Belg. J. Zool., 141 (1) : 44-55 January 2011

A reference list of fish species for a heavily modified transitional water: The Zeeschelde (Belgium)

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ABSTRACT. A crucial step in the development of a fish-based index for the ecological assessment of water bodies as provided by the European Water Framework Directive is to define a reference list of fish species occurring in pristine rivers. The aim of this study was to elaborate such a list. The reference corresponds to an ecological status that is referred to as Good or Maximal Ecological Potential (GEP/MEP). Based on historically-reported fish survey data of the Zeeschelde estuary (Belgian part of the Schelde estuary) and its tributaries, i.e. an affluent system, under tidal influence, presence/absence reference lists were compiled for different salinity zones and adjusted using information from recent catches. In addition, an MEP list of fishes occurring in the Westerschelde (Dutch part of the Schelde estuary), developed by JAGER & KRANENBARG (2004), is provided to present a complete overview of the Schelde estuary. Inclusion of fish species in the reference lists depended on their natural geographical distribution and ecological demands. These reference lists contain guild-specific information for the different zones within the estuary and its tidal tributaries.

KEY WORDS: ecological potential, fish reference list, Schelde estuary and tidal tributaries, Water Framework Directive

INTRODUCTION

All transitional waters in Flanders have been identified as heavily modified water bodies (HMWB) because their nature has changed fundamentally as a result of physical anthropogenic alterations. According to Article 4(3) of the European Water Framework Directive (WFD) the principal environmental objective for HMWB and artificial water bodies is to obtain a “good ecological potential” (GEP) and “good surface water chemical status” instead of a "good ecological status" as required for natural systems. Similarly, the reference situation in HMWB is referred to as “maximal ecological potential” (MEP) instead of a “pristine status” (EU Water Framework Directive, 2000; BORJA & ELLIOTT, 2007). According to WFD the MEP biological conditions should reflect the biological conditions associated with the closest comparable natural water body type at reference conditions as far as possible, given the MEP hydromorphological and associated physico-chemical conditions. BORJA & ELLIOTT (2007) considered the MEP as the reference conditions for HMWB. For an HMWB to be classified as attaining GEP status no more than slight changes in the values of the relevant biological quality elements must be observed as compared to their values at MEP. The biological potential can be defined once the hydromorphological and physical chemical potentials are described. The different paths of the decision procedure are illustrated in Fig. 1

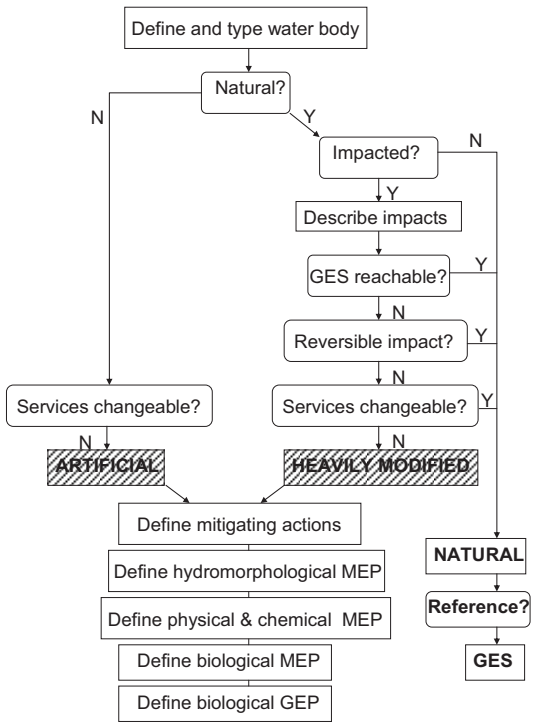

Fig. 1. – Flow diagram: guidelines to describe MEP/GEP adapted from a report of the Dutch Ministry of Transport, Public Works and Water Management (RIZA, 2006). MEP: Maximum Ecological Potential, GEP: Good Ecological Potential and GES: Good Ecological Status. Y stands for ‘yes’ to follow the indicated path; N stands for no to abort the next step.

During an international workshop on the WFD and hydromorphology held in Prague 2005 it was concluded that these biological MEP/GEP conditions can also be defined from the current status (KAMPA & KRANZ, 2005). A key difference in this approach is that the GEP is derived directly from the effect of mitigation measures, i.e. measures that reduce or remedy effects of human activities, and not indirectly from the specification and prediction of biological quality elements at MEP (KAMPA & LAASER, 2009). For the benthos in the Westerschelde, the part of the Schelde estuary that is situated in The Netherlands, ESCARAVAGE et al. (2004) suggested that when a reference based on historically pristine conditions is absent, the MEP has to be based on the knowledge of the ecosystem functioning. This concept was further elaborated by VAN DEN BERGH et al. (2005) using a scale-dependent approach. In particular ESCARAVAGE et al. (2004) defined MEP/GEP at an ecosystem scale, an ecotope scale and a macrobenthic community scale. For the Zeeschelde, the Belgian part of the Schelde estuary, BRYS et al. (2005) applied a similar hierarchical approach to define MEP/GEP for macrobenthic invertebrates and macrophytes on tidal marshes. In addition and according to the Common Implementation Strategy, they established the hydromorphological conditions required for these MEP/GEP conditions, but not for fish. We take the habitat requirements described in BREINE et al. (2008) at the guild level as the MEP/GEP conditions in estuaries for fish. Here we compile a species list for fish that should occur in the Zeeschelde estuary and its tributaries when it reaches GEP or MEP condition.

MATERIALS AND METHODS

The study area comprises the Zeeschelde estuary and its tributaries under tidal influence. JAGER & KRANENBARG (2004) defined the reference for the Westerschelde to which we add the reference list for the Belgian part of the estuary.

We defined five different zones based on the Venice system (1959, Fig. 2): the polyhaline and mesohaline part of the Zeeschelde, the oligohaline part of the Zeeschelde including the River Rupel, the freshwater part of the Zeeschelde and Durme and the freshwater tributaries under tidal influence (Rivers Dijle, Zenne, Nete, Grote Nete, Kleine Nete). Like the estuary, all tidal tributaries are heavily modified.

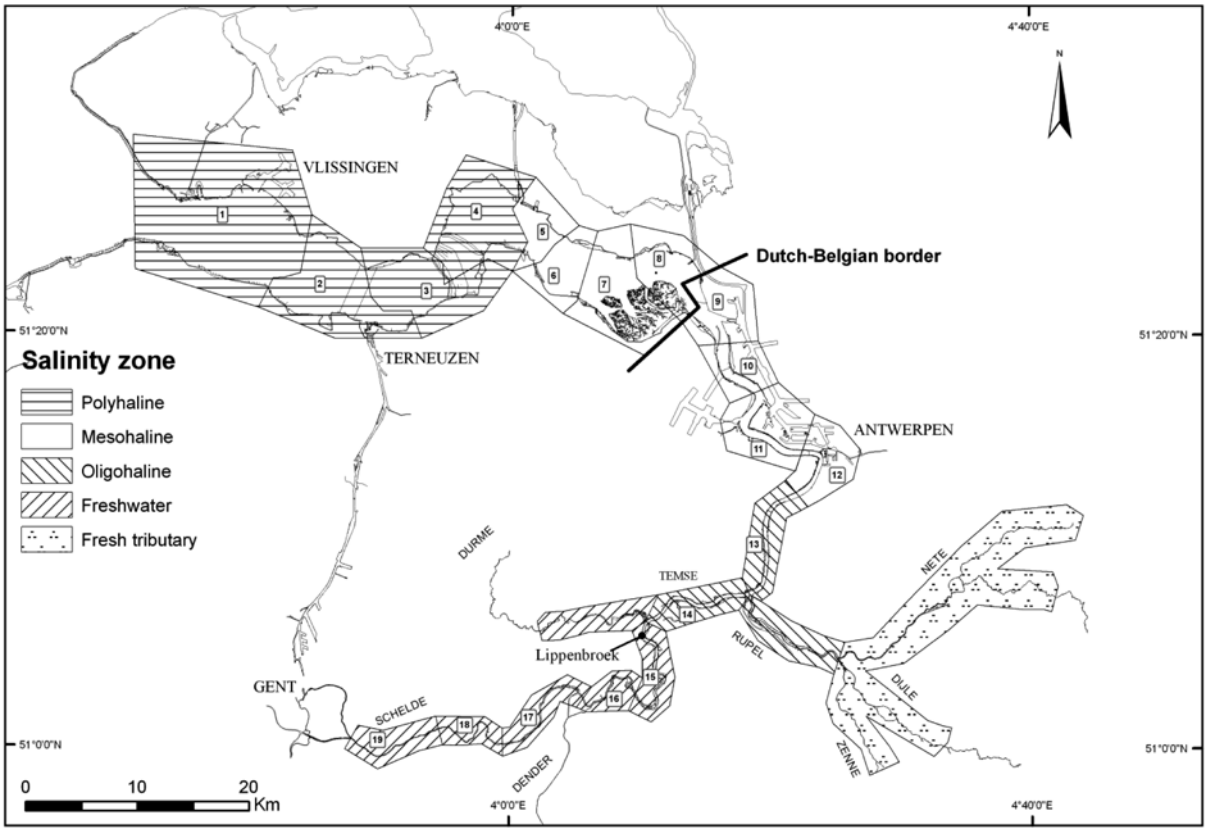

Fig. 2. – Salinity zones and Omes segments (numbers, HOFFMANN & MEIRE, 1979) in the Schelde. Omes segments are different units of the Zeeschelde that were defined in modelling studies. The Dutch-Belgian border separates the Westerschelde (downstream) from the Zeeschelde (upstream).

Next, we compiled historical records of fish that occurred in each zone of the Zeeschelde between 1842 and 1947. This list was then adjusted to an MEP/GEP reference list based on data from recent sampling programmes using fyke nets (1995-2007) and the cooling-water intake screens at the Doel power plant, situated in the mesohaline part of the Zeeschelde estuary (1991-2007). As an additional resource, we used information from peer-reviewed and grey literature reporting on non-regular sampling campaigns (Table 1). All fish species were assigned to functional groups or guilds following ELLIOTT et al. (2007) and FRANCO et al. (2008) according to their particular niche within their particular salinity zone.

TABLE 1

References, in chronological order of appearance, used to assess the presence of fish species in the Zeeschelde and tidal tributaries, classified by salinity zone.

Salinity zone	Literature
Mesohaline	DE SELYS-LONGCHAMPS (1842); POLL (1945; 1947); VAN DAMME et al. (1994); MAES et al. (1997); BREINE et al. (2001); MAES et al. (2001); ADRIAENSSENS et al. (2002); BREINE et al. (2007; 2010a)
Oligohaline	MAES et al. (1997); VRIELYNCK et al. (2003); BREINE & VAN THUYNE (2004); MAES et al. (2005); BREINE & VAN THUYNE (2005); BREINE et al. (2006); SIMOENS et al. (2006); BREINE et al. (2007; 2010a)
Freshwater	VAN DEN BOGAERDE (1825); BREINE et al. (2001); VRIELYNCK et al. (2003); BREINE & VAN THUYNE (2005); MAES et al. (2005); BREINE et al. (2006); SIMOENS et al. (2006); BREINE et al. (2007; 2010a)
Nete	YSEBOODT & MEIRE (1999); VAN LIEFFERINGHE et al. (2000); BREINE et al. (2001); VAN THUYNE & BREINE (2003a); VRIELYNCK et al. (2003); VAN LIEFFERINGHE et al. (2005); BUYSSE et al. (2007); VAN THUYNE & BREINE (2008)
Dijle and Zenne	BREINE et al. (2001); VAN THUYNE & BREINE (2003b); VRIELYNCK et al. (2003); BUYSSE et al. (2007); VAN THUYNE & BREINE 2008)

A species was included in the MEP/GEP lists if historical data indicate its presence in a particular zone or if its habitat needs correspond to the habitat potentials of that particular zone (BREINE et al., 2001; 2008). In addition, the catch frequency was considered and species that are no longer, or rarely, caught (<5% catch frequency defined by expert judgment) are retained only in the MEP list (Fig. 3). Eurytopic species, i.e. fishes that are able to tolerate a wide range of conditions, and species being tolerant to extreme conditions (e.g. low oxygen concentration) are placed in both lists. The GEP list differs from the MEP list since it should reflect a small anthropogenic impact. These historical MEP/GEP fish record lists were then adjusted following the criteria stipulated by RAMM (1990). We applied three conditions to omit some species from both the MEP and the GEP list even if they previously occurred in a particular zone: 1) fish are locally or regionally extirpated, 2) the presence in a particular zone is not an indication of good status (potential), 3) the zone is not their preferred habitat.

Stragglers or occasional visitors were not listed either since they do not depend on the estuary to complete their life cycle (ELLIOTT et al., 2007). Nevertheless, some interesting observations are reported here: e.g. the snake pipefish (*Entelurus aequoreus*) was quite rare in the Zeeschelde but is now captured more frequently at Doel. DE SELYS-LONGCHAMPS (1842) and POLL (1947) stated that the greater weaver (*Trachinus draco*) was common, in contrast with POLL (1945) where it was considered as an irregular guest. This species was never caught in recent surveys in the estuary.

All exotic species were omitted since they are indicators of disturbance (KARR, 1981), with the exception of pike-perch (*Sander lucioperca*) because this species can be considered as naturalised and has a high demand concerning oxygen concentrations (FAO, 1984). Exotic species were defined according to VERREYCKEN et al. (2007). Marine species that occur in the North Sea but were never reported in the river were also omitted.

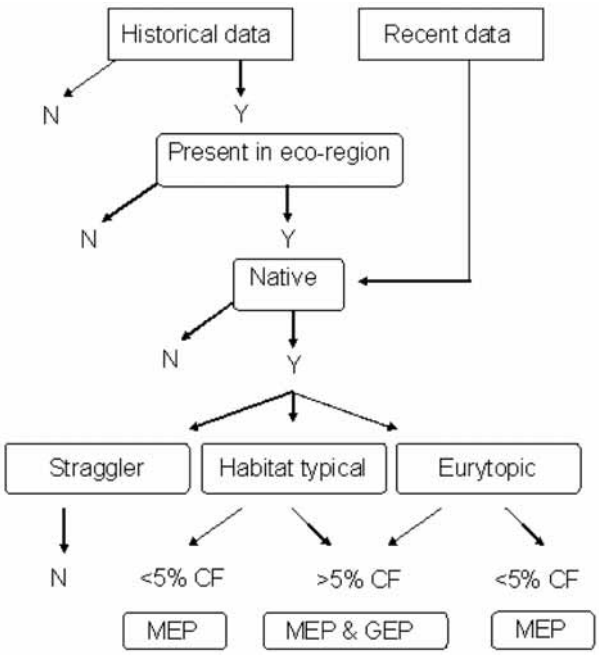

Fig. 3. – Decision tree used to allocate fish species to the Maximum Ecological Potential (MEP) and the Good Ecological Potential (GEP) list. At each level, the answer 'yes' or 'no' indicates the path along the tree. Finally, the attribution to the MEP or GEP depends on the catch frequency (CF).

TABLE 2

Historical and recent presence (1) - absence (0) fish data for the Zeeschelde estuary and GEP and MEP lists for the polyhaline zone (JAGER & KRANENBARG, 2004), mesohaline, oligohaline, freshwater zones and tidal estuaries. Fish guilds are based on FRANCO et al. (2008). For each data source it is indicated whether the study deals with the mesohaline (M), oligohaline (O), freshwater (F) zone or (T) tributary of the Schelde. Empty cells mean that no data are available; figures in italics indicate few catches or records (<5sp.); * no longer in the Zeeschelde; ** exotic species; PC: personal communication. DS: Diadromous species; ER: Estuarine species; FW: Freshwater species; MS: Marine stragglers (adventitious visitors); MM: Marine migrants (seasonal or juvenile migrant).

Scientific name	**MEP Westerschelde** JAGER & KRANENBARG, 2004	(M) fyke nets surveys, 1995-2006	(M) surveys cooling-water Doel 1991-2007	**MEP Mesohaline zone**	**GEP Mesohaline zone**	(M–O) DE SELYS-LONGCHAMPS, 1842	(M–O) POLL, 1945	(M–O) POLL, 1947	(M-O) SIMOENS et al., 2006	(M-O) BREINE et al., 2007	(M–O–F) BREINE et al., 2001	(O) fyke nets surveys, 2005-2007	(O) River Rupel BREINE et al., 2005-2007	(O) River Rupel SIMOENS et al., 2006	**MEP Oligohaline zone**	**GEP Oligohaline zone**	(F) MAES et al, 2005	(F) SIMOENS et al., 2006	(F) Durme SIMOENS et al., 2006	(F) River Durme BREINE et al., 2005-2007	(F) fyke nets surveys, 2005-2007	**MEP Freshwater zone**	**GEP Freshwater zone**	(T) BREINE et al., 2001	(T) VRIELYNCK et al. (2003)	(T) Nete SIMOENS et al., 2006	(T) Dijle & Zenne SIMOENS et al., 2006	(T) River Nete BUYSE et al., 2007 & PC	(T) River Dijle BUYSE et al., 2007 & PC	**MEP Tributaries**	**GEP Tributaries**	Guild
Abramis brama (Linnaeus, 1758)	**0**	1	1	**0**	**0**	1	1		1	1	1	1	1	1	**1**	**1**	1	1	0	1	1	**1**	**1**	1	1	0	0	1	1	**1**	**1**	FW
Acipenser baerii (Brandt, 1869)	**1**			**1**	**0**	1	*1*	*1*	0		1			0	**1**	**0**	0	0	0			**1**	**0**	1	1	0	0			**1**	**0**	DS*
Agonus cataphractus (Linnaeus, 1758)	**1**	1	*1*	**1**	**0**		1	1	0	1	1				**0**	**0**		0				**0**	**0**							**0**	**0**	ER
Alburnus alburnus (Linnaeus, 1758)	**0**			**0**	**0**	1	0		0	1		*1*	0	0	**0**	**0**		0	1	1		**1**	**0**		1	1	1	*1*	0	**1**	**0**	FW
Alosa alosa (Linnaeus, 1758)	**1**			**1**	**0**	1	*1*	*1*	0	*1*	1			0	**1**	**0**	0	0	0			**1**	**0**	1	1	0	0			**1**	**0**	DS*
Alosa fallax (Lacepède, 1803)	**1**	1	1	**1**	**1**	1	1	1	1	1	1	1		1	**1**	**1**	0	1	1		1	**1**	**1**	1	1	1	0			**1**	**1**	DS
Ammodytes tobianus (Linnaeus, 1758)	**1**		1	**1**	**0**	1	1	1	0	1	1	*1*			**0**	**0**		0				**0**	**0**							**0**	**0**	MM
Anguilla anguilla (Linnaeus, 1758)	**1**	1	1	**1**	**1**	1	1	1	1	1	1	1	1	1	**1**	**1**	1	1	1	1	1	**1**	**1**	1	1	1	1	1	1	**1**	**1**	DS
Aphia minuta (Risso, 1810)	**0**		1	**1**	**1**		1	1	1	1	1				**0**	**0**		0				**0**	**0**							**0**	**0**	ER/MM
Arnoglossus laterna (Walbaum, 1792)	**0**			**0**	**0**		1	*1*	0	1	1				**0**	**0**		0				**0**	**0**							**0**	**0**	MS
Atherina presbyter (Risso, 1810)	**0**	1	1	**1**	**0**		0		0	1		1			**0**	**0**		0				**0**	**0**							**0**	**0**	MM
Balistes capriscus (Gmelin, 1789)	**0**			**0**	**0**		0	*1*	0						**0**	**0**		0				**0**	**0**							**0**	**0**	MS
Barbatula barbatula (Linnaeus, 1758)	**0**			**0**	**0**	1	0		0					1	**0**	**0**		1	0		1	**0**	**0**			0	0	1		**1**	**0**	FW
Barbus barbus (Linnaeus, 1758)	**0**			**0**	**0**	1	0		0					1	**0**	**0**		1	0			**0**	**0**							**0**	**0**	FW
Belone belone (Linnaeus, 1761)	**1**			**1**	**0**	1	*1*	*1*	1	1	1				**0**	**0**		1				**0**	**0**		*1*	1	1			**0**	**0**	MM
Blicca bjoerkna (Linnaeus, 1758)	**0**	1	1	**0**	**0**		1		1	1		1	1	1	**1**	**1**		1	1	1	1	**1**	**1**		1	1	1	1	1	**1**	**1**	FW
Callionymus lyra (Linnaeus, 1758)	**0**		*1*	**0**	**0**	1	*1*	*1*	0	1	1				**0**	**0**		0				**0**	**0**							**0**	**0**	MS
Carassius carassius (Linnaeus, 1758)	**0**		*1*	**0**	**0**		0		0	1			0	1	**0**	**0**		1	0	*1*	1	**1**	**1**			0	0			**1**	**1**	FW
Carrasius gibelio (Bloch, 1782)	**0**	1	*1*	**0**	**0**	1			0	1		1	1	1	**0**	**0**		0	0	1	1	**0**	**0**							**0**	**0**	FW**
Chelidonichthys lucernus (Linnaeus, 1758)	**1**	1	1	**1**	**1**	1	1	1	0	1	1	*1*			**0**	**0**		0				**0**	**0**							**0**	**0**	MM
Chelon labrosus (Risso, 1827)	**1**			**1**	**0**		0	*1*	0			*1*			**0**	**0**		0				**0**	**0**							**0**	**0**	MM
Ciliata mustela (Linnaeus, 1758)	**1**	1	1	**1**	**0**		*1*	*1*	1	1		*1*			**0**	**0**		0				**0**	**0**							**0**	**0**	MM
Clupea harengus (Linnaeus, 1758)	**1**	1	1	**1**	**1**	1	1	1	1	1	1	1			**1**	**1**		1				**0**	**0**							**0**	**0**	MM
Cobitis taenia (Linnaeus, 1758)	**0**			**0**	**0**	1	0		0					1	**0**	**0**		1	1			**0**	**0**			1	1	1		**1**	**1**	FW
Conger conger (Linnaeus, 1758)	**0**			**0**	**0**	1	*1*	*1*	0	1	1				**0**	**0**		0				**0**	**0**							**0**	**0**	MS
Coregonus oxyrinchus (Linnaeus, 1758)	**1**			**0**	**0**	1	*1*	*1*	0						**0**	**0**	0	0				**0**	**0**							**0**	**0**	ER*
Cottus gobio (Linnaeus, 1758)	**0**	1	*1*	**0**	**0**	1	*1*		0	1				0	**0**	**0**		0	1		1	**1**	**0**			1	1	1		**1**	**0**	FW
Crystallogobius linearis (Düben, 1845)	**0**			**0**	**0**			*1*	0						**0**	**0**		0				**0**	**0**							**0**	**0**	MS
Ctenolabrus rupestris (Linnaeus, 1758	**0**			**0**	**0**			*1*	0						**0**	**0**		0				**0**	**0**							**0**	**0**	MS
Cyclopterus lumpus (Linnaeus, 1758)	**1**		1	**1**	**0**		*1*	*1*	0	1	1				**0**	**0**		0				**0**	**0**							**0**	**0**	MM

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Dasyatis pastinaca (Linnaeus, 1758)	**1**			**0**	**0**			*1*	0						**0**	**0**		0				**0**	**0**							**0**	**0**	MM
Dicentrarchus labrax (Linnaeus, 1758)	**1**	1	1	**1**	**1**		1	1	0	1	1	1			**1**	**1**		0				**0**	**0**							**0**	**0**	MM
Echiichthys vipera (Cuvier, 1829)	**0**		1	**0**	**0**		1	1	0	1	1	*1*			**0**	**0**		0				**0**	**0**							**0**	**0**	MS
Enchelyopus cimbrius (Linnaeus, 1766)	**0**			**0**	**0**		0	*1*	0						**0**	**0**		0				**0**	**0**							**0**	**0**	MS
Engraulis encrasicolus (Linnaeus, 1758)	**1**	1	1	**1**	**1**	1	1	1	1	1	1				**0**	**0**		1				**0**	**0**							**0**	**0**	MM
Entelurus aequoreus (Linnaeus, 1758)	**0**		1	**0**	**0**			*1*	0						**0**	**0**		0				**0**	**0**							**0**	**0**	MS
Esox lucius (Linnaeus, 1758)	**0**	1		**0**	**0**	1	1		1	1	1	*1*		1	**1**	**1**	0	1	1		1	**1**	**1**	1	1	1	1	1	0	**1**	**1**	FW
Eutrigla gurnardus (Linnaeus, 1758)	**0**		*1*	**0**	**0**		*1*		0						**0**	**0**		0				**0**	**0**							**0**	**0**	MM
Gadus morhua (Linnaeus, 1758)	**1**	1	1	**1**	**0**	1	*1*	*1*	0	1	1				**0**	**0**		0				**0**	**0**							**0**	**0**	MM
Gasterosteus aculeatus (Linnaeus, 1758)	**1**	1	1	**1**	**1**	1	1	1	1	1	1	1			**1**	**1**	1	1			1	**1**	**1**	1	1	0	0	1	1	**1**	**1**	FW/DS
Glyptocephalus cynoglossus (Linnaeus, 1758)				**0**	**0**			*1*	0						**0**	**0**		0				**0**	**0**							**0**	**0**	MS
Gobio gobio (Linnaeus, 1758)	**0**			**0**	**0**	1	0		0					1	**0**	**0**		1	1		1	**0**	**0**		1	1	1	1	*1*	**1**	**1**	FW
Gymnocephalus cernua (Linnaeus, 1758)	**1**	1	1	**1**	**1**	1	0		1	1	1	1	1	1	**1**	**1**	1	1	0	1	1	**1**	**1**	1	1	1	0			**1**	**1**	FW
Hippocampus guttulatus (Cuvier, 1829)	**0**			**0**	**0**			*1*	0	1	1				**0**	**0**		0				**0**	**0**							**0**	**0**	ER
Hippocampus hippocampus (Linnaeus, 1758)	**0**		1	**0**	**0**	1	*1*		0						**0**	**0**		0				**0**	**0**							**0**	**0**	MS
Hippoglossus hippoglossus (Linnaeus, 1758)				**0**	**0**			*1*	0						**0**	**0**		0				**0**	**0**							**0**	**0**	MS
Hyperoplus lanceolatus (Le Sauvage, 1824)	**0**			**0**	**0**	1	*1*		0	1	1				**0**	**0**		0				**0**	**0**							**0**	**0**	MS
Lampetra fluviatilis (Linnaeus, 1758)	**1**	1	1	**1**	**1**	1	1	1	1	1	1	1		1	**1**	**1**	1	1	0			**1**	**1**	1	*1*	0	0	*1*	0	**1**	**0**	DS
Lampetra planeri (Bloch, 1748)	**0**			**0**	**0**	1			0					0	**0**	**0**		0	1		1	**0**	**0**		1	0	1			**1**	**0**	FW
Leucaspius delineatus (Heckel, 1843)	**0**			**0**	**0**				0	1		*1*	0	0	**0**	**0**		0	1	1	1	**0**	**0**			0	1			**1**	**0**	FW
Leuciscus idus (Linnaeus, 1758)	**0**	1	1	**0**	**0**		0		0	1		1	1	1	**1**	**1**	1	1	0	1		**1**	**1**		1	0	0	*1*	0	**1**	**1**	FW
Leuciscus leuciscus (Linnaeus, 1758)	**0**		*1*	**0**	**0**	1	0		0					0	**0**	**0**		0	1		1	**0**	**0**			1	1	1		**1**	**0**	FW
Limanda limanda (Linnaeus, 1758)	**1**	1	1	**1**	**0**		*1*	0	0	1	1				**0**	**0**		0				**0**	**0**							**0**	**0**	MM
Liparis liparis (Linnaeus, 1766)	**1**	1	1	**1**	**1**		1	1	0	1	1				**0**	**0**		0				**0**	**0**							**0**	**0**	ER
Liza ramada (Risso, 1827)	**1**	1	1	**1**	**1**		1	1	1	1	1	1		1	**1**	**1**	1	1	0		1	**1**	**1**	1		0	0			**1**	**1**	DS
Lota lota (Linnaeus, 1758)				**1**	**0**	1	0		0					0	**1**	**0**		0	0			**1**	**0**		*1*	0	0			**1**	**0**	FW
Melanogrammus aeglefinus (Linnaeus, 1758)	**0**			**0**	**0**	1	*1*	*1*	0						**0**	**0**		0				**0**	**0**							**0**	**0**	MS
Merlangius merlangus (Linnaeus, 1758)	**1**	1	1	**1**	**1**	1	*1*	1	0	1	1	*1*			**0**	**0**		0				**0**	**0**							**0**	**0**	MM
Misgurnus fossilis (Linnaeus, 1758)	**0**			**0**	**0**	1	*1*		1	1	1			1	**1**	**1**		1	1			**1**	**1**	1	1	1	1	*1*		**1**	**1**	FW
Mullus surmuletus (Linnaeus, 1758)	**0**	1	1	**0**	**0**			0	0	1					**0**	**0**		0				**0**	**0**							**0**	**0**	MS
Myoxocephalus scorpius (Linnaeus, 1758)	**1**	1	1	**1**	**1**		1	1	0	1	1				**1**	**1**		0				**0**	**0**							**0**	**0**	ER
Nerophis ophidion (Linnaeus, 1758)	**0**			**0**	**0**			*1*	0						**0**	**0**		0				**0**	**0**							**0**	**0**	ER
Osmerus eperlanus (Linnaeus, 1758)	**1**	1	1	**1**	**1**	1	1	1	1	1	1	1	0	1	**1**	**1**	1	1	0	1	1	**1**	**1**	1	1	1	0	0	0	**1**	**1**	DS
Perca fluviatilis (Linnaeus, 1758)	**0**	1	1	**1**	**1**	1	1		1	1	1	1	1	1	**1**	**1**	1	1	0	1	1	**1**	**1**	1	1	0	0	1	1	**1**	**1**	FW
Petromyzon marinus (Linnaeus, 1758)	**1**			**1**	**1**	1	*1*	*1*	1	1	1			1	**1**	**1**	0	1	0			**1**	**1**	1		0	0			**1**	**0**	DS
Pholis gunnellus (Linnaeus, 1758)	**1**			**1**	**0**		1	1	0						**0**	**0**		0				**0**	**0**							**0**	**0**	ER
Phoxinus phoxinus (Linnaeus, 1758)	**0**			**0**	**0**		0		0					0	**0**	**0**		0	1			**0**	**0**		1	1	1			**1**	**0**	FW
Platichthys flesus (Linnaeus, 1758)	**1**	1	1	**1**	**1**	1	1	1	1	1	1	1	0	1	**1**	**1**	1	1	1	1	1	**1**	**1**	1	1	1	1	1		**1**	**1**	DS

Scientific name	MEP Westerschelde Jager & Kranenbarg, 2004	(M) fyke nets surveys, 1995-2006	(M) surveys cooling-water Doel 1991-2007	MEP Mesohaline zone	GEP Mesohaline zone	(M–O) de Selys-Longchamps, 1842	(M–O) Poll, 1945	(M–O) Poll, 1947	(M-0) Simoens et al., 2006	(M-O) Breine et al., 2007	(M–O–F) Breine et al., 2001	(O) fyke nets surveys, 2005-2007	(O) River Rupel Breine et al., 2005-2007	(O) River Rupel Simoens et al., 2006	MEP Oligohaline zone	GEP Oligohaline zone	(F) Maes et al, 2005	(F) Simoens et al., 2006	(F) Durme Simoens et al., 2006	(F) River Durme Breine et al., 2005-2007	(F) fyke nets surveys, 2005-2007	MEP Freshwater zone	GEP Freshwater zone	(T) Breine et al., 2001	(T) Vrielynck et al. (2003)	(T) Nete Simoens et al., 2006	(T) Dijle & Zenne Simoens et al., 2006	(T) River Nete Buyse et al., 2007 & PC	(T) River Dijle Buyse et al., 2007 & PC	MEP Tributaries	GEP Tributaries	Guild
Pleuronectes platessa (Linnaeus, 1758)	1	1	1	1	1	1	1	1	1	1	1				0	0		1				0	0							0	0	MM
Pollachius pollachius (Linnaeus, 1758)	0		*1*	0	0			*1*	0						0	0		0				0	0							0	0	MM
Pomatoschistus lozanoi (de Buen, 1923)	0	1	1	1	0				0	1	1				0	0		0				0	0							0	0	MM
Pomatoschistus microps (Krøyer, 1838)	1	1	1	1	1		1	1	1	1	1	1	1	1	1	1		1	1	1	1	1	0							0	0	ER
Pomatoschistus minutus (Pallas, 1770)	1	1	1	1	1	1	1	1	1	1	1	1			1	1		1			*1*	0	0							0	0	ER
Psetta maxima (Linnaeus, 1758)	1			1	0	1	*1*	1	1	1	1				0	0		1				0	0							0	0	MM
Pungitius pungitius (Linnaeus, 1758)	0	1	1	0	0	1	*1*		1	1	1	1	1	1	1	1	1	1	0	0	1	1	1	1	1	1	0	*1*		1	1	FW
Raja clavata (Linnaeus, 1758)	0			0	0	1	*1*	1	0	1	1				0	0		0				0	0							0	0	MS
Raniceps raninus (Linnaeus, 1758)	0			0	0	1			0						0	0		0				0	0							0	0	ER
Rhodeus sericeus (Pallas, 1776)	0	1	1	0	0		0		0	1		1	1	1	1	1		1	0	1	1	1	1			0	0	1	*1*	1	1	FW
Rutilus rutilus (Linnaeus, 1758)	0	1	1	0	1	1	1		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	FW
Salmo salar (Linnaeus, 1758)	1	1		1	0	1	*1*	*1*	0	1	1			0	1	0	0	0	0			1	0	1	1	0	0			1	0	DS*
Salmo trutta (Linnaeus, 1758)	1	1		1	1		*1*	*1*	0	1	1	1		0	1	1	0	0	0			1	1	1	1	0	0			1	0	DS
Sander lucioperca (Linnaeus, 1758)	0	1	1	0	1		*1*		0	1	1	1			0	1	1	0			1	0	1							0	0	FW**
Sardina pilchardus (Walbaum, 1792)	0			0	0		0	*1*	0						0	0		0				0	0							0	0	MM
Scardinius erythrophthalmus (Linnaeus, 1758)	0		1	0	0	1	1		1	1	1	1	1	1	1	1		1	1	1	1	1	1	1	1	1	1	*1*	*1*	1	1	FW
Scomberesox saurus (Walbaum, 1792)	0			0	0		*1*	*1*	0	1					0	0		0				0	0							0	0	MS
Scophthalmus rhombus (Linnaeus, 1758)	1	1		1	0	1	*1*	*1*	1	1	1				0	0		0				0	0							0	0	MS
Scyliorhinus canicula (Linnaeus, 1758)	0			0	0	1	*1*	*1*	0						0	0		0				0	0							0	0	MS
Scyliorhinus stellaris (Linnaeus, 1758)				0	0		*1*	*1*	0						0	0		0				0	0							0	0	MS
Silurus glanis (Linnaeus, 1758)	0			0	0				0				1	0	1	1	0	0	1	0	1	1	1			1	0	1	*1*	1	1	FW
Solea solea (Linnaeus, 1758)	1	1	1	1	1	1	1	1	1	1	1	1			1	1		1				0	0							0	0	MM
Spinachia spinachia (Linnaeus, 1758)	0		*1*	0	0		0	0	0						0	0		0				0	0							0	0	ER
Sprattus sprattus (Linnaeus, 1758)	1	1	1	1	1	1	1	1	1	1	1				1	1		1				0	0							0	0	MM
Squalius cephalus (Linnaeus, 1758)	0			0	0	1	0		0				0	1	0	0		1	0	*1*	1	0	0			0	0	1	0	1	0	FW
Symphodus melops (Linnaeus, 1758)	0			0	0		0	*1*	0						0	0		0				0	0							0	0	MS
Syngnathus acus (Linnaeus, 1758)	1	1	1	1	1	1	1	1	0	1	1	1			1	1		0				0	0							0	0	ER
Syngnathus rostellatus (Nilsson, 1855)	1		1	1	1	1	1	1	0	1	1				1	1		0				0	0							0	0	ER
Tinca tinca (Linnaeus, 1758)	0		*1*	0	0	1	0		0			*1*		1	0	0		1	1			0	0		1	1	1	*1*	1	1	1	FW
Trachinus draco (Linnaeus, 1758)	0			0	0	1	*1*	1	0						0	0		0				0	0							0	0	MS
Trachurus trachurus (Linnaeus, 1758)	0	1	1	0	0		*1*	1	0		1	1			0	0		0				0	0							0	0	MS
Trigloporus lastoviza (Bonnaterre, 1788)				0	0			*1*	0						0	0		0				0	0							0	0	MS
Trisopterus luscus (Linnaeus, 1758)	1	1	1	1	1	1	1	1	0	1	1	1			1	1		0				0	0							0	0	MM
Trisopterus minutus (Linnaeus, 1758)	0			0	0			*1*	0						0	0		0				0	0							0	0	MS
Xiphias gladius (Linnaeus, 1758)				0	0		*1*		0						0	0		0				0	0							0	0	MS
Zoarces viviparus (Linnaeus, 1758)	1	1	1	1	1	1	1	1	1	1	1	1			1	1		0				0	0							0	0	ER

RESULTS

Table 2 presents the reference lists for the different zones of the Zeeschelde. Species are ordered in alphabetical order. An MEP list of fishes occurring in the Westerschelde (JAGER & KRANENBARG, 2004) is also given to provide a complete overview of the Schelde estuary. The MEP and GEP lists for the Zeeschelde are grouped by salinity zone and in the last column the guild attribution is given.

DISCUSSION

We structured the discussion of these lists using the ecological guild of estuarine usage (ELLIOTT et al., 2007; FRANCO et al., 2008). We did not include information from archaeological studies (e.g. VAN NEER & ERVYNCK, 1993; 1994) as anthropogenic impact in the Schelde estuary has been almost continuous since the ninth century; therefore it is scientifically impossible to trace how an unimpaired Schelde estuary would have developed. Shifts in fish assemblages can occur due to climate effects of oceans and estuaries (TULP et al., 2008). The increase in temperature and decrease in salinity in the Baltic Sea, for example, caused a decrease in abundance of marine species and increase of freshwater species (MACKENZIE et al., 2007). DAUFRESNE & BOËT (2007) described new evidence that climate change impacted fish communities in large rivers in France. At present, no data on fish community changes due to climate change in the Zeeschelde are available. However, the decision tree (see Fig. 3) used to allocate fish species indirectly considers possible changes.

3.1 Estuarine species

Estuarine species can complete their life cycle in the estuary. Estuarine resident species are tolerant to widely varying environmental conditions that typically characterize these transitional waters (ELLIOTT et al., 2007). However, they are sensitive to the disappearance of specific estuarine habitats such as intertidal mudflats, creeks and marshes and to the accumulation of toxic substances. Therefore an estuary in MEP or in GEP status should accommodate these species. The habitat preferences for estuarine species are not fulfilled in the tributaries. According to POLL (1945; 1947), the common goby (*Pomatoschistus microps*) was quite rare in the Schelde but this species and also the sand goby (*Pomatoschistus minutus*) are at present very common (GUELINCKX et al., 2008). The common goby is regularly found far upstream, but freshwater is not its preferred habitat. The sand goby is less common in the freshwater part and is therefore not kept in the freshwater lists. Transparent goby (*Aphia minuta*) is an estuarine/marine migrant species that should normally occur in the Schelde and is regularly caught in the mesohaline zone. This species prefers a polyhaline and mesohaline habitat (VAN EMMERIK, 2003) and is therefore only included in the mesohaline GEP and MEP list, contrary to the list proposed by JAGER & KRANENBARG (2004). Straight-nosed pipefish (*Nerophis ophidion*) was only occasionally caught in the Schelde (POLL, 1947) and has never been caught in recent surveys. This species is not retained in the Westerschelde reference list (JAGER & KRANENBARG, 2004) and hence it is not considered as a GEP or MEP species here either. The greater pipefish (*Syngnathus acus*), Nilsson's pipefish (*Syngnathus rostellatus*) and the viviparous blenny (*Zoarces viviparus*) are estuarine resident species that occurred in the Schelde in the past (DE SELYS-LONGCHAMPS, 1842; POLL, 1945; 1947). At present, they are caught as far upstream as Antwerpen. These species avoid freshwater (VAN EMMERIK, 2003) and therefore are only included in the mesohaline and oligohaline MEP and GEP lists. The hooknose (*Agonus cataphractus*) is an estuarine resident species that is reported to be rare in the Schelde (POLL, 1945), which also corresponds with our catch results. Hooknose is therefore retained only in the mesohaline MEP and the polyhaline lists. Bull rout (*Myoxocephalus scorpius*) was quite common in the Schelde estuary (POLL, 1945) and is still caught from time to time. This species is included in both meso- and oligohaline GEP and MEP lists. Butterfish (*Pholis gunnellus*) is included in the reference list for the Westerschelde (JAGER & KRANENBARG, 2004). POLL (1945) stated that the species was present, but it was never caught in recent samples, which is why we excluded this species from the GEP list but included it in the mesohaline MEP list. Striped seasnail (*Liparis liparis*) used to be common in the Schelde (POLL, 1947) preferring poly- and mesohaline water. Seasnail was occasionally caught in recent campaigns and is therefore considered to be a mesohaline GEP and MEP species. Both seahorse (*Hippocampus guttulatus*) and tadpole fish (*Raniceps raninus*) are absent from the lists. In the past, seahorse was caught nearby the sea (POLL, 1945) and was considered as rare. This species prefers polyhaline water and at present is rarely caught in the Zeeschelde. Tadpole fish has been recorded for the first time in the Schelde in 1943 (POLL, 1945) Now this species is believed to be very rare in the estuary but more common in nearby Dutch coastal waters. Fifteen-spined stickleback (*Spinachia spinachia*) was not reported by DE SELYS-LONGCHAMPS (1842) or by POLL (1945) and it was only once caught in Doel. Thus it is not considered as being a GEP or MEP species.

3.2 Diadromous species

Diadromous fishes are migrating species that use both marine and freshwater habitats during their life cycles. Estuaries have a crucial role as migration routes (ABLE, 2005). According to the season different diadromous species occur in different estuarine zones. Absence of diadromous species is caused by human impacts, disrupting the connectivity and resulting in an estuary not being considered to reach the MEP or GEP status. Thus, diadromous species are included in both lists and all zones when not extirpated in the estuary or nearby estuaries. If all physical and chemical barriers were to disappear, these species should be able to swim all along the tributaries (see Table 2). The decline of sturgeon (*Acipenser sturio*), Atlantic salmon (*Salmo salar*) and allis shad (*Alosa alosa*) was already described by POLL (1945). Now, they are extirpated in the Schelde basin and are not considered as GEP species. However, it is not impossible to restore their required habitat in the Schelde basin, especially since

these species are present in some North East estuaries of the Atlantic. Their possible return would indicate MEP condition. Houting (*Coregonus oxyrinchus*) was considered as very rare or in danger of extinction by POLL (1945; 1947). At present, this species is considered to have disappeared (red list) or to be extinct (International Union for Conservation of Nature and Nature Resources: IUCN); hence, it is not in our lists. The habitat area of this species is also situated more to the north (MAITLAND, 2000). All the other diadromous species (see below) are present in the lists because they can be expected to frequent the estuary and tributaries once the habitat conditions improve (MAES et al., 2007). The brown trout (*Salmo trutta*) population was already declining in 1945 (POLL, 1945) and now individuals are rarely caught. However, their presence would indicate an MEP status as they are pollution-intolerant species. Eel (*Anguilla anguilla*) and flounder (*Platichthys flesus*) were common in the River Schelde (DE SELYS-LONGCHAMPS, 1842; POLL, 1945). Three-spined stickleback (*Gasterosteus aculeatus*) is known to be a species that is common in all types of waters in Flanders. In the mesohaline zone of the Zeeschelde, three types occur (RAEYMAEKERS et al., 2007) including the diadromous type. The Western three-spine stickleback (*Gasterosteus gymnurus*) is probably extremely rare or extinct in our study area. This species has never been observed during sampling campaigns by the Research Institute for Nature and Forest (INBO), or by other scientists intensively studying sticklebacks from Belgium and the Netherlands (RAEYMAEKERS, pers. comm.; RAEYMAEKERS et al., 2005; 2007; 2008a; 2008b; 2009; 2011). Thinlip mullet (*Liza ramada*) was previously often confounded with thicklip grey mullet (*Chelon labrosus*), a marine seasonal migrant. POLL (1945) stated that the species was abundant nearby the Belgian coast. At present specimens are recorded far upstream of Antwerpen. River lamprey (*Lampetra fluviatilis*), twaite shad (*Alosa fallax*) and smelt (*Osmerus eperlanus*) are indicators of good water quality and connectivity as well as good ecological functioning of the estuary (e.g. suitable spawning locations). They are again regularly caught in different parts of the Schelde (BREINE et al., 2010a). Sea lamprey (*Petromyzon marinus*), which was abundant according to DE SELYS-LONGCHAMPS (1842), is at present scarce (<5% catch frequency) and is kept in the MEP lists.

3.3 Freshwater species

Freshwater resident species can complete their life cycle in the tidal freshwater part of the estuary. They reproduce, grow up and feed in freshwater, but can also exploit the oligohaline zone. This is why they are also included in the oligohaline MEP/GEP list. The Zeeschelde has an important freshwater tidal zone and therefore freshwater species occupy various zones but the spatial distribution is species-dependent. Some freshwater species make regular use of different zones within the estuaries, such as seasonal migrations, nursery or feeding migrations, reproductive migrations through the estuary or the use of the estuary as a refuge (ELLIOTT et al., 2007). Freshwater stragglers are species that occupy the mesohaline zone irregularly and only for a short time. ELLIOTT et al. (2007) considered them analogous to marine stragglers but entering the estuary from the opposite end. For the tributaries, 25 freshwater species are recorded in the MEP list and 16 in the GEP list. The freshwater species ruffe (*Gymnocephalus cernua*) is mentioned by DE SELYS-LONGCHAMPS (1842) but not by POLL (1945). Presently, this species is caught in the Zeeschelde along its entire salinity gradient. POLL (1945) considered perch (*Perca fluviatilis*) to be very common in the freshwater and brackish reaches of the Zeeschelde up to Zandvliet. Recently, perch was caught all over the Zeeschelde. Roach (*Rutilus rutilus*) is captured in all zones but is not typical for the mesohaline zone, though specimens were captured in Doel and Zandvliet. Therefore its presence is justified in all GEP lists but not in the mesohaline MEP list. Bream (*Abramis brama*) and nine-spined stickleback (*Pungitius pungitius*) are typical lowland freshwater species with a tolerance for brackish water. They are opportunistic species that were caught all over the river Schelde. These species are not typical for mesohaline water and were therefore omitted from the mesohaline GEP and MEP lists. Though nine-spined stickleback is less common than the three-spined stickleback, it is to be found in all tributaries. As already mentioned above; three-spined stickleback is common in all zones. Bitterling (*Rhodeus sericeus*) is a freshwater species preferring stagnant or slow moving water with plants. Though POLL (1945) did not mention its presence in the Schelde, it has been collected in different places in the Zeeschelde (BREINE et al., 2010a). SIMOENS et al. (2006) placed this species in the reference list for fresh tidal water but not for the brackish part of the Schelde. We included it only in the oligohaline and freshwater MEP and GEP lists. Wels catfish (*Silurus glanis*) is now frequently caught all along the tidal freshwater part of the Schelde. Though this species can stand brackish water, it is kept in the freshwater and oligohaline GEP and MEP lists only, since the mesohaline is not its preferred habitat (FRIMODT, 1995). The weatherfish (*Misgurnus fossilis*) is now only caught in the tributaries. DE SELYS-LONGCHAMPS (1842) mentioned its presence in the Schelde and POLL (1945) stated that three specimens were collected in the Schelde. This species should not be present in the mesohaline zone but its presence could be indicative in the other zones. Carp (*Cyprinus carpio*) was reported by DE SELYS-LONGCHAMPS (1842) and POLL (1945) and is still caught in the freshwater and oligohaline zones. The species does not occur in our lists since it has an exotic origin and is tolerant to extreme conditions. Species such as white bream (*Blicca bjoerkna*), pike (*Esox lucius*) and rudd (*Scardinius erythrophthalmus*) were mentioned by POLL (1945) to be present in the Schelde. They are still caught in the Zeeschelde and even occasionally in Zandvliet (GUELINCKX et al., 2008). These freshwater species are not part of the mesohaline fish population but can occur in the oligohaline zone. Therefore, all three of them are kept in the oligohaline and freshwater GEP and MEP lists. Ide (*Leuciscus idus*) is a rheophilic B species i.e. some stages of its life history are confined to connected backwaters (VAN EMMERIK, 2003) with a relatively high tolerance value (BREINE et al., 2007). This species is frequently encountered in the oligohaline zone. Ide is found all along the River Schelde and in most of its tributaries. However, its abundance might be underestimated because of a possible confusion with roach. Ide is considered as being repre-

sentative for oligohaline, freshwater and tributaries GEP and MEP lists. We keep Crucian carp (*Carassius carassius*) in the freshwater list since it is occasionally captured (>5% catch frequency) in the Zeeschelde (SIMOENS et al., 2006). Pike-perch (*Sander lucioperca*) is an exotic freshwater species, which is considered as a recent native species in the Netherlands (VAN EMMERIK, 2003). This species can tolerate brackish water and is quite common along the salinity gradient. Pike-perch is sensitive to temperature changes and intolerant to oxygen deficiency and can be used as an indicator for eutrophication (VAN EMMERIK, 2003). The species prefers deeper water than provided by the tributaries and is therefore kept in the GEP lists of the main channel only. Bullhead (*Cottus gobio*) has been reported to be present over the entire salinity gradient (DE SELYS-LONGCHAMPS, 1842; POLL, 1945; 1947) and was also recently caught in Zandvliet while BUYSSE et al. (2007) caught it in the Nete. This not obligate rheophilic species (i.e. it also tolerates slow running water) lives in freshwater but can stand brackish water. SIMOENS et al. (2006) did not consider bullhead a reference species for the Schelde and its tributaries. This intolerant species has a low range of acceptable habitats (GRANDMOTTET, 1983) and prefers a hard substrate with gravel and stones. At present only the River Nete has a water quality that meets the demands of this species, but the morphological characteristics and substrate of the tributaries are not really optimal. We keep it as an indicator for the MEP status in the freshwater zone and tributaries. Burbot (*Lota lota*) has recently been reintroduced into the upper Nete. It is possible that this species will be caught in the Zeeschelde in the future, because POLL (1945) mentioned that it can tolerate mesohaline conditions. Burbot is retained in the MEP lists since it is an intolerant species. Dace (*Leuciscus leuciscus*) was not mentioned by DE SELYS-LONGCHAMPS (1842) or POLL (1945; 1947) and is only caught in the freshwater tributaries. Because of its rarity and ecological demands, this species is included in the MEP lists for tributaries only (TURNPENNY et al., 2004). The same reasoning applies for spined loach (*Cobitis taenia*) frequently caught in the River Nete but not found in the main channel. Bleak (*Alburnus alburnus*) is a freshwater species that is occasionally fished in the freshwater part of the main river and in the River Nete. DE SELYS-LONGCHAMPS (1842) mentioned its presence in the Schelde while POLL (1945; 1947) did not. According to BREINE et al. (2007), bleak has a low pollution tolerance, which is why it is only included in the freshwater and tributaries MEP lists. Stone loach (*Barbatula barbatula*) is presently caught in the freshwater tributaries only, where it indicates an MEP status (<5% CF). DE SELYS-LONGCHAMPS (1842) reported on barbel (*Barbus barbus*) and brook lamprey (*Lampetra planeri*) while POLL (1945) did not. The Zeeschelde is not their habitat, and MAES et al. (2005) and BREINE et al. (2007) did not include these two species in their reference lists. Barbel is a rheophilic A species preferring fast running water, which is not typical for the Schelde tributaries. This species has not been caught recently and it was decided not to retain barbel in the lists since the tributaries do not offer the required habitat demands. Brook lamprey was caught in the tributaries and is therefore kept in its MEP list. Eurasian minnow (*Phoxinus phoxinus*) is an intolerant species typical for upstream water (BREINE et al., 2004; 2007), preferring well-oxygenated water and gravel substrate (VOSTRADOVSKY, 1973). Minnow has never been caught in the Zeeschelde. European chub (*Squalius cephalus*) and gudgeon (*Gobio gobio*) are species mentioned by DE SELYS-LONGCHAMPS (1842) but not by POLL (1945; 1947). They were caught in the freshwater tributaries (BUYSSE et al., 2007; BREINE et al., 2007). European chub is a rheophilic A species typically occurring in creeks and fast flowing rivers (BILLARD, 1997) and its presence indicates MEP status. Belica (*Leucaspius delineatus*) is caught occasionally in the freshwater part of the Schelde but was not reported by DE SELYS-LONGCHAMPS (1842) or POLL (1945; 1947). Belica is a stagnophilic species that needs the presence of plants, which are not present in the Schelde. Therefore, this species is included in the tributaries list only. Tench (*Tinca tinca*) has been caught around Antwerpen but is considered as a species being typical for standing waters and upstream in the tributaries (ALLEN et al., 2002). Therefore, it is only included in the tributary MEP/GEP lists.

3.4 Marine migrants

ELLIOTT et al. (2007) no longer distinguished between marine seasonal migrants and marine juvenile migrants since larval and 0+ juvenile migrations into estuaries tend to be seasonal for many marine species. Either way, estuaries in MEP or GEP status are used by these migrants as feeding areas and refugia. Tributaries (i.e. the river affluent) do not offer suitable habitats for marine migrants. Herring (*Clupea harengus*) is a marine species abundant in the juvenile stage (POLL, 1945; 1947; MAES et al., 1997; 2001) and swims upstream as far as the oligohaline zone. Plaice (*Pleuronectes platessa*) was described by POLL (1945) as being very abundant in the Schelde, although adults were rarely caught. The species is now collected in small numbers at Doel and is retained in the mesohaline GEP and MEP lists. Sole (*Solea solea*) penetrated as juveniles quite far into the estuary and numerous adults were caught (POLL, 1945). Sole is now found in the mesohaline and oligohaline zones and is retained in both the GEP and MEP list. Juveniles of the marine species tub gurnard (*Chelidonichthys lucernus*) and whiting (*Merlangius merlangus*) have been reported in the Schelde by DE SELYS-LONGCHAMPS (1842) and POLL (1945; 1947). Also currently, mostly juveniles are caught. The oligohaline zone is not their habitat and they are therefore retained only for the mesohaline GEP and MEP lists. At present, seabass (*Dicentrarchus labrax*) is one of the most common species caught in the Schelde, which is in line with POLL (1945) who reported high numbers of juveniles. This species figures in the GEP and MEP lists of meso- and oligohaline waters. Pouting (*Trisopterus luscus*) is a marine species, the juveniles of which were frequently observed in the Schelde (POLL, 1945, 1947), and they are still captured up to Antwerpen. The species is included in the meso- and oligohaline GEP and MEP lists. Only juveniles of brill (*Scophthalmus rhombus*) are now found in the Zeeschelde. This species was not common in the past (POLL, 1945). Consequently, it is only included in the mesohaline MEP list. Sand smelt (*Atherina presbyter* or *A. boyeri* Risso, 1826) was reported to be quite abundant in Belgian coastal waters (POLL, 1947) and is now regu-

larly caught in the Zeeschelde. Therefore, sand smelt stays on the mesohaline MEP list. Cod (*Gadus morhua*) is an uncommon seasonal migrant, of which only juveniles wander into the estuary. Cod is included in the mesohaline MEP list only. POLL (1947) reported the occasional presence of the marine juvenile migrant dab (*Limanda limanda*). In recent surveys, this species is rarely caught and is therefore retained only for the mesohaline MEP list. Turbot (*Psetta maxima*) is rarely caught and if so, only as juveniles. Turbot is included in the Dutch list (JAGER & KRANENBARG, 2004) but kept in our mesohaline MEP list only. Pollack (*Pollachius pollachius*) was described as being rare in Belgian coastal waters (POLL, 1947); there are also no records from DE SELYS-LONGCHAMPS (1842) and POLL (1945). Pollack was not collected during recent fish campaigns in the Zeeschelde and is therefore omitted from our lists. In the past, sprat (*Sprattus sprattus*) entered the estuary between January and July in large numbers (DE SELYS-LONGCHAMPS, 1842; POLL, 1945; 1947). This species is still caught often and is a reference species for the Westerschelde (JAGER & KRANENBARG, 2004). We included it in our meso- and oligohaline GEP and MEP lists. Following POLL (1947), anchovy (*Engraulis encrasicolus*) was a seasonal guest from April to August, visiting the estuary in large numbers to spawn. At present, it is rarely caught upstream of Doel, which is why they are retained in the mesohaline MEP and GEP lists. POLL (1947) considered thicklip grey mullet (*Chelon labrosus*) as rare in the Schelde but it was occasionally caught (<5% CF) in recent surveys and is therefore included in the mesohaline MEP list. Garpike (*Belone belone*) was uncommon in the estuary (POLL, 1945). Though it was not caught recently, it has a place in the mesohaline MEP list as an indicator of good water quality and as part of the reference list for the Westerschelde (JAGER & KRANENBARG, 2004). The lumpsucker (*Cyclopterus lumpus*) was rarely caught in the 1940's (POLL, 1945; 1947) and this is still the case. Nevertheless, we kept this species in the mesohaline MEP list as it is an indicator of an undisturbed habitat. They are sensitive to dredging activities as they are nest spawners and guarders. The five-beard rockling (*Ciliata mustela*) was rarely caught in the past (POLL, 1945; 1947) but is now regularly caught in Doel and is included in the Mesohaline MEP list. Grey gurnard (*Eutrigla gurnardus*), sting ray (*Dasyatis pastinaca*) and pilchard (*Sardina pilchardus*) were only encountered occasionally in the estuary (POLL, 1945; 1947). Of them, only grey gurnard was caught erratically in Doel and consequently, none of the three species is kept in the lists. Small sandeel (*Ammodytes tobianus* or *A. lancea*) was common in the Schelde estuary (POLL, 1945). This species is occasionally caught today and therefore remains on the mesohaline MEP list. Lozano's goby (*Pomatoschistus lozanoi*) is not mentioned in historical reports but was recently caught regularly in the mesohaline zone (BREINE et al., 2001). Therefore, it is kept in the mesohaline MEP list.

CONCLUSIONS

To assess the ecological status of heavily modified transitional waters, the European Water Framework Directive requires definitions of Maximal and Good Ecological Potential (MEP/GEP) and the design of classification tools for specified biological quality elements. The hydromorphological, physical and chemical MEP/GEP are described by BRYS et al. (2005). Their approach was also used to define the guild-specific habitat needs (qualitatively) for fish in the Zeeschelde (BREINE et al., 2008). If these habitat needs are fulfilled because of restoration and mitigating actions, then we consider the estuary to be in MEP condition for fish. Near fulfilment brings it into the GEP condition. Based on a literature review in combination with recent fish catch data, we have made guild-specific qualitative MEP/GEP lists for the different salinity zones within the Zeeschelde estuary and its tidal tributaries. For each fish species, the relevance of its presence in each salinity zone was examined. The geographical spreading and ecological demands were assessed and used for the acceptance of a specific species for a certain list. The ecological knowledge of the assessed species is available and sufficient to reduce the risk of mistakes in attribution. The proposed lists should be considered as a starting point to developing quantitative guild lists i.e. including numbers instead of only presence/absence information. BREINE et al. (2010b) attributed threshold values to these quantitative lists. Thresholds for the good ecological potential (GEP) were defined from these references allowing expression of the ecological status as an ecological quality ratio (EQR) between 0 and 1. The guild approach facilitates the development of such an assessment tool. We are aware that by grouping fish into guilds particular information can be lost. On the other hand the guild approach is widely used and accepted in the development of robust assessment tools for the ecological status of surface waters. Such an evaluation system normally assesses the deviation between a reference condition and the actual condition. Therefore, the approach of defining the lists presented here can be used for other estuaries and be helpful in the development of fish-based indices.

ACKNOWLEDGEMENTS

We are grateful to all people who contributed to the collection of field data.

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Received: August 26, 2009
Accepted: May 20, 2011
Branch editor: De Troch Marleen