OSPAR report on the second application of the Comprehensive Procedure for the Belgian marine waters

Reported by: Belgium

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1. Summary

Despite the reduction of 34% in nitrogen and 61% in phosphorus discharges and emissions in Belgium in the period 1985 – 2005, the Belgian coastal zone is still characterised as a problem area with regard to eutrophication for the five-year period 2001-2005. The offshore area is characterised as a potential problem area. These results of the 2007 eutrophication assessment are similar to the first application of the Comprehensive Procedure by Belgium in 2002, which concluded that in almost all investigated years in the assessment period 1995 to 2000 winter DIN and DIP were above the thresholds and chlorophyll *a* concentration was determinant in the distribution of problem areas. Generally, problem areas appeared near the coast with an increasing gradient towards the north-east (Scheldt and Rhine/Meuse river plumes). This is still valid for the second application of the Comprehensive Procedure for the period 2001 – 2005. The following is a summary of the second Belgian eutrophication assessment in 2007.

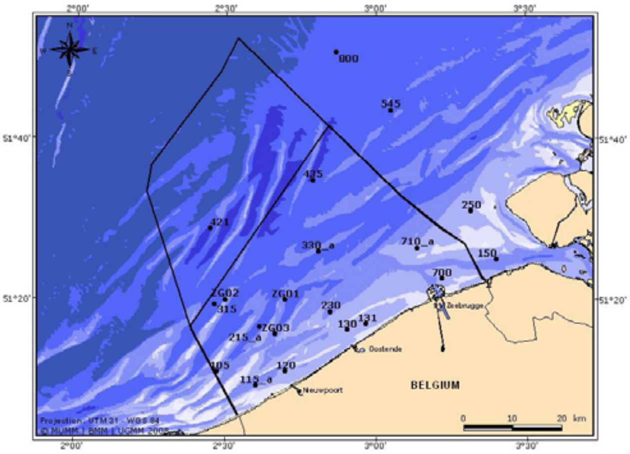

Figure 1a Belgian part of the North Sea, delineated by solid black lines and by the bathymetry. The border between the coastal and the offshore zone through the Belgian waters and the sampling stations are also indicated.

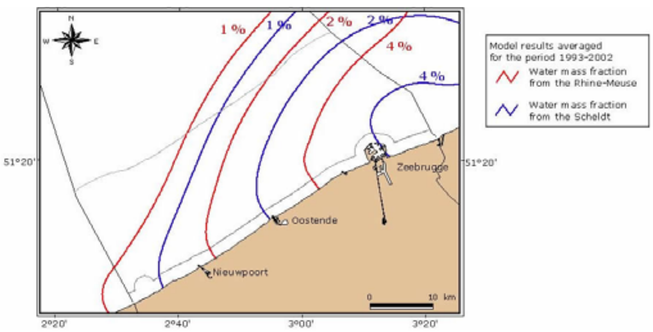

Figure 1b Delimitation of the fraction of the water masses originating from the Rhine/Meuse (blue) and the Scheldt (red). A fraction of 1% means that 1% of the water on that specific location is originating from the respective river district.

The eutrophication assessment for 2001 – 2005 covers the Belgian part of the North Sea (Figure 1a). The area is characterised by shallow waters, submerged sandbanks, strong, mainly semi-diurnal tides, frequent wind-mixing, strong horizontal advection from tide- and wind-driven currents, fully mixed water column, high turbidity, and high concentrations of suspended primarily inorganic particulate matter.

The water masses that impact the region originate from the Channel, which supplies high salinity and low nutrient water, and from the continental coastal rivers. Although nutrient loads from the Channel are not negligible, it is the loads from the rivers Scheldt and Rhine/Meuse that are responsible for the high concentrations in the coastal waters (Figure 1b). The Seine contributes significantly to nutrient concentrations further offshore. Transboundary nutrient inputs (and outputs) are thought to be very significant for the Belgian waters from the adjacent French and Dutch waters. The strong horizontal tidal mixing leads to a merging of inputs from the various rivers into a more general water mass of lower salinity, high nutrient continental coastal water. There are preliminary indications of transboundary fluxes from research models, but their detailed and reliable quantification is not yet available.

The second eutrophication assessment for the period 2001-2005 is based on riverine total nitrogen and phosphorus inputs, winter DIN and DIP concentrations, the N/P ratio, mean and 90th percentile chlorophyll *a* concentrations and oxygen deficiency. The maximum value for chlorophyll *a* concentrations has been rejected for assessment because of the strong dependence of this parameter on the sampling frequency. Satellite chlorophyll *a* imagery has been used to demonstrate the sufficiency of the spatial coverage of the monitoring network. Other assessment parameters were not used on a quantitative basis but the obvious presence of *Phaeocystis* blooms has been taken into account in the classification. The background and elevated levels for nutrients and chlorophyll *a* in coastal and offshore waters have been examined and redefined, based on observed and modeled relationships, which made a reconsideration of the correctness of the used assessment thresholds and their adaptation possible.

The spatial distributions of winter dissolved inorganic nitrogen (DIN) and dissolved inorganic phosphorus (DIP) are clearly determined by the influence of freshwater discharges. In the coastal zone, the DIN at the reference salinity exceeds the OSPAR "elevated" level for all five years; the corresponding DIP exceeds the elevated level for three out of the five assessment years. No temporal trends can be deduced from these analyses although longer-term analysis suggests a previous decrease in the riverine discharge of DIP. For none of the years in the period 2001-2005, the threshold for DIP is exceeded in the offshore zone. The overall winter means over the whole period are below the elevated level values for DIN and DIP. This averaged offshore result is identical to the "per year" result for DIP, but not for DIN, for which the threshold was exceeded in two of the five winters. As an overall result, significant nutrient enrichment of DIN and DIP has been observed in the coastal zone, but not in the offshore waters for the period 2001-2005.

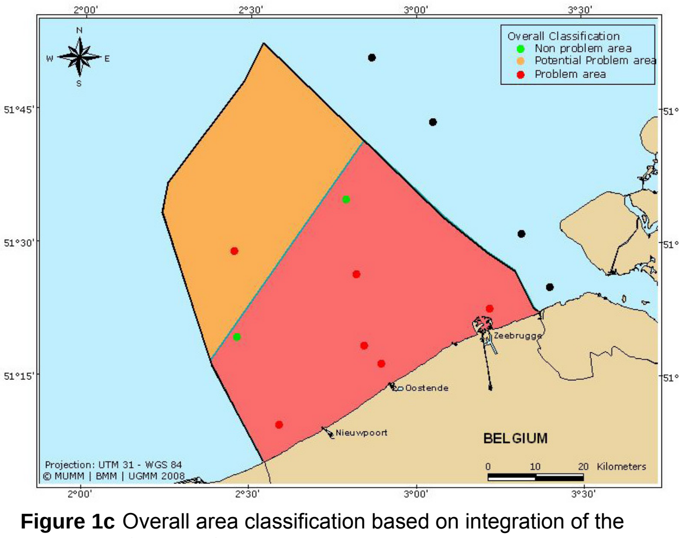

Figure 1c Overall area classification based on integration of the assessment parameters.

In the coastal zone, as well as in the offshore zone, both the mean and the 90th percentile chlorophyll *a* concentration over the growing season exceeded the elevated level for the period 2001 – 2005, where all years are considered together. The significant presence of *Phaeocystis* blooms in the coastal zone has been taken into account on a general qualitative observational basis, not on a quantitative basis. No data are available to identify the extent of the *Phaeocystis* blooms in the offshore waters, this parameter is considered to remain inconclusive for the offshore zone. Overall, the offshore waters have been defined as a potential problem area due to the insufficient spatial extent covered by the monitoring (Fig.1c).

Given the characteristics of the Belgian waters, macrophytes/macroalgae are not relevant parameters in the eutrophication assessment. Although locally some transient oxygen depletion could occur, the prevailing hydrodynamic conditions generally ensure continuous oxygen replenishment in the coastal zone, as well as in the offshore zone.

Based on different scientific research projects, it became clear that benthos shows a gradient in the Belgian waters, which is related to the eutrophication gradient, and that eutrophication can have an indirect effect on the benthos of the Belgian waters. It is planned to include these parameters in future assessments. Frequent monitoring for area-specific phytoplankton indicator species and changes/kills in zoobenthos has started in 2007 in the coastal waters in the context of the Water Framework Directive.

Algal toxins have not been coherently monitored in Belgian waters in the period 2001 – 2005 but monitoring has started in 2006 because of the development of mussel aquaculture in Belgian waters. The first analyses show that no DSP/PSP toxin producing species exceeded the threshold in that year.

Areas for improvement of the assessment concern the need

a. to further investigate and validate improved background levels for DIN, DIP and chlorophyll *a* for example by further exploring coastal ecosystem models with coupled river basin models to simulate historic "pristine" conditions*;*
b. to improve sampling for chlorophyll *a,* especially in time, to determine interannual variability, making use of continuously measuring moored instruments (e.g. "ships of opportunity") and satellite chlorophyll *a* imagery; improvement in the spatial extent of the monitoring in the offshore zone is required as well
c. to develop methods to remove interannual and long-term variability from meteorological factors in relation to chlorophyll *a* and phytoplankton species composition for example by using ecosystem models.
d. to include quantitative assessment data on phytoplankton indicator species, zoobenthos and fish kills in the evaluation of the eutrophication status. Attention should also be paid to examine and redefine appropriate evaluation indices in this respect.

2. Introduction

This report has been prepared in the framework of Belgium's obligations concerning the Second National Assessment of eutrophication status under the OSPAR Convention for the Protection of the Marine Environment in relation to the Eutrophication Strategy. The introduction provides a description of the OSPAR context of eutrophication assessment and a description of the area in terms of bathymetry and physical oceanographic processes relevant to eutrophication, including water masses dynamics and river discharges. The report covers the analysis of nutrient and chlorophyll *a* and other relevant data to assess the eutrophication status of the Belgian maritime area. Following the evaluation results for the different required parameters and the overall assessment of coastal and offshore waters, the link with the Water Framework Directive is elaborated shortly. Expected trends for future development of the status of the Belgian marine waters and suggestions for the improvement of the assessment are given at the end. The Marine Environment Service of the Federal Government has elaborated the present document in collaboration with the Management Unit of the North Sea Mathematical Models.

Motivation: OSPAR eutrophication strategy

According to the definition of OSPAR (OSPAR 2003), eutrophication means "the enrichment of water by nutrients causing an accelerated growth of algae and higher forms of plant life to produce an undesirable disturbance to the balance of organisms present in the water and to the quality of the water concerned, and therefore refers to the undesirable effects resulting from anthropogenic enrichment by nutrients as described in the OSPAR Common Procedure". The objective of the OSPAR Eutrophication Strategy (OSPAR 2003) is to "combat eutrophication in order to achieve and maintain a healthy marine environment where eutrophication does not occur". This should be achieved (OSPAR 2005) "progressively by 2010, *inter alia*, by targeted measures and programmes adopted by OSPAR and other forums. The need for measures, the assessment of their effectiveness and, accordingly, the need of any further targeted OSPAR activities (measures, programmes, monitoring, etc.) to achieve the goal set for 2010 require assessment and monitoring of the eutrophication status of OSPAR Convention waters".

Historical background: OSPAR First Assessment

Application of the Common Procedure, agreed by OSPAR to evaluate the status of eutrophication of marine waters, is split into two steps: firstly, the Screening Procedure, a broad brush approach which serves to identify areas that are obviously NPAs (non-problem areas), and, secondly, for all other areas the more detailed Comprehensive Procedure for further evaluation. For Belgium the Screening Procedure yielded no obvious NPAs and the Comprehensive Procedure was therefore applied. A first integrated application of the OSPAR Comprehensive Procedure for the Assessment of the Eutrophication Status of the OSPAR maritime area ("First Assessment") was completed in 2003 (OSPAR Commission 2003) for which the assessment of the Belgian maritime area was based on the national assessment of Belgium ("First National Assessment"), completed in 2002 (Belgium 2002).

In the case of Belgium the First Assessment (OSPAR Commission 2003) concluded that "in almost all investigated years in the assessment period 1995 to 2000, winter DIN and DIP were above the thresholds and chlorophyll *a* concentration was determinant in the distribution of PA (problem area). Generally, the Belgian coast is evaluated as a PA, but spatial differences were detected. PA appear near the coast with an increasing gradient towards the north-east. The offshore waters can be classified as PPA (potential problem area). For some years NPAs are sometimes identified at the northern limit of the Exclusive Economic Zone. The OSPAR integrated First Assessment generally used data collected for the period 1990-2001**.** The corresponding Belgian national assessment was based primarily on data for the years 1995, 1997, 1998 and 1999, because for these years the best data were available. Consideration was also made of winter nutrient concentrations for the period 1974-2001.

OSPAR Second Assessment

This report constitutes the Belgian national report on the second application of the Comprehensive Procedure. In the Second Assessment monitoring data for the period 2001-2005 is used. Identification of any trends or temporal changes between the First and Second Assessments is encouraged, particularly to evaluate the impact of any measures taken to reduce nutrient inputs to the marine environment.

Since the First Assessment was completed in 2003, the OSPAR Eutrophication Task Group (ETG) and Eutrophication Committee (EUC), two working groups that are broadly differentiated by the more technical nature of ETG and the more strategic nature of EUC, have made preparations for a Second Assessment of the Eutrophication Status of the OSPAR maritime area ("Second Assessment"). In particular ETG has defined, with the approval of EUC, the technical requirements of the Second Assessment, detailing how the classification between PA (problem area), PPA (potential problem area) and NPA (non-problem area) must be determined and how the national assessment must be reported to OSPAR. These requirements are defined in (OSPAR 2005) and follow closely the spirit of the First Assessment, but some changes in methodology since that assessment were made that result from a better scientific understanding and from agreements made at OSPAR meetings. In particular, the class of "potential problem area" is largely removed, there is some convergence between the OSPAR problem/non-problem area classification and the new European Union Water Framework Directive water quality classes. Also issues relating to spatial and temporal sampling and data processing have been clarified.

3. Description of the assessed area

The area considered in this report is the Belgian part of the North Sea as illustrated in Figure 2. The water masses that impact the Belgian part of the North Sea originate from the Channel, which supplies high salinity, low nutrient water, and the continental coastal rivers, such as the Scheldt, which discharges just East of the Belgian-Dutch border, the Rhine/Meuse, which discharges about 70 km further to the North-East, and the Seine, which discharges about 250 km to the South-West. These rivers all supply low salinity water with high concentrations of nutrients (nitrates and phosphates). Model studies show that, as regards salinity (Lacroix *et al.*, 2004), the Channel water is the dominant component (~95 % of water originates from the Channel) with salinity reduced in the near-shore waters by the impact of the Rhine/Meuse and Scheldt, and in the offshore waters by the Seine. As regards nutrients, the Channel input is not negligible, but the high concentrations found in the river waters, especially those of the Scheldt and the Rhine/Meuse, are responsible for the high concentrations found in coastal waters, while, further offshore, nutrients from the Seine contribute significantly.

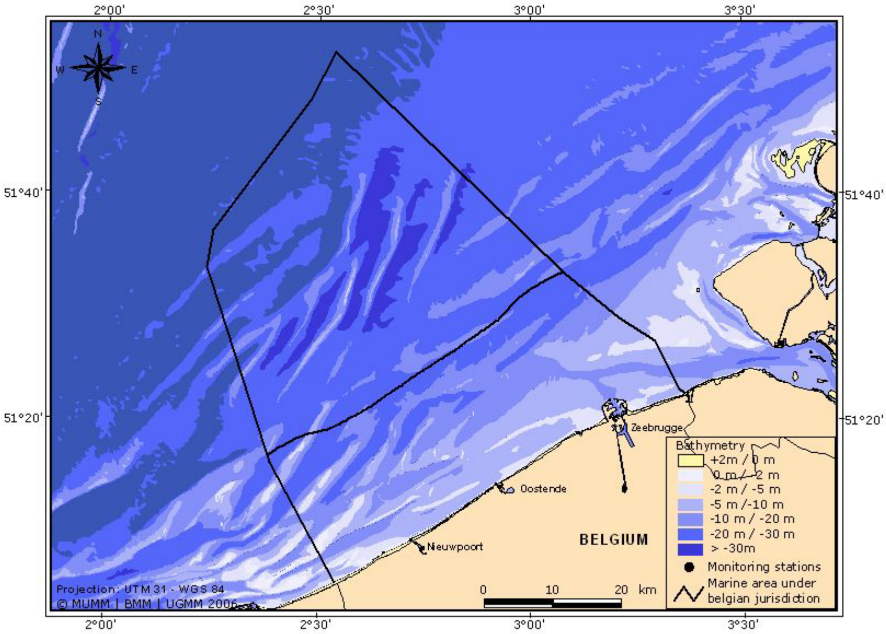

Figure 2: Belgian part of the North Sea, delineated by solid black lines and the bathymetry

Water depths in the Belgian part of the North Sea are generally shallow close to the coast (0-10 m within 15 km) with the bathymetry sloping down to the deeper waters (about 40 m) found at the offshore limit. Superimposed on this general onshore-offshore gradient in water depth there are many submerged sandbanks seen as linear bathymetric features in Figure 2.

This is a region of strong, mainly semi-diurnal tides with peak tidal current amplitude of about 1 m/s. The tides, combined with frequent wind-mixing, generate sufficient turbulence to mix fully the water column with the occasional exception that sometimes weak stratification may be observed near the mouth of the Scheldt Estuary (haline) and in deeper offshore waters (thermal) during calm and warm weather. The vertical variability of dissolved parameters, such as dissolved nitrate and phosphate concentrations, and also of phytoplankton-related parameters, such as chlorophyll *a,* is low. The horizontal variability of these eutrophication-related parameters is significant and is dictated largely by the variable mixing of waters from continental coastal rivers and from the Channel.

Because of the well-mixed characteristics, coastal upwelling as such does not occur. Transboundary fluxes of nutrients and possibly phytoplankton are thought to be considerable because of the strong horizontal advection from tide- and wind-driven currents. These fluxes are largely unquantified.

Water salinities range typically from 28 to 34.5, with the lower salinities occurring near the mouth of the Scheldt Estuary during periods of high river discharge. The long-term distribution shown in Figure 3 is modulated by high frequency variability (e.g. hours to days) caused by tidal advection and wind events and by variations in river discharge.

Water temperatures range from about 1°C to about 21°C. Most variability is temporal and follows the annual cycle of solar heating. Some spatial variability (~1 or 2°C) is sometimes observed, especially in summer, where shallower areas close to the coast and over submerged sandbanks may warm up faster.

This region has high concentrations of suspended particulate matter (1-100 g/m^3 or more) primarily of inorganic origin, especially in the near shore waters where the strong tidal currents resuspend fine, bottom material. Water turbidity is consequently generally high with Secchi depths ranging from 0.5 m or less in near shore waters up to 5-10 m in offshore waters.

Temporal variability of eutrophication-related parameters is affected by the tidal advection, by wind-driven advection and by biological processes. In particular, during the spring phytoplankton bloom and subsequent summer and autumn growing seasons, the variability of chlorophyll *a* can be fast with large variations over a few days. Nutrient concentrations are highest at the end of the winter months, just before phytoplankton growth becomes significant. Interannual variability is affected by meteorological factors such as wind and rainfall, which are correlated with the North Atlantic Oscillation (NAO) (Breton *et al.* 2006).

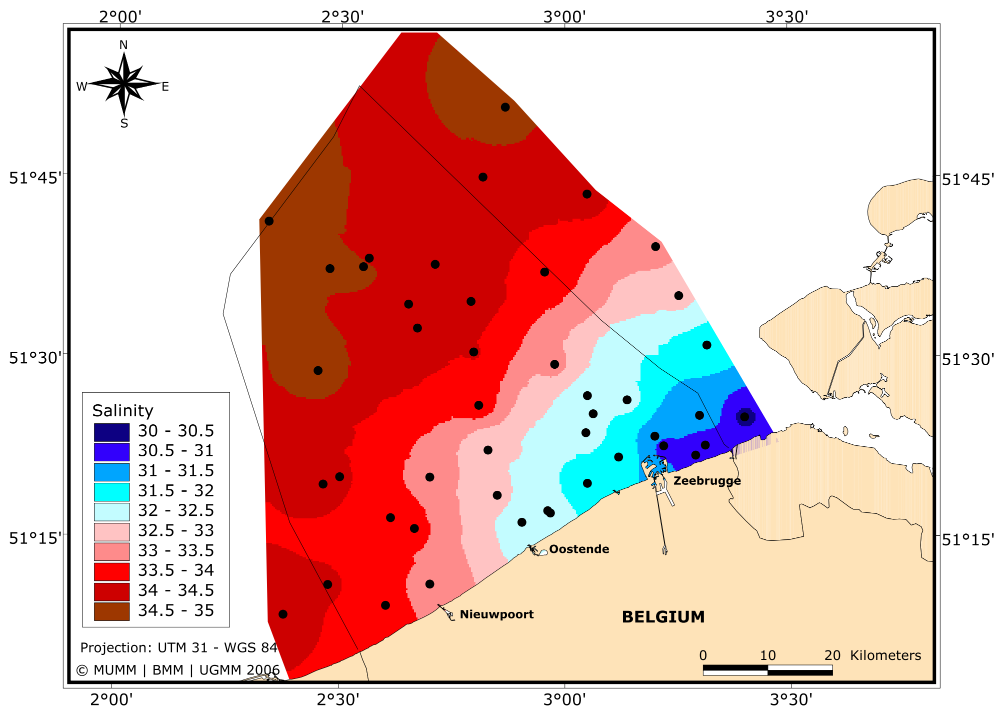

Figure 3: Long-term horizontal distribution of surface salinity obtained from averaging monitoring data over the period 1987-2005

The Comprehensive Procedure recommends subdivision of areas into “suitable assessment units”. The assessment of DIN, DIP, chlorophyll *a* concentrations and derived parameters such as eutrophication problem status (PA/PPA/NPA) is, therefore, made here for two delineated zones, the coastal zone and the offshore zone. The delineation of the coastal and the offshore area, to be assessed separately, is shown in figure 4 and based on results for salinity (34.5 PSU) of the model MIRO&CO-3D (Lacroix *et al.*, 2007) (mean 1993-2003). It presents a spatio-temporal integrated result on salinity distribution, also used by the Intersessional Correspondence Group -EMO of OSPAR for the eutrophication modelling purposes. The border between the coastal and the offshore area differs slightly from the isohaline 34.5 at the salinity map of Figure 3 where the isohaline is less accurately defined due to spatio-temporal sampling irregularity. The mean over the entire coastal area and the offshore area is given to make an overall classification for these two zones in the Belgian part of the North Sea.

The density of spatial sampling in Belgian coastal waters (Figure 4) allows a quasi-continuous representation (by interpolation) of measured parameters such as chlorophyll *a* concentration. Therefore, in addition, means are illustrated in a map for each station of the monitoring network independently, thus avoiding any loss of information from spatial binning of data, for DIN, DIP and chlorophyll *a*. This high spatial resolution also allows a better appreciation of the continuity of eutrophication effects with those reported by neighbouring countries. The spatial variability within the zone is generally found to be large scale suggesting that transboundary fluxes are important.

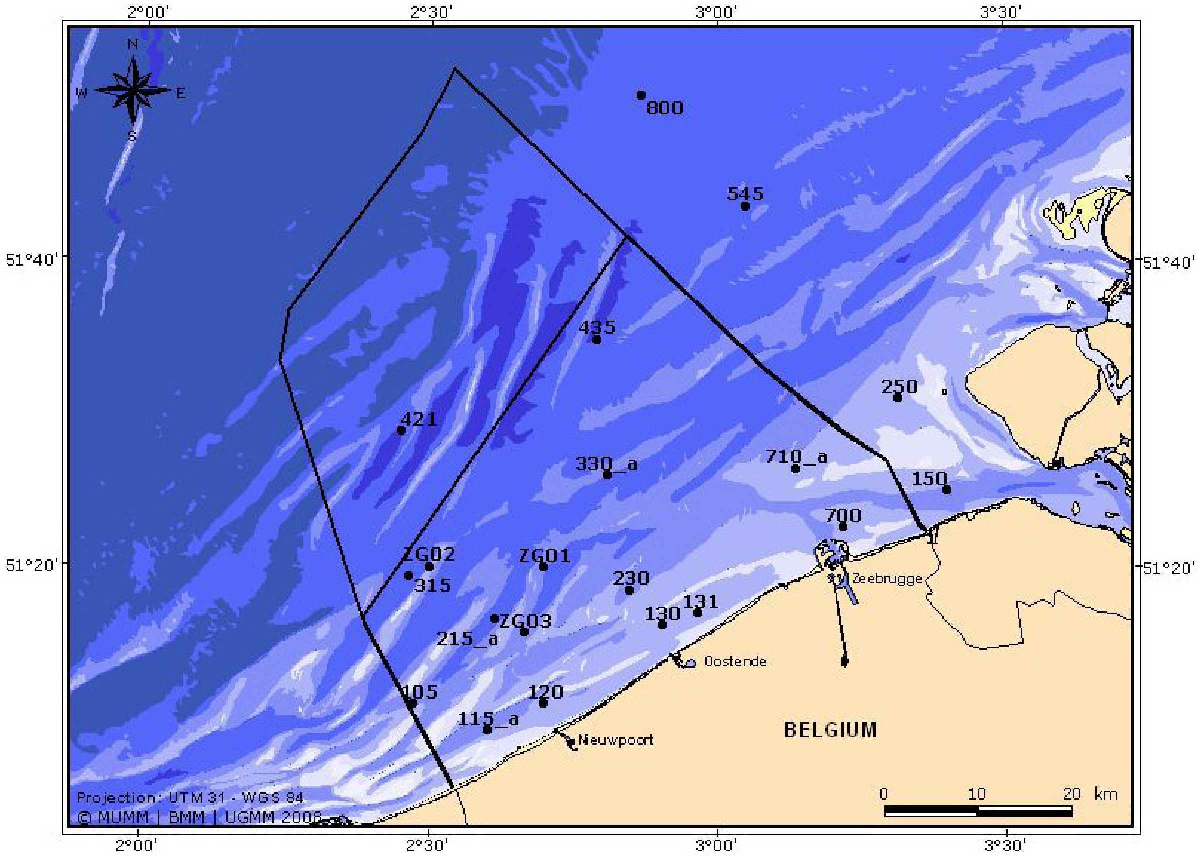

Figure 4: Delineation of the coastal and the offshore zone, based on the isohaline of 34.5 PSU derived from the model MIRO&CO-3D

4. Methods and data

4.1 Inventory of available data for the overall area assessed and sub-areas

For the second eutrophication status assessment of the Belgian part of the North Sea, riverine inputs and discharges, DIN, DIP, N/P ratio, chlorophyll *a* and oxygen concentrations are used as assessment parameters, because these were consistently monitored during the assessment period 2001-2005. The riverine total N and P inputs and direct discharges reported for Belgium are extracted from data reports on the Comprehensive Study of Riverine Inputs and Direct Discharges (RID). The quality element phytoplankton indicator species has not been routinely monitored. Based on limited scientific information, a consideration is made of their presence that is taken into account in the assessment on an overall qualitative basis for coastal waters, not on a quantitative basis due to lack of sufficient data. The same applies to the assessment parameter changes/kills in zoobenthos and fish. Kills in zoobenthos and fish are taken into account in the assessment on a general observational basis during fishery and benthos monitoring. In the future changes in zoobenthos biomass and species composition will be incorporated in the monitoring, especially in the light of other related European policies (WFD).

In the first place the direct effect parameter phytoplankton is monitored to evaluate eutrophication problems. Due to interference with other affecting parameters than eutrophication for the indirect effect parameters long-term changes in zoobenthos biomass and species composition, there is a need for high sampling density and long lasting benthos monitoring. This is difficult to achieve and not established yet, but sampling is performed for eutrophication research purposes on a project basis. Specific indices are under development, e.g. tested within the WFD, also in relation to eutrophication. Yearly monitoring for assessment purposes started in 2007 near the coast.

The assessment parameter organic carbon/organic matter is not used in the current assessment, because the available data were not fit for purpose for an overall assessment; the parameter is less relevant to a larger spatial extent on the sandbanks with strong hydrodynamics. Algal toxin information will be available in the future, due to the development of mussel aquaculture in the Belgian marine waters. Algal toxins are measured from 2006 onwards, but not yet measured in the period 2001-2005 and not used yet in the current assessment.

Macrophytes/macroalgae are not relevant in the Belgian marine waters and are therefore not assessed. Oxygen deficiency is also not considered as an important parameter, though measured values are given to illustrate that oxygen deficiency is not common or apparent.
Table 1 indicates which parameters have been taken into account for the assessment in coastal and offshore waters. In Table 2, the time period and frequency of sampling, the statistics and the background and elevated values for the assessment parameters are listed.

Table 1: Agreed harmonised assessment parameters (shaded) and additional voluntary parameters (*) applied and reported by Belgium in the second application of the Comprehensive Procedure.

Category	Parameter	BE	
		Coastal water	Offshore water
Cat. I	**Riverine inputs and direct discharges**	+	+
	Winter DIN and DIP concentrations	+	+
	N/P ratio	+	+
	*Total nitrogen, total phosphorus	-	-
	*Transboundary nutrient transport	+	+
	*Atmospheric nitrogen deposition	-	-
	*Silicate (and Si ratios)	-	-
Cat. II	**Chlorophyll *a***	+	+
	Phytoplankton indicator species	"+"	-
	Macrophytes including macroalgae	nr	nr
Cat. III	**Oxygen deficiency and lowered % saturation**	+	+
	Kills in fish and zoobenthos	"+"	-
	Long-term changes in zoobenthos biomass and species composition[1]	"+"	-
	Organic carbon	-	-
	*Secchi depth	-	-
Cat. IV	**Algal toxins**	-	-

(*) additional voluntary assessment parameters; (nr) – not relevant; (+) parameter included in the assessment, (-) parameter not included in the assessment, ("+") included in the assessment on a qualitative basis, not on a quantitative basis, from monitoring for other purposes or research projects

Table 2: The parameters of the holistic checklist with dimensions, time period of sampling, the background concentrations and elevated levels

Category	Assessment parameter	Time period and frequency	Statistic	Elevated values
Degree of nutrient enrichment (I)	Riverine total N and total P inputs and direct discharges (RID)		Annual total (kT/y)	Increased trend
	Winter DIN concentrations	Winter = Nov., Dec., Jan., Feb., DIN measured 2 times per winter	mean (reference salinity of 33.5) (µmol/l)	Background: CW 10 – Off 8 Elevated: CW 15 – Off 12
	Winter DIP concentrations	Winter = Nov., Dec., Jan., Feb., DIP measured 2 times per winter	mean (reference salinity of 33.5) (µmol/l)	Background: 0.6 Elevated: 0.8
	Increased winter N/P ratio (Redfield N/P = 16)	Winter = Nov., Dec., Jan., Feb., DIN/DIP measured 2 times per winter	Mean N / Mean P	Background: 16 Elevated: 24
Direct effects (II)	90^{th} percentile chlorophyll *a* concentration	Growing season: March – October	90^{th} percentile (µg/l)	Background: CW 10 – Off 5.6 Elevated: CW 15 – Off 8.4
	Mean chlorophyll *a* concentration	Growing season: March – October	Mean (µg/l)	Background: CW 5 – Off 2.8 Elevated: CW 7.5 – Off 4.2
	Region/area specific phytoplankton indicator species *Phaeocystis spp.*	Not included in monitoring 2001-2005 on a quantitative basis	Maximum number of cells/l	$>10^7$cells/l (>30days)
	Macrophytes/ macroalgae	Not relevant		
Indirect effects (III)	Degree of oxygen deficiency	Growing season: March - October	Mean (mg/l)	6 mg/l
	Changes/kills in zoobenthos and fish mortality	Not included in monitoring 2001-2005		
	Organic carbon/organic matter	Not included in monitoring 2001-2005		
Other possible effects (IV)	Algal toxins (DSP/PSP mussel infection events)	Not included in monitoring 2001-2005		

4.2 Calculation and quality of time series

In this section, a description is given of sampling and measurement procedures, available data, quality of the data, calculation method and the background/elevated values for the parameters used in the second assessment. Some of this information is also summarized in Table 1 and 2 and in Annex 1.

- **Sampling of nutrients and chlorophyll *a***

For dissolved inorganic nitrogen, dissolved inorganic phosphorus and chlorophyll *a* concentration, water samples are taken at 3 m depth with a Niskin bottle.

- **Dissolved inorganic nitrogen (DIN) measurements**

DIN is measured by MUMM's Chemistry Laboratory, using an autoanalyzer adaptation of the Wood *et al.* (1967) method of cadmium copper reduction to nitrite, followed by diazoreaction with sulfanilamide. For the period 2001-2005 a Technicon AA II and Skalar continuous flow system has been used. Samples are preserved at -20°C prior to analysis. Separation is achieved by filtration using membrane filters with 0.2 µm pore size. Quality control procedures include first line control (instrument calibration and performance), second line control (use of control charts for batches) and third line control (twice-yearly intercomparison within QUASIMEME). From 2005 the laboratory was accredited for analysis of this parameter as conforming with norms NBN and ISO/IEC 17025:2005.

- **Dissolved inorganic phosphorus (DIP) measurements**

DIP is measured by MUMM's Chemistry Laboratory, using an autoanalyzer adaptation of the Murphy and Riley (1962) method of production of a blue phosphomolybdene complex in the presence of ascorbic acid and antimony. For the period 2001-2005 a Technicon AA II and Skalar continuous flow system has been used. Samples are preserved at -20°C prior to analysis. Separation is achieved by filtration using membrane filters with 0.2 µm pore size. Quality control procedures include first line control (instrument calibration and performance), second line control (use of control charts for batches) and third line control (twice-yearly intercomparison within QUASIMEME). From 2005 the laboratory was accredited for analysis of this parameter as conforming with norms NBN and ISO/IEC 17025:2005.

- **Analysis of winter DIN-and/or DIP concentrations**

The Common Procedure guidance for "salinity gradient riverine influenced waters", sections 4.25 and 4.26 of (OSPAR 2005) are followed here. For the purposes of the current assessment "winter" is defined here as November, December, January and February with "winter 2001" denoting data from November 2000 until February 2001. A reference salinity of 33.5 is used, as in the Belgian First Assessment (Belgium 2002) and explained in its supporting scientific documentation (Rousseau *et al.* 2004).

Data for DIN and DIP were extracted from the data holdings of the Belgian Marine Data Centre (BMDC) for the period winter 2001 to winter 2005. Only quality-controlled data originating from MUMM's Chemistry Laboratory is included in the analysis. Geographically, data has been limited to the Belgian part of the North Sea; locations in neighbouring French and Dutch waters close to the maritime boundaries have been excluded from the analyses, but some values are shown in the figures.

For each winter, DIN and DIP data are plotted against salinity in the form of a mixing diagram. After elimination of a few obvious outlier data linear regressions are calculated for DIN and DIP against salinity for each winter. These mixing diagrams and regression analysis are presented for each year in

Annex 2 and Annex 3. The reference salinity of 33.5 (Belgium 2002; Rousseau *et al.* 2004) is used for determining the corresponding DIN and DIP concentrations that are compared with the Belgian OSPAR elevated thresholds of 15.0 µmol/l for DIN for coastal waters and 12.0 µmol/l for DIN for offshore waters, and 0.8 µmol/l for DIP for both areas.
The Comprehensive Procedure identifies "elevated levels" for winter nutrients as an area-specific % deviation, not exceeding 50%, from "background" levels. The background levels themselves cannot easily be objectively defined. For nutrients and chlorophyll *a* of Belgian coastal and offshore waters they have been examined and redefined, based on observed and modeled relationships that made a reconsideration of the correctness of the used assessment thresholds in coastal waters and a necessary adaptation in offshore waters possible. The background levels for DIN and DIP in Belgian coastal waters are taken as 10.0 µmol/l and 0.6 µmol/l respectively, based on an analysis of monitoring data available (for the whole OSPAR area) in the ICES database and based on results from coastal ecosystem models coupled with river basin models to simulate historical "pristine" conditions prior to the significant increase in anthropogenic nutrient inputs, which is thought to have occurred in the 1960s. Such models are starting to emerge (Lancelot *et al.*, 2007a) and may provide valuable information for further development of the OSPAR concept of "background" levels. Corresponding elevated levels for DIN and DIP in Belgian coastal waters are set at 15 µmol/l and 0.8 µmol/l respectively. These background and elevated levels are identical to those used in the First National Assessment. An extended explanation on the choice of these nutrient background and elevated levels is provided in Annex 1.

- **Increased winter N/P ratio**

The reference DIN and DIP concentrations are normalised to a salinity of 33.5 and are used to calculate the ratio of winter DIN:DIP for each year separately. The background level for the DIN:DIP ratio is specified as 16 (Belgium 2002; OSPAR 2005) according to the Redfield ratio for phytoplankton stoichiometery (Redfield *et al.* 1963) and the elevated level is chosen as 50% above the background value, i.e. 24.

- **Chlorophyll *a* concentration measurements**

Chlorophyll *a* concentration is measured by MUMM's Chemistry Laboratory as detailed in Steendijk and Schreurs (2002), based on the High Performance Liquid Chromatography method (HPLC). Water samples are filtered on-board with GF/C filters, and are then frozen in liquid nitrogen and stored long-term at –80°C. Pigments are extracted in 90% acetone with the use of a cell-homogenizer, followed by centrifugation. The chlorophyll pigments are separated with reversed phase HPLC. Quality control procedures include first line control (instrument calibration and performance), second line control (use of control charts for batches) and third line control (twice-yearly intercomparison within QUASIMEME). From 2005 the laboratory was accredited for analysis of this parameter as conforming to norms NBN and ISO/IEC 17025:2005.

- **Analysis of maximum and mean chlorophyll *a* concentration**

Since the First National Assessment methodological problems have been identified with the use of maximum chlorophyll *a* concentration as an assessment parameter. As noted in (OSPAR 2005) "phytoplankton chlorophyll *a* exhibits periodicity and episodic change and, as a result, tends to be asymmetrically distributed with few high values (outliers or spikes) and many low values." In the case of the Belgian waters (Belgium 2004) the maximum chlorophyll *a* concentration recorded was found to be highly dependent on the sampling frequency and the monitoring data, which gives at best one value per week at a given location, and which was found to be insufficient to estimate adequately this maximum. The approach adopted here, in accordance with section 4.37 of (OSPAR 2005) is thus to use the 90th percentile value instead of the maximum value. This approach is similar to that adopted by France for the First Assessment (except that 95% was used there) and assessed for Belgian data in a study of spatial and temporal sampling and data processing, "Method 2" of (Belgium 2004), and brings the OSPAR assessment into alignment with the approach adopted for the WFD.

Data was retrieved from the IDOD database for the years 2001-2005 for the growing season, defined here as the months from March to October inclusive. Only quality-controlled data originating from MUMM's Chemistry Laboratory is included in the analysis. It was verified that the period of the spring phytoplankton bloom was indeed covered for each year. Data for all growing seasons in the period 2001-2005 is analysed together to ensure that a representative dataset is used: splitting of data into individual years is not reliable for this parameter and cannot be used for assessment of trends because of the large uncertainty that would then be generated by the relative timing of monitoring and phytoplankton blooms (problem of undersampling in time). Monitoring locations within 1 km of each other are binned together spatially. Only locations with at least 5 measurements for the period are included in the analysis.

In the First Assessment a threshold concentration of 15 µg/l was applied to the maximum chlorophyll *a* concentration recorded during the "spring bloom" monitoring cruise of each year. In this Second Assessment this threshold is applied as threshold concentration for the 90th percentile for all growing seasons 2001-2005 together. Annex 1 provides an extended explanation on the choice of the background and elevated level.

- **Dissolved oxygen**

Dissolved oxygen is measured in situ at a depth of 3 m by MUMM's Chemistry Laboratory using a portable YSI 52 or 57 oxymeter.

- **Data availability**

Data for DIN, DIP, chlorophyll *a* and dissolved oxygen, used for the eutrophication assessment, are stored in the data holdings of the Belgian Marine Data Centre (BMDC). Data can be retrieved from the database following the instructions outlined at http://www.mumm.ac.be/datacentre/index.php.

5. Eutrophication assessment

This chapter consists of an assessment procedure to evaluate the eutrophication status, of which the first part is "step 1" of the Comprehensive Procedure (OSPAR 2005), which is itself divided into four sections entitled:

Category I – degree of nutrient enrichment (causative factors)
Category II – direct effects of nutrient enrichment
Category III – indirect effects of nutrient enrichment
Category IV – other possible effects of nutrient enrichment

Next, "step 2" of the Comprehensive Procedure, gives an integration of categorised assessment parameters for initial area classification based primarily on a table of "scores" for each assessment category. Finally, "step 3", an appraisal is made of the information presented in steps 1 and 2 in order to achieve an overall area classification, justified by (OSPAR 2005) "a sound and transparent account of the reasons for giving a particular status to the area".

5.1 Parameter-related assessment based on background concentrations/levels and assessment levels

5.1.1 Category I Assessment – degree of nutrient enrichment

5.1.1.1 Riverine inputs and direct discharges of total N and total P

Coastal waters

There are no direct discharges to Belgian convention waters since 1996 and, therefore, only the riverine inputs are included in Table 3 and are extracted from data reports on the Comprehensive Study on Riverine Inputs and Direct Discharges (RID). Over the decade 1996-2005 nitrogen inputs have decreased with about 21% and phosphorus inputs with about 40%. The RID data show that N values are decreasing with 0,9 kton per year in the period 1996-2005.

Table 3: Riverine inputs of total N and total P in kT/y into Belgian marine waters

	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
N	53	44	65	43	57	46	68*	44	43	42
P	5.2	6.4	5.2	3.8	5.3	2.8	8.2*	4.0	3.7	3.1

*The riverine inputs of 2002 are higher than in the other years, due to heavy rainfall in this year.

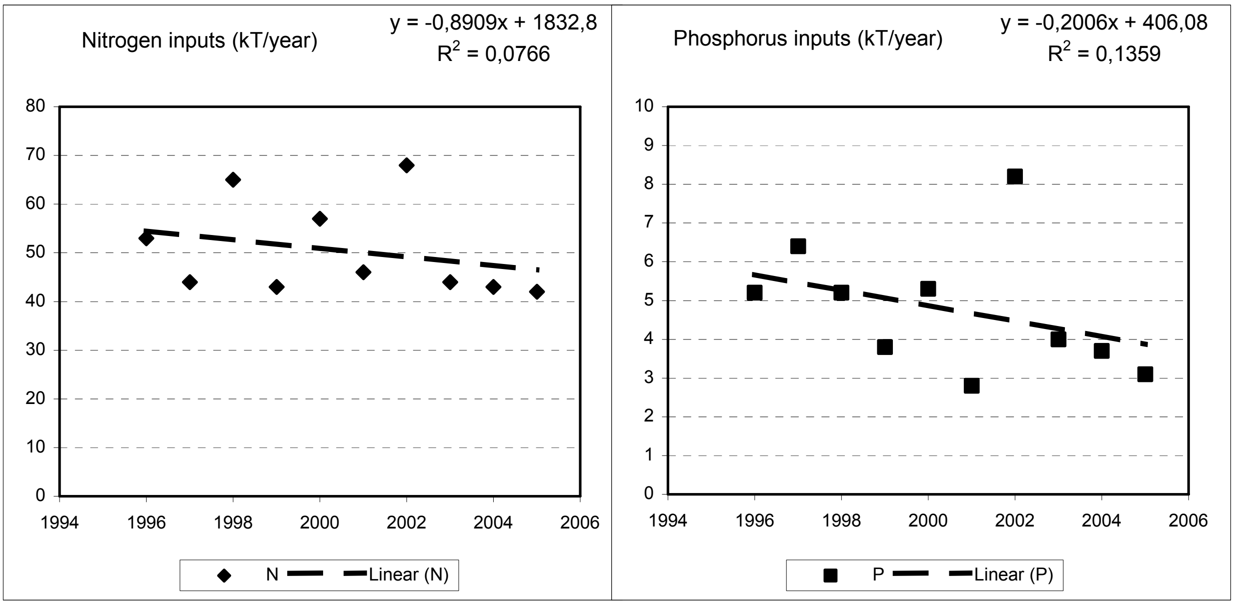

Figure 5: Riverine inputs of total N and total P in kT/y into Belgian marine waters

In the PARCOM Recommendation 88-2 reporting, based on data of 2005 following a source-oriented approach, the N and P losses are estimated to have reduced significantly with 34 % and 61 %, respectively, in comparison to 1985. For N this decrease corresponds to 1,7 kton/year over the period 1985-2005. The calculated N losses are estimated to be about 30 % higher than the estimated riverine inputs of the RID data, but the reduction estimated for N losses is about 50 % higher compared to the reduction estimated for N riverine inputs. The major reduction in N losses took place between 1995 and 2005 when N losses reduced from 85.724 ton/year to 61.532 ton/year. The major reduction in P losses took place between 1985 and 1995 from 17.458 ton/year to 10.261 ton/year, corresponding to a reduction of 0,72 ton/year. The further reduction from 0,3 kton/year from 1995 until 2005 can be considered comparable to the 0,2 kton/year estimated for riverine P inputs for the period 1996-2005.

In this assessment, the RID parameter is included in the assessment, which was not the case in the first application of the Common procedure. No information on seasonal variation is available yet. Since no increasing trend is observed in comparison with the previous years and a decrease of 21 % for N and 40 % for P is observed over a ten-year period, this parameter has been evaluated as absence of increased trends. However, a comparison of the current riverine inputs with background loads or reference conditions has not been possible.

The reported riverine inputs of total N and total P into the Belgian waters are based on inputs from mainly the Scheldt estuary and other small Belgian rivers. However, the hydrodynamical model, developed by Lacroix *et al*. (2004), shows that the influence on the Belgian water composition is not only determined by the mixture of Channel water and the Scheldt, but is more complex, because the Seine-Somme and Rhine-Meuse have also their influence, sometimes stronger than the Scheldt (Figure 6). Figure 6 shows the fraction of water originating from the Rhine/Meuse or Scheldt along the Belgian coast. The Seine has mainly an influence on the offshore waters. Therefore, it is crucial to know the relative contribution of each river on the nutrient concentration of the Belgian part of the North Sea, which has been investigated in Lacroix *et al*. (2007). The main conclusion is that a reduction in N and P of the channel input is the most important factor for an improvement of the offshore waters and that concerning the riverine inputs, most effect is expected from the Seine river in offshore waters and from the Scheldt for the Belgian coastal area.

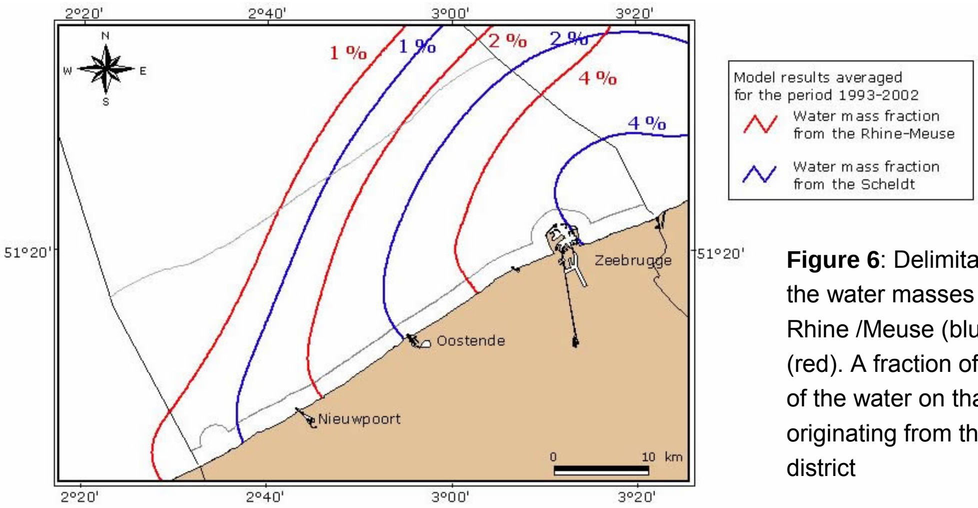

Figure 6: Delimitation of the fraction of the water masses originating from the Rhine /Meuse (blue) and the Scheldt (red). A fraction of 1% means that 1% of the water on that specific location is originating from the respective river district

5.1.1.2 Winter nutrient (DIN and/or DIP) concentrations

Coastal waters

The key assessment parameters for this region are the winter-time total dissolved inorganic nitrogen (DIN=NO_3+NO_2+NH_4) and ortho-PO4 (DIP). Dissolved silicate (SiO_4) is also monitored but is not reported here since it is not a significant causative factor for eutrophication in this region.

The reference salinity of 33.5 (Belgium 2002; Rousseau *et al.* 2004) out of the regression (Annex 2 and 3) is used for determining the DIN and DIP concentrations that are compared with the Belgian OSPAR elevated thresholds of 15.0 µmol/l for DIN and 0.8 µmol/l for DIP. These data are presented in

Figure 7 and Figure 8. In all the years the elevated level is exceeded for DIN, whereas for DIP in three of the five years. Hence, the averaged result for coastal waters is identical to the "per year" result for DIN, but not for DIP, for which 60% of the years exceeds the threshold. The OSPAR threshold for DIN and DIP is exceeded for the waters within about 20 km of the coast for the period 2001-2005 (Figure 9 and Figure 10), but for DIP with the exception of the water at the Belgian-French maritime boundary, where DIP is just below the OSPAR threshold.

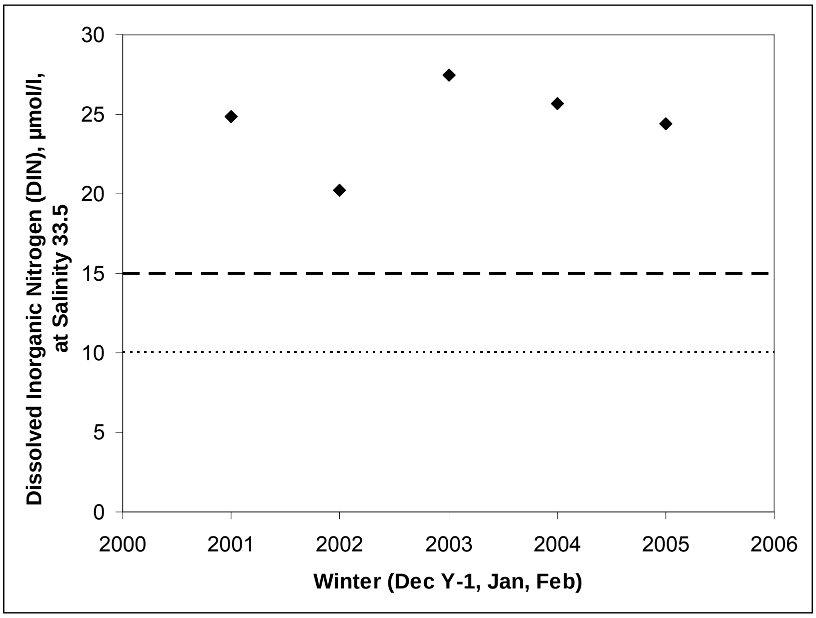

Figure 7: Dissolved inorganic nitrogen (DIN) normalised to a reference salinity of 33.5 for the winters 2001-2005 as deduced from salinity-DIN mixing diagrams (data: diamonds). The Belgian OSPAR background and elevated concentrations are given as dotted and dashed lines.

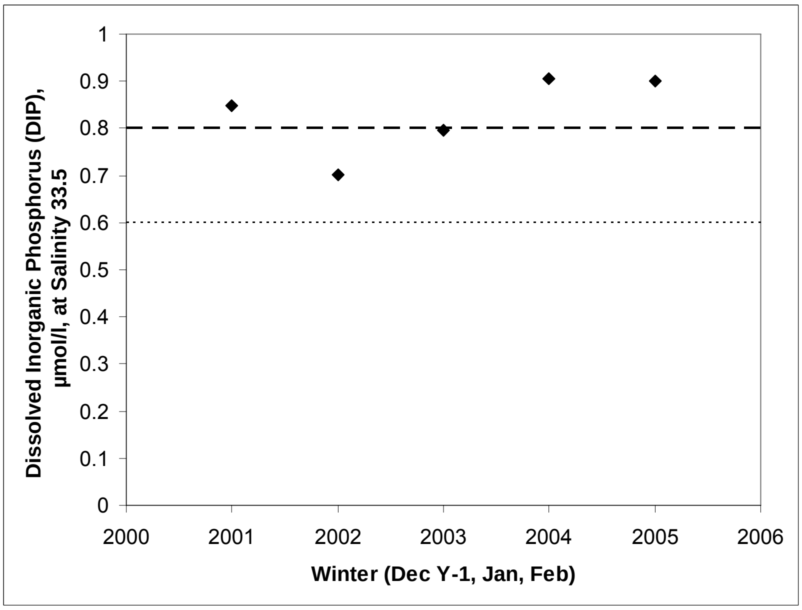

Figure 8: Dissolved inorganic phosphorus (DIP) normalised to a reference salinity of 33.5 for the winters 2001-2005 as deduced from salinity-DIP mixing diagrams. The Belgian OSPAR background and elevated concentrations are given as dotted and dashed lines.

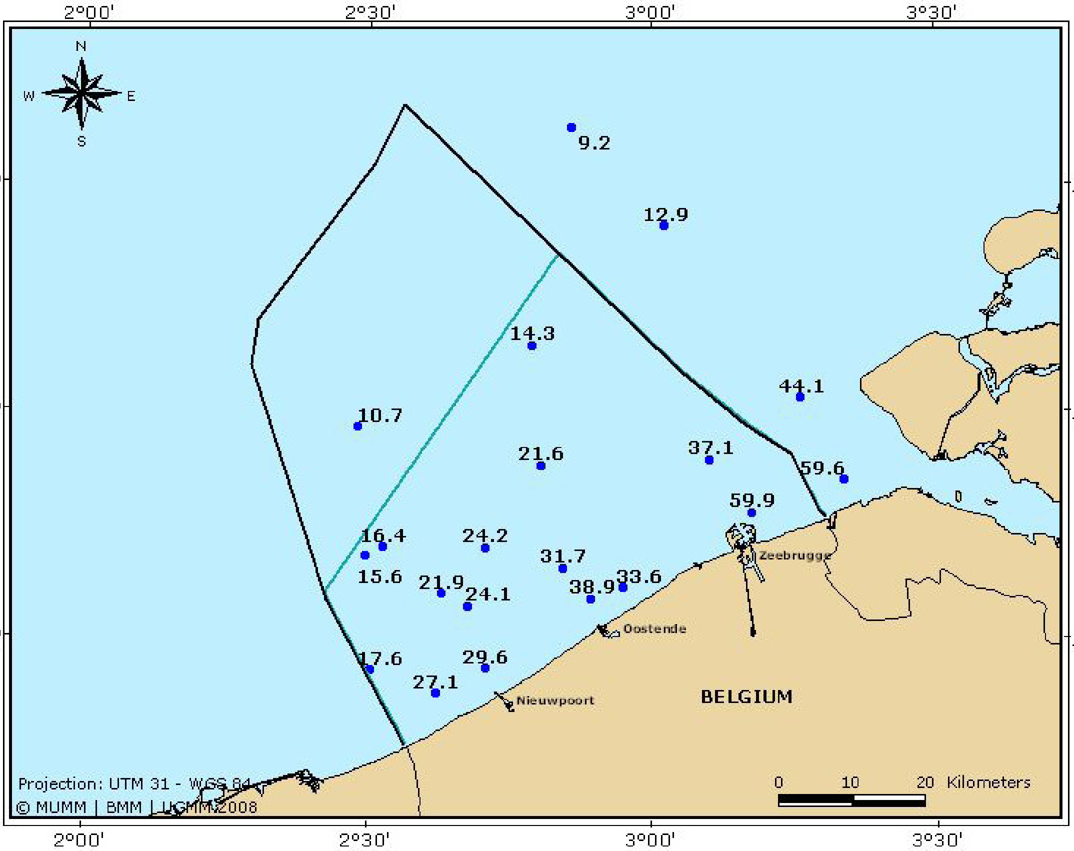

Figure 9: Mean of all winter DIN concentrations per station for the winter periods 2001-2005

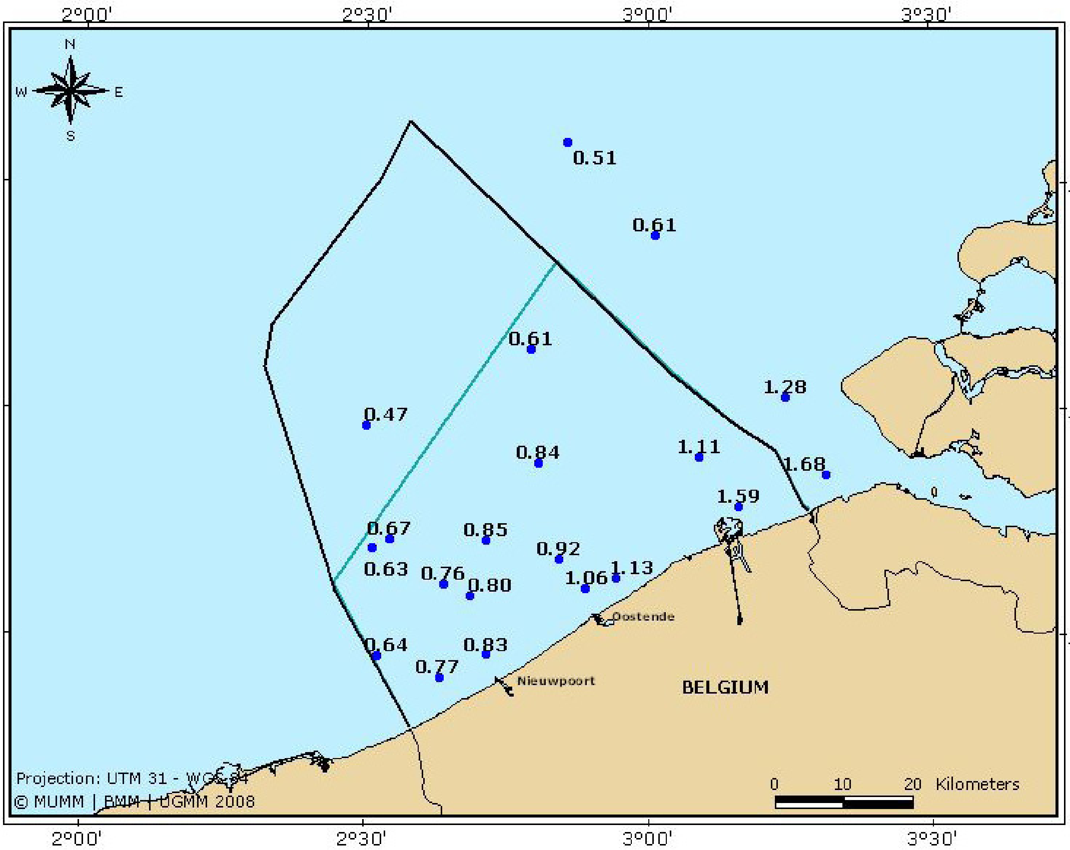

Figure 10: Mean of all winter DIP concentrations per station for the winter periods 2001-2005

The horizontal variability of surface DIN and DIP is presented as surface maps in Figure 9 and Figure 10. Here, for each location the mean is calculated for all winter months in the period 2001-2005 with values presented only for stations where at least 3 measurements were available over this period. These figures show a clear correlation with the long-term salinity distribution shown in Figure 3 and the average winter DIN and DIP distributions. This correlation and the related correlation evident from the salinity nutrient mixing diagrams of Annex 2 and Annex 3 indicates that the main source of DIN and DIP for the coastal waters is fresh water from the continental coastal rivers.

No long term trend is apparent from the data of Figure 7 and Figure 8 and similar data from Belgium (2002). DIN data for the period 2001-2005 has a similar range to the previously analysed data going back to 1974. DIP data for the period 2001-2005 has a similar range to the previously analysed data going back to 1995, but is generally lower than data previous to 1995 as already noted in point 5.1.1.1 of this report and in Belgium (2002) and Rousseau *et al.* (2004).

Offshore waters

For the offshore waters data are available only for one station from 8 sampling campaigns, one or two sampling campaigns per winter equally spread over early and late winter. For none of the years in the period 2001-2005, the threshold for DIP is exceeded. The mean over the whole period for DIN is 10,73 µmol/l and for DIP 0,47 µmol/l (Figure 9 and Figure 10). Both means are below the elevated threshold values 12 µmol/l for DIN and 0,8 µmol/l for DIP, respectively. The averaged result is identical to the "per year" result for DIP, but not for DIN, for which the threshold was exceeded in two of the five winters. For the winter 2001-2002 and winter 2002-2003 the DIN concentration was 14,2 and 12.7 µmol/l respectively. As an overall result, no significant nutrient enrichment of DIN or DIP has been observed in the offshore waters for the period 2001-2005.

5.1.1.3 Winter N/P ratio

Coastal waters

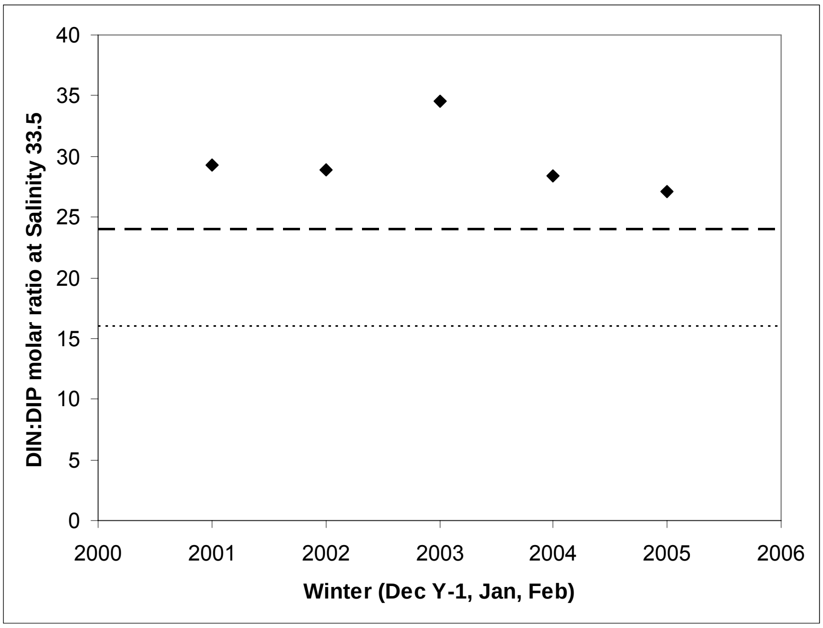

Figure 11: Ratio of DIN:DIP deduced from the mixing diagram regressions for a reference salinity of 33.5 for the winters 2001-2005. The OSPAR background and elevated concentrations are given as dotted and dashed lines

The background level for the DIN:DIP ratio is specified as 16 (Belgium 2002; OSPAR 2005) according to the Redfield ratio for phytoplankton stoichiometery (Redfield *et al.* 1963) and the elevated level is chosen as 50% above the background value, i.e. 24. As in the First Assessment for Belgian waters, the threshold DIN:DIP molar ratio is exceeded for the reference salinity of 33.5 in all assessment years in the coastal waters.

Offshore waters

For none of the years in the period 2001-2005, the threshold DIN:DIP molar ratio is exceeded at the offshore station, based on one or two sampling campaigns per winter equally spread over early and late winter. The averaged result is identical to the "per year" result.

5.1.2 Category II Assessment – direct effects of nutrient enrichment

5.1.2.1 Maximum and mean chlorophyll *a* concentration

Coastal waters

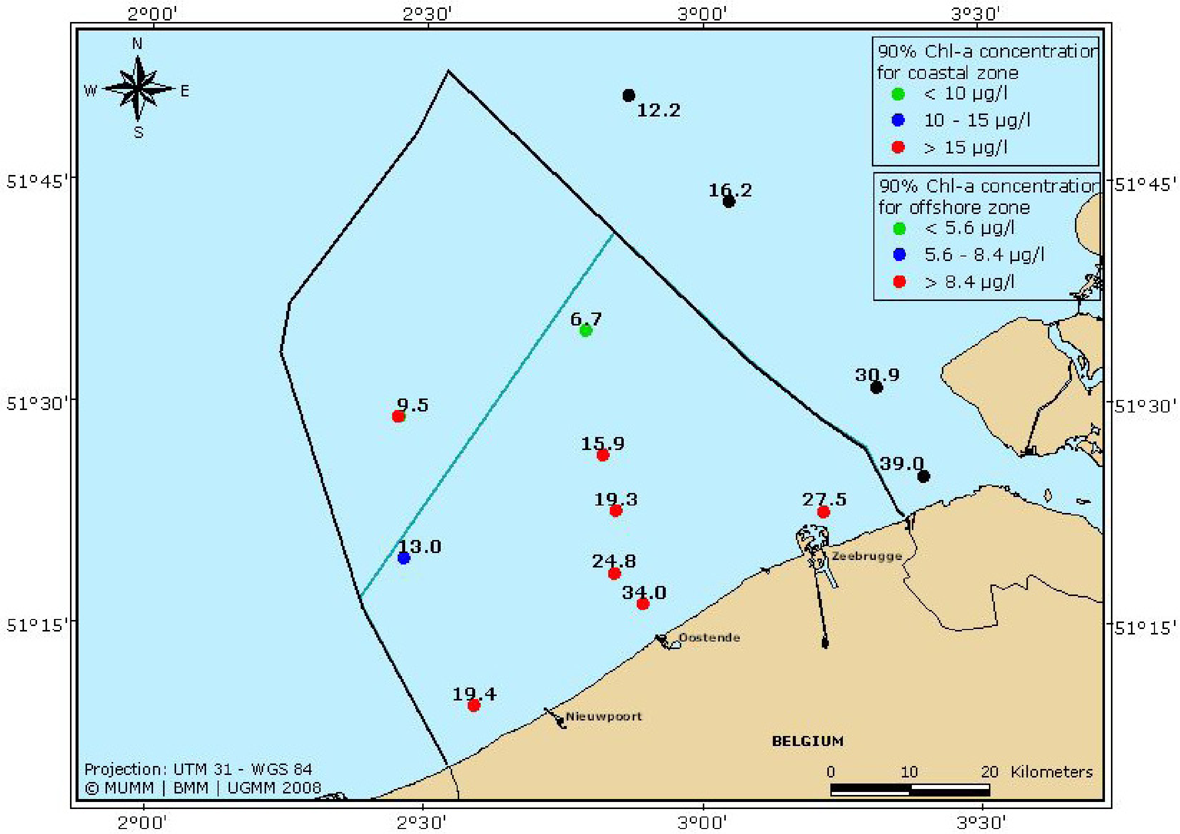

Figure 12: 90th percentile of chlorophyll *a* concentration per station for the growing seasons 2001-2005

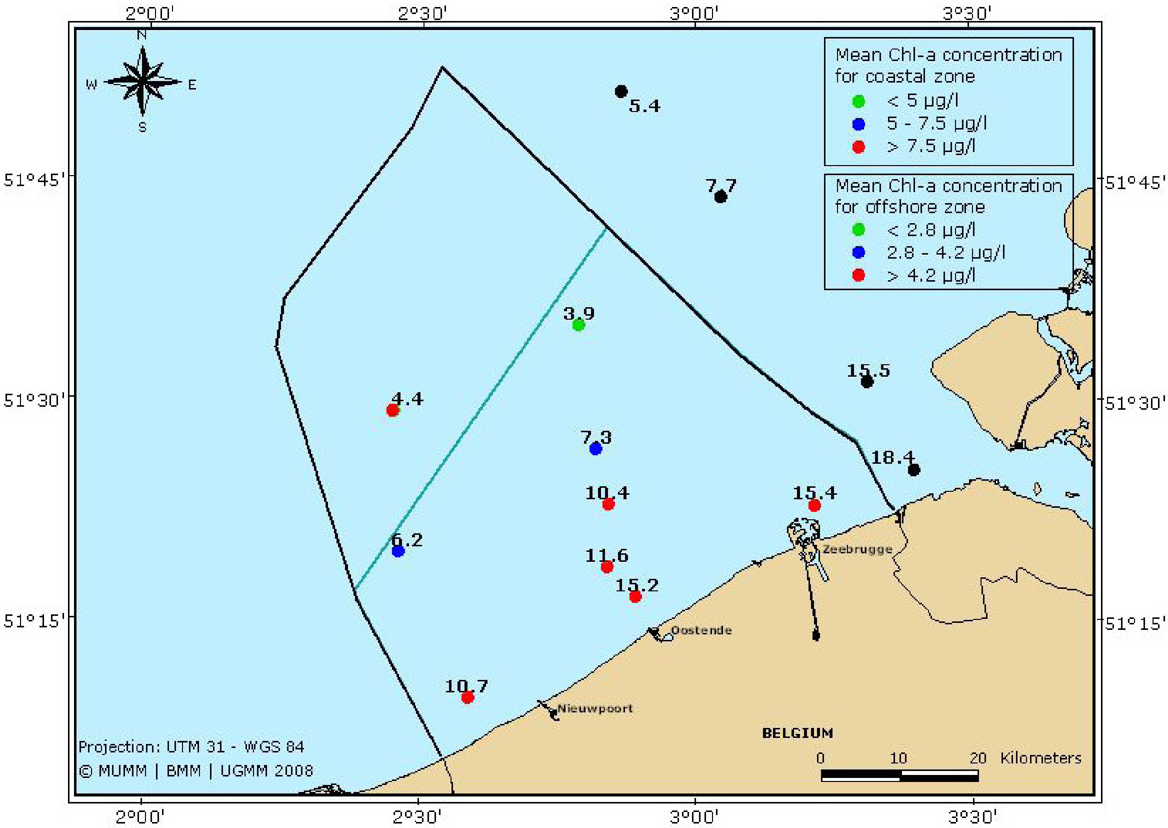

Figure 13: Mean chlorophyll *a* concentration per station for the growing seasons 2001-2005

The results for the 90th percentile and mean chlorophyll *a* concentrations are shown in Figure 12 and Figure 13 respectively. In the First Assessment an elevated threshold concentration of 15 µg/l was applied to the maximum chlorophyll *a* concentration recorded during the “spring bloom” monitoring cruise of each year. In this Second Assessment the same threshold is applied, but to the 90th percentile for all growing seasons 2001-2005 together. The elevated threshold used for the mean chlorophyll *a* concentration is 7.5 µg/l. Figure 12 and Figure 13 show the spatial extent at sampling station detail for which the thresholds are exceeded for the 90th % or the mean chlorophyll *a* concentration for the period 2001-2005. Except for one station, the figures show exactly the same situation and indicate that thresholds are exceeded for the Belgian waters within about 20 km (near Nieuwpoort) to 30 km (near Belgian-Dutch maritime border) of the coastal waters.

Offshore waters

The results for Chlorophyll *a* 90% concentration show that the averaged result exceeds the threshold value of 8,4 µg/l. The same applies to the mean chlorophyll *a* concentration exceeding the threshold value of 4,2 µg/l. However, this result is preliminary, as it was not based on sufficient spatial extent of the monitoring over the entire offshore zone.

5.1.2.2 Phytoplankton indicator species

Coastal waters

Phytoplankton indicator species have not been measured in Belgian waters as part of the standard monitoring programme until 2006. Of the phytoplankton indicator species listed in Annex 3a of (OSPAR 2005) *Phaeocystis* spp. and *Noctiluca scintillans* occur regularly in the Belgian marine waters and especially *Phaeocystis* spp. cause massive blooms every spring (Lancelot *et al*., 2007b). Cell counts for *Phaeocystis* spp. and *Noctiluca scintillans* were not available for the assessment period 2001-2005 at the monitoring stations in order to evaluate if *Phaeocystis* spp. reaches the elevated levels (> 10^7 cells/l during more than 30 days). Based on model simulations, this threshold is exceeded for parts of the Belgian marine waters (Lacroix *et al*., 2007). This is also confirmed by single scientific surveys in 2003 and 2004, which reveals that *Phaeocystis* spp. and also *Noctiluca scintillans* do occur in elevated levels in the Belgian part of the North Sea (AMORE project data; Lancelot *et al*. 2007). Based on this scattered information it can be concluded that *Phaeocystis spp.* is still a problem in the Belgian coastal waters for the period 2001-2005, but monitoring data on the spatial extent and the extent to the offshore waters is not available. The success of this non-siliceous phytoplankton species (*Phaeocystis*) results in both its ability to use anthropogenic nitrate in P-regenerated conditions (Rousseau, 2000) and its “resistance” to grazing (Gasparini *et al*., 2000). Most of the adverse impacts of *Phaeocystis* colony blooms in the Southern Bight of the North Sea concern biological resources, the fishing industry and tourism, which are of obvious socio-economical interest in the area. The effects have been reported as deposits of floam on the beaches or as clogging of the fishing nets as a consequence of huge accumulation of ungrazed gelatinous *Phaeocystis* colonies. Reports of these damage are however mostly anecdotal and the loss for tourism and fishing industry of the region is not established. These blooms are not directly detrimental to human health as other toxic blooming algae.

In this assessment, the Phytoplankton indicator species parameter is considered in the assessment, although a sufficient amount of quantitative data is not available. The presence of obvious massive *Phaeocystis* blooms is considered as an existing significant direct effect of eutrophication in the Belgian coastal waters.

Offshore waters

No data are available to identify the extent of the *Phaeocystis* blooms until the offshore waters. Therefore this parameter is considered to remain inconclusive for the offshore waters.

5.1.2.3 Macrophytes including macroalgae

Monitoring this indicator is not relevant for the Belgian part of the North Sea, since in Belgium, the main marine bottom substrates consist of soft sediments (sand, silt). Macroalgal mats occur only very rarely in the Belgian coastal waters. Macroalgae predominantly occur on hard artificial substrates, such as groynes and harbour walls. These hard substrates are in most cases very exposed to wave action, and the most common species of macroalgae on them are brown seaweeds (fucoid algae) and the green seaweeds *Ulva lactuca* and *Enteromorpha* spp. A red algae zone hardly exists due to the turbidity of the water. Introduced species such as wakame *Undaria pinnatifida* and the japweed *Sargassum muticum* occur mainly within harbours. Also in harbours some introduced red algae occur. Because they are unimportant for the coastal and offshore waters this quality element is not taken into account for the assessment and considered as not relevant.

5.1.3 Category III Assessment – indirect effects of nutrient enrichment

5.1.3.1 Oxygen deficiency

Oxygen deficiency problems in the sediment are not observed, but can occur very locally and shortly in accumulation zones of decaying organic matter. Most of the organic matter derived from ungrazed colonies is remineralized in the water column by intense bacterial activity (Rousseau *et al.*, 2000). Although this could create locally some transient oxygen depletion, no serious oxygen problems have been reported in Belgian coastal and offshore waters. Mean values have never dropped below the threshold value of 6 mg of O2/l over the last decade (Table 4). The prevailing hydrodynamic conditions (strong tide and wind mixing) ensure continuous oxygen replenishment.

Table 4: Mean values of dissolved oxygen for all the stations in the Belgian part of the North Sea between 1996 and 2005 (3 m depth).

	1996	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**
Mean (mg/l)	9,49	9,74	9,86	10,20	9,62	9,89	9,56	9,85	9,56	10,30

5.1.3.2 Changes / kills in zoobenthos and fish

Kills of zoobenthos and fish due to eutrophication (oxygen deficiency) or toxic algae are not reported in the Belgian marine waters.

The impact of eutrophication on changes in zoobenthos has not been investigated in the monitoring programme up to 2006. Based on different scientific research projects, it became clear that the benthos shows a gradient in the Belgian part of the North Sea, related to the eutrophication gradient. For example, the macrobenthic *Abra alba* community shows an impoverishing gradient from the southwest to the northeast (Van Hoey *et al*., 2005). The northeast of the Belgian coast is the area with the largest eutrophication problems, due to the influence of the Scheldt and Rhine/Meuse plumes. Locally, organic enrichment, due to the break-down of the *Phaeocystis* blooms, has an effect on the density and diversity of the benthos (Van Hoey, 2000; Vincx *et al*., 2002; Vanaverbeke, 2003; Bonne, 2003). During the phytoplankton bloom in spring opportunistic benthic species are observed to take advantage of the enrichment in organic matter at the bottom, to a large extent originating from decaying *Phaeocystis* colonies, which changes the community composition. Based on this, it can be concluded that eutrophication can have an indirect effect on the benthos of the Belgian part of the North Sea, but this is not quantitatively measured in the period 2001-2005 and will be included in the context of the WFD monitoring programme.

Preliminary results on the impact of eutrophication have been achieved testing the BEQI (Benthic Ecosystem Quality Index) on a temporal dataset (1995-2003) at a slightly organically enriched station in the Belgian coastal waters for the Water Framework Directive assessment. The BEQI evaluates the benthic status on habitat/water body level (by directly pooling the samples). Only the third level of the BEQI method is applied in this case to evaluate density, species richness and community composition in relation to organic enrichment/eutrophication. The parameter biomass could not be included due to lack of sufficient data. This analysis delivers 22 assessment cases (based on 200 samples) where each assessment contains a series of samples in one season. With the current method, the status of the macrobenthos is classified as good and moderate in the years 2002-2003 (Figure 14 and 15). If this deviation is attributed to eutrophication only is not clear, since the multipressure set-up of the BEQI detects the impact of a combination of pressures on the benthos, not only eutrophication or enrichment with organic matter or specific substances, but also physical disturbances or impacts of invasive species. Also, the amount of reference data used within the BEQI is still very limited and not ideal yet. This has an influence on the reliable estimation of the natural reference situation and the derived statistical boundaries. Further elaboration of the reference dataset and improvement of the method is necessary. However, this cannot be done on the very short time and will be performed as part of the monitoring.

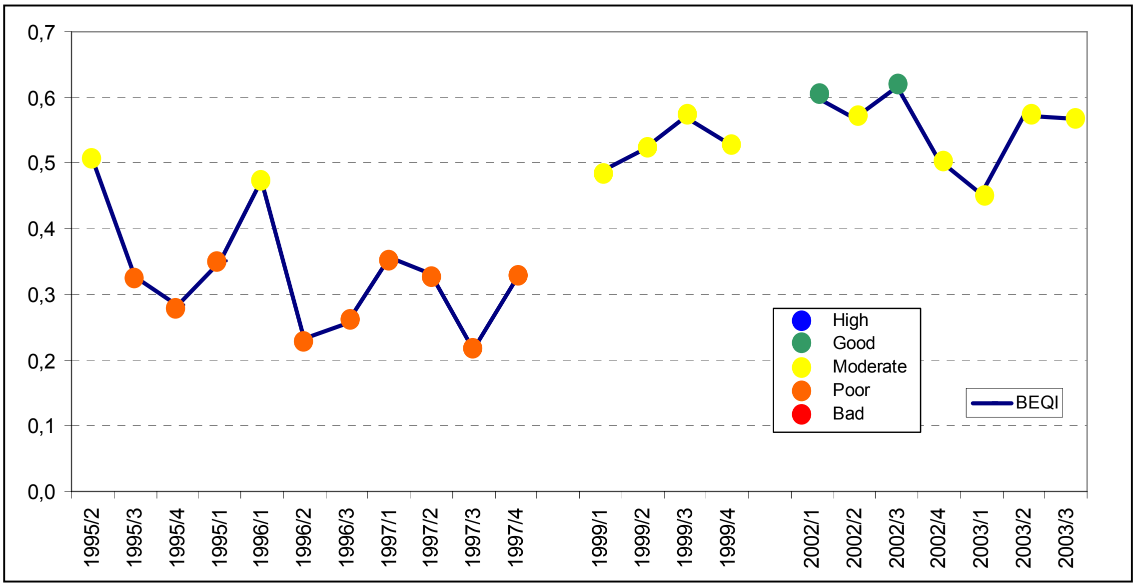

Figure 14: Overall result for the BEQI for 22 assessments of one site that is subject to some organic enrichment in the Belgian coastal waters. One assessment is a cluster of a series of samples per season (indicated by number 1 to 4). The X-axis represents a time series and the Y-axis gives a value from 0 to 1 as the EQR value (Ecological Quality Ratio with the value 1 reflecting a status similar to the reference situation, the lower the value, the worse the situation)

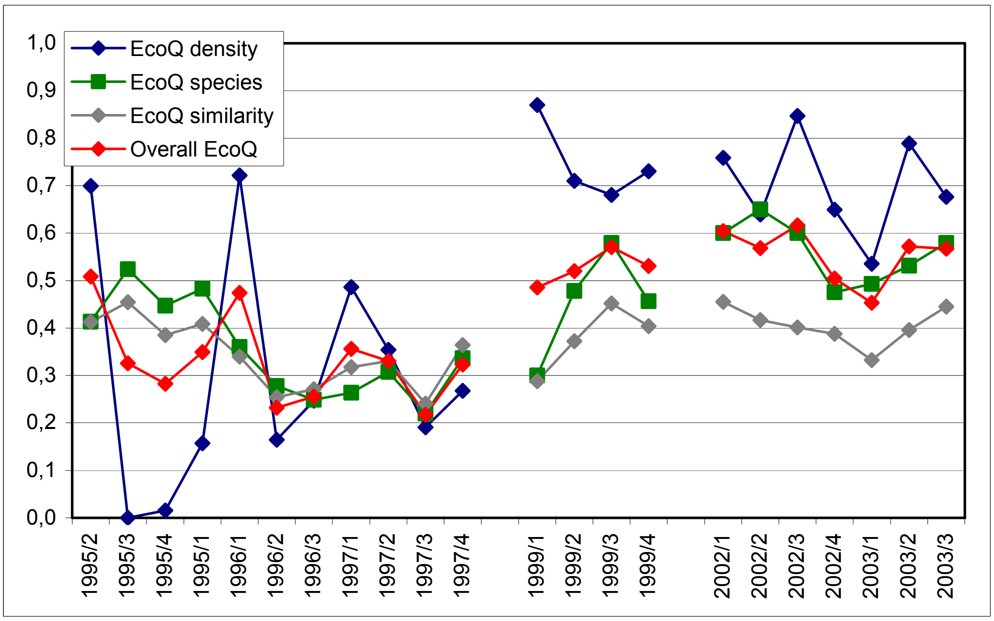

Figure 15: Results for the 3 sub-indices (density, species richness and community similarity) of the BEQI for 22 assessments of one site that is subject to some organic enrichment in the Belgian coastal waters. One assessment is a cluster of a series of samples per season (indicated by number 1 to 4). The X-axis represents a time series and the Y-axis gives a value from 0 to 1 as the EQR value (Ecological Quality Ratio with the value 1 reflecting a status similar to the reference situation, the lower the value, the worse the situation)

5.1.3.3 Organic carbon/organic matter

Organic carbon/organic matter is not included as an assessment parameter for the Belgian marine waters because the available data is not fit for purpose in this assessment.

5.1.4 Category IV Assessment – other possible effects of nutrient enrichment

5.1.4.1 Algal toxins

Among the toxin producing species, only *Dinophysis* spp. and *Prorocentrum* spp. have already been reported in the Belgian part of the North Sea, but no cell count information is available during the assessment period. Algal toxins have not been coherently monitored in the Belgian marine waters in the period 2001-2005 because of the absence of shellfish harvesting for human consumption. However, temporally monitoring for algal toxins has started in 2006 because of the development of mussel aquaculture in Belgian waters. The first analyses show that no DSP/PSP toxin producing species exceed the threshold in that year.

5.2 Consideration of supporting environmental factors and quality of data

The identification of long-term trends in the 90th percentile and mean chlorophyll *a* concentration data, which might be related to nutrient reduction measures, is hampered by two factors that are explained in the section 8.2 on improvement of the assessment.

5.3 Initial and overall assessment

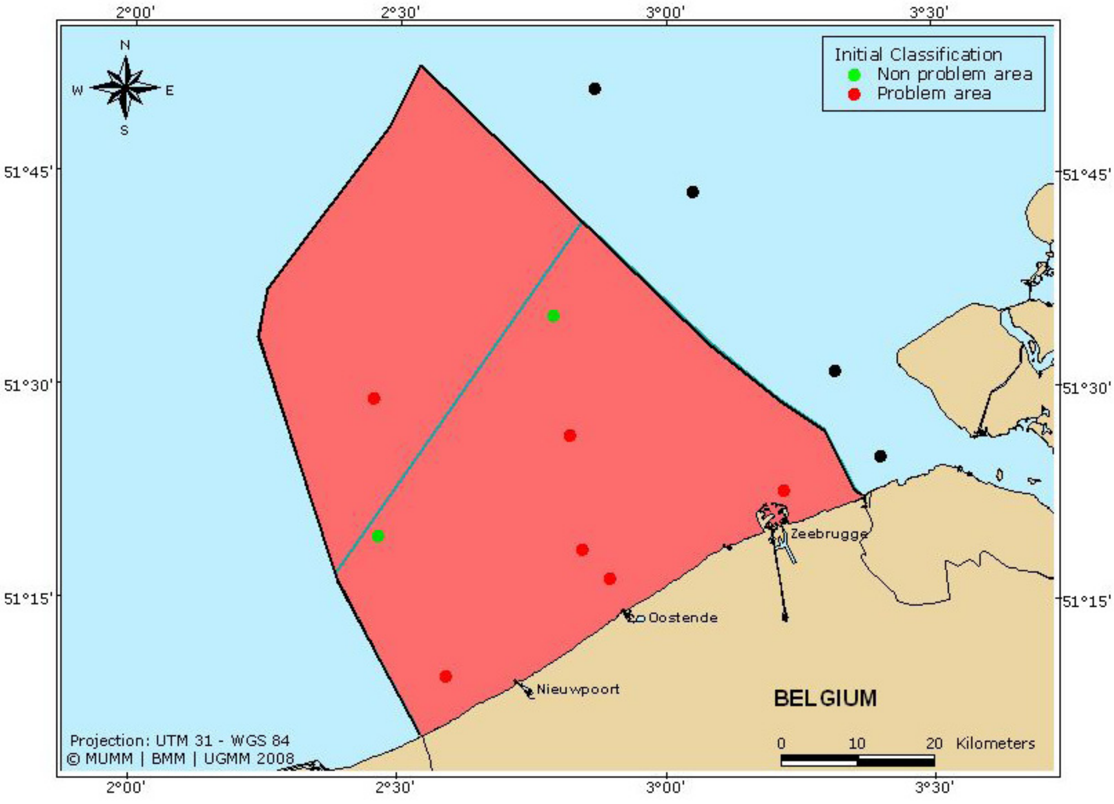

Figure 16: Initial area classification based on the integration of the assessment parameters.

As step 2 of the Common Procedure, the assessment parameters detailed in the previous sections are integrated using the methodology defined in (OSPAR 2005) and summarized in Table 5 for the coastal zone and Table 6 for the offshore zone.

Table 5: Overview of the results of the OSPAR Comprehensive Procedure for the Belgian coastal waters. (+) indicates increased trends, elevated levels, shifts or changes in the respective assessment parameters; ("+") indicates that it is not based on quantitative monitoring data, but on scattered scientific information; (-) indicates neither increased trends nor elevated levels nor shifts nor changes in the respective assessment parameters; ? indicates not enough data to perform an assessment or the data available is not fit for the purpose. Categories I, II and/or III/IV are scored '+' in cases where one or more of its respective assessment parameters is showing an increased trend, elevated level, shift or change.

Category	Assessment parameters	Description of Results	Score
Degree of Nutrient Enrichment (I)	Riverine total N and total P inputs and direct discharges (RID)	no increasing trend observed in comparison with previous years / decrease of 21 % for N and 40 % for P over a 10-year period	-
	Winter DIN- and/or DIP concentrations	DIN always exceeding threshold value, the averaged result is identical to the "per year" result, DIP for 60% of the assessment period exceeding the threshold value	+
	Increased winter N/P ratio (Redfield N/P = 16)	For every assessment year exceeding the threshold value, the averaged result is identical to the "per year" result	+
Direct Effects (II)	Mean and 90th percentile chlorophyll *a* concentration	Exceeding the threshold values within about 20 km (southwest) and 30 km (northeast) off the coast	+
	Region/area specific phytoplankton indicator species *Phaeocystis spp.*	Not quantified in detail for the current assessment, but based on an overall qualitative appraisal	"+" ?
	Macrophytes including macroalgae (region specific)	Not relevant for the assessment	
Indirect effects (III)	Degree of oxygen deficiency	Always below threshold value	-
	Changes/Kills in zoobenthos and fish mortality	No kills observed, changes not quantitatively assessed but have been observed on research project basis	? "+"
	Organic carbon/organic matter	Not used for the current assessment	?
Other possible effects (IV)	Algal toxins (DSP/PSP mussel infection events)	Not quantified in detail for the period 2001-2005, exceeding of thresholds not observed in 2006	? (-)
Classification			PA

Table 6: Overview of the results of the OSPAR Comprehensive Procedure for the Belgian offshore waters. (+) indicates increased trends, elevated levels, shifts or changes in the respective assessment parameters; (-) indicates neither increased trends nor elevated levels nor shifts nor changes in the respective assessment parameters; ? indicates not enough data to perform an assessment or the data available is not fit for the purpose. Categories I, II and/or III/IV are scored '+' in cases where one or more of its respective assessment parameters is showing an increased trend, elevated level, shift or change.

Category	Assessment parameters	Description of Results	Score
Degree of Nutrient Enrichment (I)	Riverine total N and total P inputs and direct discharges (RID)	no increasing trend observed in comparison with previous years / decrease of 21 % for N and 40% for P over a 10-year period	-
	Winter DIN- and/or DIP concentrations	DIN and DIP not exceeding threshold values, the averaged result is identical to the "per year" result for DIP, not for DIN	-
	Increased winter N/P ratio (Redfield N/P = 16)	For every assessment year below the threshold value	-
Direct Effects (II)	Mean and 90th percentile chlorophyll *a* concentration	The averaged result exceeding the threshold value	+ ?
	Region/area specific phyto-plankton indicator species *Phaeocystis spp.*	Not used for the current assessment	?
	Macrophytes including macroalgae (region specific)	Not relevant for the assessment	
Indirect effects (III)	Degree of oxygen deficiency	Always below threshold value	-
	Changes/Kills in zoobenthos and fish mortality	Not used for the current assessment	?
	Organic carbon/organic matter	Not used for current assessment	?
Other possible effects (IV)	Algal toxins (DSP/PSP mussel infection events)	Not used for the current assessment	? (-)
Classification			PA

The assessments for nutrients and chlorophyll *a* (mean assessment parameters) are combined and the resulting problem areas are plotted for the Belgian part of the North Sea. Thus, Figure 16 represents as problem areas those zones where the winter DIN threshold has been exceeded (Figure 7) and/or where the 90th percentile chlorophyll *a* concentration has been exceeded (Figure 12). For the data analysed the winter DIN distribution showed a more severe exceedance than the winter DIP threshold and the former thus determines the category I (degree of nutrient enrichment) component of Table 5 and Figure 16.

It is important to note that the initial classification can be improved, because it does not account for sufficient quantitative information on some category III and IV indirect effects parameters for the period 2001-2005 and quantitative information on the temporal and spatial distribution of phytoplankton indicator species (category II), due to lack of better information.

The final overall classification is shown in Figure 17 and contains the coastal waters as problem area and the offshore waters as a potential problem area. For the overall classification in step 3 the problem area for the offshore waters has been redefined as a potential problem area due to the following reasons:

- Nutrient enrichment in winter has not been observed and the confidence of the observation of direct effects is quite low.
- The chlorophyll *a* 90th percentile is not based on monthly measurements during the growing season but measurements biased towards the peak blooming period in April. Therefore the reported result is not an average over the entire growing period but an average from an amount (concentration) of higher values in early spring and may reflect an overestimation in comparison to an average made over the entire growing period.
- Only one sampling station can be taken into account for the offshore area, which is located near the border between coastal and offshore waters. Information from the area further offshore is not available and not taken into account. The spatial coverage/representativeness of the offshore waters is thus very low. Due to the close proximity of the coastal waters, still causing fluctuations in salinity at the offshore station as well, the currently available data may overestimate the concentration of chlorophyll *a* in the offshore area in comparison to an average that would result from stations covering the entire offshore area.
- The elevated level for 90th % chlorophyll *a* is used to evaluate this parameter in the offshore waters. This threshold is lower than the one used by some neighbouring contracting parties. This elevated level has been defined based on the relationships between nutrients and chlorophyll *a* and nutrients and salinity that should be taken into account to set thresholds for nutrients and chlorophyll *a*.
- No information was available on the spatial and temporal extent of the *Phaeocystis* blooms in the offshore area.

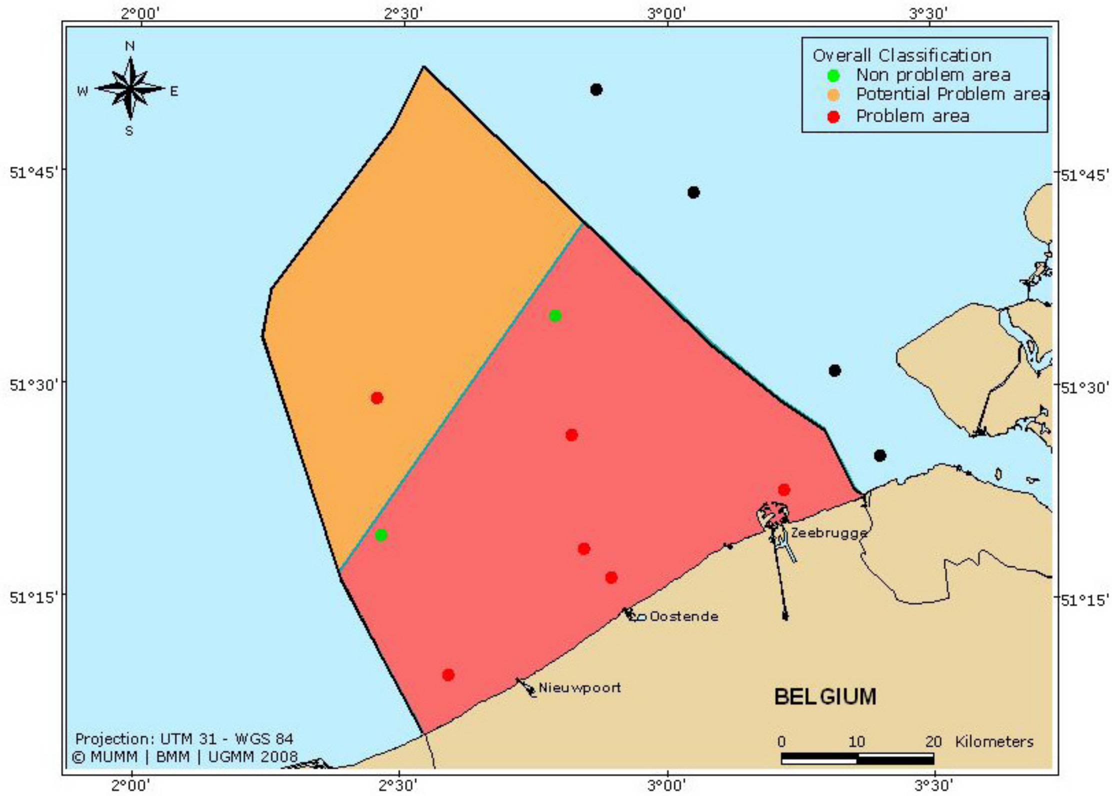

Figure 17: Overall area classification based on integration of the assessment parameters.

Climate change

Climate change might affect eutrophication in Belgian waters via a variety of processes, including change of biological rates and/or species distribution as function of sea temperature, change of nutrient inputs from rivers as affected by rainfall and land use (including changes in agricultural practice such as increase in biofuel production), change in hydrography because of changing wind patterns, and changes in light availability (related to wind-induced resuspension and/or cloudiness). The magnitude of these changes has not been evaluated, but is likely to be small compared to the impact that could be expected from a 50% reduction in nutrient inputs to the region. Current scientific work is being undertaken to investigate the impact of temperature changes (project AMORE III http://www.ulb.ac.be/assoc/esa/AMORE/amore.htm). However, the main factor driving eutrophication in Belgian waters is nutrient inputs from rivers and changes in that input are likely to be the main driving force for any changes in eutrophication status in the coming 5-10 years (based on historical data and on the sensitivity of the MIRO&CO-3D model to various forcing factors).

5.4 Comparison with preceding assessment

The results for all parameters are to a large extent comparable with the results of the previous period (1995-2000). In the case of Belgium the First Assessment (OSPAR Commission 2003) concluded that "in almost all investigated years in the assessment period 1995 to 2000, winter DIN and DIP were above the thresholds and chlorophyll *a* concentration was determinant in the distribution of PA (problem area). Generally, the Belgian coast is evaluated as a PA, but spatial differences were detected. PAs appear near the coast with an increasing gradient towards the north-east. The offshore waters can be classified as PPA (potential problem area). For some years NPAs are sometimes identified at the northern limit of the Exclusive Economic Zone. In the current Second Assessment the coastal zone of the Belgian part of the North Sea is still a problem area, where especially the coastal area from the Scheldt mouth to the French-Belgian border is still identified as a problem area, whereas the offshore area is characterized as a potential-problem area. In order to define the eutrophication status of the offshore area in the future, improvements in the spatial coverage of sampling stations have been made, as explained in section 8.

Table 7: Changes of assessed areas between COMPP 2003 and 2008

	Area/parameter	Type	NI	DI	NP	Ca	Pis	Mp	O2	Ck	Oc	At	IC	FC	
Belgium	Coastal water	CW	- ?	+ +	+ ?	+ +/-	?/+ ?	Nr Nr	- -	?(+) ?	? ?	?(-) ?	PA PA	PA PA	2008 2003
	Offshore water	Off	? ?	- ?	- ?	+ +/-	? ?	Nr Nr	- -	? ?	? ?	?(-) ?	PA PPA	PPA NPA	2008 2003
	? for 2008		1	0	0	0	1	0	0	2	2	2			
	n.i. for 2008		0	0	0	0	0	0	0	0	0	0			
	Total for 2008		1	0	0	0	1	0	0	2	2	2			
	Number + for 2008		0	1	1	2	1	0	0	0	0	0			
	Number – for 2008		1	1	1	0	0	0	2	0	0	0			

5.5 Voluntary parameters

5.5.1 Transboundary nutrient transports

There is a growing recognition that eutrophication problems from one maritime area may result from nutrients originating in a different maritime area and transported by currents. Although extensive measurement of transboundary nutrient fluxes is not feasible with present instrumentation and resources, ecosystem models are considered as a tool that may provide some information on the direction and magnitude of transboundary nutrient fluxes as well as their origin.

Transboundary nutrient inputs (and outputs) are thought to be very significant for this region from the adjacent French and Dutch areas. Indeed there are no major rivers discharging directly along the Belgian coast, unless the Scheldt Estuary (whose drainage basin covers much of Belgium but which reaches the sea just to the East of the coastal limit of the Belgian part of the North Sea) is considered. The strong horizontal mixing from tides leads to a merging of inputs from the various rivers into a more general water mass of lower salinity, high nutrient continental coastal water. Some preliminary indications of transboundary fluxes are available from research models, but a detailed and reliable quantification of the fluxes is not yet available. Monitoring data allows only an evaluation of concentrations and not fluxes, however the high spatial density of the monitoring network does give a reliable indication of the variability across the area, which is associated with the transboundary fluxes.

Atmospheric deposition of nitrogen is also an important source for N in the Belgian waters. More information can be found in Bartnicki and Fagerli (2006).

5.5.2 Total nitrogen and phosphorus

Total nitrogen and phosphorus are routinely monitored in Belgian waters but are not at present considered as eutrophication assessment parameters. The further monitoring of these parameters should support further threshold setting for nutrients and examination of relationships between nutrients and phytoplankton biomass.

6. Comparison and/or links with European eutrophication related policies Water Framework Directive (WFD)

In view of the growing importance of EU legislation, there is a tendency to convergence between the OSPAR eutrophication assessment and the EU's Water Framework Directive (WFD). The overlap between these two administrative frameworks is described in detail in Chapter 8 of OSPAR 2005. Since the Second OSPAR Assessment the PPA classification is destined to be deleted, with the OSPAR PA classification corresponding to "Bad", "Poor" or "Moderate" quality water classifications of the WFD; and the OSPAR NPA classifications corresponding to "Good" and "High" quality water under the WFD.

Differences persist, however, in geographical coverage since the WFD covers waters up to only one nautical mile from the coast for biological quality elements, including nutrients and oxygen. For the WFD the ecological quality objectives are leading, while nutrients and oxygen conditions are supporting physico-chemical elements. Two WFD ecological quality elements, phytoplankton and macrobenthos are in accordance with the OSPAR assessment parameters chlorophyll *a* concentration, phytoplankton indicator species and changes in zoobenthos.

Phytoplankton and supporting parameters

Currently, chlorophyll *a* concentration is already monitored and evaluated, while phytoplankton indicator species and changes in zoobenthos are monitored from 2007 onwards and assessed in the framework of the WFD monitoring and will also be used in the context of OSPAR in the future.

The Belgian coastal waters are part of the eco-region North Sea within the Northeast Atlantic region and are identified as the type CW-NEA1/26, described as shallow, mesotidal, euhaline, exposed, fully mixed and sandy within the WFD.
In table 8 an overview is given on the threshold values that will be applied as boundaries between the different ecological classes of the WFD for the physico-chemical parameters DIN and DIP and the phytoplankton parameters including chlorophyll *a* and the indicator species *Phaeocystis*.

Table 8: An overview of the threshold values that will be applied as boundaries between the different ecological classes of the WFD for the physico-chemical parameters DIN and DIP and the phytoplankton parameters including chlorophyll *a* and the indicator species *Phaeocystis*
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Class Ecological status WFD	DIN Winter mean (µmol/l)	DIN Winter mean (µmol/l)	DIP Winter mean (µmol/l)	Ratio N/P	Chl a 90^{th} percentile during growing season (March – September) (µg/l)	Frequency (percentage of 12 samples per year) *Phaeocystis* cell counts above a threshold of 10^6 cells/l
	30 Salinity	33.5 Salinity			30 - 33.5 Salinity	
Bad	> 90	> 45	> 2,4		> 45	> 80%
Poor	> 60 – 90	> 30 – 45	> 1,6 – 2,4		> 30 – 45	> 35%
Moderate	> 30 – 60	> 15 – 30	> 0,8 – 1,6	N/P > 24	> 15 – 30	> 17%
Good	> 24,5 – 30	> 12,25 – 15	> 0,7 – 0,8	N/P = 16	> 10 – 15	> 9 – 17%
High	< 24,5	< 12,25	< 0,7	N/P = 16	< 10	< 9 %

Within the intercalibration process of the WFD, United Kingdom, France, Belgium and the Netherlands agreed a chlorophyll *a* 90^{th} percentile threshold concentration of 15 µg/l as the boundary between good and moderate for the coastal waters, which corresponds to the threshold between problem and non-problem area in OSPAR. Within the OSPAR assessment, 10 µg/l is considered as the reference or background concentration, whereas within the WFD, the boundary between high and good has been defined as 10 µg/l, the reference concentration being lower and equal to 6,67 µg/l. Therefore, there is a slight shift in reference concentration used for OSPAR and for WFD assessment, although the elevated level concentration is the same (15 µg/l).

Macrobenthos

The ecological quality assessment and the status classification of the benthos of the Belgian coastal waters within the WFD is based on the BEQI (Benthic Ecosystem Quality Index) assessment method that will be used for the WFD monitoring. The Benthic Ecosystem Quality Index, developed by the Netherlands Institute of Ecology, is based on an ecosystem functioning approach (Ysebaert & Herman, 2004), which aims to give an indication about ecosystem structure and functioning, and about biological relationships. The BEQI is a multi-metric method distinguishing three scale levels to assess overall ecosystem functioning.

- The first assessment level is at the ecosystem level (the whole water body within the WFD). Central at this level is the role of the macrobenthos in ecosystem functioning. The macrobenthic community is an important link in the food web between primary production and predatory invertebrate, fish and bird populations. As such it exerts top down control on the primary producers and bottom up control on the higher trophic levels, while the reverse, control by primary producers and predatory consumers on the macrobenthic community act just as well. The dynamics of this interplay is fundamental to ecosystem functioning. On this level one can evaluate if the benthic macrofauna fulfils the functional role one might expect given the current ecological circumstances.
- The second level is the habitat level, where the distribution of habitats (habitat completeness and complexity) can be evaluated. The macrobenthic communities in the ecosystem depend on the physical and chemical characteristics of the habitat. The diversity of habitats, characterized by the occurrence and the relative surface area of different habitat types, is a major factor determining occurrence, density and biomass of macrobenthos.
- The third level evaluates the state and quality of the benthos within each distinguished habitat based on 4 parameters (sub-indicators): total biomass, total density, number of species and species composition. These parameters are community characteristics that respond to different types of stress, including eutrophication, and that can explain possible deviations. The type of response may serve as a first indicator of the stressor type. Detection of changes in within-habitat communities may also help understanding responses at the ecosystem level. The parameter results strongly depend on the sampling effort (sediment surface) that is deployed. Therefore, the reference values for the parameters were calculated per habitat from permutations executed over increased sampling surfaces. A minimum required sampling surface is defined for reference values specification and status assessment. BEQI evaluates at the scale of a whole water body, contrary to methods applied by other Member States that evaluate the ecological status per sampling station for the WFD.

The BEQI multimetric integrates the information of these three levels and primarily aims at providing a signal that is capable of showing significant deviations from a defined reference state. The method is explained in detail in Van Hoey *et al.* (2007a).

The reference values for reaching good status (good/moderate boundary, required sampling surface of 1,5 m²) for the 4 parameters of the third level of the BEQI are presented in Table 9 for the fine muddy sand coastal habitat of the Belgian coast. Reference values for other habitats still have to be defined.

Table 9: Reference values for reaching good status (good/moderate boundary) for the 4 parameters of the third level of the BEQI

Habitat type	**Sampling surface**	**Number of species**	**Similarity**	**Density (ind/m^2)**	**Biomass (gAFDW/ m^2)**
Fine muddy sand – *Abra alba* community	1.5 m^2	60	0.84	1516 (lower boundary) and 5394 (upper boundary)	Not defined yet

The analysis of the macrobenthos at the first level of the BEQI assessment method for the WFD, based on a very limited amount of samples along the coast, revealed that the macrobenthos at system level obtains a moderate status in the Belgian coastal waters (Van Hoey *et al*., 2007b). The within-habitat analysis at the third level of the BEQI assessment method gives the *Abra alba* community a moderate status, the only community of the four occurring communities for which sufficient data were available to make an assessment. For this general assessment it was not clear how much of the changes could be assigned to eutrophication effects or impacts of other pressures.

7. Implementation of integrated set of EcoQOs for eutrophication

The coastal waters of the Belgian part of the North Sea are classified as a problem area in terms of eutrophication and therefore this area did not reach the overall Ecological Quality Objective that an area should have the status of a non-problem area for eutrophication. For the offshore area it was not clear if the overall Ecological Quality Objective is met, as it could not be classified clearly as a problem or a non-problem area.

The individual objectives on nutrient enrichment parameters, chlorophyll *a* concentration and phytoplankton nuisance species like *Phaeocystis* are not met in the coastal waters. In the offshore waters only a preliminary assessment on nutrient enrichment parameters and chlorophyll *a* was possible, but only based on insufficient monitoring results. Kills in zoobenthos and fish have not been observed to occur in Belgian marine waters and were only taken into account in the assessment on a general observational basis during fishery and benthos monitoring (set up for other purposes then for eutrophication evaluation). This EcoQO is not considered very relevant or suitable for the Belgian marine waters for eutrophication assessment purposes. In the future further development of an indicator is required, defining significant changes in zoobenthos biomass and species composition. An integrated assessment for changes in macrobenthos was not made for coastal or offshore waters since no data fit for purpose were available to make an appropriate assessment for the period 2001-2005. A preliminary assessment of eutrophication has been performed based on a time series for only one station.

With respect to the adequacy of monitoring of the integrated set of five eutrophication EcoQOs the following can be concluded (Table 10). The horizontal and vertical length scales and the time scale for monitoring the variation of the EcoQO parameters DIN, DIP, chlorophyll *a* and oxygen deficiency monitoring practices in Belgium are adequate for the purposes of determination of eutrophication problem and non-problem areas (Belgium 2006) in the coastal waters. But this can for example further be improved by the use of satellite imagery from the MERIS sensor (see Annex 4). The spatial and temporal variation of DIN, DIP and chlorophyll *a* was not sufficiently addressed in the offshore area. In order to define the eutrophication status of the offshore area, improvements in the spatial coverage of sampling stations have been made, as explained in the text on improvement of assessment in section 8. Monitoring of phytoplankton indicator species (no cell counts for *Phaeocystis spp*.) and changes in zoobenthos was not sufficient in coastal and offshore waters, but will be improved in the context of the WFD monitoring in the coastal area and further extended offshore as soon as possible and feasible.

The parameters DIN, DIP, chlorophyll *a* and oxygen deficiency are all considered suitable parameters to be used as EcoQO. However, on the parameter chlorophyll *a* a remark has to be made on the use of the maximum chlorophyll *a* concentration. In the case of the Belgian waters the maximum chlorophyll *a* concentration recorded was found to be highly dependent on the sampling frequency and the monitoring data, which was found to be insufficient to estimate adequately this maximum. The approach to be adopted here, is thus to use the 90th percentile value instead of the maximum value.

Table 10: Overview of (in)sufficiency in temporal and spatial monitoring of assessment parameters of the comprehensive procedure. +: sufficient monitoring; -: insufficient monitoring; * monitoring will be improved

Key of table 10:

Key of table 10:	NI	Riverine total N and total P inputs and direct discharges
	DI	Winter DIN and DIP concentrations
	NP	winter N/P ratios
	Ca	Mean and 90th percentile chlorophyll *a* concentration
	Ps	Region/area specific phytoplankton indicator species
	Mp	Macrophytes/macroalgae
	O2	Degree of oxygen deficiency
	Ck	Changes/kills in zoobenthos and fish kills
	Oc	Organic carbon/organic matter
	At	Algal toxins (DSP/PSP) mussel infection events

Belgium	Category I	Category II	Category III	Category IV
Coastal	NI: +	**Ca: +**	**O_2: +**	At: - / *
	DI: +	**Ps: - / ***	**Ck: - / ***	
	NP: +	Mp: Not relevant	Oc: -	
Offshore	NI: +	**Ca: - / ***	**O2: +**	At: -
	DI: - / *	**Ps: - / ***	**Ck: -**	
	NP: - / *	Mp: Not relevant	Oc: -	

The suitability of the EcoQO for phytoplankton (nuisance and toxic) species is still considered questionable. In order to assess sufficiently this EcoQO, weekly sampling would be necessary, which is hardly achievable for long-term monitoring. It is recognised that this parameter has to be monitored but an alternative assessment methodology is being worked out for Belgian waters. In the light of the improvement of the suitability of OSPAR EcoQO's and the development of Water Framework Directive classification methods, some recommendations can be made on phytoplankton species and zoobenthos evaluation.

Table 11: Implementation of the integrated set of EcoQOs by Belgium through the OSPAR Comprehensive Procedure

Contracting Party	**Status of implementation taken from National Reports**	**OSPAR EcoQO Implementation assessment** **Score based on information provided on the trial application of the overarching and the sub-EcoQOs for eutrophication taken from National reports indicating their suitability to function as objectives.** **"+" indicates they were evaluated**					
		Overaching	**DIN/DIP**	**Chlor A**	**Phytoplankton species**	**O2 conc**	**Benthic kills**
Belgium	Partial implementation	+ (suitable)	+ (suitable)	+ (suitable)	+ (not fully implemented with long-term monitoring but info on alternative assessment options given)	+ (suitable)	- (further development of indicator required)

Phytoplankton species (*Phaeocystis*) EcoQO development

Identification of ecological quality criteria for *Phaeocystis* in relation to anthropogenic pressures (i.e. nutrient river loads) is being addressed by combining field observation analysis and model simulations (Lancelot *et al.*, 2008). The proposed methodology is being developed within the Belgian Science Policy projects AMORE III (http://www.ulb.ac.be/assoc/esa/AMORE/amore.htm) and TIMOTHY (http://www.astr.ucl.ac.be/TIMOTHY/), funded by the Science for Sustainable Development and by the Interuniversity Attraction Poles Programme, respectively, and the EC integrated project Thresholds of Environmental Sustainability (THRESHOLDS). The methodology includes in the first place the definition of a reference *Phaeocystis* cell density from which the disturbance could be scaled. This reference was derived from a *Phaeocystis* indicator that reflects ecosystem disturbance i.e. the capacity of *Phaeocystis* colonies that, once formed, can reach sizes unmanageable for indigenous copepods. Based on analysis of *Phaeocystis* observations, the reference was set at 4 10^6 cells L^{-1} and corresponds to the maximum *Phaeocystis* cells contained in grazable colonies (<400 µm) recorded in the Belgian waters between 1988 and 2000. Historical reconstruction of nutrient loads and phytoplankton bloom was then made using the coupled river-coastal model RIVERSTRAHLER-MIRO (R-MIRO). For this application, the RIVERSTRAHLER model, describing carbon and nutrient transformations along the river system as a function of meteorological conditions and human activity, was coupled to the biogeochemical MIRO model describing diatom and *Phaeocystis* blooms in the marine domain. Model simulations obtained for the period 1950-2000 constrained by real forcings were compared with a pristine reference (watershed covered by primary forest). *Phaeocystis* and diatom trends were simulated for the pristine situation and compared to the ecologically-based *Phaeocystis* colony threshold (4 10^6 cells L^{-1}), derived from the maximum amount of cells transferable into the food chain. Interestingly, this threshold was similar to the maximum *Phaeocystis* colony cells simulated for pristine time by the coupled RIVERSTRAHLER-MIRO (R-MIRO) model suggesting that natural *Phaeocystis* ecosystems are well balanced and transfer efficiently their production to higher trophic levels. Field observations obtained during the 1988-2000 period and the 1950-2000 historical reconstruction of eutrophication in the Belgian coastal zone simulated by the R-MIRO model were showing *Phaeocystis* colony cell maxima well above the reference value. Considering that the return to the pristine reference value was not achievable, another methodology was then proposed based on historical R-MIRO simulations of annual primary and copepod productions, these ratios (CP:PP) are an indicator of trophic efficiency. The analysis of changing CP:PP ratios in relation to simulated winter concentrations and annual inputs of nutrients showed that the decrease in trophic efficiency was related to the imbalanced DIN and DIP inputs (N/P>25) explained here by the intended decrease of DIP loads after 1985 while DIN were maintained elevated. On this basis a critical equilibrium of the N:P balance has to be maintained in order to favour diatoms over *Phaeocystis* colonies.

As a result of this research, two new *Phaeocystis* thresholds and EcoQOs may be proposed:

- A reference concentration of 4 10^6 cells L^{-1} reflecting a well balanced natural *Phaeocystis* ecosystem that can transfer efficiently its production to higher trophic levels.
- An updated winter N/P ratio threshold reflecting imbalanced DIN and DIP inputs is set at N/P > 25 in the project AMORE III and may also be defined as an EcoQO. The currently defined N/P elevated level in OSPAR is 24 and can be maintained as such. Based on results on the discovered relationship between N/P and *Phaeocystis* cell density, an elevated level can be defined for *Phaeocystis* cell density. The more unbalanced the relation of N over P, the higher the contribution of *Phaeocystis* cells to the phytoplankton community. Thus, the corresponding *Phaeocystis* cell density can be defined in a nutrient situation of N/P = 25 to be used as a threshold for eutrophication assessment and as EcoQO.

Macrobenthos EcoQO development

The ecological quality assessment of the macrobenthos of the Belgian coastal waters within the WFD is based on the BEQI (Benthic Ecosystem Quality Index) assessment method. The method aims at evaluating the water body (ecosystem) as a whole, based on the function of the zoobenthos, the distribution of habitats and the biological quality of each distinguished habitat (within-habitat level). In order to incorporate these three aspects, the BEQI is a multi-metric method distinguishing three scale levels to assess overall ecosystem functioning. At the first ecosystem level total macrobenthos biomass needs to be assessed in relation to primary production in order to evaluate the functional role of zoobenthos. The second level is the habitat level, where the distribution of habitats (habitat completeness and complexity) can be evaluated. At the within-habitat level four parameters are evaluated: density, biomass, number of species and species similarity. Therefore monitoring data are required on these four parameters of the macrobenthos for each habitat, in addition to the distribution of habitats and the total primary production. The within-habitat parameters or the overall BEQI result may be considered to develop an EcoQO for zoobenthos.

8. Perspectives

8.1 Observed trends and implemented and further planned measures:

Observed trends as a result of implemented measures

- National data (based on a source oriented approach) show that emissions, discharges and losses of nutrients have been significantly reduced in the period 1985 – 2005. In 2005, an emission reduction of P of more then 50 % has been achieved for the Belgian rivers influencing the Belgian coast, but the 50 % reduction objective has not been met for nitrogen where the emission reduction compared to 1985 is about 34 % in 2005 (Figure 18). The Flemish Region, the Brussels Capital Region and the Walloon Region respectively, reached 45 %, 21 % and 13 % of reduction in N_{tot} emissions in 2005, corresponding to an overall national reduction of 34 %. Values for P_{tot} reduction for the same regions are respectively 65 %, 47 % and 57 % resulting in an overall national reduction of 61 %. The decrease in N corresponds to 1,7 kton/year over the period 1985-2005, but the major reduction in N losses took place between 1995 and 2005. The major reduction in P losses took place between 1985 and 1995, corresponding to a reduction of 0,72 ton/year. The further reduction from 1995 until 2005 equals about 0,3 kton/year.

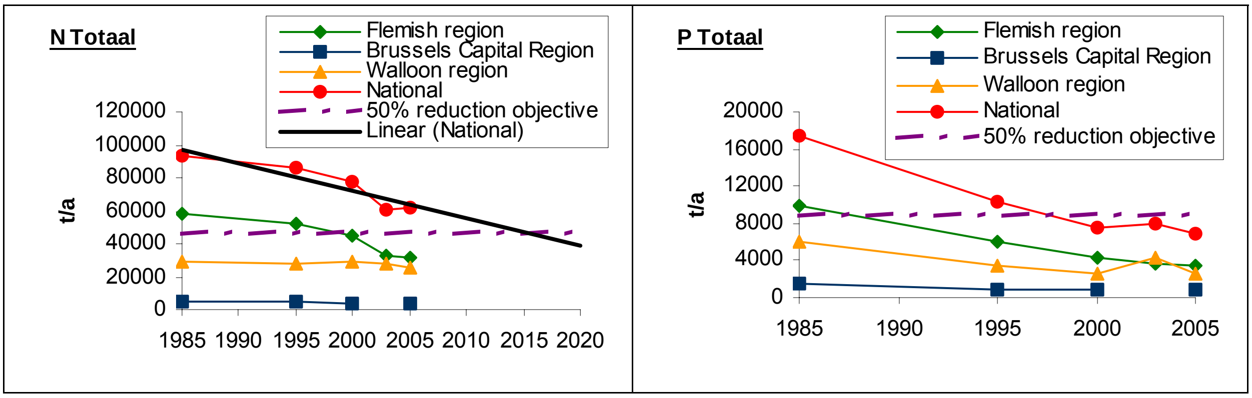


Figure 18: Preliminary results for N_{tot} and P_{tot} values from the PARCOM 88/2 and 89/4 recommendations implementation reporting of Belgium.

For the Walloon region it has to be clarified that the rise shown in Figure 18 does not reflect higher phosphorus emissions but is the result of changes made in the way amounts of phosphorus, released through urban, industrial and agricultural waste water, are estimated. The current method is more reliable and is based on more data. Due to lack of data it is not possible to recalculate in retrospect the values for the previous years.

- A list of measures implemented by the different regions to reduce pollution from sources in different sectors is given in the PARCOM 89/4 national implementation report of 2007.
- Riverine and direct inputs (based on RID data) of nitrogen have decreased with about 21 % and phosphorus inputs with about 40 % over the decade 1996-2005. The RID data show that N values are decreasing with 0,9 kton per year in the period 1996-2005. For riverine P inputs the decrease over this period amounts to 0,2 kton/year.
- Figures for atmospheric deposition of nitrogen to the Belgian marine waters are not available at the required scale, due to the small size of the marine area under Belgian jurisdiction. Trends on atmospheric nitrogen deposition are therefore not taken into account. At a larger scale nitrogen deposition dropped from 2 to 1 mg N/m².
- The overall results of the second application of the Comprehensive Procedure are very similar to the outcome of the first application of the Comprehensive Procedure. The reductions achieved and reported for emission, discharges and losses of nutrients as well as the respective reductions for nutrient inputs are not reflected yet in sufficiently reduced nutrient concentrations to drop below the threshold values or clearly reduced primary eutrophication effects in the marine environment.

Further planned measures

Belgium will proceed with implementing the OSPAR agreements (50 % emission reduction of both N and P compared to 1985). Preventive measures are further applied and planned in sectors like agriculture, sewage and industry in order to reduce the N and P loads of the rivers in the different regions of Belgium. The new waste water treatment plant in the Brussels Capital Region, operational since October 2007, should lead to a significant decrease of nitrogen and phosphorus emissions. In the Flemish Region new decrees and codes have been set up in the sectors of agriculture and sewage and in the Walloon Region measures have been taken for a more sustainable management of nitrogen in agriculture and urban waste water purification. Some more details for each region are given below. More details on implemented and planned measures can be found in the PARCOM 89/4 national implementation report.

Flanders

- In the 90's, much attention was paid to a sector-based approach in Flanders. Specific measures have been developed for agriculture, sewage collection and treatment, and industrial pollution.
- The new Manure Decree end 2006 has been a new Action Program for the Nitrates Directive (91/676/EEC).
- Concerning sewage, the whole of Flanders has been assigned as vulnerable area in 1995. The connection and treatment rate for households has been increased, the working of Waste Water Treatment Plants has been optimized and in 2004, the effluent standards were tightened. End 2004, the wastewater treatment sector has been reorganized, focusing on ecological and economical regulation. In 2006, the procedure for a decision on zoning plans was started for each of the Municipalities. Through an implementation plan, the (phasing of the) realizations of these engagements will be made concrete.

- Directive (91/271/EEC) and the IPPC Directive (96/61/EC). There is an emission reduction program by optimizing the permit system for industrial wastewater. Effluent standards in permits are based on best available techniques.
- In 2003, the **decree on Integrated Water Policy** (Belgium Law Gazette, 14.11.2003) has been adopted in Flanders and transposed the European Water Framework Directive into Flemish legislation. It goes even further by regulating and fully integrating all qualitative and quantitative aspects of the surface- and groundwater. The different already existing measures on sector basis are developed further and the instruments of the new decree will also contribute to a better water quality once the execution of it is at speed. There is no information available on the exact timing for achieving the reduction target. The Decree lays the foundation of an integrated water management in Flanders and describes the administrative organisation. Moreover, it creates new tools for integrated water management, such as the 'water test'. This instrument is part of the permitting procedure for construction, housing or industrial activity applications. The 'water test' should determine whether or not the construction or activity could cause any damage to the water system. In this respect, environmental aspects on water are a central part of the licensing procedure. The same evaluation of possible damages to water has to be made by making up policy plans. For the main districts and each basin at the different levels, catchment area management plans have been elaborated, including different measures and actions. The management plans for the 11 river sub-basins have been prepared and are subject to public consultation before adoption of the plans.
- The Dutch and Flemish Government have agreed on the phased implementation of the **Long Term Vision**, a Dutch-Flemish managerial plan for the Scheldt estuary (LTVS), signed in February 2001 and March 2002, and determined as “the development of a healthy and multi-functional estuarine water system that can be utilized sustainable for human needs”. The LTVS set quality targets for the estuary in the year 2030 and the management measures to achieve them. Goals and management measures were integrated from three central perspectives: accessibility, flood management and ecology. In the first phase goals and management measures for the year 2010 were set in the so called ‘**Development outline 2010**’, an agreement signed on 21 December 2005 by the Netherlands and Flanders. This plan contained the midterm objectives for morphology, flood control, external safety, accessibility, ecology, fisheries and recreation and the measures needed to realise them. The measures include the extension and the creation of new estuarine nature to restore the ecological quality of the Scheldt estuary and to reduce the effects of the enlargement of the seaway. In the frame of the realisation of the updated Sigmaplan, arrangements are made for an optimal protection against floods through the creation of flood control areas (FCA) and through local dike elevations. In addition to the measures defined in the Development Outline 2010 and the updated Sigmaplan, approved by the Flemish Government on 17 December 2004, also additional measures for the ecological restoration of the Seascheldt have been concluded on 22 July 2005. The extension and the creation of new estuarine nature to restore the quality of the Scheldt estuary and to achieve the overall goal of the Long Term Vision to improve the estuarine ecosystem with its typical habitats and communities and to reinstate essential physical, chemical and ecological processes, can definitely be expected to have a long-term positive effect on the quality of the coastal waters.

Brussels Capital Region

- The main source of phosphorus and nitrogen from the Brussels Region is coming from the households. The new Waste Water Treatment Plant from the north of Brussels treats now all the wastewater from the Brussels Region, operational since October 2007, with tertiary treatment. It is also planned to increase the connection rate to the sewer system, or by dispensation to article 2 from decree dated 23/03/94 related to the Urban Waste Water Treatment to use individual systems or any other appropriate systems leading to the same level of protection of the environment.

Walloon Region

- A new decline in N and P should be reported soon because efforts on urban wastewater purification and on agriculture have been taken and will be made to meet the requirements for the Water Framework Directive. It is difficult to determine when the reduction target will be reached, but the Walloon Region has carried out studies to model the whole water cycle (PIRENE programme) as part of the water inventories. Following on from this programme, agriculture-related studies have been carried out to evaluate the effects of the action programme that has been implemented to meet the requirements as provided for in the Nitrates Directive and the Water Framework Directive.
- For other sources, the Walloon Region is continuing to invest in wastewater purification. The procedures governing the issue of an environmental permit have been applicable since 2002.
- Concerning agriculture, the Decree of the Walloon Government of 15 February 2007 amends sustainable nitrogen management provisions in Volume II of the Environmental Code that constitutes the Water Code.
- Since December 2006, three vulnerable areas have been added to the four existing zones (since 2001) in order to take into account the eutrophication of the North Sea more efficiently. About half of the Walloon agricultural area is now sensitive zone.
  - Ministerial Decree of 22 December 2006 defining the area located north of the Sambre-Meuse valley as vulnerable area (Belgian Law Gazette of 6 March 2007)
  - Ministerial Decree of 22 December 2006 amending the boundaries of the vulnerable area of « Sud Namurois » (Belgian Law Gazette of 6 March 2007)

  Mandatory action programmes have been set up on the whole territory of the Region. Sensitive zones are subject to more stringent measures. These measures apply to manure storage, application of fertilisers, maximum quantities to be used, the principle of area requirement for farms, and the structure called Nitrawal and created to accompany/guide farmers in their steps to manage their livestock manure.
- Concerning sewage, the whole Walloon Region has been designated as vulnerable area in 2001 in compliance with Directive 91/271/EEC. A water purification programme 2005-2009 is being implemented, giving priority to agglomerations of more than 2000 p.e. to meet the obligations imposed by Directive 91/271/EEC. All plants with more than 10 000 p.e. have been, are, or will be provided with systems for tertiary treatment of nitrogen and phosphorus by 2009.
- For industry, the application of the decree of the Walloon Government on environmental permits holds since 1st October 2002. The general, sectoral and specific discharge conditions are taken into account so as to prevent any nitrogen and phosphorus pollution. The environmental permit covers the IPPC Directive and the related EPER Decision.

8.2 Outlook:

i. Expected trends

The first priority of Belgium is to proceed to fully implement the OSPAR agreement to reduce the N emission with 50 % compared to 1985. The 50 % reduction in P emissions has been achieved in 2000. In 2005 the P emissions reduction was about 61 %. However, the N reduction only amounted to 34 %. When P emissions would be further reduced until a reduction of 70 %, some modeling results predicted on average a 1 % reduction in winter DIP. Model responsiveness for winter DIP is low in the Belgian coastal waters, resulting in a reasonable range of values with almost no gradient. This may be due to the already achieved reductions in phosphate, with apparently limited influence of UK rivers in this area. Overall, given the range of values predicted, these results are classified as medium confidence. For N, on average a 27 % reduction in winter DIN is predicted when a N load reduction of 50 % in comparison to 1985 would be achieved, and 36 % reduction in winter DIN when a N load reduction of 70 % would be reached, hence about half a reduction in DIN achieved in coastal waters compared to the % reduction in riverine nitrogen load. However, these modelling results are classified as having low confidence. A comparison of measurements in the 90ties with measurements from 2001-2005 indicates that DIN concentrations have indeed decreased considerably. However, given the current DIN measurements, a further decrease in riverine nitrogen load until 70 % (an extra reduction of 36 % from 2005 onwards) would not result in a sufficient decrease of the DIN concentrations to drop below the elevated level for DIN concentration of 15 µg/l. Investigations on the effect of reducing river nutrient discharge on the reduction of the coastal eutrophication in Belgian waters, have shown that a 50 % reduction of river nutrient inputs would not be sufficient to reach a NPA status and that a 90 % N and P reduction would be necessary to reach this goal (Lacroix *et al.* 2006; Lacroix *et al.* 2007). A decrease in riverine nitrogen load until 90 % (an extra reduction of 56 % from 2005 onwards) may result in a sufficient decrease of N concentrations in the coastal waters. The results of Lacroix *et al.* show also that a future management plan aiming at *Phaeocystis* reduction should prioritise N reduction. Concerning chlorophyll *a* reduction estimations, mean summer chlorophyll *a* concentration is less responsive to load reduction than DIN or DIP and generally had a similar response in offshore and coastal target areas. On average a 10 % reduction in chlorophyll is predicted with a 50 % reduction in N and P riverine loads, and 18 % reduction with a reduction of 70 % in N and P riverine loads. Here, the models show good agreement on both values and gradient, giving the results a high confidence level.

The new waste water treatment plant in the Brussels Capital Region, operational since October 2007, should lead to a significant decrease of nitrogen and also phosphorus emissions. In the Flemish Region new decrees, codes or agreements have been set up in the sectors of agriculture and sewage, and in estuary habitat restoration and in the Walloon Region measures have been taken for a more sustainable management of nitrogen in agriculture and urban waste water purification. Prospective modeling scenario’s for 2015 have shown that with the implementation of these required measures to reduce P and N inputs the chlorophyll *a* concentration may drop underneath the threshold of 15 µmol/l, but that this concentration of primary production can still be dominated by *Phaeocystis* instead of diatoms, due to an imbalance of availability of N and P. Hence chlorophyll *a* thresholds always have to be combined with *Phaeocystis* or nutrient relationship thresholds in order to assess eutrophication problems, reflecting a disturbance of the natural equilibrium. A nutrient threshold for *Phaeocystis* disturbance is being developed based on historical MIRO model simulations making use of RIVERSTRAHLER simulations as nutrient loads.

Further nutrient reduction scenario modeling has revealed that, in general, winter DIN and DIP were more responsive to N and P load reduction in coastal target areas than offshore target areas. On average a 17 % reduction in winter DIN is predicted in offshore waters with a 50 % reduction in N riverine loads and 24 % reduction in winter DIN with a reduction of 70 % in N riverine loads. The models predict a wide range of values (variation by a factor > 2) and different slopes. As a consequence this result is designated as having low confidence. Concerning reduction in winter DIP, a wide range of values is predicted with different gradients, leading to a classification of low confidence. Concerning the direct effect of eutrophication, on average a 7 % reduction in chlorophyll *a* is predicted with a 50 % riverine N and P reduction and 9 % reduction in chlorophyll *a* with a 70 % riverine N and P reduction. Model responsiveness is very similar for all applied models, with similar values and gradients. This leads to a classification of the results as high confidence.

ii. Improvement of assessments

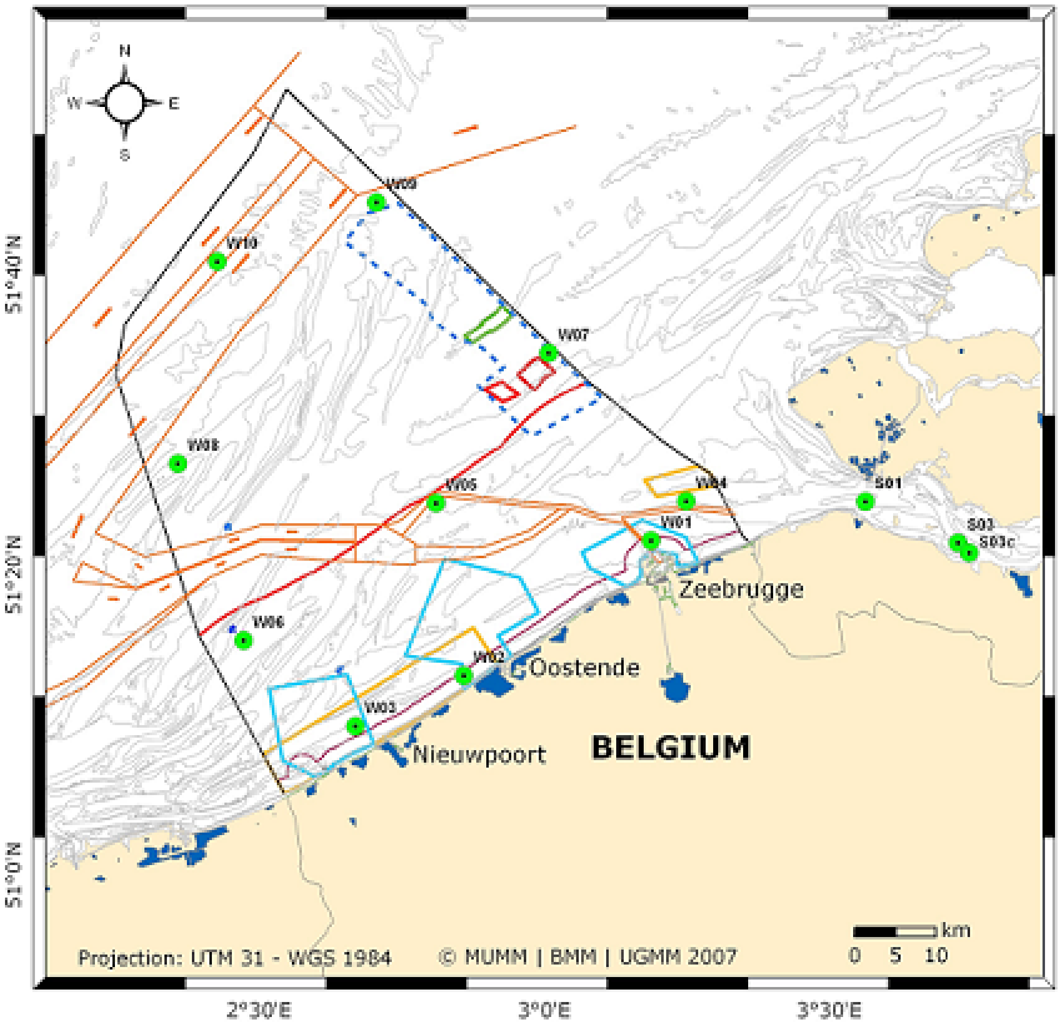
Spatial distribution of monitoring stations

The assessment will be improved in the future on different aspects. The spatial representativeness in the offshore zone has been increased due to the monitoring of two additional offshore stations (stations W09 and W10 in Figure 19). The monitoring station network has been restructured at the end of 2006 to meet the monitoring objectives of OSPAR and the WFD at the same time (Belgium, 2007). Figure 19 shows the locations of the nine OSPAR monitoring stations in the Belgian marine waters and three stations in the Wester Scheldt. Three of these stations near the coast (W01, W02, W03) are monitored for ecological parameters for the Water Framework Directive. Three stations in the territorial waters are also monitored for chemical parameters for the Water Framework Directive (one, W01, in common with the ecological parameters). All the sampling stations illustrated on Figure 19 are monitored within the OSPAR framework. Table 12 gives an overview of the monitoring activities at the nine stations in the Belgian marine waters for OSPAR and WFD.

Extension of monitored parameters

The assessment will improve also due to monitoring of the parameter phytoplankton indicator species (including toxic algal species) and zoobenthos species in the context of the WFD. Phytoplankton composition is analysed monthly at three stations near the coast (W01, W02, W03 in Figure 19). These measurements will be extended further offshore as soon as possible. The most frequent sampling of the toxic phytoplankton species will only be performed in zones where mussels are grown (Mariculture zones in Figure 19).

To evaluate eutrophication problems, phytoplankton is monitored in the first place and has received more attention than long-term changes in zoobenthos biomass and species composition so far. Due to interference with other affecting parameters than eutrophication, there is a need for high sampling density and long lasting benthos monitoring, which is difficult to achieve and not established yet. Specific indices are under development, e.g. tested within the WFD in relation to different pressures, and also in relation to eutrophication. Yearly macrobenthos monitoring for ecological quality assessment purposes started in 2007 near the coast.



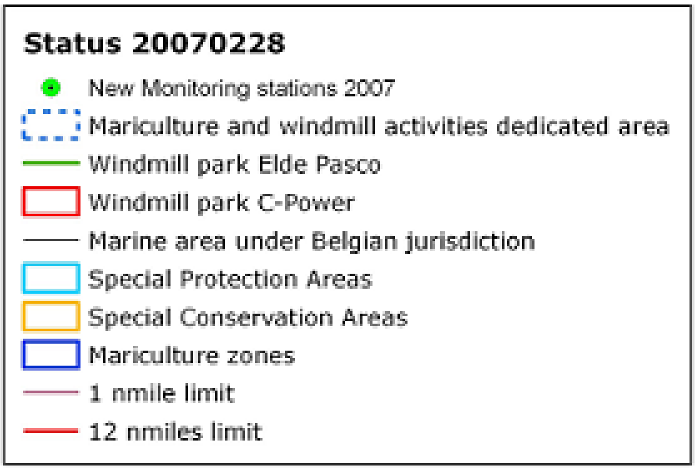


Figure 19: Location of the monitoring stations in the Belgian part of the North Sea.

Table 12: Overview of monitoring activities at the Belgian monitoring stations

Station	Purpose	Parameters[1]	Matrix
S01	OSPAR-CEMP	Nutrients	Water
S03	OSPAR-CEMP	Nutrients	Water
W01	OSPAR-CEMP	Nutrients, heavy metals, organic substances	Water, sediment
	OSPAR-CEMP	Chlorofyl a	Water
	WFD	Nutrients, chlorofyl a and phytoplankton composition	Water
	WFD	Organic substances	Water
W02	OSPAR-CEMP	Nutrients, heavy metals, organic substances	Water, sediment
	OSPAR-CEMP	Chlorofyl a	Water
	WFD	Nutrients, chlorofyl a and phytoplankton composition	Water
W03	OSPAR-CEMP	Nutrients, heavy metals, organic substances	Water, sediment
	OSPAR-CEMP	Chlorofyl a	Water
	WFD	Nutrients, chlorofyl a and phytoplankton composition	Water
W04	OSPAR-CEMP	Nutrients, heavy metals, organic substances	Water, sediment
W05	OSPAR-CEMP	Nutrients, heavy metals, organic substances	Water, sediment
	WFD	Organic substances	Water
W06	OSPAR-CEMP	Nutrients, heavy metals, organic substances	Water, sediment
	WFD	Organic substances	Water
W07	OSPAR-CEMP	Nutrients, heavy metals, organic substances	Water, sediment
W08	OSPAR-CEMP	Nutrients, heavy metals, organic substances	Water, sediment
W09	OSPAR-CEMP	Nutrients, heavy metals, organic substances	Water, sediment
W10	OSPAR-CEMP	Nutrients, heavy metals, organic substances	Water, sediment
Blankenberge	OSPAR-CEMP	Organic substances and heavy metals	Mussels
	WFD	Methylmercury	Mussels
Oostende	OSPAR-CEMP	Organic substances and heavy metals	Mussels
	WFD	Methylmercury	Mussels
Zeebrugge	OSPAR-CEMP	Organic substances and heavy metals	Mussels
	WFD	Methylmercury	Mussels

[1] Measurements of the main parameters are always accompanied by a number of additional parameters DOC, POC, SPM, etc.

Improvement of assessment thresholds (background and elevated levels)

An improvement or more detailed investigation on the background levels for DIN, DIP and Chlorophyll *a* is advisable, since they cannot easily be objectively defined. The use of coastal ecosystem models with coupled river basin models can further be explored to simulate historical “pristine” conditions prior to the significant increase in anthropogenic nutrient inputs, which is thought to have occurred in the 1960s. Such models are starting to emerge (Lancelot *et al.* 2007a) and may provide valuable information for future refinement and development of the OSPAR concept of “background” levels. The background levels have been examined and updated as explained in Annex 1. Further developments are necessary to decrease the uncertainty of these results.

Trend analysis

The identification of long-term trends in the 90th percentile and mean chlorophyll *a* concentration data, which might be related to nutrient reduction measures, is hampered by two factors:

- Insufficient sampling in time: the natural variability of chlorophyll *a* is high at short time scales (hours/days/weeks), relating to tide and wind events and to the fast biological processes occurring during a phytoplankton bloom. Interannual variability or long-term changes in the sampling (e.g. timing of data acquisition with respect to the timing of the spring phytoplankton bloom, number of data values collected and distribution over year, etc.) will affect results significantly.
- Distinguishing nutrient-related trends from other variability and trends: the natural interannual variability of chlorophyll *a* and phytoplankton species composition (Breton *et al.* 2006) is also high because of interannual variability in the forcing meteorological conditions (wind, rainfall, cloudiness, temperature). The latter may also have long-term trends (either natural or related to anthropogenic climate change). The effect of any nutrient reduction measures on changes in chlorophyll *a* would thus require removal of the interannual and long-term variability from meteorological factors.

The following tools may help tackle these problems in the future:

1. The use of continuously measuring moored instruments of, perhaps, instruments mounted on ships of opportunity (Hydes *et al.* 2006) with a regular route could provide more information on high frequency temporal variability and thus allow better identification of underlying interannual trends.
2. The use of satellite chlorophyll *a* imagery has established that sampling in space in the Belgian coastal waters is sufficient (see Annex 4) and is beginning to provide a considerable improvement for temporal sampling, at least for the high concentration conditions (e.g. 90th percentile) where the satellite data is most reliable. However, a long-time series is not yet available because of the relatively recent launch (since 2002-2003 for MODIS-AQUA/TERRA and MERIS).
3. Ecosystem models could help distinguish between the direct effects of nutrient enrichment and similar effects resulting from changes in meteorological factors. For example, the simulation of nutrient reduction scenarios enables comparison of a control or “baseline” situation with a hypothetical situation with identical meteorology but different nutrient input.

Other factors such as monitoring of nutrients transboundary fluxes and measuring of the deposition of N_2 would also improve the level of assessment.

9. Conclusions

For the second application of the OSPAR Comprehensive Procedure to assess the eutrophication status of the Belgian waters, the assessment parameters used and associated results, are the following:

- There are no direct discharges to Belgian convention waters since 1996. Therefore, only the riverine inputs are assessed. Since no increasing trend is observed for the period 2001-2005 in comparison with the previous years and a decrease of 21 % for N and 40 % for P is observed over a ten-year period, this parameter has been evaluated as absence of increased trends. However, a comparison of the current riverine inputs with background loads or reference conditions has not been possible.

Coastal zone

- The winter dissolved inorganic nitrogen (DIN) at the reference salinity of 33.5 exceeds the OSPAR “elevated” threshold for all five years; the corresponding dissolved inorganic phosphorus (DIP) exceeds the elevated threshold for three out of the five assessment years. No temporal trends can be deduced from these analyses although the longer-term analysis suggested a previous decrease in the riverine discharge of DIP (Rousseau *et al*. 2004).
- The N/P ratio exceeds the elevated level in every assessment year.
- In the coastal zone the 90^{th} percentile chlorophyll *a* concentration exceeded the elevated level, more precisely along the Belgian coast from the Belgian-French border to the Belgian-Dutch border and extends offshore from about 20km in the western part of the Belgian coast to about 30 km in the East (Dutch border). An evaluation of the mean chlorophyll *a* concentration gives the same result.
- Macrophytes are not relevant for the Belgian marine waters and oxygen concentration has always been reported as above the threshold.
- The other assessment parameters were not systematically monitored for the current assessment, but the significant presence of *Phaeocystis* blooms and the evidence for changes in zoobenthos communities has contributed to the overall area classification as a eutrophication problem area.

Offshore zone

- For none of the years in the period 2001-2005, the threshold for DIP is exceeded. The winter means are below the elevated threshold values for DIN and DIP. The averaged result is identical to the “per year” result for DIP, but not for DIN, for which the threshold was exceeded in two of the five winters. As an overall result, no significant nutrient enrichment of DIN or DIP has been observed in the offshore waters for the period 2001-2005.
- For Chlorophyll *a* 90% concentration, the averaged result exceeds the threshold value. However, this result is preliminary as it was not based on a sufficient spatial extent of the monitoring.
- No data are available to identify the extent of the *Phaeocystis* blooms until the offshore waters. Therefore this parameter is considered to remain inconclusive for the offshore waters

→ Overall result: Despite the reduction in N and P inputs during the previous years, the Belgian coast is still assessed as a problem area, whereas the offshore area is characterized as a potential problem area, for the period 2001-2005.

10. Acknowledgements

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12. Annexes

Annex 1

Table 13 gives an overview of the background and elevated threshold concentrations for the nutrient enrichment and direct effect parameters, used for the eutrophication status assessment for the period 2001-2005, and discussed in this Annex 1 section.

Table 13: Background and elevated threshold concentrations for DIN, DIP and chlorophyll *a*.

<table>
<tr><th colspan="2">Category</th><th colspan="2">Coast (<= 34,5)</th><th colspan="2">Offshore (> 34,5)</th></tr>
<tr><td></td><td></td><td>Background concentration >= H/G boundary</td><td>Elevated concentration >= G/M boundary</td><td>Background concentration</td><td>Elevated concentration</td></tr>
<tr><td rowspan="2">Nutrient enrichment (I) (µmol/l) (at reference salinity 33,5)</td><td>Winter DIN concentrations</td><td>10</td><td>15</td><td>8</td><td>12</td></tr>
<tr><td>Winter DIP concentrations</td><td>0,6</td><td>0,8</td><td>0,6</td><td>0,8</td></tr>
<tr><td rowspan="2">Direct effects (II) (µg/l)</td><td>90% chlorophyll a concentration</td><td>10</td><td>15</td><td>5,6</td><td>8,4</td></tr>
<tr><td>Mean chlorophyll a concentration</td><td>5</td><td>7,5</td><td>2,8</td><td>4,2</td></tr>
</table>

In annex 2c (on the area-specific background concentrations of nutrients during winter (XI-II) and chlorophyll *a* during growing season (III-X) and their related elevated levels) of the Common Procedure for the Identification of the Eutrophication Status of the OSPAR Maritime Area (Reference number: 2005-3) a chlorophyll *a* concentration of 10 µg/l was defined as background concentration and 15 µg/l as the elevated level for the mean chlorophyll *a* concentration. A chlorophyll *a* concentration of 15 µg/l was defined as background concentration and 22,5 µg/l as the elevated level for chlorophyll maxima. In the first application of the Common Procedure a background concentration of 10 µg/l and an elevated level of 15 µg/l had been defined for both the mean and the maxima, although it had only been applied to the maxima in the first assessment. To differentiate the levels between the mean and the maxima, the levels were adjusted for the maxima. However, Figure 20a and 20b indicate that, using these thresholds, problems of exceedence of the threshold would occur in a smaller area than assessed for nutrients. A better corresponding result was obtained applying the background concentration of 10 µg/l and the elevated level of 15 µg/l to the 90th percentile chlorophyll *a* concentration, comparable to the application of these levels to the maxima in the first application. Because of the created confusion on the adjustment of the levels, the background and elevated levels for chlorophyll *a* and nutrients have been investigated on their correctness, as illustrated below.

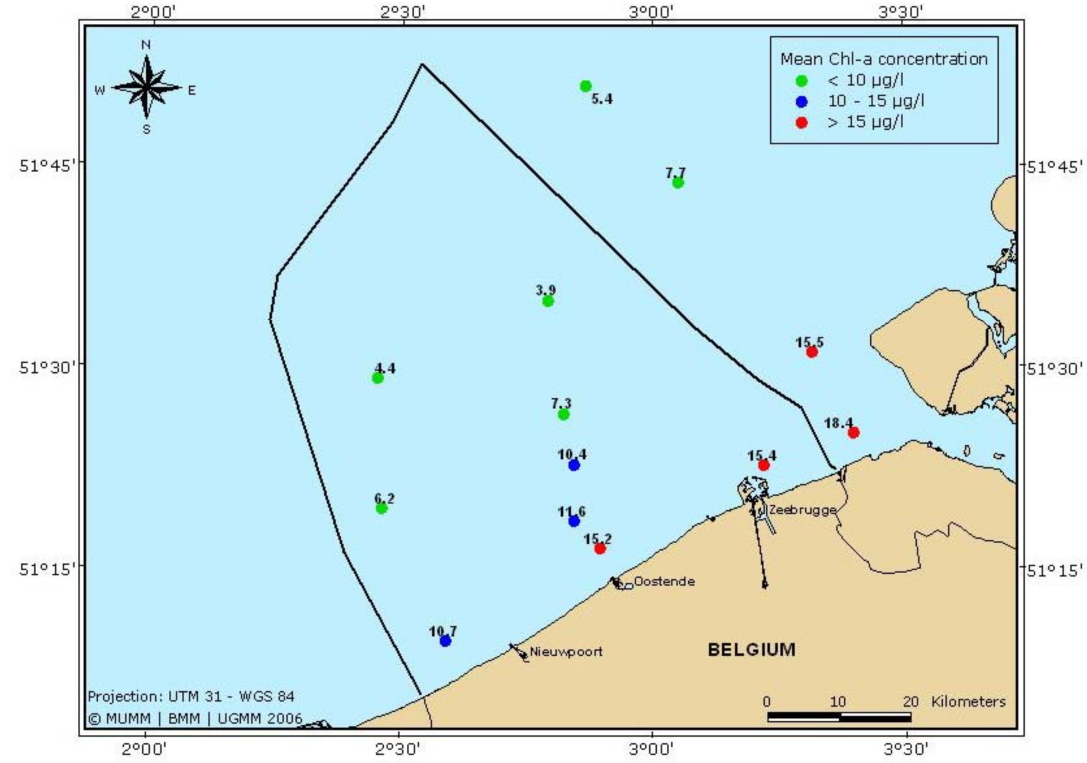


Figure 20a: Mean chlorophyll *a* concentration for the growing seasons 2001-2005.

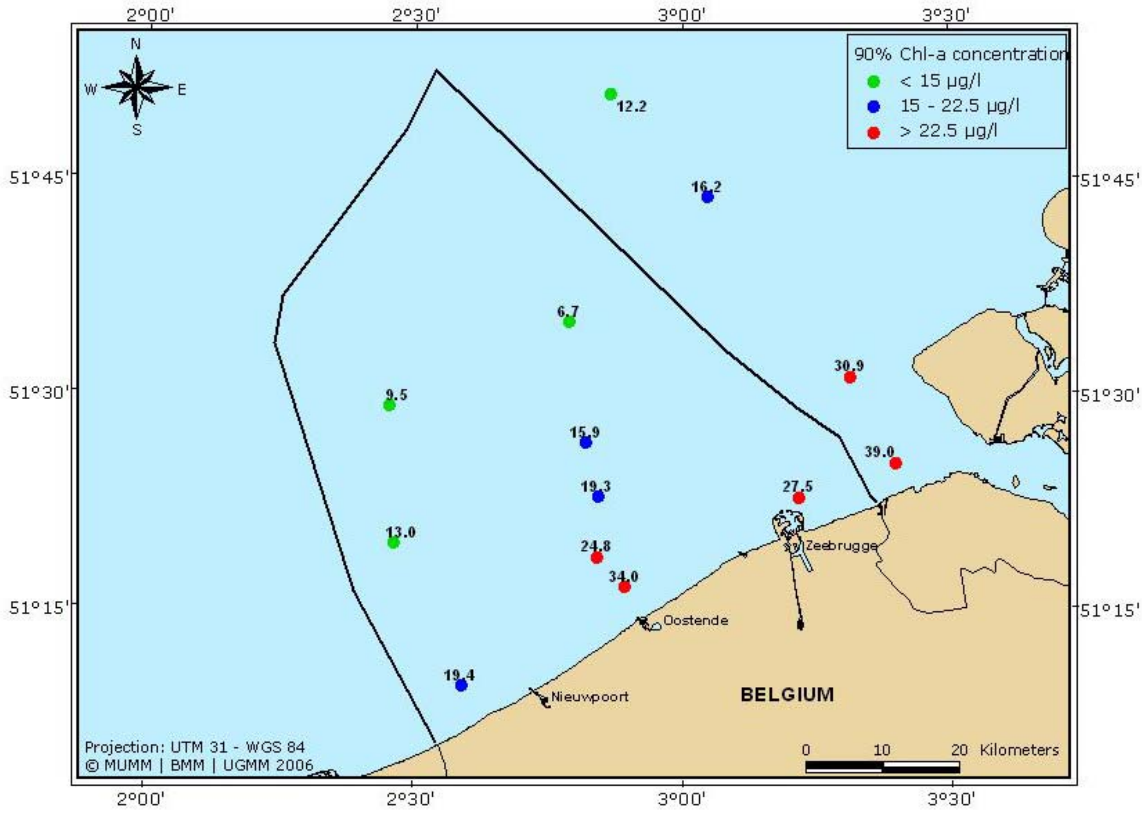


Figure 20b: 90th percentile of chlorophyll *a* concentration for the growing seasons 2001-2005

NUTRIENTS – NUTRIENT ENRICHMENT

Belgian reference / background DIN concentrations

The background levels themselves cannot easily be objectively defined. A currently developing approach is using coastal ecosystem models with coupled river basin models to simulate historical “pristine” conditions prior to the significant increase in anthropogenic nutrient inputs, which is thought to have caused the most severe impacts from the 1960s onwards. Such models are starting to emerge (Lancelot *et al.* 2007) and are providing valuable information for the further development of Belgian reference or “background” levels. However, for the first application of the OSPAR Common Procedure (Belgium 2002), the background levels were chosen somewhat arbitrary. The background levels for DIN and DIP in Belgian waters were taken as 10.0 µmol/l and 0.6 µmol/l respectively, based on an analysis of monitoring data available (for the whole OSPAR area) in 2001 in the ICES database. Corresponding elevated levels for DIN and DIP in Belgian waters were set at 15 µmol/l and 0.8 µmol/l respectively. These background and elevated levels are also used in the second application of the Common Procedure but for coastal waters only. A distinction has been made between coastal and offshore waters (waters with mean annual salinity of > 34,5) in the second application of the OSPAR Common Procedure (Belgium 2007).

Modeling reference/background conditions through modeling of retrospective scenarios:
The modeling results of four projects (financed by the Federal Science Policy of Belgium) have been taken into account to define the natural background nutrient and phytoplankton concentrations in Belgian coastal waters:

- Project AMORE: Advanced Modeling and Research on eutrophication (three periods: AMORE: 1/1/1997-31/12/2001, AMORE II: 1/2/2002-30/4/2006, AMORE III: 15/12/2006-31/1/2009) in combination with project IZEUT (Identification of maritime zones affected by eutrophication: 1/1/2000-31/12/2001)
- Project REFCOAST: Typology, Reference condition and Classification of the Belgian coastal waters: 15/12/2003-31/10/2006
- Project TIMOTHY: Tracing and Integrated Modeling of Natural and Anthropogenic Effects on Hydrosystems: The Scheldt River Basin and Adjacent Coastal North Sea: 15/12/2006-31/1/2009.

In different research projects, the RIVERSTRAHLER model, an idealized biogeochemical model of the river system, has been coupled to MIRO, a complex biogeochemical model describing diatom and *Phaeocystis* blooms in the marine domain, to investigate the link between changing human activities over the past 50 years and coastal eutrophication in the eastern Channel and Southern Bight of the North Sea with a focus on the Belgian coastal zone (Lancelot *et al.*, 2007b). The link between the variations over the past 50 years in watershed agricultural, domestic and industrial activities and the nitrogen, phosphorus and silica delivery to the sea, has been established for the river Seine (Billen *et al.* 2001) and the river Scheldt (Billen *et al.* 2005), based on results obtained with the idealized RIVERSTRAHLER model. The 1950–1998 variations in winter nutrient concentrations and stoichiometry have been estimated from these coupled RIVERSTRAHLER–MIRO simulations for a station in the center of the Belgian marine waters with a reference salinity of 33,5. Modeling results have been validated with nutrient and phytoplankton concentrations, intensively monitored at this station (Rousseau, 2000; Breton *et al.*, 2006) over the 1992–1998 period (Rousseau *et al.*, 2004). Unfortunately such data are not detailed for the early seventies when both N and P loads increased

(Billen *et al.*, 2005). For modeled winter NO_3 concentrations, an increase from 15 µM in 1950 up to 40 µM in 1994 has been simulated, whereas R–MIRO winter NH_4 shows little variation around 5 µM. This means that a winter concentration of about 20 µM of DIN was modeled for 1950. Winter PO_4 shows the most complex behavior over the simulated period, being minimal in early 1950 at a value of about 1 µM. However, the situation in the fifties reflected already a situation of enrichment of nutrients and cannot be considered as a pristine reference situation. Based on the outcome of the REFCOAST chlorophyll *a* modeling for a pristine scenario, values were about half (55%) the concentrations of the fifties. This means that roughly, the background winter DIN concentrations should be at least about half of the concentrations found in the fifties, this results in about 10 µM as background level.

Projects AMOREIII - TIMOTHY
Modeling results of retrospective scenarios for nutrients earlier than the fifties have not been reported yet, but some preliminary indicative results are available (unpublished yet). Further applications conducted with the multi-box MIRO have focused on the search of ecological reference conditions for *Phaeocystis*-dominated coastal ecosystems based on an historical reconstruction of eutrophication (-50 years) and with reference to a 'pristine scenario'. Preliminary historical MIRO model simulations of winter nutrient conditions at a station in the center of the Belgian marine waters (reference salinity of 33,5), making use of RIVERSTRAHLER simulations as nutrient loads, showed a reference DIN concentration of 10 µmol/l and for DIP a concentration of 0.73 µmol/l for the pristine scenario, presented as a hypothetical state of the Scheldt basin before any human disturbance. Other retrospective scenarios, including 'traditional' cottage economy, are under consideration for the Scheldt river system, but are presently not available.
The nutrient standards to be selected for Belgian coastal waters are subject to further research within the project TIMOTHY.

Relationship along salinity gradient

In order to verify if selected threshold values for coastal and offshore waters relate in the right way to each other, Belgian DIN data are plotted against salinity in the form of a mixing diagram for the winters from 2000 to 2005 (Figure 21). After elimination of a few obvious outliers, the measured values can be compared with nutrient standards defined for different salinities along the outflow of the river, in order to verify the consistency and correctness of different nutrient standards used at different places (salinities) along the mouth and the outflow of the river. For the Belgian situation, the point of departure for the nutrient setting along a salinity gradient was the estimated and modeled background concentration of 10 µmol/l DIN at a station in the center of the Belgian marine waters with reference salinity 33,5.
An offshore endpoint value at a salinity of 34,5 should then be chosen in this way that, in connection with the value at salinity 33,5, the reference values' trendline has a slope, leading to an acceptable freshwater end reference DIN value for salinity 0 = 77 µM. In this way the value of 8 µmol/l DIN has been chosen for salinity 34,5. So far, linearity is assumed as a simple representation of the relationship between DIN and salinity. A background value of 17 µmol/l DIN for a reference salinity of 30 fits perfectly on this trendline.

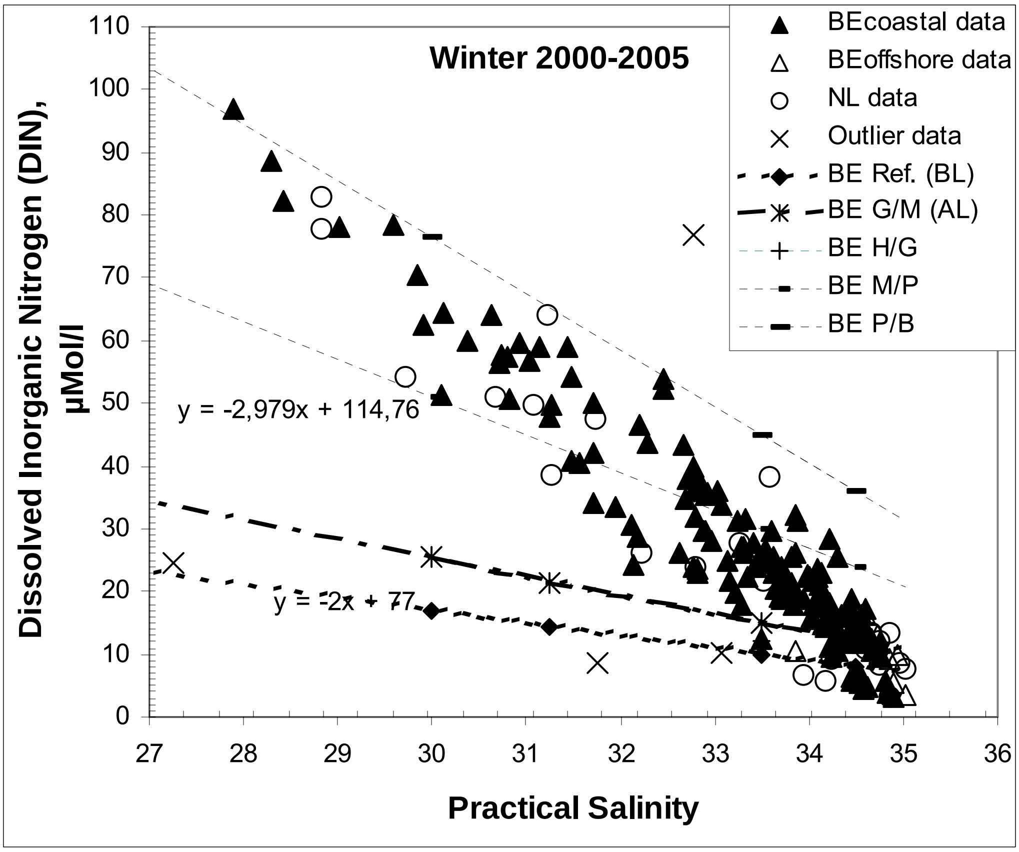


Figure 21: Winter DIN values from 2000-2005 with threshold trendlines for OSPAR background (BL) and assessment levels (AL) and WFD status class thresholds fitted along the salinity gradient. WFD terminology: B = bad, P = poor, M = moderate, G = good, H = high. P/B is the threshold between the classes poor and bad.

DIRECT EFFECTS OF NUTRIENT ENRICHMENT

SETTING PHYTOPLANKTON THRESHOLDS:

For the first application of the OSPAR Common Procedure (Belgium 2002), the assessment level for chlorophyll *a* (15 µmol/l) was defined based on threshold concentrations of *Phaeocystis* that would not ensure the ecological functioning of the coastal ecosystem.

Historical records of *Phaeocystis* blooms in the Eastern Southern Bight of the North Sea trace back to the end of the 19th century (Cadée and Hegeman, 1991). Coupling the coastal MIRO model to the RIVERSTRAHLER model in the AMORE project, historical reconstruction back to the fifties suggests that *Phaeocystis* colonies were already blooming in BCZ in the early 1950's and were sharing almost equally with diatoms, the bulk of annual primary production (Lancelot *et al.*, 2007b). Since *Phaeocystis* is also occurring in natural conditions in the Belgian coastal waters, a natural background concentration of *Phaeocystis* has to be defined in relation to an unacceptable concentration due to eutrophication.

A chlorophyll threshold has been defined as the sum of a natural diatom chlorophyll *a* background concentration and a maximum acceptable chlorophyll *a* concentration of *Phaeocystis*. The natural diatom chlorophyll *a* background concentration has been defined as follows. Analysis of the

Phaeocystis pre-bloom situation during a 13-year time series at a monitoring station (330) located in the centre of the Belgian coastal zone (reference salinity 33,5) showed an average of 9.2 µg L^{-1} Chl-a diatom concentration. A *Phaeocystis* cell concentration of 10^7 L^{-1} has been identified as an eutrophication problem. This cell concentration equals a mean Chl-a concentration of 5 µg l^{-1} (C:Chla = 29) using 0.5 pg Chl-a per *Phaeocystis* cell (Rousseau *et al.*, 1990). Therefore, the threshold of a MEAN concentration of 15 µg l-1 chlorophyll *a* has been defined from which nutrient over-enrichment would result in ecosystem disturbance in the coastal area. Since this value is now applied to the 90% instead of the mean, this means that a threshold is applied that is twice as strict as for the mean. Further preliminary evidence of unacceptable *Phaeocystis* concentrations is found in the fact that *Phaeocystis* colonies above 400 µm, corresponding to 4 10^6 cells L^{-1} *Phaeocystis* cell density, start to have such a size that they may not be ingested anymore by copepods as explained in the section on Ecological Quality Objectives of this report.

Modelling of pristine scenario

Further applications conducted within the projects AMOREIII - TIMOTHY with the multi-box MIRO have focused on the search of ecological reference conditions for *Phaeocystis*-dominated coastal ecosystems with reference to a 'pristine scenario'. The modeled mean chlorophyll *a* concentration amounts to about 3 µg/l, corresponding to (x 2.0435 (Figure 22)) a 90% chlorophyll *a* background concentration of 6,13 µg/l. This value approaches the value of 7 µg/l that has been calculated from the relationship between chlorophyll *a* and DIN (background concentration of 10 µmol/l) and approaches the reference value for chlorophyll *a* in the WFD (6,67 µmol/l for 90th percentile), but is still below the the estimated background level of 10 µg/l chlorophyll *a* for the OSPAR assessment.

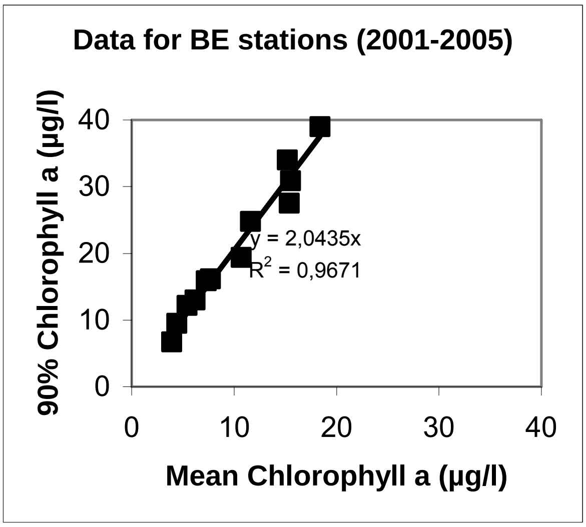


Figure 22: relationship between mean chlorophyll *a* and 90% chlorophyll a concentration

Relationship between winter DIN and spring chlorophyll a concentration

Another relationship that can support the consistency in parameter setting is the relationship between winter DIN and spring chlorophyll *a* concentration. This has been examined plotting DIN and chlorophyll *a* data from 2001 until 2005 in a mixing diagram (Figure 23). The derived relationship is the following: spring 90 % chlorophyll *a* concentration = 0.7 X mean winter DIN concentration or spring mean chlorophyll *a* concentration = 0.33 X mean winter DIN concentration.

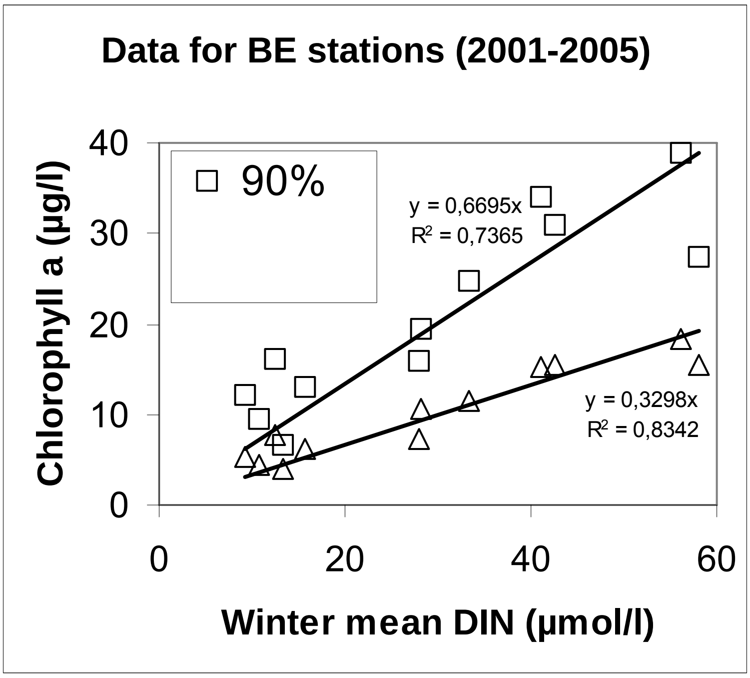


Figure 23: relationship between mean and 90% chlorophyll *a* concentration and winter DIN concentration.

A difficulty is that OSPAR EUC agreed to adopt two single values for the background and the assessment value for chlorophyll *a*, not corrected to a reference salinity, whereas chlorophyll *a* shows also a relationship with salinity, through the relationship of chlorophyll *a* with DIN (DIP). Table 14 illustrates calculations of the corresponding chlorophyll *a* concentrations in relation to DIN concentrations for the two extremes of salinity (30 and 33,5) occurring along the Belgian coastal area. The outcome for chl a concentration based on the DIN concentration for the reference salinity 33,5 is lower than the result that had been estimated based on diatom and *Phaeocystis* concentrations that would not ensure the ecological functioning of the coastal ecosystem. The 90th percentile background concentration of 10 µg/l and the elevated level of 15 µg/l can be considered as an acceptable median value between the values at salinity 30 and 33,5. Further examination is needed on the relationships of chlorophyll *a* with TN and TP instead of with winter DIN and DIP, in order to verify the choice of correct chlorophyll *a* background concentrations and elevated threshold levels.

Table 14: Calculated 90th percentile chlorophyll *a* background and elevated concentrations based on the relationship between DIN and chlorophyll *a* derived from measurements

For the coastal area:

	Background/reference concentration		Elevated/assessment concentration	
Reference salinity	30 (near mouth of the Scheldt)	33,5 (near the French border)	30 (near mouth of the Scheldt)	33,5 (near the French border)
DIN	17 µmol/l	10 µmol/l	25,5 µmol/l	15 µmol/l
Chlorophyll *a* (= DIN x 0.7)	12 µg/l	7 µg/l	18 µg/l	10,5 µg/l
Mean of two values	9,5 µmol/l		14,25 µmol/l	

For the offshore area:

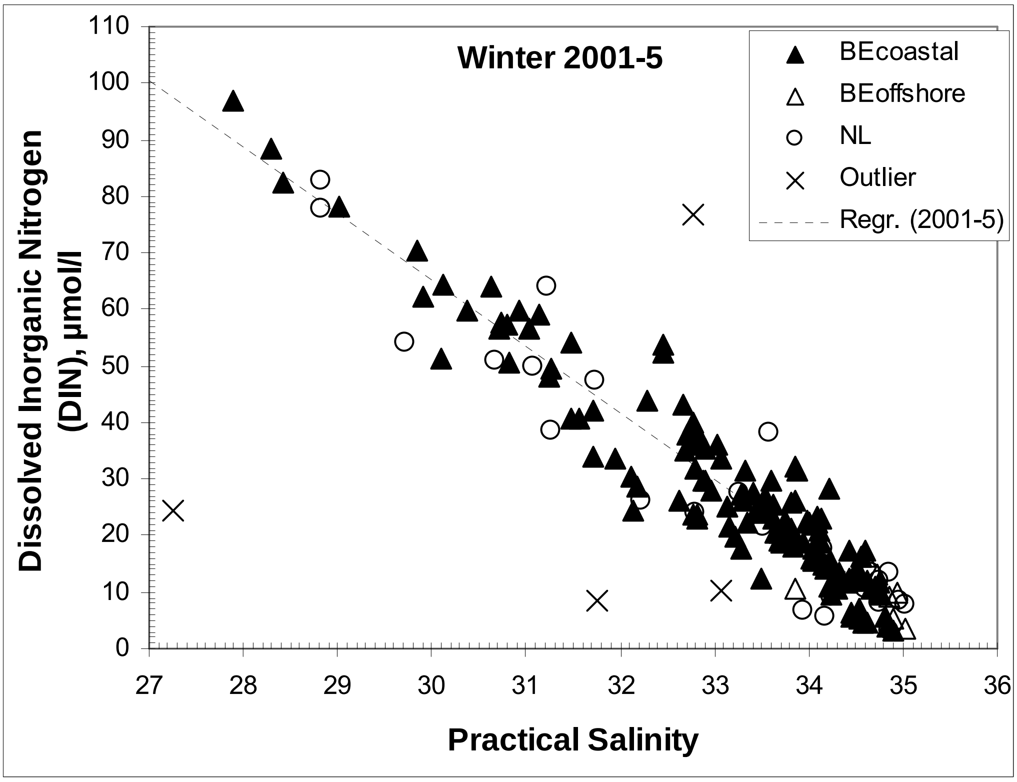
Offshore zone	Background/reference concentration	Elevated/assessment concentration
DIN	8 µmol/l	12 µmol/l
Chlorophyll *a* (= DIN x 0.7)	5,6 µg/l	8,4 µg/l

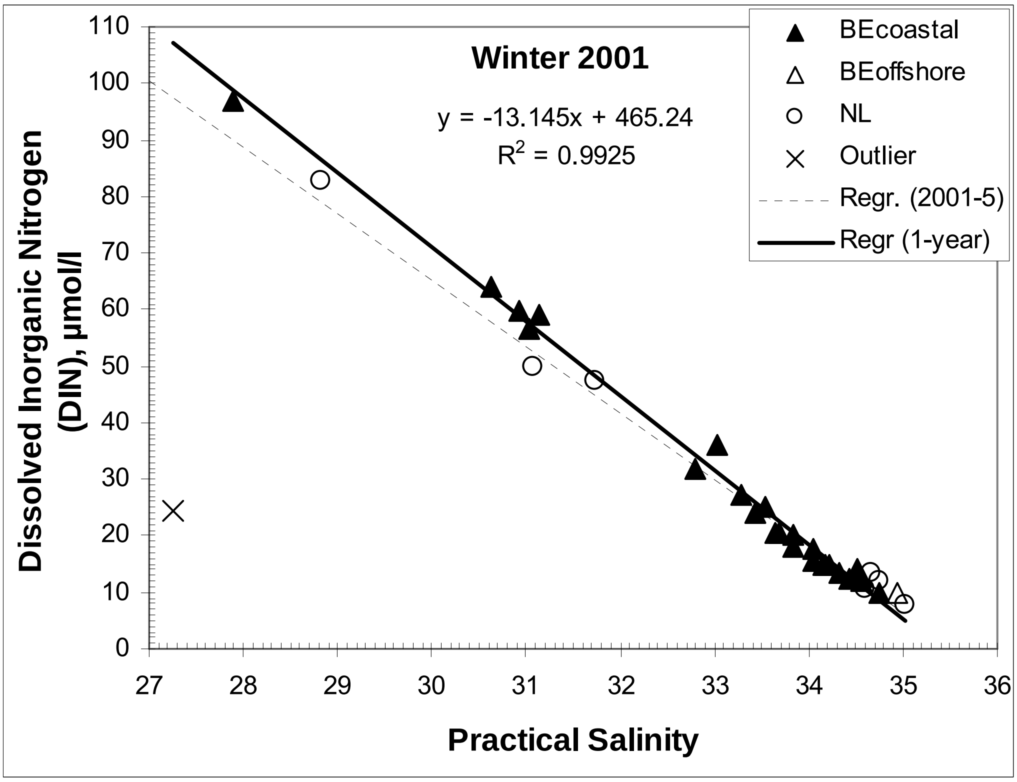
Prospective modeling scenario's for 2015 have shown that with the implementation of required measures to reduce P and N inputs the chlorophyll *a* concentration may drop underneath the threshold of 15 µmol/l, but that this concentration of primary production can still be dominated by *Phaeocystis* instead of diatoms, due to an imbalance of availability of N and P. Hence chlorophyll *a* thresholds always have to be combined with *Phaeocystis* or nutrient relationship thresholds in order to assess eutrophication problems, reflecting a disturbance of the natural equilibrium. A nutrient threshold for *Phaeocystis* disturbance has been therefore developed based on historical MIRO model simulations making use of RIVERSTRAHLER simulations as nutrient loads.

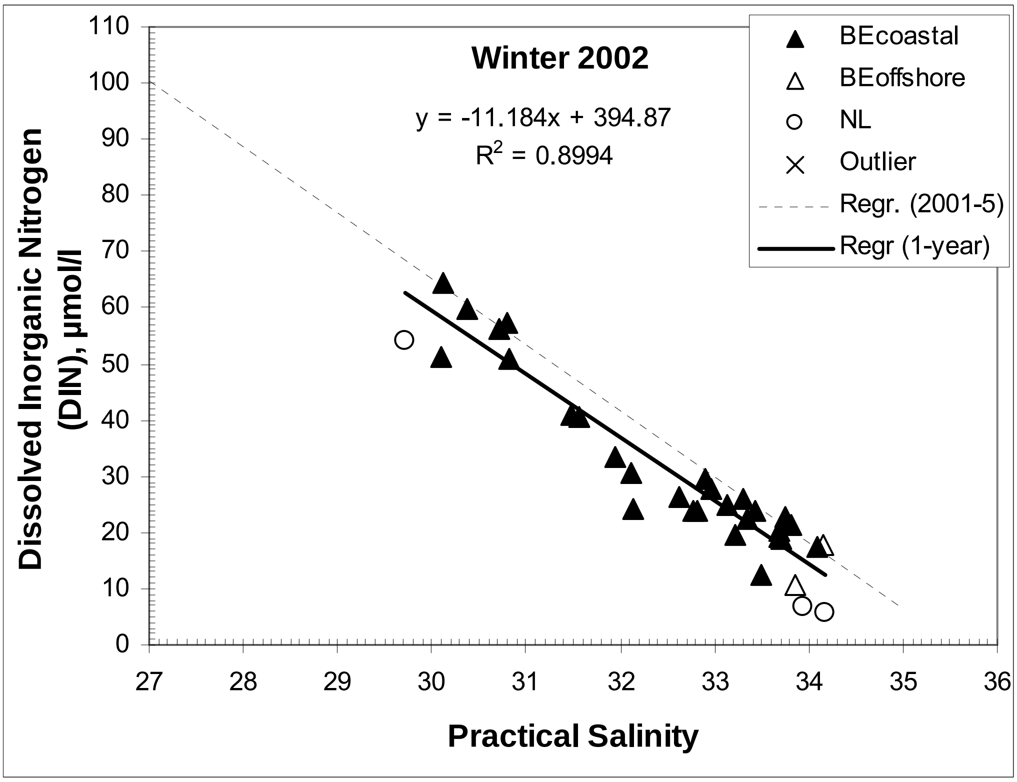
References

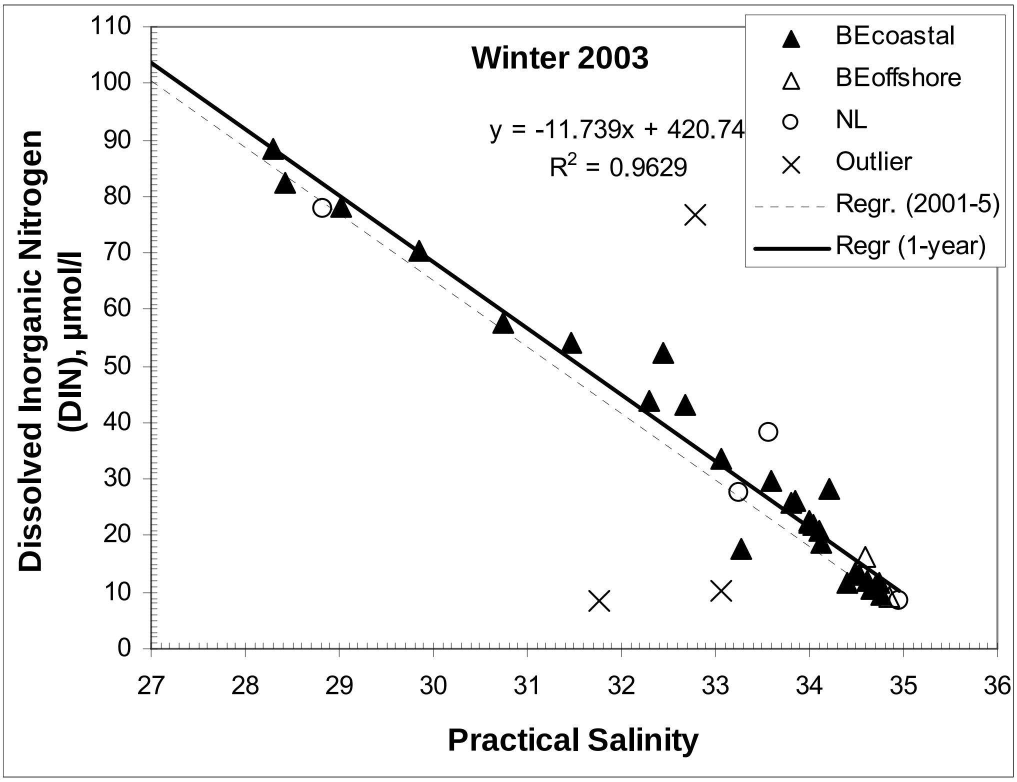
Included in section 11 above in the references of the report.

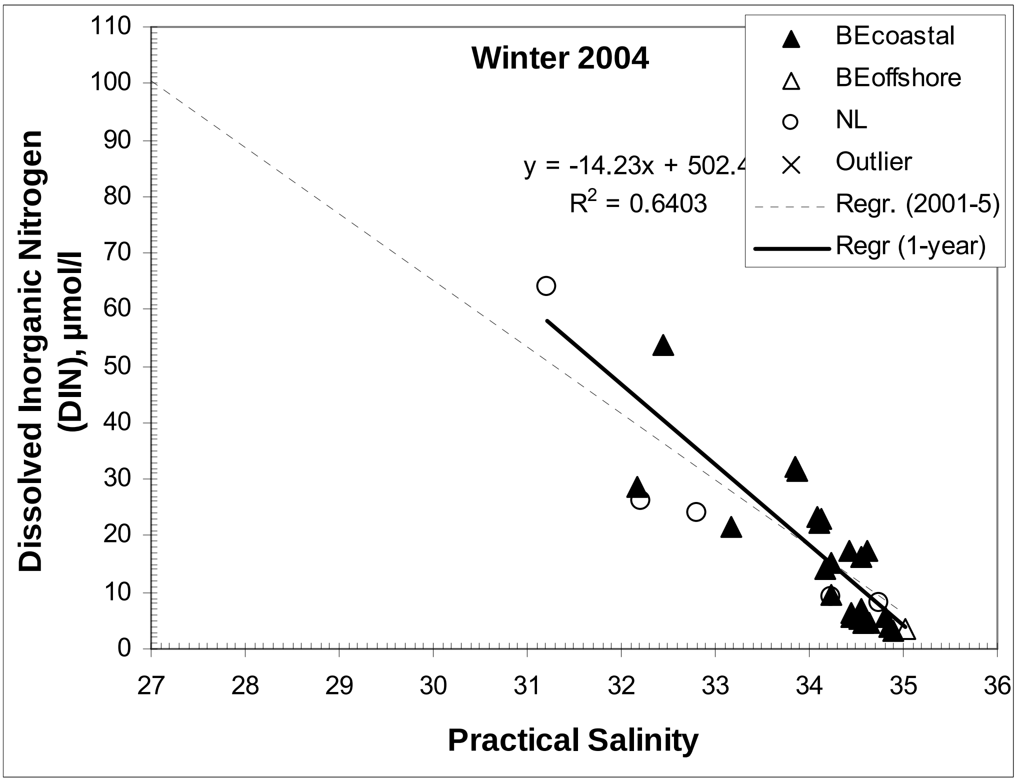
Annex 2 – Salinity-DIN mixing diagrams for winters 2001-2005. The linear regression for each year is shown as a solid line. For comparison the 5-year regression line is shown as a dashed line. Data rejected as outliers are given as crosses, accepted data in Belgian coastal waters (salinity-gradient influenced) are given as solid triangles. For information, data in Belgian offshore waters (open triangles) and nearby Dutch waters (open circles) are also given but are not used for calculation of the regression line.

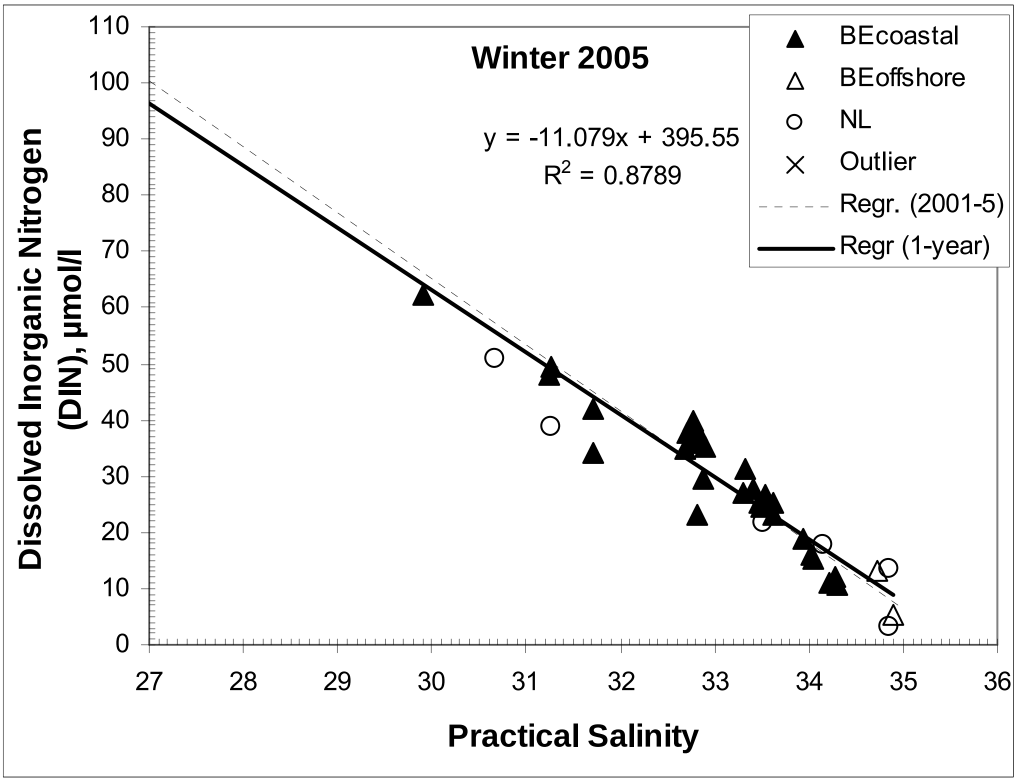



Winter 2001
y = -13.145x + 465.24
R2 = 0.9925
BEcoastal
BEoffshore
NL
Outlier
Regr. (2001-5)
Regr (1-year)
Dissolved Inorganic Nitrogen (DIN), µmol/l
Practical Salinity

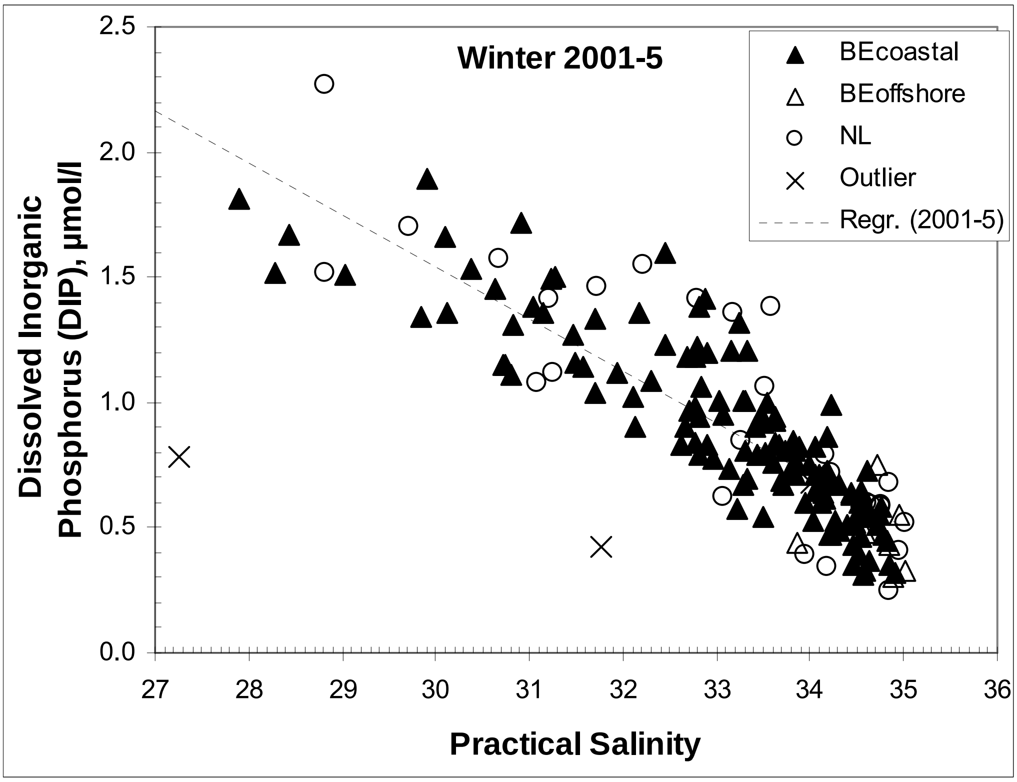

Winter 2002
y = -11.184x + 394.87
R2 = 0.8994
BEcoastal
BEoffshore
NL
Outlier
Regr. (2001-5)
Regr (1-year)
Dissolved Inorganic Nitrogen (DIN), µmol/l
Practical Salinity

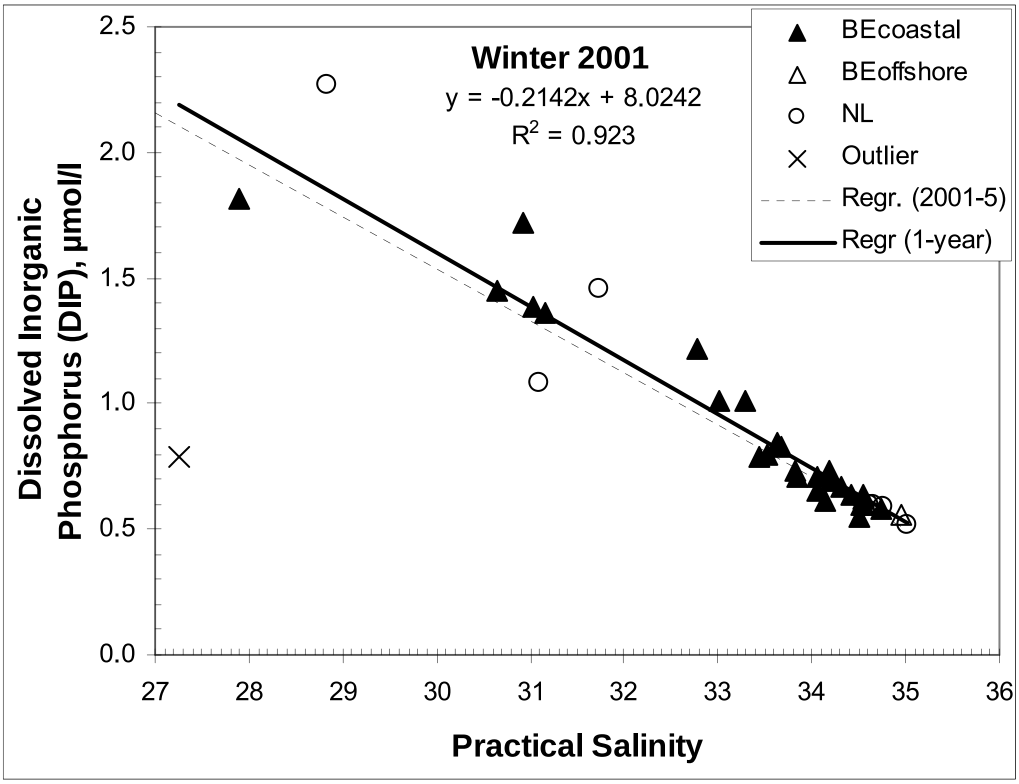

Winter 2003
y = -11.739x + 420.74
R^2 = 0.9629
BEcoastal
BEoffshore
NL
Outlier
Regr. (2001-5)
Regr (1-year)
Dissolved Inorganic Nitrogen (DIN), µmol/l
Practical Salinity

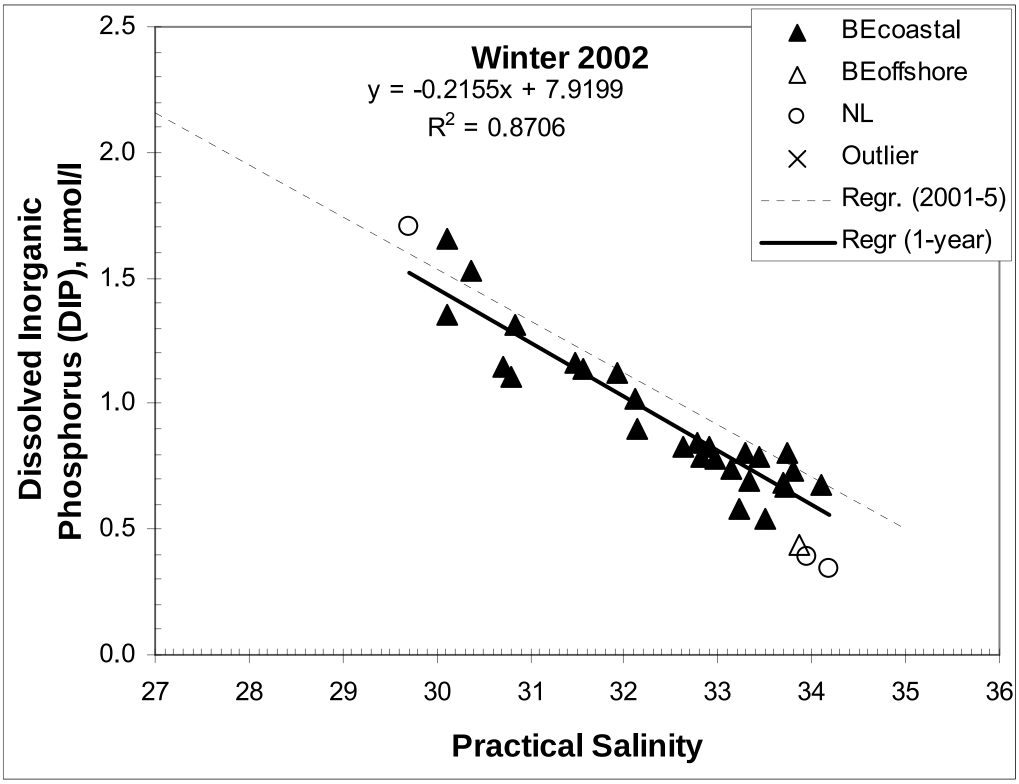

Winter 2004
y = -14.23x + 502.4
R^2 = 0.6403
BEcoastal
BEoffshore
NL
Outlier
Regr. (2001-5)
Regr (1-year)
Dissolved Inorganic Nitrogen (DIN), µmol/l
Practical Salinity

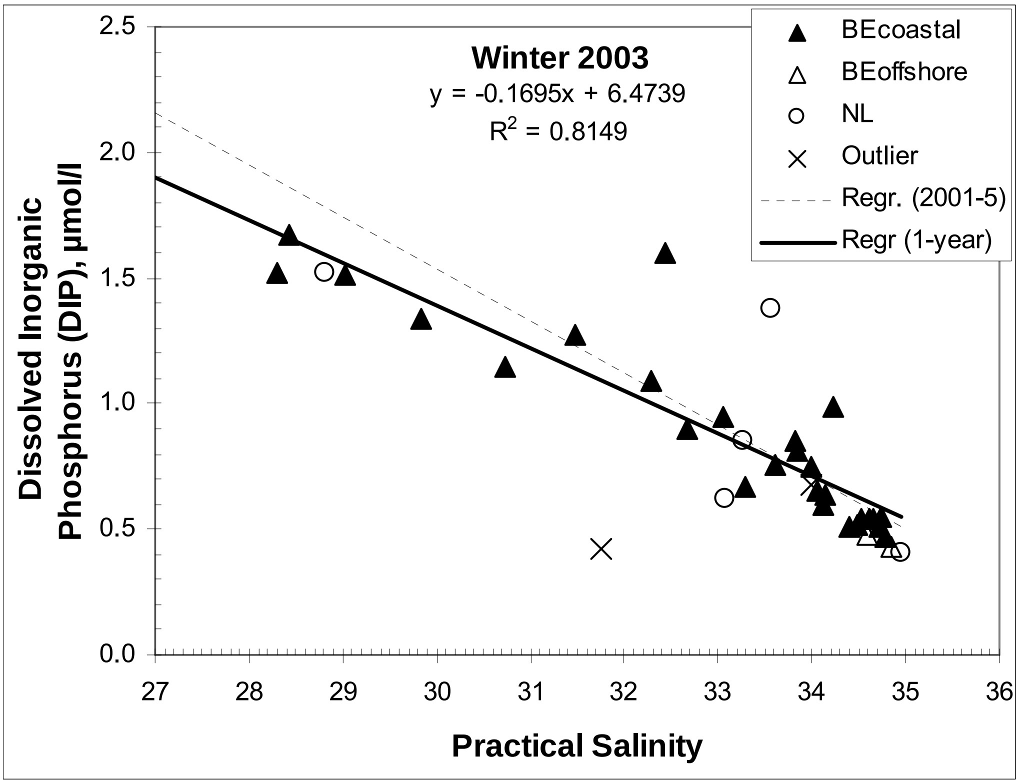

Winter 2005
y = -11.079x + 395.55
R^2 = 0.8789
BEcoastal
BEoffshore
NL
Outlier
Regr. (2001-5)
Regr (1-year)
Dissolved Inorganic Nitrogen (DIN), µmol/l
Practical Salinity
110
100
90
80
70
60
50
40
30
20
10
0
27
28
29
30
31
32
33
34
35
36

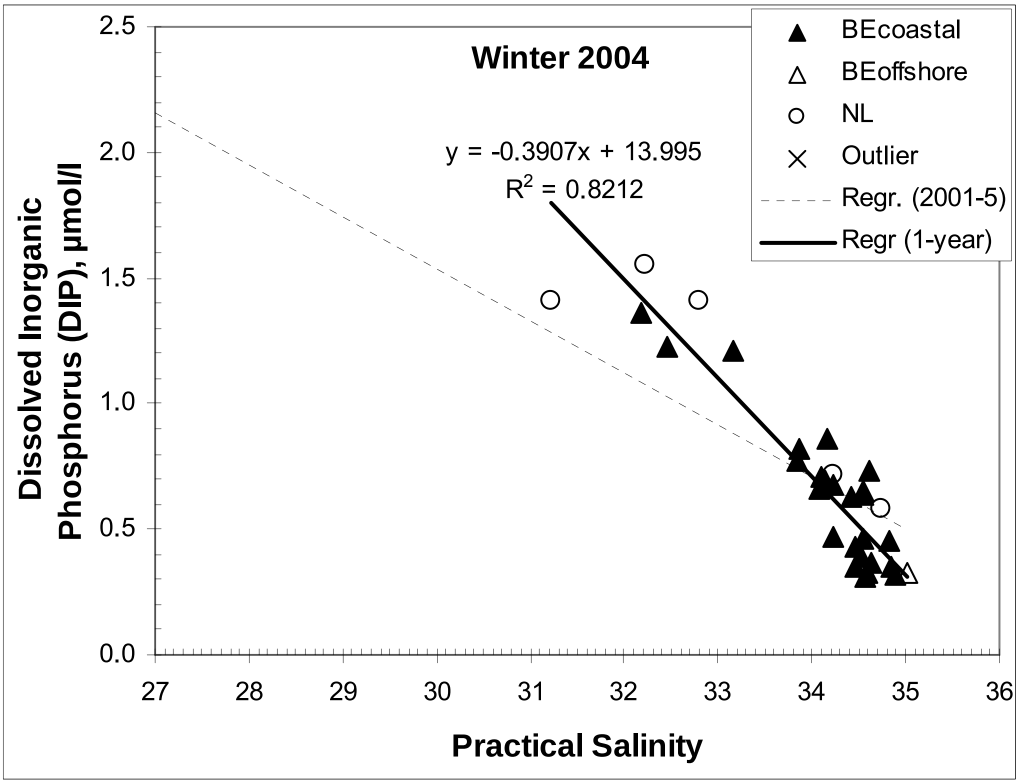
Annex 3 – Salinity-DIP mixing diagrams for winters 2001-2005. The linear regression for each year is shown as a solid line. For comparison the 5-year regression line is shown as a dashed line. Data rejected as outliers are given as crosses, accepted data in Belgian coastal waters (salinity-gradient influenced) are given as solid triangles. For information, data in Belgian offshore waters (open triangles) and nearby Dutch waters (open circles) are also given but are not used for calculation of the regression line.

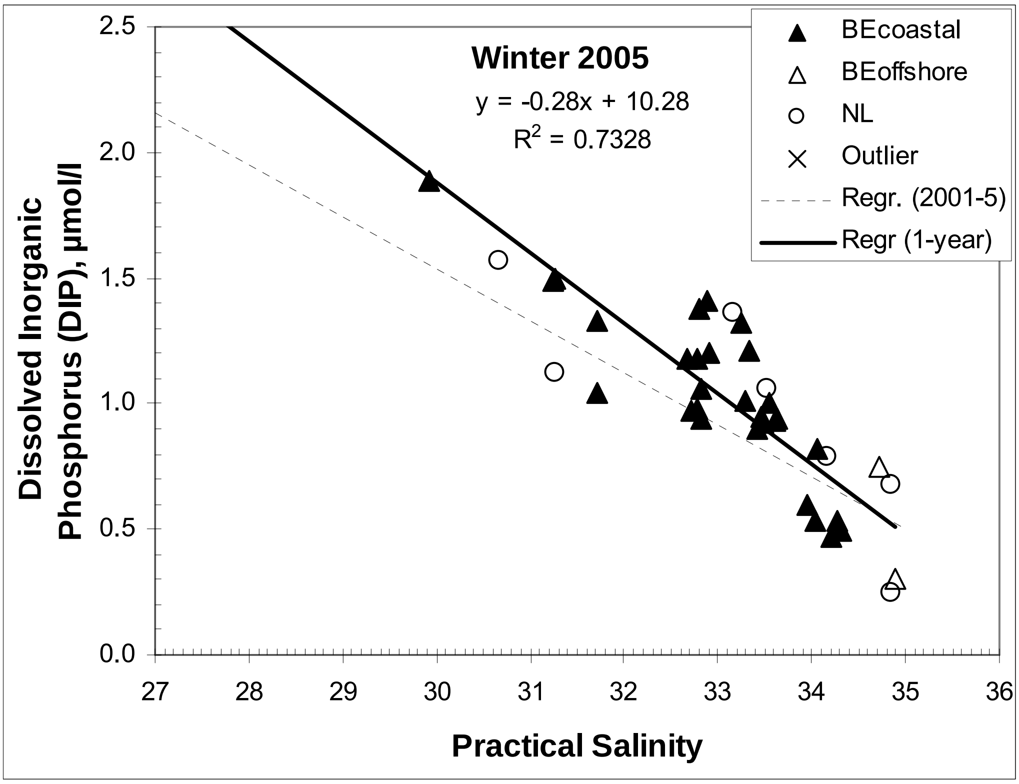



Winter 2001
y = -0.2142x + 8.0242
R2 = 0.923
BEcoastal
BEoffshore
NL
Outlier
Regr. (2001-5)
Regr (1-year)
Dissolved Inorganic Phosphorus (DIP), µmol/l
Practical Salinity
2.5
2.0
1.5
1.0
0.5
0.0
27
28
29
30
31
32
33
34
35
36


Winter 2002
y = -0.2155x + 7.9199
R2 = 0.8706
BEcoastal
BEoffshore
NL
Outlier
Regr. (2001-5)
Regr (1-year)
Dissolved Inorganic Phosphorus (DIP), µmol/l
Practical Salinity
2.5
2.0
1.5
1.0
0.5
0.0
27
28
29
30
31
32
33
34
35
36


Winter 2003
y = -0.1695x + 6.4739
R2 = 0.8149
BEcoastal
BEoffshore
NL
Outlier
Regr. (2001-5)
Regr (1-year)
Dissolved Inorganic Phosphorus (DIP), µmol/l
Practical Salinity
2.5
2.0
1.5
1.0
0.5
0.0
27
28
29
30
31
32
33
34
35
36


Winter 2004
y = -0.3907x + 13.995
R2 = 0.8212
BEcoastal
BEoffshore
NL
Outlier
Regr. (2001-5)
Regr (1-year)
Dissolved Inorganic Phosphorus (DIP), µmol/l
Practical Salinity
2.5
2.0
1.5
1.0
0.5
0.0
27
28
29
30
31
32
33
34
35
36



Winter 2005
y = -0.28x + 10.28
R^2 = 0.7328
BEcoastal
BEoffshore
NL
Outlier
Regr. (2001-5)
Regr (1-year)
Dissolved Inorganic Phosphorus (DIP), µmol/l
Practical Salinity
2.5
2.0
1.5
1.0
0.5
0.0
27
28
29
30
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36

Annex 4 - Use of satellite data for the analysis of spatio-temporal sampling strategy for assessment of eutrophication direct effects.

It is recognized that the procedure that has been defined for classification of an area as a eutrophication problem, potential problem or non-problem area depends on the spatio-temporal sampling and processing of eutrophication-related data. As a trivial example, it was demonstrated (Belgium 2004) that, for Belgian waters, if data acquired during the month of April (the time of the highest biomass phytoplankton blooms) is excluded from the analysis then the OSPAR Comprehensive Procedure would result in classifying these waters as a non-problem area instead of a problem area. In recognition of such problems, the JAMP required the preparation of Guidelines on monitoring frequency and spatial coverage for nutrients and eutrophication parameters and the ETG set up a Intersessional Correspondance Group on monitoring (ICG Monitoring) to compile documents describing "case studies" and existing "good practice" guidance documents relating to the variability of eutrophication assessment parameters and corresponding spatial and temporal sampling strategies. In the present annex the spatial sampling strategy for chlorophyll *a* is assessed using satellite imagery from the MERIS sensor.

Case studies of Belgian waters (Belgium 2004) have shown that:

- Spatial surveys carried out monthly or less frequently cannot be used to detect long term trends in eutrophication effects.
- Even weekly sampling at a single location carries a large uncertainty for estimation of maximum and mean chlorophyll during the growing season.

A summary of the horizontal and vertical length scales and the time scale for variation of DIN, DIP, chlorophyll *a* and phytoplankton and monitoring practice in Belgium (Belgium 2006) concluded that for the purposes of determination of eutrophication problem and non-problem areas the spatial and temporal sampling of monitoring data that will be available for the 2nd Comprehensive Assessment of Belgian waters (period 2001-5) is thought to be adequate. The following weaknesses were, however, noted, in order of decreasing importance:

1. Chlorophyll *a* concentration during the spring bloom varies rapidly and there may be some impact of under sampling on results particularly for maximum concentration. This sampling problem was outlined in (Belgium 2004) and requires further investigation with theoretical analysis, *in situ* data, model simulations and satellite data.

2. All assessment parameters vary in time because of horizontal advection by tide- and wind-driven currents. In view of this high frequency natural variability, the temporal sampling is probably insufficient to assess any underlying trends that could be related to long term variability between the 1995-1999 and the 2001-2005 applications of the Comprehensive Procedure. Moreover, even if sampling is sufficient it may then be difficult to distinguish between natural (Breton *et al*., 2006) and anthropogenic variability.

3. The sampling of phytoplankton has been less extensive in the 2001-2005 compared to the previous application of the Comprehensive Procedure.

4. There is a gap in sampling of the very shallow waters (less than 8m depth) close to the coast.

Chlorophyll *a* data from MERIS is being validated by a number of European scientific groups, within the framework of the MERIS Validation Team and via international and national projects. While some problems of data quality have been found, particularly for turbid coastal waters with high absorption, in general this data is considered as reliable for detection of high biomass blooms in Belgian waters and for giving an indication of spatial variability over the region (REVAMP project 2005; Park *et al.* 2006). While not used for the eutrophication assessment itself the MERIS data is used here for assessing the adequacy of the seaborne sampling strategy for eutrophication assessment.

The question addressed in the present annex can be summarised as: “Taking account, on the one hand, of Belgium’s international obligation to report eutrophication status to OSPAR on the basis of adequate sampling and, on the other hand, of the resource constraints inherent in seaborne monitoring, at what locations should measurements be made of chlorophyll *a* concentration?”

Previous experience has shown that the critical period for sampling of chlorophyll *a* for the purpose of eutrophication assessment is the month of April. MERIS imagery has, therefore, been collected for April 2003, 2004 and 2005 from the data distribution websites (http://merci-srv.eo.esa.int/merci and http://www.brockmann-consult.de/merci). All the imagery was recently reprocessed by ESA using the latest processor version MEGS 7.4. The monthly mean chlorophyll imagery was generated by averaging the chlorophyll parameter which is either algal1 or algal2 products depending on the case2 water flag for each pixel and excluding less reliable data using the product confident flags. Monthly mean composite maps are shown for each year in Figure 24 as well as for the average over the three years in Figure 25.

Taking the MERIS data from Figure 25 as a proxy for seaborne chlorophyll *a* concentration, alternative spatial sampling schemes can be assessed by subsampling the satellite data. After subjective trials, a good compromise was found between representing the essential spatial variability of the region and limiting the number of sampling stations using 9 stations, distributed along three cross-shore transects, respectively close to the French-Belgian border, close to the Dutch-Belgian border and cross-shore through the centre of the region (approximately cross-shore from Oostende). The corresponding contour plot derived from the satellite data is shown in Figure 26. Comparison of Figure 25 and Figure 26 shows that no significant loss of information has occurred when reducing the number of sampling stations from the MERIS resolution to 9. The 13 seaborne measurement locations used for the assessment shown in Figure 13 are, therefore, considered sufficient or even represent possible oversampling in space for the requirements of eutrophication assessment in the OSPAR context.

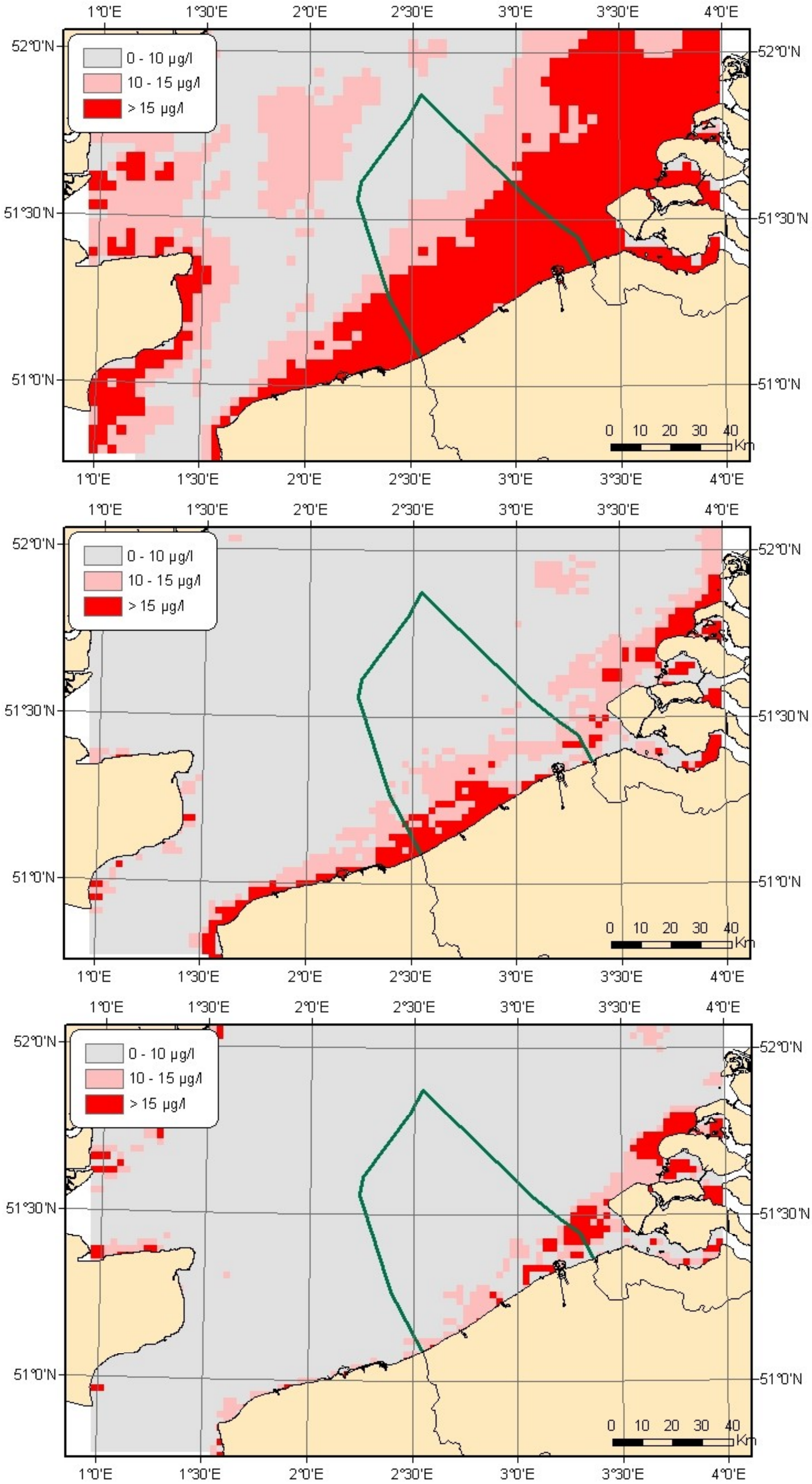

Figure 24: Monthly mean chlorophyll *a* derived from MERIS imagery for April 2003 (top), April 2004 (middle) and April 2005 (bottom).

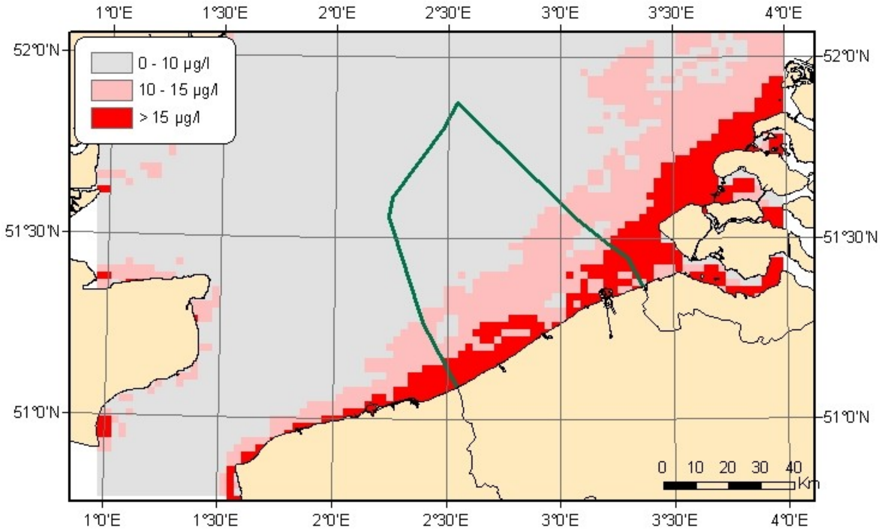

Figure 25: Mean chlorophyll *a* derived from MERIS imagery for April using data from 2003-2005.

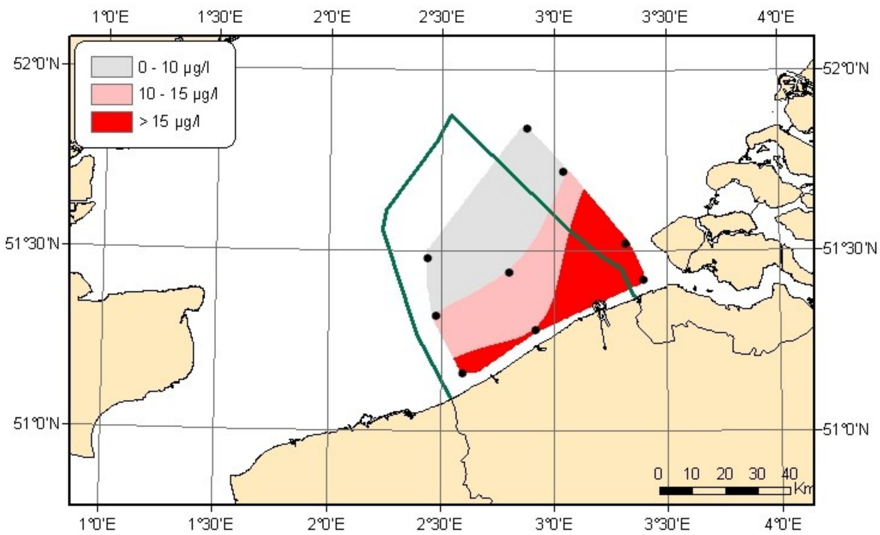

Figure 26: Contour plot of chlorophyll *a* concentration derived by subsampling the satellite data at 9 locations, shown as black dots.

Thus, for the objective of improving the assessment of eutrophication status of Belgian waters and considering the study of (Belgium 2004) it would be reasonable to retain or perhaps slightly reduce the spatial sampling of chlorophyll *a*, but to increase the temporal sampling of the seaborne surveys during the spring phytoplankton bloom.

Neither the satellite data nor the in situ data chlorophyll *a* is considered as suitable for interannual trend detection because of the inadequate frequency of sampling (limited by cloud cover for the satellite data and by ship-time for the in situ data) during the days/weeks of the highest biomass spring phytoplankton bloom.

Annex 5 Reporting Table Overall Classification

Key to the table

NI Riverine inputs and direct discharges of total N and total P
DI Winter DIN and/or DIP concentrations
NP Increased winter N/P ratio
Ca Maximum and mean chlorophyll *a* concentration
Ps Area-specific phytoplankton indicator species

Mp Macrophytes including macroalgae
O_2 Oxygen deficiency
Ck Changes/kills in zoobenthos and fish kills
Oc Organic carbon/organic matter
At Algal toxins (DSP/PSP mussel infection events)

\+ = Increased trends, elevated levels, shifts or changes in the respective assessment parameters

\- = Neither increased trends nor elevated levels nor shifts nor changes in the respective assessment parameters

? = Not enough data to perform an assessment or the data available is not fit for the purpose

Note: Categories I, II and/or III/IV are scored '+' in cases where one or more of its respective assessment parameters is showing an increased trend, elevated levels, shifts or changes.

Area	Category I Degree of nutrient enrichment		Category II Direct effects		Category III and IV Indirect effects/ other possible effects				Initial classification	Appraisal of all relevant information (concerning the harmonised assessment parameters, their respective assessment levels and the supporting environmental factors)	Final classification	Assessment period
BELGIUM												
Coastal waters	NI	-	Ca	+	O_2	-	At	? (-)	Problem area	No change in status compared with previous years	Problem area	2001-2005 Comparison: <1995-2000
	DI	+	Ps	+/?	Ck	+/?						
	NP	+	Mp	Nr	Oc	?						
Offshore waters	NI	-	Ca	+	O_2	-	At	? (-)	Problem area	No change in status compared with previous years. Due to the lowering of chlorophyll a assessment levels from 15 to 8.4 µg/l it turned to a problem area, but the spatial extent of the monitoring offshore is still considered insufficient to provide a reliable assessment.	Potential problem area	2001-2005 Comparison: <1995-2000
	DI	-	Ps	?	Ck	?						
	NP	-	Mp	Nr	Oc	?						