Ministerie van Verkeer en Waterstaat

Rijkswaterstaat

Development of a Water Framework Directive Fish Index for Transitional Waters in the Netherlands.

25 augustus 2006

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Contents

1. Introduction

The Water Framework Directive (WFD, EU, 2000) recognizes fish as a biological quality element for transitional waters. In this context, the condition of a water system is determined from the composition and abundance of species. This information is compared with that for the undisturbed state, on the basis of which a good ecological status (GES) is defined.

The present document implements the WFD for the biological quality element of fish in the transitional waters type. The Ems-Dollard and the Westerschelde serve as examples. The water type concerned is classified under the Dutch transposition of the WFD as "O1" or "O2".

A reference description and a description of the current status are required. The essential principle is the relationship between the pressures and impacts, i.e. human exploitation, on the one hand and the metrics, i.e. the parameters which reflect the status of the fish in the transitional waters, on the other.

The difference between O1 and O2 lies in the tidal regime (low and moderate respectively); this influences the intertidal areas, the duration of flooding of the tidal flats, and the current velocities which may occur in an area. O1 no longer exists in the Netherlands in natural form, and is not therefore included in the present report.

The report was produced exclusively from existing data, this being the terms of reference. The RIVO Demersal Fish Survey (DFS) constituted an important source of data. The report, as it is now, relates to the mesohaline and polyhaline regions of the transitional waters.

Consultation is desired with colleagues in other countries who are also currently involved in developing parameters for fish in transitional waters.

A conference was held in Haren on 16 September 2003 with the German counterparts responsible for the Ems river basin. It appeared that at that time, no investigations were as yet in progress in Germany into the interpretation of fish as a biological quality element in transitional waters.

On 13 October 2003, a visit was paid to the UK Environment Agency and discussions held with Steve Coates, Matt Robson and Steve Colclough. In the UK, researchers were still collecting supplementary data by conducting sampling in a wide range of waters, and their attention remained directed at a favourable clustering of the large number of transitional waters (at least 175 estuaries). They had not yet begun the development of parameters.

On 23 October 2003, discussions were held with Jan Breine of the Belgian Institute for Forestry and Game Management (Instituut voor Bosbouw en Wildbeheer).

Quality assurance
The present document was discussed on 30 October 2003 by the national Fish expert group, and on 3 November 2003 by the Development Agenda (Ontwikkelagenda) project team led by Joost Stronkhorst. Written comments have also been submitted by Jan Breine.

In the second phase, the document was discussed with experts from the Netherlands Institute for Fisheries Research (RIVO). With the aid of the RIVO, a supplementary sub-parameter was defined based upon the incidence of twaite shad.

2. Analysis

2.1 Methods for definition of the reference

The method employed for creation of a reference description is described in Nijboer (2003).

Step 1: Classification of the Dutch waters according to the water types in the typology. Classification of the various (sub-)water systems according to the water typology is the responsibility of the water management authority. At the time of writing of the present document, the definitive classification had not yet been completed. In the provisional classification, the Ems-Dollard, the Westerschelde, and possibly also certain other bodies of water, are classified as Type "O2, estuary with moderate tidal range".

Step 2. Existing reference waters
In the Netherlands, no reference water body of this type exists which is still in a relatively undisturbed state. For that matter, no undisturbed reference water body may be found anywhere else in Europe (Elliott & Hemingway, 2002).

Step 3. Creation of an inventory of the type of reference data already available
A reference can be produced in a number of different ways (Breine et al.):
1. By the use of historical data from a period in which anthropogenic influence was still minimal
2. Based upon study of the "optimum" ecology of a healthy brackish water ecosystem
3. By the use of data from comparable European estuaries
4. By deduction from the current status with the use of "expert judgement"
5. By the use of models (Whitfield & Elliott 2002, De Leeuw et al., 2002)

2.2 Mechanisms of action of pressures and impacts upon fish indicators

The point of departure for development of the parameters is the attempt to establish a relationship between the indicators and the anthropogenic influences (pressures and impacts) upon the water system. The optimum result is obtained by inclusion of a metric in the inventory on all levels, from cell, through individual, population and community, to ecosystem (Whitfield & Elliott, 2002) (Table 2.1).

Table 2.1
Proposal for metrics at all organizational levels (Whitfield & Elliott, 2002).

Level	Healthy fish fauna	Fish fauna under pressure	Metrics (own definition)
Cell	Stable lysosomes, genetic integrity	Presence of detoxification mechanisms, genetic damage	EROD activity, contaminant contents in fish (eelpout)
Individual	No morphological deviations, good condition, few parasites, natural behaviour	Lesions, fin rot, tumours, ulcers, poor condition, abnormal behaviour	% ulcers, lymphocystis, liver tumours or fin rot (flounder)
Population	Satisfactory larval recruitment, age structure as expected, distribution as expected	Poor larval recruitment, low numbers of juveniles, adult stadia under-represented, changes in spatial distribution	Abundance/catch density of juvenile plaice in the estuary in October in the DFS
Community	Diversity as expected, composition of ecological guilds normal, presence of species exhibiting normal seasonal progression	Reduced availability of prey, reduced diversity, loss of unusual or sensitive* species	Number of species, relationship between ecological guilds, presence of unusual species, presence of sensitive species
Ecosystem	No physico-chemical impairments, carrying capacity OK, predator-prey relationships as expected	Fewer niches, reduced habitat integrity, changes in the food web, reduction in top predators	Abundance of smelt, abundance of flounder, top predator (=cod)

Table 2.2 shows an estimation of the most significant pressures and impacts acting in the transitional waters, and of how they may potentially impact upon fish through their influence upon the habitats. The impact upon metrics/indicators remains a matter of speculation, and is therefore shown in grey.

Table 2.2
Pressures and impacts upon fish in transitional waters.

Pressures on fish in transitional waters	**Effect upon habitat/ecotope**	**Effect upon fish**	Metric
Barrages/sluices/dams/pumping stations			Number of CA species
	Interruption in longitudinal connectivity between upper and lower river	Loss of (migration routes) of CA species	
	Creation of fishery and predation hotspots	Loss of (commercial) diadromous species, presence of predators	
Dependent upon the location of the pressure in the estuary:	Loss of tidal and seawater/freshwater dynamics upstream; loss of seawater/freshwater dynamics downstream of the obstruction	Loss of brackish and marine species upstream; loss of diadromous species; loss of freshwater species downstream of the obstruction	
Pumping stations	The above + obstruction to downstream migration	Decrease in CA species	
Dykes/river training/sewerage			Number of CA and ER species
	Increase of sewage and dynamics of principal current	Increased washing out of fish larvae of non-vegetation spawners	Density of shad, smelt
	Introduction of hard substrate	Increase in hard substrate species	Densities of gunnel, bull rout, eel pout

Pressures on fish in transitional waters	**Effect upon habitat/ecotope**	**Effect upon fish**	Metric
	Loss of shallow-water habitat, decrease in habitat diversity	Decrease in habitat-specific species, decrease in number of species	River lamprey? (larval stage)
Dredging/cement recovery			
	Increase in turbidity	Loss of visual predators	Densities of dab
	Increased penetration of tidal wave	Influence upon larval transport	
	Loss of substrate with biota and bottom nourishment	Reduced production of benthivore fish	Abundance of ER species
	Reduction in oxygen	Reduction in species sensitive to oxygen	Abundance or mortality of smelt
Mining activities			Unknown effect upon fish
	Extraction of sand/clay/shellfish	Loss of substrate spawners	
Natural gas	Subsidence, modification of tidelines, duration of tideland flooding	Shift in (MJ) species?	
Salt	Subsidence	See natural gas	
Water extraction			
	Extraction and exploitation of water	Mortality and damage, particularly amongst young fish	Number of fish in intake, relationship between species
Connection of river basins			
This pressure primarily affects freshwater systems which are to some degree salt-tolerant	Competition for habitat	Colonization by exotic fish species; loss of native fish species; hybridization	Presence of exotic species (tubenose goby)
	Colonization by exotic species (non-fish species, including pathogens)	Modification of fish feed; decrease in native fish species	
Shipping (commercial/recreational)			
	Noise, vibration	Disturbance, damage, mortality	
	Ballast water	Introduction of new species and diseases	
	Sediment turbulence; effect upon vegetation and the oxygen content	Decrease in species bound to specific vegetation, decrease in species sensitive to oxygen	Abundance of garfish, pipefish, smelt
Fisheries			
Fish (target fishery species)	Removal of target species and by-catches	Damage, fish mortality, influencing of age structure	Specific to target species, sensitive by-catch species
Shellfish (cockles, mussels)	Loss of hard substrate, disturbance to bottom	Decrease in species bound to a specific biotope	Density of eelpout, bull rout, gunnel
Shrimp	Disturbance to substrate, removal of feed, by-catch (juvenile flat-)fish	Drop in MJ index; decrease in shrimp-feeders in the autumn	Density of juvenile plaice, cod, rockling, dab, sea snail
Fisheries in the coastal zone	By-catch of sensitive species; reduced reproduction	Decrease in K strategists; decrease in proportion of MJ/MS in the estuary	Absence of Elasmobranchii MA/MS species in the estuary
Release of fish	Dependent upon the species released	Reduced growth due to competition; exotics/hybrids	Number of exotic/hybrid species (sturgeon)
Angling	Digging for lugworms	Decrease in feeding organisms	
Discharges			
Nutrients	Increased productivity	Increased production of MJ species	Density of MJ (e.g. juvenile plaice)
	Reduced visibility	Decrease in visual predators	Density of dab in the polyhaline zone
	Loss of submerged vegetation (seagrass)	Decrease in habitat-specific species	Abundance of sea stickleback, gar, broad-nosed pipefish
	Increase in seaweed/sea lettuce; rotting processes	Decrease in suitable substrate, onset of oxygen depletion	
Freshwater	Strongly fluctuating and decreased salinity	Change in the migration stimulus of diadromous species (attractant flow effect)	Ulcers in flounder, condition factor, elver/stickleback, presence in spring
Cooling water	Increased water temperature	Changes in production or survival amongst species/stadia sensitive to temperature	Overwintering of juvenile bass

Pressures on fish in transitional waters	Effect upon habitat/ecotope	Effect upon fish	Metric
Organic	Decreased oxygen content	Decreased production or survival of species/stadia sensitive to oxygen	Incidence of mass mortality amongst sandeel; abundance of sandeel
Microcontamination, hormonal and chemical	Direct effect	Specific effects, depending upon the form of contamination	Densities of resident species (long-term presence in the estuary)
Natural factors			
Climate change	Change in freshwater discharge and dynamics	Recruitment of anadromous species	Year class success of shad, (anadromous) smelt
	Changes in temperature	Relationship between warm/cold-water species	Dependent upon geographical distribution with regard to the area
NAO (North Atlantic Oscillation)	Ambiguous	Correlation between the abundance of certain species and the NAO	See Attrill & Power (2002)

Since the number of transitional waters in the Netherlands was limited, no attempt is made to formulate an "impact score" relating to the scale of influence upon them.

2.3 Functional groups

In order for the species composition to be assessed, the species were divided functionally into ecological groups or guilds. Use was made of the classification in Elliott & Hemingway (2002). Under this classification, flounder and houting for example fall in the category ER, whereas these species could also justifiably be assigned to the guild CA. Regardless of the classification selected, some fish species will never be clearly assignable to one category or another.

2.4 Data

An overview of all known fish data for the Ems-Dollard and the Westerschelde is shown in Annex 10.1 (based upon Hovenkamp & Van der Veer, 1993). During development of the parameters for fish in transitional waters, use was made of the DFS (Demersal Fish Survey) data of the RIVO, supplemented with project data obtained for the Ems-Dollard and the Westerschelde. Recent data concerning the fish fauna of the Ems-Dollard estuary were collected by Kleef & Jager (2002). In 1999-2001, a quantitative survey of the fish stock was conducted by fishing at two locations in the estuary at monthly intervals using a vessel-mounted anchor net or a stow net (at Oterdum and Dollard respectively). Only the data from 2001 were suitable for estimations of the fish abundance in the Ems-Dollard, owing to the fact that in the previous years, only the diadromous fish had been assessed quantitatively. In 2001, however, an enormous and atypical abundance of juvenile sea snail (*Liparis liparis*) was observed in the spring; in this respect, 2001 was certainly not representative. Owing to the intrinsically high variability of the estuarine fish fauna, satisfactory conclusions regarding abundance cannot by definition be drawn on the basis of measurements performed in a single year. Supplementary data for the Ems-Dollard were obtained from the sampling conducted at the Eemspower station by RIZA (the Dutch Institute for Inland Water Management and Waste Water Treatment) (1981/1982, Jager 1992) and KEMA (Hadderingh et al. 1997, Hadderingh & Jager, 2002). The "BOEDE" data from the 1970s (Stam, 1978, 1984, 1989) are not available in digital form and were not therefore considered in the present report.

Data from Hostens et al. (1996) were employed for the Westerschelde.

The dataset from the DFS (RIVO) is the only time series (1970 to the present) which exists for both estuaries. This survey is conducted in October of each year in the channels by means of a beam trawl. This means that pelagic species and small specimens are not sampled representatively. The DFS covers only a part of the transition between seawater and freshwater: the oligohaline zone (salinity 0.5-<5‰) is not sampled at all, and the mesohaline zone (5-18‰) is sampled only to a very limited degree (De Boer et al., 2001).

3. Discussion

3.1 What is transitional water?

Strictly speaking, the transitional water comprises the entire transitional area between a salinity of 0.5‰ and 30‰. In the current (albeit provisional) classification of the water bodies as Type O2, the salinity limit on the seaward side was set at 20-25‰, and on the upstream side at substantially more than 0.5‰. The DFS covers the euhaline (30-40‰), polyhaline (18-30‰) and to a limited extent mesohaline (5-18‰) zones. In accordance with the estuarine salinity classification (De Leeuw & Backx, 2001), the majority of the DFS samples are taken on the seaward side of the transitional waters. For the oligohaline (0.5-5‰) tract, virtually no data are available from the Ems-Dollard, and only limited data from the Westerschelde. For these reasons, the descriptions contained in the present report refer primarily to the mesohaline and polyhaline parts of the estuaries.

Salinity is the most important structuring factor for the fish community (abundance of species, biomass) in estuarine waters (Thiel et al., 1995). In the Haringvliet (before the dam), the fish composition likewise varied over the longitudinal axis of the estuary as a function of the salinity zones (Kranenbarg, in preparation). In the Schelde estuary, the density of the majority of fish species was higher in the mesohaline zone than in the polyhaline zone (Hostens et al., 1996). The greater abundance of food in the mesohaline zone, with a large area of shallows and/or tidelands, is suggested as an explanation for this observation. De Boer et al. (2001) were unable to establish any correlation between fish densities in the DFS and the salinity. This is presumably because the salinity range within the DFS sampling points is limited, owing to the fact that the oligohaline zone is not fished at all and the mesohaline zone is fished only to a limited degree.

3.2 Advantages and disadvantages of fish as an indicator

The advantages and disadvantages of fish as an indicator of the estuarine water system quality are listed in Table 3.1.

Table 3.1
Advantages and disadvantages of fish as an indicator of ecosystem quality (from Whitfield & Elliott, 2002, Harrison & Whitfield, in press).

Advantage	Disadvantage
Fish are present in the majority of aquatic systems	Fish remain present even in polluted and modified waters
Fish are easy to identify	Fish are difficult to sample (fishing gear is always selective)
Information on their ecology is available for the majority of fish species	(Many estuarine fish are not of commercial interest and are not therefore well studied; their ecology is not well known)
Fish are able to exhibit external pathology as a reaction to pollution	

Fish frequently exhibit a physiological, morphological or behavioural response to stress	The mobility of fish leads to distorted results; seasonal and tidal dynamic
	Fish are mobile and are able to avoid some forms of stress
Fish are able to integrate various aspects of relatively large-scale habitat effects	
Fish have a relatively long life are relatively long-lived	
Fish communities represent all levels in the food web, in particular the higher trophic levels	Organisms high in the food chain do not always provide a timely (early warning) signal of water quality problems
Fish communities encompass many functional guilds, and are also capable of reflecting negative effects in other parts of the ecosystem (e.g. the absence of anadromous fish may indicate upstream problems)	A good survey of fish requires considerable sampling effort
Fish are of interest to the public (fish is edible, some fish species are of commercial importance, some are important to anglers)	Some fish species are influenced by water management measures (releases) and fishing

Although fish may be a suitable indicator of the status of a water system, the above table shows interpretation of the signals reflected in the fish fauna to be a complex issue. A one-to-one relationship will seldom exist between a pressure or impact and a fish metric. Knowledge continues to be insufficient of the ecology and habitat requirements of many specifically estuarine fish species; estuarine fish exhibit high variation in numbers (tidal, seasonal, annual) and are difficult to sample quantitatively. In addition, estuarine fish are influenced by factors outside the estuary (e.g. nursery species the adult population of which lives in the North Sea and may be influenced by fishing; diadromous species which require suitable upstream areas for spawning or growth).

In addition to anthropogenic influences, natural variation (NAO, Attrill & Power 2002) is also a factor causing variability in the fish populations. The separate contributions of anthropogenic and natural variation are not readily disentangled and remain for the most part unclear.

3.3 Brief comments regarding the DFS

The only regular monitoring conducted in the Dutch estuaries is the DFS (Demersal Fish Survey), which has been performed by the RIVO in virtually unchanged form since 1969. This survey was originally launched in order to permit early assessment of the density of juvenile flatfish for the purpose of North Sea fishing. It is the only long-term source of data to provide quantitative information on fish densities in the Westerschelde and the Ems-Dollard.

DFS monitoring was not therefore intended for the sampling of the estuarine fish, and the data from this monitoring programme are limited in their suitability for the development and testing of an estuarine fish index. The survey does not cover the entire transitional water. The euhaline (corresponding to the marine environment) and polyhaline (strongly brackish) zones are sampled the most extensively. The mesohaline (brackish) and oligohaline (weakly brackish) zones, which are characteristic of the estuarine environment, are represented in the DFS by only a small number of sampling points, and no sampling points respectively. Fish densities in brackish waters with a salinity of <15‰ cannot therefore be estimated from these data (De Boer et al., 2001).

The DFS is performed (only) once each year (in September/October), using selective fishing gear (a 3 m trawl). The number of hauls performed in the DFS in the autumn in the Westerschelde is 30 per survey (average figure for the last 30 years). For the Ems-Dollard, the average number of hauls over the 30-year period is 23. Sampling is concentrated in the channels; owing to the nature of the fishing gear employed, the near-bottom zone is primarily fished. As a result, species inhabiting the estuary in the winter, spring or summer are present in the catches only in small numbers, if at all. The same applies to the pelagic species, which inhabit the upper water layers, and species which make use of specific habitats outside the channels (tidal flats, mussel beds, sea grass meadows).

Samples taken using an anchor net (Kleef & Jager 2002) encompass a larger proportion of the fish fauna (pelagic, demersal and benthic) and integrate spatial information despite the performance of fishing at a single point, since the water masses move back and forth with the tide (over a distance of approximately 12 km in the case of the Ems-Dollard) (Table).

The results obtained for the Ems-Dollard by the fishing methods employing a beam trawl (DFS) and a stow net (RIKZ, the Dutch National Institute for Coastal and Marine Management) are compared (Table 3.2).

Table 3.2
Comparison of the metric scores obtained by the RIVO DFS (trawl) (unpublished data) and RIKZ samples (Kleef & Jager, 2002) in the Ems estuary.

Metric	Reference (Lohmeijer 1907)	Ems – DFS (1970-2002)	Ems – RIKZ (2000-2001)
Number of diadromous species	10	2,5	7
Number of resident species	13	8,8	10
Number of nursery spicies	10	6	8.5
Number of marine seasonal species	5	1	4

For the metrics "number of diadromous species" and "number of species of marine seasonal visitors" in particular, the score is conspicuously dependent upon the source of the data, i.e. the fishing method. However, no single fishing method exists which is not in some way selective. For this reason, the UK Environment Agency recommends the use of several fishing methods in combination for the survey of fish stocks ("multi-method sampling") (S. Colclough, personal communication).

The DFS data were analyzed by De Boer et al. (2001) by means of GLM (general linear modelling). This revealed that approximately 30% of the variation in the (log transformed) densities was accounted for by the GLM model. Of this 30%, the factors year class strength and regional differences between water systems each account for half. The remaining 70% of the variation remains unexplained. The year class strength of marine juvenile species is explained by factors other than habitat, and is probably related to the success of reproduction in the North Sea. For definition of the abundance metrics, consideration must be given to this high annual variability, which at the same time is a case for monitoring at annual intervals. Where resident species are concerned, habitat factors in the estuary are a greater factor in determining the abundance.

De Boer et al. (2001) also analyzed trends in the densities of certain fish species and shrimps, in the average water temperature and salinity, and in the depth at which the hauls were performed. They found that the average water temperature in Dutch coastal waters had risen by 3 °C over the previous 30 years, that the salinity had fallen slightly, and that the average depth of sampling had increased slightly. The temperature and salinity factors reflect a separate development which cuts through the anthropogenic influence. The change in the sampling depth may be a method-related factor.

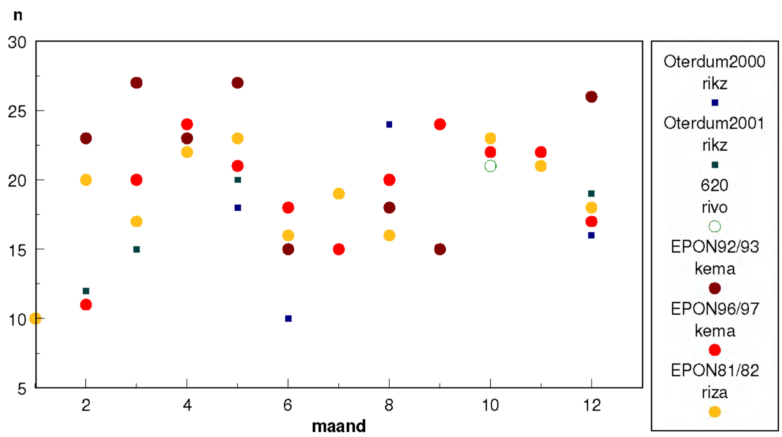
A number of species are not determined to the species level in the DFS. The species concerned are the gobies (common goby and sand goby), the pipefish (greater and lesser pipefish) and the Ammodytidae (lesser and greater sandeel). Analysis of the gobies and pipefish as separate species was consequently not possible, although they do in fact exhibit a difference in their preference for environmental factors (De Boer et al., 2001). The greater pipefish for example is prevalent in greater numbers in coastal waters with sandy and muddy bottoms, whereas the lesser pipefish is more prevalent on sandy bottoms with sea grass or seaweed and at lower salinity levels (Nijssen & De Groot, 1987).

4.Indicators

4.1 Species composition

Number of species
The total number of species is an indicator of the biodiversity. Minor disturbances may cause the species diversity to increase slightly. Severe anthropogenic disturbances may lead to a reduction in the number of species; conversely, a reduction in the disturbance does not always result in an increase in the number of species. This parameter is therefore not entirely unequivocal (Breine et al., 2001). Considerable variation exists in the "number of species" metric, both within a single year, between different sampling methods, and from one year to another, as is illustrated by the data for the Ems-Dollard (Fig. 4.1). As a rule, October-November is the period of the year in which the highest number of species are encountered. The variation in the number of species for a given month appears lowest in October, November and April. The highest number of species is found in the data set of impingement into the Eems power station (Jager 1992, Hadderingh & Jager 2002). The Eems power station is located on the seaward boundary of the transitional water. The middle region of the Ems estuary (Oterdum) and the Dollard differ significantly from each other in terms of the total number of species found (Kleef & Jager, 2002). The number of species is structurally higher at Oterdum.

Figure. 4.1
Seasonal variation in the "number of species" metric (n) based upon different datasets (see legend))



In view of the variation between the methods and the seasonal variation which are reflected in the number of species, the "number of species" metric is considered **not suitable** as such.

Number of diadromous species (CA)
"Diadromous" is a collective term for fish species which exploit both marine and freshwater habitats over their life cycle. These species are, on the one hand, the anadromous species, which reproduce in freshwater (such as the salmon), and on the other the catadromous species, which reproduce in seawater (such as the eel). The presence of diadromous species in the transitional water does not necessarily indicate the presence of a self-sustaining population in the estuary. Anadromous species, for example salmon, sea trout and houting, are occasionally released. This may be the origin of examples of these species which are encountered in the estuaries. Their presence does however indicate satisfactory potential for diadromous species in terms of their availability from the sea and the quality of the transitional waters. The structural absence of these species indicates that bottlenecks exist somewhere in the river basin. Diadromous species are very sensitive to physical barriers (dams, sluices), the loss of (upstream) spawning biotopes, poor water quality (particularly with regard to oxygen), and fishing. The shad, sea trout, lamprey and river lamprey are Red List species which have also been included in the European Habitats Directive. Other Red List species are the sturgeon, allis shad, houting, salmon and eel.
The decline in river migratory fish in the Rhine system (Table 4.1.) is described by De Groot (1989, 1990a, 1990b, 1990c, 1991, 1992a, 1992b,1992c, 2003). The lampreys were disregarded in this study.

Table 4.1
Period and principal cause of decline in diadromous fish species (De Groot, 2003)

Species	Start of decline	End	Main causes
Sturgeon	1893	1910	Fishing, loss of spawning habitat, pollution, turbidity
Allis shad	1900	1910	Fishing, damming, loss of spawning habitat
Salmon	1885	1932	River regulation, shipping, pollution, fishing
Houting	1916	1939	Eutrophication, fishing, damming, loss of spawning habitat
Shad	1939	1966	Damming of the Haringvliet
Sea trout	?	?	
Smelt	1932	?	Afsluitdijk closure dyke
Eel	1980	?	Fishing, pollution, ocean currents, habitat

The species are listed in the table in order of their sensitivity to anthropogenic influence. Should a species disappear from several estuaries, its restoration will be extremely difficult, and success will entail measures such as restocking.

Number of estuarine resident (ER) species
The estuarine resident species may spend their entire life cycle in the estuary, and are therefore sensitive to the disappearance of specific habitats and to the accumulation of toxic substances. Their reproductive strategy is adapted to the estuarine conditions, i.e. it frequently involves a form of brood care (guarding of nests). Extreme examples are the pipefish (brood pouch) or eelpout (viviparous). The ER

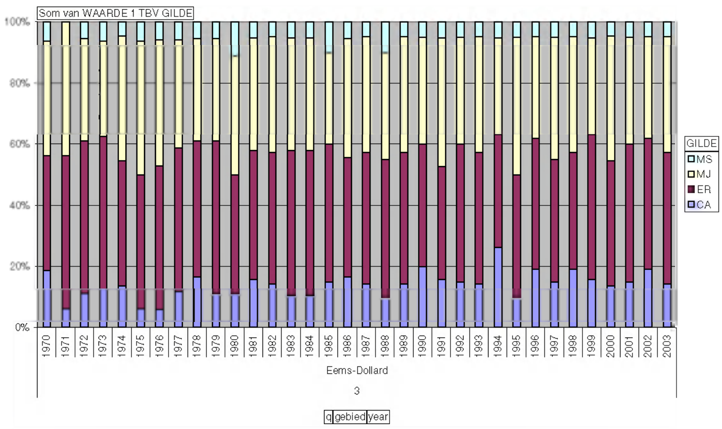
species are sensitive to disruptions in their habitat, toxic contamination, and the extraction of cooling water.

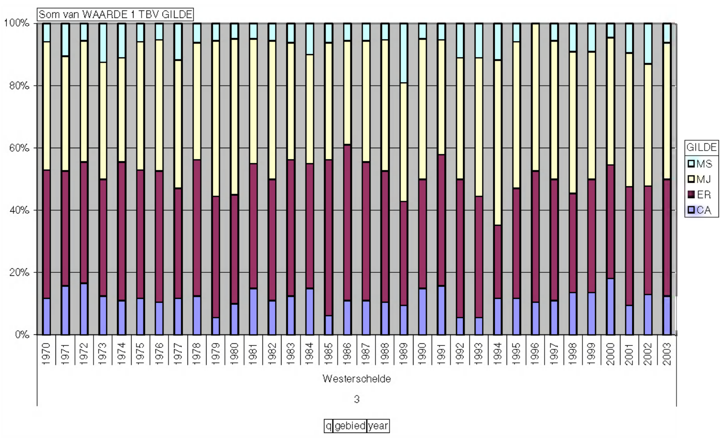
Number of marine juvenile species (MJ)
The MJ species are those which exploit the transitional waters as a nursery. This group includes species which are fished commercially in the North Sea, such as herring, plaice and sole, and cod. It thus follows that factors outside the scope of the WFD (including fishing) may impact upon the densities of these species. For plaice, the year class strength of the 0 group is seen *de facto* to be determined during the larval transport phase (North Sea).

Number of seasonal visitors (MS)
The sprat is the most numerous and common representative of this guild. Other MS species may also use the estuaries for spawning. Their presence in the estuary is frequently brief and dependent upon favourable abiotic conditions there (such as adequate visibility, high water temperatures compared to the coastal zone). With their highly seasonal and brief presence in the estuary, these species can easily be missed by a monitoring measure of short duration.

Relationship between ecological guilds
The proportions of the ecological guilds fluctuate over the longer term, without exhibiting a clear trend (Fig. 4.2).

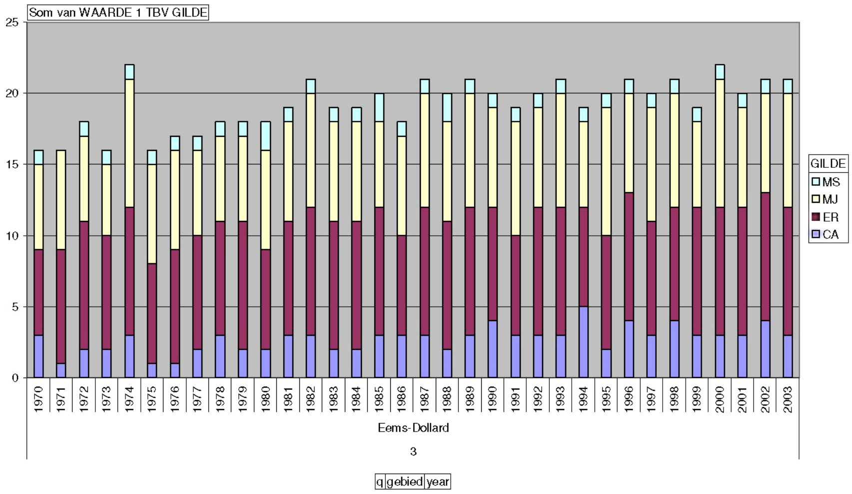
Figure 4.2
Relationship in % between four ecological guilds in the RIVO-DFS autumn samples in 1970-2003 for the Ems-Dollard (above) and the Westerschelde (below). MS=marine seasonal, MJ=marine juvenile, ER=estuarine resident, CA=catadromous/anadromous species.

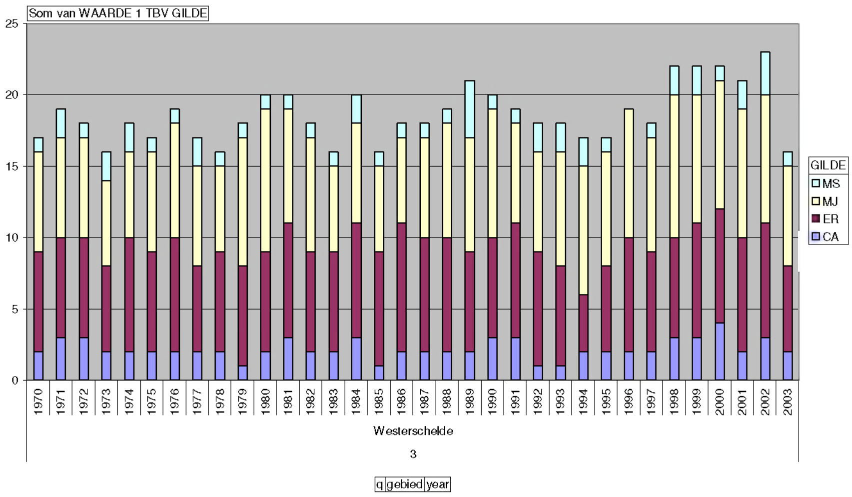




The absolute figure provides somewhat more information (Fig. 4.3); its interpretation is however unclear.

Figure 4.3
Trend in the absolute number of species per guild for four ecological groups (i.e. not including the marine seasonal and freshwater species) in the autumn sample (RIVO-DFS) for the Ems-Dollard (top) and the Westerschelde (bottom) for the years 1970-2003. Legend: see above figure





In the DFS, the resident species account for approximately 32% and the marine juvenile species for 68% of the total density of fish caught. The high proportion of marine juvenile species underlines the importance of the transitional waters as a nursery for marine species.

4.2 Abundance

The metrics which provide information on the abundance cannot easily be defined for fish. The abundance of species is difficult to determine, owing to variations in densities over space and time and to the limits posed by the various sampling methods. From the data available from the DFS, an estimation was nevertheless made of the densities of a number of species, such as those measured over the previous 30 years in the Ems-Dollard and the Westerschelde.

Abundance of diadromous species
The densities of salmonids are currently so low as to permit quantitative monitoring only with great effort. The abundances of, for example, stickleback, twaite shad, eel or smelt are sufficient to permit assessment. In this case, smelt has been selected to represent the diadromous species which are still present. The smelt is a type-specific indicator species for the estuary.

The youngest smelt (0 group) appear in the catches in July, whilst the abundance of older smelt (1+ group) is fairly constant throughout the year (Fig. 4.4, Kleef & Jager, 2002).

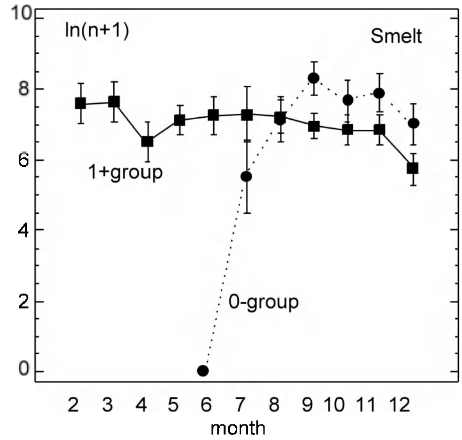
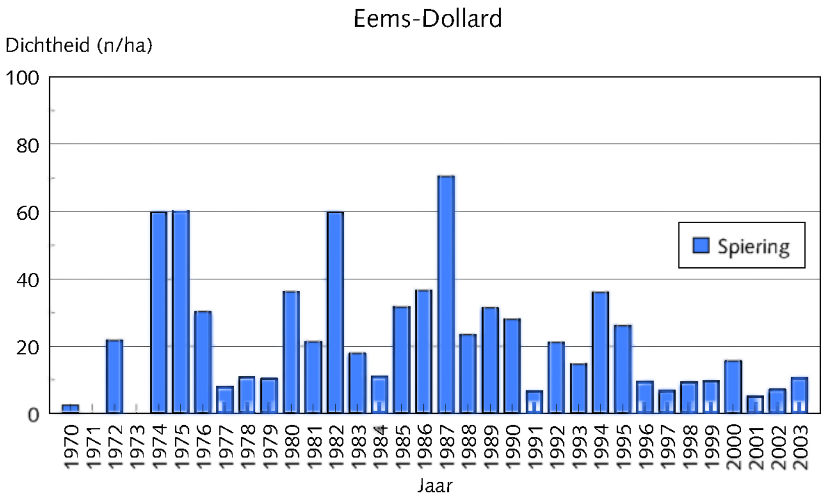


Figure 4.4
Seasonal variation in the abundance (in terms of number standardized per 100 m^2 per tide) of smelt (Osmerus eperlanus) in stow-net sampling in the Ems-Dollard (Kleef & Jager, 2002)

The DFS data were employed for an insight into the long-term trends in smelt abundance. Note that this survey is unfortunately not ideally suited to the quantitative sampling of smelt. A notable difference in densities exists between the ED and the WS (Fig. 4.5). In the WS, smelt is completely missing during sampling in many years prior to 1996, possibly owing to poor water quality. Upstream of the Belgian-Dutch border, organic contamination of the water system leads to high bacterial activity, as a result of which oxygen depletion occurs in some months (Hostens et al., 1996, Maes et al., 1998). Smelt is very sensitive to (low) oxygen levels and is thus a good indicator of the physico-chemical water quality. In view of this, the low catch density of smelt in the Ems-Dollard since 1996 may be ominous. No reference value exists for this metric.

Abundance of estuarine resident species.
The densities of resident species are determined by factors in the estuary. The drawback is that resident species do not react very sensitively to changing abiotic conditions, since they are adapted to the highly dynamic conditions in estuaries. The resident species are however able to indicate the effects of (toxicological) water quality, since exposure occurs over a longer period. An outstanding species in this respect is the eelpout. This species reproduces relatively slowly, and is one of the few viviparous species of fish. According to reports, the preferred habitat of the eelpout is between mussel beds; in the DFS, however, no relationship was established between the densities of eelpout and the distance from mussel beds (De Boer et al., 2001).

Figure 4.5
Densities (number per ha) of smelt (Osmerus eperlanus) in the Ems-Dollard and the Westerschelde as recorded in the autumn sampling of the DFS.



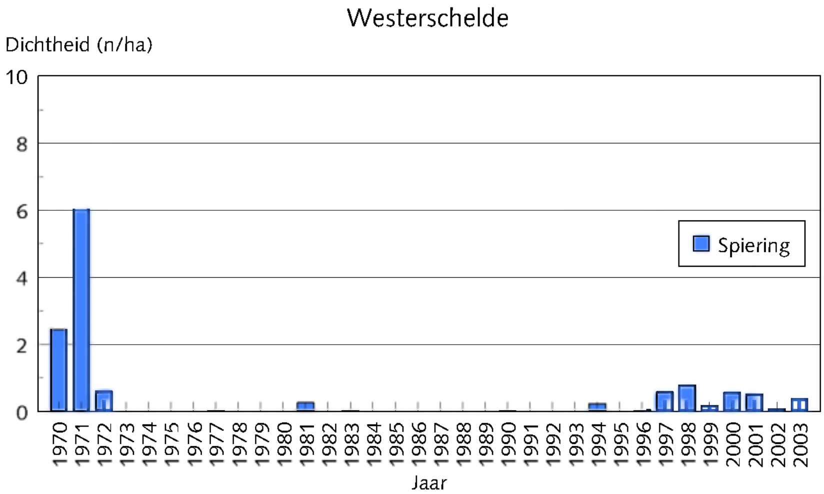
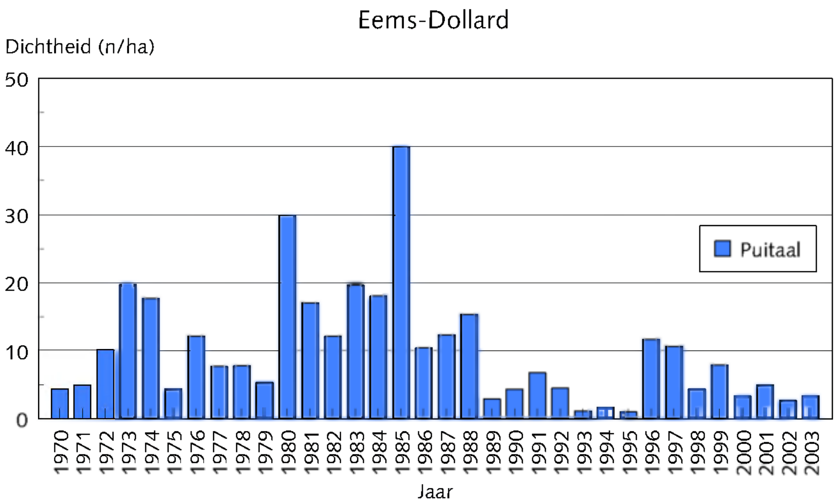
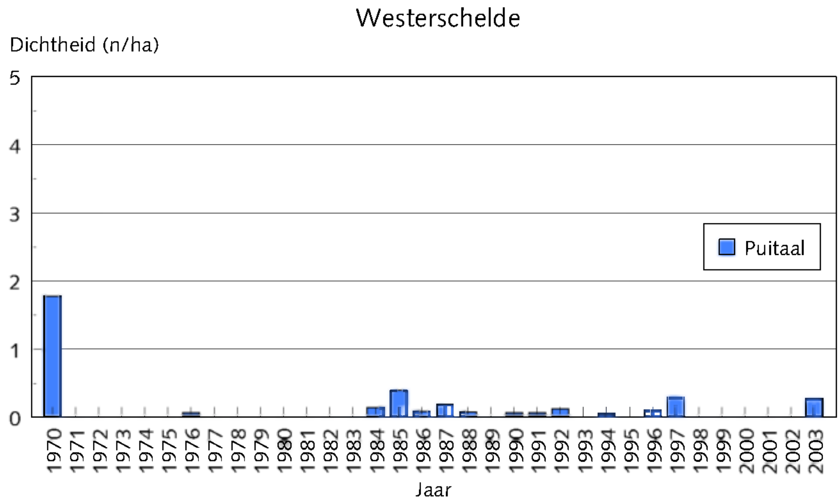


Figure 4.6
Densities of eelpout (Zoarces viviparus) in the Ems-Dollard and the Westerschelde as recorded in the DFS



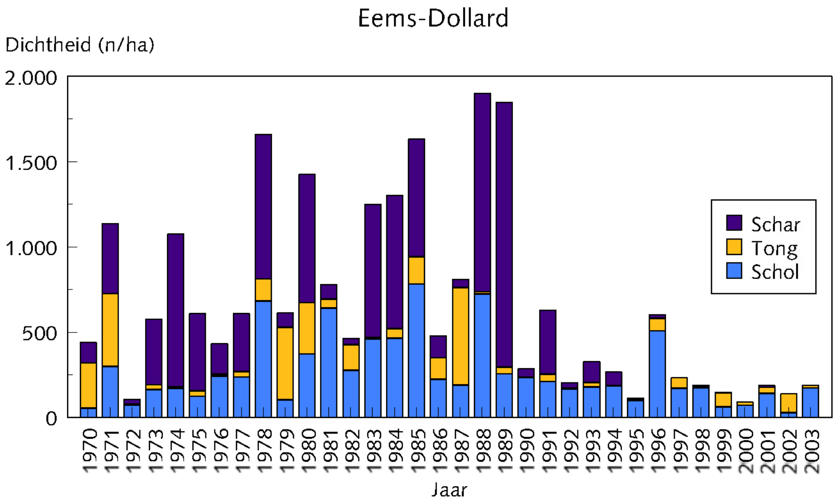


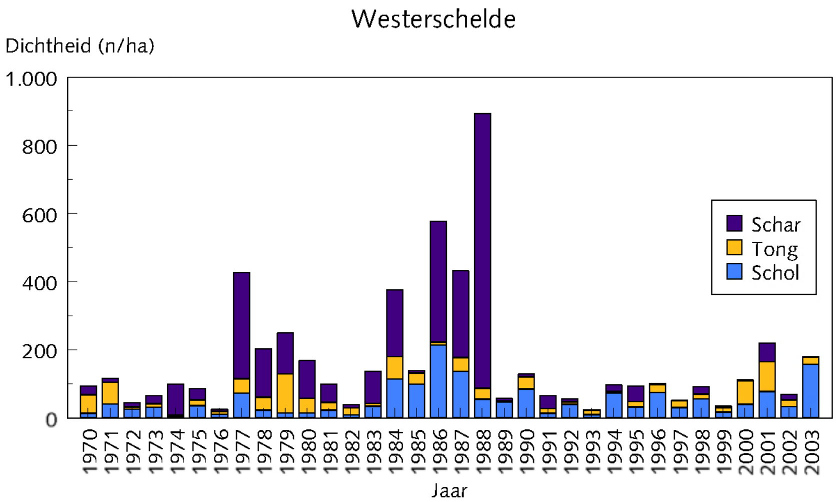
The densities of eelpout in the Westerschelde are much lower than in the Ems-Dollard (note: different y axis scales), and eelpout is not caught every year in the Westerschelde (Fig. 4.6). Taken over the period as a whole (1970-2000), no statistically significant trend in density is evident (De Boer et al 2001). The eelpout stock might be related to toxic substances (such as mercury), and also to the presence of suitable habitat (possible preference for mussel beds). The fry of eelpout cannot survive under conditions of high mercury concentration (Ref.#), whereas the mercury concentrations in the sediment of the Westerschelde are 4 to 20 times those of the background values in the North Sea. No reference value exists. Other species should also be suitable in place of eelpout (bull rout, flounder, etc.).

Abundance of marine juveniles
Juvenile flatfish, young herring or cod can be selected as the representative of the nursery species. Young cod is present in the estuary primarily in the winter months, and is not therefore sampled well in the DFS. Young herring is a pelagic species, and is sampled equally poorly in the DFS. The DFS was originally intended for assessing the density of young flatfish in an early stage for the purpose of recruitment to the fishery. For this reason, the densities of young plaice, sole and dab are presented here (Fig. 4.7). Note the difference in scale on the y axis for the Ems-Dollard and the Westerschelde.

A sharp drop since the late 1980s is evident in the densities of young flatfish in the Ems-Dollard and the Westerschelde. An explanation for this trend cannot be provided without closer analysis.

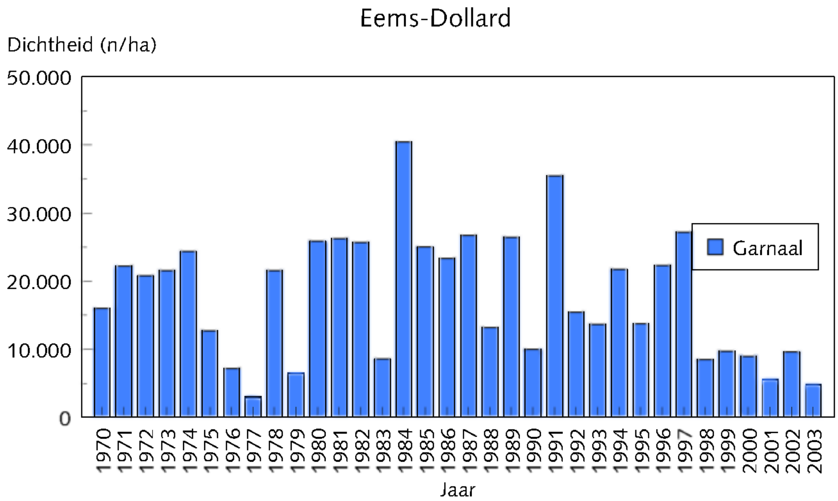
Figure 4.7
Densities of young flatfish (plaice, sole and dab) in the Ems-Dollard and the Westerschelde, as measured in the autumn survey of the DFS





Abundance of shrimp (Crangon crangon)
Shrimp belong to the Crustacea and are obviously not fish. Consideration will nevertheless be given here to shrimp, since they are disregarded in the ecological assessment based upon the macrozoobenthos. This important group thus falls between two tools in the WFD. Shrimp constitute an important part of the by-catch during fish sampling, and can readily be combined with fish monitoring. A large number of estuarine fish species feed on shrimp. The top ten fish species which feed on shrimp are: the bearded brotula, cod, pogge, five-bearded rockling, whiting, bull rout, dab, smelt, goby and eelpout (Tiews, 1978).

The density of small shrimp (Fig. 4.8) shows a significant reduction in both the Ems-Dollard and the Westerschelde over the period 1970-2000 (De Boer et al., 2001).



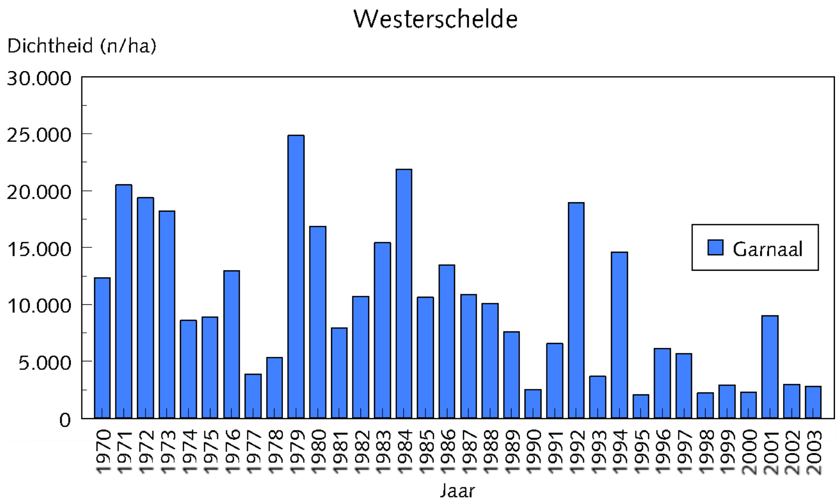


Figure 4.8
Densities of shrimp in the Ems-Dollard and the Westerschelde as measured in the autumn survey of the DFS

4.3 Health (cell/individual)

In the JAMP (Joint Assessment Monitoring Program), the following parameters are measured: 1-OH-pyrene content in the bile of flounder; liver tumours. At the same time, screening is performed for a number of external conditions such as lymphocystis (a viral infection) and ulcers (a bacteriological infection) (Pieters & Vethaak, 2003). In the Ems-Dollard, Bocht van Watum is sampled; in the Westerschelde, the Molenplaat/Middelgat. No data are available for the Nieuwe Waterweg.

Lymphocystis
Lymphocystis is a viral infection which occurs when the condition of a contaminated individual deteriorates. The prevalence of lymphocystis correlates positively with salinity and age, and is also sex-dependent. These characteristics suggest that the prevalence of lymphocystis is less

suitable as a metric, and it is not therefore considered further in the present report.

Ulcers

Ulcers in flounder in estuaries (Fig. 4.9) may be employed as an indicator of the general water quality (Vethaak, in preparation). The advantage of ulcers as an indicator is that this metric is independent of the age or sex, and that it provides a direct response to environmental factors. In situations in which fresh water is discharged artificially into the sea, in particular, the prevalence of ulcers may indicate peaks, as for example was observed at Den Oever in 1988.
Ulcers can be determined externally, which is practical for monitoring purposes.

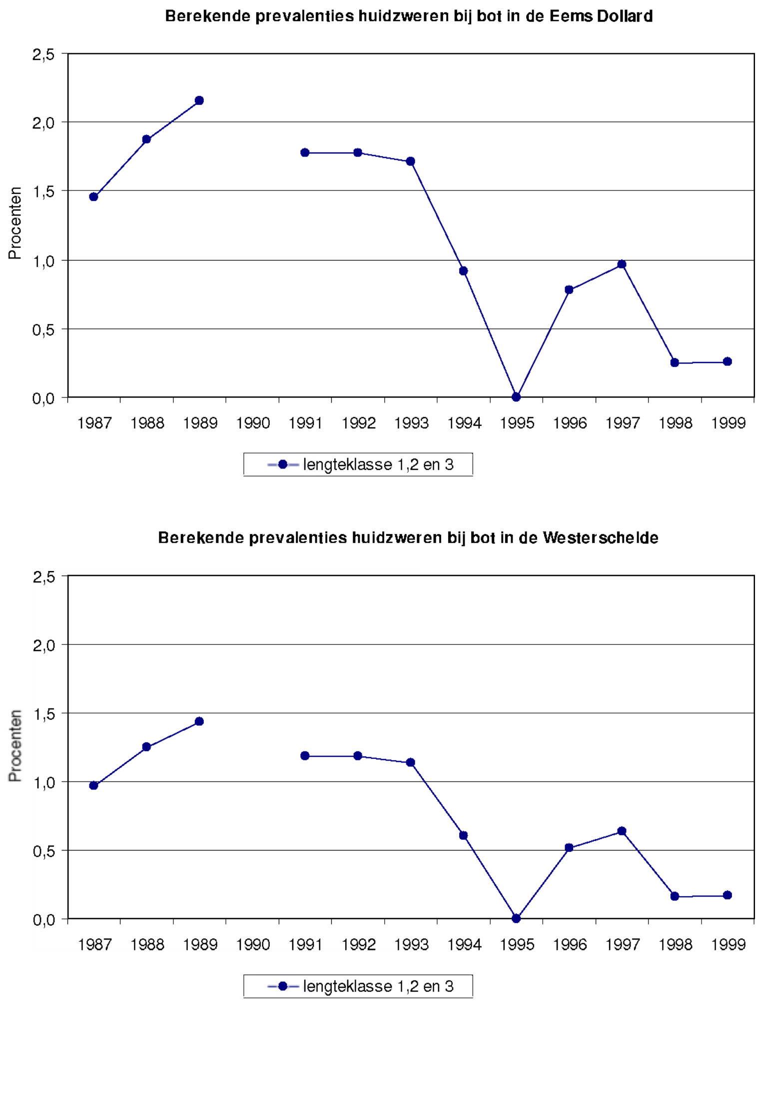


Figure 4.9
Trend in ulcers in flounder in the Ems-Dollard and the Westerschelde (data: JAMP, Pieters & Vethaak, 2003).

Liver tumours and 1-OH pyrene

Liver tumours are associated with PAH concentrations in sediment; the reference value for the incidence of tumours is zero. Tumours develop over a longer period of time. Once a tumour has arisen, it does not disappear again when the conditions improve. This indirect response is a drawback for a metric with regard to the WFD. A higher concentration of 1-OH pyrene in the bile (Fig. 4.10) is an early indicator of the development of tumours. This metric thus appears more suitable for use than that of "liver tumours".

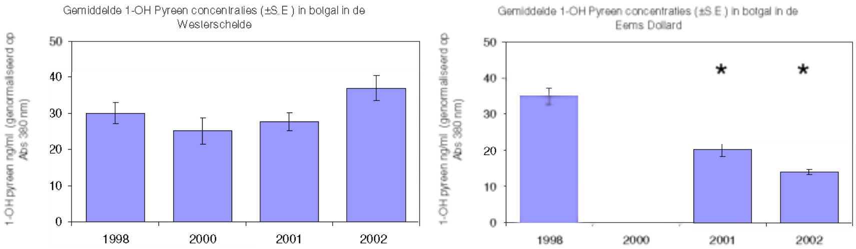


Figure 4.10
Concentration of 1-OH pyrene in flounder

4.4 From indicator to IBI (index of biotic integrity)

An extensive study has been conducted in Flanders into application of the fish index as an instrument for measurement of the biotic integrity of inland waterways in Flanders (Breine et al., 2001, Breine et al., 2004). This study also considers the estuaries (transitional waters), the Westerschelde serving as an example. Breine et al. (2001) describe a method for creation of an estuarine fish index, and a proposal for its translation into metrics.

Based upon the published IBIs and metrics (see Annex VI), the available data were studied with regard to the metrics and sub-parameters which may be applied in the Dutch situation.

The general picture is that the published IBIs exhibit overlap with regard to the metrics, but that they are not all suited to the Dutch transitional waters owing to the limitations in available fish data.

4.5 Incidence of juvenile twaite shad and mature twaite shad

The twaite shad is an anadromous species which migrates from the sea to freshwater in order to spawn. In April and May, the twaite shad spawn in the fresh/tidal water region (De Groot, 1992). The migration ends in the region of the boundary at which a tidal effect is still perceptible. The spawning season lasts for approximately three weeks. Shad require gravel banks as their spawning habitat (Maitland & Hatton-Ellis, 2003). Following spawning, the adults return to the sea. The eggs are spawned in the freshwater. When the larvae hatch, they drift downstream; in the Netherlands, generally to the Wadden Sea area, where they remain for a year in the pelagic zone (De Groot, 1992). Thereafter, they reside in the pelagic zone in the open sea. During the freshwater phase, young shad feed on small crustaceans, mysid shrimp and insect larvae. In the sea, the shad particularly feed on fish larvae (herring, sprat and gobies) and small crustaceans (copepods) (De Groot, 1990). In freshwater, adult twaite shad do not feed.

The incidence of twaite shad in the Wadden Sea is low. Twaite shad have been caught in the area in only two of the last five years: a single individual in 2001, and three in 1999. These shad in the Wadden Sea are probably all one-year-old individuals. Twaite shad are hardly ever found in the adjoining coastal area. They have however been caught regularly at the Kornwerderzand sluices, with peaks in the spring and autumn. The shad caught at the Afsluitdijk closure dyke are for the most part fully grown (maturity stage IV or higher). The average length was 30-40 cm in 2000 and 35-45 cm in 2001 and 2002. Large (>45 cm) and small (<45 cm) shad exhibit the same seasonal pattern.

In the usual period of migration to the spawning grounds, few twaite shad are caught in the IJsselmeer. Since shad are dependent in early life upon a well functioning estuary, which is not present in the IJsselmeer, it remains unlikely that the juveniles mature in the IJsselmeer. The juvenile twaite shad caught in the IJsselmeer are therefore probably temporary visitors from the sea. In the past, the twaite shad spawned in the Merwede and the Bergse Maas; the actual spawning grounds have however never been located (de Groot, 2002). Young twaite shad approximately 10 cm in length were found in August 1999 in the middle reaches of the Ems (Kleef & Jager, 2002). Studies conducted in response to the conjecture that twaite shad spawn in the Ems estuary did not however reveal any further evidence of this (Jager & Kleef, 2003).

In the Demersal Fish Survey (DFS), the fish fauna are sampled by means of a 3 m shrimp net. Only once has a shad been caught by this method in the Wadden Sea (Tien et al., 2003). In various monitoring programmes conducted by the Netherlands Institute for Fisheries Research, fish were sampled with the aid of fyke nets (Winter et al., 2004, Tulp et al., 2003).
The advantage of this passive method is that the sampling effort is much greater than for an active sampling method, therefore yields useful information even at low fish densities. On average, between 0.1 and 2.7 shad per fyke catch were caught by this method on the Wadden Sea side of the Afsluitdijk. For larger specimens (>40 cm), the figure varied between 0.1 and 0.2 per fyke day catch.
Square drop nets were employed for the sampling of fish larvae (Gerkens & Thiel, 2001). Twaite shad larvae were caught by this method in the Elbe in the period between 26 May and 10 July. A stow net is employed for young shad and a trawl for the shallow areas.

Various alternatives exist for establishing whether shad spawn in the area:
1. The presence of mature specimens in April-May
2. The presence of 0+ specimens at the end of August
3. The presence of eggs or larvae
4. Spawning activity

The densities of mature shad are very low and variable. In addition, no reference density is available. It is therefore difficult to define a sub-parameter for abundance. The presence of mature specimensin the spawning period can however serve as an indicator of whether the area serves as a spawning area. Monitoring must then take place in the April-May period.

The most reliable indicator of spawning activity is the presence of eggs and/or larvae. Determining this presence is however difficult, since the exact spawning location must be known. In addition, the sampling measures required are intensive and therefore costly. The presence of 0+ examples should also be an indicator of spawning activity in the area. They must however then be distinguishable from 1+ examples. This difference is difficult to discern on the basis of length (Kleef & Jager, 2003); instead, it must either be determined on the basis of otolith readings, or be calibrated to such readings. The presence of 1+ shad in an area is no guarantee that they originated there.

Since the spawning of shad is accompanied by loud splashing noises, it should be possible to detect their spawning activity by patrols of likely areas on still nights (Jager & Kleef, 2003). Again, the potential spawning locations must be known for this purpose.

To conclude: the most suitable parameter appears to be formulation of a combination of (1) fyke net sampling of mature twaite shad in April-May (in combination with the sampling of other diadromous species) and (2) sampling of 0+ examples in August by means of a anchor net (or possibly other fishing gear).

4.6 Selection of indicators

A selection was made from amongst the indicators stated (Table 4.2) for the further development of parameters in Section 7.6.

Table 4.2
Selected metrics for fish in transitional waters (O2)

Category	Metric
Species composition	Number of diadromous species
Species composition	Number of estuarine resident species
Species composition	Number of nursery species
Species composition	Number of seasonal visitor species
Abundance	Density of smelt
Abundance	Density of eelpout
Abundance	Density of juvenile (flat)fish
Other	Density of shrimp
Other	% ulcers in flounder
Other	Presence of juvenile twaite shad and mature twaite shad

5. Reference

5.1 Step-by-step definition of a reference description

Assignment of water to typology

Ems-Dollard

The estuarine transition of the Ems extends from Herbrum to the tidal inlet at Borkum (the mouths of the western Ems), and encompasses the full range from an oligohaline, mesohaline and polyhaline to a euhaline tract, each with a characteristic fish fauna. The water is ultimately assigned to a type by the water management authority. The regional authority for the northern Netherlands (Rijkswaterstaat) has proposed an assignment to types (see Fig. 5.1). The sub-area marked "Ems Ästuar" has been classified **provisionally** as Type O2 (transitional waters with moderate tidal range). Within the area classified as O2, it may be advantageous to distinguish two sub-areas with regard to the fish fauna: the middle area of the Ems estuary, and the Dollard. This is based upon the difference between the ratios between channel and intertidal flats (1.3 and 1.1 for the outer and middle area respectively), and 0.2 for the Dollard (Jager, 1998). For the time being, the Dollard has not been considered separately.

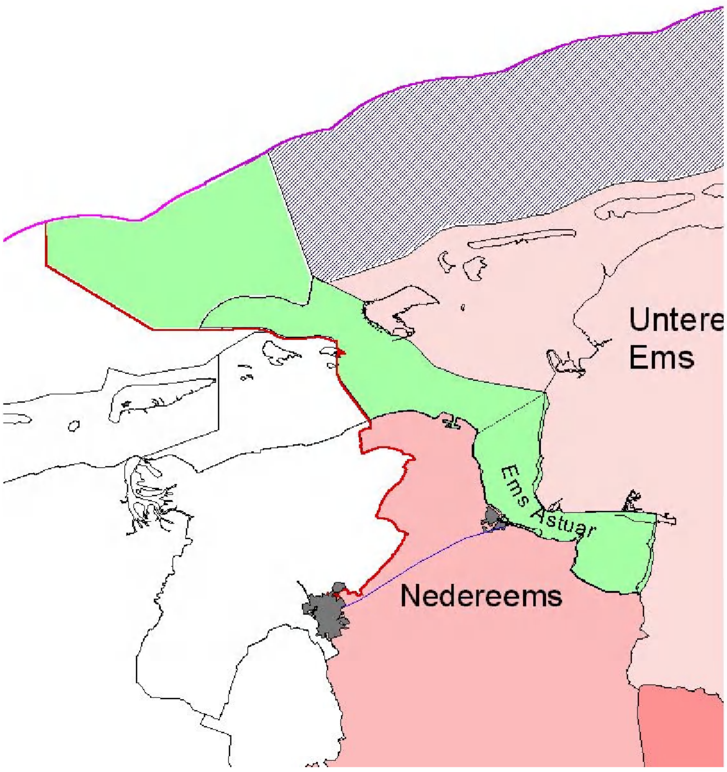


Figure 5.1
Provisional typology of the Ems-Dollard transitional waters by the water management authority

Westerschelde

The O2 typology applies provisionally to the area in the Westerschelde bounded on the seaward side by the Vlissingen-Breskens line and on the freshwater side by the Dutch-Belgian border (personal communication from B. Kornman, RIKZ, Fig. 5.2).

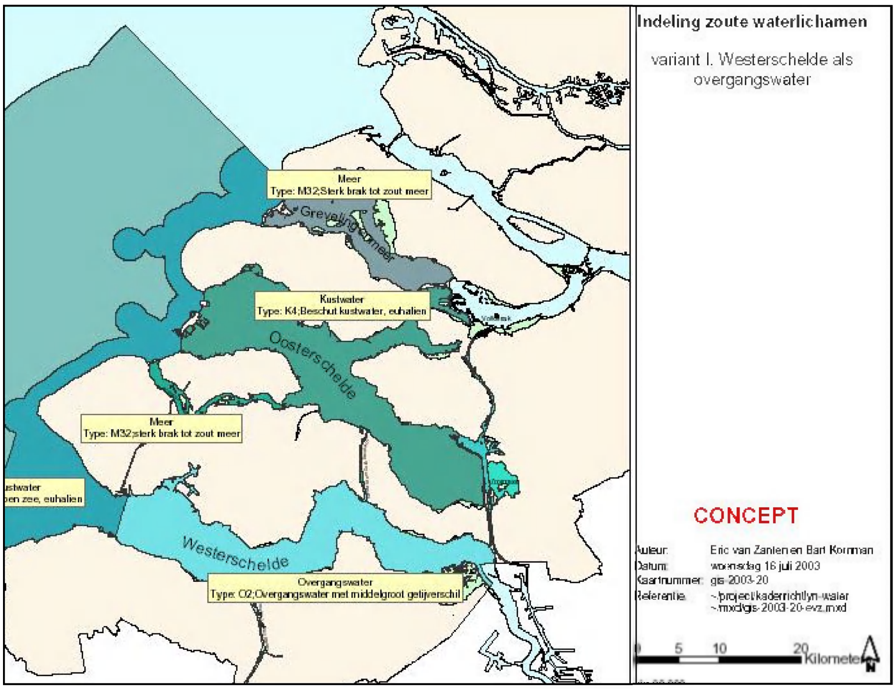


Figure 5.2
Provisional typology assigned by the water management authority of the transitional waters of the Westerschelde.

Available reference waters

Undisturbed reference waters no longer exist. The Ems-Dollard is considered the most representative Type "O2" body of water for the Netherlands, closely followed by the Westerschelde.

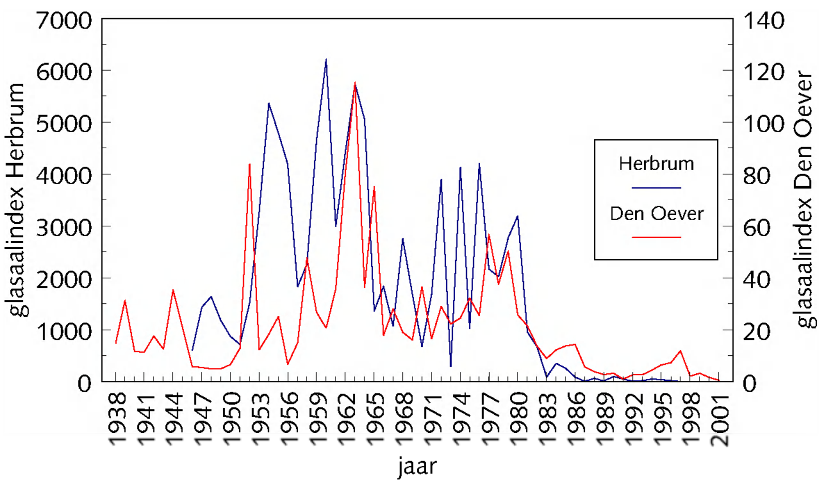
Indexing of existing reference data

Historical

For the Ems-Dollard, Stratingh & Venema (1855) and Lohmeijer (1907) are two sources providing serviceable (qualitative) descriptions. They may assist in illustrating the species composition, but provide no support in determining abundances. Data are also available from catches from the fishery in the Ems estuary (Venema, 1868; Jaarboeken visserij LNV 1947-1965). After 1965, the catches were no longer recorded separately for the Ems-Dollard; comparison between the present status and the reference situation on the basis of fisheries data is not therefore possible. The reference can therefore be based only in part upon the oldest data available, those from around 1850, but even in these sources, the onset of changes in the fish stocks was already being reported. The year 1850 must be regarded in the context of the morphological/hydrological developments in the area. The description by Lohmeijer (1907) is enlightening in a number of respects. For

example, he mentions the presence of glass eel which "im Frühjahr in ungeheuren Scharen aus dem Meer und Brackwasser in die Flussmündungen aufsteigen" (migrate in the spring in tremendous numbers from the sea and brackish water into the river mouths). The presence of glass eel in such high numbers soon ceased to be observed in the Ems (Fig. 5.3).
As also shown by the figure, this decline is also observed at Den Oever and elsewhere in Europe. The causes can only partly be found within the Ems river basin.

Figure 5.3
Elver index for Herbrum (Ems, Germany) and Den Oever from 1938 to the present (source: W. Dekker, RIVO).



The oldest description of fish for the Westerschelde is that of De Selys-Longchamps (1842) (Breine et al, 2001). A reference framework for the lower Zeeschelde with description exists in which three pivotal periods can be identified: the 12th to 14th century; the period around 1900; and the period around 1930. Around 1900, rare species such as the Atlantic salmon disappeared, and the anchovy stocks declined strongly, probably as a result of overfishing of the coastal waters (Breine et al., 2001).

The fish fauna of the Zuiderzee is described by Redeke (1907, 1922). The species found there are the same as those in the Westerschelde and the Ems-Dollard. For Haringvliet, data exist from Vaas from 1968; these were however not used for defining the reference, since the water quality must already have deteriorated considerably by this period.

Optimum ecological status
In transitional waters, the number of species, belonging to various ecological guilds, is frequently present in fixed ratios (Elliott & Dewailly 1995). Elliott & Hemingway (2002) provide a basis for the overall picture (regarding the species composition) for European estuaries with which the Dutch transitional waters can be compared. The use of habitat by fish in estuaries was charted by division into nine habitat types; the area of each habitat was estimated for the Ems-Dollard and the Westerschelde (Elliott & Hemingway, 2002) (Table 5.1). Although certain habitat types are not represented in the Westerschelde and the Ems-Dollard, the number of species which may be anticipated on

average in the habitat concerned can be indicated based upon the known data for 18 estuaries in the EU.

Table 5.1
Area of various habitat types in the Ems-Dollard and Westerschelde and global estimation of the average number of fish species per habitat, based upon a comparison of European estuaries (Elliott & Hemingway, 2002)

Habitat type	Ems-Dollard (km^2)	Westerschelde (km^2)	Average number of fish species per habitat
Tidal fresh water	16.5	30	14
Reed beds	1.2	5.2	8
Saltmarsh	14.1	31.7	13
Intertidal soft substratum	254.7	112.4	25
Intertidal hard substratum	0	0	5
Subtidal soft substratum	220.6	176	50
Subtidal hard substratum	0.1	0	19
Subtidal sea grass beds	0	0	18
Biogenic reefs	0.4	0	24
Total intertidal area	261	149.3	
Total area	498.7	355.3	

The number of fish species varies by habitat type; the measures employed for sampling are however also a factor. The number of habitats present in each estuary may vary. The (sub-)parameters developed in the present report are based to a large extent upon the "intertidal soft substratum" and "subtidal soft substratum" (including the channels) habitat types, since these account for the largest part of the transitional waters in the Netherlands.

Geographical references
Elliott & Dewailly (1995) present a cluster of a number of European estuaries which illustrates the relationships between them. Unfortunately, the Ems was not included in this analysis. In a cluster analysis based upon semiquantitative species data, the Westerschelde is seen to be related most closely to the Oosterschelde, the Voordelta, and consequently to the Humber, Forth, Tyne and Solway (Elliott & Dewailly, 1995). A study into the best (in terms of quality) available water types outside the Netherlands on the basis of fish data (presence or absence of species) was conducted by the UK Environment Agency (Coates et al, 2004). The MDS (multidimensional scaling) analysis conducted by these researchers on the basis of the presence/absence of species reveals that the Ems-Dollard, Westerschelde and Oosterschelde are very similar and exhibit considerable overlap with the Thames, Humber, Mersey, Weser and Elbe.

Where a range of different estuaries are to be compared to each other, a reference number of species can be defined from the average number of species of the uppermost quartile (Harrison & Whitfield, in press).

Expert judgement
Selection and formulation of the parameter of fish in transitional waters is based heavily upon expert judgement. The present report attempts to substantiate the considerations and selections as far as possible.

Use of models
p.m. (no serviceable models are applicable).

5.2 Reference fish in transitional waters (O2)

A reference species list was compiled based upon historical descriptions for the Ems-Dollard and the Westerschelde (Table 7.5.2). Although, in the period 1850-1900, the abundance of a number of species (e.g. sturgeon, salmon, allis shad) had already fallen as a result of anthropogenic influence, the species composition still exhibited full integrity (the majority of species that have died out in the Netherlands did so between 1910 and 1940). The reference species list is based upon the species lists for the Westerschelde and the Ems-Dollard in the historical situation. The crosses in bold in the column for the Westerschelde indicate that Breine et al. (2001) considered the species concerned as belonging on the reference species list. The gunnel is not indicated as a reference species for the Westerschelde; it is, however, a species typical of estuaries and one which should certainly be included within the reference for the estuarine fish fauna. It may possibly not have been caught there owing to its life cycle and the sampling method employed. In the remaining cases in which a species in one of the two estuaries is not present on the historical list, the species in question has not been included on the reference list. The sea-horse, for example, is included by Breine et al. (2001) on the reference species list, but is now regarded as a "fluke" (J. Breine, personal communication). The Ems-Dollard lies at the northern boundary of this species' area of distribution. In warm years, the sea-horse may (theoretically) be found in the Ems-Dollard; reports have occasionally been received in recent years of sea-horses in the German Bight.

The freshwater species (ecologically of the FW guild) were not included in the reference species list for transitional waters. They may however occasionally be encountered. The incidence of freshwater species in the brackish parts of the estuary may indicate a favourable transition between seawater and freshwater areas, but may also be caused by washing-out at discharge points. Since a "fresh tidal water" type (R8) is also defined, it is assumed that these species are included there.

The marine adventitious species (ecologically in the MA guild) are also omitted from the reference list. They exhibit no dependency upon the estuary, and their incidence there primarily reflects their presence and influence in the coastal zone.

Table 5.2
Reference species list for transitional waters, water type O2.

1	*Acipenser sturio*	Sturgeon	CA
2	*Alosa alosa*	Allis shad	CA
3	*Alosa fallax*	Twaite Shad	CA
4	*Anguilla anguilla*	Eel	CA
5	*Gasterosteus aculeatus*	Three-spined stickleback	CA
6	*Lampetra fluviatilis*	River lamprey	CA
7	*Osmerus eperlanus*	Smelt	CA
8	*Petromyzon marinus*	Sea Lamprey	CA
9	*Salmo salar*	Salmon	CA
10	*Salmo trutta*	Sea trout	CA
11	*Agonus cataphractus*	Pogge	ER
12	*Ammodytes tobianus*	Lesser sandeel	ER
13	*Aphia minuta*	Transparent goby	ER
14	*Coregonus oxyrinchus*	Houting	ER
15	*Liparis liparis*	Seasnail	ER
16	*Myoxocephalus scorpius*	Bull rout	ER
17	*Pholis gunnellus*	Gunnel	ER
18	*Platichthys flesus*	Flounder	ER
19	*Pomatoschistus microps*	Common goby	ER
20	*Pomatoschistus minutus*	Sand goby	ER
21	*Syngnathus acus*	Greater pipefish	ER
22	*Syngnathus rostellatus*	Lesser pipefish (Nilsson's pipefish)	ER
23	*Zoarces viviparus*	Eelpout	ER
24	*Clupea harengus*	Herring	MJ
25	*Dicentrarchus labrax*	Sea bass	MJ
26	*Gadus morhua*	Cod	MJ
27	*Limanda limanda*	Dab	MJ
28	*Merlangius merlangus*	Whiting	MJ
29	*Pleuronectes platessa*	Plaice	MJ
30	*Scophthalmus maximus*	Turbot	MJ
31	*Scophthalmus rhombus*	Brill	MJ
32	*Solea solea*	Sole	MJ
33	*Trigla lucerna*	Tub gurnard	MJ
34	*Belone belone*	Garfish	MS
35	*Cyclopterus lumpus*	Lumpsucker	MS
36	*Dasyatis pastinaca*	common Sting-ray	MS
37	*Engraulis encrasicolus*	Anchovy	MS
38	*Sprattus sprattus*	Sprat	MS

No single sample from the estuary is ever likely to contain all species present. In addition, strong seasonal variation occurs, as a result of which all potential visitors to the estuary can be identified only after at least one year. These are factors which must be considered during development of a monitoring programme for fish in transitional waters (see Section 7.8).

Table 5.3 summarizes the reference values for the sub-parameters.

Table 5.3
Reference values for each sub-parameter for Type O2 (transitional waters)

Species composition sub-parameter	Reference value
Number of diadromous species	10
Number of estuarine resident species	13
Number of nursery species	10
Number of seasonal visitor species	5

A reference for abundances could not be defined from the available data.

6. Yardstick

The WFD anticipates a binding statement on the biological quality element of fish in terms of the species composition and the abundance.

Development of the yardstick (scoring system) involves the following procedural steps:

1. Selection of applicable metrics (see Section 7.4)
2. Identification of the reference values associated with these metrics (including bandwidths) (see Section 7.5)
3. Assignment of class limits to these metrics, i.e. development of a sub-scoring system (this section)
4. Aggregation of the sub-parameters to form a final assessment for the biological quality element of fish. For aggregation, criteria were drawn up for the final assessment, and also for assessment of the underlying sub-parameters.
5. Application of the index to the relevant transitional waters (see Section 7.7)

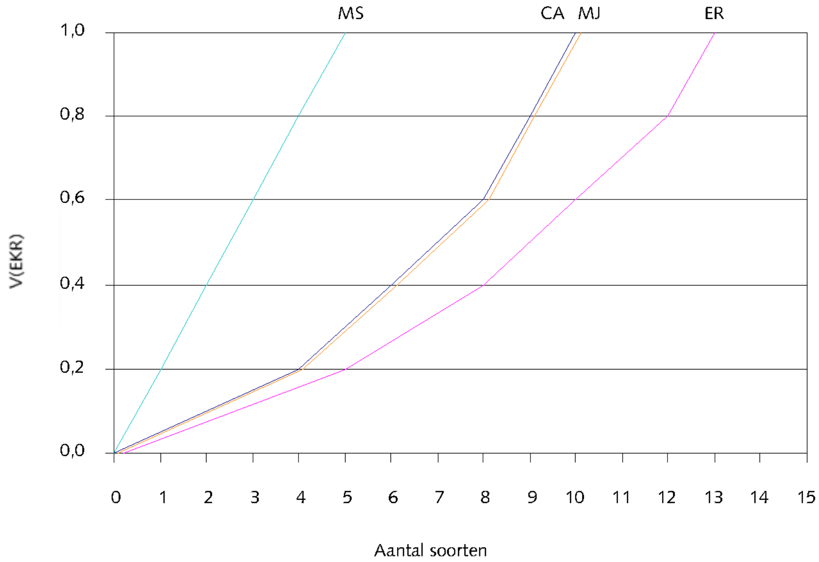
Ad 1. Section 7.4 provides an overview of various metrics which may conceivably be used for assessing the status of the water system on the basis of the fish fauna. A number of metrics were deemed to be less suitable. The metrics which have a bearing upon the abundance could not be elaborated owing to insufficient data. A sub-scoring system is defined in this section for each of the remaining metrics. The selection of metrics which has now been completed constitutes an initial proposal. Adjustment may still be made in connection with further findings being made in the subsequent course of the project, with further provisions set out by the WFD, and with the practical applicability of the current parameter.

Ad 2. The reference values now indicated for the numbers of species are based upon the period 1850-1900. In this period, the sources had already begun reporting the onset of changes in the fish stocks. In consideration of anthropogenic influences, this period cannot be regarded as being completely undisturbed. An important aspect which is not addressed by the WFD is that of the temporal and spatial scales which are relevant for identification of the undisturbed state.

No reference was identified for the metrics for abundance. Historical data are not comparable with current data. A geographical reference was hampered by the (poor) comparability of data gathered by means of different fishing methods. The estuarine fish fauna is so variable spatially and temporally (tidal phase, season, year) that it is clearly impractical to define a scoring system for it.

Ad 3. The relationship between the metric and the V(EQR) is not necessarily linear. Regarding the number of fish species as a function of the ecological quality: a species does not disappear overnight; several years first pass during which the abundance progressively decreases under pressure from the conditions. As the situation deteriorates further, the most sensitive or vulnerable species bears the brunt of the change. It is followed by other species. Under poor conditions, a small number of species which are capable of survival will always remain. For the metrics relating to the species composition, an (arbitrary) relationship was drawn up in consultation with M. van Herwijnen (VU Amsterdam) (Fig. 6.1).

Figure 6.1
Grading function between the measured value and the ecological quality ratio



This grading function is used to define the class boundaries in relation to the species composition (Table 6.1).

No parameter can be defined (as yet) for the abundance.

An expert judgement has been provided by A.D. Vethaak (RIKZ) for ulcers and 1-OH pyrene (Table 6.1).

The parameter for twaite shad is based upon the incidence of adults and 0+ fish. The densities of fully grown shad are very low and variable. In addition, no reference density is available. It is therefore difficult to define a sub-parameter for abundance. The presence of mature specimens in the spawning period can however serve as an indicator of whether the area serves as a spawning ground. Monitoring must then take place in the April-May period. The most reliable indicator of spawning activity is the presence of eggs and/or larvae. Determining this presence is however difficult, since the exact spawning location must be known. In addition, the sampling measures required are intensive and therefore costly. The presence of 0+ examples (August) is therefore employed as an indicator of spawning activity in the area (Table 6.1).

Table 6.1
Classification of the sub-parameters for fish in transitional waters (O2).

Fish sub-parameter	Very good	Good	Moderate	Poor	Bad
Number of diadromous species	10	9	7-8	4-6	≤3
Number of estuarine resident species	13	11-12	9-10	6-8	≤5
Number of nursery species	10	9	7-8	4-6	≤3
Number of seasonal visitor species	5	4	3	2	1
Density of CA (esp. smelt)	?	?	?	?	?
Density of ER (e.g. eelpout)	?	?	?	?	?
Density of MJ (plaice, herring?)	?	?	?	?	?
Density of shrimp	?	?	?	?	?
% ulcers in flounder	0%	0-2%	2-5%	5-20%	>20%
1-OH pyrene in bile of flounder (ng/ml)	<50	50-200	200-500	500-2000	>2000
presence of adult twaite shad	+	+	+	-	-
presence of 0+ twaite shad	+	+	-	-	-

Ad 4. The species composition has a quantitative aspect (how many species are present in the transitional waters), a qualitative aspect (to what extent do these species correspond to the historical reference), and a functional aspect (what is the activity of these species in the transitional waters, and what factors may potentially influence this functionality).

Points of departure for the species composition are as follows:
a. Quantity and quality must be high.
b. The functional aspect must be good.

These two criteria are expressed in the sub-scoring systems for the number of species per ecological guild. In other words: all sub-scoring systems must be "good".

An IBI (or the aggregated parameter) provides an overall assessment of the transitional waters with regard to fish, but provides no factual information on the causes responsible for its status. For identification of the causes, recourse must be made to the underlying metrics and sub-parameters.

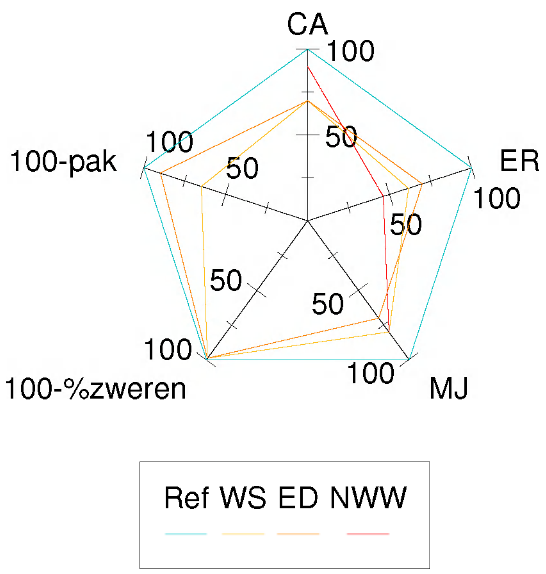
The parameter may be detailed by inclusion of long-term trends in the species' development; these trends provide an early indication of the direction in which certain metrics are moving. On the one hand, the water management authority can thus be alerted that the state is still good but that the trend is moving in a negative direction, and respond accordingly. On the other, the arrangement signals to the water management authority whether the measures employed in combination with the autonomous development of the area are likely to produce the desired ecological status. It should however be noted here that where fish species are subject to strong annual fluctuations, a long period of time is required before statistically significant trends in numbers can be detected.

Interpretation of the trends (as shown in Section 7.4) necessitates a more far-reaching (statistical) analysis. Such an analysis is provided in part by De Boer et al. (2001).

The metrics which are based upon abundance continue to present difficulties with regard to establishment of the reference situation and creation of a classification. This remains a serious knowledge gap, in view of the fact that it prevents fulfilment of the requirement set out in the WFD, namely of providing a complete assessment of the biological quality element of fish.

The parameter can be presented elegantly in the form of a radar plot (see also Breine et al., 2001), as shown in Fig. 6.2.

Figure 6.2
Example of an "AMOEBE" indicator system for fish, for presentation of the scores for various metrics against a reference value (Ref) of 100%. WS: Westerschelde, ED: Ems-Dollard, NWW: Nieuwe Waterweg



Considerable information is lost when all metrics are aggregated to form a single score for fish in transitional waters (as in the Belgian and South African method, among others). By contrast, a form of AMOEBE indicator system for fish (Fig. 6.2) provides an immediate impression of which indicator (ideally related to a specific combination of pressures and impacts) is responsible for the deterioration in the water system.

7. Application

Table 7.1 contains the provisional sub-scoring systems for initial application of the assessment method for Dutch estuaries.

The Nieuwe Waterweg has been included here as an example of a water system which has been substantially modified.

Table 7.1
Application of the sub-parameters for fish in certain transitional waters

Metric	Reference	Westerschelde	Ems-Dollard	Nwe Waterweg
Number of diadromous species	10	7[1]	7[1]	9[3]
Number of estuarine resident species	13	8[2]	9[2]	6[3]
Number of nursery species	10	8[2]	7[2]	8[3]
Number of seasonal visitor species	5	1[2]	1[2]	3[3]
ASSESSMENT OF SPECIES COMPOSITION		Poor	Moderate	Poor
Density of CA (smelt)	?			
Density of ER (eelpout)	?			
Density of MJ (plaice, herring?)	?			
ASSESSMENT OF ABUNDANCE				
Density of shrimp	?			
% ulcers in flounder	0%	0.2-0.6	0.5-1	No data
1-OH pyrene in the bile of flounder (ng/ml)	<50	40	15	No data
Presence of shad of spawning age	+	+	+	+
Presence of 0+ shad	+	-	-+	-

[1]Source: Elliott & Hemingway 2002, [2] Source: RIVO-DFS, [3] Source: fyke data, MWTL

Since the sampling method (DFS) is not suitable for indicating seasonal visitors, the waters do not score satisfactorily on this sub-parameter. For this reason, this sub-parameter has not been included in the final assessment. Owing to the different fishing methods (fyke net instead of beam trawl), the score for the numbers of species for the Nieuwe Waterweg is not comparable with that for the Westerschelde and the Ems-Dollard. A fyke net catches a greater number of species than does a trawl, and in particular, more diadromous species, since the fykes are in place for the greater part of the year and thus have a greater chance of intercepting these species during the brief period of their migration. The trawl reflects an instantaneous sample.

The transitional waters generally return the score "moderate". Owing to the low score for the number of estuarine species, two waters even return the score "poor". The picture is even less favourable, as expected, when the abundances and criteria such as sustainable populations are also included in the consideration. Conversely, waters are now assessed with a parameter for natural transitional waters, despite this description by no means applying to all the bodies of water.

8. Gaps in knowledge & recommendations

8.1 Gaps in knowledge

Many of the estuarine resident species are particularly adapted to the dynamic conditions in their habitat. Since these species are not fished commercially, stock estimates are not available, and much remains unknown regarding their biology.

The metrics relating to abundance cannot (as yet) be formulated owing to:
- No means existing for definition of a reference value
- The absence of reliable quantitative data

In MWTL, the current national water system monitoring programme for the Netherlands, no fish is as yet monitored in transitional waters. A considerable deficit exists for the Ems-Dollard and the Westerschelde with regard to accessible and serviceable data, in particular for formulation of the metrics which indicate abundance.

As soon as the definitive choice of metrics has been made, a fish monitoring programme for transitional waters and geared to the WFD can be developed. Consideration must be given in the process to the temporal and spatial variation inherent to estuarine fish fauna.

8.2 Temporal variation

Table 12 shows, for the species on the reference species list, the period in which they were encountered in the estuary, and that in which the densities peaked. This overview is based upon the data for the intake of cooling water at the Eemscentrale power plant (Jager 1992), the overview produced by Ybema & Backx (2001), who drew up a table of the inward and outward migration period of estuarine fish on the basis of 17 references, and the characteristic over time of the estuarine species observed during fish stock sampling measures in the Schelde (Hostens et al, 1996). The table also indicates in which estuarine zone the species dominated in the Westerschelde (Hostens et al, 1996). The final column of the table indicates what fishing tackle is suitable, and the month in which sampling may best be performed.

8.3 Fishing gear

The fishing methods employed for the sampling of fish communities often differ. The reason for this is that the various habitats in which fish are found cannot all be sampled (efficiently) with a single fishing method. Different forms of fishing gear differ in their catch efficiency as a function of their position in the water column, the shore zone or the open water, the presence of structural elements, the presence of currents, the visibility, the salinity, and of course the behaviour and dimensions of the fish species. A distinction is drawn between active fishing methods, which are moved through the water in order to catch fish, and passive fishing methods, in which fishing nets are located at a fixed point and trap fish.

Active fishing gear employed in estuaries are the beam trawl, stow net and seine net. The seine net is employed for fishing of the shore zone. The seine net is drawn out in a semicircle from the shore. The net stands vertical in the water. The top line (floatline) of the seine is kept afloat by corks. The bottom line (footrope) is held on the bottom by lead or stones. A beam trawl is a towed fishing net; it is held open at the front by a metal or wooden beam and is used for sampling demersal fish species. The stow net functions on the same principle; in this case, however, the fishing depth can be adjusted by means of floats at the top and weights at the bottom edge of the net.

Passive fishing gear which can be used in the estuary are fykes and the vessel-mounted stow net (anchor net). Fykes consist of cylindrical or spherical pockets which are mounted on rings or hoops and are surrounded on all sides by a net structure. They are placed on the bottom and used in shallow water. Where a anchor net is mounted on a vessel, the ship lies at anchor and a net is lowered into the water on either side. The net is held open by the current. When the tide turns, the ship must also be turned. The role of the vessel is thus passive; the fish are driven into the net by the current. Fykes sample the lowest part of the water column in the shore zone, whereas the anchor net, depending upon the size of the vertical net opening, fishes the pelagic part of the principal current or possibly even the entire water column.

The catch efficiency of the above fishing methods differs according to its type and as a function of its position in the water column. Pelagic species such as herring and sprat, for example, are caught in proportionally much lower densities in fykes. These species are also frequently caught in lower densities with a beam trawl than with an anchor netnet or a (large) seine.

8.4 Recommendations concerning monitoring

Certain general comments can be made concerning estuarine fish monitoring:

- As a rule, rare species are not adequately monitored in routine, low-frequency sampling. Where unusual species are concerned, a proportionally greater effort must be made in order to make the probability of a catch acceptable. This can be attained by involving professional fishermen and having them report particular species.

This method is also employed in the programme for the monitoring of rare fish in the IJsselmeer.

- Where the incidence of a species is strongly seasonal, monitoring must be adjusted accordingly.
- Deviations in the seasonal incidence of species may also be indicative.
- For estuarine resident species which are tied to a specific habitat, monitoring must be adjusted to the habitats concerned.
- Where numbers fluctuate widely from year to year, an annual sampling frequency provides superior monitoring than one of every three years.
- Regarding the selection of a fishing method, preference should be given to the particular fishing methods which are employed by the professional fishermen in the area concerned; they have frequently perfected the most effective fishing technique over many years of experience.
- Whether the data are to be qualitative or quantitative in nature is also relevant for the selection of the fish monitoring method.
- Since each fishing method has its own particular features and limitations, application of several techniques in combination is advisable. A combination of active and passive sampling may for example be appropriate.
- Monitoring for the WFD is best split into two parts:

1. Monitoring in the period March to August, geared to the spawning and migratory functions of diadromous species and species diversity with fykes and stow nets, which interfaces with the river monitoring.
2. Monitoring with the seine and (fine-meshed) beam trawl in August-September, geared to the density of species for the purpose of determining the ecological quality as a habitat for ER species and as a nursery for MJ species.