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Report on the third application of the OSPAR Comprehensive Procedure to the Belgian marine waters

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1. Summary

In this report the eutrophication status of the Belgian waters for the period 2006-2014 is assessed according to the third application of the OSPAR comprehensive procedure. The Belgian coastal zone, the most sensitive part of the Belgian Continental Shelf (BCS) is still characterized as a 'problem area'. Offshore, the area has been classified as 'non problem area'. For the coastal waters, this assessment is in accordance with the second assessment (COMP2, Belgium, 2007) in which elevated nutrient and chlorophyll *a* concentrations were reported. In general, problems appear near the coast where riverine nutrient loads have the strongest influence. COMP2 classified the offshore area as 'potential problem area'. The current change of status of the offshore area is mainly due to an improved assessment of the direct effects in that area.

The Belgian part of the North Sea with a surface of about 3500 km^2 shows water depths of less than 20 m near the coast increasing till 45 m offshore. The area is characterized by the presence of sandbanks, strong tidal currents (often more than 1m/s), wind driven currents and a high turbidity. The shallow waters combined with strong currents assure a continuously mixed water column. The water masses that impact this region originate from the Channel and different rivers with, as most important contributors, the Scheldt and the Rhine-Meuse, and to a lesser extent the Seine. These water inputs also contribute to significant cross-border nutrient inputs in the Belgian waters, increasing the winter N concentrations and, hence, the N content of phytoplankton (mean 2000-2010 winter DIN contributions in the coastal area are 28% from the Scheldt, 17% from the Rhine-Meuse, 9% from the Seine, 27% from the Atlantic and 19% from the atmospheric deposition).

The coastal waters show a strong coastal-offshore gradient in salinity. According to the OSPAR recommendation, two subareas are defined in the BCP separated by the 34.5 isoline of salinity. In accordance with the previous assessment, the coastal and offshore zones have been evaluated separately.

The reported riverine nutrient inputs mainly consist in the Belgian contribution to the Scheldt nutrient loads near the Belgian-Dutch border and in other small Belgian rivers and channels. After the wet years 2001 and 2002, a decrease in annual nutrient loads could be noticed in Belgian rivers, followed by oscillations since 2005 mainly related to changes in water discharge. A lower mean annual load of total nitrogen and total phosphorus for the period 2006-2014 is reported compared to the previous reporting period. However, the winter nutrient concentrations in the BCS at salinity 33.5 remain high. The decreasing trend in DIN observed since the '90s halted and was followed by yearly oscillations around 30 µmol/l during the last decade. Winter DIP has stabilized with oscillations around 0.9 µmol/l for DIP, very close to the threshold. The DIN/DIP ratio stabilizes around 32-33 without a significant trend over the whole period. In the offshore waters, winter DIN, DIP and DIN/DIP ratios do not show elevated levels.

Chlorophyll *a* maximum tendency is estimated through its 90th percentile (CHL-P90) obtained via remote sensing. The high temporal frequency of these measurements leads to more accurate estimates. The CHL-P90 is elevated in the major part of the coastal waters, more or less corresponding to the area within a distance of 12 nautical miles from the coastline. The percentage surface of the BCP that shows elevated levels of CHL-P90 also features high interannual variabilities and does not reveal any significant trend. The 6-year averages, limited in time to 2011, show an increase that seems to be linked to hydrometeorological variability. In situ data cover a longer time period and lower values are observed after 2011. The average in situ CHL-P90 calculated over the

period 2006-2014 is slightly lower than during the previous decade, but no clear long-term increasing or decreasing trend can be identified.

The offshore waters do not show an elevated chlorophyll *a* level on the classified satellite-observed CHL-P90 map calculated over 6 years.

Phaeocystis cell counts, performed in 2008-2010, exceeded the threshold in most monitoring stations within the one nautical mile area. The highest value of excessive abundance during this period was noticed in 2008. Generally no problems with oxygen deficiency occur in the BCS due to the prevailing hydrodynamic conditions ensuring continuous oxygen replenishment. No zoobenthos or fish kills have been observed.

Although nutrient loads are lower than during the previous assessment period, the situation at sea has not significantly improved. A significant reduction in nutrients is needed to reach the status of non-problem area in the receiving coastal zone. The amount has been quantified by a large-scale modelling study (EMoSEM). Based on different nutrient reduction scenarios, it has been concluded that an in-depth change in the agro-food systems will be needed to reach any significant mitigation in coastal eutrophication. Due to the trans-boundary origin of nutrients in coastal basins, an international collaboration is likely to be needed to tackle the problem of national eutrophication in Belgium and adjacent countries.

The current assessment is based on riverine total nitrogen and phosphorus inputs, winter DIN and DIP concentrations, N/P ratio and CHL-P90. Besides, oxygen measurements and a 3-year dataset of *Phaeocystis* abundance have been taken into account. The criteria regarding macrophytes, organic carbon/organic matter and algal toxins are not used. Changes/kills in zoobenthos and fish kills are evaluated based on general observational basis for occurrence of acute mortality. However, sufficient data regarding nutrient enrichment and phytoplankton biomass, consisting of high frequency satellite-observed chlorophyll *a*, are available for a reliable assessment of the eutrophication status in the BCS. Evaluation methods and thresholds of nutrients and chlorophyll *a* applicable to the coastal area are in accordance with the targets defined within WFD and MSFD. Nutrient concentrations at salinity 33.5 are well correlated with satellite-born Chl-P90 along the coastal-offshore gradient. The surface of high chlorophyll *a* areas can be estimated by remote sensing. The 6-years averaged evolution of the surface of these areas is considered to be an objective indicator of the eutrophication trend. The elevated levels for nutrients have been evaluated and redefined for DIN and N/P ratio based on a recent research project providing information on concentrations in pristine situation.

Future assessments will benefit further from the satellite-born chlorophyll *a* products. With the new generation of satellites, an improvement of the spatial resolution is expected as well as continuous data collection. Undesirable species, like e.g. *Phaeocystis*, is defined as an additional target to be followed when the situation improves. Information on the presence of undesirable species would further complete future assessment. An improvement and alignment of the assessment methods for undesirable species used in the frame of OSPAR and WFD is recommended.

2. Introduction

This report contains the third application of the OSPAR comprehensive procedure to assess the eutrophication status of the Belgian waters for the period 2006-2014. It is the third report in a series of periodic assessments according to the OSPAR Common Procedure or 'COMP' (OSPAR, 2013) required in the framework of the Oslo and Paris Commission for the Prevention of Marine Pollution (OSPAR). The first and second national assessment (Belgium, 2002; Belgium, 2007) served as basis for the assessment of the eutrophication status of the OSPAR maritime area (OSPAR, 2003; OSPAR, 2009). In both assessments the Belgian coast is classified as problem area.

3. Description of the assessed area

The area considered in this report is the Belgian Continental Shelf (BCP) which is illustrated in Figure 1.

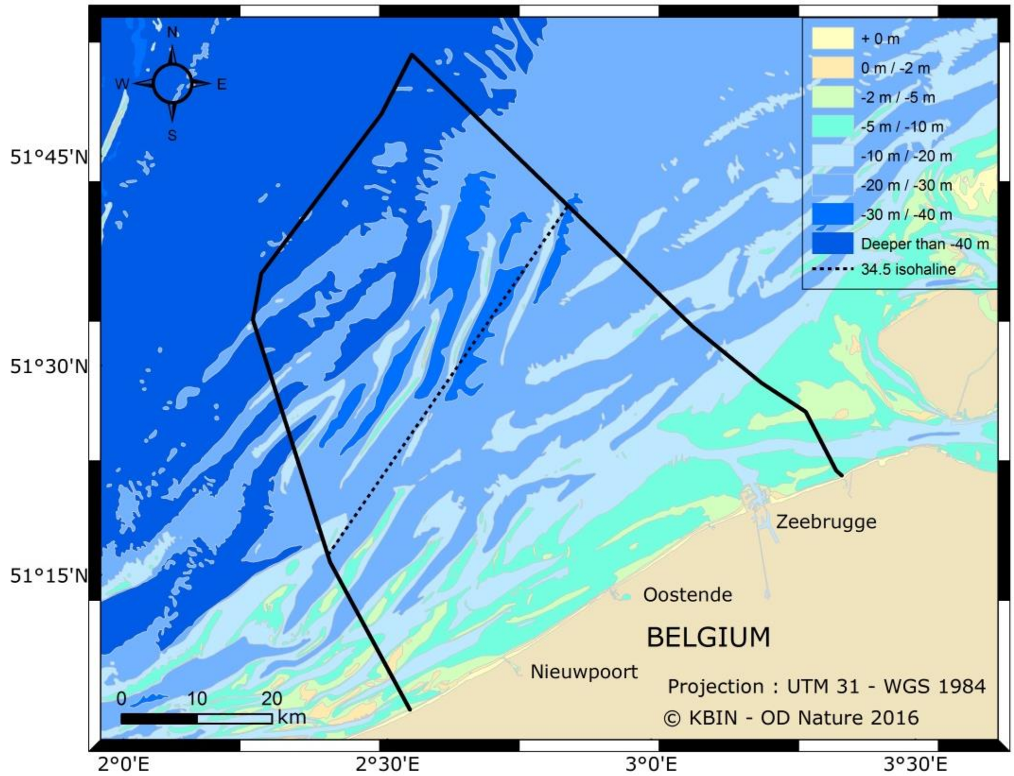

Figure 1. Belgian Continental Shelf (BCS), delineated by solid black lines, bathymetry and isohaline of 34.5 as border between coastal and offshore zone.

Water depths in the BCS are generally shallow close to the coast (less than 20m within 15km) with the bathymetry sloping down to the deeper waters (about 45m) found at the offshore limit. Superimposed on this general onshore-offshore gradient in water depth there are many submerged sandbanks, 15 to 30 km long and often about 20 m of height, seen as linear bathymetric features in Figure 1. The area is characterised by strong tidal currents, often more than 1m/s, in the coastal zone mainly parallel to the coastline. Besides the tides, wind and storms have an important impact on the hydrodynamics. The shallow waters combined with the strong currents assure a continuous mixing of the water column.

Water temperatures, ranging from 1 to 21°C, show a seasonal cycle with a clear difference of 15°C between winter and summer temperature. A spatial variability of 1 to 2°C is observed; with in summer warmer water close to the coast and the reverse pattern in winter (Ruddick & Lacroix, 2006).

The BCS is characterised by a turbidity maximum along the coast. The amount of suspended matter in the coastal waters is always high, ranging from 100mg/l to 1000mg/l. Lower concentrations are found offshore (<5mg/l). The turbidity maximum shows a clear vertical gradient with higher concentrations encountered near the bottom (Fettweis *et al*. 2010; Baeye *et al*. 2011).

Near the coast, salinity is influenced by river discharges with salinities ranging from 25 to 32. Offshore salinities typically reach 34.5. Long-term changes are influenced by wind-events, seasonal changes by the seasonal cycle of wind, precipitation and river discharge.

The water masses that impact this region originate from the English Channel, supplying high salinity, low nutrient water, and different rivers supplying low salinity water with high concentration of nutrients. The Scheldt, discharging east of the BCS, has the strongest influence in the Belgian coastal waters. But also the Rhine and Meuse, discharging approximately 70km further to the North-East, and to a lesser extent the Seine-Somme, discharging around 250km to the South-West influence the Belgian coastal waters, sometimes even stronger than the Scheldt depending on the meteorological and hydroclimatological circumstances (Lacroix *et al.*, 2004).

Figure 2 shows the relative contributions of the water masses for the period 1993-2012 based on a hydrodynamical model applicable for passive substances. The most important contribution originates from the English Channel (not displayed). On average the contribution of the Seine is smaller than 1% in the BCP and the contribution of the Thames can be considered as negligible. The most important sources of riverine water are the Rhine-Meuse and the Scheldt for which the average contributions are respectively around 1% near the French-Belgian border and 5% near the Dutch Belgian border.

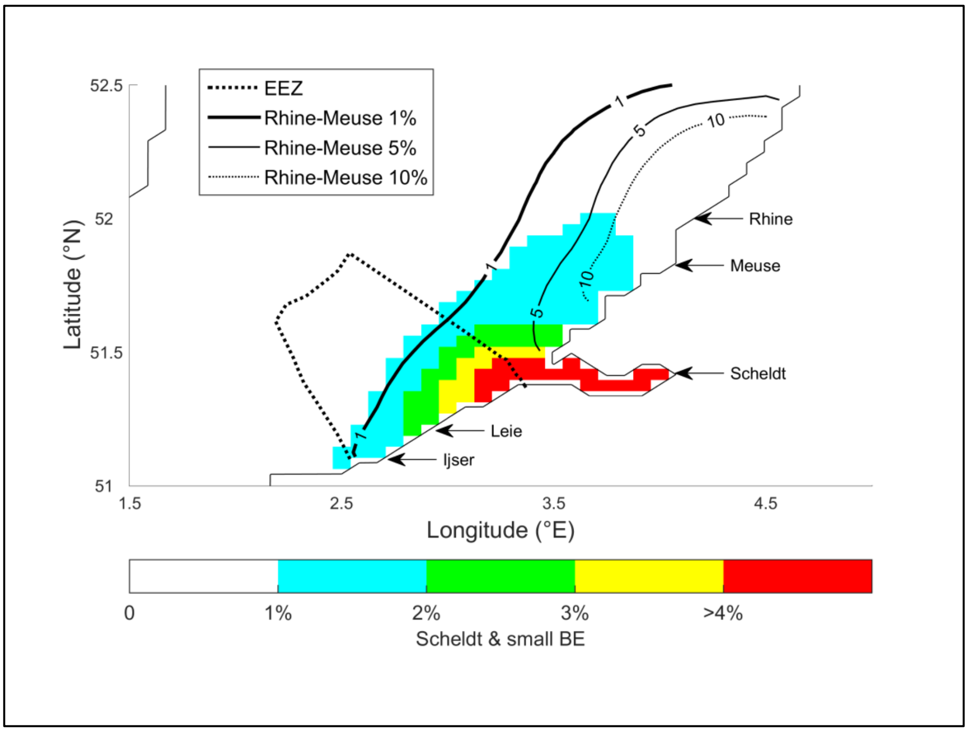

Figure 2 Delineation of the fraction of water masses originating from the Rhine/Meuse (black lines) and the Scheldt (color scale). A fraction of 1% means that 1% of the water on that specific location is originating from the respective river district. Adapted from Lacroix et al, 2004.

The vertical variability of dissolved parameters, such as dissolved nitrate and phosphate concentrations, and phytoplankton-related parameters, such as chlorophyll *a,* is low due to the well mixed water column. The horizontal variability of these eutrophication-related parameters is important and related to the variable influence of riverine discharges resulting in a coastal-offshore gradient. Cross-border nutrient inputs are important in the open Belgian coastal waters. Modelling has allowed quantifying the origin of nitrogen (see 5.1.1.1.).

A major part of the BCP is characterized by a high salinity gradient and can be considered as area of coastal influence. According to the recommendation of the Comprehensive Procedure, the BCP has been subdivided in two subareas based on the salinity regime. Similar to the previous assessment, the coastal and offshore zones are identified separated by the 34.5 isoline of salinity as shown in Figure 1.

4. Methods and data

An overview of the parameters used to assess the eutrophication status is listed in Table 1. The background and elevated levels are included.

Nutrient enrichment is evaluated based on riverine nutrient inputs, concentrations of winter dissolved inorganic nitrogen (DIN) and phosphorus (DIP) and N/P ratio.

For direct effects, the chlorophyll-*a* concentration is considered the main assessment parameter. Macrophytes are not monitored in the Belgian marine waters as they are not relevant.

Regarding the indirect effects, oxygen deficiency is not considered an important parameter in the Belgian marine waters due to the prevailing hydrodynamic conditions. However results are presented to illustrate this. The evaluation for changes/kills in zoobenthos & fish kills is based on general observations on the occurrence of acute mortality during fishery and benthos monitoring. The problem of benthos & fish kills has not yet been observed in the BCP. Changes in zoobenthos are not included in the assessment. In 2009, the EUTROF project investigated possible eutrophication impacts on soft bottom benthos. Offshore no effect was encountered. A possible effect was observed when muddy sand lacked habitat structuring and bioturbating species. The observed impact, however, cannot solely be attributed to eutrophication due to the presence of several anthropogenic activities (Van Hoey et al, 2009). Concentrations of organic carbon/organic matter are not considered in this assessment; no important sedimentation areas are present in the BCP. Algal toxins are not incorporated in routine monitoring and are not used in this assessment. Measurements have been carried out in a limited period (Denayer et al, 2010) but the link with eutrophication in the BCP is too uncertain.

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

The data availability, covered time period and frequency of measurements, are indicated for all assessment parameters in Table 1. The locations of the monitoring stations for in-situ data collection are shown in Figure 3. The monitoring network has been optimized in 2007 with an improved distribution of the sampling stations over the BCP including the offshore area.

Table 1. 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 (RID)		Annual total (kT/y)	Increased trend
	Winter DIN concentrations	Winter (Jan.-Feb.)	Normalized at salinity 33.5 (µmol/l), offshore: mean	Coastal: Background: 15 Elevated: 22.5 Offshore: Background: 8 Elevated: 12
	Winter DIP concentrations	Winter (Jan.-Feb.)	Normalized at salinity 33.5 (µmol/l) offshore: mean	Background: 0.6 Elevated: 0.8
	Increased winter N/P ratio (Redfield N/P = 16)	Winter(Jan.-Feb.)	Normalized ratio	Coastal: Elevated: 30 Offshore: Background: 16 Elevated: 24
Direct effects (II)	Maximum chlorophyll *a* concentration	Growing season: March – October High frequency (satellite observations)	90^{th} percentile (µg/l)	Coastal: Background: 10 Elevated: 15 Offshore: Background: 5.6 Elevated: 8.4
	Mean chlorophyll *a* concentration	Not used		
	Region/area specific phytoplankton indicator species: *Phaeocystis spp.*		Maximum number of cells/l	$>4.10^6$cells/l
	Macrophytes/macroalgae	Not relevant		
Indirect effects (III)	Degree of oxygen deficiency	Not relevant	Mean (mg/l)	6
	Changes/kills in zoobenthos and fish kills	Not included		
	Organic carbon/organic matter	Not included		
Other possible effects (IV)	Algal toxins (DSP/PSP mussel infection events)	Not included		

Nutrients are generally sampled twice during the winter period. Winter nutrient concentrations are normalized to the reference salinity of 33.5 making use of the winter nutrient measurements over the whole salinity range. The derived winter nutrient concentrations are evaluated against the assessment levels. Since the previous assessment, these levels, being based on estimated background concentrations, have been slightly adjusted. The DIN background concentration, DIN elevated level and N/P ratio at reference salinity 33.5 have been redefined based on the results of the research project EMoSEM[1]. In this project, the past projections of a pristine situation suggested a DIN background concentration of about 15 µmol/l in coastal areas. The elevated level of 22.5 µmol/l is reached by adding 50% to obtain the assessment level. In addition, this adjusted elevated level of DIN leads to a DIN/DIP ratio that is more suitable for the coastal area. According to the EMoSEM simulations and another study (Desmit *et al.*, 2015) DIN/DIP ratios of about 30 molN/molP are to be expected in Belgian coastal areas. The DIP background concentration is supported by EMoSEM simulations. Additionally, offshore nutrient concentrations have been averaged and compared with the elevated level.

Chlorophyll-*a* is measured monthly to 3-monthly during the period March-October. Besides the results of the routine monitoring, additional research project data has been included. Seen the relative low number of in situ measurements, the current assessment also makes use of remote sensing data. In contrast to in situ data, remote sensing observations show a high temporal resolution. As they are in good correlation with the in situ data, these products provide a more reliable estimate of the chlorophyll *a* maximum tendency. In addition, the high spatial resolution offers an overview for the whole BCP for this assessment parameter. To reduce the effect of interannual variability, the 6-years average of remote-sensing Chl P90 (chlorophyll a 90th percentile) is evaluated. The time series is limited to 2012 since MERIS (ENVISAT-ESA) stopped data collection. New operational data is expected to become available in 2016.

Phaeocystis cell counts have been performed monthly, with additional samples during the growing season at three coastal stations (W01, W02, W03) in the period 2008-2010. Seen resource limitations and no sign of significant improvement, this monitoring has not been continued and the focus is put on the extended chlorophyll *a* data set (satellite observations inclusive) for the assessment of the direct effects. For future assessments, the threshold can be adjusted since the scientifically determined value of 4.10^6 can be considered a background reference which would lead to an elevated level of 6.10^6 (and possibly rounded to 10^7 cells/l to be in accordance with other countries).

The focus for eutrophication monitoring and evaluation in the Belgian marine waters lies on the coastal waters as it is characterized by the highest levels of phytoplankton biomass. The improvement of the situation in this area is of prime importance. The elevated levels defined at salinity 33.5 are to be considered representative for the overall area and are in accordance with the goals defined by Belgium in the frame of the MSFD for which the state of the Belgian Continental Shelf is evaluated.

[1] http://odnature.naturalsciences.be/emosem

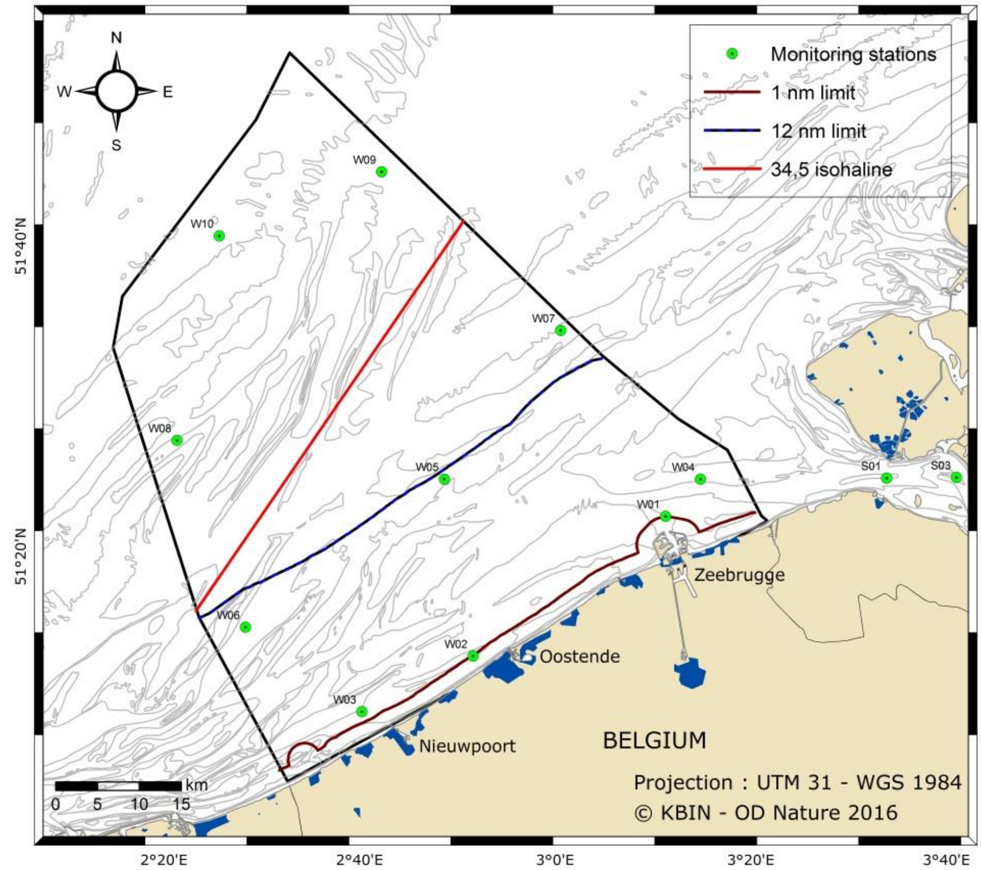

Figure 3. Monitoring stations in the BCP

4.2. Calculation and quality of time series

The marine in-situ data originate from the Belgian monitoring programs and have been retrieved from the Belgian Marine Data Centre (BMDC, www.bmdc.be). For chlorophyll *a* and nutrients, water samples are taken with a Niskin bottle at a sampling depth of 3m. Oxygen is measured using a portable oxymeter at the same time and sampling depth. ECOCHEM, the laboratory responsible for the analysis of nutrients and chlorophyll *a* is accredited according to ISO17025 for a.o. ammonium, nitrate+nitrite, nitrite and chlorophyll *a*. The laboratory participates in QUASIMEME intercomparison exercises. Methodological details are described in standard operational procedures.

<u>Winter DIN, DIP</u>

Time series of winter nutrient concentrations and N/P ratio are normalized by winter salinity. Winter nutrient concentrations are plotted for each year in relation to the related measured salinity value. As in the previous assessment, the winter nutrient concentration at reference salinity of 33.5 is calculated from the mixing diagram of any particular year.

Chlorophyll *a*

For chlorophyll *a*, the 90th percentile values (CHL-P90) calculated over the growing season are considered. The analysis of in situ chlorophyll *a* is performed in the ECOCHEM laboratory using HPLC. To increase the number of data for the 90th percentile calculation, the dataset has been extended with results measured in the frame of research projects. The differences between the techniques used in different projects potentially introduce some uncertainty in the time series. The in situ results are also used to validate the data obtained by remote sensing. While routine monitoring of this parameter continues at the monitoring stations, additional sampling efforts have been started which focus on the validation of the remote sensing products. Hereby, the objective is to increase the number of matchups by focusing sampling to match the time of the satellite overpass. This is especially important for validation of new data acquired by the recently launched Sentinel-3/OLCI (Ocean & Land Colour Instrument) sensor.

Chlorophyll *a* by optical remote sensing

Chlorophyll *a* concentration was generated from daily Ocean Colour data of the ENVISAT-MERIS satellite sensor for the years 2003-2011. The HIGHROC Water Quality Monitoring service provides satellite-based support for the water quality assessment of chlorophyll *a* concentration in the frame of Belgium's obligations in the context of eutrophication[2].

The algorithms used to derive data from the satellite sensors correspond to the best available algorithms (algal-1 and algal 2 products, MEGS 7.5 processing, ESA) given a certain area and time period. Quality control has been applied according to the standard MERIS product confidence flags. Data is supplied at approximately 1 km resolution on a geographical grid with equal spacing in longitude and latitude covering the described region. The daily satellite chlorophyll *a* products are validated by match-up analysis between MERIS and available in situ (seaborne) chlorophyll *a* observations for the entire BCS (Figure 5). This analysis shows a strong correlation between satellite-observed and in situ chlorophyll *a* observations. A time series was produced for the validation period (2007-2011) for the coastal monitoring station W01: the satellite-derived chlorophyll *a* concentrations were superimposed on in situ chlorophyll *a* concentrations (Figure 5). This allows a qualitative assessment of the ability of the MERIS satellite data to capture the growing dynamics of phytoplankton in the Belgian waters.

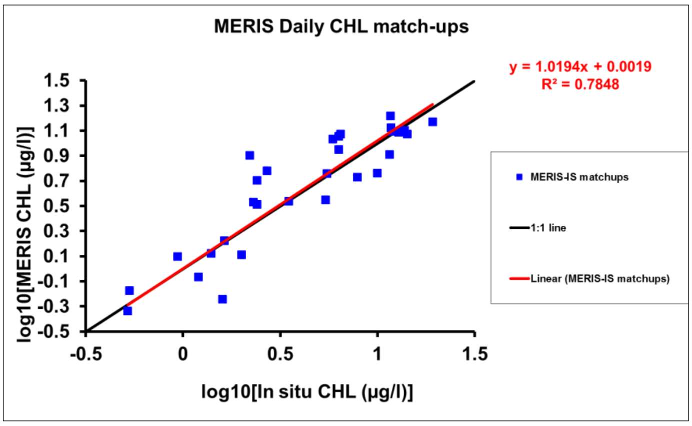

Figure 4. Regression-plot for CHL match-ups between MERIS and in-situ data for the entire BCS.

[2] http://www.highroc.eu/

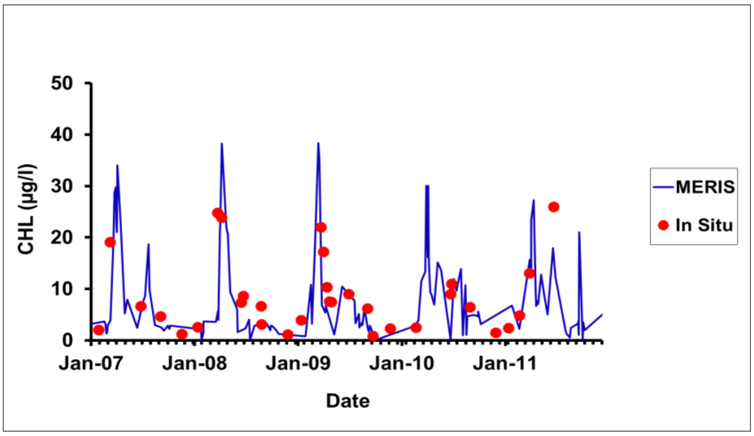

Figure 5. Time series of satellite-derived CHL (blue line) superimposed on in situ CHL observations for station W01 for the period 2007-2011.

The use of satellite-observed chlorophyll *a* with a high temporal frequency allows deriving a more accurate chlorophyll *a* 90th percentile since timing and frequency of in situ measurements do not ensure that samples are taken during the peak of the bloom.

<u>Nutrient input</u>

The load calculations for the coastal and Scheldt river basin are delivered by VMM (Vlaamse Milieumaatschappij) and are based on the formula in “Principles of the Comprehensive Study on Riverine Inputs and Direct Discharges (RID)”. These calculated loads have to be interpreted as estimations seen the choice and frequence of sampling locations and parameters. Time series of nutrients inputs consist of annual loads.

5. Eutrophication assessment

This chapter consists of an assessment procedure following a three-step approach (OSPAR 2008). In a first step, assessment criteria and their corresponding assessment levels are set and applied for a given area. Then the scores are integrated leading to an initial classification. Finally, all relevant information is considered to give a final area classification.

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. Nutrient inputs

Since 1996, there are no direct discharges in the Belgian waters.

With regards to riverine input, two basins can be considered: the coastal and the Scheldt river basin. For the Scheldt river basin, the loads are calculated for the Scheldt and the channel Gent-Terneuzen near the Belgian-Dutch border. The coastal basin encompasses small Belgian rivers and channels (Ijzer, Brugge-Oostende, …) along the Belgian coast.

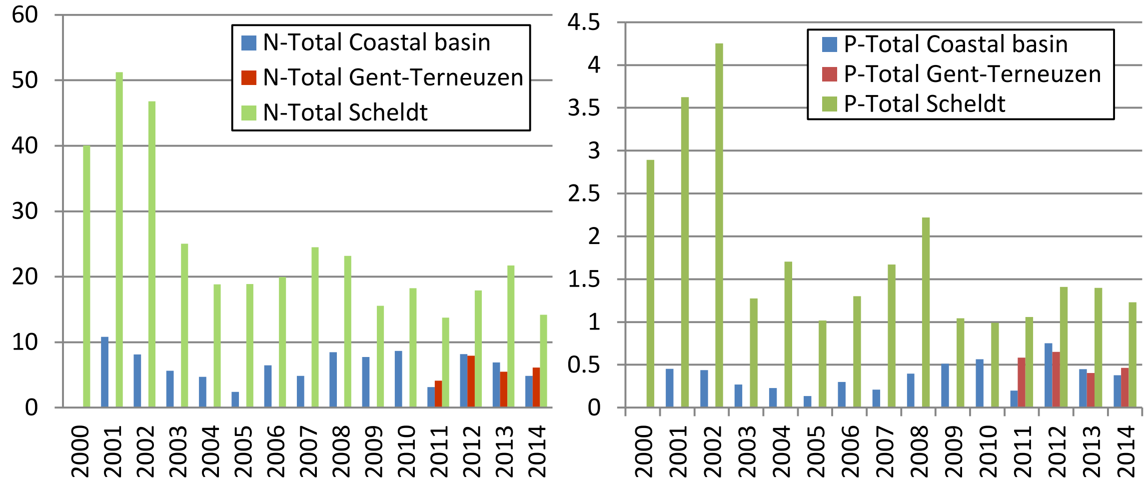

Figure 6. Loads of total N (kT/year) for the coastal and Scheldt basin (Scheldt(Antwerpen) and channel Gent Terneuzen).

Figure 6 shows the annual loads for respectively total nitrogen and total phosphorus since 2000 for the coastal and Scheldt river basin. Nutrient loads for the channel Gent-Terneuzen, which is a part of the Scheldt river basin, have only been calculated since 2011 due to a lack of flow measurements. A clear decrease in nitrogen as well as phosphorus loadings can be noticed after 2001-2002 in the coastal basin and in the Scheldt river. This reduction is partly related to the measures for nutrient reduction policies implemented by the EU member states and partly due to the decrease in the Scheldt annual flow following the wet years of 2001 and 2002 (Figure 7). Since 2005 oscillations can be observed in the annual load. These are also related to the changes in the annual flow and mainly result from nutrient diffuse sources caused by a.o. fertilizers leaching on agricultural land (Figure 7).

No obvious decreasing trend in nutrient loads over the last ten years can be observed. When comparing the annual averages over the assessment periods, lower values are encountered for the current assessment period 2006-2014. The average annual load of total nitrogen and total phosporus for the period 2006-2014 is respectively 28.0 kT/year and 2.0 kT/year compared to 38.5 kTon/year and 2.7 kTon/year for the period 2001-2005.

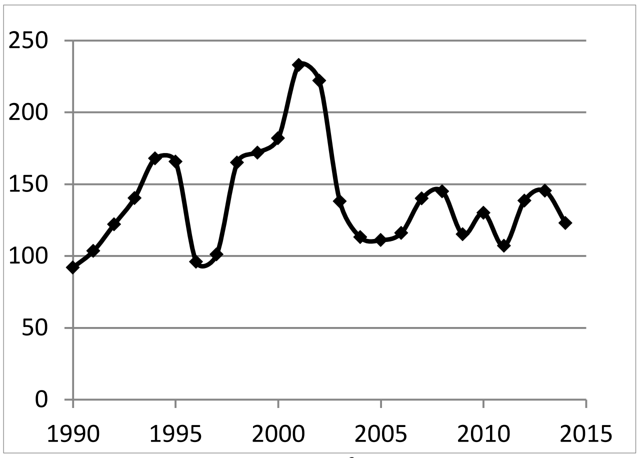

Figure 7. Average annual flow in m³/s of the Scheldt

Beside Belgian inputs into coastal waters, the Belgian coastal waters are also influenced by other rivers like e.g. Rhine-Meuse (see 3). Identification of the main nutrient sources to the BCS is obtained by modelling and shown in 5.5.1.

5.1.1.2. Winter nutrient (DIN, DIP) concentrations

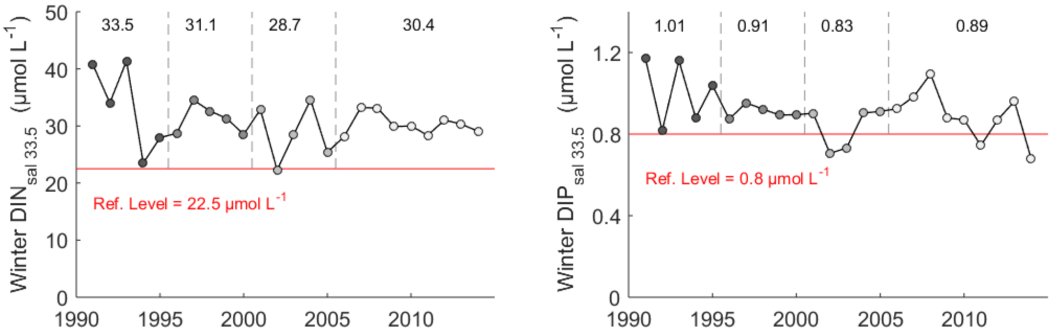

Figure 8. Long-time series of winter DIN (left) and DIP (right) projected at salinity 33.5 in the Belgian EEZ (in situ data). The periods 1991-1995, 1996-2000, 2001-2005 and 2006-2014 are represented respectively by black, grey, light grey and white dots. The multiyear mean values for each period are indicated on top of the graph. The red line indicates the reference level.

Coastal waters

The winter DIN projected at salinity 33.5 shows a decreasing trend in the period 1990-2014, with stabilization around a value of 30 µmol/l in the last decade (Figure 8). The winter DIN concentrations at salinity 33.5 never go below the reference level (22.5 µmol/l) during this time period. The observed oscillations are linked to the interannual variability of hydroclimatic conditions (oceanic input, river discharge, water circulation). The winter DIP projected at salinity 33.5 also shows a slight decreasing trend in the period 1990-2014, with stabilization around value 0.9 µmol/l. In the period 2006-2014, the winter DIP concentration at salinity 33.5 reaches values lower than the reference level (0.8 µmol/l) on two occurences, i.e. 2011 and 2014 (see also Table 2).

Table 2. Yearly values of winter DIN, DIP and DIN/DIP ratio projected at salinity 33.5 in the Belgian EEZ during the period 2006-2014 (in situ data). The green values point out when an indicator is below its reference level.

Year	Winter DIN µmol/l	Winter DIP µmol/l	Winter DIN/DIP mol/mol
2006	28.1	0.925	29.7
2007	33.2	0.984	32.2
2008	33.1	1.10	28.4
2009	29.9	0.879	33.4
2010	30.0	0.871	31.4
2011	28.4	0.744	36.1
2012	31.0	0.870	33.3
2013	30.3	0.961	31.8
2014	29.1	0.679	41.0

In the offshore waters, nutrients have been measured generally twice during the winter period at three stations (W08, W09 and W10). The average winter DIN concentration over the period 2008-2014 at the three locations is always lower than 12 µmol/l, with an overall mean value of 10.6 µmol/l. In 2011, the yearly average DIN concentration reaches a value around the threshold level (12 µmol/l). Average winter DIP concentrations at the three stations are always well below 0.8 µmol/l in the same period, with an overall mean value of 0.48 µmol/l. The offshore DIN and DIP mean concentrations are comparable to those reported in the second application of the Comprehensive Procedure for the Belgian marine waters (respectively 10.7 µmol/l and 0.47 µmol/l). For the considered period, no elevated levels of DIN or DIP have been observed in the offshore waters (Table 3).

Table 3. Yearly values of winter DIN, DIP and DIN/DIP ratio in the offshore area of the BCP during the period 2008-2014 (in situ data).

Year	Winter DIN µmol/l	Winter DIP µmol/l	Salinity	DIN/DIP mol/mol
2008	10.67	0.68	35.2	16
2009	9.47	0.35	35.2	27
2010	11.15	0.57	35.0	20
2011	12.23	0.52	34.9	24
2012	9.84	0.49	35.2	20
2014	10.45	0.41	34.4	25

5.1.1.3. Winter DIN/DIP ratio

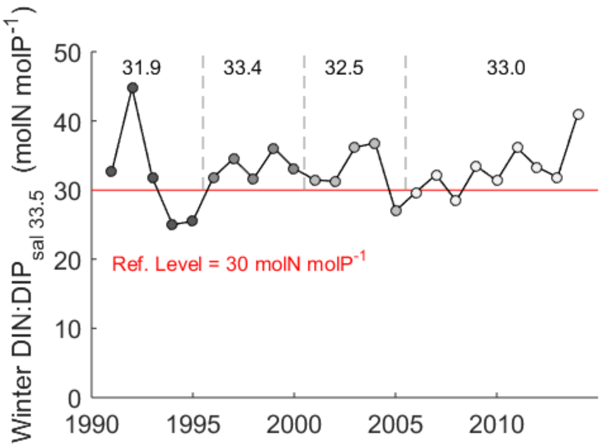

Figure 9. Long-time series of winter DIN-to-DIP ratio projected at salinity 33.5 in the Belgian EEZ (in situ data).The periods 1991-1995, 1996-2000, 2001-2005 and 2006-2014 are represented respectively by black, grey, light grey and white dots. The multiyear mean values for each period are indicated on top of the graph. The red line indicates the reference level.

The projection of the winter DIN/DIP ratio at salinity 33.5 is represented in Figure 9. The yearly relationships of DIN/DIP vs. salinity (not shown) are not always as linear as for the corresponding nutrients. The winter DIN/DIP ratio at salinity 33.5 remains stable around value 32-33 molN/molP without a significant trend over the whole period. The DIN/DIP ratio variability is dependent on the variability of the nutrients (see above). During this assessment period, the winter DIN/DIP ratio was lower than the elevated level of 30 molN/molP in 2006 and 2008 (see Figure 9).

In the offshore waters, the overall average DIN/DIP ratio is 22 with values higher than 24 only in the years 2009 and 2014 (see Table 3). Both years show the lowest average winter DIP concentrations.

5.1.2. Category II Assessment – direct effects of nutrient enrichment

5.1.2.1. Chlorophyll *a* concentration

Chlorophyll *a* in seawater is an indicator of phytoplankton biomass and hence a useful parameter to assess the direct effect of nutrient enrichment. A large fluctuation in chlorophyll *a* concentrations can be observed between years and seasons. The indicator of choice is the chlorophyll *a* 90th percentile (CHL-P90, expressed in µg/l) over the phytoplankton growing season (i.e. March –October incl.) as it is a fair estimate of the optimum tendency. The CHL-P90 is the chlorophyll *a* concentration below which 90 percent of observations fall.

In situ data

The CHL-P90 values are shown in Figure 10 for both the Belgian coastal and offshore zones, both being delimited by the salinity isoline 34.5.

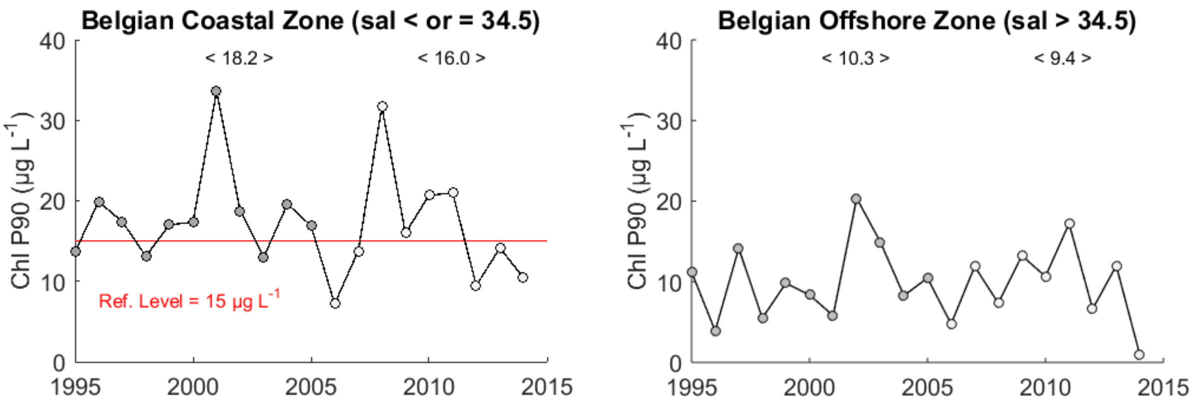

Figure 10. Long-time series of CHL-P90 in the Belgian Coastal Zone (left) and in the Belgian Offshore Zone (right) during the period 1995-2014 (in situ data). The periods 1995-2005 and 2006-2014 are represented respectively by grey and white circles. The multiyear mean values for each period are indicated on top of the graph.

There are systematically higher CHL-P90 in the coastal zone compared to the offshore zone as a result of the coastal-offshore gradient in nutrient concentrations, and in spite of a higher coastal turbidity. Both coastal and offshore zones show a strong oscillation of chlorophyll maximum tendency linked to the interannual variability of hydroclimatic conditions. Over the time period, no clear increasing or decreasing trend can be identified. The in situ CHL-P90 generally exceeds the threshold with a slight improvement for both zones when averaged over the period 2006-2014 compared to the previous period.

However, the scarcity of in situ data may sometimes significantly influence the result of the CHL P90. Some very low values can be noticed (Table 4). It is one of the main reasons why satellite-observed CHL is regarded as a much better tool than in situ sampling to assess levels of CHL-P90 in the North East Atlantic (incl. the BCS).

Table 4. Yearly CHL-P90 in the Belgian Coastal and Offshore Zones during the period 2006-2014 (in situ data).

Year	CHL BCZ µg/l	CHL BOZ µg/l
2006	7.2	4.8
2007	13.8	11.9
2008	31.7	7.4
2009	16.0	13.2
2010	20.7	10.7
2011	21.0	17.2
2012	9.5	6.6
2013	14.1	12.0
2014	10.5	0.9

Earth Observation data

While *in situ* data acquisition is still considered as the main monitoring tool there is a growing tendency to use optical remote sensing as a supporting tool to achieve the monitoring requirements because of severe resource constraints of available ship time and manpower. For example, in Belgium *in situ* measurements are collected 5-7 times in average per growing season in 10 stations distributed in the BCZ (Ruddick *et al.*, 2008). These numbers are too low to calculate CHL-P90 values with sufficient accuracy. Satellite data enables the calculation of CHL-P90 pixel-by-pixel resulting in a map product which is expected to provide more accurate CHL-P90 estimates due to an increased temporal and spatial resolution compared to the *in situ* data (Van der Zande *et al.*, 2011).

The satellite-based CHL-P90 product for the period 2006-2011 is presented in Figure 11 showing the highly productive coastal areas. Subsequently, the CHL-P90 data was classified. The area of the Belgian Coastal Zone which shows concentration higher than the elevated level is shown in red on Figure 12.

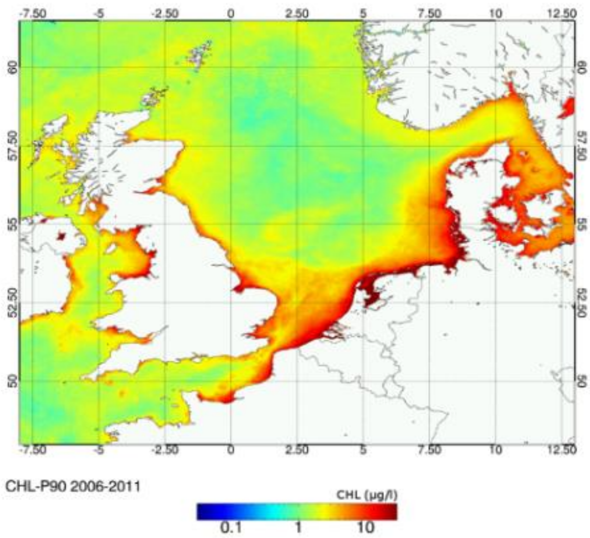

Figure 11. The multi-temporal CHL-P90 product (March-October, 6-year period) based on satellite observations (ENVISAT-MERIS, ESA) in the North Sea used as eutrophication indicator.

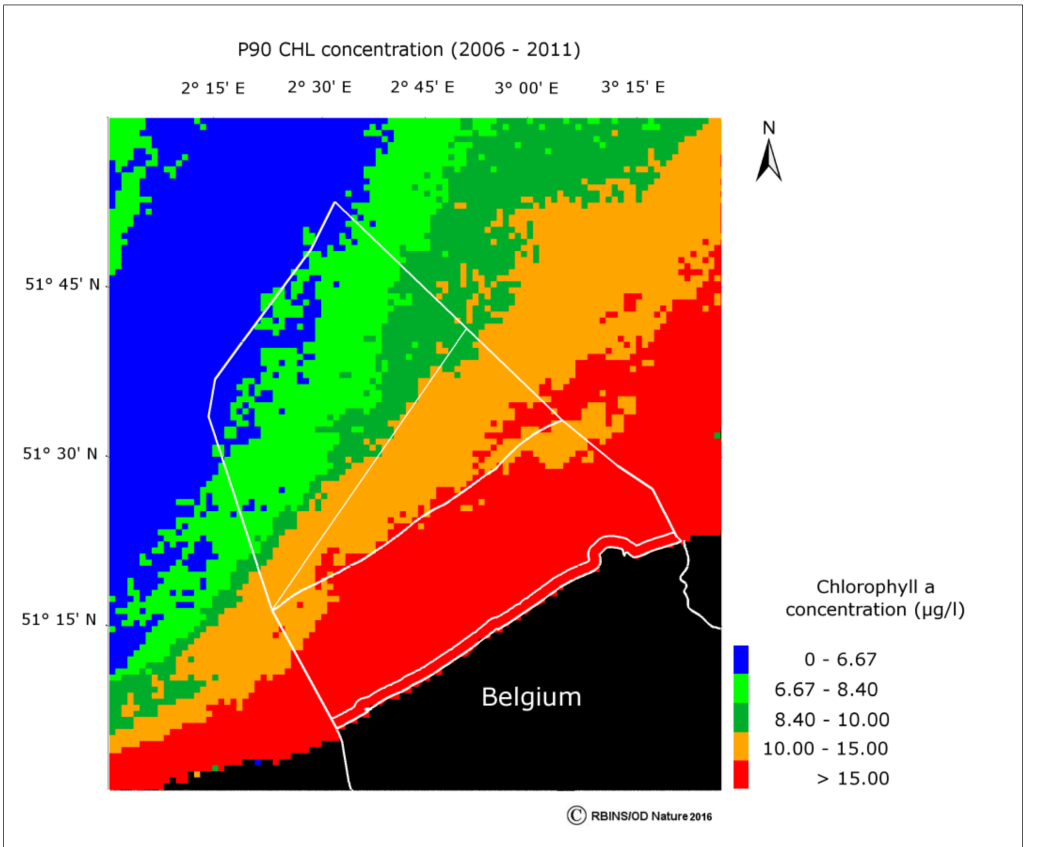

Figure 12. Classification of the CHL-P90 product for the BCP with the red class CHL-P90 > 15µg/l.

Figure 13 (right) shows the percentage surface of the Belgian Coastal Zone which falls into the category of 'CHL-P90 > 15µg/l' (i.e. red zone in Figure 12) as an objective indicator of eutrophication based on 6-yearly composites. Yearly CHL-P90 maps are presented in Annex. The surface of the 'CHL-P90 > 15µg/l' class increases moderately (1.41%) between composites 2003-2008 and 2004-2009 but increases more strongly (6.45%) between composites 2004-2009 and 2005-2010. Finally, an increase of 10.97% could be observed between the periods 2005-2010 and 2006-2011.

The yearly percentage surface of the Belgian Coastal Zone which falls into the category of 'CHL-P90 > 15µg/l' for the period 2003-2011 are presented in Figure 13 (left). The CHL-P90 values vary strongly with three years showing low CHL-P90 values (i.e; 2004, 2005 and 2006). This appears to be linked to the hydrometeorological variation with relatively dry years followed by much wetter years, indicating the importance of riverine nutrient inputs. This graph shows that yearly CHL-P90 variation is stronger than the 6-yearly variation (Figure 13, right) and that no long term trend can be detected based on the presented data set. MERIS (ENVISAT-ESA) stopped collecting data in April 2012. This satellite is replaced by the Sentinel-3 satellite (ESA) which has been launched in March 2016. We expect operational data to become available by August 2016.

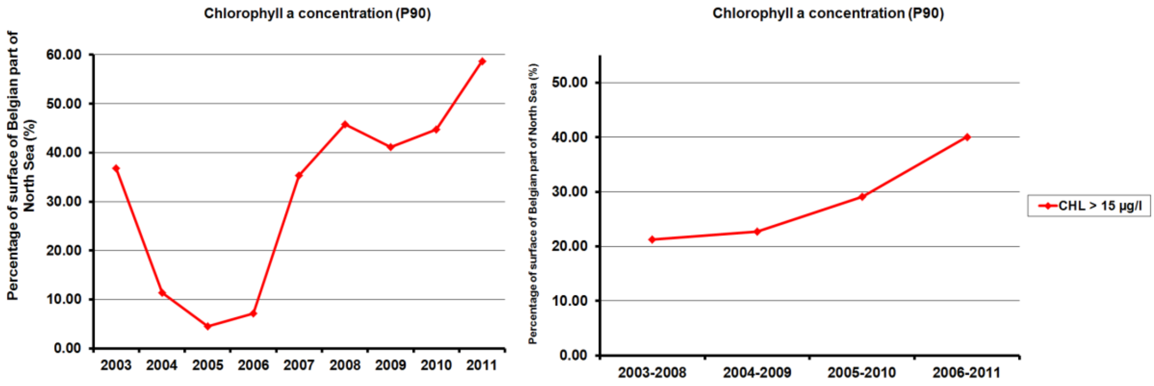

Figure 13. The percentage surface of the BCS of which the yearly (left) and 6-yearly (right) CHL-P90 > 15µg/l as an objective indicator of eutrophication.

5.1.2.2. Phytoplankton indicator species

Nuisance species *Phaeocystis*

Phaeocystis cell counts have been performed in the period 2008-2010 at three stations located in the one nautical mile zone (WFD coastal waters). Samples were collected every month with 4 to 5 additional samples collected during the growing season. In most locations in 2009 and 2010 (except once), the number of cells exceeded twice the threshold of 4.10^6 cells/l. In 2008, the number of samples exceeding this threshold ranged from 4 to 6. Based on this threshold and including the cell counts of all samples, the exceedances for 2008, 2009 and 2010 are respectively 44%, 10% and 17%. No data are available over the whole period.

5.1.2.3. Macrophytes including macroalgae

The monitoring of this indicator is not relevant for the Belgian part of the North Sea since the bottom substrates mainly consist of soft sediments and macroalgal mats hardly occur in these waters. This quality element is not taken into account for the assessment.

5.1.3. Category III Assessment – indirect effects of nutrient enrichment

5.1.3.1. Oxygen deficiency

Oxygen deficiency in the water column has not been reported in the Belgian marine waters. The prevailing hydrodynamic conditions (strong tide and wind mixing) ensure continuous oxygen replenishment. Dissolved oxygen concentrations in the coastal waters are always above 6 mg/l, except once a value of 5 mg/l in one coastal station. Offshore, the lowest oxygen concentration encountered is 7.8 mg/l.

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 observed in the BCP during fishery and benthos monitoring. A dedicated study (EUTROF project; Van Hoey *et al.*, 2009) focused on the possible impacts of eutrophication on soft bottom benthos. This study confirmed the absence of acute mortality based on seasonal to monthly sampling at 10 stations on the BCP in 2009.

5.1.3.3. Organic carbon/organic matter

Organic carbon/organic matter is not included as an assessment parameter.

5.1.4. Category IV Assessment – other possible effects of nutrient enrichment

5.1.4.1. Algal toxins

Algal toxins have not been assessed.

5.2. Consideration of supporting environmental factors and quality of data

The annual flow of the Scheldt has been presented as time series in Figure 7.

Salinity measurements, sampled simultaneously with nutrients, have been used to normalize the winter nutrient concentrations at salinity 33.5. ECOCHEM is also accredited for this parameter (ISO17025).

5.3. Initial and overall assessment

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 for the Belgian coastal waters in Table 5 and for the Belgian offshore area in Table 6.

The Belgian coastal waters are regarded as a 'problem area' due to the elevated nutrient levels accompanied by high chlorophyll *a* levels (Figure 14).

The Belgian offshore waters are initially classified as a 'non problem area'. Nutrient levels and CHL-P90 are below threshold and no problems are observed linked to oxygen deficiency. Compared to the previous assessment, the confidence in the assessment of the direct effect parameter chlorophyll *a* increased considerably. Additional offshore stations have been added in the monitoring program. Even more important, remote sensing has provided a lot of data to enable an accurate calculation of the chlorophyll *a* 90^{th} percentile.

No measurements on *Phaeocystis* abundance are available in the offshore area but model results (MIRO&CO, not shown) indicate that the Belgian offshore area is almost never submitted to high CHL blooms or exceeding *Phaeocystis* concentrations. This is explained by the fact that the Belgian offshore area is predominantly washed by Atlantic waters and, to a much lesser order, by riverine waters. The dominating northward current tends to push the Rhine region of freshwater influence towards the north, especially in the Belgian offshore waters. The TBNT modelling (Desmit *et al.* 2015a, Dulière *et al.* submitted) shows that riverine contributions to nutrient levels are on average low enough to avoid any eutrophication nuisance in the Belgian offshore area. Rhine/Meuse and Scheldt influences are however significant in terms of nutrients in the Belgian coastal zone. Phosphorus, the nutrient responsible for the magnitude of the spring peak of chlorophyll *a* and *Phaeocystis* (Desmit *et al*, 2015b) in Belgian and Dutch coastal waters did not exceed the threshold in any year.

The absence of elevated nutrient levels, satellite-born CHL-P90, model results and expert judgement confirm the initial classification. The final classification of the Belgian offshore area remains 'non problem area' (Figure 14).

Table 5. Overview of the results of the OSPAR Comprehensive Procedure for the Belgian coastal waters.

Category	**Assessment Parameters**	**Description of Results**	**Score (+ - ?)**
Degree of Nutrient Enrichment (I)	Riverine inputs and direct discharges of total N and total P	No increasing trend. Variations in total nutrient loads are observed over the last 10 years after a period of decrease since 2001-2002.	-
	Winter DIN and/or DIP concentrations	Observed oscillations with winter DIN always above the threshold and winter DIP lower than threshold in 2011 and 2014.	+ (+++++++++)
	Winter N/P ratio	Above 30 except for 2006 and 2008.	+ (-+-++++++)
Direct Effects (II)	Maximum chlorophyll *a* concentration	6 years average (2006-2011) biggest part of coastal zone exceeds the threshold. Big yearly variation and no clear long term trend.	+
	Area-specific phytoplankton indicator species. *Phaeocystis spp.*	2008-2010, 3 stations: monthly + 4-5 additional samples in growing season: generally 2 exceedances with 4-6 exceedances in 2008.	+
	Macrophytes including macroalgae	Not relevant.	
Indirect Effects (III)	Oxygen deficiency	Not relevant Always above threshold except once.	-
	Changes/kills in zoobenthos and fish kills	No kills observed.	-
	Organic carbon/organic matter	Not used.	?
Other Possible Effects (IV)	Algal toxins (DSP/PSP mussel infection events)	Not used.	?

+ = 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

Table 6. Overview of the results of the OSPAR Comprehensive Procedure for the Belgian offshore waters.

Category	**Assessment Parameters**	**Description of Results**	**Score (+ - ?)**
Degree of Nutrient Enrichment (I)	Riverine inputs and direct discharges of total N and total P	Not relevant	
	Winter DIN and/or DIP concentrations	Winter nutrient concentrations below threshold with only for DIN a slight exceedance in 2011.	- (??---+-?-)
	Winter N/P ratio	Average of 22 with values higher than 24 in 2009 and 2014.	- (??-+---?+)
Direct Effects (II)	Maximum and mean chlorophyll *a* concentration	6 years average (2006-2011) offshore waters do not exceed the threshold. Big yearly variation and no clear long term trend.	-
	Area-specific phytoplankton indicator species. *Phaeocystis spp.*	Not used.	
	Macrophytes including macroalgae	Not relevant.	
Indirect Effects (III)	Oxygen deficiency	Not relevant. Always above threshold.	-
	Changes/kills in zoobenthos and fish kills	No kills observed.	-
	Organic carbon/organic matter	Not used.	?
Other Possible Effects (IV)	Algal toxins (DSP/PSP mussel infection events)	Not used.	?

+ = 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

Reporting format on the results of the OSPAR Comprehensive Procedure (*continued*)

5. 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 classifica tion	Appraisal of all relevant information (concerning the harmonised assessment parameters, their respective assessment levels and the supporting environmental factors)	Final classification	Assessment period
Coastal area	NI	-	Ca	+	O_2	-	At	?	problem area	Problem area based on all assessment parameters, except for the indirect effects and riverine inputs.	problem area	2006-2014
	DI	+	Ps	+	Ck	-						
	NP	+	Mp	nr	Oc	?						
Offshore are	NI	nr	Ca	-	O_2	-	At	?	non-problem area	Non-problem area based on all assessment parameters. Model results confirm the initial classification.	non-problem area	2006-2014
	DI	-	Ps	?	Ck	-						
	NP	-	Mp	nr	Oc	?						

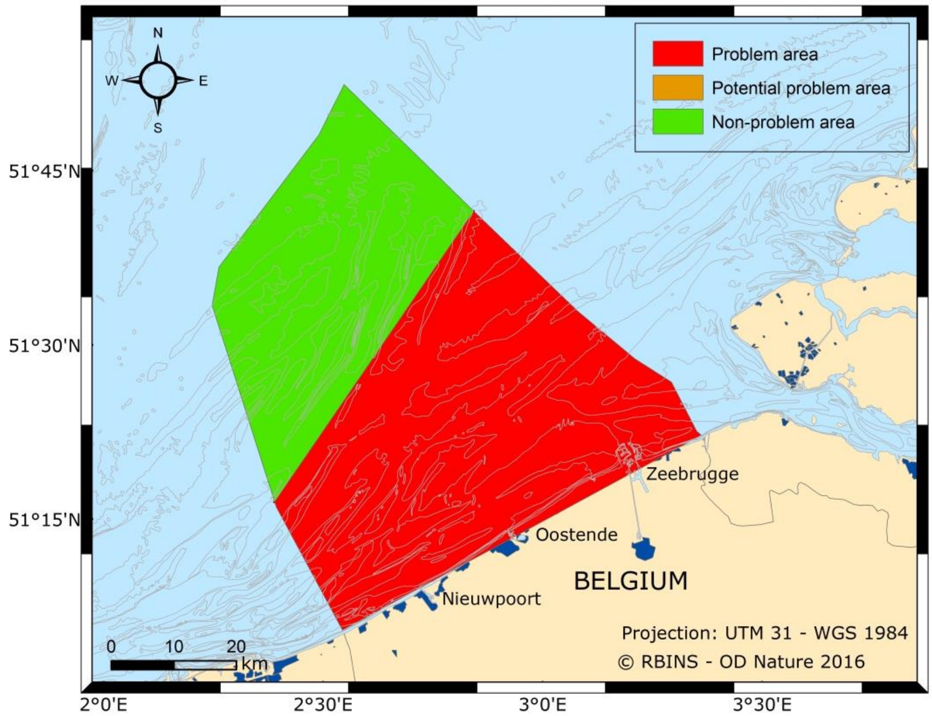

Figure 14. Overall area classification based on integration of the assessment parameters.

5.4. Comparison with preceding assessment

Similar to the previous evaluation, winter nitrogen concentrations exceeded every year the threshold. The yearly winter phosphate concentrations are again close to threshold with some years showing a value below the threshold. The average winter nutrient levels and associated N/P ratio for 2006-2014 are in the same range of values as in the previous assessment period. Chlorophyll *a* clearly exceeds the threshold in the first 12 nautical miles which is comparable to the previous assessment of this parameter. *Phaeocystis* cell countings that are available for some years of this assessment period confirm the presence of *Phaeocystis* blooms in the coastal waters, as noticed by observations in the second assessment.

However, unlike previously evaluated, the offshore area does not show elevated levels for chlorophyll *a*. This difference can be explained by the lack of offshore data during the previous assessment period with only one station located close to the coastal waters as well as measurements biased to the peak of the bloom. The initial classification for offshore waters, 'non problem area', differs from COMP2 (Belgium, 2007). For this assessment, information on the spatial distribution of phytoplankton biomass is available for the whole area, including the offshore area. The reliable evaluation of CHL-P90, the absence of elevated nutrient concentrations complemented with model results support the classification as 'non-problem area'. More importantly, coastal waters remain 'problem area'.

5.5. Voluntary parameters

5.5.1. Transboundary nutrient transports

The relative contribution of the different nitrogen sources to winter DIN (January-February) concentration and nitrogen content in phytoplankton (*Phaeocystis*) during the growing season (March-October) in Belgian coastal waters (defined as Belgian waters with 30 < salinity < 34.5), has been computed with MIRO&CO using a tagging technique (Ménesguen *et al.*, 2006). Results have been averaged over the period 2000-2010. The different sources considered are: the atmospheric depositions, the Atlantic waters represented by the western and northern boundaries of the model domain (WBC and NBC respectively), the Scheldt and small Belgian rivers (Ijser, Gent-Terneuzen Canal, Gent-Ostend Canal), the Seine and small French rivers (Somme, Authie, Canche, Liane, Wimereux, Slack and Aa), the Rhine-Meuse rivers and the Thames river. The model results showed that:

- on average for the coastal waters the nitrogen content in winter DIN (Figure 15, left) originates from the Scheldt and small Belgian rivers (28%), the Rhine-Meuse (17%), the Seine and small French rivers (9%), the Thames (< 1%) and finally the Atlantic water (27%). The N content in phytoplankton (*Phaeocystis*) during the growing season comes from (Figure 15, right): the Scheldt and small Belgian rivers (34%), the Rhine-Meuse (25%), the Seine and small French rivers (7%), the Thames (< 1%) and finally the Atlantic water (19%).
- 19 % of N within winter DIN (see Figure 15, left) and 15% of N content in phytoplankton (*Phaeocystis*) during the growing season (see Figure 15, right) in seawater are from atmospheric origin, and thus not negligible.

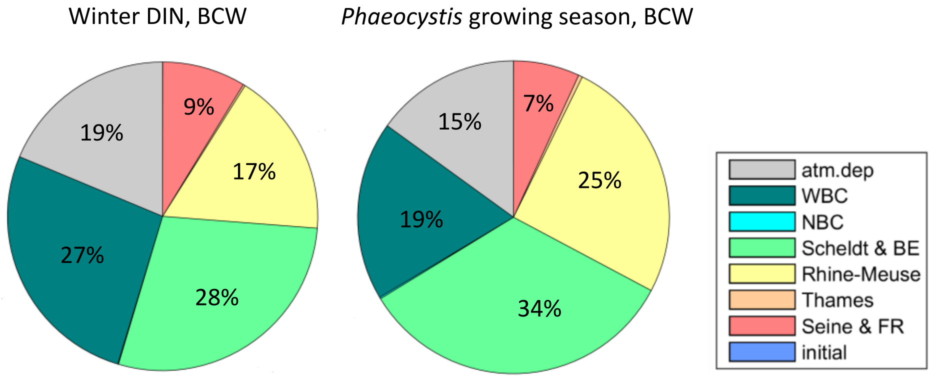

Figure 15. 2000-2010 averaged relative contribution of different N sources to winter DIN (left) and Mar-Oct Phaeocystis in Belgian coastal waters (BCW defined as Belgian waters with 30 < salinity < 34.5) as estimated by MIRO&CO using actual river loads (G. Lacroix, pers. comm. Adapted from Desmit et al. (2015a).

6. Comparison and/or links with European eutrophication related policies

6.1. Water Framework Directive (WFD)

In the frame of the WFD, the biological quality element phytoplankton is evaluated for the coastal waters defined by the one nautical mile limit. In the frame of OSPAR, coastal waters are defined by the 34.5 isohaline. The different eutrophication-related variables assessed during the first revision of the river basin management plan for the Belgian coastal waters are shown in Table 7 together with the thresholds.

Table 7. Assessment parameters: WFD boundary 'Good'/'Moderate' and OSPAR COMP3 elevated levels

	WFD	OSPAR COMP3
Riverine nutrient input	Not evaluated	Increased trend
Winter DIN (reference salinity 33.5)	15 µmol/l	22.5 µmol/l
Winter DIP (reference salinity 33.5)	0.8 µmol/l	0.8 µmol/l
N/P	16	30
Chlorophyll *a* P90 (growing season, 6 years)	15 µg/l	15 µg/l
Nuisance species (*Phaeocystis*)	17% samples containing more than 10^6 cells/l	>4.10^6cells/l
Degree of oxygen deficiency	6 mg/l	Not relevant (6 mg/l)

The majority of the thresholds are similar except for the nuisance species. Winter nutrient thresholds in the frame of WFD have been based on the OSPAR elevated levels. It appears different in the table due to the recent adjustments made for winter DIN and N/P ratio. The WFD coastal waters have been defined as 'moderate' due to the elevated phytoplankton biomass and nutrient concentrations and ratio. Also the *Phaeocystis* threshold has been exceeded, but it should be noticed that additional samples collected during the growing season greatly influence the result (determine the difference between the WFD classes 'moderate' and 'good') and that no data is available over a 6-year period. With this evaluation method, timing has a big influence on the result.

The final result is in accordance with the current assessment.

6.2. Marine Strategy (MSFD)

The evaluation in the frame of the MSFD is carried out for the whole of the BCP with goals defined in accordance to the OSPAR thresholds for coastal waters (chlorophyll *a*, nutrients) and WFD objectives (chlorophyll *a*, *Phaeocystis*).

7. Perspectives

7.1. Implemented and further planned measures

Since eutrophication mainly originates from the continent, most measures need to be taken upstream. These aspects are dealt with in the frame of the WFD by the different regions in Belgium. The implementation of the measures envisaged in the WFD and MSFD will have an impact on the quality of the seawater.

7.2. Outlook

7.2.1. Expected trends

Since several efforts attempt to reduce nutrient input, it is expected that the situation will slightly improve. It is however not expected that the good status will soon be achieved as this requires a substantial change and international collaboration.

To improve the situation in the marine environment, modelling has demonstrated that a significant reduction in nutrients, including transboundary nutrients, is necessary. Modelling carried out in the frame of EMoSEM considered the whole North-East Atlantic area (NEA) differentiating between different target areas (WFD, MSFD). The results for the NEA WFD water masses are mentioned below illustrating the amount of reduction needed.

Two marine ecosystem models, coupled to a new generic river-basin model have been used to compute the percentage of riverine N and P reduction needed to reach GES at sea within the North-East Atlantic (see EMoSEM final report, Desmit *et al*., 2015a). The EMoSEM study makes use of a slightly higher marine threshold for DIN (19.5 µmolN/l) and a slightly lower marine threshold for DIP (0.56 µmolP/l) than the ones chosen in the WFD (15 µmolN/l and 0.8 µmolP/l respectively for DIN and DIP). The resulting DIN/DIP ratio of 30 corresponds more to natural conditions in coastal waters as estimated from a simulation representative of pristine conditions. The results obtained, considering the WFD water masses as the target area on which the DIN and DIP thresholds have to be reached, showed that:

- A 35-40% reduction of riverine DIN is needed to reach a threshold of 19.5 µmolN/l for the winter DIN within the WFD water masses..
- A reduction of ~20 % of riverine DIP is needed to reach a threshold of 0.56 µmolP/l for the winter DIP within the WFD water masses.

Based on different nutrient reduction scenarios, it can be concluded that an in-depth change in the agro-food systems (encompassing local-organic agriculture and demitarian food consumption) will be needed to achieve a significant N reduction in the river and marine waters. The diffuse agricultural sources should be targeted to reach a significant reduction. Additional or improved wastewater treatment plants will have only a minor effect since it is almost fully implemented. Atmospheric N depositions are far from negligible and show an increasing relative contribution when riverine nutrient loads are reduced. It is recommended to reduce atmospheric deposition in parallel with river loads (Desmit, 2015a).

7.2.2. Improvement of assessments

In this third application of the Comprehensive Procedure some improvements have been made. The spatial distribution of the monitoring stations has been optimized. The frequency of chlorophyll *a* concentrations have been slightly diminished but the high amount of satellite-observed chlorophyll *a* has provided more accurate information. A full spatial overview is obtained and the percentage of the area below the elevated level is considered as an effective way to present the situation, as well as the evolution, of phytoplankton biomass in the BCP. With respect to the presence of undesirable species, no routine monitoring takes place. *Phaeocystis* monitoring is envisaged (in accordance with the environmental targets defined in the frame of MSFD) when the eutrophication state improves. The results for plankton cell counts would add to the existing information on the eutrophication state of the BCP. However, an improvement and alignment of the assessment methods used in the frame of OSPAR and WFD is recommended.

7.2.3. Future perspectives

Mature services now exist to support the monitoring and reporting of water quality, e.g. in the framework of the OSPAR convention, by using satellite sensors such as MERIS and the recently launched Sentinel-3/OLCI satellite (ESA). In the long-term planning of these operational services continuous data collection is foreseen and as a consequence no data gaps are to be expected.

Despite the improved coverage of this satellite data with respect to in situ monitoring (typically one image per cloud-free day), the satellite data is still limited in spatial resolution (not better than 250m). With the FP7-HIGHROC project, RBINS/OD Nature aims to derive coastal water quality parameters from Sentinel-2 at 10-20m resolution and Landsat-8 at 30m resolution, thus dramatically improving the spatial resolution as compared to the existing satellite data sources.

8. Conclusions

Eutrophication still remains problematic in the Belgian marine waters. The coastal zone is classified as ‘problem area’ whereas the offshore area is classified as ‘non problem area’. In COMP2, the offshore area was classified as ‘potential problem area’ due to the low confidence in the assessment of the direct effects. Offshore measurements were scarce and biased in time and space.

The reported riverine nutrient inputs mainly consist in the Belgian contribution to the Scheldt nutrient loads near the Belgian-Dutch border and in other small Belgian rivers and channels. After the wet years 2001 and 2002, a decrease in annual nutrient loads could be noticed in Belgian rivers, followed by oscillations since 2005 mainly related to changes in water discharge. A lower mean annual load of total nitrogen and total phosphorus for the period 2006-2014 is reported compared to the previous reporting period. However, the winter nutrient concentrations in the BCS at salinity 33.5 remain high. The decreasing trend in DIN observed since the ‘90s halted and was followed by yearly oscillations around 30 µmol/l during the last decade. Winter DIP has stabilized with oscillations around 0.9 µmol/l for DIP, very close to the threshold. The DIN/DIP ratio stabilizes around 32-33 without a significant trend over the whole period. In the offshore waters, winter DIN and DIP do not show elevated levels. Offshore DIN/DIP ratios are generally below 24 with exceedances in two years, both years showing the lowest average winter DIP concentration.

Chlorophyll *a* maximum tendency is estimated through its 90th percentile (CHL-P90) obtained via remote sensing. The high temporal frequency of these measurements leads to more accurate estimates. The CHL-P90 is elevated in the major part of the coastal waters, more or less corresponding to the area within a distance of 12 nautical miles from the coastline. The percentage surface of the BCP that shows elevated levels of CHL-P90 also features high interannual variabilities and does not reveal any significant trend. The 6-year averages, limited to 2011, show an increase that seems to be linked to hydrometeorological variability. In situ data cover a longer time period and lower values are observed after 2011. The average in situ CHL-P90 calculated over the period 2006-2014 is slightly lower than during the previous decade, but no clear long-term increasing or decreasing trend can be identified.

The offshore waters do not show elevated chlorophyll *a* level on the classified satellite-observed CHL-P90 map calculated over 6 years.

Phaeocystis cell counts, performed in 2008-2010, exceeded the threshold in most monitoring stations within the one nautical mile area. The highest value of excessive abundance during this period was noticed in 2008. Generally no problems with oxygen deficiency occur in the BCS due to the prevailing hydrodynamic conditions ensuring continuous oxygen replenishment. No zoobenthos or fish kills have been observed.

Although nutrient loads are lower than during the previous assessment period, the situation at sea has not significantly improved. A significant reduction in nutrients is needed to reach the status of non-problem area in the receiving coastal zone.

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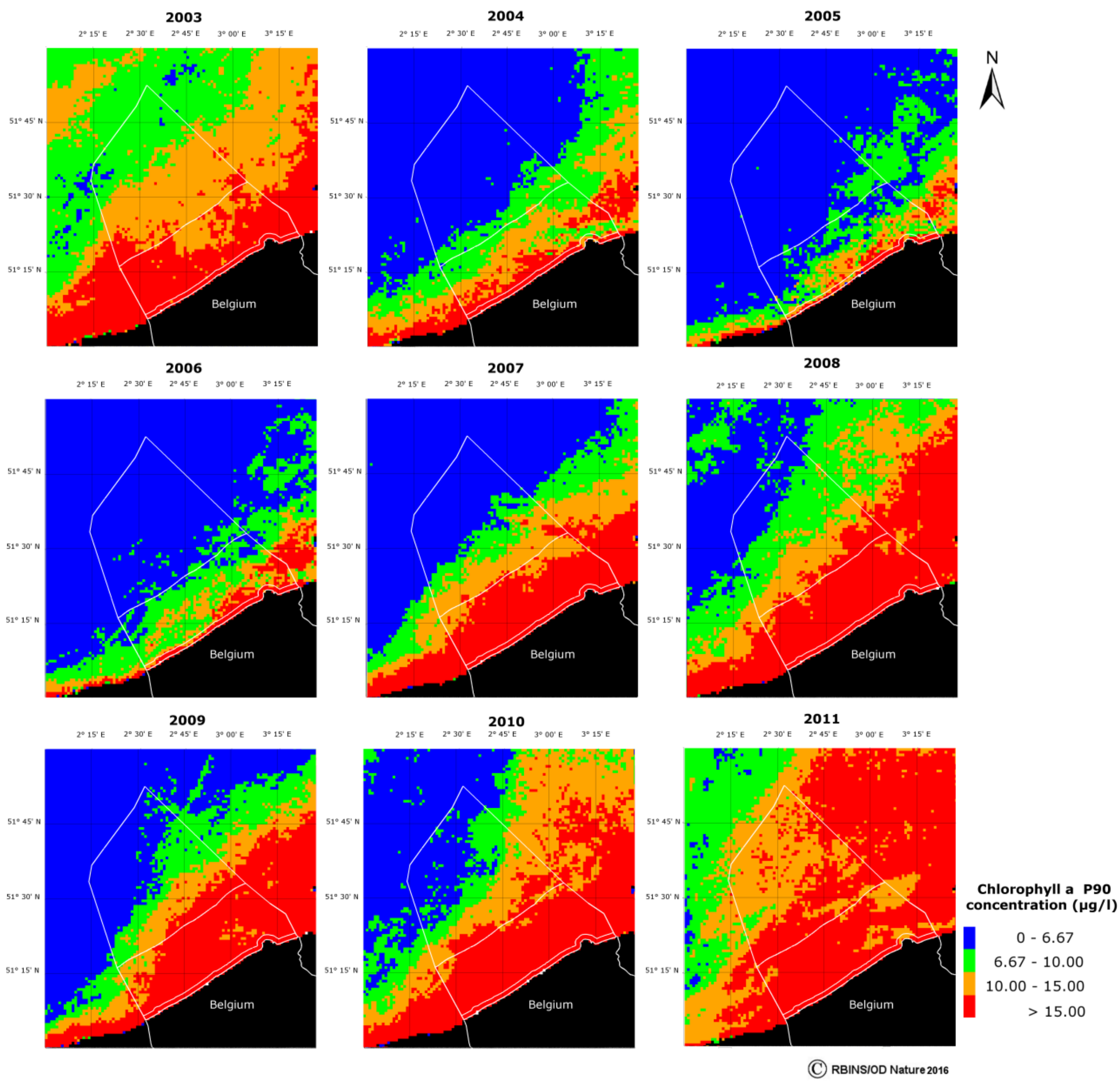
Annex: Yearly CHL-P90 maps for the BCP



Presentation of the yearly chlorophyll P90 products (March-Oct incl.) for 2003 to 2011. These yearly composites allow a detailed view of the changes in the chlorophyll a P90 concentration between the different growing seasons. The presentation clearly shows how 2003 and 2011 were exceptional years in terms of chlorophyll a concentrations in the North Sea.

❍ COLOPHON

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