++	+							
Pleuronectes platessa L.	MA	++	++							
Trisopterus luscus (L.)	MA	++	++							
Gadus morhua L.	MA	++	++	+						
Solea solea (L.)	MA	+++	++	+						
Limanda limanda (L.)	MA	+++	++	++						
Dicentrarchus labrax (L.)	MA	+++	++	++						
Merlangius merlangus (L.)	MA	+		+						
Ictalurus nebulosus (Le Sueur, 1819)	FW		+							

Fish species	E. T.	brackish water part					fresh water part			
		A	B	C	D	E	F	G	H	I
Blicca bjoerkna (L.)	FW		+							
Syngnathus acus L.	MA		++	++						
Syngnathus rostellatus Nilsson, 1855	MA		+							
Sprattus sprattus (L.)	MA			+						
Lepomis gibbosus (L.)	FW			+						
Liza ramada (Risso, 1826)	MA	++	+	++	+					
Pomatoschistus minutus (Pallas, 1770)	MA	++	++	++	++	++				
Pleuronectes flesus L.	MA	+++	+++	+++		++				
Osmerus eperlanus (L.)	MA	++	++		+					
Clupea harengus L.	MA	++	++	+++	+++	++				
Gasterosteus aculeatus L.	FW	++	+	+		++				
Lampetra fluviatilis (L.)	AN	+			++	++				
Anguilla anguilla (L.)	CA	+++	+++	+++	+++	++	++	++	++	++
Perca fluviatilis L.	FW	+	++	++	++	++	++	++		
Stizostedion lucioperca (L.)	FW	++	++	++	++	++	++	+		
Rutilus rutilus (L.)	FW	+	++			++	++	++	+	+
Cyprinus carpio L.	FW			++		++	++	++		
Rutilus erypthrophthalmus (L.)	FW					++	++	++	++	
Carassius carassius (L.)	FW						++	++		
Crustacean species										
Callinectes sapidus Rathbun, 1860	MA		+							
Rhithropanopeus harrissi (Gould, 1841)	MA	+	++	+						
Eriocheir sinensis H. Milne Edwards, 1851	MA	++	++	++						
Carcinus maenas (L.)	MA	+++	++	+	+	+				
Crangon crangon (L.)	MA	+++	+++	+++						
Palaemonetes varians (Leach, 1814)	MA	++	+++	+++	+++	+++	++			
Astacus astacus (L.)	FW			+						

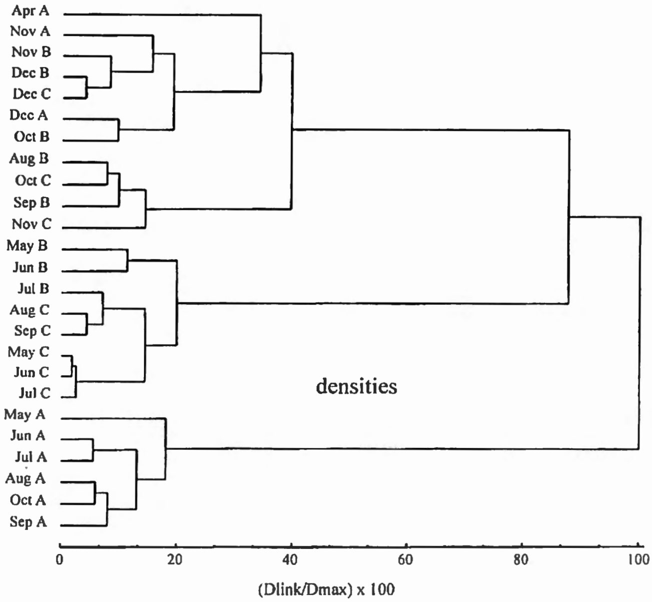
It is interesting to note that except for the eel all dominant species are marine. They occur up to station E (Table 2) which can be considered as the final station of the brackish water part. Upstream of station E only fresh water and diadromous species were caught (Table 2). According to REMANE & SCHLIEPER (1971) who defined a relation between salinity and species number one should expect the species number to increase in the fresh water part of the Zeeschelde estuary. But the number of species as well as abundance of fish and crustaceans were probably reduced due to critical oxygen concentrations (<1 mg/l) during most of the year (Table 1). As a result of this hypoxia caused by heavy eutrophication (VAN DAMME *et al.*, 1995) only a few species can be caught. Similar results for the Elbe estuary were found by MÖLLER & SCHOLTZ (1991) who found flounder and smelt (*Osmerus eperlanus*) concentrated downstream from the low-oxygen zone, avoiding the fresh water reach. Only eel was able to tolerate oxygen concentrations < 1.4 mg/l (MÖLLER & SCHOLZ, 1991). Apart from one record of roach (*Rutilus rutilus*) only eel occurred at station I, the station with the lowest oxygen concentration. Although the sampling effort in the fresh water zone was less than in the first three stations, it does not preclude the possibility that neither fish nor crustaceans can survive the above mentioned low oxygen concentrations.

In polluted systems such as the upper Zeeschelde where the distribution of fresh water species is strongly affected by reduced oxygen levels, these later species profit from the more favourable oxygen conditions in the brackish part of the Zeeschelde. Indeed most fresh water fish were recorded between station A and station E where mean annual salinities approach 10 ‰ and 2 ‰ respectively (CLAESSENS, 1988). These species probably originate from surrounding docks of the Antwerpen Port Area that connect the Lower Zeeschelde with the Albert Channel and the Schelde-Rijn Channel (MAES, unpublished). Sampling in these waterways indeed suggests the presence of important populations of fresh water species and therefore they function as refuges.

Besides the spatial distribution of fish and crustaceans in the Zeeschelde we attempt to describe temporal patterns in the community structure using cluster analysis on densities and on wet weights. Since a monthly sampling regime could not be maintained at all sampling stations only the first 3 locations (A-B-C) are considered (Fig. 2). In both plots the spatial distribution of the community seems to dominate over the temporal pattern. Samples taken at the same location more or less co-occur. In the density plot the first division is made between samples taken at station A between May and October and all other samples including April A, November A and December A. Further clustering however does not result in a seasonal structure with summer samples separated from winter samples. Clustering the wet weight data resulted in the same information. All samples taken at location A except for «December A» are separated from the other samples. Once again no seasonal trends can be detected by the analysis. Many authors nevertheless identify clear seasonal patterns in the composition of estuarine fish and crustacean communities (WHARFE *et al.*, 1984; CLARIDGE *et al.*, 1986; HENDERSON & HOLMES, 1987). In this case the lack of a temporal structure could be once again be the consequence of a selective fishing technique. Because of the exclusion of an important number of species frequently occurring in estuaries such as gobies and clupeids clear seasonal trends were not expressed.

CONCLUSIONS

A major conclusion of this study concerns the fishing gear used. Fyke netting can be most useful to obtain qualitative data in areas where other methods do not succeed because of difficult field conditions. The results show indeed the existence of a stable and permanent community in the brackish part of the Zeeschelde whereas the fish and crustacean community in the Upper Zeeschelde can be described as unstable and temporary. With the prospect of an ecological recovery of the fresh water part of the Zeeschelde as a result of recent waste water treatment programmes fykes could be an appropriate tool to monitor the ecosystem. On the other hand it seems obvious that a complete description of the struc-



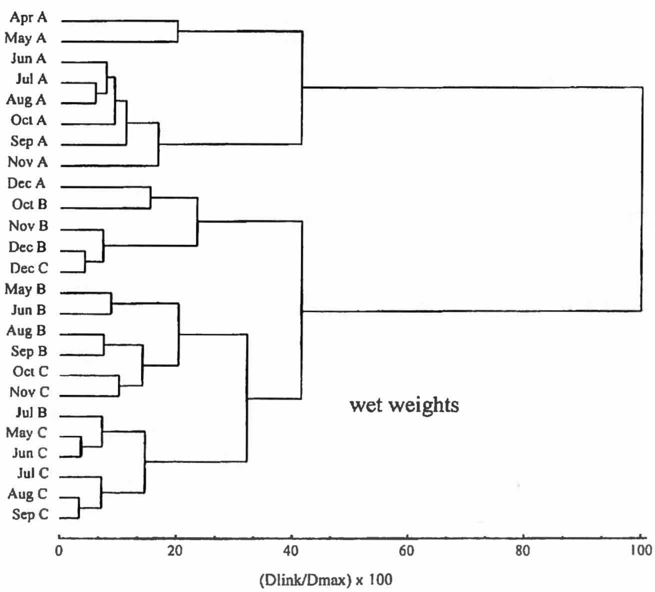


Fig. 2. – Cluster analysis (Ward's Method, Euclidean distances) on the log (x + 1) transformed densities and wet weights of all species recorded between April 1995 and December 1995 on sampling sites A, B and C. The linkage distance (Dlink) is presented as a percentage of the maximum linkage distance (Dmax). The maximum linkage distance is 13.20 for the analysis on densities and 18.29 for the analysis on wet weights.

ture and functioning of an entire fish and crustacean community requires a less selective fishing method such as stow net fisheries or sampling at cooling water intakes, allowing the collection of a fully quantitative and qualitative dataset.

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