APPENDIX 3E – AIR QUALITY

A3e.1 INTRODUCTION

Whilst air quality is not monitored routinely at offshore sites, regular air quality monitoring is carried out by local authorities in coastal areas adjacent to each Regional Sea. The air quality of all local authority areas is generally within national standards set by the UK government's air quality strategy (DEFRA 2007b), though several Air Quality Management Areas (AQMAs) have been declared to deal with problem areas. Industrialisation of the coast and inshore area adjacent to certain parts of the central North Sea has led to increased levels of pollutants in these areas which decrease further offshore, though oil and gas platforms provide numerous point sources of atmospheric pollution.

A3e.2 UK CONTEXT

The Government's revised *Air Quality Strategy for England, Scotland, Wales and Northern Ireland* has set national air quality standards with the objective of protecting human health. In the longer term, these standards along with other strategies connected with climate change could significantly improve air quality and achieve reductions in CO_2 by 2050 (DEFRA 2007b). Many of the standards set in the strategy are derived from EU obligations for the reduction or non-exceedance of a particular pollutant. The pollutant concentration levels have their origin in the 1996 Air Quality Framework Directive (1996/62/EC) and subsequent 'daughter' directives. The most recent version of this directive was released upon adoption in April 2008 (2008/50/EC) with the following key elements:

- For clarity, existing legislation should be merged into a single directive with no changes to air quality objectives
- New objective for $PM_{2.5}$ including a limit value and exposure related objectives – there is no minimum concentration identifiable for $PM_{2.5}$ where risks to human health are reduced
- The possibility to exclude natural sources of pollution in assessing compliance values where they can be reliably measured and where exceedances are due in whole or part to natural contributions
- Possible time extensions of three (PM_{10}) or five (NO_2, benzene) years (i.e. 2011, 2013) for compliance with the limit values, based on conditions and assessment by the EC

The current objectives set by the EU were transposed into UK law in the Air Quality Standards Regulations (2007), which came into force on the 15th January 2007. Limit values for pollutants can be found via the UK Air Quality Archive website, or the Air Quality Standards Regulations (2007) document located on the Office of Public Sector Information website. A 'Climate Change Bill' is currently in the process of being approved, which puts into statute the UK's CO_2 targets of a 60% reduction by 2050.

Part 5 of the Environment Act 1995 requires local authorities to review and assess the present air quality in their areas and its probable future trajectory. Since 1997 each local authority in the UK has been assessing their air quality and making projections on how it might change in years to come, with the aim of meeting the national air quality objectives by the relevant deadlines. An Air Quality Management Area (AQMA) must be declared where the local authority finds that it is unlikely to meet the objective of reducing pollution by the specified amount, and in accordance with the Air Quality Framework Directive, a

Local Air Quality Action Plan must be used to coordinate and improve air quality, guidance for which is provided by DEFRA (2003a, b) – this guidance is under review and renewed consultation at the time of writing (August 2008). There are a number of AQMAs in the UK and these are indicated in Table A3e.1. AQMAs are as large as is required to meet air quality objectives, and in many cases may consist of an area surrounding just a few streets or a major route way. There are no AQMAs north of Aberdeen in the east and Carlisle in the west, reflecting the relatively small level of industrialisation in the north and west of Scotland, and the Northern and Western Isles.

Table A3e.1 – Air Quality Management Areas in each Regional Sea

RS	Local Authority	No. of Management Areas	Pollutants Declared
1	Scarborough BC	1	PM_{10}, SO_2
	South Tyneside MBC	2	NO_2
	Newcastle CC	2	NO_2
	Gateshead MBC	2	NO_2
	Blyth Valley BC	1	PM_{10}
	Midlothian Council	1	*Not stated*
	Edinburgh	2	NO_2
	Falkirk Council	1	SO_2
	Perth & Kinross	1	*Not stated*
	Aberdeen City	1	NO_2, PM_{10}
2	North East Lincolnshire	1	PM_{10}
	Boston BC	2	NO_2
	King's Lynn & West Norfolk BC	1	NO_2
	Suffolk Coastal DC	1	NO_2
	Canterbury City Council	1	NO_2
	Thanet DC	1	NO_2
	Dover DC	3	SO_2, NO_2
3	Bournemouth BC	1	Not stated
	New Forest DC	3	NO_2, SO_2
	Southampton CC	8	NO_2
	Eastleigh BC	3	NO_2
	Winchester CC	1	NO_2, PM_{10}
	Chichester DC	3	NO_2
	Adur DC	2	NO_2
	Brighton & Hove	1	NO_2
	Lewes DC	1	NO_2
	Hastings BC	1	PM_{10}
	Dover DC	3	SO_2, NO_2
4	Swansea	1	NO_2
	Neath Port Talbot CB	1	PM_{10}
	Rhondda Cynon Taff CB	8	NO_2
	Cardiff CC	4	NO_2
	Newport CB	7	NO_2
	Bristol CC	1	PM_{10}
	Kerrier DC	1	NO_2
	South Hams DC	1	NO_2
	Teignbridge DC	4	NO_2
	Mid Devon DC	2	NO_2, PM_{10}
	West Dorset DC	1	*Not stated*
6	Ballymena	2	PM_{10}

RS	Local Authority	No. of Management Areas	Pollutants Declared
	Antrim	1	SO_2
	Newtownabbey	1	NO_2
	Belfast City	4	NO_2, PM_{10}
	Newry & Mourne	5	NO_2, PM_{10}
	Carlisle CC	1	NO_2
	South Lakeland DC	1	NO_2
	Lancaster CC	2	NO_2
	Blackpool BC	1	NO_2
	Liverpool CC	2	NO_2

Notes: RS = Regional Sea. Source: UK Air Quality Archive

In addition to AQMAs, smoke control areas are also declared for a number of regions in the UK. These areas relate to legislation described in the Clean Air Act (1993), where local authorities may prohibit the emission of smoke from chimneys and boilers within designated areas, and impose fines on those who pollute without authorisation. Some fuels (e.g. gas, electricity) are inherently smokeless and so exempt, and some appliances (e.g. wood burners) are exempt as these can burn smoky fuels with no smoke emissions. No smoke control areas are present north of Fife, indicative of a reduced level of urban development further north.

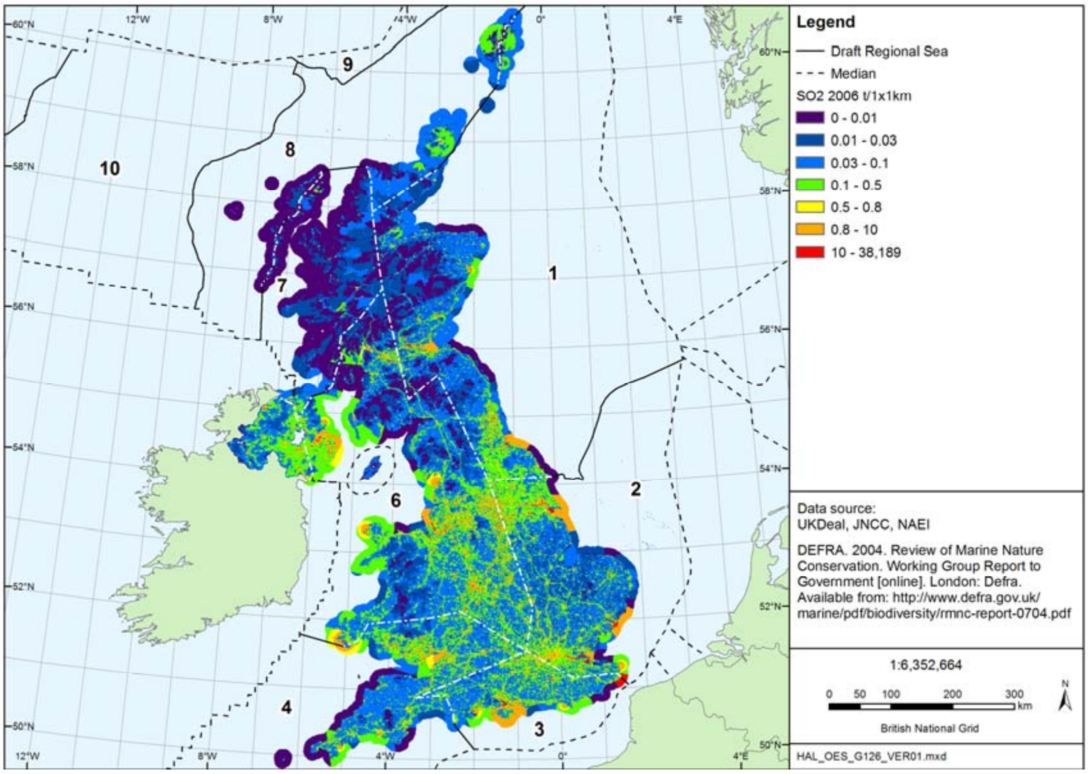
Regional Air Quality Data can be studied online at the UK Air Quality Archive website. A number of stations around the UK record atmospheric pollutants in precipitation and aerosol as part of the *Comprehensive Atmospheric Monitoring Programme* (CAMP) set up within the framework of the OSPAR convention. The data produced by these stations is used to assess the atmospheric input of selected contaminants to the maritime environment on an annual basis, determine long-term trends and validate atmospheric transport models used to assess inputs to the maritime area. Station coverage is small and data collection and reporting has been varied over the period of operation since 1987 (OSPAR 2005). In addition to the CAMP network, the *Automatic Urban and Rural Network* (AURN) monitors certain pollutants at hourly intervals for a range of locations across the UK. The location of these stations can be viewed at the AURN website, and data are made available via the UK Air Quality Archive online.

A3e.3 ATMOSPHERIC EMISSIONS OF POLLUTANTS

A3e.3.1 Gaseous and particulate matter emissions

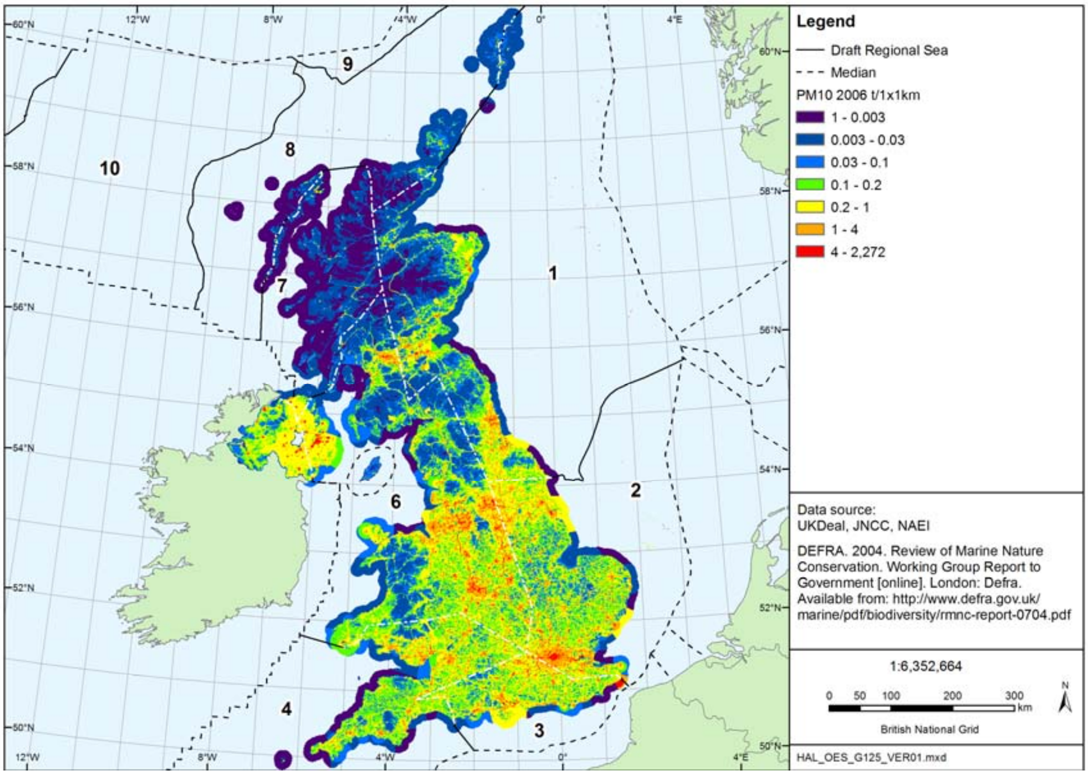
The National Atmospheric Emissions Inventory contains a database listing the emissions of a range of pollutants across the UK. Emission inventories are estimates of the amount and type of pollutants that are emitted to the air each year from all sources (e.g. industrial point sources, shipping, rail, road traffic). The details of a number of pollutants are described below and their emissions are graphically represented in Figures A3e.1-4. In the offshore area, Oil & Gas UK provides NAEI with data relating to offshore flaring, gas use and other operations.

Figure A3e.1 – Emissions of Sulphur Dioxide (SO_2) in 2006



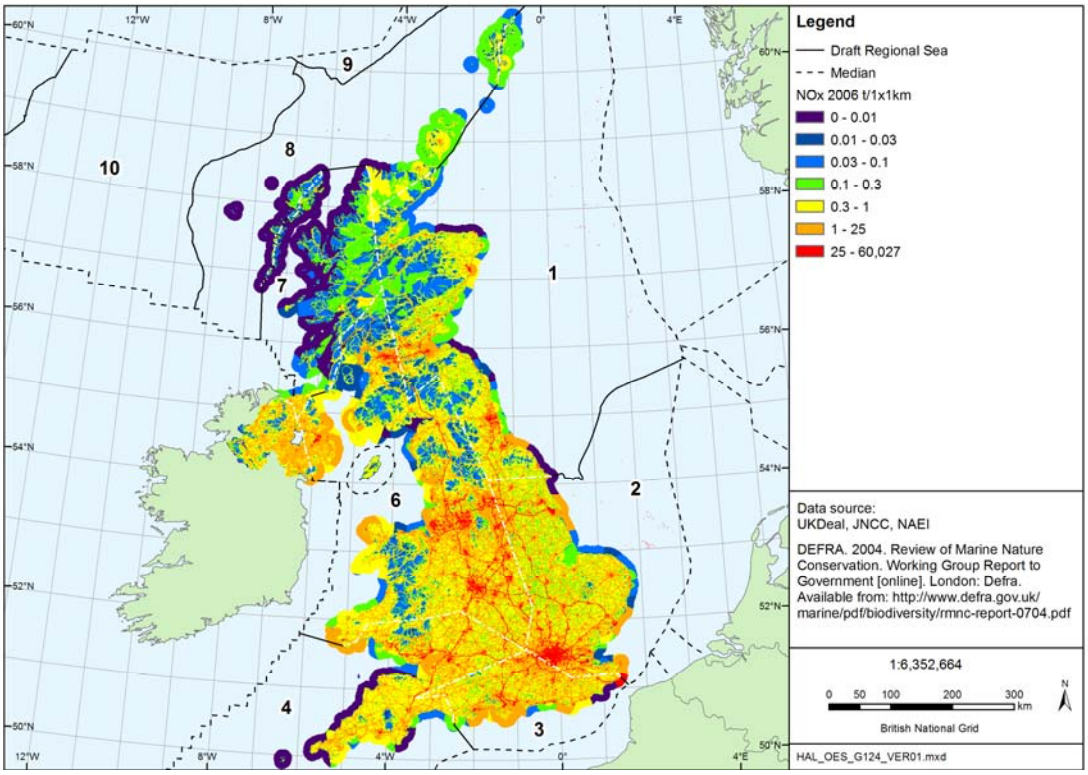
UK emissions are dominated by combustion of fuels containing sulphur, such as coal and heavy oils by power stations and refineries. In some parts of the UK, notably Northern Ireland, coal for domestic use is a significant source (DEFRA 2007b).

Figure A3e.2 – Emissions of Particulate Matter (PM_{10}) in 2006



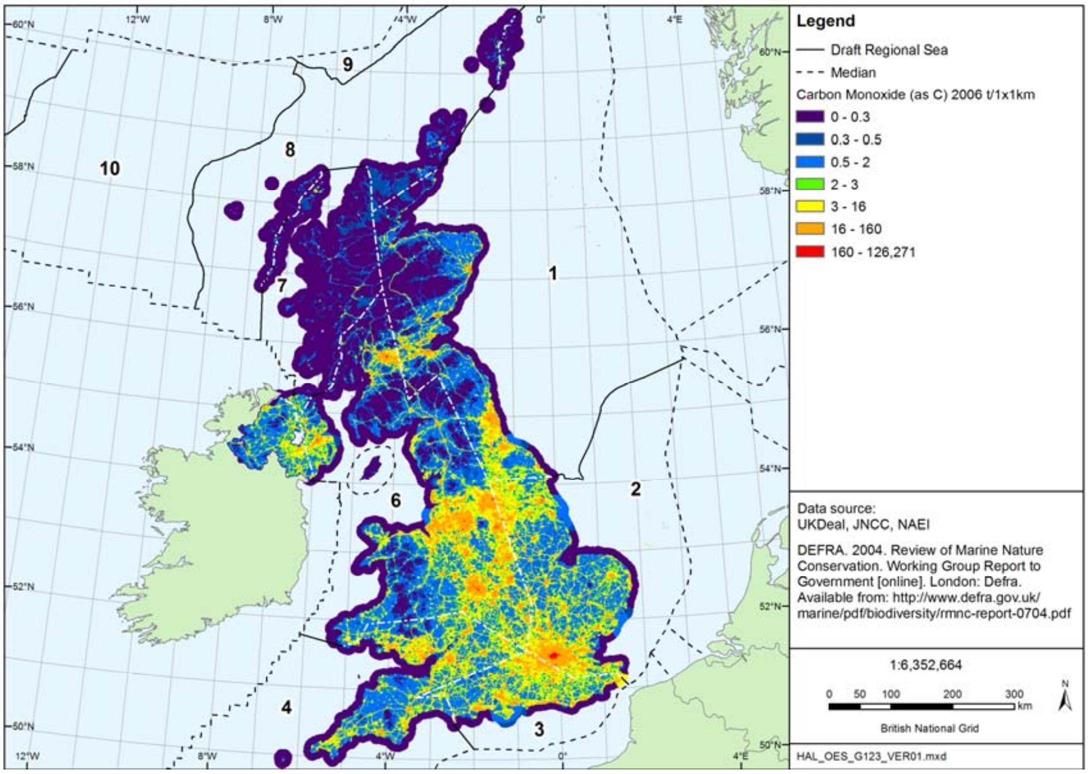
Particulate Matter is generally categorised on the basis of the size of the particles (for example $PM_{2.5}$ consists of particles with a diameter of less than 2.5μm). Concentrations of PM comprise primary particles emitted directly into the atmosphere from combustion sources and secondary particles formed by chemical reactions in the air. In the UK the biggest human-made sources are stationary fuel combustion and transport (DEFRA 2007b). Most monitoring is associated with PM_{10} concentrations, though smaller fractions ($PM_{2.5}$ and PM_1) are becoming of increasing interest in relation to any possible health side-effects. Recent research has indicated some problems in measuring particulate mass reliably, which may have led to the over-estimation of PM_{10} and $PM_{2.5}$ levels (Maggs *et al.* 2008).

Figure A3e.3 – Emissions of Nitrogen Oxides (NO_x) in 2006



All combustion processes in air produce oxides of nitrogen (NO_X). Nitrogen dioxide (NO_2) and nitric oxide (NO) are both oxides of nitrogen and together are referred to as NO_X. Road transport is the main source, followed by the electricity supply industry and other industrial and commercial sectors (DEFRA 2007b).

Figure A3e.4 – Emissions of Carbon Monoxide (CO) in 2006



Carbon Monoxide (CO) is formed from incomplete combustion of carbon containing fuels. The largest source is road transport, with residential and industrial combustion making significant contributions (DEFRA 2007b).

A3e.4 ATMOSPHERIC DEPOSITION OF POLLUTANTS

A3e.4.1 Metals

With the exception of mercury, the deposition of all metal components in the OSPAR area has fallen since 2000 (OSPAR 2007). The reduced use of lead in fuels has resulted in a substantial reduction in its emission and associated deposition across the UK. Wet and dry metal deposition is recorded at a number of stations as part of the CEH monitoring network for heavy metals. This work is reported by Fowler *et al.* (2006) who detailed estimated deposition levels using a series of UK scale 5x5km grid maps. These maps are the result of interpolation between station data using GIS techniques and geographically determined variations such as orographically enhanced deposition.

Metal deposition for coastal areas of Regional Sea 1 is generally low, with a tendency for higher concentrations to be found to the west and across upland areas, into Regional Seas 6 and 7. The higher rainfall in these areas leads to an increase in wet deposition rates, particularly where precipitation exceeds 1500mm, as the wet fraction constitutes 60-70% of total deposition (Fowler *et al.* 2006). For instance, modelled estimates indicate that the north-west Highlands have higher deposition figures for metals than the north-east and east despite being comparatively rural. There is a general reduction in atmospheric pollution offshore though the proximity of the southern North Sea to industrialised areas on land exposes certain areas to high levels of atmospheric deposition (OSPAR 2000a). Numerous OSPAR (2002a, 2005, 2006b, 2007) Commission reports provide deposition data for stations in the UK CAMP network (Table A3e.2).

Table A3e.2 – Reported mean annual deposition of heavy metals in precipitation (µg/m²/p.a.)

RS	Station	Year	As	Cd	Cr	Cu	Pb	Ni	Zn
1	East Ruston	2000	225	57	158	1295	1198	262	19,646
2	Heigham Holmes	2005	69	16	44	460	655	158	2,965
4	Yarner Wood	2004	117	103	94	634	832	302	6,478
		2005	551	46	-	-	799	445	5,302
	Penallt*	2004	116	18	68	362	930	122	3,928
		2005	184	41	34	510	733	147	3,957
6	Lough Navar	2004	396	20	185	702	483	97	3,991
7	Inverpolly	2004	138	37	52	625	157	413	3,076
		2005	41	3	48	145	108	36	1,777

*Notes: RS = Regional Sea. Source: OSPAR (2002a, 2005, 2006b, 2007), *Fowler et al. (2006)*

High levels of arsenic (As) in deposition within Regional Sea 4 reflect the legacy of an 18th century mining heritage (OSPAR 2007); high levels were also observed in Regional Sea 6. The CEH Heavy Metals Monitoring Network maintains the station at Penallt, Monmouthshire, which is located specifically to capture the output of the metal processing industry at Avonmouth and South Wales (Fowler *et al.* 2006).

The Greater North Sea

The combined observed pollutant concentrations derived from the CAMP monitoring network have been used by OSPAR to generate an estimate of total pollutant loadings to the North Sea. Estimates are generated using *Method 3a,* and are based on a mass of wet (precipitation) and dry (sedimentation) metal deposition reaching the entire North Sea area (525,000km²). The methodology is described in *Calculation of atmospheric inputs of contaminants to the North Sea 1987-92*, Oslo and Paris Commission (1994), Assessment and Monitoring series report 1994/25. It is estimated that the deposition of metals and nitrogen to the North Sea basin has decreased since 2000, but for many metals there is no significant trend, though copper (Cu) and lead (Pb) show significant reductions over the reported period (OSPAR 2005). Zinc (Zn) and Nickel (Ni) are more variable, and increases in deposition are observed for the years 1996-98 and 2000-02 (Table A3e.3, Figure A3e.5).

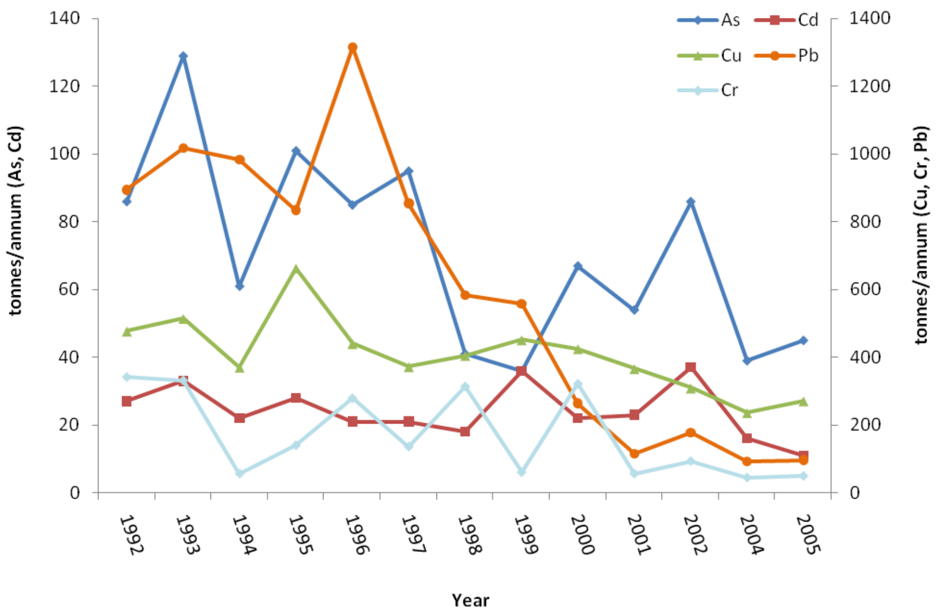
Table A3e.3 – Estimated total annual depositions of metals to the North Sea basin, 1992-2005 (tonnes/p.a.) based on *Method 3a*

Year	As	Cd	Cr	Cu	Ni	Pb	Zn
1992	86	27	342	477	249	893	3,088
1993	129	33	332	514	228	1,017	3,362
1994	61	22	56	370	136	983	3,037
1995	101	28	140	663	203	833	3,419
1996	85	21	279	440	183	1,314	4,901
1997	95	21	136	372	103	853	3,362
1998	41	18	314	405	169	583	4,047
1999	36	36	60	451	117	557	2,862
2000	67	22	322	425	635	263	3,721
2001	54	23	56	366	448	114	3,429
2002	86	37	93	309	530	176	3,760
2004	39	16	44	236	289	92	1,552
2005	45	11	49	271	333	96	1,575

Source: OSPAR (2005, 2007)

The values indicated in Table A3e.3 and Figure A3e.5 must be interpreted with care. OSPAR (2005) indicate that high concentrations of pollutants, such as high Zn figures for the BE0004 (Knokke, Belgium) station in 1996, can significantly influence the estimates made by *Method 3a*, which may result in figures which are not representative of the North Sea as a whole. OSPAR (2005) suggest that *Method 3a* is now dated and should be re-assessed.

Table A3e.5 - Estimated total annual depositions of selected metals to the North Sea basin, 1992-2005 (tonnes/p.a.)



Source: OSPAR (2007)

A separate methodology for the total annual deposition of metals to the North Sea from UK sources is described in Playford & Baker (2000). Here, estimated precipitation and the area of the North Sea (525,000km^2) are used to estimate deposition of pollutants. The results of this study, based on three UK stations (Banchory, High Muffles, East Ruston), are provided in Table A3.4 and Figure A3e.6.

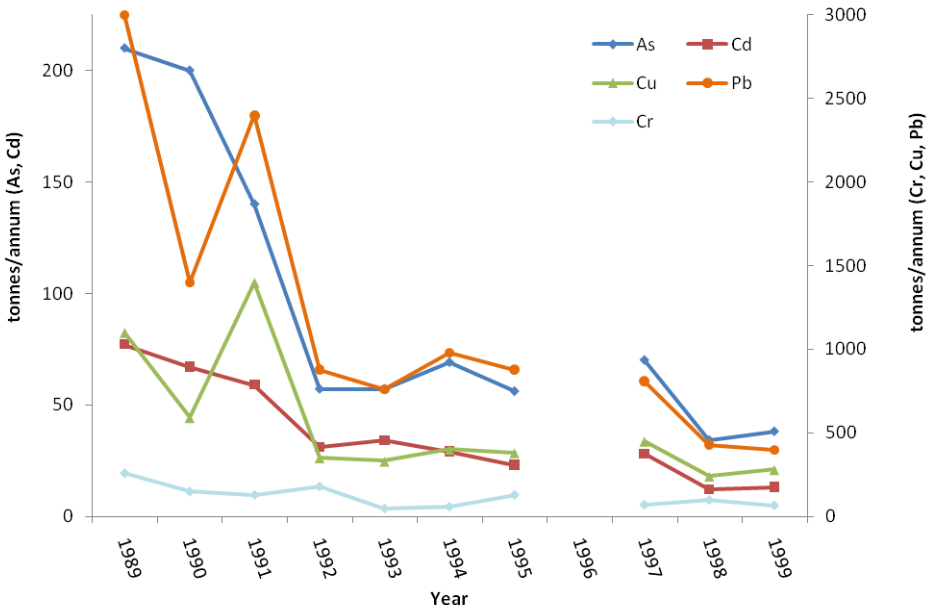
Table A3e.4 - Estimated total annual depositions of metals to the North Sea basin from the UK (tonnes/p.a.) based on the methodology in Cambray *et al.* (1975)

Year	As	Cd	Cr	Cu	Ni	Pb	Ti	Zn
1987	-	98	280	970	360	3,500	770	5,400
1988	-	100	320	930	340	3,500	970	5,300
1989	210	77	260	1,100	440	3,000	1,100	6,100
1990	200	67	150	590	340	1,400	500	4,900
1991	140	59	130	1,400	450	2,400	800	5,800
1992	57	31	180	350	250	880	630	2,800
1993	57	34	48	330	150	760	240	2,700
1994	69	29	59	400	220	980	390	5,700
1995	56	23	130	380	250	880	310	4,100
1996	-	-	-	-	-	-	-	-
1997	70	28	71	450	67	810	480	3,300

Year	As	Cd	Cr	Cu	Ni	Pb	Ti	Zn
1998	34	12	99	240	79	430	280	2,300
1999	38	13	67	280	72	400	180	1,400

Source: Playford & Baker (2000)

Figure A3e.6 - Estimated total annual depositions of metals to the North Sea basin from the UK (tonnes/p.a.) based on the methodology in Cambray *et al.* (1975) – no data for 1996

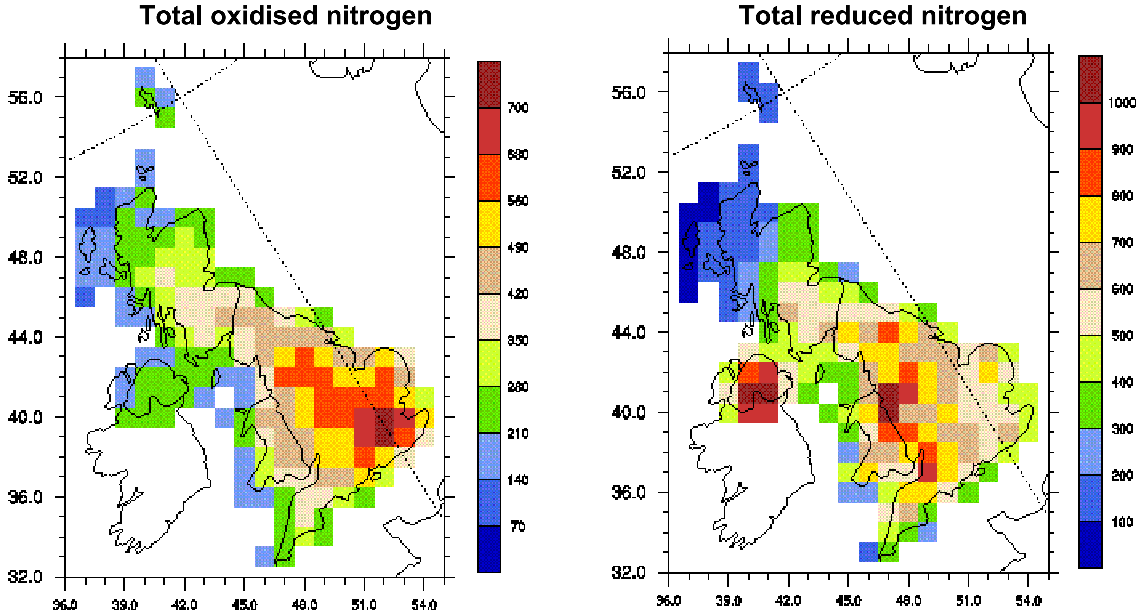


Source: Playford & Baker (2000)

A3e.4.2 Nitrogen

Nitrogen is an important component of air pollution due to its influence on ecosystem nutrient balance. Eutrophication is an undesirable side-effect of nutrient enrichment which can lead to changes in species composition and in extreme cases the creation of algal blooms and macroalgal mats (Ducrotoy *et al.* 2000), which at the coast can produce anaerobic conditions, decreased diversity of infaunal species, increased abundance of opportunistic species and discourage wading birds (Scott *et al.* 1999, cited in Ducrotoy *et al.* 2000). Atmospheric inputs of nitrogen to the North Sea are dominated by nitrate and ammonium (de Leeuw *et al.* 2003). Sources include industry and transport, and (ammonium) agriculture. Atmospheric conditions at the coast determined by factors such as surf and sea-spray have a significant influence on deposition of, in particular, ammonia (de Leeuw *et al.* 2003). Atmospheric inputs to the sea can be scavenged by sea-salt aerosol, and gaseous components (NH_3 and HNO_3) may be removed from the air within 10-20km from the coast (de Leeuw *et al.* 2003). Despite this, it is estimated that deposition of nitrogen from atmospheric sources to the seas within Europe accounts for 30-40% of all anthropogenic input (EEA 2007). The deposition of nitrogen to the North Sea has not changed appreciably in the last 20 years (OSPAR 2005). There tends to be a seasonal trend in ammonium and nitrate deposition, with a peak in March to April (OSPAR 2007).

Figure A3e.7 – Estimated atmospheric deposition of nitrogen on the UK mainland and coasts, 2006 (mg/m²/p.a.)



Source: EMEP website

Table A3e.5 below indicates levels of ammonium and nitrate deposition at monitoring stations relevant to the current SEA. The regional distribution of nitrogen deposition can be observed in Figure A3e.7, which displays a prominent south-east maximum and north-west minimum.

Table A3e.5 – Estimated mean annual deposition of nitrogen in precipitation (mg/m²/p.a.)

RS	Location	Year	Ammonium	Nitrate	Precipitation (mm)
1	High Muffles	2004	410	318	719.5
	Glen Dye	2004	312	480	816.4
4	Yarner Wood	2004	278	252	954.0
6	Lough Navar	2004	234	124	1,300.6

Notes: RS = Regional Sea. Source: OSPAR (2006b)

A3e.4.3 PCBs and PAHs

Poly Chlorinated Biphenyls (PCBs) have an extremely long residence time in the atmosphere and can therefore have significant transboundary effects (OSPAR 2000a). Like other pollutants, at sea atmospheric deposition is the dominant source of PCBs, whereas at the coast riverine inputs contribute the largest fraction. Wet deposition to the OSPAR area (II) for 1992-94 was 3-7t/year. Polycyclic Aromatic Hydrocarbons (PAHs) enter the coasts and seas also through atmospheric deposition, estimated for 1990 to be 7,000 tonnes for the North Sea – considered to be an underestimate due to data gaps – from terrestrial and offshore sources including shipping and oil and gas installations (OSPAR 2000a).

OSPAR (2000b) have monitored and modelled PCB deposition to the west coast of the UK (OSPAR area III), including the area encompassed by Regional Sea 6, and estimate that for 1994 a depositional flux of 2.2-4.2µg total PCBs/m²/p.a. was likely. Modelled estimates of deposition for the Irish Sea amount to 1.0-2.5µg total PCBs/m²/p.a. PCBs continue to be released to the atmosphere from legacy sources – inputs from the North American continent resulting from predominant eastern tracking weather systems may also have an input to the Regional Seas 4, 6, 7 and 8 (OSPAR 2000b).

Modelled estimates of PAH deposition to the Irish Sea have been made by Baart *et al.* (1995 – cited in OSPAR 2000b), which are comparable to measurements from peat cores made by Sanders *et al.* (1995 – cited in OSPAR 2000b) taken from rural locations in NW England. The measured figures from peat cores indicate that PAH contamination peaked in the 1930s, reducing to a modern depositional flux of *c.* 0.74mg/m^2/p.a.

A3e.5 EVOLUTION OF THE BASELINE/ENVIRONMENTAL ISSUES

Deleterious air quality has been an environmental and human health issue since the industrial revolution. More recently, there is a growing body of evidence to suggest that climate change may result from the emission of certain gases (CO_2, CH_4), while others (SO_2, NO_x, NO and NO_2) are known to be involved in acid deposition which in turn may lead to acidification, crop and building damage and human health issues (Bell & Walker 2005). Particulate matter is of concern in urban areas, this is generated by vehicles (accounting for 22% of PM emissions) and industrial processes. There may be significant health implications to humans from particulate emissions which are not yet well understood, though levels have been generally declining since the 1980s due to stricter regulation and the adoption of improved technology (Maggs *et al.* 2008). Metal emissions, and by association deposition, have been declining over the past 20 years and it can be expected that this will continue. Heavy metals can pose a range of contamination problems in the natural environment when they interact with soil, groundwater and runoff, and in turn may be incorporated into the food chain and may result in ecotoxicity.