

## 18 Annex 8 - Northern North Sea (Region 1)

Name and map (geographical location: longitude, latitude)

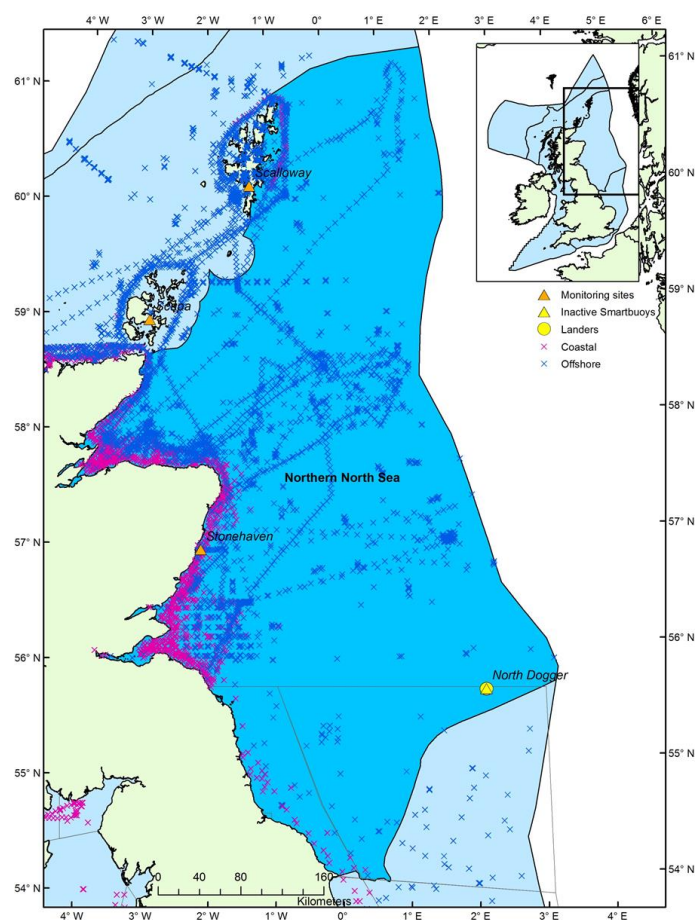


Figure A8.1: Map showing the location of the northern North Sea (Region 1, dark blue). Grey lines indicate UK marine areas from the second application of the COMP which fall into this region (part of the northern North Sea, and the NE England Coast). The locations of sites (X) where data were available from 2006 onwards are shown: red = coastal (salinity 30-34.5), blue = offshore sites (salinity >34.5). Data were obtained from multiple sources (Annex 2).

### 18.1 Description of the area

Including environmental information

This area (Figure A8.1) includes the northern part of the North Sea from Shetland to Scarborough Head, is bordered by the coasts of north east England and eastern Scotland, and extends to the UK jurisdictional boundary. Much of the region is 'seasonally stratified' and a very narrow coastal area is exposed to freshwater influence. Inflowing Atlantic water (Scotland's Marine Atlas p. 62) sets the background nutrient concentrations though these may be modified with distance along transport paths. The offshore northern North Sea has a high transparency with records at the 'North Dogger' site showing light penetration in excess of 50 m during the summer months (Capuzzo et al 2013). A century-scale time series analysis of Secchi disc depths and other measures of light attenuation has shown that transparency in this region has decreased significantly since the 1950s (Capuzzo et al 2015).

The northern North Sea has been assessed as a Non-Problem Area through subsequent applications of the OSPAR Common Procedure.

The Water Framework Directive (WFD) assessments of the status of transitional and coastal waters in this region have identified three Problem Areas: the Ythan estuary (Scotland), Holy Island and Budle Bay (England), and the Tees estuary (England).

### Risks

*Human pressures:* Shifts in human population, changes in nutrient management practices within the catchment, top-down control through recovering fisheries and benthos.

*Environmental pressures:* Long-term changes in hydrodynamics, changes in inflows, stratification, mixing.

*Assessment of risk* – Although human populations are slowly increasing in the north of the UK, agricultural practices and sewage treatment are controlled so that **there is a very low probability** that the influence of anthropogenic nutrients in the northern North Sea will change in the next 10 years.

### **18.2 Description of monitoring design in relation to spatial and temporal variability of assessment parameters in the area**

As a Non-Problem Area, the northern North Sea is subject to the relevant requirements of the OSPAR Eutrophication Monitoring Programme to measure DIN, DIP, salinity and temperature in marine waters about every three years in winter. Estuarine and transitional waters are monitored by the Scottish Environment Protection Agency (SEPA) and the Environment Agency (EA) to meet WFD and other Directive requirements.

**Nutrients:** A time series of nutrients is available from the Marine Scotland Science (MSS) station at Stonehaven (Figure A8.1). Stonehaven is the most important sentinel site for the northern North Sea due to the wide range of variables measured. Winter nutrients have been collected on CSEMP monitoring cruises since 2001. Marine Scotland, and less frequently Cefas, use research vessel cruises to collect occasional samples in winter from the northern North Sea. Cefas conducted an intensive 18-month research campaign including a SmartBuoy with automated nutrient sampling at the ‘North Dogger’ site during 2007-2008.

A range of other readily available information has been obtained to support the assessment.

**Chlorophyll:** Chlorophyll data are routinely collected at the MSS monitoring station at Stonehaven. Chlorophyll measurements are also made on oceanographic surveys in the region.

**Oxygen:** There is no routine monitoring of oxygen concentrations as this is a Non Problem Area. At a site north of the Dogger Bank, Greenwood et al (2010) showed that oxygen concentrations decrease through the late spring, summer and early autumn as strong stratification and weak tidal currents prevents ventilation of the bottom waters. Queste et al (2013) showed that the extent of oxygen depletion has increased in the past decade relative to previous years.

**Phytoplankton composition:** A time series of phytoplankton species composition has been collected by Marine Scotland at the Stonehaven site (visualisation at the ICES site [http://www.st.nmfs.noaa.gov/copepod/time-series/site\\_\\_northsea-scotland-stonehaven-phy/](http://www.st.nmfs.noaa.gov/copepod/time-series/site__northsea-scotland-stonehaven-phy/)). Pigment-based taxonomy and flow cytometric analysis on Q3 IBTS surveys shows that the phytoplankton community of the northern and central North Sea is dominated by small-celled picoplankton and nanoplankton (Owen 2013). These phytoplankton are difficult to identify by light microscopy. Coccolithophores form prominent surface blooms in May-June which are visible from

space as milky-turquoise colorations between Scotland and Norway. The CPR captures some large-celled species of phytoplankton (albeit with a very low capture efficiency) and recent data shows a reduction of dinoflagellates relative to diatoms (Hinder et al 2012).

#### **Seagrasses and seaweeds:**

*Offshore:* the depth of the seafloor offshore is too deep to allow attached vegetation to grow under present irradiance conditions.

*Inshore:* three Scottish east coast estuaries show signs of accelerated growth of opportunistic green algae (OGA): the Ythan and Eden estuaries and Montrose Bay (Scotland's Marine Atlas). These waterbodies are monitored under the WFD.

### **18.3 Assessment**

#### **Nutrients:**

Mean winter concentrations of DIN ( $\mu\text{M}$ ) per year in the northern North Sea during the assessment period, 2006 to 2014 are shown on Figure A8.2. Results are shown separately for coastal waters and offshore waters, using data from all depths sampled. Results are shown as normalised mean concentrations (on the left; coastal data normalised to salinity 32, offshore data normalised to 34.5) and non-normalised mean concentrations (on the right).

Normalised mean winter DIN concentrations in coastal water (7 - 15  $\mu\text{M}$ ) and offshore water (6 - 11  $\mu\text{M}$ ) were below the assessment thresholds of 18  $\mu\text{M}$  and 15  $\mu\text{M}$ , respectively. Standard errors indicate low variability in the data; confidence levels for concluding that concentrations were below the assessment threshold were high in both coastal and offshore waters (100%, Tables A8.1, A8.2). Similar results were obtained using non-normalised mean values for DIN, which generally were lower (6 - 13  $\mu\text{M}$  coastal and 6.5 - 9.5  $\mu\text{M}$  offshore, data not shown). For TOxN (Figure A8.3, Tables A8.3 and A8.4), similar results were also obtained but more data were available for the analyses. For both DIN and TOxN, overall confidence in mean values over the assessment period (2006-2014) was high (100%).

For assessment purposes (see below), the normalised mean winter DIN values were used.

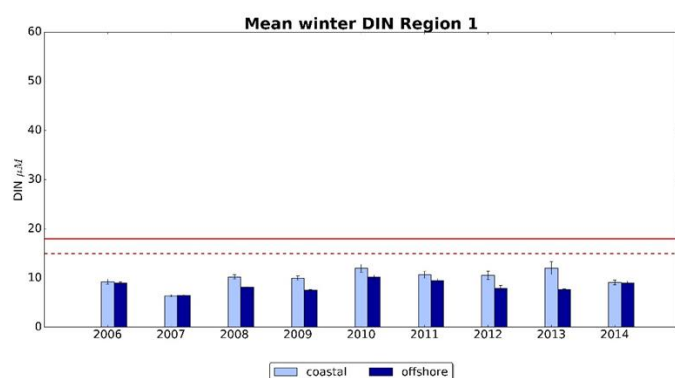
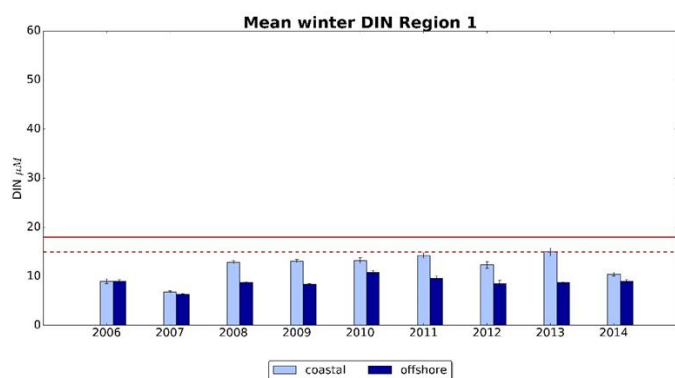


Figure A8.2: Mean winter concentrations of DIN ( $\mu\text{M}$ ) per year in the northern North Sea during the assessment period, 2006 to 2014. Results are shown separately for coastal waters and offshore waters, using data from all depths sampled. Data are shown as normalised means (left) and non-normalised means (right). Coastal data were normalised to salinity 32, offshore data were normalised to 34.5. Assessment thresholds for coastal (18  $\mu\text{M}$ , solid red line) and offshore waters (15  $\mu\text{M}$ , dashed red line) are shown.

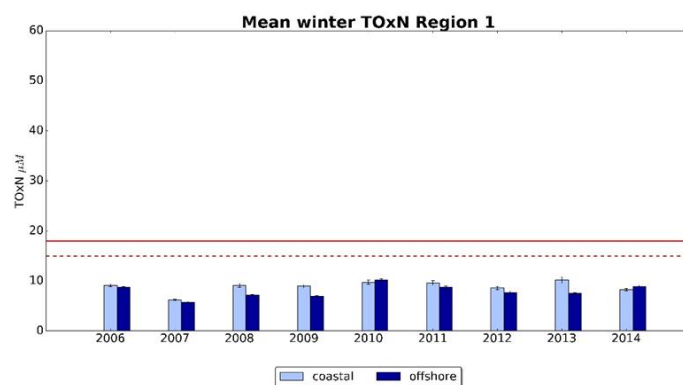
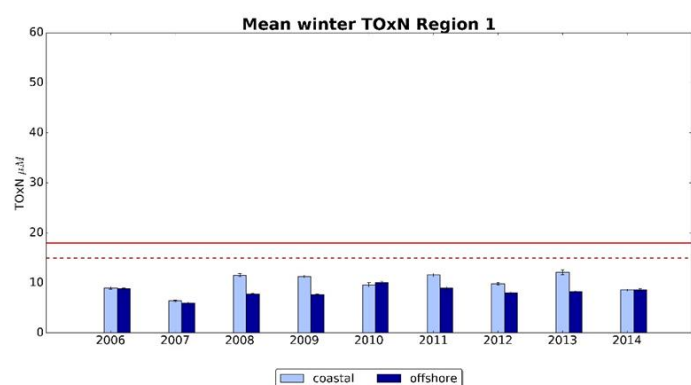


Figure A8.3: Mean winter concentrations of TOxN ( $\mu\text{M}$ ) per year in the northern North Sea during the assessment period, 2006 to 2014. Results are shown separately for coastal waters and offshore waters, using data from all depths sampled. Data are shown as normalised means (left) and non-normalised means (right). Coastal data were normalised to salinity 32, offshore data were normalised to 34.5. Assessment thresholds for coastal (18  $\mu\text{M}$ , solid red line) and offshore waters (15  $\mu\text{M}$ , dashed red line) are shown.

Table A8.1: Normalised means and yearly confidence levels for winter DIN in Region 1 coastal. The assessment threshold, minimum value, maximum value, standard error and number of samples are shown. All = overall values and confidence levels (see Table 5 of main report).

Region	Location	Assessm Threshold ( $\mu\text{M}$ )	Year	Min Value	Max Value	Normalised Mean	Std Error	Number of Samples	Confidence Level (%) for concluding Non Problem
1	Coastal	18	2006	8	13.8	9	0.24	26	100
1	Coastal	18	2007	4.22	11	6.84	0.11	170	100
1	Coastal	18	2008	5.88	24.99	12.88	0.18	229	100
1	Coastal	18	2009	5.46	22.1	13.12	0.16	187	100
1	Coastal	18	2010	7.58	15.83	13.25	0.28	32	100
1	Coastal	18	2011	6.24	26.5	14.24	0.26	101	100
1	Coastal	18	2012	6.76	21.83	12.32	0.33	75	100
1	Coastal	18	2013	4.14	32.74	14.96	0.42	67	100
1	Coastal	18	2014	5.84	17.58	10.47	0.2	95	100
			All	4.14	32.74	12.18	0.09	982	100

*Table A8.2: Normalised means and yearly confidence levels for winter DIN in Region 1 offshore. The assessment threshold, minimum value, maximum value, standard error and number of samples are shown. All = overall values and confidence levels (see Table 6 in main report).*

Region	Location	Assessm Threshold ( $\mu\text{M}$ )	Year	Min Value	Max Value	Normalised Mean	Std Error	Number of Samples	Confidence Level (%) for concluding Non Problem
1	Offshore	15	2006	5.92	12.14	9.03	0.15	73	100
1	Offshore	15	2007	5.56	7.47	6.3	0.08	47	100
1	Offshore	15	2008	4.17	13.5	8.7	0.07	335	100
1	Offshore	15	2009	5.57	11.36	8.39	0.07	371	100
1	Offshore	15	2010	7.5	13.28	10.75	0.22	49	100
1	Offshore	15	2011	5.75	17.29	9.55	0.27	64	100
1	Offshore	15	2012	4.7	29.23	8.51	0.35	73	100
1	Offshore	15	2013	3.2	10.35	8.7	0.1	176	100
1	Offshore	15	2014	5.3	21.48	8.93	0.2	103	100
			All	3.2	29.23	8.51	0.05	1291	100

*Table A8.3: Normalised means and yearly confidence levels for winter TOxN in Region 1 coastal. The assessment threshold, minimum value, maximum value, standard error and number of samples are shown. All = overall values and confidence levels (see Table 5 in main report).*

Region	Location	Assessm Threshold ( $\mu\text{M}$ )	Year	Min Value	Max Value	Normalised Mean	Std Error	Number of Samples	Confidence Level (%) for concluding Non Problem
1	Coastal	18	2006	4.89	16.12	9.02	0.13	115	100
1	Coastal	18	2007	4.13	10.71	6.4	0.08	250	100
1	Coastal	18	2008	5.14	20.82	11.56	0.16	239	100
1	Coastal	18	2009	5.35	18	11.27	0.14	192	100
1	Coastal	18	2010	4.86	12.5	9.61	0.22	53	100
1	Coastal	18	2011	5.9	23.1	11.58	0.19	127	100
1	Coastal	18	2012	5.48	18.6	9.82	0.13	161	100
1	Coastal	18	2013	3.97	24.04	12.13	0.24	96	100
1	Coastal	18	2014	5.3	14.6	8.56	0.12	159	100
			All	3.97	24.04	9.91	0.06	1392	100

*Table A8.4: Normalised means and yearly confidence levels for winter TOxN in Region 1 offshore. The assessment threshold, minimum value, maximum value, standard error and number of samples are shown. All = overall values and confidence levels (see Table 6 in main report).*

Region	Location	Assessm Threshold ( $\mu\text{M}$ )	Year	Min Value	Max Value	Normalised Mean	Std Error	Number of Samples	Confidence Level (%) for concluding Non Problem
1	Offshore	15	2006	4.72	11.25	8.85	0.07	318	100
1	Offshore	15	2007	3.16	8.02	6	0.08	77	100
1	Offshore	15	2008	1.35	12.1	7.74	0.07	355	100
1	Offshore	15	2009	5.29	9.26	7.64	0.06	378	100
1	Offshore	15	2010	5.68	14.6	10.05	0.12	170	100
1	Offshore	15	2011	4.7	15.1	8.95	0.17	137	100
1	Offshore	15	2012	4.55	28.73	7.97	0.12	232	100
1	Offshore	15	2013	1.69	10.12	8.29	0.06	340	100
1	Offshore	15	2014	4.9	21.2	8.63	0.12	193	100
			All	1.35	28.73	8.13	0.04	2200	100

## DIN:DIP ratios

Mean winter DIN:DIP ratios (Figure A8.4) were well below the threshold of 24, indicating no problems with nitrogen enrichment in the region. Standard errors indicate more variability in offshore data than in coastal data; nonetheless, confidence levels for concluding Non Problem Area were high (97-100%, Tables A8.5, A8.6). Overall confidence in mean values over the assessment period (2006-2014) was high (100%).

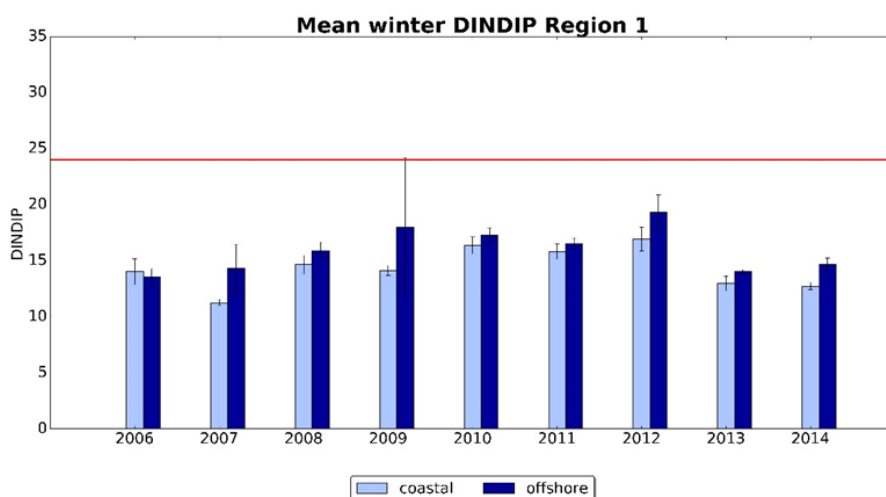


Figure A8.4: Mean winter ratios of DIN:DIP per year in in the northern North Sea during the assessment period, 2006 to 2014. Results are shown separately for coastal waters and offshore waters, using data from all depths sampled. The assessment threshold of 24 is shown by the red line.

Table A8.5: Means and yearly confidence levels for winter DIN:DIP in Region 1 coastal. The assessment threshold, minimum value, maximum value, standard error and number of samples are shown. All = overall values and confidence levels (see Table 5 of main report).

Region	Location	Assessm Threshold	Year	Min Value	Max Value	Mean Value	Std Error	Number of Samples	Confidence Level (%) for concluding Non Problem
1	Coastal	24	2006	9.97	20.63	14.02	0.55	23	100
1	Coastal	24	2007	7.9	16.31	11.26	0.13	170	100
1	Coastal	24	2008	6.72	48.17	14.67	0.41	191	100
1	Coastal	24	2009	10.6	27.85	14.13	0.22	141	100
1	Coastal	24	2010	13.54	18.87	16.38	0.35	15	100
1	Coastal	24	2011	12.17	23.4	15.81	0.34	63	100
1	Coastal	24	2012	12.45	24.41	16.93	0.52	33	100
1	Coastal	24	2013	8.65	18.45	12.97	0.33	60	100
1	Coastal	24	2014	10.08	20.36	12.72	0.16	94	100
			All	6.72	48.17	13.68	0.14	790	100



Table A8.6: Means and yearly confidence levels for winter DIN:DIP in Region 1 offshore. The assessment threshold, minimum value, maximum value, standard error and number of samples are shown. All = overall values and confidence levels (see Table 6 of main report).

Region	Location	Assessm Threshold	Year	Min Value	Max Value	Mean Value	Std Error	Number of Samples	Confidence Level (%) for concluding Non Problem
1	Offshore	24	2006	9.41	28.19	13.58	0.36	69	100
1	Offshore	24	2007	8.5	45.06	14.31	1.07	47	100
1	Offshore	24	2008	5.47	82.78	15.88	0.41	332	100
1	Offshore	24	2009	3	858	18.02	3.15	371	97.08
1	Offshore	24	2010	10.85	22.17	17.26	0.34	49	100
1	Offshore	24	2011	10.86	22.11	16.52	0.25	58	100
1	Offshore	24	2012	9.66	33.5	19.31	0.79	68	100
1	Offshore	24	2013	11.93	20.39	14.06	0.08	172	100
1	Offshore	24	2014	7.79	37.03	14.65	0.3	102	100
			All	3	858	16.24	0.93	1268	100

## Chlorophyll

Concentrations of chlorophyll ( $\mu\text{g l}^{-1}$ ) per year in the northern North Sea during the assessment period, 2006 to 2014 are shown as 90<sup>th</sup> percentiles on Figure A8.5. Results are shown separately for coastal waters and offshore waters, using data from all depths sampled.

For coastal waters, sufficient data were available for an assessment in eight of the nine years and confidence levels in the assessments were high (88-100%, Table A8.7). In all years assessed, 90<sup>th</sup> percentiles were below the assessment threshold of  $15 \mu\text{g l}^{-1}$ . The highest value ( $12.18 \mu\text{g l}^{-1}$ ) was observed in 2010. Overall confidence in 90<sup>th</sup> percentiles over the assessment period (2006-2014) was high (100%).

In offshore water, 90<sup>th</sup> percentiles ( $\leq 4 \mu\text{g l}^{-1}$ ) were below the assessment thresholds of  $10 \mu\text{g l}^{-1}$ . Confidence levels for concluding Non Problem Area were high (65-100%, Table A8.8).

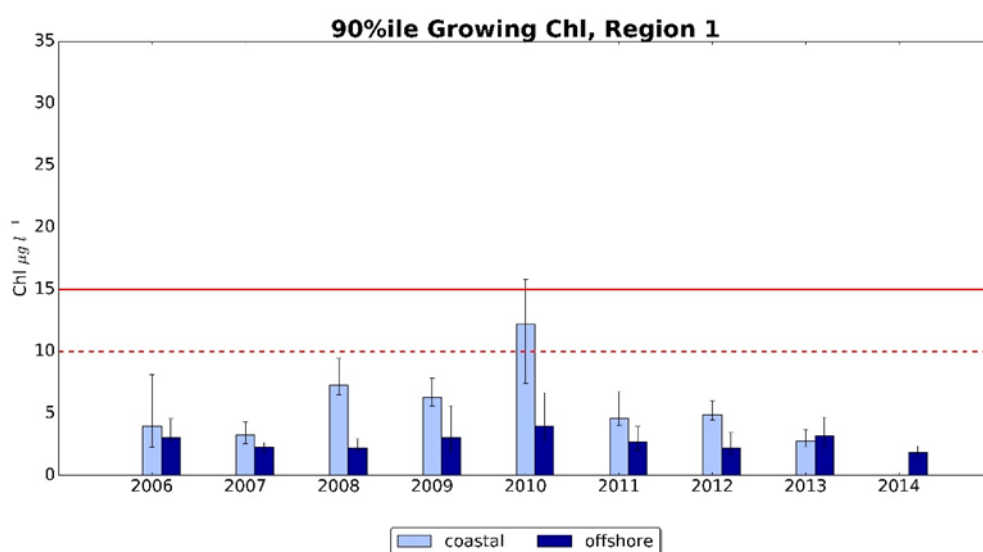


Figure A8.5: Growing season chlorophyll per year in the northern North Sea during the assessment period, 2006 to 2014, shown as 90<sup>th</sup> percentiles. Results are shown separately for coastal water and offshore water, using data from all depths sampled. Assessment thresholds for coastal ( $15 \mu\text{g l}^{-1}$ , solid red line) and offshore waters ( $10 \mu\text{g l}^{-1}$ , dashed red line) are shown.

Table A8.7: Chlorophyll growing season 90<sup>th</sup> percentiles in Region 1 coastal, and confidence levels per year. The assessment threshold, standard deviation, number of samples, and the number of data points below the threshold are shown. nan = no data. All = overall values and confidence levels (see Table 5 of main report).

Region	Location	Assessm Threshold ( $\mu\text{g l}^{-1}$ )	Year	90 <sup>th</sup> percentile	Mean	Std Dev	Number of Samples (n)	95% Conf Limit lower	95% Conf Limit upper	Number (n) below the assessment threshold	Confidence level (%)
1	Coastal	15	2006	3.98	1.72	1.94	20	2.28	8.12	20	87.84
1	Coastal	15	2007	3.27	1.58	1.17	42	2.57	4.34	42	98.8
1	Coastal	15	2008	7.3	3.45	2.47	89	6.52	9.45	89	99.99
1	Coastal	15	2009	6.32	3.22	2.08	80	5.6	7.86	80	99.98
1	Coastal	15	2010	12.18	4.74	4.41	71	7.43	15.82	68	93.35
1	Coastal	15	2011	4.6	1.93	1.91	165	4.05	6.77	165	100
1	Coastal	15	2012	4.89	2.36	1.92	100	4.46	6.03	100	100
1	Coastal	15	2013	2.8	1.5	1.04	93	2.3	3.7	93	99.99
1	Coastal	15	2014	nan	nan	nan	nan	nan	nan	nan	nan
			All	6.01	2.57	2.51	660	5.19	6.52	657	100

Table A8.8: Chlorophyll growing season 90<sup>th</sup> percentiles in Region 1 offshore, and confidence levels per year. The assessment threshold, standard deviation, number of samples, and the number of data points below the threshold are shown. All = overall values and confidence levels (see Table 6 of main report).

Region	Location	Assessm Threshold ( $\mu\text{g l}^{-1}$ )	Year	90 <sup>th</sup> percentile	Mean	Std Dev	Number of Samples (n)	95% Conf Limit lower	95% Conf Limit upper	Number (n) below the assessment threshold	Confidence level (%)
1	Offshore	10	2006	3.05	1.57	1.27	113	2.66	4.59	113	100
1	Offshore	10	2007	2.26	1	0.92	164	1.88	2.66	164	100
1	Offshore	10	2008	2.22	1.33	0.94	93	1.9	2.97	93	99.99
1	Offshore	10	2009	3.06	1.45	1.3	42	1.9	5.61	42	98.8
1	Offshore	10	2010	4	1.51	1.77	76	2.8	6.69	76	99.97
1	Offshore	10	2011	2.72	1.27	1.35	170	2	3.96	170	100
1	Offshore	10	2012	2.22	0.92	1.03	71	1.66	3.46	71	99.94
1	Offshore	10	2013	3.22	1.38	1.19	88	2.3	4.7	88	99.99
1	Offshore	10	2014	1.84	1.2	0.51	10	1.47	2.38	10	65.13
			All	2.67	1.28	1.24	827	2.35	3.14	827	100

### Phytoplankton indicator species

Phytoplankton data are collected at the Stonehaven site. The outcome from the application of the WFD phytoplankton tool to these data was high (Final EQR 0.88). At the North Dogger site, insufficient data were available (2007-2008 only) to apply the WFD tool.

### Oxygen deficiency

Concentrations ( $\text{mg l}^{-1}$ ) and percentage saturation of near-bed dissolved oxygen per year during the assessment period (2006-2014) are shown as mean values in the lowest quartile of the data during the stratified season, for coastal and offshore areas (Figure A8.6). The number of samples in the lowest quartile of the data was generally low ( $n < 10$ ), and often insufficient for assessment purposes ( $n \geq 5$ ). For dissolved oxygen, the total number of available data (i.e. near-bed samples)



was used as the criterion for assessments, and not the number of samples in the lowest quartile (Tables A8.9 and A8.10).

In coastal waters, available data showed that dissolved oxygen concentrations were above the threshold ( $6 \text{ mg l}^{-1}$ ) from 2008 to 2014 (Figure A8.6). Confidence for concluding Non Problem Area was high (99-100%, Table A8.9). Overall confidence in mean values over the assessment period (2006-2014) was high (100%). Oxygen saturation was higher than 60% (Figure A8.6), and confidence in classifications was also high (data not shown).

In offshore waters, data were available for all years. Dissolved oxygen concentrations and percentage saturation were above the thresholds (Figure A8.6); confidence in the mean values was high (96-100%, Table A8.10). Overall confidence in mean values over the assessment period (2006-2014) was high (100%).

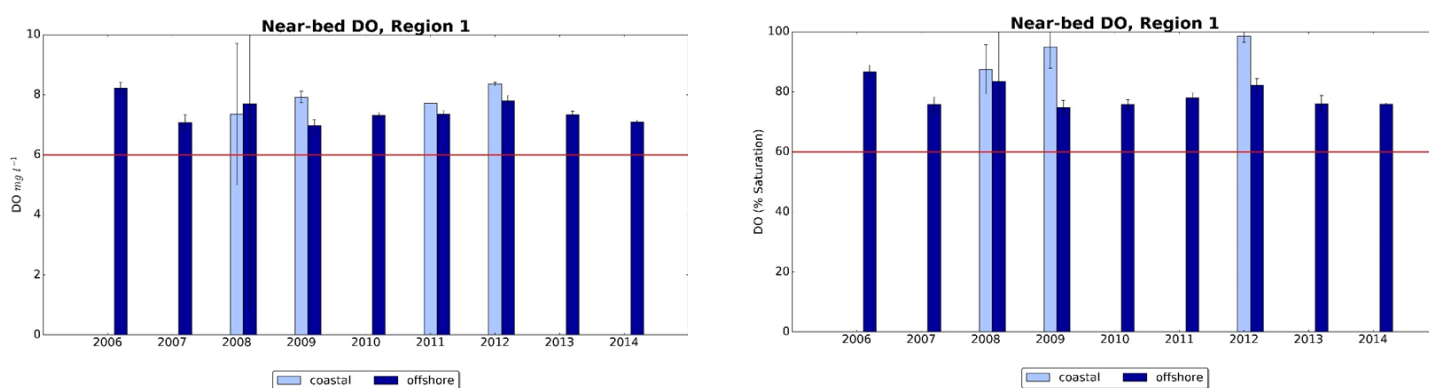


Figure A8.6: Near-bed dissolved oxygen (DO) per year in the northern North Sea during the assessment period, 2006 to 2014, shown as concentrations ( $\text{mg l}^{-1}$ , left) and percentage saturation (right). Results are given as mean values in the lowest quartile of the data during the stratified season, and are shown separately for coastal waters and offshore waters. Results are shown for years with five or more data points. Thresholds of  $6 \text{ mg l}^{-1}$  and 60% saturation are shown by the red lines.

### High frequency data

High frequency data from a benthic lander north of the Dogger Bank over two years (2007 and 2008, Figure A8.7) indicate seasonal trends in dissolved oxygen concentrations in the offshore waters of the northern North Sea. Concentrations decreased during the stratification season (from about April) and increased in late autumn/winter (from about November), when water column stratification started to break down (see also Greenwood et al. 2010). The assessments are carried out using data obtained during the stratification season (June to October, inclusive), and the means of the lowest quartiles should reflect these changes. The lander data were included in the dataset, using weekly averages as individual data points, as described in the methods in Annex 2.

*Table A8.9: Near-bed dissolved oxygen (mg l<sup>-1</sup>) in Region 1 coastal, and confidence levels per year. The table shows thresholds used, the mean and standard error in the lowest quartile of the data (Q25), number of data points in the lowest quartile and in the available dataset (total), and confidence levels in assessment outcomes. nan = no data. Minimum (Min) and maximum (Max) values in the total dataset are also shown. All = overall values and confidence levels (see Table 5 in main report).*

Region	Location	Assessm Threshold (mg l <sup>-1</sup> )	Year	Min Value	Max Value	Mean (Q25)	Std Error (Q25)	Number of Samples (Q25)	Number of Samples (total)	Confidence Level (%) for concluding Non Problem
1	Coastal	6	2006	nan	nan	nan	nan	nan	0	nan
1	Coastal	6	2007	nan	nan	nan	nan	nan	0	nan
1	Coastal	6	2008	7.17	9.38	7.36	0.185	2	8	99.09
1	Coastal	6	2009	7.91	8.59	7.93	0.015	2	7	100
1	Coastal	6	2010	nan	nan	nan	nan	nan	0	nan
1	Coastal	6	2011	7.71	8.76	7.71	nan	1	5	nan
1	Coastal	6	2012	8.35	9.05	8.36	0.005	2	6	100
1	Coastal	6	2013	nan	nan	nan	nan	nan	0	nan
1	Coastal	6	2014	8.2	8.53	8.2	nan	1	3	nan
			All	7.17	9.38	7.71	0.106	7	29	100

*Table A8.10: Near-bed dissolved oxygen (mg l<sup>-1</sup>) in Region 1 offshore, and confidence levels per year. The table shows thresholds used, the mean and standard error in the lowest quartile of the data (Q25), number of available data points in the lowest quartile and in the available dataset (total), and confidence levels in assessment outcomes. Minimum (Min) and maximum (Max) values in the total dataset are also shown. All = overall values and confidence levels (see Table 6 in main report).*

Region	Location	Assessm Threshold (mg l <sup>-1</sup> )	Year	Min Value	Max Value	Mean (Q25)	Std Error (Q25)	Number of Samples (Q25)	Number of Samples (total)	Confidence Level (%) for concluding Non Problem
1	Offshore	6	2006	7.93	9.29	8.22	0.071	5	14	100
1	Offshore	6	2007	6.78	9.1	7.07	0.092	5	21	100
1	Offshore	6	2008	7.16	8.99	7.7	0.536	2	9	95.65
1	Offshore	6	2009	6.85	9.6	6.97	0.067	4	17	99.99
1	Offshore	6	2010	7.1	8.3	7.31	0.039	7	18	100
1	Offshore	6	2011	7.15	11.65	7.35	0.05	8	31	100
1	Offshore	6	2012	7.57	8.29	7.8	0.068	5	18	100
1	Offshore	6	2013	7.26	8.05	7.34	0.035	4	15	100
1	Offshore	6	2014	7.02	8.3	7.1	0.025	6	23	100
			All	6.78	11.65	7.19	0.023	42	166	100

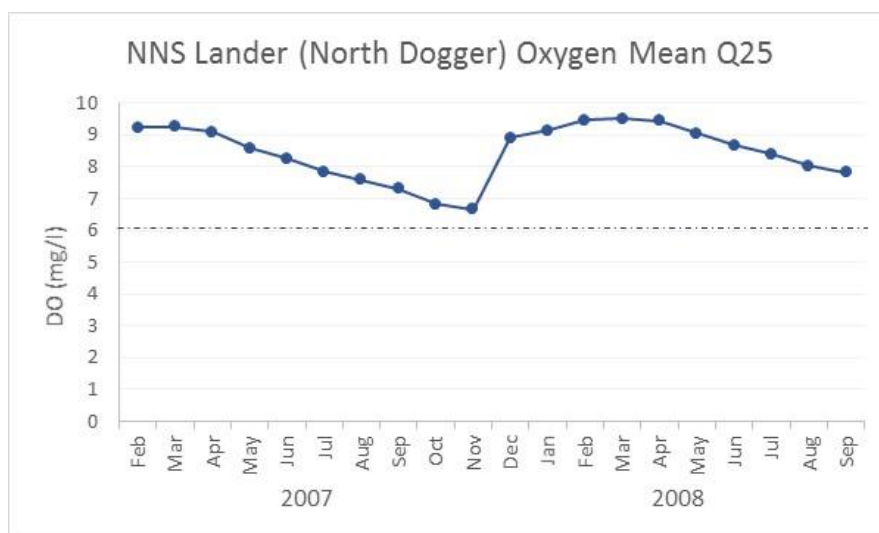


Figure A8.7: Mean monthly concentrations of near-bed DO (mg l<sup>-1</sup>) in the northern North Sea from February 2007 to September 2008, shown as the mean of the lowest quartile (Q25) of the data. Concentrations were measured by a sensor on a benthic lander deployed at the North Dogger SmartBuoy site (Figure 2; see Greenwood et al. 2010). Daily averages of the half-hourly burst data were used to calculate monthly means. A threshold of 6 mg l<sup>-1</sup> is shown by the dashed blue line.

### Assessment Outcomes for northern North Sea

2003 - In OSPAR integrated report, 1995-2001: Non Problem Area.

2008 - Period 2001-2005: Non Problem Area.

Score table:

- Nutrient enrichment parameters did not show elevated levels in all 5 years (2001-2005):  
**Winter DIN Score:** 4 times – (no data in 2002)  
**Nutrient ratio Score:** 4 times – (no data in 2002)
- Chlorophyll did not show elevated levels in 4 years (2000-2004; no data in 2005):  
**Score:** 4 times -
- No elevated levels of other direct effect or indirect effect parameters in years where data were available
  - DO score: 2 times – (data only in 2001, 2004)

2014 - Third application of the Common Procedure (2006-2014):

Initial and final classification for northern North Sea: Non Problem Area (2006-2014).

Table A8.11: Assessment table (Northern North Sea, 2006-2014). Aggregated confidence ratings (Tables 5 and 6 in the main report) were calculated over the nine-year assessment period.

Category	Assessment Parameters	Description of Results	Score (+ - ?)	Aggregated confidence rating (%)
<b>Degree of Nutrient Enrichment (I)</b>	Riverine inputs and direct discharges of total N and total P	N - P -	- .-	
	Winter DIN concentrations (normalised)	Coastal: - - - - -	Coastal -	100
		Offshore: - - - - -	Offshore -	100
	Winter DIN:DIP ratio	Coastal: - - - - -	Coastal: -	100
		Offshore: - - - - -	Offshore: -	100
<b>Direct Effects (II)</b>	90 <sup>th</sup> percentile chlorophyll concentration	Coastal: - - - - - ?	Coastal: -	100
		Offshore: - - - - -	Offshore: -	100
	Area-specific phytoplankton indicator species	Coastal: -	-	
	Macrophytes including macroalgae	Not assessed		
<b>Indirect Effects (III)</b>	Oxygen deficiency (mg l <sup>-1</sup> )	Coastal: ? ? - - ? - ? ?	Coastal: -	100
		Offshore: - - - - -	Offshore: -	100
	Changes/kills in zoobenthos and fish kills	Not assessed		
	Organic carbon/organic matter	Not assessed		
<b>Other Possible Effects (IV)</b>	Algal toxins (DSP/PSP mussel infection events)	Not assessed		

#### Key to the Score

- + = 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 are not fit for the purpose

Table A8.12: Results of the OSPAR Comprehensive Assessment 2016 for Northern North Sea, 2006-2014. PA = Problem Area, NPA = Non Problem Area.

**Key to the table**

NI	Riverine inputs and direct discharges of total N and total P	Mp	Macrophytes including macroalgae
DI	Winter DIN and/or DIP concentrations	O <sub>2</sub>	Oxygen deficiency
NP	Increased winter N/P ratio	Ck	Changes/kills in zoobenthos and fish kills
Ca	90 <sup>th</sup> percentile, maximum and mean chlorophyll <i>a</i> concentration	Oc	Organic carbon/organic matter
Ps	Area-specific phytoplankton indicator species	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 were available for assessments. These data were not required or used to confirm Non Problem Status

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	Overall appraisal of all relevant information (concerning the harmonised assessment parameters, their respective assessment levels and the supporting environmental factors)	Final classification	Assessment period
Northern North Sea – coastal water	NI	-	Ca	-	O <sub>2</sub>	-	At		NPA	<ul style="list-style-type: none"> <li>There is good evidence that the area is not nutrient enriched (high confidence) based on nutrient data with good representivity.</li> <li>There is evidence that there is no accelerated growth (high confidence) in the area based on chlorophyll data with good representivity.</li> <li>The available evidence does not suggest any undesirable disturbance (high confidence) based on dissolved oxygen data with moderate representivity.</li> <li>It is confirmed that this area remains a Non Problem Area (high confidence) based on the available evidence. Nutrient inputs to the area are decreasing but there is a small increasing trend in chlorophyll.</li> </ul>	NPA	2006-2014
	DI	-	Ps	-	Ck							
	NP	-	Mp		Oc							
Northern North Sea – offshore water	NI	-	Ca	-	O <sub>2</sub>	-	At		NPA	<ul style="list-style-type: none"> <li>There is good evidence that the area is not nutrient enriched (high confidence) based on nutrient data with good representivity.</li> <li>There is evidence that there is no accelerated</li> </ul>	NPA	2006-2014
	DI	-	Ps		Ck							
	NP	-	Mp		Oc							

									<p>growth (high confidence) in the area based on chlorophyll data with good representivity.</p> <ul style="list-style-type: none"> <li>• The available evidence does not suggest any undesirable disturbance (high confidence) based on dissolved oxygen data with moderate representivity.</li> <li>• It is confirmed that this area remains a Non Problem Area (high confidence) based on the available evidence. Nutrient inputs to the area are decreasing but there is a small increasing trend in chlorophyll.</li> </ul>		
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## 19 Annex 9 - Southern North Sea (Region 2)

Name and map (geographical location: longitude, latitude)

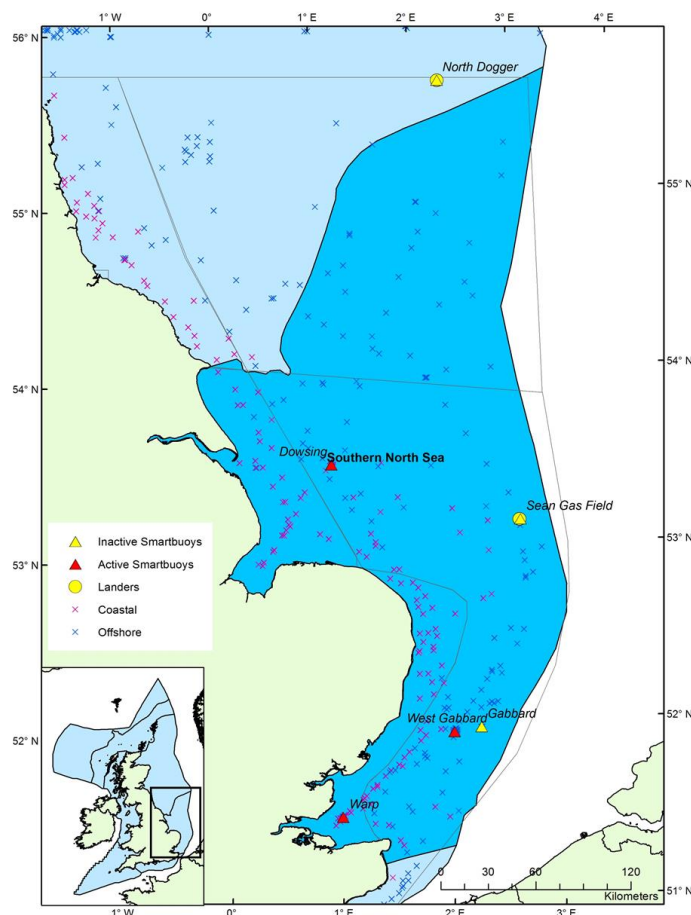


Figure A9.1: Map showing the location of the southern North Sea (Region 2, dark blue). Grey lines indicate the UK marine areas from the second application of the COMP which fall into this region (the southern North Sea, the East England Coast and East Anglia). The locations of sites (X) where data were available from 2006 onwards are shown: red = coastal (salinity 30-34.5), blue = offshore sites (salinity >34.5). The location of monitoring sites with moorings (SmartBuoys and landers) is also shown.

### 19.1 Description of the area

Including environmental information

The southern North Sea within UK boundaries (Figure A9.1) is delineated on its northern edge by a hydrodynamic change reflected in the seasonally stratified water to the north and more mixed waters to the south. Nearshore waters are largely classified as 'permanently mixed' from GETM model results (van Leeuwen et al. 2015), while offshore waters stratify intermittently (Annex 3). Water depth over much of the region is less than 40 m.

The region is characterised by turbid water with poor light penetration (Capuzzo et al 2013). It is likely that nutrients are transported some distance before they can be effectively used by phytoplankton and converted into biomass. This weakens the link between nutrient inputs and signs of eutrophication such as accelerated growth of algae.

The southern North Sea has been assessed as a Non-Problem Area through subsequent applications of the OSPAR Common Procedure.

The Water Framework Directive assessments of the status of transitional and coastal waters in this region have identified all water bodies in this region as Non Problem Areas.

### Risks

*Human pressures:* Shifts in human population, changes in nutrient management practices within the catchment resulting from economic pressures. There are also changes in sediment loading which influence light penetration and nutrient uptake. This may result, for example, from the large-scale coastal engineering which occurs in the estuaries of the region.

*Environmental pressures:* Changes in storminess affecting nutrient run-off from land and turbidity in the sea.

*Assessment of risk* – Human populations in the catchment of the southern North Sea are dense and are likely to increase in the coming decade. London alone has a population approaching 9 million people. Decreasing trends in nutrient loading to the region (Section 5.1) indicate that nutrient management measures successfully offset the rising population. There is a low-medium probability that inputs of anthropogenic nutrients in the southern North Sea will increase in the next 10 years. Of equal importance to changes in nutrient loading is the fact that any change to the system which reduces suspended sediment concentrations will alter the location and rate at which conversion of dissolved nutrients to algal biomass occurs. There is a low-medium probability that reductions in sediment loading may occur e.g. by decreased seabed disturbance in certain areas.

## **19.2 Description of monitoring design in relation to spatial and temporal variability of assessment parameters in the area**

*This section should include information on how the monitoring design addresses the particular typology and main hydrographical dynamics in the area, so as to provide evidence of representativeness of monitoring.*

As a Non-Problem Area the southern North Sea is subject to the relevant requirements of the OSPAR Eutrophication Monitoring Programme to measure DIN, DIP, salinity and temperature about every three years in winter.

**Nutrients:** There are three active Cefas SmartBuoys in the southern North Sea: in the Thames estuary near Southend (the Warp mooring), offshore from the Thames at West Gabbard, and off the Humber estuary (the Dowsing mooring). Although salinities are variable, two buoys (West Gabbard and Dowsing) are located largely in the offshore marine area, and one in the coastal area (Warp).

The SmartBuoy moorings have been operational for between 4 and 13 years and their primary purpose is to collect data on nutrients. The use of an automated nutrient analyser gives a high frequency of measurements and allows winter nutrient concentrations to be accurately estimated. Occasional ship-based measurements of winter nutrients give a smaller, additional dataset which can be used to examine spatial variability within the regions.

A range of other readily available information has been obtained to support the assessment.

**Light attenuation:** The concentration of suspended sediments largely determines the attenuation of light in turbid, shallow regions (Devlin et al 2009). Suspended Particulate Matter concentrations are measured optically by instruments at the SmartBuoy sites. Attempts to directly estimate light attenuation from sensors on buoys have so far been inconclusive. Historically, light attenuation has been estimated from Secchi disc depth and recent work has established a merged Secchi/SPM/light attenuation time series for the southern North Sea. A recent paper (Capuzzo et

al 2015) showed that turbidity in the southern region has increased since the 1950s, but the reasons for this are unclear.

**Chlorophyll:** The Cefas SmartBuoys provide an estimate of chlorophyll concentrations providing that fluorescence measurements on moorings are regularly calibrated against laboratory-analysed seawater samples

**Oxygen:** Oxygen sensors were fitted to the Cefas SmartBuoys at the Warp (Thames estuary) and Dowsing (off the Humber), recording near-surface oxygen concentration. Values at the well-mixed Warp mooring rarely decreased below 95% saturation, and often showed super-saturation in excess of 140% during short-lived algal blooms. Any organic material produced in the estuary is likely to be either consumed in the local food-web, or exported offshore. There do not appear to be oxygen-deficient areas in the southern North Sea at present, due to the moderate levels of primary productivity and constant mixing.

**Phytoplankton composition:** Samples for the analysis of phytoplankton species composition have been collected at different SmartBuoy since 2001 (see Annex 2, Table A2.2). Selected samples, predominantly those collected during the phytoplankton growing season, have been analysed by microscopy. The available data were used to apply the WFD phytoplankton tool in this region.

**Seagrasses and seaweeds:** Although turbid, the offshore southern North Sea is sufficiently shallow in places to allow light to reach the seabed which, if the correct substratum is present, may allow the establishment of microphytobenthos and attached macrophytes.

The inshore estuaries and intertidal areas of eastern England do not appear to exhibit excessive growth of opportunistic macroalgae. These regions are monitored and assessed under the WFD.

### 19.3 Assessment

#### Nutrients

Normalised and non-normalised mean winter concentrations of DIN ( $\mu\text{M}$ ) per year during the assessment period, 2006 to 2014, are shown for coastal and offshore waters (Figure A9.2).

In coastal waters, normalised winter mean DIN values show that concentrations (20-59  $\mu\text{M}$ ) exceeded the assessment threshold (18  $\mu\text{M}$ ) in all years during the assessment period. Standard errors indicate low variability in the data; confidence levels for concluding Non Problem Area were low (<1%, Table A9.1). The non-normalised means were lower ( $\leq 35 \mu\text{M}$ ), but exceeded the threshold in all years except 2009 and 2012. Overall confidence for concluding Non Problem Area over the assessment period was low (0%). Results were similar for TOxN.

For offshore waters, normalised winter DIN means were above the threshold (15  $\mu\text{M}$ ) in 2006, 2007 and 2013, but below the threshold in the other six years. Standard errors indicate low variability in the data. Yearly confidence levels for concluding Non Problem Area ranged from 0% to 100% (Table A9.2). Overall confidence levels for winter DIN were high (60%). Using non-normalised values, concentrations were below 10  $\mu\text{M}$  in all years, and therefore below the assessment threshold (15  $\mu\text{M}$ ) in all years. For TOxN, results were similar but overall confidence in mean values over the assessment period (2006-2014) was higher (100%).

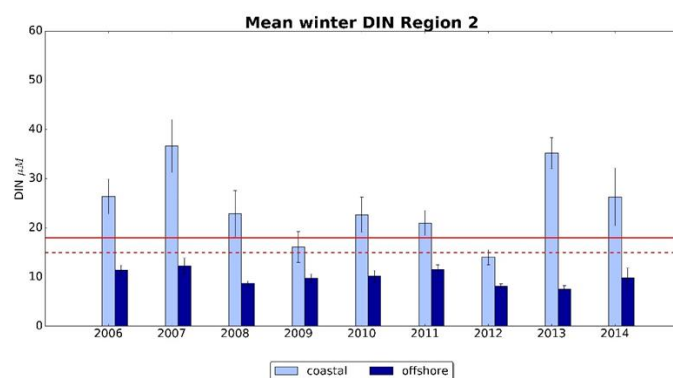
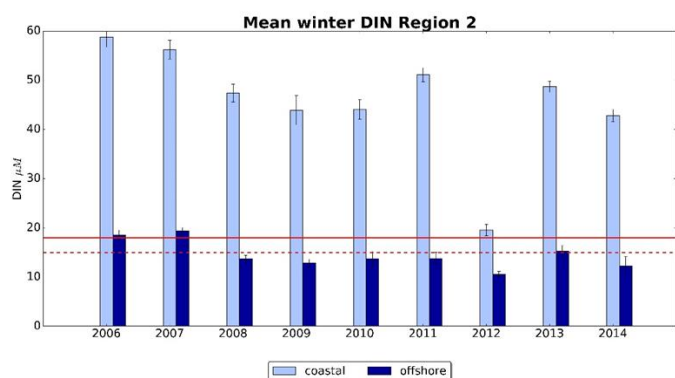


Figure A9.2: Mean winter concentrations of DIN ( $\mu\text{M}$ ) per year in the southern North Sea during the assessment period, 2006 to 2014. Results are shown separately for coastal waters and offshore waters, using data from all depths sampled. Data are shown as normalised means (left) and non-normalised means (right). Coastal data were normalised to salinity 32, offshore data were normalised to 34.5. Assessment thresholds for coastal (18  $\mu\text{M}$ , solid red line) and offshore waters (15  $\mu\text{M}$ , dashed red line) are shown.

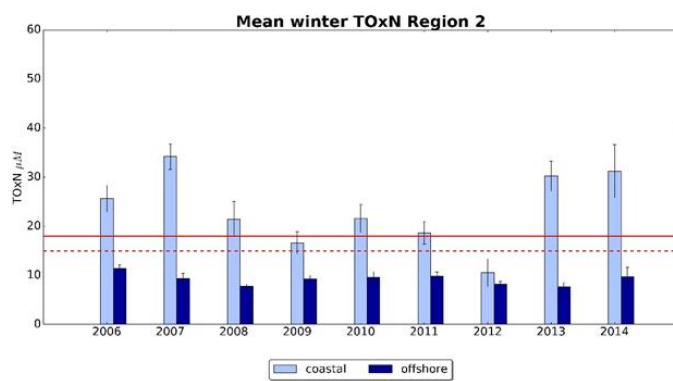
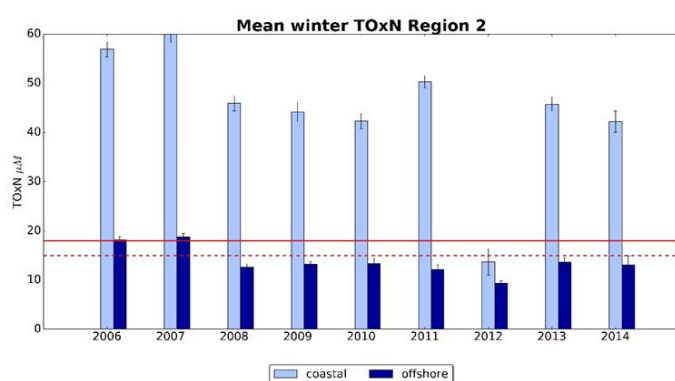


Figure A9.3: Mean winter concentrations of TOxN ( $\mu\text{M}$ ) per year in the southern North Sea during the assessment period, 2006 to 2014. Results are shown separately for coastal waters and offshore waters, using data from all depths sampled. Data are shown as normalised means (left) and non-normalised means (right). Coastal data were normalised to salinity 32, offshore data were normalised to 34.5. Assessment thresholds for coastal (18  $\mu\text{M}$ , solid red line) and offshore waters (15  $\mu\text{M}$ , dashed red line) are shown.

Table A9.1: Normalised means and yearly confidence levels for winter DIN in Region 2 coastal. The assessment threshold, minimum value, maximum value, standard error and number of samples are shown. All = overall values and confidence levels (see Table 5 in main report).

Region	Location	Assessm Threshold ( $\mu\text{M}$ )	Year	Min Value	Max Value	Normalised Mean	Std Error	Number of Samples	Confidence Level (%) for concluding Non Problem
2	Coastal	18	2006	12.9	82.6	58.73	0.99	44	0
2	Coastal	18	2007	23.8	45.3	56.22	0.81	8	0
2	Coastal	18	2008	6.1	76.8	47.39	0.91	56	0
2	Coastal	18	2009	7.1	29.4	43.9	1.42	20	0
2	Coastal	18	2010	9.2	42.2	44.06	0.98	28	0
2	Coastal	18	2011	7.4	50.7	51.1	0.72	65	0
2	Coastal	18	2012	10.7	23.1	19.54	0.53	15	0.52
2	Coastal	18	2013	7.7	57.52	48.68	0.55	42	0
2	Coastal	18	2014	8.5	55.6	42.82	0.61	23	0
			All	6.1	82.6	47.08	0.38	301	0

*Table A9.2: Normalised means and yearly confidence levels for winter DIN in Region 2 offshore. The assessment threshold, minimum value, maximum value, standard error and number of samples are shown. All = overall values and confidence levels (see Table 6 in main report).*

Region	Location	Assessm Threshold ( $\mu\text{M}$ )	Year	Min Value	Max Value	Normalised Mean	Std Error	Number of Samples	Confidence Level (%) for concluding Non Problem
2	Offshore	15	2006	2.6	61.1	18.53	0.51	118	0
2	Offshore	15	2007	5.9	18.7	19.4	0.3	17	0
2	Offshore	15	2008	4.65	13.6	13.69	0.36	58	99.97
2	Offshore	15	2009	7.5	18.7	12.89	0.37	43	100
2	Offshore	15	2010	4	18.9	13.72	0.73	30	95.56
2	Offshore	15	2011	4.7	19.5	13.75	0.63	56	97.4
2	Offshore	15	2012	4.3	13.6	10.54	0.31	69	100
2	Offshore	15	2013	5.36	10.7	15.22	0.58	23	35.4
2	Offshore	15	2014	5.8	16.3	12.26	0.89	17	99.65
			All	2.6	61.1	14.94	0.22	431	59.89

*Table A9.3: Normalised means and yearly confidence levels for winter TOxN in Region 2 coastal. The assessment threshold, minimum value, maximum value, standard error and number of samples are shown. All = overall values and confidence levels (see Table 5 in main report).*

Region	Location	Assessm Threshold ( $\mu\text{M}$ )	Year	Min Value	Max Value	Normalised Mean	Std Error	Number of Samples	Confidence Level (%) for concluding Non Problem
2	Coastal	18	2006	12.8	82.5	56.9	0.77	59	0
2	Coastal	18	2007	22.4	44	60.05	0.89	22	0
2	Coastal	18	2008	3.8	75.3	45.91	0.77	80	0
2	Coastal	18	2009	7	28.6	44.19	1	31	0
2	Coastal	18	2010	8.2	40.9	42.31	0.76	36	0
2	Coastal	18	2011	5.85	49.1	50.3	0.63	78	0
2	Coastal	18	2012	0.1	23	13.71	1.29	20	99.83
2	Coastal	18	2013	3	55.22	45.75	0.72	63	0
2	Coastal	18	2014	8.3	80	42.18	1.07	38	0
			All	0.1	82.5	45.02	0.34	427	0

*Table A9.4: Normalised means and yearly confidence levels for winter TOxN in Region 2 offshore. The assessment threshold, minimum value, maximum value, standard error and number of samples are shown. All = overall values and confidence levels (see Table 6 in main report).*

Region	Location	Assessm Threshold ( $\mu\text{M}$ )	Year	Min Value	Max Value	Normalised Mean	Std Error	Number of Samples	Confidence Level (%) for concluding Non Problem
2	Offshore	15	2006	2.5	60.3	18.16	0.38	165	0
2	Offshore	15	2007	3.76	17	18.72	0.38	36	0
2	Offshore	15	2008	4.55	12.2	12.59	0.35	65	100
2	Offshore	15	2009	2.85	18.25	13.16	0.31	60	100
2	Offshore	15	2010	2.3	19	13.3	0.59	43	99.7
2	Offshore	15	2011	4.3	16.9	12.09	0.51	82	100
2	Offshore	15	2012	4.1	16.83	9.29	0.28	99	100
2	Offshore	15	2013	4.4	19.47	13.64	0.46	42	99.75
2	Offshore	15	2014	5.7	16.1	13.04	0.88	17	98.05
			All	2.3	60.3	14.35	0.18	609	99.99

### High frequency data

High frequency data obtained from four SmartBuoys in the southern North Sea (Figure A9.4, see Annex 6) were analysed to calculate mean winter TOxN values per year at each mooring. The Warp SmartBuoy is closest to the coast, where salinities are generally typical of coastal water. The others are further offshore, where salinities are highly variable, indicating variable influences of coastal and offshore waters at these sites. At the Warp, mean winter TOxN concentrations were typical of coastal waters (14-50  $\mu\text{M}$ , Figure A9.4). At the other sites, mean winter TOxN concentrations (<10  $\mu\text{M}$ ) were more typical of offshore waters. These high frequency data were included in the final dataset used in the assessment (see Annex 2), contributing towards temporal and spatial representivity of the data in this region. Salinities were used to assign each derived data point to either coastal water (salinity  $\leq 34.5$ ) or offshore water (salinity  $> 34.5$ ).

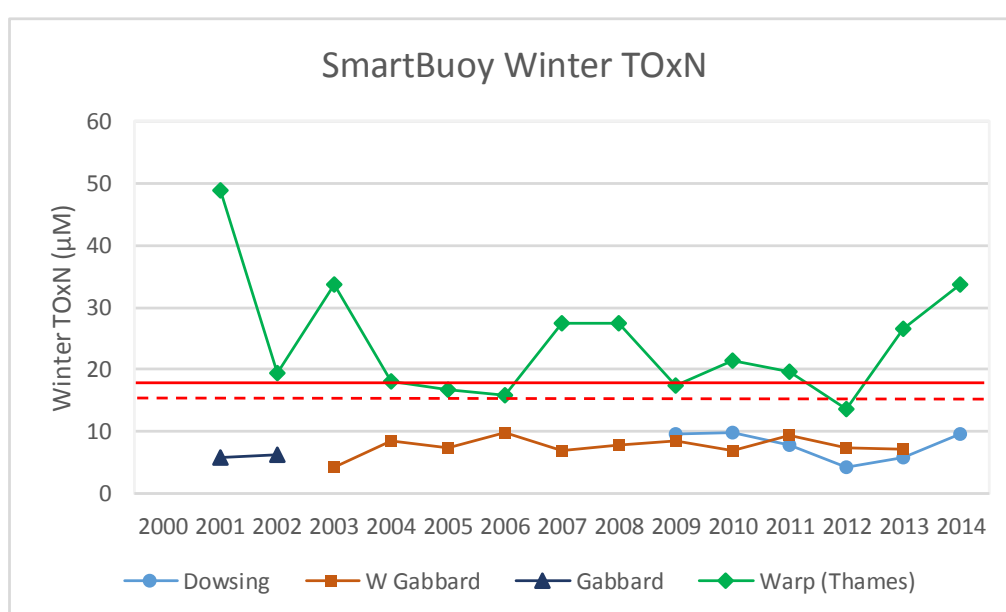


Figure A9.4: Mean winter concentrations of total oxidised nitrogen (TOxN,  $\mu\text{M}$ ) per year in the southern North Sea from fixed moorings at four locations (Dowsing, West Gabbard, Gabbard and Thames, See Figure 2), 2002 to 2014. Salinity in these regions is highly variable (see Annex 6). Assessment thresholds for coastal (18  $\mu\text{M}$ , solid red line) and offshore waters (15  $\mu\text{M}$ , dashed red line) are shown.

### DIN:DIP ratios

Mean winter DIN:DIP ratios (Figure A9.5) were below the Redfield ratio of 16 in offshore waters. Mean ratios were higher ( $>18$ ) in coastal waters, and exceeded the threshold in 2013 and 2014, indicating some potential problems with nitrogen enrichment in coastal waters. Standard errors indicate more variability in coastal data than in offshore data; nonetheless, yearly confidence levels in the mean values for concluding Non Problem Area (excluding coastal waters in 2013 and 2014) were high (69-100%, Tables A9.5, A9.6). The overall confidence levels for concluding Non Problem Area over the assessment period were high (95-100%).



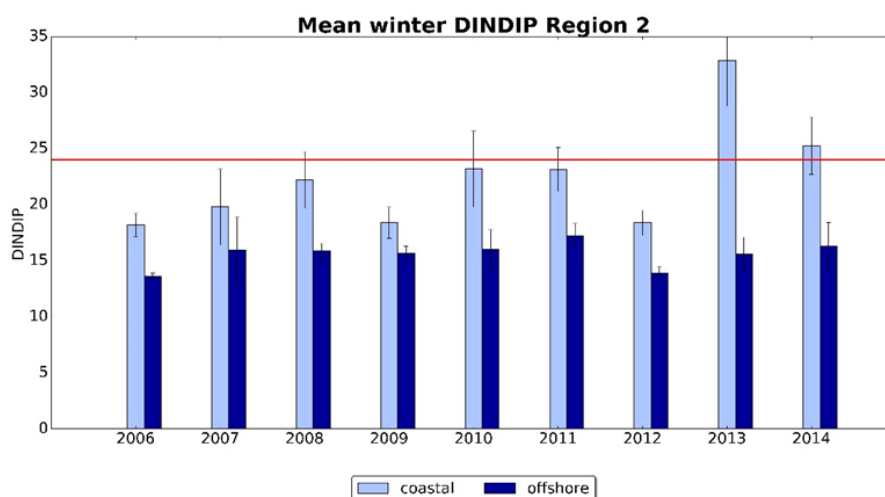


Figure A9.5: Mean winter ratios of DIN:DIP per year in the southern North Sea during the assessment period, 2006 to 2014. Results are shown separately for coastal waters and offshore waters, using data from all depths sampled. The assessment threshold of 24 is shown by the red line.

Table A9.5: Means and yearly confidence levels for winter DIN:DIP in Region 2 coastal. The assessment threshold, minimum value, maximum value, standard error and number of samples are shown. All = overall values and confidence levels (see Table 5 in main report).

Region	Location	Assessm Threshold	Year	Min Value	Max Value	Mean Value	Std Error	Number of Samples	Confidence Level (%) for concluding Non Problem
2	Coastal	24	2006	11.7	30.08	18.2	0.52	44	100
2	Coastal	24	2007	11.11	24.79	19.8	1.44	8	99.05
2	Coastal	24	2008	10.34	45.86	22.21	1.25	56	92.2
2	Coastal	24	2009	13.4	22.96	18.41	0.67	20	100
2	Coastal	24	2010	11.36	41.55	23.18	1.65	28	68.76
2	Coastal	24	2011	8.71	42.56	23.16	0.98	65	80.38
2	Coastal	24	2012	15.92	24.84	18.38	0.53	15	100
2	Coastal	24	2013	9.38	71.01	32.84	2	42	0
2	Coastal	24	2014	12.69	33.72	25.25	1.23	23	16.01
			All	8.71	71.01	23.13	0.53	301	94.84

Table A9.6: Means and yearly confidence levels for winter DIN:DIP in Region 2 offshore. The assessment threshold, minimum value, maximum value, standard error and number of samples are shown. All = overall values and confidence levels (see Table 6 in main report).

Region	Location	Assessm Threshold	Year	Min Value	Max Value	Mean Value	Std Error	Number of Samples	Confidence Level (%) for concluding Non Problem
2	Offshore	24	2006	7.65	18.75	13.59	0.15	118	100
2	Offshore	24	2007	9.33	28.62	15.93	1.4	17	100
2	Offshore	24	2008	9.9	20.79	15.87	0.34	58	100
2	Offshore	24	2009	11.72	21.45	15.65	0.32	43	100
2	Offshore	24	2010	8	32.38	16.04	0.84	30	100
2	Offshore	24	2011	7.72	23.84	17.2	0.56	56	100
2	Offshore	24	2012	8.6	17.31	13.88	0.3	69	100
2	Offshore	24	2013	10.19	20.58	15.61	0.72	23	100
2	Offshore	24	2014	9.84	20.94	16.32	0.99	17	100
			All	7.65	32.38	15.1	0.16	431	100

## Chlorophyll

Concentrations of chlorophyll ( $\mu\text{g l}^{-1}$ ) per year in the southern North Sea during the assessment period, 2006 to 2014 are shown as 90<sup>th</sup> percentiles in coastal and offshore water (Figure A9.6).

For coastal waters, 90<sup>th</sup> percentiles were below the assessment threshold ( $15 \mu\text{g l}^{-1}$ ) in all years. The highest value ( $10.07 \mu\text{g l}^{-1}$ ) was observed in 2008. Confidence levels for concluding Non Problem Area were high (61-99.98%, Table A9.7). The overall confidence level for concluding Non Problem Area over the assessment period was high (100%).

In offshore water, 90<sup>th</sup> percentiles were below the assessment thresholds of  $10 \mu\text{g l}^{-1}$  in all years except 2007 ( $13.9 \mu\text{g l}^{-1}$ ). Confidence levels for concluding Non Problem Area were 55-99.96% (Table A9.8), except in 2007 (0.4%, Table A9.8). Data from the West Gabbard SmartBuoy site showed a similar peak in 2007 (Figure A9.7), either supporting these findings, or contributing to them. Despite this result for 2007, overall confidence ratings for chlorophyll over the assessment period was high (100%).

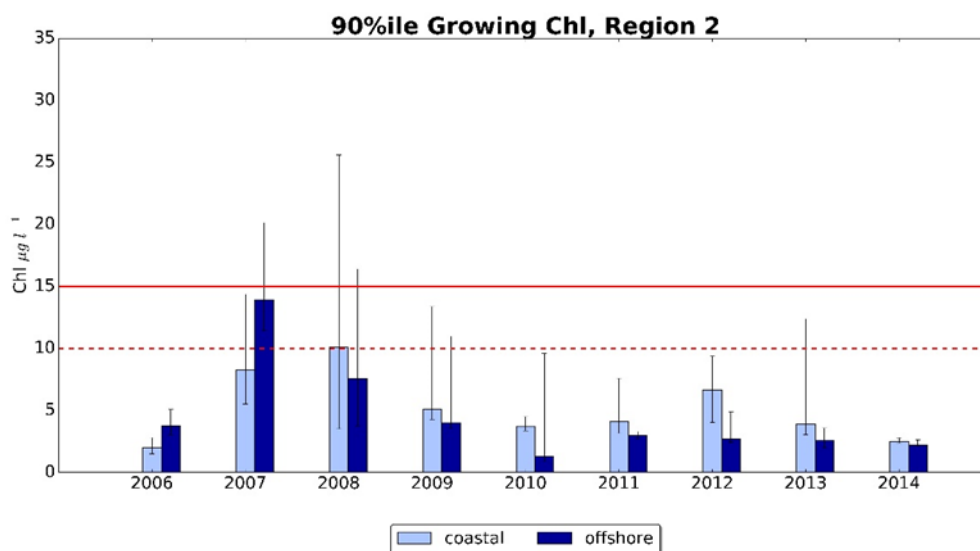


Figure A9.6: Growing season chlorophyll per year in the southern North Sea during the assessment period, 2006 to 2014, shown as 90<sup>th</sup> percentiles. Results are shown separately for coastal waters and offshore waters, using data from all depths sampled. Assessment thresholds for coastal ( $15 \mu\text{g l}^{-1}$ , solid red line) and offshore waters ( $10 \mu\text{g l}^{-1}$ , dashed red line) are shown.

*Table A9.7: Chlorophyll growing season 90<sup>th</sup> percentiles in Region 2 coastal, and confidence levels per year. The assessment threshold, standard deviation, number of samples, and the number of data points below the threshold are shown. nan = no data. All = overall values and confidence levels (see Table 5 in main report).*

Region	Location	Assessm Threshold ( $\mu\text{g l}^{-1}$ )	Year	90 <sup>th</sup> percentile	Mean	Std Dev	Number of Samples (n)	95% Conf Limit lower	95% Conf Limit upper	Number (n) below the assessment threshold	Confidence level (%)
2	Coastal	15	2006	1.99	1.23	0.64	17	1.51	2.8	17	83.32
2	Coastal	15	2007	8.29	3.39	3.92	71	5.52	14.37	69	97.77
2	Coastal	15	2008	10.07	3.91	5.27	31	3.53	25.6	29	61.14
2	Coastal	15	2009	5.09	2.87	2.65	26	4.26	13.39	26	93.54
2	Coastal	15	2010	3.72	1.97	1.34	83	3.35	4.51	83	99.98
2	Coastal	15	2011	4.1	2.12	2.22	78	3.17	7.58	78	99.97
2	Coastal	15	2012	6.65	2.66	2.2	68	4.04	9.39	68	99.92
2	Coastal	15	2013	3.91	2.62	3.26	64	3.06	12.4	63	99.04
2	Coastal	15	2014	2.52	1.63	0.69	22	2.37	2.79	22	90.15
			All	4.52	2.54	2.91	460	4.12	5.52	455	100

*Table A9.8: Chlorophyll growing season 90<sup>th</sup> percentiles in Region 2 offshore, and confidence levels per year. The assessment threshold, standard deviation, number of samples, and the number of data points below the threshold are shown. All = overall values and confidence levels (see Table 6 in main report).*

Region	Location	Assessm Threshold ( $\mu\text{g l}^{-1}$ )	Year	90 <sup>th</sup> percentile	Mean	Std Dev	Number of Samples (n)	95% Conf Limit lower	95% Conf Limit upper	Number (n) below the assessment threshold	Confidence level (%)
2	Offshore	10	2006	3.77	1.86	1.52	74	3.04	5.08	74	99.96
2	Offshore	10	2007	13.93	4.82	6.15	58	11.42	20.15	46	0.42
2	Offshore	10	2008	7.54	3.19	3.46	49	3.77	16.4	45	55.03
2	Offshore	10	2009	4	2.7	3.04	70	3.57	10.99	65	71.28
2	Offshore	10	2010	1.32	0.78	1.62	35	0.89	9.6	35	97.5
2	Offshore	10	2011	2.99	1.38	1.29	137	2.69	3.3	137	100
2	Offshore	10	2012	2.71	1.69	1.18	73	2.42	4.9	73	99.95
2	Offshore	10	2013	2.59	1.52	0.66	43	1.98	3.6	43	98.92
2	Offshore	10	2014	2.19	1.66	0.46	16	2.11	2.64	16	81.47
			All	3.85	2.15	2.91	555	3.33	4.74	534	100

### High frequency data

High frequency data obtained from five SmartBuoys in the southern North Sea (Figure A9.7) were used to calculate chlorophyll 90<sup>th</sup> percentiles during the growing season of each year at each mooring. Apart from 2001 and 2007, all 90<sup>th</sup> percentiles were below the thresholds for both coastal (15  $\mu\text{g l}^{-1}$ ) and offshore (10  $\mu\text{g l}^{-1}$ ) waters. These high frequency data were included in the final dataset used in the assessment (see Annex 2), contributing towards temporal and spatial representivity of the data in this region. Salinities were used to assign each derived data point to either coastal water (salinity <34.5) or offshore water (salinity  $\geq$ 34.5).

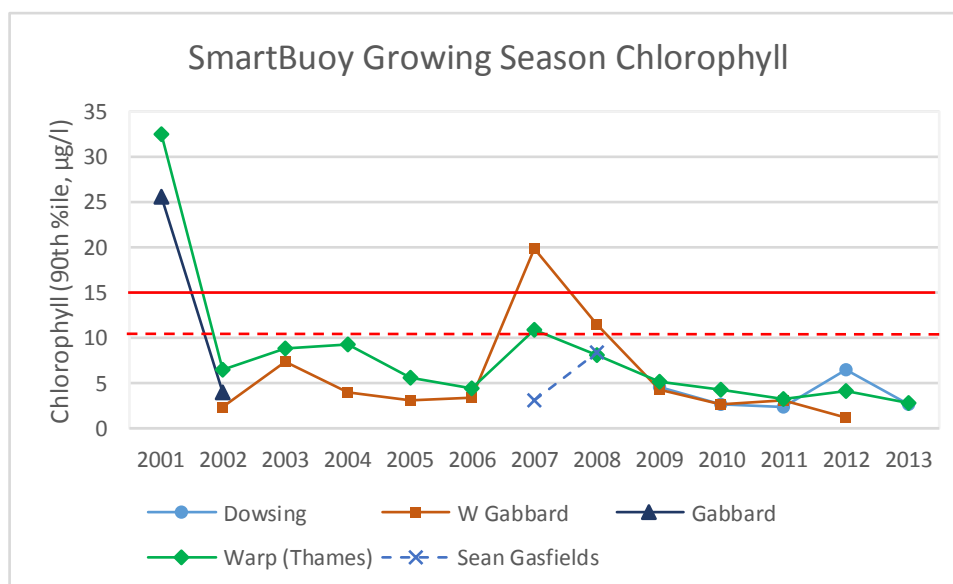


Figure A9.7: Growing season chlorophyll concentrations (90<sup>th</sup> %ile March to October,  $\mu\text{g l}^{-1}$ ) per year in the southern North Sea from fixed moorings at five locations (Dowsing, West Gabbard, Gabbard, Thames and the Sean Gasfields, see Figure 2), 2001 to 2013. Assessment thresholds for coastal ( $15 \mu\text{g l}^{-1}$ , solid red line) and offshore waters ( $10 \mu\text{g l}^{-1}$ , dashed red line) are shown.

### Phytoplankton indicator species

The WFD tool was applied to data from the SmartBuoy sites in the southern North Sea. The overall outcome for each site was high (Figure A9.8), but the tool could not be applied fully due to insufficient data for 'seasonal succession'.

WaterBody Name	Normalised EQR			SE(EQR)			No. of tools with EQR	Final EQR			Confidence of class (%)					
	90 <sup>th</sup> %ile	ElevatedCounts	SeasSuccess	90 <sup>th</sup> %ile	ElevatedCounts	SeasSuccess		Final EQR	SE	Face Value Class	High	Good	Moderate	Poor	Bad	GoodOrBetter
							0									
Dowsing	0.926	0.922		0.011	0.030		2	0.924	0.016	High	1.00	0.00	0.00	0.00	0.00	1.00
Warp	0.845	0.955		0.033	0.014		2	0.900	0.018	High	1.00	0.00	0.00	0.00	0.00	1.00
West Gabbard	0.899	0.888		0.033	0.020		2	0.894	0.019	High	1.00	0.00	0.00	0.00	0.00	1.00

Figure A9.8: Results of the WFD phytoplankton index applied to SmartBuoy data from sites in the southern North Sea during the assessment period.

### Oxygen deficiency

Concentrations ( $\text{mg l}^{-1}$ ) and percentage saturation of near-bed dissolved oxygen per year during the assessment period (2006-2014) are shown as mean values in the lowest quartile of the data during the stratified season, for coastal and offshore areas (Figure A9.9). The number of samples in the lowest quartile of the data was generally low ( $n < 5$ ), and insufficient for assessment purposes. The total number of available data (i.e. near-bed samples, Tables A9.9 and A9.10) was therefore used for the criterion ( $n \geq 5$ ) for assessments. Where there were still less than 5 data

points, the results were not used in the assessment (see Figure A9.9), but are reported in the tables.

In coastal waters, sufficient data for assessments using concentrations of dissolved oxygen were available from only two years, 2007 and 2014. In both years, concentrations were above the assessment threshold ( $6 \text{ mg l}^{-1}$ ). Confidence for concluding Non Problem Area was high (100%, Table A9.9). In years where there were insufficient data for the assessment, mean values in the lowest quartile of the data were below the threshold ( $6 \text{ mg l}^{-1}$ ) in only one year, 2010. Overall confidence in assessments of dissolved oxygen concentrations (2006-2014) was high (99.8%). Oxygen saturation data were only available in 2007 and were above the 60% threshold (Figure A9.8).

In offshore waters, sufficient data were available for three years, 2012-2014. The mean values in the lowest quartile were above the assessment threshold ( $6 \text{ mg l}^{-1}$ ). Confidence for concluding Non Problem Area was high (99-100%, Table A9.10). In years when there were data, but insufficient for an assessment, the mean value in the lowest quartile was above the threshold, except in 2010. Overall confidence in assessments of dissolved oxygen concentrations (2006-2014) was high (99.6%). No oxygen saturation data were available.

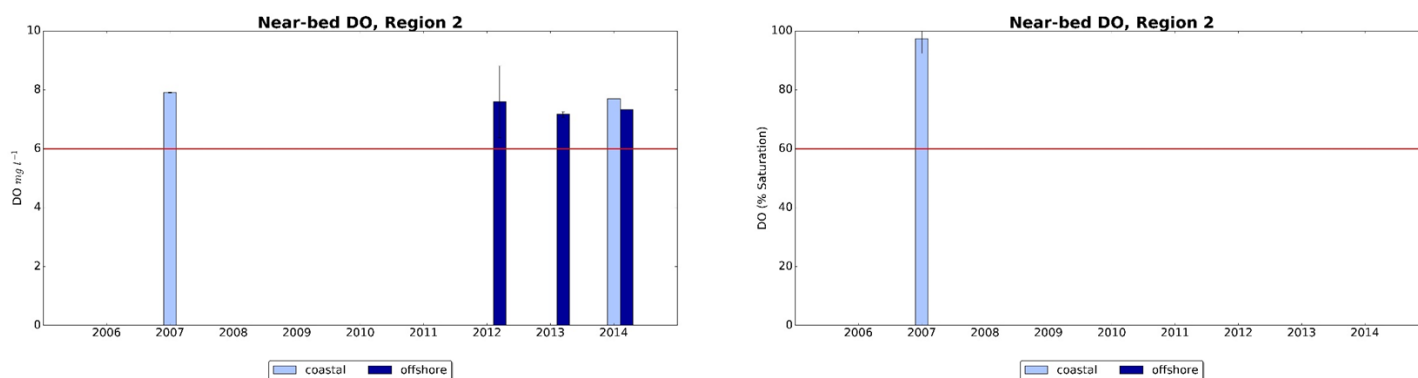


Figure A9.9: Near-bed dissolved oxygen (DO) per year in the southern North Sea during the assessment period, 2006 to 2014. shown as concentrations ( $\text{mg l}^{-1}$ , left) and percentage saturation (right). Results are given as mean values in the lowest quartile of the data during the stratified season, and are shown separately for coastal waters and offshore waters, for years with five or more data points. Thresholds of  $6 \text{ mg l}^{-1}$  and 60% saturation are shown by the red lines.

### High frequency data

High frequency data from a benthic lander at the Sean Gas Fields in the southern North Sea over two years (2007 and 2008, Figure A9.10) did not indicate any seasonal trend in dissolved oxygen concentrations in the offshore waters of this region, which is permanently mixed (Annex 3). These data were included in the final dataset for assessments, using weekly averages as individual data points, as described in the methods in Annex 2.

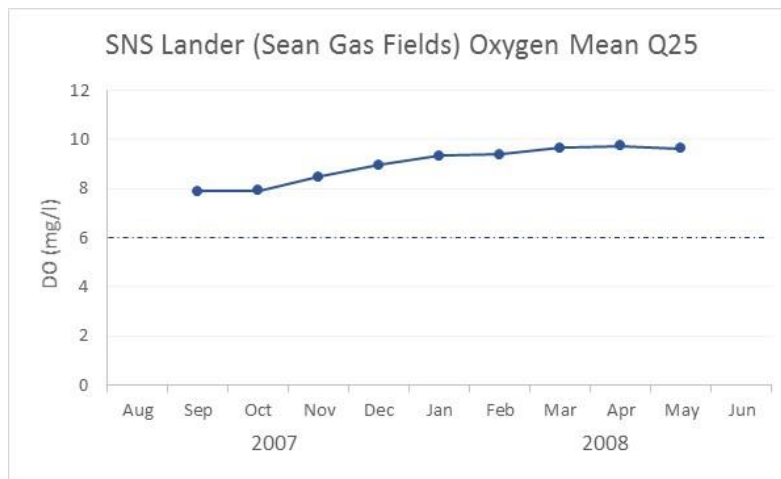


Figure A9.10: Mean monthly concentrations of near-bed DO (mg l<sup>-1</sup>) in the southern North Sea from September 2007 to May 2008, shown as the mean of the lowest quartile (Q25) of the data. Concentrations were measured by a sensor on a benthic lander deployed at the Sean Gas Fields (Figure 2; see Painting and Forster 2013, Greenwood et al. 2010). Daily averages of the half-hourly burst data were used to calculate monthly means. A threshold of 6 mg l<sup>-1</sup> is shown by the dashed blue line.

Table A9.9: Near-bed dissolved oxygen (mg l<sup>-1</sup>) in Region 2 coastal, and confidence levels per year. The table shows thresholds used, the mean and standard error in the lowest quartile of the data (Q25), number of available data points in the lowest quartile and in the available dataset (total), and confidence levels in assessment outcomes. Minimum (Min) and maximum (Max) values in the total dataset are also shown. All = overall values and confidence levels (see Table 5 in main report).

Region	Location	Assessm Threshold (mg l <sup>-1</sup> )	Year	Min Value	Max Value	Mean (Q25)	Std Error (Q25)	Number of Samples (Q25)	Number of Samples (total)	Confidence Level (%) for concluding Non Problem
2	Coastal	6	2006	8.86	9.15	8.86	nan	1	2	nan
2	Coastal	6	2007	7.9	8.29	7.91	0.003	4	14	100
2	Coastal	6	2008	7.86	8.23	7.86	nan	1	2	nan
2	Coastal	6	2009	7.13	7.97	7.13	nan	1	3	nan
2	Coastal	6	2010	4.7	4.7	4.7	nan	1	1	nan
2	Coastal	6	2011	8.2	8.37	8.2	nan	1	3	nan
2	Coastal	6	2012	7.4	8.54	7.4	nan	1	3	nan
2	Coastal	6	2013	7.45	9.67	7.45	nan	1	4	nan
2	Coastal	6	2014	7.69	9.11	7.69	nan	1	5	nan
			All	4.7	9.67	7.21	0.321	9	37	99.78

Table A9.10: Near-bed dissolved oxygen (mg l<sup>-1</sup>) in Region 2 offshore, and confidence levels per year. The table shows thresholds used, the mean and standard error in the lowest quartile of the data (Q25), number of available data points in the lowest quartile and in the available dataset (total), and confidence levels in assessment outcomes. Minimum (Min) and maximum (Max) values in the total dataset are also shown. nan = no data.

Region	Location	Assessm Threshold (mg l <sup>-1</sup> )	Year	Min Value	Max Value	Mean (Q25)	Std Error (Q25)	Number of Samples (Q25)	Number of Samples (total)	Confidence Level (%) for concluding Non Problem
2	Offshore	6	2006	9.15	9.36	9.15	0	2	3	100
2	Offshore	6	2007	nan	nan	nan	nan	nan	0	nan
2	Offshore	6	2008	nan	nan	nan	nan	nan	0	nan
2	Offshore	6	2009	6.99	7.55	6.99	nan	1	3	nan
2	Offshore	6	2010	4.99	7.26	4.99	nan	1	2	nan
2	Offshore	6	2011	7.69	8.3	7.69	nan	1	4	nan
2	Offshore	6	2012	7.5	8.56	7.59	0.096	2	7	99.82
2	Offshore	6	2013	7.16	8.15	7.17	0.007	2	9	100
2	Offshore	6	2014	7.32	8.3	7.32	nan	1	5	nan
			All	4.99	9.36	6.93	0.281	8	33	99.46



## Assessment outcomes for southern North Sea

2003 - In OSPAR integrated report, 1995-2001: Non Problem Area.

2008 - Period 2001-2005: Non Problem Area.

Score table:

- Nutrient enrichment parameters showed elevated levels in 1 parameter in 1 of 5 years (2001-2005) in offshore waters; in coastal waters, they showed elevated levels in all 5 years for winter DIN, and in 1 year for nutrient ratios:

**Offshore Winter DIN Score:** - - - + -

**Coastal Winter DIN:** + + + + +

- Chlorophyll showed elevated levels in some years (2001-2005):

**Offshore Overall Chl a score:** + + - - -

**Coastal Overall Chl a score:** - + + + ? (insufficient data in 2005)

- No elevated levels of other direct effect or indirect effect parameters in 2 of 5 years (2001-2005) where there were sufficient data:

**DO Score:** ? ? ? - - (no data in 2001, 2002; insufficient data in 2003)

2014 - Third application of the Common Procedure (2006-2014):

Initial and final classification for the southern North Sea: Non Problem Area (2006-2014).

*Table A9.11: Assessment table (southern North Sea, 2006-2014). Aggregated confidence ratings (Tables 5 and 6 in the main report) were calculated over the nine-year assessment period.*

Category	Assessment Parameters	Description of Results	Score (+ - ?)	Aggregated confidence rating
<b>Degree of Nutrient Enrichment (I)</b>	Riverine inputs and direct discharges of total N and total P	N - P -	N - P -	
	Winter DIN concentrations (normalised)	Coastal: + + + + + + + +	Coastal: +	0
		Offshore: + + - - - - + -	Offshore: -	59.89
	Winter DIN:DIP ratio	Coastal: - - - - - + -	Coastal: -	94.84
		Offshore: - - - - - - -	Offshore: -	100
<b>Direct Effects (II)</b>	90 <sup>th</sup> percentile chlorophyll concentration	Coastal: - - - - - - -	Coastal: -	100
		Offshore: - - - - - - -	Offshore: -	100
	Area-specific phytoplankton indicator species	?	?	

	Macrophytes including macroalgae	Not assessed		
<b>Indirect Effects (III)</b>	Oxygen deficiency	Coastal: ? - ? ? ? ? ? ? -	Coastal: -	99.78
		Offshore: ? - ? ? ? ? ? ? ?	Offshore: -	99.46
	Changes/kills in zoobenthos and fish kills	Not assessed		
	Organic carbon/organic matter	Not assessed		
<b>Other Possible Effects (IV)</b>	Algal toxins (DSP/PSP mussel infection events)	Not assessed		

### Key to the Score

- + = 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 are not fit for the purpose

Table A9.12: Results of the OSPAR Comprehensive Assessment 2016 for Southern North Sea, 2006-2014. PA = Problem Area, NPA = Non Problem Area.

**Key to the table**

NI	Riverine inputs and direct discharges of total N and total P	Mp	Macrophytes including macroalgae
DI	Winter DIN and/or DIP concentrations	O <sub>2</sub>	Oxygen deficiency
NP	Increased winter N/P ratio	Ck	Changes/kills in zoobenthos and fish kills
Ca	90 <sup>th</sup> percentile, maximum and mean chlorophyll <i>a</i> concentration	Oc	Organic carbon/organic matter
Ps	Area-specific phytoplankton indicator species	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 were available for assessments. These data were not required or used to confirm Non Problem Status

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	Overall appraisal of all relevant information (concerning the harmonised assessment parameters, their respective assessment levels and the supporting environmental factors)	Final classification	Assessment period
Southern North Sea – coastal water	NI	-	Ca	-	O <sub>2</sub>	-	At		NPA	<ul style="list-style-type: none"> <li>There is good evidence that the area is nutrient enriched (high confidence) based on nutrient data with good representivity.</li> <li>There is evidence that there is no accelerated growth (high confidence) based on chlorophyll data with good representivity.</li> <li>The available evidence does not suggest any undesirable disturbance (high confidence) based on dissolved oxygen data with low representivity.</li> </ul> <p>It is confirmed that this area remains a Non Problem Area (high confidence) based on the available evidence. Nutrient inputs to the area are decreasing and there is a decreasing trend in DIN.</p>	NPA	2006-2014
	DI	+	Ps		Ck							
	NP	-	Mp		Oc							
Southern North	NI	-	Ca	-	O <sub>2</sub>	-	At		NPA	<ul style="list-style-type: none"> <li>There is good evidence that the area is not</li> </ul>	NPA	2006-2014

Sea – offshore water	DI	-	Ps		Ck				<p>nutrient enriched (high confidence) based on nutrient data with good representivity.</p> <ul style="list-style-type: none"> <li>• There is good evidence that there is no accelerated growth (high confidence) based on chlorophyll data with good representivity.</li> <li>• The available evidence does not suggest any undesirable disturbance (low confidence) based on limited dissolved oxygen data.</li> </ul> <p>It is confirmed that this area remains a non Problem Area (high confidence) based on the available evidence. Nutrient inputs to the area are decreasing.</p>		
	NP	-	Mp		Oc						

## 20 Annex 10 - Eastern Channel (Region 3)

Name and map (geographical location: longitude, latitude)

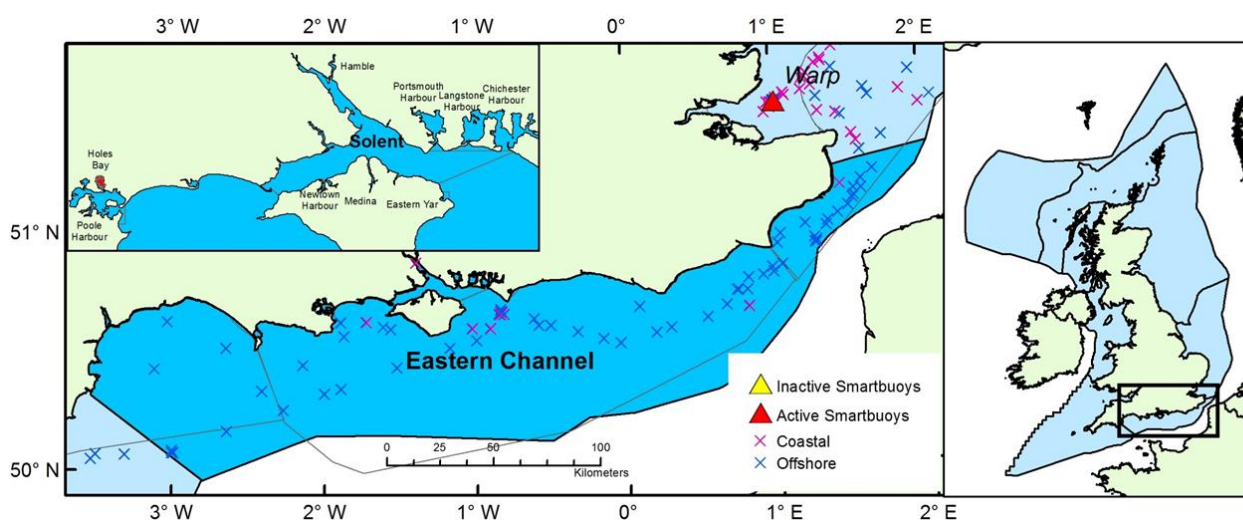


Figure A10.1: Map showing the location of the Eastern Channel (Region 3, dark blue). Grey lines indicate UK marine areas from the second application of the COMP which fall into this region (viz. the eastern English Channel and the southernmost extent of the southern North Sea). The locations of sites (X) where data were available from 2006 onwards are shown: red = coastal (salinity 30-34.5), blue = offshore sites (salinity >34.5).

### 20.1 Description of the area

*Including environmental information*

This area (Figure A10.1) includes one main marine region, the eastern English Channel, and several coastal and estuarine regions. The region is largely 'permanently mixed' (van Leeuwen et al. 2015, Annex 3), with some areas which stratify intermittently. It includes the coastal waters of the Solent, which lies between the Isle of Wight and the mainland and has a complex tidal pattern. Transitional waters in the Solent include Southampton Water, which is an estuary which receives fresh water from the rivers Test, Itchen and Hamble. These water bodies are all assessed under the WFD. Estuaries and harbours adjacent to the Solent include the Eastern Yar, the Hamble estuary, the Medina estuary, Chichester Harbour, Langstone Harbour, Newtown Harbour and Portsmouth Harbour. All of these water bodies have been designated or assessed under previous Directives (Urban Waste Water Treatment Directive or the Habitats Directive).

The Water Framework Directive (WFD) assessments of the status of transitional and coastal waters in this region have confirmed nine Problem Areas: Holes Bay, Poole Harbour, Chichester Harbour, Portsmouth Harbour, Fleet Lagoon, the Hamble, the Eastern Yar, the Medina estuary, and Newtown River.

#### Risks

**Human pressures:** Shifts in human population, changes in nutrient management practices within the catchment resulting from economic pressures. The Solent catchment is the most rapidly-growing urban area of the UK.

**Environmental pressures:** Increased incidence of coastal HAB events could be linked to warmer conditions and long-distance transport of non-native species.

*Assessment of risk* – Although there is a medium-risk possibility that levels of nutrient enrichment may increase due to increasing economic activity, the offshore part of the region is resilient to eutrophication due to its hydrodynamics. Strong mixing limit algal growth and prevent oxygen depletion from occurring. Certain coastal bays and estuaries are, however, at risk of eutrophication and this has been recognised in previous OSPAR reports.

## **20.2 Description of monitoring design in relation to spatial and temporal variability of assessment parameters in the area**

*This section should include information on how the monitoring design addresses the particular typology and main hydrographical dynamics in the area, so as to provide evidence of representativeness of monitoring.*

As a Non-Problem Area the Eastern Channel is subject to the relevant requirements of the OSPAR Eutrophication Monitoring Programme to measure DIN, DIP, salinity and temperature about every three years in winter.

**Nutrients:** In the absence of a sentinel site, ship based sampling of winter nutrients is the main source of data.

**Light attenuation:** This region has not been adequately studied for optics or the conditions for algal growth.

**Chlorophyll:** In the absence of a sentinel site, ship based sampling of is the main source of data.

**Oxygen:** No data are available in this region for an assessment.

**Phytoplankton composition:** No phytoplankton data were available for an assessment in this region.

**Seagrasses and seaweeds:** The enclosed bays and harbours in the Solent region are monitored under the WFD.

## **20.3 Assessment**

### **Nutrients:**

Normalised and non-normalised mean winter concentrations of DIN ( $\mu\text{M}$ ) per year were calculated for the period from 2006 to 2014.

In coastal waters, insufficient data were available for assessment, and no assessment results are shown (Figure A10.2). Normalised mean winter DIN values calculated from available data per year (Table A10.1) were above the assessment threshold of  $18 \mu\text{M}$ . Confidence levels in the normalised means of the available data ( $n = 10$  in total) were low (2.6-24%, Table A10.1). The overall confidence level for concluding Non Problem Area over the assessment period using normalised means was low (0%). If non-normalised mean winter DIN values were used, all means were below the assessment threshold, confidence levels in the means of the available data ( $n = 10$  in total) were higher (85-100%, data not shown), and overall confidence levels were higher (96%). Due to poor data availability ( $n = 10$  in total), and the fact that on a year by year basis insufficient data were available for assessment, these outcomes were considered to be unreliable.

In offshore waters, normalised mean values showed that winter DIN concentrations exceeded the assessment threshold ( $15 \mu\text{M}$ ) in 2006, 2008 and 2009 (Fig. A10.2). Available data showed that the mean value also exceeded the threshold in 2010 (Table A10.2), although insufficient data were available for the assessment. Confidence levels for concluding Non Problem Area status were low



(0 -30.7%, Table A10.2) from 2006-2009, and high (>99%) from 2011. The overall confidence level for concluding Non Problem Area over the assessment period was 67.99%. Non-normalised winter means were below the threshold in all years with sufficient data (Figure A10.2). Using these means, the overall confidence level in assessments was 100% (data not shown).

For TOxN (Figure A10.3, Tables A10.3 and A10.4), similar results were obtained. Overall confidence levels were 0% in coastal waters and 98.5% in offshore waters. Normalised mean winter DIN concentrations were used in the assessment.

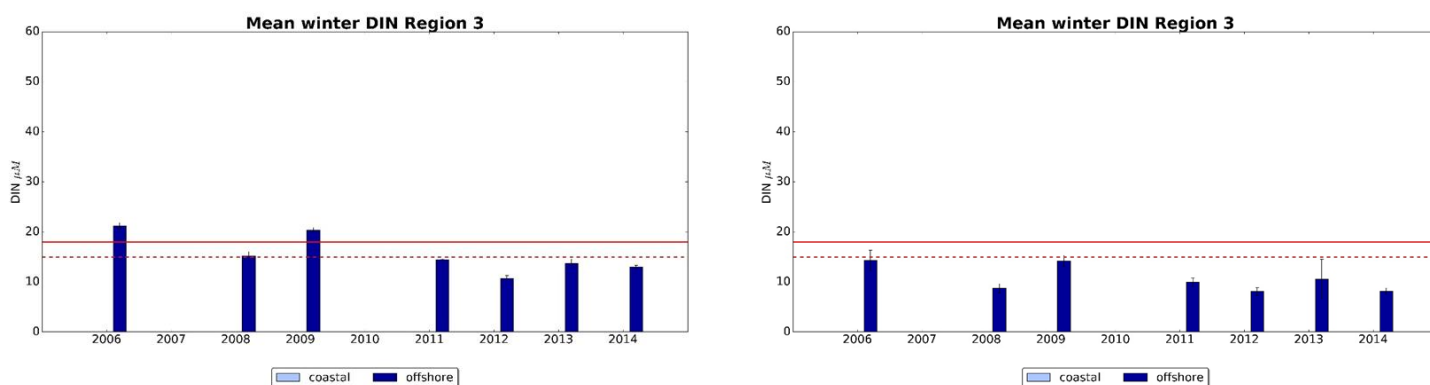


Figure A10.2: Mean winter concentrations of DIN ( $\mu\text{M}$ ) per year in the Eastern Channel during the assessment period, 2006 to 2014. Results are shown separately for coastal waters and offshore waters, using data from all depths sampled. Data are shown as normalised means (left) and non-normalised means (right). Coastal data were normalised to salinity 32, offshore data were normalised to 34.5. Assessment thresholds for coastal (18  $\mu\text{M}$ , solid red line) and offshore waters (15  $\mu\text{M}$ , dashed red line) are shown.

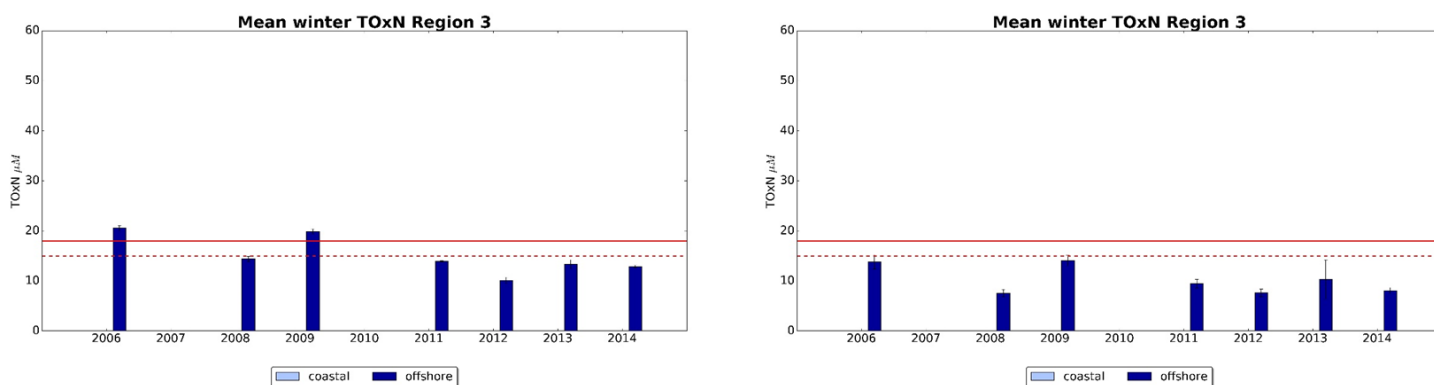


Figure A10.3: Mean winter concentrations of TOxN ( $\mu\text{M}$ ) per year in the Eastern Channel during the assessment period, 2006 to 2014. Results are shown separately for coastal waters and offshore waters, using data from all depths sampled. Data are shown as normalised means (left) and non-normalised means (right). Coastal data were normalised to salinity 32, offshore data were normalised to 34.5. Assessment thresholds for coastal (18  $\mu\text{M}$ , solid red line) and offshore waters (15  $\mu\text{M}$ , dashed red line) are shown.

Table A10.1: Normalised means and yearly confidence levels for winter DIN in Region 3 coastal. The assessment threshold, minimum value, maximum value, standard error and number of samples are shown. nan = no data. All = overall values and confidence levels (see Table 5 in main report).

Region	Location	Assessm Threshold ( $\mu$ M)	Year	Min Value	Max Value	Normalised Mean	Std Error	Number of Samples	Confidence Level (%) for concluding Non Problem
3	Coastal	18	2006	nan	nan	nan	0	nan	0
3	Coastal	18	2007	nan	nan	nan	nan	nan	nan
3	Coastal	18	2008	17.6	17.6	38.05	1.66	1	2.63
3	Coastal	18	2009	nan	nan	nan	0	nan	0
3	Coastal	18	2010	nan	nan	nan	0	nan	0
3	Coastal	18	2011	14.5	14.5	39.91	0	2	0
3	Coastal	18	2012	6.35	6.35	19.76	1.65	1	23.95
3	Coastal	18	2013	18.19	18.2	35.14	0.05	3	0
3	Coastal	18	2014	16.05	18.9	31.98	0.22	3	0
			All	6.35	18.9	36.89	0.79	10	0

Table A10.2: Normalised means and yearly confidence levels for mean winter DIN in Region 3 offshore. The assessment threshold, minimum value, maximum value, standard error and number of samples are shown. nan = no data. All = overall values and confidence levels (see Table 6 in main report).

Region	Location	Assessm Threshold ( $\mu$ M)	Year	Min Value	Max Value	Normalised Mean	Std Error	Number of Samples	Confidence Level (%) for concluding Non Problem
3	Offshore	15	2006	8.4	19.7	21.21	0.28	11	0
3	Offshore	15	2007	nan	nan	nan	nan	nan	nan
3	Offshore	15	2008	6.3	13.7	15.2	0.4	18	30.71
3	Offshore	15	2009	12.45	20.2	20.36	0.24	18	0
3	Offshore	15	2010	6.4	16.3	15.09	1.42	4	47.75
3	Offshore	15	2011	7	14.4	14.46	0.05	27	100
3	Offshore	15	2012	5.8	11.4	10.65	0.3	22	100
3	Offshore	15	2013	6.77	14.53	13.69	0.35	6	99.54
3	Offshore	15	2014	7.4	10.3	13.02	0.13	9	100
			All	5.8	20.2	14.92	0.18	115	67.99

Table A10.3: Normalised means and yearly confidence levels for winter TOxN in Region 3 coastal. The assessment threshold, minimum value, maximum value, standard error and number of samples are shown. nan = no data.

Region	Location	Assessm Threshold ( $\mu$ M)	Year	Min Value	Max Value	Normalised Mean	Std Error	Number of Samples	Confidence Level (%) for concluding Non Problem
3	Coastal	18	2006	nan	nan	nan	0	nan	0
3	Coastal	18	2007	nan	nan	nan	nan	nan	nan
3	Coastal	18	2008	16.5	16.5	38.63	1	1	1.54
3	Coastal	18	2009	nan	nan	nan	0	nan	0
3	Coastal	18	2010	nan	nan	nan	0	nan	0
3	Coastal	18	2011	14	14	39.11	0	2	0
3	Coastal	18	2012	5.85	5.85	19.09	1.63	1	31.28
3	Coastal	18	2013	17.7	17.8	34.42	0.02	3	0
3	Coastal	18	2014	15.95	18.6	31.67	0.23	3	0
			All	5.85	18.6	37.12	0.76	10	0

Table A10.4: Normalised means and yearly confidence levels for winter TOxN in Region 3 offshore. The assessment threshold, minimum value, maximum value, standard error and number of samples are shown. nan = no data.

Region	Location	Assessm Threshold ( $\mu$ M)	Year	Min Value	Max Value	Normalised Mean	Std Error	Number of Samples	Confidence Level (%) for concluding Non Problem
3	Offshore	15	2006	8.3	19.6	20.55	0.25	16	0
3	Offshore	15	2007	nan	nan	nan	nan	nan	nan
3	Offshore	15	2008	4.9	12.15	14.41	0.24	18	98.82
3	Offshore	15	2009	12.35	19.7	19.88	0.23	18	0
3	Offshore	15	2010	5.7	13	11.96	1.1	4	97.48
3	Offshore	15	2011	6.5	13.8	13.93	0.05	27	100
3	Offshore	15	2012	5.4	10.95	10.11	0.29	22	100
3	Offshore	15	2013	6.57	14.13	13.34	0.34	6	99.85
3	Offshore	15	2014	7.3	10.2	12.88	0.13	9	100
			All	4.9	19.7	14.61	0.18	120	98.51

#### DIN:DIP ratios

Insufficient data were available for assessment in coastal waters. Mean winter DIN:DIP ratios (Figure A10.4) were below the threshold of 24 in offshore waters. Confidence levels for concluding Non Problem Area in offshore waters were high (91-100%, Table A10.6). The overall confidence level in mean values for concluding Non Problem Area over the assessment period was low in coastal waters and high in offshore waters (4.57% and 100% respectively).

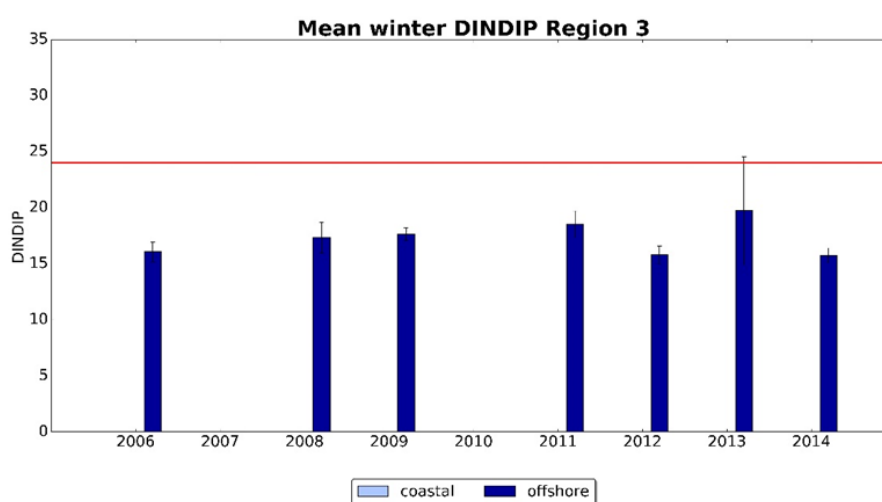


Figure A10.4: Mean winter ratios of DIN:DIP per year in the Eastern Channel during the assessment period, 2006 to 2014. Results are shown separately for coastal waters and offshore waters, using data from all depths sampled. The assessment threshold of 24 is shown by the red line.

Table A10.5: Means and yearly confidence levels for winter DIN:DIP in Region 3 coastal. The assessment threshold, minimum value, maximum value, standard error and number of samples are shown. nan = no data.

Region	Location	Assessm Threshold	Year	Min Value	Max Value	Mean Value	Std Error	Number of Samples	Confidence Level (%) for concluding Non Problem
3	Coastal	24	2006	nan	nan	nan	nan	nan	nan
3	Coastal	24	2007	nan	nan	nan	nan	nan	nan
3	Coastal	24	2008	27.94	27.94	27.94	0	1	0
3	Coastal	24	2009	nan	nan	nan	nan	nan	nan
3	Coastal	24	2010	nan	nan	nan	nan	nan	nan
3	Coastal	24	2011	25.44	25.44	25.44	0	2	0
3	Coastal	24	2012	14.12	14.12	14.12	0	1	100
3	Coastal	24	2013	31.91	31.93	31.92	0	3	0
3	Coastal	24	2014	25.68	29.08	26.96	0.87	3	2.11
			All	14.12	31.93	26.96	1.58	10	4.57

Table A10.6: Means and yearly confidence levels for winter DIN:DIP in Region 3 offshore. The assessment threshold, minimum value, maximum value, standard error and number of samples are shown. nan = no data.

Region	Location	Assessm Threshold	Year	Min Value	Max Value	Mean Value	Std Error	Number of Samples	Confidence Level (%) for concluding Non Problem
3	Offshore	24	2006	14.24	19.78	16.06	0.39	11	100
3	Offshore	24	2007	nan	nan	nan	nan	nan	nan
3	Offshore	24	2008	14.63	24.04	17.33	0.65	18	100
3	Offshore	24	2009	15.82	20	17.64	0.27	18	100
3	Offshore	24	2010	11.64	25.87	17.47	3.51	3	91.98
3	Offshore	24	2011	14.89	24.41	18.52	0.58	27	100
3	Offshore	24	2012	12.34	19.32	15.79	0.39	22	100
3	Offshore	24	2013	15.04	24.63	19.74	1.87	6	96.85
3	Offshore	24	2014	14.51	17.76	15.74	0.29	9	100
			All	11.64	25.87	17.24	0.26	114	100

## Chlorophyll

For coastal waters, insufficient data were available for an assessment in any year and confidence levels in the assessments were low (<34.4%, per year and 46.9% overall, Table A10.7). The few data points which are available indicated low values for the 90<sup>th</sup> percentiles (*ca.* 2 µg l<sup>-1</sup>).

In offshore waters, data were available for 2009 and 2011; the 90<sup>th</sup> percentiles were low (<3 µg l<sup>-1</sup>) and below the assessment threshold (10 µg l<sup>-1</sup>). In these years, confidence levels in the mean values for concluding Non Problem Area were 47 to 65%, Table A10.8. Overall confidence was 86.5%.

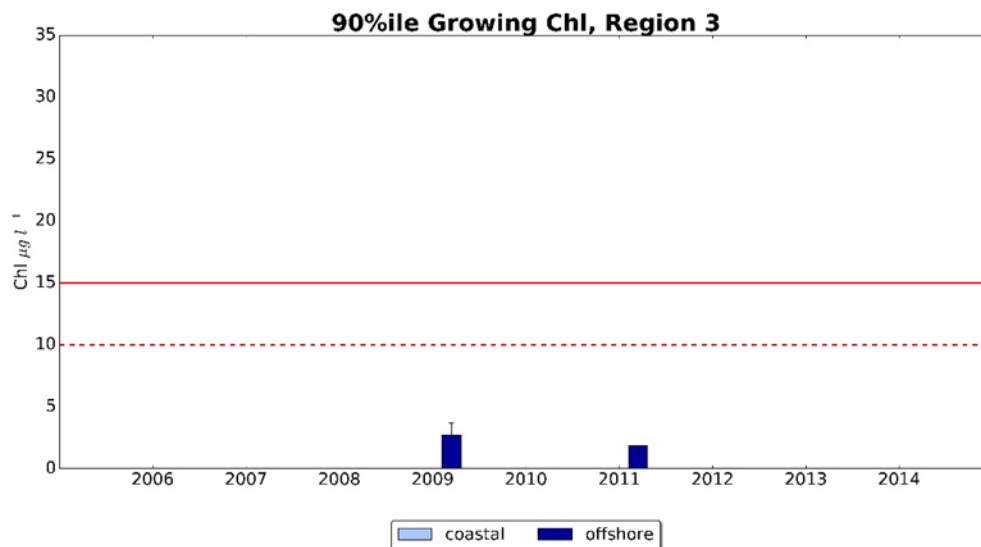


Figure A10.5: Growing season chlorophyll per year in the Eastern Channel during the assessment period, 2006 to 2014, shown as 90<sup>th</sup> percentiles. Results are shown separately for coastal waters and offshore waters, using data from all depths sampled. The assessment thresholds are shown for offshore waters (10  $\mu\text{g l}^{-1}$ , dashed red line) and coastal waters (15  $\mu\text{g l}^{-1}$ ).

Table A10.7: Chlorophyll growing season 90<sup>th</sup> percentiles in Region 3 coastal, and confidence levels per year. The table shows thresholds used, the number of available data points (n), and the number of data points below the threshold. nan = no data.

Region	Location	Assessm Threshold ( $\mu\text{g l}^{-1}$ )	Year	90 <sup>th</sup> percentile	Mean	Std Dev	Number of Samples (n)	95% Conf Limit lower	95% Conf Limit upper	Number (n) below the assessment threshold	Confidence level (%)
3	Coastal	15	2006	2.01	1.51	0.62	2	nan	nan	2	19
3	Coastal	15	2007	nan	nan	nan	nan	nan	nan	nan	nan
3	Coastal	15	2008	nan	nan	nan	nan	nan	nan	nan	nan
3	Coastal	15	2009	nan	nan	nan	nan	nan	nan	nan	nan
3	Coastal	15	2010	1.75	1.46	0.3	4	1.75	1.75	4	34.39
3	Coastal	15	2011	nan	nan	nan	nan	nan	nan	nan	nan
3	Coastal	15	2012	nan	nan	nan	nan	nan	nan	nan	nan
3	Coastal	15	2013	nan	nan	nan	nan	nan	nan	nan	nan
3	Coastal	15	2014	nan	nan	nan	nan	nan	nan	nan	nan
			All	1.94	1.47	0.43	6	1.75	2.13	6	46.86

Table A10.8: Chlorophyll growing season 90<sup>th</sup> percentiles in Region 3 offshore, and confidence levels per year. The table shows thresholds used, the number of available data points (n), and the number of data points below the threshold. nan = no data.

Region	Location	Assessm Threshold ( $\mu\text{g l}^{-1}$ )	Year	90 <sup>th</sup> percentile	Mean	Std Dev	Number of Samples (n)	95% Conf Limit lower	95% Conf Limit upper	Number (n) below the assessment threshold	Confidence level (%)
3	Offshore	10	2006	nan	nan	nan	nan	nan	nan	nan	nan
3	Offshore	10	2007	nan	nan	nan	nan	nan	nan	nan	nan
3	Offshore	10	2008	nan	nan	nan	nan	nan	nan	nan	nan
3	Offshore	10	2009	2.73	1.9	0.89	10	2.52	3.69	10	65.13
3	Offshore	10	2010	0.17	0.17	0	1	nan	nan	1	10
3	Offshore	10	2011	1.86	1.18	0.53	6	1.16	1.89	6	46.86
3	Offshore	10	2012	nan	nan	nan	nan	nan	nan	nan	nan
3	Offshore	10	2013	nan	nan	nan	nan	nan	nan	nan	nan
3	Offshore	10	2014	nan	nan	nan	nan	nan	nan	nan	nan
			All	2.54	1.46	0.88	19	1.94	3.69	19	86.49

## Phytoplankton Indicator Species

No phytoplankton data were available to apply the WFD tool.

## Oxygen

Insufficient data were available for assessments during the period 2006 to 2014 (Figure 10.6). In coastal waters, there were no data (Table A10.9). In offshore waters, two data points were available in 2009 and one in 2013 (Table A10.10), but were insufficient for any assessment.

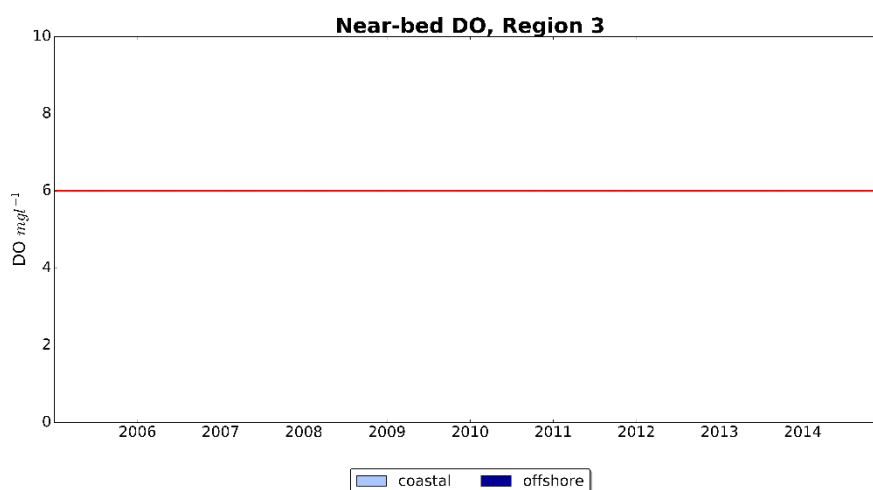


Figure A10.6: Near-bed concentrations of dissolved oxygen (DO) per year in the Eastern Channel during the assessment period, 2006 to 2014. Results are given as the mean value in the lowest quartile of the data, separately for coastal waters and offshore waters. A threshold of 6 mg l<sup>-1</sup> is shown by the dashed blue line

Table A10.9: Near-bed dissolved oxygen (mg l<sup>-1</sup>) in Region 3 coastal, and confidence levels per year. The table shows thresholds used, the mean and standard error in the lowest quartile of the data (Q25), number of available data points in the lowest quartile and in the available dataset (total), and confidence levels in assessment outcomes. Minimum (Min) and maximum (Max) values in the total dataset are also shown. nan = no data.

Region	Location	Assessm Threshold (mg l <sup>-1</sup> )	Year	Min Value	Max Value	Mean (Q25)	Std Error (Q25)	Number of Samples (Q25)	Number of Samples (total)	Confidence Level (%) for concluding Non Problem
3	Coastal	6	2006	nan	nan	nan	nan	nan	0	nan
3	Coastal	6	2007	nan	nan	nan	nan	nan	0	nan
3	Coastal	6	2008	nan	nan	nan	nan	nan	0	nan
3	Coastal	6	2009	nan	nan	nan	nan	nan	0	nan
3	Coastal	6	2010	nan	nan	nan	nan	nan	0	nan
3	Coastal	6	2011	nan	nan	nan	nan	nan	0	nan
3	Coastal	6	2012	nan	nan	nan	nan	nan	0	nan
3	Coastal	6	2013	nan	nan	nan	nan	nan	0	nan
3	Coastal	6	2014	nan	nan	nan	nan	nan	0	nan
			All	nan	nan	nan	nan	nan	nan	nan

Table A10.10: Near-bed dissolved oxygen ( $\text{mg l}^{-1}$ ) in Region 3 offshore, and confidence levels per year. The table shows thresholds used, the mean and standard error in the lowest quartile of the data (Q25), number of available data points in the lowest quartile and in the available dataset (total), and confidence levels in assessment outcomes. Minimum (Min) and maximum (Max) values in the total dataset are also shown. nan = no data.

Region	Location	Assessm Threshold ( $\text{mg l}^{-1}$ )	Year	Min Value	Max Value	Mean (Q25)	Std Error (Q25)	Number of Samples (Q25)	Number of Samples (total)	Confidence Level (%) for concluding Non Problem
3	Offshore	6	2006	nan	nan	nan	nan	nan	0	nan
3	Offshore	6	2007	nan	nan	nan	nan	nan	0	nan
3	Offshore	6	2008	nan	nan	nan	nan	nan	0	nan
3	Offshore	6	2009	7.40	7.74	7.40	nan	1	2	nan
3	Offshore	6	2010	nan	nan	nan	nan	nan	0	nan
3	Offshore	6	2011	nan	nan	nan	nan	nan	0	nan
3	Offshore	6	2012	nan	nan	nan	nan	nan	0	nan
3	Offshore	6	2013	7.84	7.84	7.84	nan	1	1	nan
3	Offshore	6	2014	nan	nan	nan	nan	nan	0	nan
			All	7.40	7.84	7.40	nan	1	3	nan

### Assessment outcomes for Eastern Channel

2003 - In OSPAR integrated report, 1995-2001: Non Problem Area.

2008 - Period 2001-2005: Non Problem Area.

Score table:

- Nutrient enrichment parameters show elevated levels in 4 out of 5 years in coastal waters (2001-2005) and in one year on offshore waters:

**Offshore Winter DIN Score:** - ? - - + (no data in 2002)

**Coastal Winter DIN:** + + + + ? (no data in 2005)

- Chlorophyll did not show elevated levels in all 5 years (2001-2005):

**Offshore Overall Chl a score:** ? - ? ? ?

**Coastal Overall Chl a score:** - + - ? ?

- No elevated levels of other direct effect or indirect effect parameters in all 5 years (2001-2005):

**DO Score:** 5 times –

2014 - Third application of the Common Procedure (2006-2014):

The Solent was assessed under the Water Framework Directive (WFD). Assessments have confirmed four Problem Areas: Chichester Harbour, Holes Bay (Poole Harbour), Portsmouth Harbour, and Newtown River. The Eastern Yar, Medina estuary and Pagham Harbour have been classified as Potential Problem Areas.

Initial and final classification for the Eastern Channel: Non Problem Area (2006-2014).



Table A10.11: Assessment table (Eastern Channel, 2006-2014). Aggregated confidence ratings (Tables 5 and 6 in the main report) were calculated over the nine-year assessment period.

Category	Assessment Parameters	Description of Results	Score (+ - ?)	Aggregated confidence rating
<b>Degree of Nutrient Enrichment (I)</b>	Riverine inputs and direct discharges of total N and total P	N - P -	N - P -	
	Winter DIN concentrations (normalised)	Coastal: ? ? ? ? ? ? ? ?	Coastal: ?	0
		Offshore: + ? + + ? - - - -	Offshore: -	67.99
	Winter DIN:DIP	Coastal: ? ? ? ? ? ? ? ?	Coastal: ?	5.39
		Offshore: - ? - - ? - - - -	Offshore: -	100
<b>Direct Effects (II)</b>	90 <sup>th</sup> percentile chlorophyll concentration	Coastal: ? ? ? ? ? ? ? ?	Coastal: ?	46.86
		Offshore: ? ? ? - ? - ? ? ?	Offshore: -	86.49
	Area-specific phytoplankton indicator species	Not assessed		
	Macrophytes including macroalgae	Not assessed		
<b>Indirect Effects (III)</b>	Oxygen deficiency	Coastal: ? ? ? ? ? ? ? ?	Coastal: ?	-
		Offshore: ? ? ? ? ? ? ? ?	Offshore: ?	-
	Changes/kills in zoobenthos and fish kills	Not assessed		
	Organic carbon/organic matter	Not assessed		
<b>Other Possible Effects (IV)</b>	Algal toxins (DSP/PSP mussel infection events)	Not assessed		

#### Key to the Score

- + = 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 are not fit for the purpose

Table A10.12: Results of the OSPAR Comprehensive Assessment 2016 for the Eastern Channel, 2006-2014. PA = Problem Area, NPA = Non Problem Area.

**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 90<sup>th</sup> percentile, maximum and mean chlorophyll *a* concentration  
 Ps Area-specific phytoplankton indicator species

Mp Macrophytes including macroalgae  
 O<sub>2</sub> 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 were available for assessments. These data were not required or used to confirm Non Problem Status

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	Overall appraisal of all relevant information (concerning the harmonised assessment parameters, their respective assessment levels and the supporting environmental factors)	Final classification	Assessment period
Eastern Channel – coastal water	NI	-	Ca	?	O <sub>2</sub>	?	At		Not known	<ul style="list-style-type: none"> <li>There is evidence that the area is nutrient enriched (low confidence) based on limited nutrient data with moderate representivity.</li> <li>There is evidence that there is no accelerated growth (low confidence) based on limited chlorophyll data with low representivity.</li> <li>There is no evidence to assess undesirable disturbance.</li> </ul> It is confirmed that the status of the area is not known due to lack of data. Nitrogen inputs to the area are decreasing (but not significant) and, based on previous NPA status, it is likely that the area is a Non Problem Area.	Not known	2006-2014
	DI	?	Ps		Ck							
	NP	?	Mp		Oc							
Eastern Channel – offshore water	NI	-	Ca	-	O <sub>2</sub>	?	At		NPA	<ul style="list-style-type: none"> <li>There is evidence that the area is not nutrient enriched (medium confidence) based on nutrient data with moderate representivity.</li> <li>There is evidence that there is no accelerated</li> </ul>	NPA	2006-2014
	DI	-	Ps		Ck							
	NP	-	Mp		Oc							

									<p>growth (high confidence) based on limited chlorophyll data with low representivity.</p> <ul style="list-style-type: none"> <li>• There is no evidence to assess undesirable disturbance.</li> </ul> <p>It is confirmed that this area remains a Non Problem Area (low confidence) based on the absence of nutrient enrichment and accelerated growth.</p>		
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## 21 Annex 11 - Western Channel and Celtic Sea (Region 4)

Name and map (geographical location: longitude, latitude)

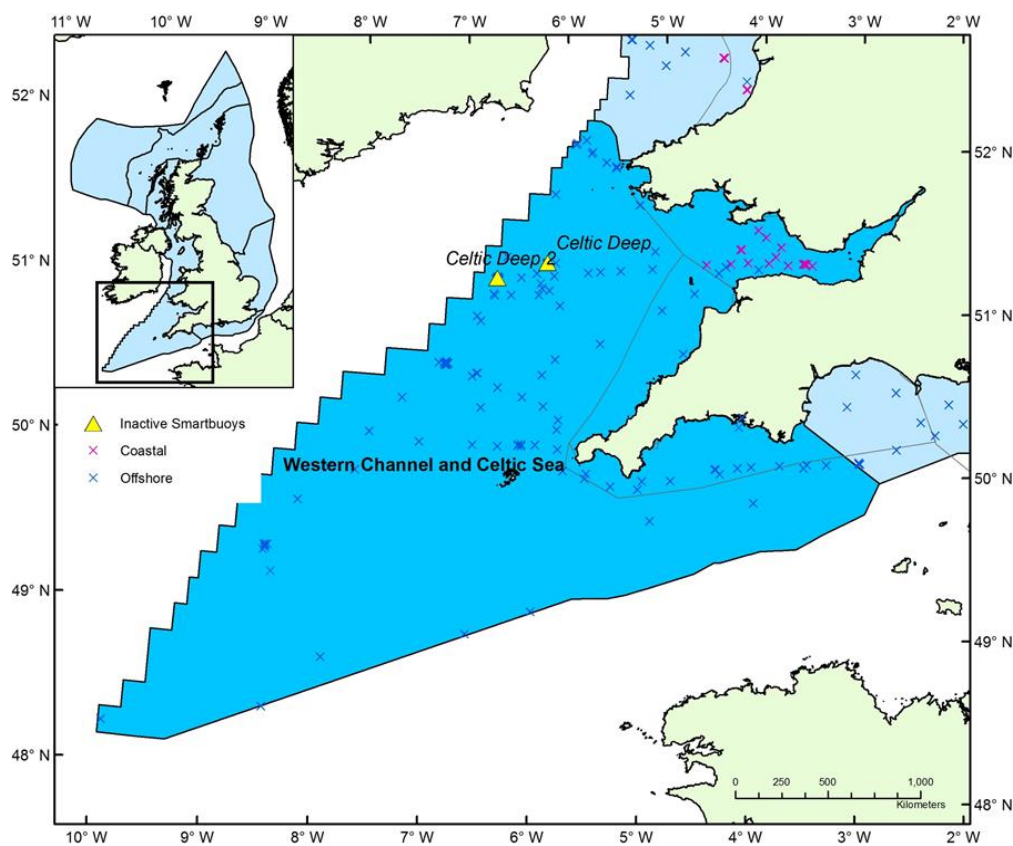


Figure A11.1: Map showing the location of the Western Channel and Celtic Sea (Region 4, dark blue). Grey lines indicate UK marine areas from the second application of the COMP which fall into this region (only the Bristol Channel was assessed). The locations of sites (X) where data were available from 2006 onwards are shown: red = coastal (salinity 30-34.5), blue = offshore sites (salinity >34.5).

### 21.1 Description of the area

Including environmental information

The Western Channel and Celtic Sea (Figure A11.1) contains three inshore marine areas from the second application of the Comprehensive Procedure. These areas are the Bristol Channel, North Cornwall, and the western part of South-West England coast. The remainder of Region 4 is the UK's offshore sector of the Celtic Sea. In the previous application of the OSPAR Common Procedure, most regions were screened out prior to application of the Comprehensive Procedure. The Bristol Channel was found to be nutrient enriched, but there was no evidence of accelerated growth or undesirable disturbance, and it was classified as a Non Problem Area. The Bristol Channel, and the water bodies therein, is assessed under the Water Framework Directive (see Figure 10b in main report).

A wide range of ecohydrodynamic types are present (Annex 3). The Western Channel water column is deep (ca. 100 m) and shows seasonal stratification. The offshore Celtic Sea is deep and strongly stratified for most of the year. Two transitional or frontal regions of seasonally stratified water border the Celtic Sea to the north (towards the Irish Sea) and to the east. The Bristol Channel is shallower (<50 m) with strong tidal mixing, and the water column is either permanently mixed or variable depending on location.

The Water Framework Directive assessments of the status of transitional and coastal waters in this region have identified three water bodies in this region as Problem Areas: Burry Inlet Inner, the Taw, and the Tawe (Wales; Beaufort Weir to the Barrage). A fourth water body, Kingsbridge, has not yet been formally classified as a Problem Area, but it likely to be designated as a Polluted Water (Eutrophic) under the Nitrates Directive.

### Risks

This is largely an offshore area with strong advective flows from the open Atlantic to the south-west, especially in winter. Land areas have low population densities although this varies seasonally and can be high in summer from tourism. Agricultural practices are variable but overall pressure is low. Transboundary transport may be important due to high intensity agriculture for example, in northern France, which has caused localised eutrophication problems in the bays of Brittany (Ménèsquen and Gohin 2006). Fish kills are occasionally reported along the English south-west coast, although the reasons for this are unclear (Coates et al. 2009).

*Human pressures:* Shifts in human population, changes in nutrient management practices within the catchment resulting from economic pressures.

*Environmental pressures:* Gradual warming of seabed temperature which would quicken biogeochemical cycling and potentially increase risk of hypoxia in the deeper areas. Increased incidence of HAB events could be linked to warmer conditions and long-distance transport of non-native species.

*Assessment of risk* – Human populations in the catchment of the Celtic Sea are comparatively low compared to the southern North Sea. Terrestrial nutrient management measures are resulting in significant decreases in sewage and industrial loads to the region (Defra 2010, OSPAR QSR 2010).

**There is a very low probability** that inputs of anthropogenic nutrients to the Celtic Sea proper will increase in the next 10 years. There is a **medium probability** that the south-west coastal region or Bristol Channel will have increased nutrients in the future, with potential for localised eutrophication.

### **21.2 Description of monitoring design in relation to spatial and temporal variability of assessment parameters in the area**

*This section should include information on how the monitoring design addresses the particular typology and main hydrographical dynamics in the area, so as to provide evidence of representativeness of monitoring.*

As a Non-Problem Area, the Western Channel and Celtic Seas are subject to the relevant requirements of the OSPAR Eutrophication Monitoring Programme to measure DIN, DIP, salinity and temperature about every three years in winter. More recent NERC and other research studies focussing on the region will provide additional data for the next assessment.

**Nutrients:** There has been a low level of statutory monitoring and opportunistic sampling in the Celtic Sea over the assessment period. This provides a limited amount of winter data for assessment purposes.

**Light attenuation:** The availability of underwater light measurements, turbidity or attenuation for this region has not been investigated for this report.

**Chlorophyll:** There has been a low level of monitoring and opportunistic sampling in the Celtic Sea over the past decade, providing a limited amount of data for assessment purposes.

**Oxygen:** Very few measurements of near-bed oxygen concentration have been made in this region.

**Phytoplankton composition:** There is a long history of phytoplankton analysis at the Plymouth labs, and regular measurements of phytoplankton species and functional types are assessed by flow cytometry, pigment analysis and microscopy continue at the L4 time series station (Widdicombe et al. 2010).

**Seagrasses and seaweeds:**

An assessment of seagrasses and seaweeds in this region has not been made for this report.

The Western Channel Observatory provides a time series of data for the coastal and offshore waters in South-West England (<http://www.westernchannelobservatory.org.uk/data.php>). The L4 and E1 sites will be valuable sentinel sites for the region. Nutrients, chlorophyll and phytoplankton are measured on a weekly or fortnightly basis. A SmartBuoy was recently deployed at the Celtic Deep and will provide a reference for chlorophyll in offshore, stratified water. Two further sources of information for future assessments are the Plymouth-Roscoff Ferrybox route operated by Station Biologique Roscoff, and the Ferrybox observations of *RV Cefas Endeavour*.

### **21.3 Assessment**

**Nutrients:**

In coastal waters, sufficient nutrient data for carrying out an assessment were available in 2012 and 2013 (Figures A11.2 and A11.3). In both years, normalised mean winter DIN values were above the threshold (18  $\mu\text{M}$ , Table A11.1). Confidence levels for concluding Non Problem Area status were low (0%, Table A11.1). The overall confidence level for concluding Non Problem Area over the assessment period was low (0%). Non-normalised mean winter DIN values were lower in both years for which data were available, but still exceeded the threshold (Figure A11.2). Using non-normalised values for mean winter DIN, confidence levels were also low (0%-0.2%, per year and 0% overall, data not shown).

In offshore waters, sufficient data were available for assessments in four years (2008, 2011-2013). Normalised mean values for winter DIN concentrations were below the assessment threshold (15  $\mu\text{M}$ ) in all four years (Fig. A11.2, Table A11.2). Confidence levels in the mean values for each of these year were high (100%, Table A11.2). The overall confidence level over the assessment period was also high (100%). Non-normalised means showed the same outcome, with mean values all below the assessment threshold (Figure A11.2) and confidence levels of 100%.

For TOxN (Figure A11.3, Tables A11.3 and A11.4), similar results were obtained. Normalised mean winter DIN concentrations were used in the assessment.

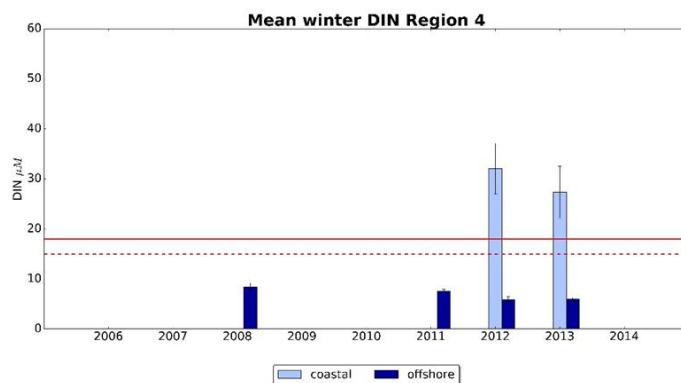
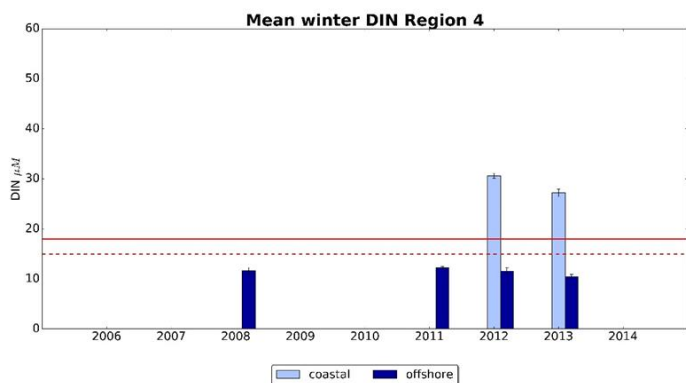


Figure A11.2: Mean winter concentrations of DIN ( $\mu\text{M}$ ) per year in the Western Channel and Celtic Sea during the assessment period, 2006 to 2014. Results are shown separately for coastal waters and offshore waters, using data from all depths sampled. Data are shown as normalised means (left) and non-normalised means (right). Coastal data were normalised to salinity 32, offshore data were normalised to 34.5. Assessment thresholds for coastal (18  $\mu\text{M}$ , solid red line) and offshore waters (15  $\mu\text{M}$ , dashed red line) are shown.

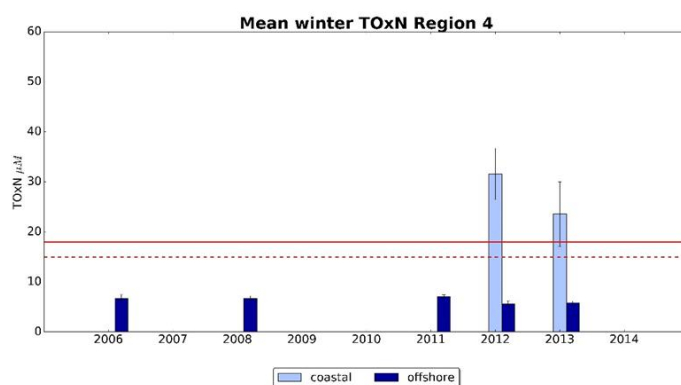
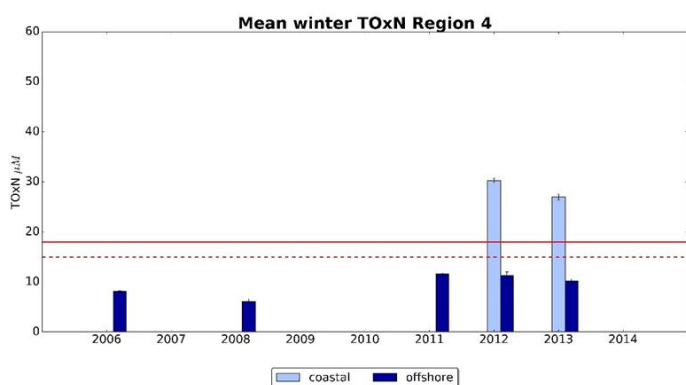


Figure A11.3: Mean winter concentrations of TOxN ( $\mu\text{M}$ ) per year in the Western Channel and Celtic Sea during the assessment period, 2006 to 2014. Results are shown separately for coastal waters and offshore waters, using data from all depths sampled. Data are shown as normalised means (left) and non-normalised means (right). Coastal data were normalised to salinity 32, offshore data were normalised to 34.5. Assessment thresholds for coastal (18  $\mu\text{M}$ , solid red line) and offshore waters (15  $\mu\text{M}$ , dashed red line) are shown.

Table A11.1: Normalised means and yearly confidence levels for winter DIN in Region 4 coastal. The assessment threshold, minimum value, maximum value, standard error and number of samples are shown. nan = no data. All = overall values and confidence levels (see Table 5 in main report).

Region	Location	Assessm Threshold ( $\mu\text{M}$ )	Year	Min Value	Max Value	Normalised Mean	Std Error	Number of Samples	Confidence Level (%) for concluding Non Problem
4	Coastal	18	2006	nan	nan	nan	nan	nan	nan
4	Coastal	18	2007	nan	nan	nan	nan	nan	nan
4	Coastal	18	2008	nan	nan	nan	0	nan	0
4	Coastal	18	2009	nan	nan	nan	nan	nan	nan
4	Coastal	18	2010	nan	nan	nan	0	nan	0
4	Coastal	18	2011	17.35	17.35	27.57	0	2	0
4	Coastal	18	2012	9.3	45.2	30.62	0.24	23	0
4	Coastal	18	2013	15.7	33.6	27.2	0.31	7	0
4	Coastal	18	2014	nan	nan	nan	nan	nan	nan
			All	9.3	45.2	30	0.34	32	0



Table A11.2: Normalised means and yearly confidence levels for winter DIN in Region 4 offshore. The assessment threshold, minimum value, maximum value, standard error and number of samples are shown. nan = no data. All = overall values and confidence levels (see Table 6 in main report).

Region	Location	Assessm Threshold ( $\mu$ M)	Year	Min Value	Max Value	Normalised Mean	Std Error	Number of Samples	Confidence Level (%) for concluding Non Problem
4	Offshore	15	2006	nan	nan	nan	nan	nan	nan
4	Offshore	15	2007	nan	nan	nan	nan	nan	nan
4	Offshore	15	2008	6.9	11	11.62	0.32	13	100
4	Offshore	15	2009	nan	nan	nan	nan	nan	nan
4	Offshore	15	2010	8.5	13.9	-10.91	0.58	4	100
4	Offshore	15	2011	6.2	11.1	12.29	0.1	55	100
4	Offshore	15	2012	0.7	14.14	11.56	0.35	60	100
4	Offshore	15	2013	3.3	10.2	10.49	0.2	53	100
4	Offshore	15	2014	nan	nan	nan	nan	nan	nan
			All	0.7	14.14	11.94	0.16	186	100

Table A11.3. Normalised means and yearly confidence levels for winter TOxN in Region 4 coastal. The assessment threshold, minimum value, maximum value, standard error and number of samples are shown. nan = no data.

Region	Location	Assessm Threshold ( $\mu$ M)	Year	Min Value	Max Value	Normalised Mean	Std Error	Number of Samples	Confidence Level (%) for concluding Non Problem
4	Coastal	18	2006	nan	nan	nan	0	nan	0
4	Coastal	18	2007	nan	nan	nan	nan	nan	nan
4	Coastal	18	2008	nan	nan	nan	0	nan	0
4	Coastal	18	2009	nan	nan	nan	nan	nan	nan
4	Coastal	18	2010	nan	nan	nan	0	nan	0
4	Coastal	18	2011	16.8	16.8	26.33	0	2	0
4	Coastal	18	2012	9.2	45	30.28	0.23	23	0
4	Coastal	18	2013	9.6	33.4	26.98	0.25	9	0
4	Coastal	18	2014	nan	nan	nan	nan	nan	nan
			All	9.2	45	29.54	0.31	34	0

Table A11.4. Normalised means and yearly confidence levels for winter TOxN in Region 4 offshore. The assessment threshold, minimum value, maximum value, standard error and number of samples are shown. Note: negative mean values are a result of the normalisation of the mean values. nan = no data.

Region	Location	Assessm Threshold ( $\mu$ M)	Year	Min Value	Max Value	Normalised Mean	Std Error	Number of Samples	Confidence Level (%) for concluding Non Problem
4	Offshore	15	2006	5.6	7.45	8.11	0.04	5	100
4	Offshore	15	2007	nan	nan	nan	nan	nan	nan
4	Offshore	15	2008	4.8	9.1	6.1	0.25	17	100
4	Offshore	15	2009	nan	nan	nan	nan	nan	nan
4	Offshore	15	2010	7	11	-5.22	0.49	4	100
4	Offshore	15	2011	5.6	10.5	11.58	0.11	59	100
4	Offshore	15	2012	0.6	13.96	11.29	0.35	60	100
4	Offshore	15	2013	2.7	10	10.23	0.2	55	100
4	Offshore	15	2014	nan	nan	nan	nan	nan	nan
			All	0.6	13.96	11.42	0.14	200	100

## DIN:DIP ratios

Mean winter DIN:DIP ratios (Figure A11.4, Tables A11.5 and A11.6) were calculated for years in which there were sufficient data. In coastal waters, the ratio was below the threshold (24) in 2012, and above the threshold in 2013. High values may indicate potential problems with nitrogen enrichment. In offshore waters, DIN:DIP ratios were below the threshold in all four years for which there were sufficient data for an assessment (2008, 2011-2013). Confidence levels for concluding Non Problem Area in offshore waters were high (100%, Table A11.6). The overall confidence level in mean values for concluding Non Problem Area over the assessment period was 76.82% in coastal waters and 100% in offshore waters (see Tables 5 and 6 in main report).

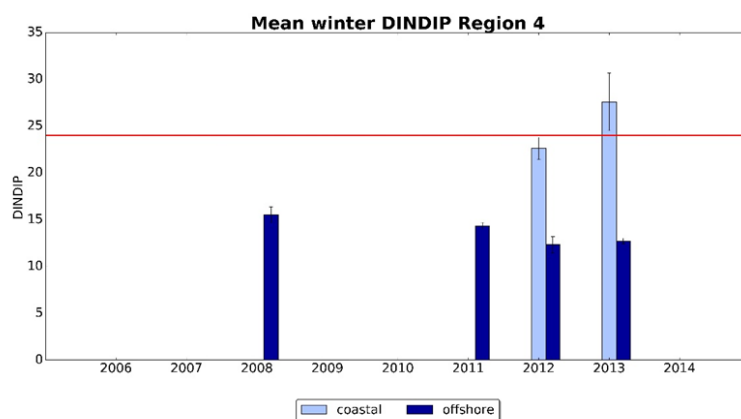


Figure A11.4: Mean winter ratios of DIN:DIP per year in the Western Channel and Celtic Sea during the assessment period, 2006 to 2014. Results are shown separately for coastal waters and offshore waters, using data from all depths sampled. The assessment threshold of 24 is shown by the red line.

Table A11.5. Means and yearly confidence levels for winter DIN:DIP in Region 4 coastal. The assessment threshold, minimum value, maximum value, standard error and number of samples are shown. nan = no data.

Region	Location	Assessm Threshold	Year	Min Value	Max Value	Mean Value	Std Error	Number of Samples	Confidence Level (%) for concluding Non Problem
4	Coastal	24	2006	nan	nan	nan	nan	nan	nan
4	Coastal	24	2007	nan	nan	nan	nan	nan	nan
4	Coastal	24	2008	nan	nan	nan	nan	nan	nan
4	Coastal	24	2009	nan	nan	nan	nan	nan	nan
4	Coastal	24	2010	nan	nan	nan	nan	nan	nan
4	Coastal	24	2011	19.83	19.83	19.83	0	2	100
4	Coastal	24	2012	13.88	25.33	22.61	0.57	23	98.82
4	Coastal	24	2013	23.09	32	27.6	1.26	7	1.21
4	Coastal	24	2014	nan	nan	nan	nan	nan	nan
			All	13.88	32	23.53	0.64	32	76.82

Table A11.6. Means and yearly confidence levels for winter DIN:DIP in Region 4 offshore. The assessment threshold, minimum value, maximum value, standard error and number of samples are shown. nan = no data

Region	Location	Assessm Threshold	Year	Min Value	Max Value	Mean Value	Std Error	Number of Samples	Confidence Level (%) for concluding Non Problem
4	Offshore	24	2006	nan	nan	nan	nan	nan	nan
4	Offshore	24	2007	nan	nan	nan	nan	nan	nan
4	Offshore	24	2008	13.53	18.03	15.51	0.39	13	100
4	Offshore	24	2009	nan	nan	nan	nan	nan	nan
4	Offshore	24	2010	13.33	22.06	16.44	2.3	3	97.69
4	Offshore	24	2011	12.64	17.62	14.35	0.17	55	100
4	Offshore	24	2012	1.76	23.55	12.33	0.44	60	100
4	Offshore	24	2013	10.28	15.43	12.72	0.15	53	100
4	Offshore	24	2014	nan	nan	nan	nan	nan	nan
			All	1.76	23.55	13.34	0.18	185	100

### Chlorophyll:

For coastal waters, no data were available for assessments (Figure A11.5, Table A11.7).

In offshore waters, sufficient data were available in 2009, 2013 and 2014; the 90<sup>th</sup> percentiles were low ( $<1.5 \mu\text{g l}^{-1}$ ) and below the assessment threshold ( $10 \mu\text{g l}^{-1}$ ). In these years, confidence levels in the mean values were 85 to 98%, Table A11.8. Overall confidence was 100%.

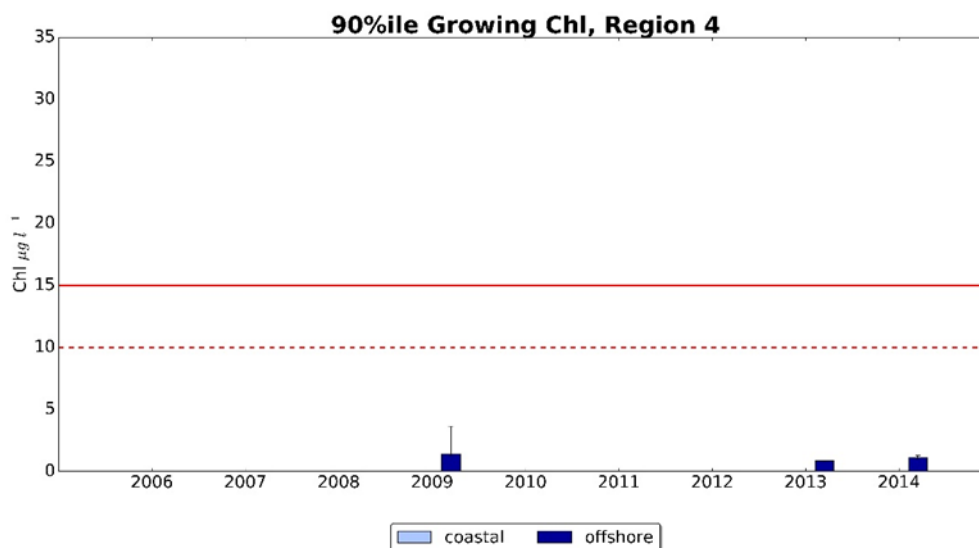


Figure A11.5: Growing season chlorophyll per year in the Western Channel and Celtic Sea during the assessment period, 2006 to 2014, shown as 90<sup>th</sup> percentiles. Results are shown separately for coastal waters (no data) and offshore waters, using data from all depths sampled. Assessment thresholds are shown for offshore waters ( $10 \mu\text{g l}^{-1}$ ) and coastal waters ( $15 \mu\text{g l}^{-1}$ ).

Table A11.7. Chlorophyll growing season 90<sup>th</sup> percentiles in Region 4 coastal, and confidence levels per year. The table shows the assessment threshold, the number of available data points (n), and the number of data points below the threshold. nan = no data. All = overall values and confidence levels (see Table 5 in main report).

Region	Location	Assessm Threshold ( $\mu\text{g l}^{-1}$ )	Year	90 <sup>th</sup> percentile	Mean	Std Dev	Number of Samples (n)	95% Conf Limit lower	95% Conf Limit upper	Number (n) below the assessment threshold	Confidence level (%)
4	Coastal	15	2006	nan	nan	nan	nan	nan	nan	nan	nan
4	Coastal	15	2007	nan	nan	nan	nan	nan	nan	nan	nan
4	Coastal	15	2008	nan	nan	nan	nan	nan	nan	nan	nan
4	Coastal	15	2009	nan	nan	nan	nan	nan	nan	nan	nan
4	Coastal	15	2010	nan	nan	nan	nan	nan	nan	nan	nan
4	Coastal	15	2011	nan	nan	nan	nan	nan	nan	nan	nan
4	Coastal	15	2012	nan	nan	nan	nan	nan	nan	nan	nan
4	Coastal	15	2013	nan	nan	nan	nan	nan	nan	nan	nan
4	Coastal	15	2014	nan	nan	nan	nan	nan	nan	nan	nan
			All	nan	nan	nan	nan	nan	nan	nan	nan

Table A11.8. Chlorophyll growing season 90<sup>th</sup> percentiles in Region 4 offshore, and confidence levels per year. The table shows the assessment threshold, the number of available data points (n), the number of data points below the threshold, and the % of samples below the threshold. nan = no data. All = overall values and confidence levels (see Table 6 in main report).

Region	Location	Assessm Threshold ( $\mu\text{g l}^{-1}$ )	Year	90 <sup>th</sup> percentile	Mean	Std Dev	Number of Samples (n)	95% Conf Limit lower	95% Conf Limit upper	Number (n) below the assessment threshold	Confidence level (%)
4	Offshore	10	2006	nan	nan	nan	nan	nan	nan	nan	nan
4	Offshore	10	2007	nan	nan	nan	nan	nan	nan	nan	nan
4	Offshore	10	2008	nan	nan	nan	nan	nan	nan	nan	nan
4	Offshore	10	2009	1.4	0.93	0.73	37	1.24	3.64	37	97.97
4	Offshore	10	2010	1.42	0.88	0.5	4	1.25	1.49	4	34.39
4	Offshore	10	2011	nan	nan	nan	nan	nan	nan	nan	nan
4	Offshore	10	2012	nan	nan	nan	nan	nan	nan	nan	nan
4	Offshore	10	2013	0.84	0.46	0.27	18	0.76	0.89	18	84.99
4	Offshore	10	2014	1.12	0.59	0.42	37	0.98	1.29	37	97.97
			All	1.26	0.72	0.59	98	1.15	1.9	98	100

## Phytoplankton Indicator Species

The WFD tool was not applied in this region.

## Oxygen

In coastal waters, no data on dissolved oxygen were available. In offshore waters, sufficient data were available in 2014 (Figure A11.6, Table A11.9). Results are shown only for dissolved oxygen concentrations (Figure A11.6) as no temperature or salinity data were available to calculate percentage saturation. The mean concentration in the lowest quartile of the data was just below the threshold ( $6 \text{ mg l}^{-1}$ ) in 2014. Confidence in the mean was low (*ca* 2%) in 2014 and low overall (43%, Table A11.9).

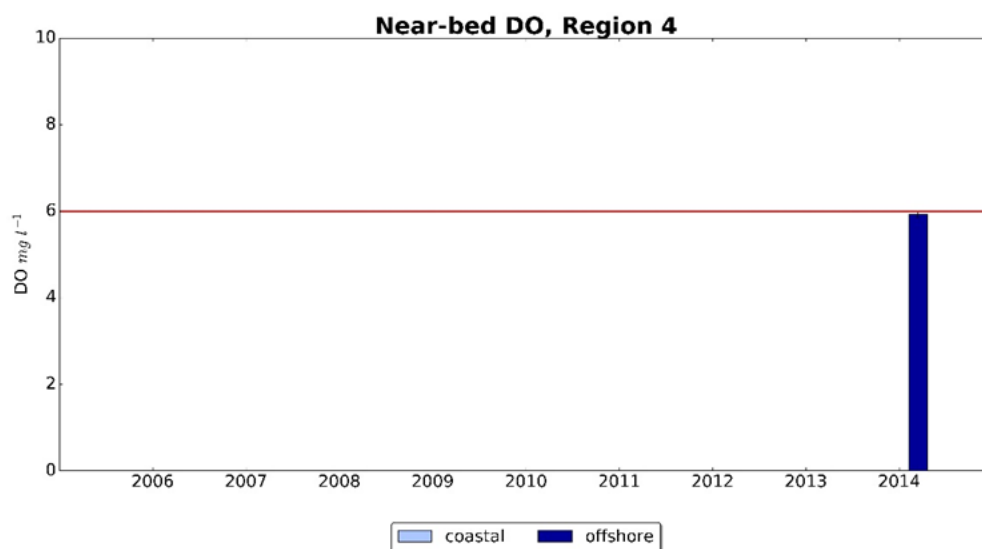


Figure A11.6: Near-bed dissolved oxygen(DO) concentrations ( $\text{mg l}^{-1}$ ) per year in the Western Channel and Celtic Sea during the assessment period, 2006 to 2014. Results are given as mean values in the lowest quartile of the data, for coastal data (none) and offshore data. A threshold of  $6 \text{ mg l}^{-1}$  is shown by the red line.

Table A11.9: Near-bed dissolved oxygen ( $\text{mg l}^{-1}$ ) in Region 4 offshore, and confidence levels per year. The table shows the threshold used, the mean and standard error in the lowest quartile of the data (Q25), the number of available data points in the lowest quartile and in the available dataset (total), and confidence levels in assessment outcomes. Minimum (Min) and maximum (Max) values in the total dataset are also shown. nan = no data. All = overall values and confidence levels (see Table 6 in main report).

Region	Location	Assessm Threshold ( $\text{mg l}^{-1}$ )	Year	Min Value	Max Value	Mean (Q25)	Std Error (Q25)	Number of Samples (Q25)	Number of Samples (total)	Confidence Level (%) for concluding Non Problem
4	Offshore	6	2006	nan	nan	nan	nan	nan	0	nan
4	Offshore	6	2007	nan	nan	nan	nan	nan	0	nan
4	Offshore	6	2008	nan	nan	nan	nan	nan	0	nan
4	Offshore	6	2009	6.75	6.75	6.75	nan	1	1	nan
4	Offshore	6	2010	nan	nan	nan	nan	nan	0	nan
4	Offshore	6	2011	nan	nan	nan	nan	nan	0	nan
4	Offshore	6	2012	nan	nan	nan	nan	nan	0	nan
4	Offshore	6	2013	7.02	7.5	7.02	nan	1	3	nan
4	Offshore	6	2014	5.91	7.56	5.93	0.02	3	11	1.88
			All	5.91	7.56	5.99	0.06	4	15	42.45

## Assessment outcomes Western Channel and Celtic Seas

2003 - In OSPAR integrated report, 1995-2001: Non Problem Area.

2008 - Period 2001-2005: Non Problem Area.

In 2001-2005, the assessment was carried out for the Bristol Channel only:

Score table:

Nutrient enrichment parameters:

- **Coastal Winter DIN:** + + + ? ? (insufficient data in 2004, no data in 2005)
- **Coastal DIN:DIP ratio score:** + + + - ? (no data in 2005)

Chlorophyll did not show elevated levels (2001-2005):

- **Coastal chlorophyll:** - - - - ? no data in 2005)

No elevated levels of other direct effect or indirect effect parameters the 5 year period (2001-2005):

- **DO:** 5 times –

2014 - Third application of the Common Procedure (2006-2014):

Initial and final classification for the Western Channel and Celtic Sea (2006-2014): Non Problem Area.

*Table A11.1: Assessment table (Western Channel and Celtic Sea, 2006-2014). Aggregated confidence ratings (Tables 5 and 6 in the main report) were calculated over the nine-year assessment period.*

Category	Assessment Parameters	Description of Results	Score (+ - ?) • Coastal • Offshore	Aggregated confidence rating
<b>Degree of Nutrient Enrichment (I)</b>	Riverine inputs and direct discharges of total N and total P	N - P -	N - P -	
	Winter DIN concentrations	Coastal: ? ? ? ? ? + + ?	Coastal: +	0
		Offshore: ? ? - ? ? - - - ?	Offshore: -	100
	Winter DIN:DIP ratio	Coastal: ? ? ? ? ? ? - + ?	Coastal: ?	76.82
		Offshore: ? ? - ? ? ? - - - ?	Offshore: ?	100
<b>Direct Effects (II)</b>	90 <sup>th</sup> percentile chlorophyll concentration	Coastal: ? ? ? ? ? ? ? ? ?	Coastal: ?	-
		Offshore: ? ? ? ? - ? ? ? ? - -	Offshore: -	100
	Area-specific phytoplankton indicator species	Not assessed		
	Macrophytes including macroalgae	Not assessed		
<b>Indirect Effects (III)</b>	Oxygen deficiency	Coastal: ? ? ? ? ? ? ? ? ?	Coastal: ?	-
		Offshore: ? ? ? ? ? ? ? ? ? +	Offshore: ?	42.45

	Changes/kills in zoobenthos and fish kills	Not assessed		
	Organic carbon/organic matter	Not assessed		
<b>Other Possible Effects (IV)</b>	Algal toxins (DSP/PSP mussel infection events)	Not assessed		

#### Key to the Score

- + = 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 are not fit for the purpose



Table A11.2: Results of the OSPAR Comprehensive Assessment 2016 for the Western Channel and Celtic Sea, 2006-2014. PA = Problem Area, NPA = Non Problem Area.

**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 90<sup>th</sup> percentile, maximum and mean chlorophyll *a* concentration  
 Ps Area-specific phytoplankton indicator species

Mp Macrophytes including macroalgae  
 O<sub>2</sub> 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 were available for assessments. These data were not required or used to confirm Non Problem Status

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	Overall appraisal of all relevant information (concerning the harmonised assessment parameters, their respective assessment levels and the supporting environmental factors)	Final classification	Assessment period
Western Channel and Celtic Sea – coastal water	NI	-	Ca	?	O <sub>2</sub>	?	At	NPA	<ul style="list-style-type: none"> <li>There is evidence that the area is nutrient enriched (low confidence) based on very limited nutrient data with moderate representivity.</li> <li>There are no data to assess the presence of any accelerated growth nor any undesirable disturbance.</li> <li>The area is adjacent to the Bristol Channel, known to be nutrient enriched but not experiencing accelerated growth or undesirable disturbance due to its high turbidity/very low light climate.</li> </ul> <p>It is confirmed that the status of the area is not known due to lack of data. Nutrient inputs to the area are decreasing and, based on previous NPA status, it is likely that the area is a Non Problem Area.</p>	Not known	2006-2014
	DI	+	Ps		Ck						
	NP	?	Mp		Oc						

Western Channel and Celtic Sea – offshore water	NI	-	Ca	-	O <sub>2</sub>	-	At	NPA	<ul style="list-style-type: none"> <li>There is evidence that the area is not nutrient enriched (high confidence) based on available nutrient data of moderate representivity. Nutrient concentrations are decreasing.</li> <li>There is evidence that there is no accelerated growth (high confidence) based on limited chlorophyll data of low - moderate representivity.</li> <li>The available evidence does not suggest any undesirable disturbance (low confidence) based on limited dissolved oxygen data.</li> </ul> <p>It is confirmed that this area remains a Non Problem Area (medium confidence) based on the available evidence. Nutrient inputs to the area are decreasing and winter nutrient concentrations are decreasing.</p>	NPA	2006-2014
	DI	-	Ps		Ck						
	NP	?	Mp		Oc						