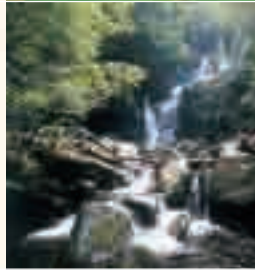
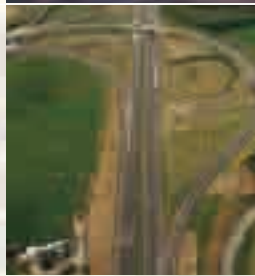


# Long-Term Measurements of Atmospheric Mercury at Mace Head, Carna, Co. Galway



# Environmental Protection Agency

The Environmental Protection Agency (EPA) is a statutory body responsible for protecting the environment in Ireland. We regulate and police activities that might otherwise cause pollution. We ensure there is solid information on environmental trends so that necessary actions are taken. Our priorities are protecting the Irish environment and ensuring that development is sustainable.

The EPA is an independent public body established in July 1993 under the Environmental Protection Agency Act, 1992. Its sponsor in Government is the Department of the Environment, Heritage and Local Government.

## OUR RESPONSIBILITIES

### LICENSING

We license the following to ensure that their emissions do not endanger human health or harm the environment:

- waste facilities (e.g., landfills, incinerators, waste transfer stations);
- large scale industrial activities (e.g., pharmaceutical manufacturing, cement manufacturing, power plants);
- intensive agriculture;
- the contained use and controlled release of Genetically Modified Organisms (GMOs);
- large petrol storage facilities.

### NATIONAL ENVIRONMENTAL ENFORCEMENT

- Conducting over 2,000 audits and inspections of EPA licensed facilities every year.
- Overseeing local authorities' environmental protection responsibilities in the areas of - air, noise, waste, waste-water and water quality.
- Working with local authorities and the Gardaí to stamp out illegal waste activity by co-ordinating a national enforcement network, targeting offenders, conducting investigations and overseeing remediation.
- Prosecuting those who flout environmental law and damage the environment as a result of their actions.

### MONITORING, ANALYSING AND REPORTING ON THE ENVIRONMENT

- Monitoring air quality and the quality of rivers, lakes, tidal waters and ground waters; measuring water levels and river flows.
- Independent reporting to inform decision making by national and local government.

### REGULATING IRELAND'S GREENHOUSE GAS EMISSIONS

- Quantifying Ireland's emissions of greenhouse gases in the context of our Kyoto commitments.
- Implementing the Emissions Trading Directive, involving over 100 companies who are major generators of carbon dioxide in Ireland.

### ENVIRONMENTAL RESEARCH AND DEVELOPMENT

- Co-ordinating research on environmental issues (including air and water quality, climate change, biodiversity, environmental technologies).

### STRATEGIC ENVIRONMENTAL ASSESSMENT

- Assessing the impact of plans and programmes on the Irish environment (such as waste management and development plans).

### ENVIRONMENTAL PLANNING, EDUCATION AND GUIDANCE

- Providing guidance to the public and to industry on various environmental topics (including licence applications, waste prevention and environmental regulations).
- Generating greater environmental awareness (through environmental television programmes and primary and secondary schools' resource packs).

### PROACTIVE WASTE MANAGEMENT

- Promoting waste prevention and minimisation projects through the co-ordination of the National Waste Prevention Programme, including input into the implementation of Producer Responsibility Initiatives.
- Enforcing Regulations such as Waste Electrical and Electronic Equipment (WEEE) and Restriction of Hazardous Substances (RoHS) and substances that deplete the ozone layer.
- Developing a National Hazardous Waste Management Plan to prevent and manage hazardous waste.

### MANAGEMENT AND STRUCTURE OF THE EPA

The organisation is managed by a full time Board, consisting of a Director General and four Directors.

The work of the EPA is carried out across four offices:

- Office of Climate, Licensing and Resource Use
- Office of Environmental Enforcement
- Office of Environmental Assessment
- Office of Communications and Corporate Services

The EPA is assisted by an Advisory Committee of twelve members who meet several times a year to discuss issues of concern and offer advice to the Board.

# **Long-Term Measurements of Atmospheric Mercury at Mace Head, Carna, Co. Galway**

## **Environmental Research Centre Report**

### **Authors:**

**Stephan Leinert, Phillip O'Brien, Peter Mooney, Ralf Ebinghaus,  
Hans Kock and Gerard Spain**

### **ENVIRONMENTAL PROTECTION AGENCY**

An Ghníomhaireacht um Chaomhnú Comhshaoil  
PO Box 3000, Johnstown Castle, Co. Wexford, Ireland

Telephone: +353 53 916 0600 Fax: +353 53 916 0699

E-mail: [info@epa.ie](mailto:info@epa.ie) Website: [www.epa.ie](http://www.epa.ie)

© Environmental Protection Agency 2008

## **ACKNOWLEDGEMENT**

This report is published as part of the Science, Technology, Research and Innovation for the Environment (STRIVE) Programme 2007–2013. The programme is financed by the Irish Government under the National Development Plan 2007–2013. It is administered on behalf of the Department of the Environment, Heritage and Local Government by the Environmental Protection Agency which has the statutory function of co-ordinating and promoting environmental research.

## **DISCLAIMER**

Although every effort has been made to ensure the accuracy of the material contained in this publication, complete accuracy cannot be guaranteed. Neither the Environmental Protection Agency nor the author(s) accept any responsibility whatsoever for loss or damage occasioned or claimed to have been occasioned, in part or in full, as a consequence of any person acting, or refraining from acting, as a result of a matter contained in this publication. All or part of this publication may be reproduced without further permission, provided the source is acknowledged.

Reports produced through the Environmental Research Centre are intended as contributions to inform policy makers and other stakeholders to the necessary debate on environmental protection.

## **ENVIRONMENTAL RESEARCH CENTRE PROGRAMME 2007–2013**

Published by the Environmental Protection Agency, Ireland

ISBN: 1-84095-264-4

Price: Free

**Online version**

## Details of Project Partners

### **Stephan Leinert**

Environmental Protection Agency  
McCumiskey House  
Richview  
Clonskeagh Road  
Dublin 14  
Ireland

Tel.: +353 1 2680184  
Fax: +353 1 2680199  
E-mail: [s.leinert@epa.ie](mailto:s.leinert@epa.ie)

### **Peter Mooney**

Environmental Protection Agency  
McCumiskey House  
Richview  
Clonskeagh Road  
Dublin 14  
Ireland

Tel.: +353 1 2680181  
Fax.: +353 1 2680199  
E-mail: [p.mooney@epa.ie](mailto:p.mooney@epa.ie)

### **Hans Kock**

Institute for Coastal Research  
GKSS-Forschungszentrum Geesthacht GmbH  
Max-Planck-Straße 1  
21502 Geesthacht  
Germany

Tel.: +49 4152 87 2368  
Fax: +49 4152 87 2366  
E-mail: [hans.kock@gkss.de](mailto:hans.kock@gkss.de)

### **Phillip O'Brien**

Environmental Protection Agency  
McCumiskey House  
Richview  
Clonskeagh Road  
Dublin 14  
Ireland

Tel.: +353 1 2680177  
Fax: +353 1 2680199  
E-mail: [p.obrien@epa.ie](mailto:p.obrien@epa.ie)

### **Ralf Ebinghaus**

Department for Environmental Chemistry  
Institute for Coastal Research  
GKSS-Forschungszentrum Geesthacht GmbH  
Max-Planck-Straße 1  
21502 Geesthacht  
Germany

Tel.: +49 4152 87 2354  
Fax.: +49 4152 87 2332  
E-mail: [ralf.ebinghaus@gkss.de](mailto:ralf.ebinghaus@gkss.de)

### **Gerard Spain**

Mace Head Research Station  
Carna  
Co. Galway  
Ireland

Tel.: +353 95 32754



# Table of Contents

<b>Acknowledgement</b>	<b>ii</b>
<b>Disclaimer</b>	<b>ii</b>
<b>Details of Project Partners</b>	<b>iii</b>
<b>Executive Summary</b>	<b>vii</b>
<b>1 Introduction</b>	<b>1</b>
1.1 Mercury Measurements at Mace Head	1
1.2 Why Mercury?	1
1.3 Why Long-Term Measurements?	1
1.4 Mace Head	1
<b>2 Background: Mercury Air Pollution</b>	<b>2</b>
<b>3 Site and Measurement</b>	<b>4</b>
3.1 Location	4
3.2 Instrumentation	4
3.3 Quality Assurance	6
3.4 Data Quality Control	7
<b>4 Results and Discussion</b>	<b>8</b>
4.1 Data Analysis	8
4.2 Influence of Wind Direction	11
<b>5 Conclusions</b>	<b>13</b>
<b>References</b>	<b>14</b>
<b>Appendix A</b>	<b>16</b>
<b>Appendix B</b>	<b>21</b>
<b>Appendix C</b>	<b>46</b>



# Executive Summary

Total gaseous mercury (TGM) has been measured at Mace Head since 1995.

The Mace Head mercury (Hg) data for background marine conditions are invaluable for monitoring changes in Northern Hemispheric background concentrations. It is also possible to assess national and transboundary contributions from Europe to Hg concentrations at the site, based on detailed backward trajectory analysis of air masses arriving from non-marine sectors.

The long-term average Hg concentration at Mace Head is  $1.7 \text{ ng/m}^3$ . There is evidence of a reduction in the annual mean concentration since 2000; however, a longer-term data set is required to confirm the trend.

A seasonal pattern is also evident, with minimum concentrations observed in summer. The amplitude of the seasonal variability is of the order of  $0.3 \text{ ng/m}^3$ . However, both the timing and magnitude of the seasonal signal are variable. The seasonal pattern may be linked to an enhanced photochemical sink due to reaction of the OH radical.

The Mace Head seasonal signal contrasts sharply with observations made at other high-latitude stations. These stations experience significant low concentration episodes, or mercury depletion events (MDEs), during spring. It is thought that these events are due to the regional influence of sea ice, which is

absent at Mace Head. Therefore, the seasonal pattern at Mace Head is less pronounced than has been observed at other locations.

The highest concentrations of atmospheric Hg are observed at Mace Head during short-lived pollution episodes. These episodes are directly linked to pollutant transport to Mace Head due to emissions in Ireland, the UK and mainland Europe, and the influence of emission sources in these regions.

There is some evidence of a gradual reduction in Hg concentrations during pollution episodes. The frequency of pollution episodes with peak daily average Hg concentrations greater than  $0.3 \text{ ng/m}^3$  above seasonal average has reduced between 1996 and 2001. Modest reductions have continued since 2001.

This suggests that European emission source strength has reduced. However, the total hemispheric source, natural and anthropogenic combined, appears to be relatively constant.

National monitoring of ambient atmospheric Hg is required under the EU 4th Daughter Directive (2004/107/EC). The Mace Head installation meets this requirement. The data capture rate is good for those years where contractual structures were in place to fund the monitoring programme.



# 1 Introduction

## 1.1 Mercury Measurements at Mace Head

Total gaseous mercury (TGM) has been measured at Mace Head since 1995. Mace Head was one of the first research stations (together with a Canadian site in the high Arctic (Alert, Nunavut, NWT)) generating highly time-resolved concentration measurements of TGM on a routine basis (Schroeder *et al.*, 2001). The record is one of the longest running, continuous mercury (Hg) records at good quality and high time resolution (15 min) in the world.

The Mace Head data for clean marine conditions are invaluable for the monitoring of Northern Hemispheric background levels. The Mace Head data will also be used to meet the reporting requirements under the EU 4th Daughter Directive (2004/107/EC).

## 1.2 Why Mercury?

Mercury is a global environmental pollutant. The lifetime for gaseous Hg in the atmosphere is about 1 year. This allows for transboundary, even hemispheric, transport of Hg. Mace Head data show that background levels in the Northern Hemisphere are about 1.7 ng/m<sup>3</sup>. The transformation of Hg to more toxic methylmercury compounds and their

accumulation in the aquatic food chain have motivated intensive research on Hg.

## 1.3 Why Long-Term Measurements?

Long-term measurements are necessary to monitor the background levels of total gaseous Hg. A long record helps in judging if a possible change in Hg levels is part of the normal fluctuation, or has to be considered unusual. Long-term monitoring also is necessary to assess the effectiveness of policy measures introduced.

## 1.4 Mace Head

Mace Head is located on the fringes of Western Europe, in Carna, Co. Galway, about 90 km west of Galway City, exposed to the North Atlantic Ocean, with a wide clean sector between 180° and 300°. Its location is ideal for studies of the atmosphere under Northern Hemispheric background conditions, and also for European conditions during easterly winds. An additional important aspect to the Mace Head facility is the suite of ancillary measurements of chemical tracers, meteorological and other parameters. This allows more complete analysis and interpretation of the Hg data, including the selective filtering of data biased by local influences.

## 2 Background: Mercury Air Pollution

Mercury is a global environmental pollutant of continuing concern. Anthropogenic emissions are contributing to a general increase in environmental exposure to Hg on local, regional and global scales.

Mercury is emitted into the atmosphere from a number of natural (Ferrara *et al.*, 2000) as well as anthropogenic sources (Pacyna *et al.*, 2001; Pirrone *et al.*, 2001) (see Table 2.1). There is a growing body of evidence suggesting that present Hg emissions from anthropogenic sources are at least as great as those from natural sources (Fitzgerald *et al.*, 1998; Martinez-Cortizas *et al.*, 1999).

Long-range atmospheric transport of gaseous Hg, its transformation to more toxic methylmercury compounds, and its bioaccumulation in the aquatic food chain have motivated intensive research on Hg as a pollutant of global concern. The importance of Hg is reflected in the fact that this element is on the priority list of a large number of international agreements and conventions aimed at the protection of the environment, including human health and wildlife (e.g. Protection of the Baltic Sea: HELCOM; Protection of the North Sea and the North Atlantic: OSPAR; Protection of the Arctic Ecosystem: AMAP). Pirrone (2001) has outlined the present status in the preparation of the new European Union policy aimed to regulate Hg emissions into the atmosphere.

In view of these international agreements, the following three questions of sources and trends of Hg are of particular importance:

1. Have the sources of Hg, its long-range transport and deposition substantially increased in comparison with pre-industrial times?
2. How do atmospheric Hg concentrations reflect the control measures adopted to control and reduce anthropogenic Hg emissions?
3. What further actions are required to address Hg emissions and impacts on national, European and global scales.

Almost all information on historical trends in atmospheric Hg concentrations and subsequent deposition has been derived from analysis of dated soils, sediments and peat cores (Lockhart *et al.*, 1995; Coggins, 2000). These data suggest that the present Hg deposition is two to five times higher than pre-industrial ones. Although Hg emission inventories have large uncertainties, model estimates based on these inventories show an increase in Hg deposition by about a factor of 3 compared with pre-industrial times, which is in fairly good agreement with experimental data derived from sediment, soil and peat analyses (Slemr, 1996).

Long-term monitoring of atmospheric Hg concentrations may provide direct evidence of temporal trends. Mercury has an atmospheric residence time of about 1 year (Slemr *et al.*, 1985; Lindqvist and Rodhe, 1985). Decisive measures in the mitigation of Hg emissions should quickly manifest in the background concentrations observed at Mace Head. There should also be a marked influence on the magnitude of pollution episodes observed within air masses of European origin. Both effects have been

**Table 2.1. Northern Hemisphere mercury emission sources.**

Continent	Stationary combustion	Non-ferrous metal production	Pig iron and steel production	Cement production	Waste disposal	Total
Europe	185.5	15.4	10.2	26.2	12.4	249.7
North America	104.8	25.1	4.6	12.9	66.1	213.5
Asia	860.4	87.4	12.1	81.8	32.6	1074.3

Source: Pacyna and Pacyna, 2000.

observed at Mace Head previously for the continuous measurements of the chlorofluorocarbons (CFCs), controlled under the Montréal Protocol.

Slemr (1996) has reviewed the few existing publications on long-term monitoring of Hg starting with early data published by Stock and Cucuel (1934) and concludes that the reconstruction of trends by combining data of these reports is hardly possible for several reasons:

1. The quality of reported TGM concentration measurements is mostly unknown.

2. Mercury monitoring has only rarely been accompanied by supporting measurements of chemical tracers that will allow the elimination of locally influenced data.

3. Most of the reported measurements of TGM in air are very limited in time and space.

Based on these uncertainties and the systematic gaps in previous knowledge on Hg, Fitzgerald (1995) proclaimed the need for a global atmospheric Hg-monitoring network.

## 3 Site and Measurement

### 3.1 Location

Mace Head is located in Co. Galway near Carna on the west coast of Ireland at  $53^{\circ} 20' \text{ N}$ ,  $9^{\circ} 54' \text{ W}$  (Fig. 3.1). It is exposed to the North Atlantic Ocean having a wide clean sector between  $180^{\circ}$  and  $300^{\circ}$ . It is ideally situated to study atmospheric composition under Northern Hemispheric background conditions and also under European continental conditions, generally when the air masses are originating from an easterly direction (Jennings *et al.*, 1993; Oltmans and Levy, 1994; Ebinghaus *et al.*, 1995). The meteorological records show that on average over 50% of the air masses arriving at Mace Head are within the clean sector (T.G. Spain, University College Galway, personal communication, 1995) (Fig. 3.2). The climate

at Mace Head may be classified as maritime. There is no industrial activity that would influence measurements at the station. The nearest major conurbation is Galway City, located 80 km east of Mace Head (Fig. 3.3).

Mace Head is a Global Atmosphere Watch site, and hosts a number of national and international monitoring programmes. An outline of additional activities at the Mace Head Atmospheric Research Station can be found at the official website <http://macehead.nuigalway.ie>.

### 3.2 Instrumentation

Continuous measurements of TGM concentrations with 15 min time resolution have been carried out at the



Figure 3.1. Location of Mace Head.

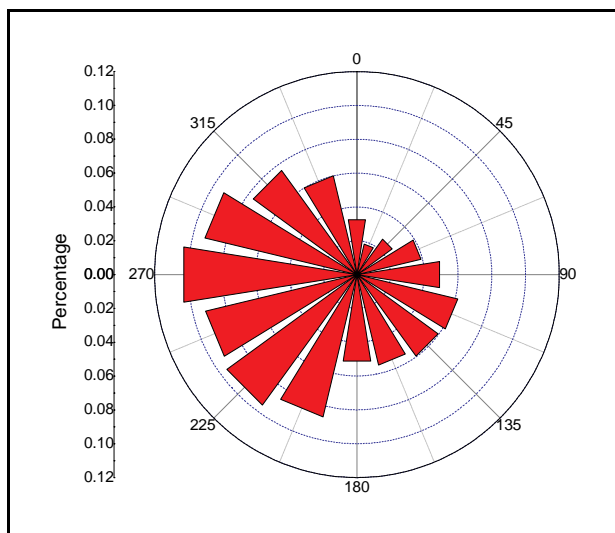


Figure 3.2. Wind rose for Mace Head (2003–2006).

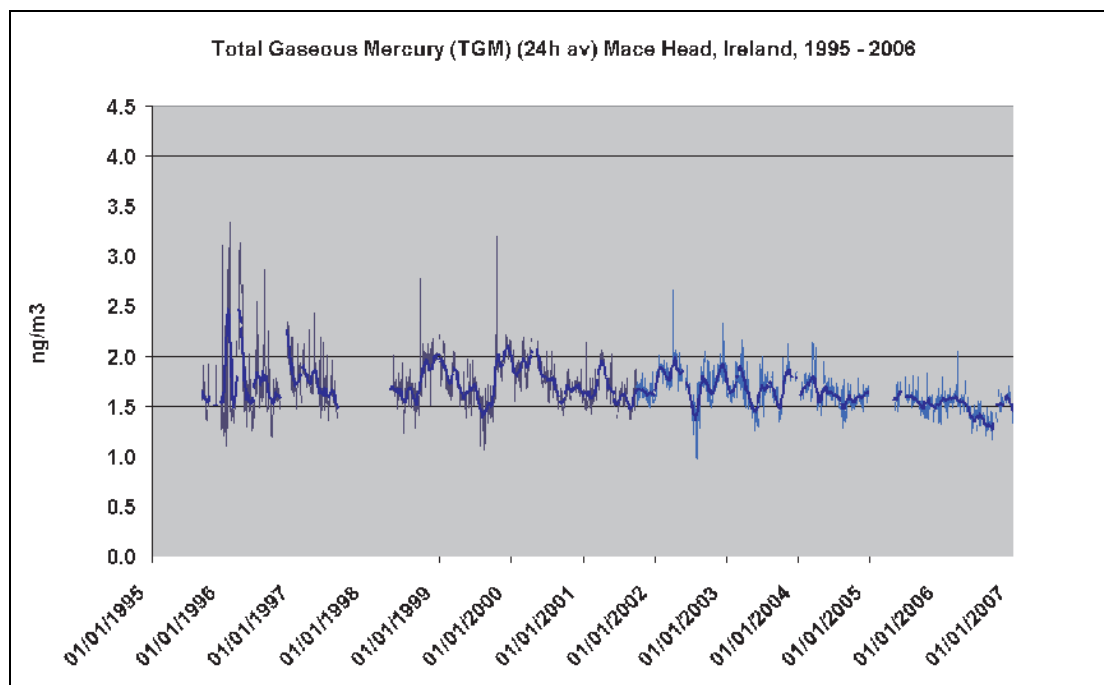


Figure 3.3. Location of Mace Head relative to Galway City.

atmospheric research station at Mace Head from September 1995 to the present day (Fig. 3.4). Monitoring work commenced on a contractual basis for the Irish Environmental Protection Agency in October 2001.

Two main techniques that have been used for highly time-resolved Hg measurements in ambient air are the

automated atomic fluorescence (AFS) analyser (Schroeder *et al.*, 1995a) and the automated atomic absorption (AAS) analyser (Urba *et al.*, 1995). Because of the extremely low concentrations at which Hg species normally exist in the atmosphere, both techniques involve a pre-concentration step (amalgamation with gold).



**Figure 3.4. Long-term record of TGM concentration measured at the Mace Head site.**

In the remote atmosphere, the TGM fraction consists of gaseous elemental mercury (GEM), and reactive gaseous mercury (RGM). GEM is the dominant compound by far, and the operationally defined RGM is present in much lower concentrations. Besides GEM and RGM, other volatile organic mercury species, such as dimethylmercury and monomethylmercury chloride, can also interact with gold absorbers. However, their contribution to the TGM fraction can be neglected under background conditions.

An automated dual channel, single amalgamation, cold vapour atomic fluorescence analyser is in operation at Mace Head (Tekran-Analyzer Model 2537A, Tekran Inc., Toronto, Canada). It is capable of measuring TGM concentrations with a minimum temporal resolution of 5 min. The instrument features two gold cartridges. While one is adsorbing mercury during a sampling period the other is being thermally desorbed and is subsequently analysed for TGM. The functions of each cartridge are then reversed, allowing continuous sampling of the incoming air stream. A 45-mm diameter Teflon pre-filter (pore size 0.2  $\mu\text{m}$ ) protects the sampling cartridges against contamination by particulate matter. The amalgamated mercury is thermally desorbed into an argon carrier gas stream

and analysed using cold vapour atomic fluorescence spectroscopy (CVAFS). A detection limit of the order of 0.3  $\text{ng Hg/m}^3$  can be achieved under these conditions. The Tekran-Analyzer is equipped with an internal permeation source so that the instrument can be automatically calibrated. The instrument is connected to a PC that records the serial output data.

### 3.3 Quality Assurance

The accuracy and precision of the applied instrumentation has been assessed through comparisons with commonly used manual methods at an urban/industrial site in Windsor, Ontario, Canada (Schroeder *et al.*, 1995b), at a remote site in Tuscany, Italy (Munthe *et al.*, 2001), as well as at Mace Head (Ebinghaus *et al.*, 1999) showing good agreement between the different techniques. The inter-comparison exercise conducted at Mace Head in September 1995 marks the starting point of the long-term measurements reported at this site. Monitoring work at Mace Head started immediately after completion of the exercise.

The Tekran-Analyzer automatically re-calibrates every 25 h using the internal permeation source. Two point calibrations (zero and span) are performed separately

for each cartridge. The internal permeation tube provides approximately 1 pg/s at 50°C. Manual injections were used to initially calibrate the permeation device against a saturated mercury vapour standard. The adjustment of the permeation rate for drift correction was of the order of 1% per year over the entire measurement period.

Additionally, the instrument is calibrated approximately every 3 months (with a portable mercury source, Tekran, Model 2505) by manual injections of 8 µl of Hg-saturated air with a gas-tight syringe at defined temperatures. Fundamental work on this calibration technique has been carried out by Braman and Johnson (1974), Dumarey *et al.* (1985), Fitzgerald and Gill (1979) and others.

For quality assurance, the critical values obtained from a *t*-table at  $p = 95\%$  and the particular degrees of freedom are compared with the calculated mean from the measured TGM concentrations. If they are larger, no significant differences between the theoretical and the measured values are present. The accuracy of the measurements was verified over the entire measurement period following this procedure.

### **3.4 Data Quality Control**

During routine operation, the data capture rate is high over the duration of the measurements from 1995 to 2006. However, a number of significant data gaps

have occurred due to equipment and logistical failures. Approximately two-thirds of the months show a data capture of 90% or better (i.e. less than 3 days missing per month). From commencement of monitoring to the end of 2006, the instruments were non-operational for a total of 12 months.

In summer 2005, the GKSS Tekran instrument was replaced by a Tekran instrument funded by the EPA. This instrument is generally reliable.

Missing data for the new instrument have been due to:

- (a) a shortage of purified argon, with the supplier unable to supply in time (9–29 June 2005)
- (b) ageing/deactivation of gold traps – they had to be replaced by new ones, spare traps had to be obtained (20 September to 14 October 2006)
- (c) calibration and maintenance of the instrument, as well as change of data acquisition system (some days during 17–27 October 2006)
- (d) an unstable faulty power supply for the UV lamp and detector (12–20 November 2006).

The annual and monthly data capture rates are summarised in [Appendix B](#). To ensure high data capture, it is recommended to avoid a shortage of argon by keeping a sufficient supply in stock.

## 4 Results and Discussion

### 4.1 Data Analysis

The annual average concentration level at Mace Head derived from the entire measurement data between 1995 and 2006 is  $1.69 \text{ ng/m}^3$ , with a standard deviation of  $0.24 \text{ ng/m}^3$  (Fig. 4.1).

At Mace Head, the daily averaged concentration values show a short-term variability on the scale of a day to a few days. This short-term variability may be explained by pollution events influenced by local or regional sources as indicated by back trajectory analysis, and supported by *in situ* wind direction, black carbon mass concentration, and condensation nuclei measurements recorded at the site (Cooke *et al.*, 1997; Coggins, 2000). This effect was also observed by Slemr and Scheel (1998) in Bavaria and by Schroeder and Schneeberger (1996) in the high Canadian Arctic.

The TGM concentrations measured at Mace Head reflect Northern Hemispheric background values. Measurements of TGM at Harwell (Lee *et al.*, 1998), a rural site in southern central England, using similar instrumentation between June 1995 and April 1996 measured an average concentration of  $1.68 \text{ ng/m}^3$ .

Measurements in the Canadian Arctic (Schroeder and Schneeberger, 1996), during 1992 and 1993, showed a mean concentration of  $1.63 \text{ ng/m}^3$ . Burke *et al.* (1995) measured TGM concentrations at a number of rural sites in the Great Lakes region of North America and found a mean TGM concentration of between  $1.59$  and  $1.93 \text{ ng/m}^3$ .

There is some evidence of a decreased variability in the Hg signal, especially with regard to the maximum Hg concentrations observed during pollution episodes. Between 1996 and 1997, multiple pollution episodes were recorded with Hg concentrations greater than  $2.50 \text{ ng/m}^3$ . Since 2000, there has been no episode of this magnitude (Fig. 4.2). Figure 4.3 shows the change in variability in terms of standard deviation in daily mean values over the years. Although biased by the high 1996 value, which appears to have been anomalous, the variability seems to have dropped from  $0.20$  to  $0.12 \text{ ng/m}^3$  since start of monitoring. This may be due to the introduction of effective emission controls in Europe (IPPC Directive 96/61/EC, Directive 2001/80/EC) and North America (the Clean Air Act).

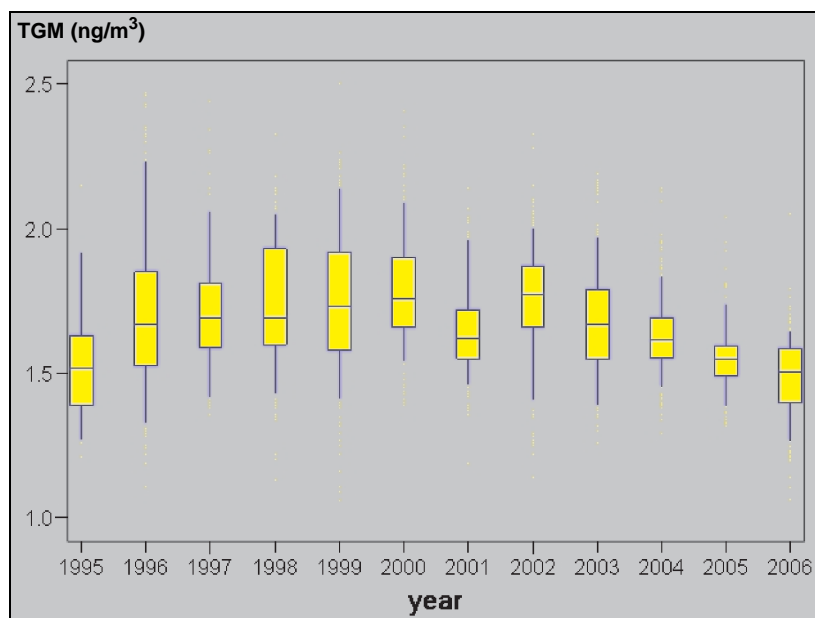


Figure 4.1. Annual box plot for total gaseous mercury (TGM) measurements at Mace Head.

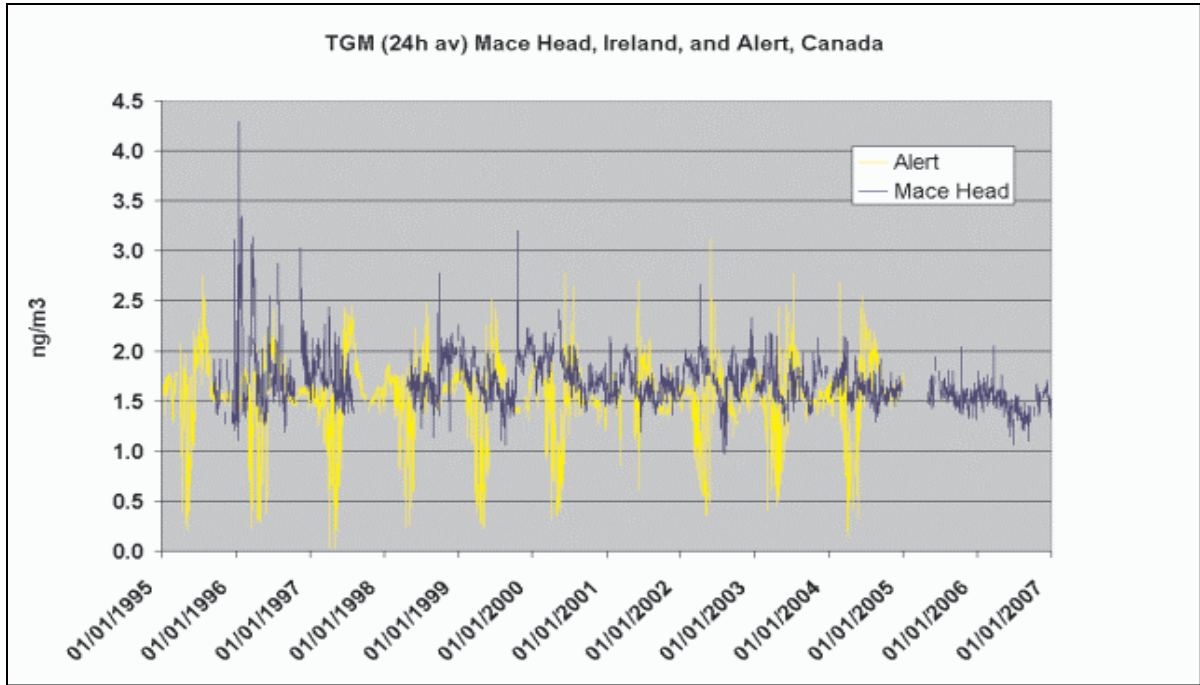


Figure 4.2. A comparison of total gaseous mercury (TGM) for Alert and Mace Head. Alert data show regular mercury depletion events.

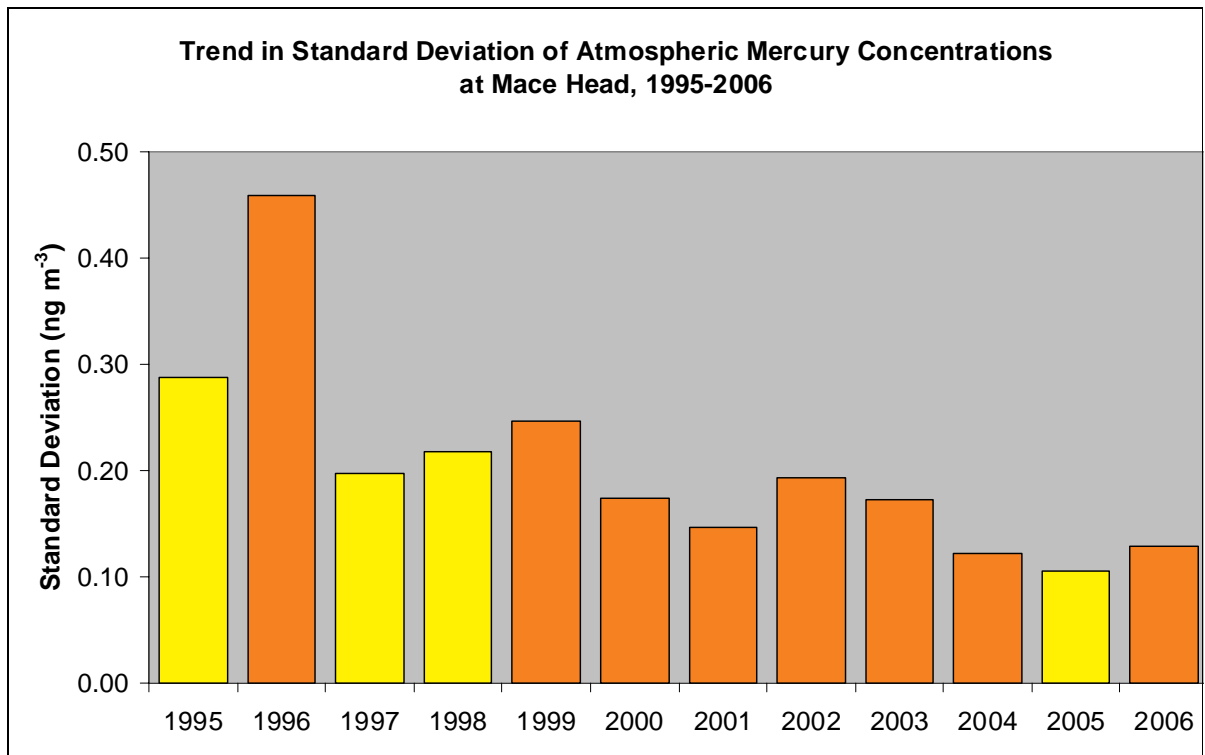


Figure 4.3. Reduction in variability of mercury concentration with time. The yellow bars indicate years when data capture rates were below 80%.

The hemispheric background Hg concentration seems to be decreasing at the rate of 0.05 ng/m<sup>3</sup>/year; however, the signal is difficult to define due to complex seasonal patterns.

Comparison with four short-term monitoring data sets of two Swedish sites that measured TGM in 1998/99 with similar instrumentation (Wängberg *et al.*, 2001) reveals an unexpected west to east gradient seen between Mace Head and the Swedish sites. The average Mace Head data are about 0.2–0.3 ng/m<sup>3</sup> higher than those of the two Scandinavian background stations. Transport from North America across the Atlantic may well occur, but such large-scale processes should not only affect the Mace Head station, but also the Swedish sites close to Stockholm and Gothenburg. Confirmation of this result needs to be made using a comparison between observations made upon ‘shared air masses’, i.e. those air masses which passed in close proximity to Mace Head at some stage prior to arrival at the Swedish sites. No local anthropogenic emission source exists near Mace Head. Higher concentrations at Mace Head may partly be explained by emissions of Hg from the ocean surface or by removal processes of TGM while the air masses are travelling from west to east.

A south to north concentration gradient of atmospheric Hg between highly industrialised Eastern Germany and Central Sweden has been reported by Schmolke

*et al.* (1999) and could be attributed to regional anthropogenic emissions especially from the area around Halle/Leipzig/Bitterfeld in Eastern Germany. The reason for the observed west to east decreasing gradient from Mace Head to remote sites in Scandinavia is not yet clear, but may be attributed to Hg emissions to the atmosphere in the marine boundary layer (Gardfeldt *et al.*, 2001; Hedgecock and Pirrone, 2001). However, it should be noted that in general the concentration levels measured at Mace Head are on average lower than those found at continental European sites that are influenced by anthropogenic Hg emissions.

Lowest TGM concentrations have been observed in summer (April to September), with approximately 1.6 ng/m<sup>3</sup>, whereas the average concentrations during wintertime (October to March) are around 1.9 ng/m<sup>3</sup> (Fig. 4.4). The difference between the seasonal average for the winter/spring periods and summer/autumn periods is approximately 0.3 ng/m<sup>3</sup>. This difference corresponds to approximately 20% when referred to the overall TGM average concentration of 1.7 ng/m<sup>3</sup>.

Summer minimum TGM concentrations have also been observed by Slemr (1996) at the Wank Summit and by Brosset (1982) in Sweden. Total gaseous mercury measurements at the Wank Mountain in Southern Germany increased from a minimum during

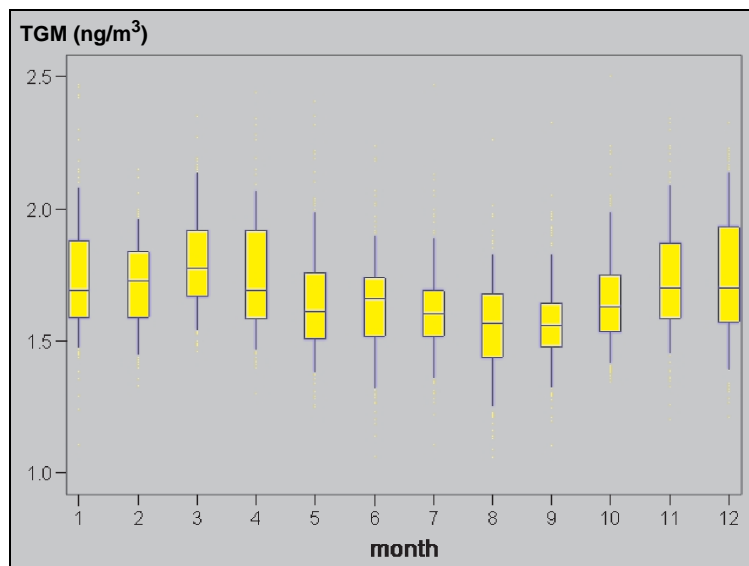


Figure 4.4. Monthly box plot for total gaseous mercury (TGM) for all years.

December and January to a maximum concentration in February, March and April. From April onwards, concentrations decreased towards a minimum. The peak to peak amplitude of seasonal variation observed at the Wank Summit was  $0.75 \text{ ng/m}^3$  which corresponded to 30% of the average TGM concentration observed at the site. A spring maximum is also consistent with TGM measurements made by Brosset (1982) between October 1979 and September 1980, in Sweden. However a second maximum in September and October was also observed in this data set. Brosset (1987) observed another seasonal variation in measurements in Sweden between July 1983 and June 1984 in which TGM concentrations were at a maximum between October and December.

These two types of seasonal variation are explained by Slemr (1996). The seasonal variation, with summer minima observed at the Wank Mountain and in Sweden (Brosset, 1982), is characteristic of the majority of trace gases of which almost all are removed from the atmosphere by oxidation processes (Warneck, 1988). The major oxidation species in the troposphere is the OH radical which has a pronounced seasonal cycle at middle and higher latitudes (Logan, 1985; Warneck, 1988). Higher OH concentrations in summer lead to faster removal by oxidation and to a summer minimum in pollutant concentrations. Polluted air masses move in regions with low photochemical activity (Beine, 1997).

The seasonal trend observed in the Mace Head data may also be influenced by the seasonal cycle in the consumption of fossil fuels. Fossil fuel combustion for domestic heating is greatest during the winter and spring period (Cooke *et al.*, 1997).

Another interesting aspect is the comparison of the Mace Head data with those obtained at Alert ( $82.5^\circ \text{ N}$ ;  $62.3^\circ \text{ W}$ ) in the Canadian Arctic. Both data sets start in 1995 (January and September, respectively) and are ongoing (Schroeder *et al.*, 2001). The long-term average at both sites is around  $1.7 \text{ ng/m}^3$  over the years. Neither site shows a trend in concentrations over time. However, at Alert the phenomenon of the so-called MDEs can be observed each year after polar sunrise (Schroeder *et al.*, 1998). By a complex

sequence of photolytically mediated chemical and physical processes (which are not yet completely understood) atmospheric Hg concentrations drop below the background value on a number of occasions for extended periods, from several hours up to days.

Recently, MDEs have also been detected at Barrow, Alaska ( $71^\circ 19' \text{ N}$ ;  $156^\circ 37' \text{ W}$ ), Kuujjuarapik at the Eastern part of Hudson Bay ( $55^\circ 30' \text{ N}$ ;  $77^\circ 73' \text{ W}$ ) and Neumayer Station, a coastal site in the Antarctic ( $70^\circ 39' \text{ S}$ ,  $8^\circ 15' \text{ W}$ ) (Poissant *et al.*, 2001; Ebinghaus *et al.*, 2002; Lindberg *et al.*, 2002).

Although Mace Head is only  $2^\circ$  latitude south of the Canadian station Kuujjuarapik, MDEs have not been observed in the data set between 1995 and 2006. The total absence of sea ice at this coastal location may be a possible explanation. The MDEs may have a stronger influence at the Swedish sites, which may also serve to explain the west to east gradient in Hg concentrations reported above.

## 4.2 Influence of Wind Direction

Mace Head receives clean marine air masses some of the time. However, wind direction alone is not a sufficient indicator for the origin of an air mass.

As an example, data for March 2006 are shown in Fig. 4.5.

The time series for March 2006 shows two episodes of relatively high Hg concentrations at Mace Head, on the 15th of March, and around the 24th of March. There are low concentrations measured preceding the second episode.

When plotted as a function of wind direction (Fig. 4.6), there is no clear relationship between wind direction and Hg levels. For easterly winds, there are high Hg levels, as well as low levels observed. For the 'clean sector' (between  $180^\circ$  and  $300^\circ$ ), there are low levels observed, as well as some high values. The best one can say is that easterly wind directions have a greater variability, with a higher probability of elevated Hg concentrations.

The episode from the 23rd to the 25th March is discussed in more detail in Appendix A.

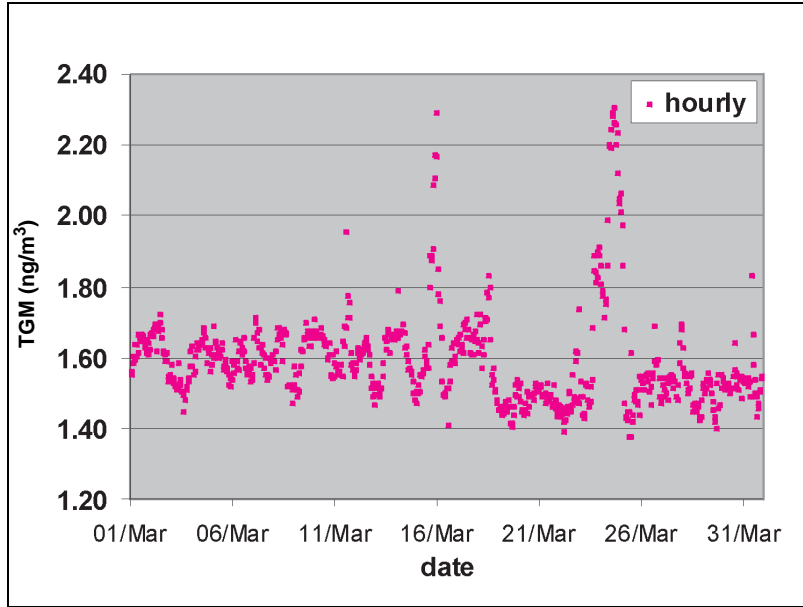


Figure 4.5. Time series for total gaseous mercury (TGM) concentrations at Mace Head during March 2006.

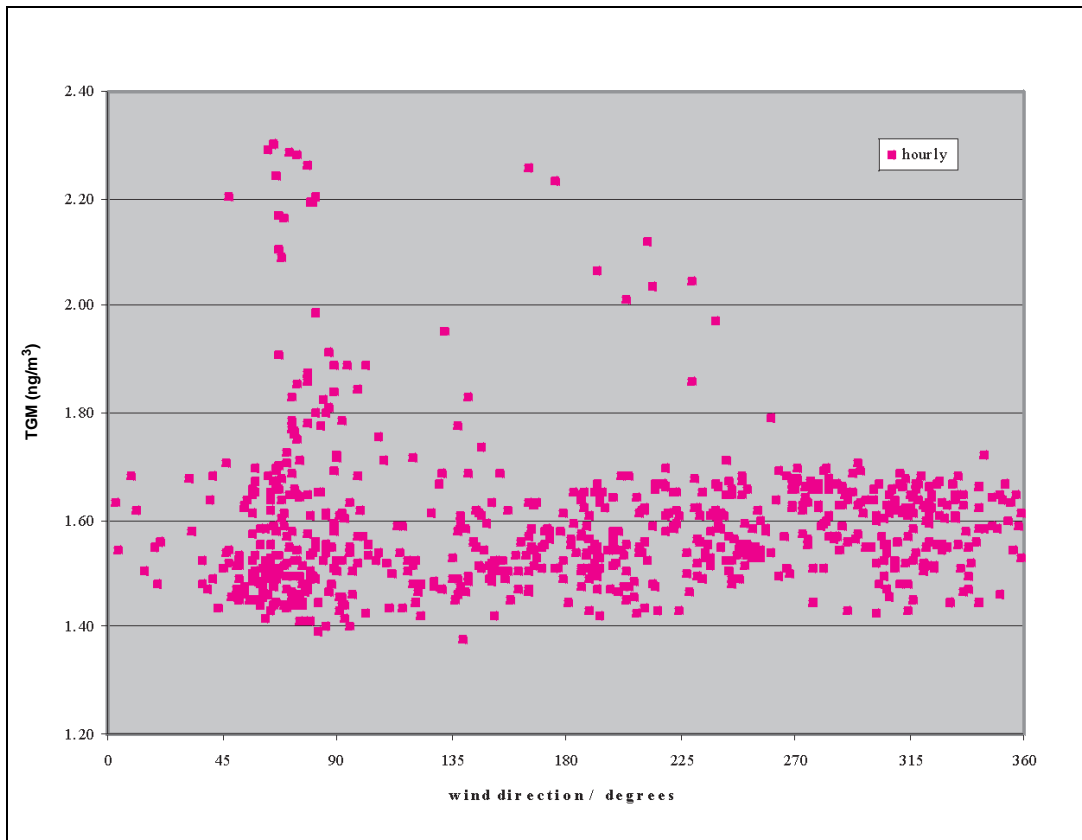


Figure 4.6. The influence of wind direction on total gaseous mercury (TGM) concentrations.

## **5 Conclusions**

The programme of measurement of TGM at Mace Head is shown to be important in terms of monitoring both hemispheric background concentrations and the efflux of emissions from Europe.

The majority of the data set is of high quality; however, the integrity of the time series has been threatened by a number of avoidable breaks during which measurements were halted. Of particular concern are those stoppages that are due to failure to maintain

stores of consumables and spare parts on site. It is recommended that effective systems management procedures be put in place to avoid reoccurrence of these logistical failures.

The analysis confirms Mace Head as a suitable site to meet the requirements for national monitoring of ambient atmospheric Hg required under the EU 4th Daughter Directive (2004/107/EC). Details in [Appendix C](#).

## References

- Beine, H.J., 1997. Measurements of CO in the high Arctic. American Geophysical Union, Fall meeting 1997.
- Braman, R.S. and Johnson, D.L., 1974. Selective absorption tubes and emission technique for the determination of ambient forms of mercury in air. *Environmental Science and Technology* **8**: 996–1003.
- Brosset, C., 1982. Total airborne mercury and its possible origin. *Water, Air, and Soil Pollution* **17**: 37–50.
- Brosset, C., 1987. The behavior of mercury in the physical environment. *Water, Air, and Soil Pollution* **34**: 145–166.
- Burke, J., Hoyer, M., Keeler, G. and Scherbatskoy, T., 1995. Wet deposition of mercury and ambient mercury concentration at a site in the Lake Champlain basin. *Water, Air, and Soil Pollution* **80**: 353–362.
- Coggins, A.M., 2000. *Long-Term Measurements of Total Gaseous Mercury (TGM) at Mace Head and Atmospheric Deposition of Heavy Metals in Ombrogenous Peats in the West of Ireland*. PhD Thesis, National University of Ireland, Galway, Ireland.
- Cooke, W.F., Jennings, S.G. and Spain, T.G., 1997. Black carbon measurements at Mace Head, 1989–1996. *Journal of Geophysical Research* **102**: 25,339–25,346.
- Dumarey, R., Temmermann, E., Dams, R. and Hoste, J., 1985. The accuracy of the vapor-injection calibration method for the determination of mercury by amalgamation/cold vapour atomic absorption spectrometry. *Analytica Chimica Acta* **170**: 337–340.
- Ebinghaus, R., Kock, H.H., Jennings, S.G., McCartin, P. and Orren, M.J., 1995. Measurements of atmospheric mercury concentrations in Northwestern and Central Europe – comparison of experimental data and model results. *Atmospheric Environment* **29(22)**: 3333–3344.
- Ebinghaus, R., Jennings, S.G., Schroeder, W.H., Berg, T., Donaghy, T., Guentzel, J., Kenny, C., Kock, H.H., Kvietkus, K., Landing, W., Munthe, J., Prestbo, E.M., Schneeberger, D., Slemr, F., Sommar, J., Urba, A., Wallschläger, D. and Xiao, Z., 1999. International field intercomparison measurements of atmospheric mercury species at Mace Head, Ireland. *Atmospheric Environment* **33**: 3063–3073.
- Ebinghaus, R., Kock, H.H., Temme, Ch., Einax, J.W., Löwe, A.G., Richter, A., Burrows, J.P. and Schroeder, W.H., 2002. Antarctic springtime depletion of atmospheric mercury. *Environmental Science and Technology* **36(6)**: 1238–1244.
- Ferrara, R., Mazzolai, B., Lanzillotta, E. and Pirrone, N., 2000. Volcanoes as emission sources of atmospheric mercury in the Mediterranean basin. *Science of the Total Environment* **259**: 115–121.
- Fitzgerald, W.F., 1995. Is mercury increasing in the atmosphere? The need for an atmospheric mercury network (AMNET). *Water, Air, and Soil Pollution* **80**: 245–254.
- Fitzgerald, W.F. and Gill, G.A., 1979. Subnanogram determination of mercury by two-stage gold amalgamation and gas-phase detection applied to atmospheric analysis. *Analytical Chemistry* **51**: 1714–1720.
- Fitzgerald, W.F., Engstrom, D.R., Mason, R.P. and Nater, E.A., 1998. The case for atmospheric mercury contamination in remote areas. *Environmental Science and Technology* **32**: 1–7.
- Gardfeldt, K., Xinbin F., Sommar, J. and Lindqvist, O., 2001. Total gaseous mercury exchange between air and water at river and sea surfaces in Swedish coastal regions. *Atmospheric Environment* **35**: 3027–3038.
- Hedgecock, I.M. and Pirrone, N., 2001. Mercury and photochemistry in the marine boundary layer-modelling studies suggest the in situ production of reactive gas phase mercury. *Atmospheric Environment* **35**: 3055–3062.
- Jennings, S.G., McGovern, F. and Cooke, W.F., 1993. Carbon mass concentration measurements at Mace Head, on the west coast of Ireland. *Atmospheric Environment* **27A**: 1229–1239.
- Lee, D.S., Dollard, G.J. and Pepler, S., 1998. Gas phase mercury in the atmosphere of the United Kingdom. *Atmospheric Environment* **32**: 855–864.
- Lindberg, S.E., Brooks, S., Lin, C.J., Scott, K.J., Landis, M.S. and Stevens, R.K., 2002. Dynamic Oxidation of Gaseous Mercury in the Arctic Troposphere. *Environmental Science and Technology* **36(6)**: 1245–1256.
- Lindqvist, O. and Rodhe, H., 1985. Atmospheric mercury – a review. *Tellus* **37B**: 136–159.
- Lockhart, W.L., Wilkinson, P., Billeck, B.N., Hunt, R.V., Wagemann, R. and Brunskill, G.J., 1995. *Water, Air, and Soil Pollution* **80**: 603–610.
- Logan, J.A., 1985. Tropospheric ozone: seasonal behaviour, trends, and anthropogenic influence. *Journal of Geophysical Research* **86**: 7210–7254.
- Martinez-Cortizas, A., Pontevedra-Pombal, X., Garcia-Rodeja, E., Novoa-Munoz, J.C. and Shotyk, W., 1999. Mercury in Spanish peat bog: Archive of climate change and atmospheric metal deposition. *Science* **284**: 939–929.
- Munthe, J., Wängberg, I., Pirrone, N., Iverfeldt, A., Ferrara, R., Costa, P., Ebinghaus, R., Feng, X., Gardfeldt, K., Keeler, G., Lanzillotta, E., Lindberg, S.E., Lu, J., Mamane, Y., Nucaro, E., Prestbo, E., Schmolke, S.R., Schroeder, W.H., Sommer, J., Sprovieri, F., Stevens, R.K., Stratton, W., Tuncel, G. and Urba, A., 2001. Intercomparison of methods for sampling and analysis of atmospheric mercury species. *Atmospheric Environment* **35(17)**: 3007–3017.
- Oltmans, S.J. and Levy II, H., 1994. Surface ozone measurements from a global network. *Atmospheric Environment* **28**: 9–24.
- Pacyna, J.M. and Pacyna, E.G., 2000. *Assessment of Emissions/Discharges of Mercury Reaching the Arctic Environment*. The Norwegian Institute for Air Research, NILU Report OR 7/2000, Kjeller, Norway.
- Pacyna, E.G., Pacyna, J.M. and Pirrone, N., 2001. European emissions of atmospheric mercury from anthropogenic

- sources in 1995. *Atmospheric Environment* **35**: 2987–2996
- Pirrone, N., 2001. Mercury research in Europe: towards the preparation of the EU air quality directive. *Atmospheric Environment* **35**: 2979–2986.
- Pirrone, N., Costa, P., Pacyna, J.M. and Ferrara, R., 2001. Mercury emissions to the atmosphere from natural and anthropogenic sources in the Mediterranean region. *Atmospheric Environment* **35**: 2997–3006.
- Poissant L. *et al.*, 2001. *Atmospheric Mercury Transport, Oxidation and Fallout in Northern Québec (Nunavik): An Important Potential Route of Contamination*. Northern Contaminants Program, Synopsis of Research 2000–2001, Indian and Northern Affairs Canada. ISBN 0-662-30872-7, 125–129.
- Schmolke, S.R., Schroeder, W.H., Kock, H.H., Schneeberger, D., Munthe, J. and Ebinghaus, R., 1999. Simultaneous measurements of total gaseous mercury at four sites on a 800 km transect: spatial distribution and short-time variability of total gaseous mercury over central Europe. *Atmospheric Environment* **33**: 1725–1733.
- Schroeder, W.H. and Schneeberger, D., 1996. High temporal resolution measurements of total gaseous mercury at Alert, Northwest Territories, Canada. In: Ebinghaus, R., Petersen, G., Tümpling, U. (eds) 4<sup>th</sup> Int. Conf. on *Mercury as a Global Pollutant*. Hamburg, 4–8 August 1996.
- Schroeder, W.H., Lamborg, C., Schneeberger, D., Fitzgerald, W.F. and Srivastava, B., 1995a. Comparison of a manual method and an automated analyzer for determining total gaseous mercury in ambient air. In: Wilken, R.-D., Förstner, U. and Knöchel, A. (eds) *Proceedings of the 10th International Conference on Heavy Metals in the Environment*. CEP Consultants Ltd., Publisher, Edinburgh, U.K., Vol. 2, pp. 57–60.
- Schroeder, W.H., Keeler, G., Kock, H., Roussel, P., Schneeberger, D. and Schaedlich, F., 1995b. International field intercomparison of atmospheric mercury measurement methods. *Water, Air, and Soil Pollution* **80**: 611–620.
- Schroeder, W.H., Anlauf, K.G., Barrie, L.A., Lu, J.Y., Steffen, A., Schneeberger, D.R. and Berg, T., 1998. Arctic springtime depletion of mercury. *Nature* **394**: 331–332.
- Schroeder, W.H., Steffen, A., Lawson, G. and Strachan, W., 2001. Mercury measurements at Alert. In: Kalhok, S. (ed.) *Synopsis of Research Conducted under the 2000/2001 Northern Contaminants Program*. Ottawa ON, Indian and Northern Affairs Canada, pp. 130–135.
- Slemr, F., 1996. Trends in atmospheric mercury concentrations over the Atlantic Ocean and the Wank summit and the resulting constraints on the budget of atmospheric mercury. In: Baeyens, W., Ebinghaus, R. and Vasiliev, O. (eds) *Global and Regional Mercury Cycles: Sources, Fluxes and Mass balances*. NATO ASI Series 2. Environment Vol. 21, Kluwer, Dordrecht, The Netherlands, pp. 33–84.
- Slemr, F. and Scheel, H.E., 1998. Trends in atmospheric mercury concentrations at the summit of the Wank mountain, southern Germany. *Atmospheric Environment* **32**: 845–853.
- Slemr, F., Schuster, G. and Seiler, W., 1985. Distribution, speciation and budget of atmospheric mercury. *Journal of Atmospheric Chemistry* **3**: 407–434.
- Stock, A. and Cucuel, F., 1934. Die Bestimmung des Quecksilbergehalts der Luft. *Berichte der Deutschen Chemischen Gesellschaft* **67**: 122–127.
- Urba, A., Kvietkus, K., Sakalys, J., Xiao, Z. and Lindqvist, O., 1995. A new sensitive and portable mercury vapor analyzer Gardis-1A. *Water, Air, and Soil Pollution* **80**: 1305–1309.
- Wängberg, I., Munthe, J., Pirrone, N., Iverfeldt, Å., Bahlmann, E., Costa, P., Ebinghaus, R., Feng, X., Ferrara, R., Gärdfeldt, K., Kock, H., Lanzillotta, E., Mamane, Y., Mas, F., Melamed, E., Osnat, Y., Prestbo, E., Sommar, J., Spain, G., Sprovieri, F. and Tuncel, G., 2001. Atmospheric mercury distribution in Northern Europe and in the Mediterranean region. *Atmospheric Environment* **35**: 3019–3025.
- Warneck, P., 1988. *Chemistry of the Natural Atmosphere*. Academic Publications, New York, USA.
- European Directives and Decision**
- Directive 96/61/EC of 24 September 1996 concerning integrated pollution prevention and control, OJ L 257, 10.10.96.
- Directive 2001/80/EC of the European Parliament and of the Council of 23 October 2001 on the limitation of emissions of certain pollutants into the air from large combustion plants, OJ L 309, 27.11.2001.
- Commission Decision 2000/479/EC of 17 July 2000 on the implementation of a European pollutant emission register (EPER) according to Article 15 of Council Directive 96/61 concerning integrated pollution prevention and control, OJ L192, 28.7.2000.
- Recent Publications with Reference to Mace Head Long-Term Data Set**
- Ebinghaus, R., Kock, H.H., Coggins, A.M., Spain, T.G., Jennings, S.G. and Temme, Ch., 2002. Long-term measurements of atmospheric mercury at Mace Head, Irish west coast between 1995 and 2001. *Atmospheric Environment* **36**: 5267–5276.
- Ki-Hyun, K., Ebinghaus, R., Schroeder, W.H., Blanchard, P., Kock, H.H., Steffen, A., Froude, F.A., Kim, M.-Y., Hong, S., Kim, J.-H., 2005. Atmospheric mercury concentrations from several observatory sites in the Northern Hemisphere. *Journal of Atmospheric Chemistry* **50**: 1–24.
- Kock, H.H., Bieber, E., Ebinghaus, R., Spain, T.G. and Thees, B., 2005. Comparison of long-term trends and seasonal variations of atmospheric mercury concentrations at the two European coastal monitoring stations Mace Head, Ireland and Zingst, Germany. *Atmospheric Environment* **39**: 7549–7556.
- Slemr, F., Brunke, E., Ebinghaus, R., Temme, Ch., Munthe, J., Wängberg, I., Schroeder, W., Steffen, A. and Berg, T., 2003. Worldwide trend of atmospheric mercury since 1977. *Geophysical Research Letters* **30**(10): 1516. DOI: 10.1029/2003GL016954.
- Temme, C., Ebinghaus, R., Einax, J.W., Steffen, S. and Schroeder, W.H., 2004. Application of time series analysis on long-time data sets of atmospheric mercury concentrations at two different sites. *Analytical and Bioanalytical Chemistry* **380**: 493–501. DOI: 10.1007/s00216-004-2715

## **Appendix A Anatomy of a Mercury Pollution Episode**

### **Introduction**

For much of the time, Mace Head experiences westerly airflows that are strongly influenced by marine conditions. The air quality is pristine, with low concentrations of pollutants. Except for the occasional coherent transport of pollutants from North American sources, the major pollutants are either well dispersed or have been removed from the atmosphere prior to arrival on the west coast of Ireland.

Approximately 30% of the air masses arriving at Mace Head have European trajectories and show the influence of recent emissions. Pollutant concentrations at Mace Head do not reach the high levels observed in the industrial heartland of Germany, or the UK for example. However, short-lived episodes of elevated pollutant concentrations are observed which give an insight into the source activity along the air mass trajectory.

The period from the 22nd to the 25th of March 2005 was a typical pollution episode at Mace Head and provides a good opportunity to examine the transboundary transport of pollutants from western European sources to Ireland.

### **Meteorology**

The general synoptic situation during the episode was a high-pressure system centred over NE England on the 22nd March, which led to south-easterly airflows in the west of Ireland.

On the 23rd of March, the high-pressure system was gradually pushed north-eastward by a low-pressure system moving in from the Atlantic to the south-west of Ireland. Locally, this caused a shift to more easterly airflows at Mace Head. By the 24th of March the low-pressure system was nearing the SW coast of Ireland, and passed over Ireland over the following day. There was some frontal activity with localised heavy showers. The system was slow moving, winds over Ireland were light and variable in direction. With the passage of the low-pressure system on the 25th of March, heading northward, a stronger south-westerly airflow began to dominate.

Back trajectory analysis provides more insight into the high mercury concentration episode. Back trajectories provide an estimate of the history of an air in the hours and days prior to its arrival at the Mace Head station. Looking at the back trajectories, it becomes clear that conditions hundreds of kilometres away, and some days before, have had a major influence on the air quality observed.

## A1 Anatomy of a Mercury Pollution Episode: Day 1

Background concentrations of mercury at Mace Head during March are of the order of  $1.4 \text{ ng/m}^3$ . The colour coding in both the mercury concentration (Fig. A1) and back trajectory diagrams (Fig. A2) indicates time of day.

During the early hours of the 22nd of March 2006, a north-easterly airflow brings relatively clean air from

the North Sea over Scotland and Northern Ireland and onwards to Mace Head.

As the day progresses the general airflow pattern shifts, with the air passing over more southern areas of Ireland, and the north of England. Though these regions have potentially larger emission sources, there is only a modest increase, to  $1.6 \text{ ng/m}^3$ , in the observation at Mace Head.

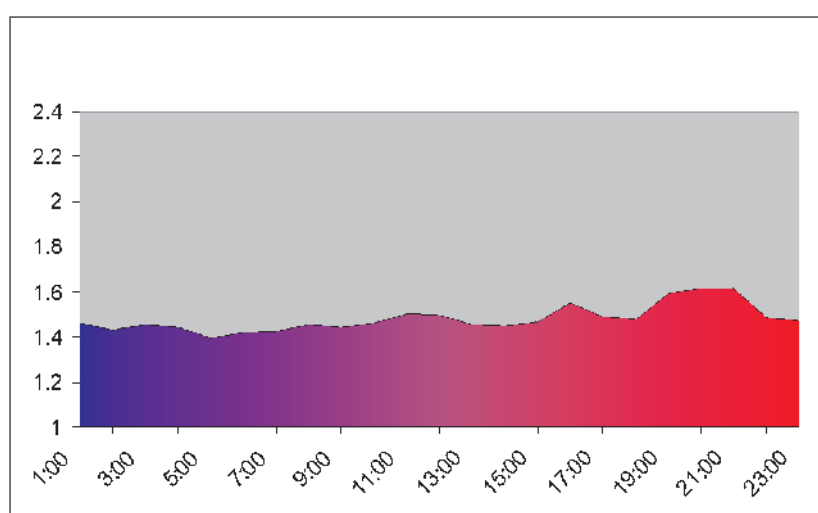


Figure A1. Mercury concentrations at Mace Head on the 22nd of March 2006.

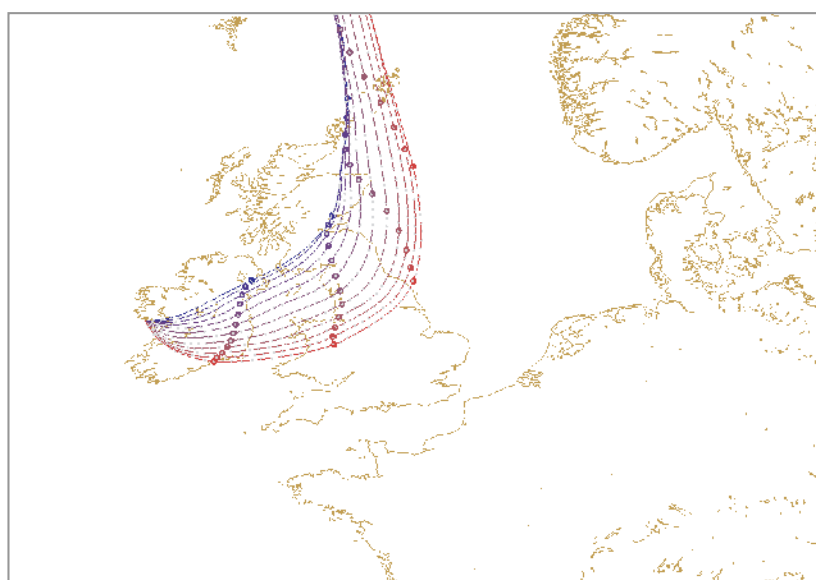


Figure A2. Back trajectory analysis of mercury concentrations on the 22nd of March 2006.

## A2 Anatomy of a Mercury Pollution Episode: Day 2

Slightly elevated mercury concentrations are observed in the early hours of the 23rd of March. Concentrations have returned to near background levels before dawn. Concentrations begin to rise again in the late afternoon and on into the night (Fig. A3).

As the day progresses airflows arriving at Mace Head come from easterly and south-easterly directions

(Fig. A4). However, it is clear that the local wind direction at Mace Head is not a good indicator of the origins of the air mass beyond 12–24 h.

By mid-afternoon, air masses from the south-east of England begin to arrive, with a notable increase in mercury concentrations.

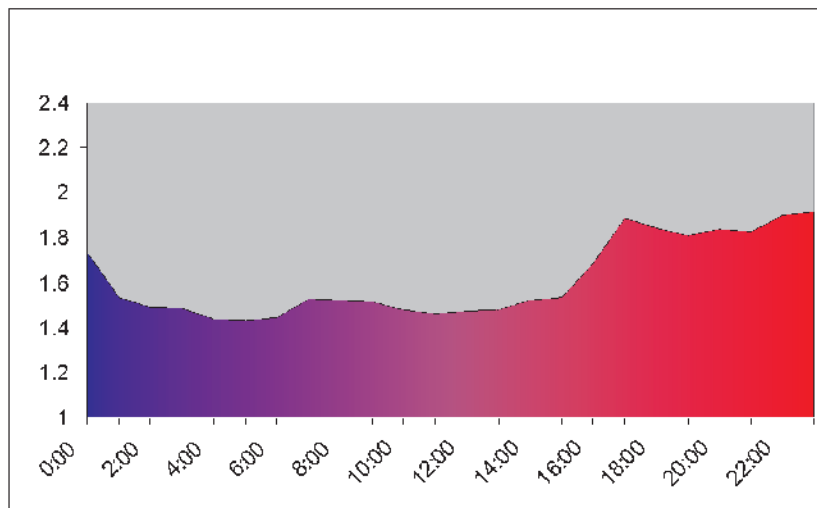


Figure A3. Mercury concentrations at Mace Head on the 23rd of March 2006.

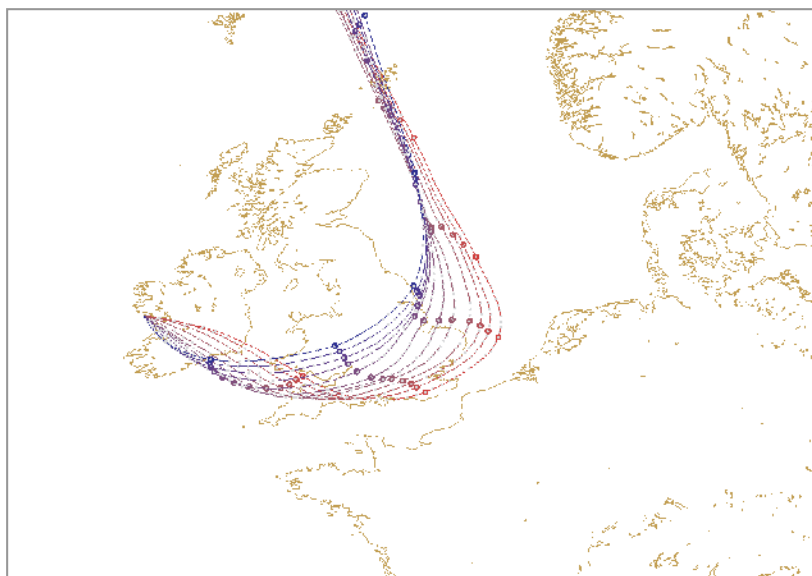


Figure A4. Back trajectory analysis of mercury concentrations on the 23rd of March 2006.

### A3 Anatomy of a Mercury Pollution Episode: Day 3

Elevated mercury concentrations are observed in the early hours of the 24th of March, and continue throughout the day, with a marked increase just before noon (Fig. A5).

Air masses continue to arrive at Mace Head from the south-east of England (Fig. A6). A shift in the flow

pattern increases the potential for mercury contamination as the air masses also pass over the Netherlands and Belgium.

The air masses are slow moving, especially in the latter half of the day. This allows ample opportunity to accumulate pollution over source regions.

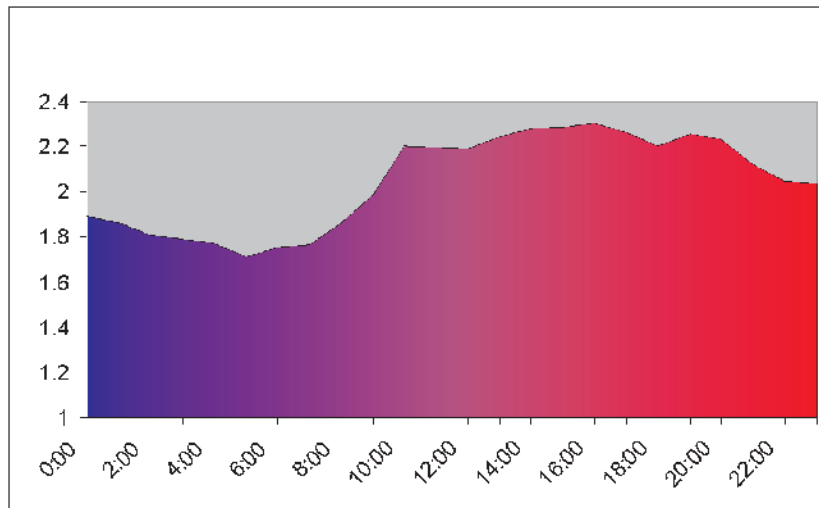


Figure A5. Mercury concentrations at Mace Head on the 24th of March 2006.

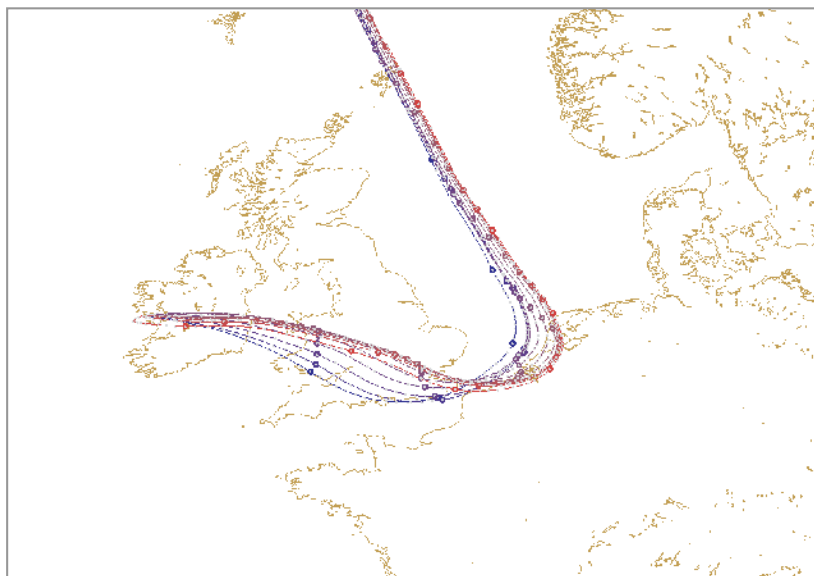


Figure A6. Back trajectory analysis of mercury concentrations on the 24th of March 2006.

#### A4 Anatomy of a Mercury Pollution Episode: Day 4

Elevated mercury concentrations are observed in the early hours of the 25th of March, but rapidly drop to background levels by 06:00 h, marking the end of the episode (Fig. A7).

Although the local wind direction at Mace Head during the early hours indicates a westerly airflow, the back trajectory analyses indicate some recirculation of

polluted air, heavily influence by Europe and the UK (Fig. A8).

This is another reminder that local wind direction is often not a good indicator of source region or the potential influence of long-range transport on air quality.

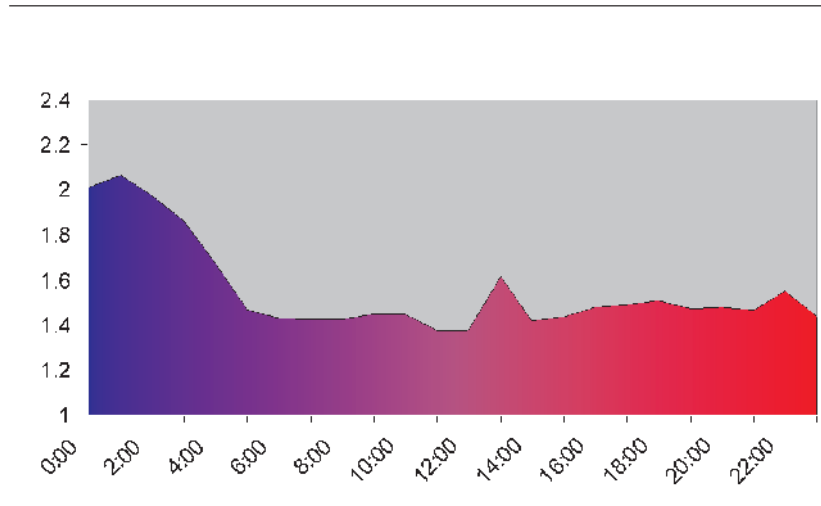


Figure A7. Mercury concentrations at Mace Head on the 25th of March 2006.

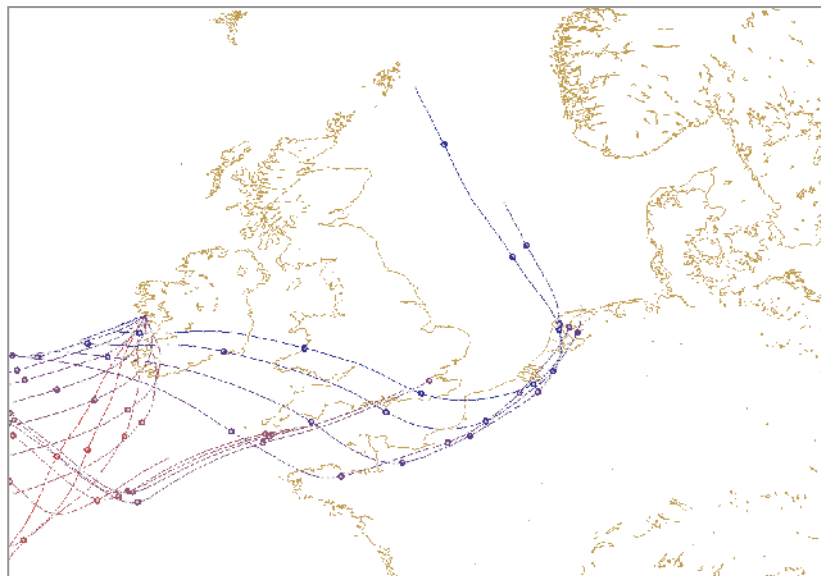


Figure A8. Back trajectory analysis of mercury concentrations on the 25th of March 2006.

## Appendix B Annual Mercury Reports

The EU 4th Daughter Directive (2004/107/EC) requires reporting of annual ambient concentrations of mercury in the atmosphere. It is also recommended that the quality of the monitoring system be assessed in terms of data capture rate. In a given year, a capture rate of less than 80% is deemed to be insufficient to provide a

reliable estimate of the annual statistics.

Table B1 presents a summary of the mercury data from Mace Head. Thereafter, a more detailed synopsis of each year, from 1995 to 2006, is provided in this appendix.

**Table B1. Mercury concentrations at Mace Head.**

Year	Annual mean	Standard deviation	Data capture rate
1995	1.57	0.29	15%
1996	1.82	0.46	84%
1997	1.71	0.20	56%
1998	1.74	0.22	68%
1999	1.75	0.25	96%
2000	1.79	0.17	88%
2001	1.65	0.15	94%
2002	1.75	0.19	93%
2003	1.68	0.17	86%
2004	1.63	0.12	92%
2005	1.55	0.11	58%
2006	1.48	0.13	89%

Highlighted cells: capture rate is insufficient for reliable estimate of annual mean (<80%).

## B1 Total Gaseous Mercury at Mace Head, 1995

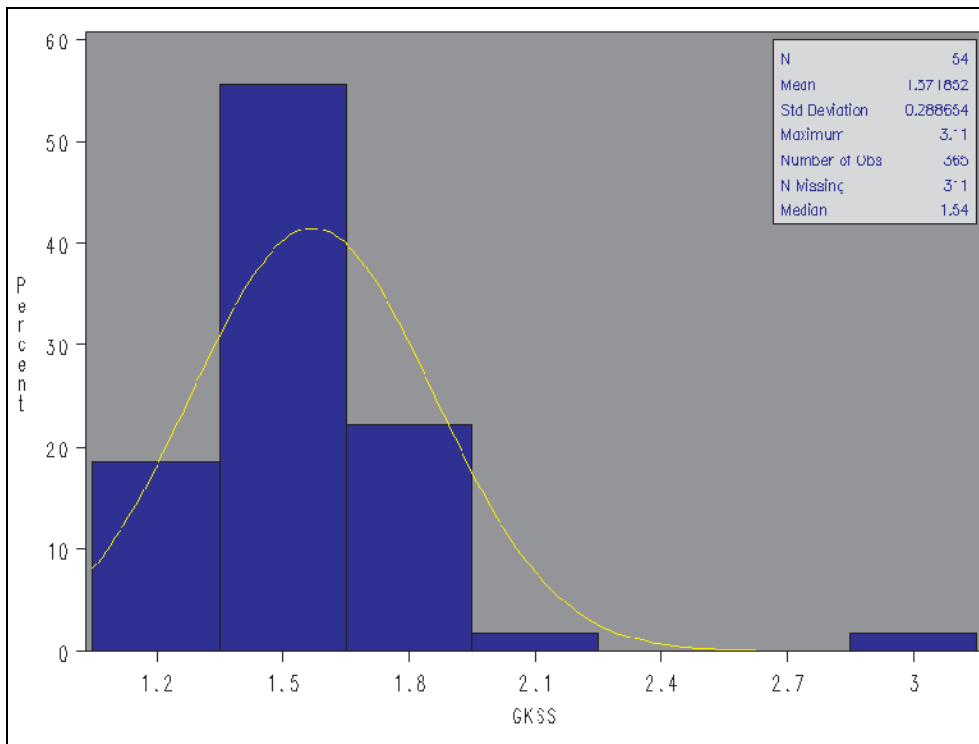
There are insufficient data to comment on annual mean concentrations. The seasonal data, from autumn into early winter, are consistent with those recorded in later years.

### Data Quality and Control

- During the start-up phase of the mercury monitoring programme data capture rates were poor.

**Table B2. Summary statistics for TGM at Mace Head, 1995.**

Average daily mean	1.57 ng/m <sup>3</sup>
Standard deviation	0.29 ng/m <sup>3</sup>
Minimum daily mean	1.21 ng/m <sup>3</sup>
Maximum daily mean	3.11 ng/m <sup>3</sup>
No. days operation	54



**Figure B1. Frequency distribution of daily mean values for 1995.**

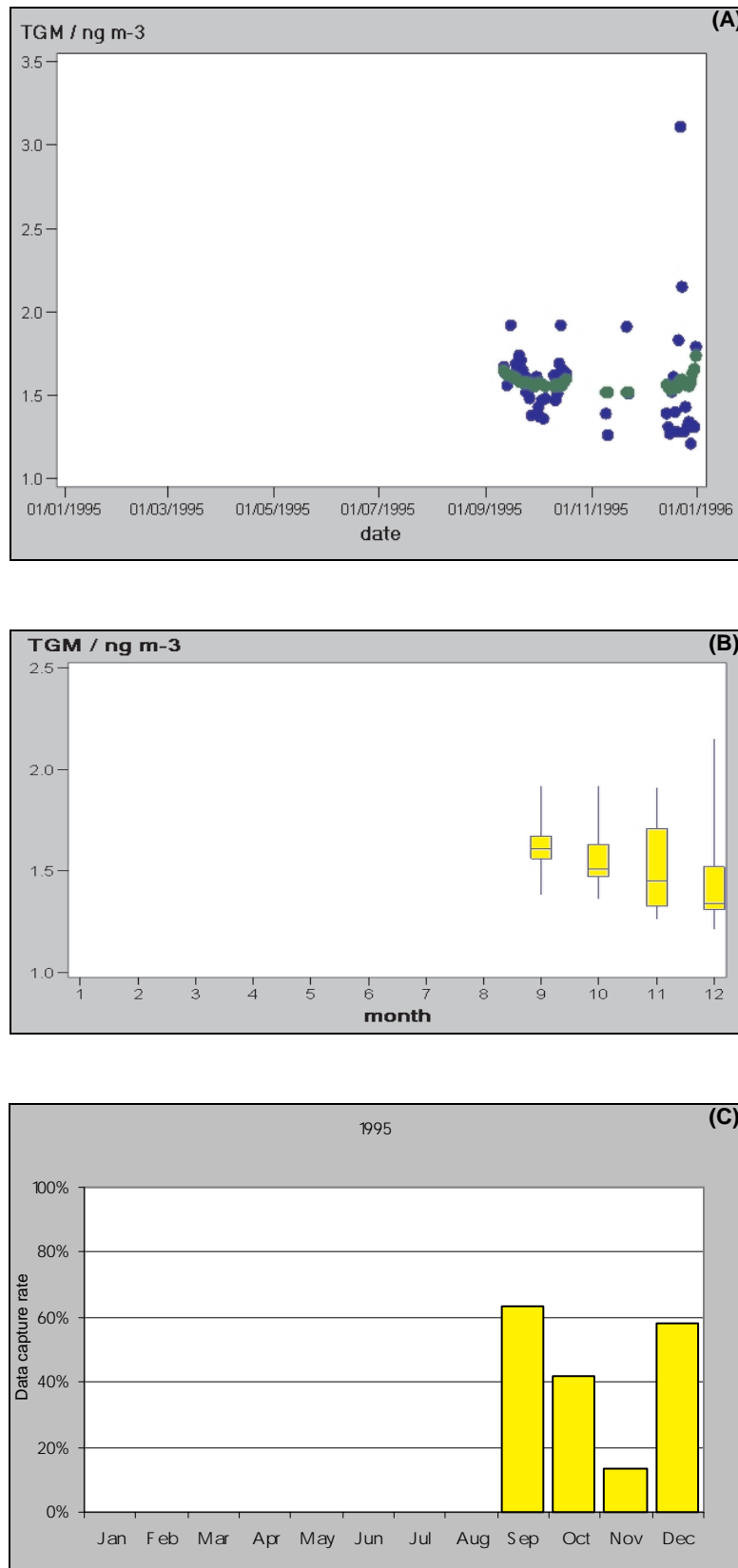


Figure B2. (A) Time series, daily values (blue) and 28-day running average (green) for total gaseous mercury (TGM). (B) Statistics for each month of 1995, with the mean, quartiles (box), and 5/95% quartiles (whiskers) for total gaseous mercury (TGM). (C) Data capture rate for each month (yellow indicates <80%).

## B2 Total Gaseous Mercury at Mace Head, 1996

Concentrations during early January are unseasonably low. However, the highest daily average over the entire data set was also recorded in this period.

There is a break in the data during November. A sharp increase in concentration was recorded upon recommencement of measurement. The magnitude of the increase is consistent with the episodes earlier in the year.

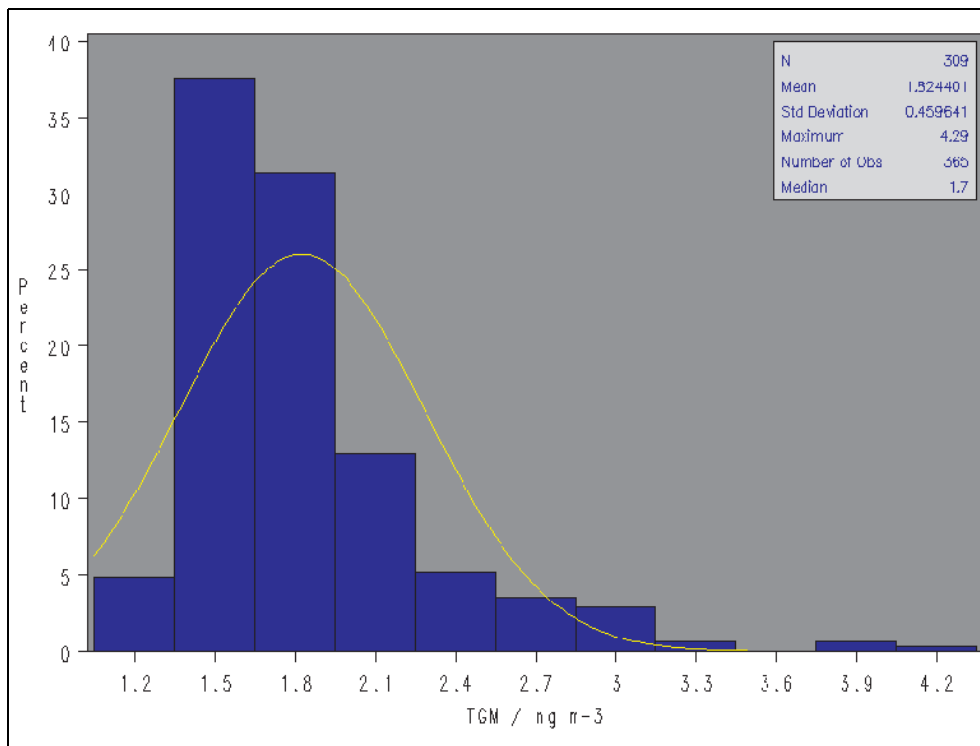
The distribution of daily mercury concentrations is not normal, but skewed strongly towards low concentrations.

### Data Quality and Control

- The first complete year of operation saw a reasonable data capture rate of 84%.

**Table B3. Summary statistics for TGM at Mace Head, 1996.**

Average daily mean	1.82 ng/m <sup>3</sup>
Standard deviation	0.46 ng/m <sup>3</sup>
Minimum daily mean	1.11 ng/m <sup>3</sup>
Maximum daily mean	4.29 ng/m <sup>3</sup>
No. days operation	309



**Figure B3. Frequency distribution of daily mean values for 1996.**

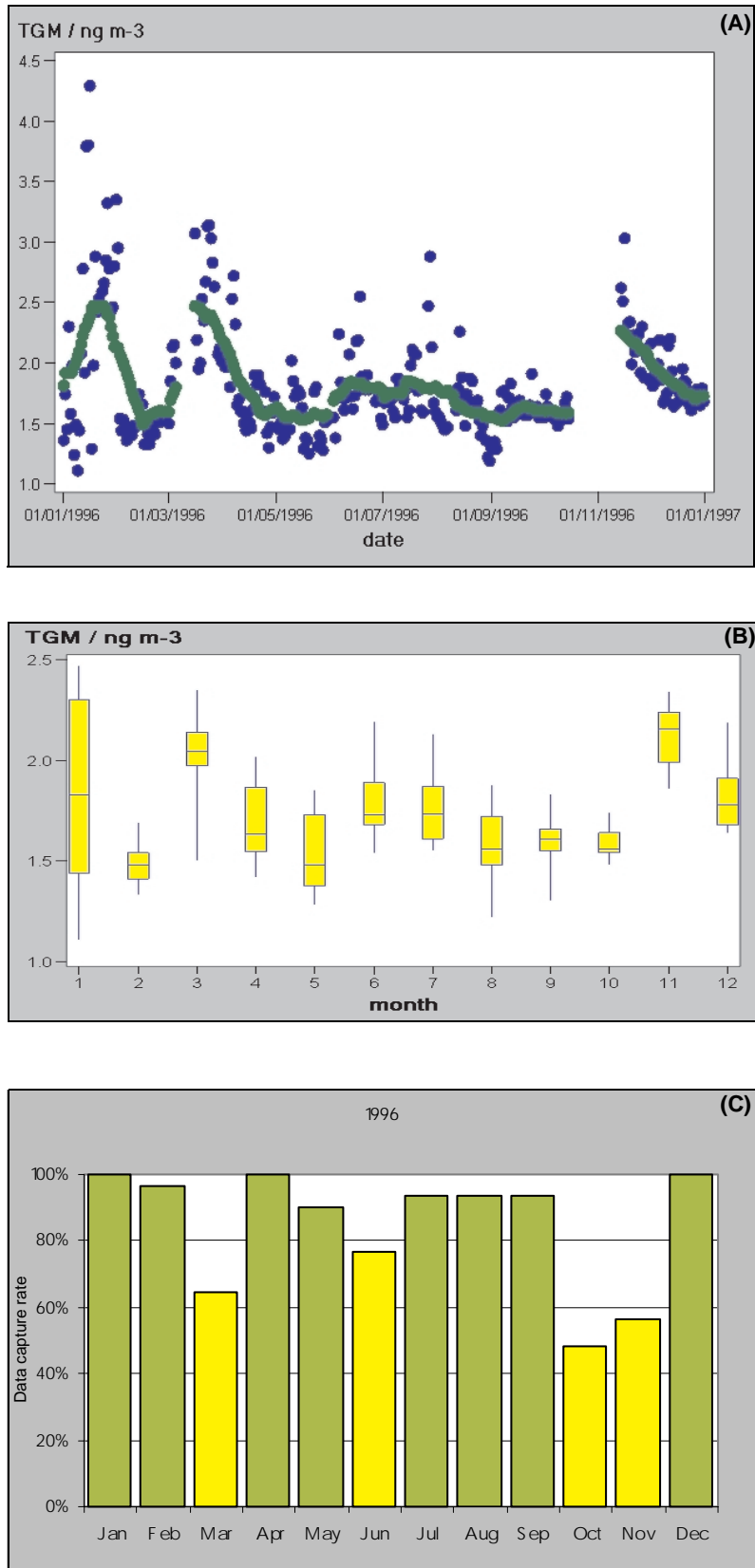


Figure B4. (A) Time series, daily values (blue) and 28-day running average (green) for total gaseous mercury (TGM). (B) Statistics for each month of 1996, with the mean, quartiles (box), and 5/95% quartiles (whiskers) for total gaseous mercury (TGM). (C) Data capture rate for each month (yellow indicates <80%).

### B3 Total Gaseous Mercury at Mace Head, 1997

The time series shows the fall in concentration from spring to summer. The break in measurements means that the annual average is not valid.

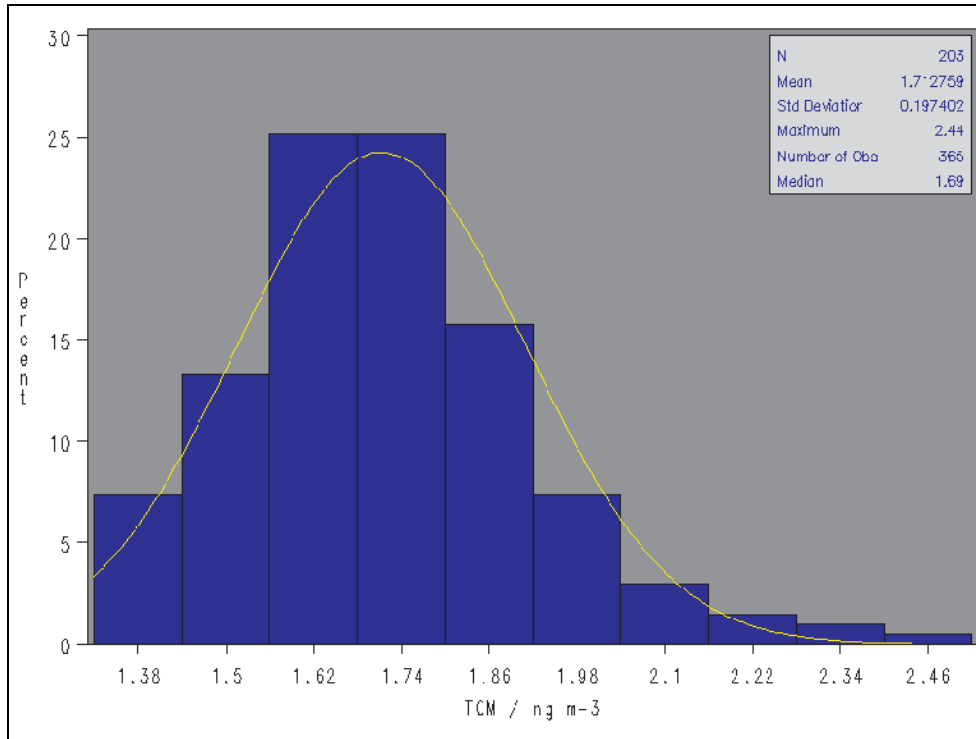
The researchers were unable to continue monitoring from alternative funding sources.

#### Data Quality and Control

- The overall data capture rate was 56%. However, performance was excellent during the first half of the year.
- The gap in data from July to December 1997 was due to the end of the original research funding.

**Table B4. Summary statistics for TGM at Mace Head, 1997.**

<b>Average daily mean</b>	1.71 ng/m <sup>3</sup>
<b>Standard deviation</b>	0.20 ng/m <sup>3</sup>
<b>Minimum daily mean</b>	1.36 ng/m <sup>3</sup>
<b>Maximum daily mean</b>	2.44 ng/m <sup>3</sup>
<b>No. days operation</b>	203



**Figure B5. Frequency distribution of daily mean values for 1997.**

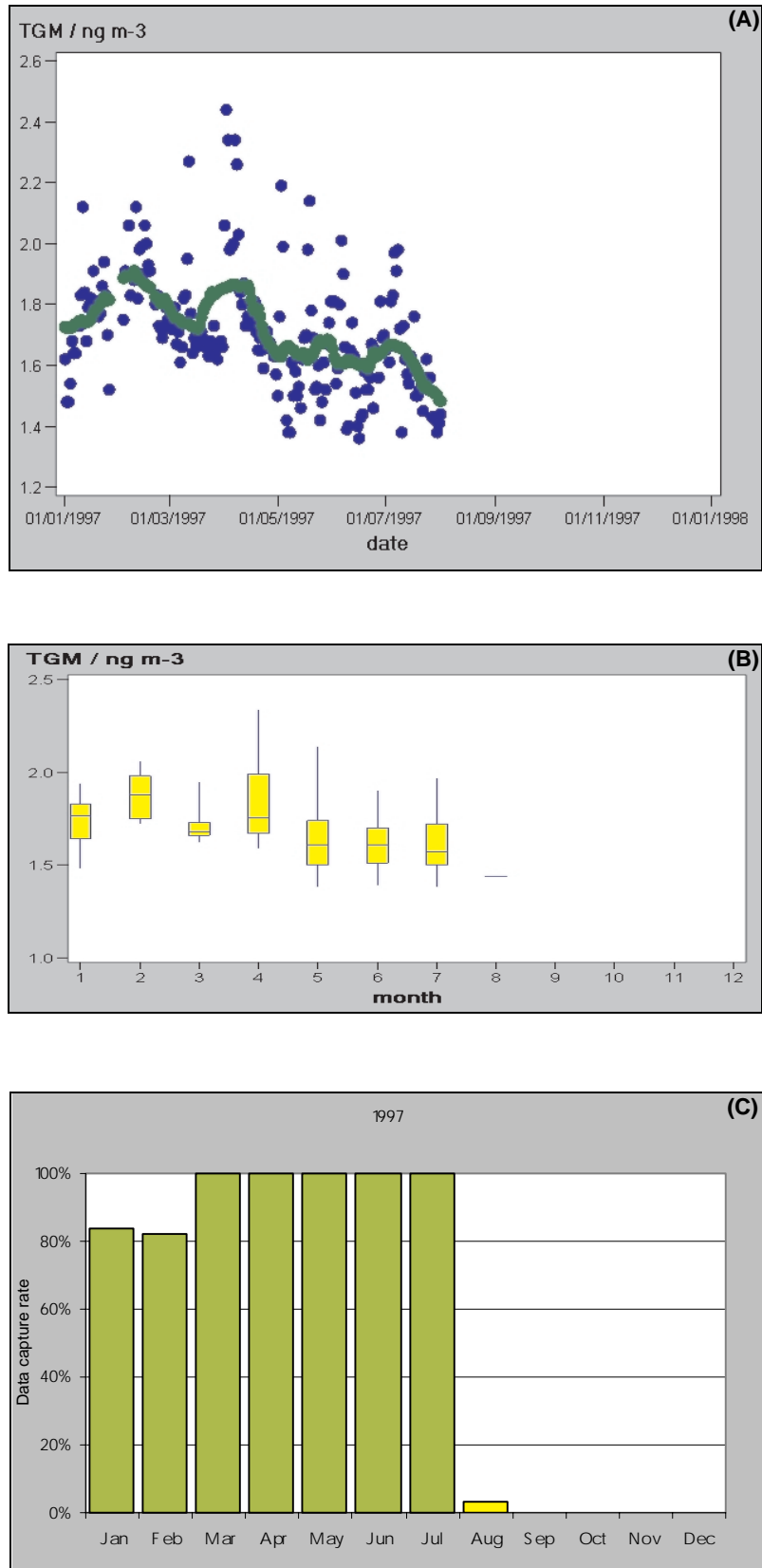


Figure B6. (A) Time series, daily values (blue) and 28-day running average (green) for total gaseous mercury (TGM). (B) Statistics for each month of 1997, with the mean, quartiles (box), and 5/95% quartiles (whiskers) for total gaseous mercury (TGM). (C) Data capture rate for each month (yellow indicates <80%).

### B4 Total Gaseous Mercury at Mace Head, 1998

Measurements did not recommence at Mace Head until early summer, therefore the annual mean is not valid.

Thereafter, the seasonal pattern is consistent with a summer minimum and a winter maximum. There appears to be one high concentration episode of note, which occurred in October. There was also a significant, unseasonably low concentration event during November.

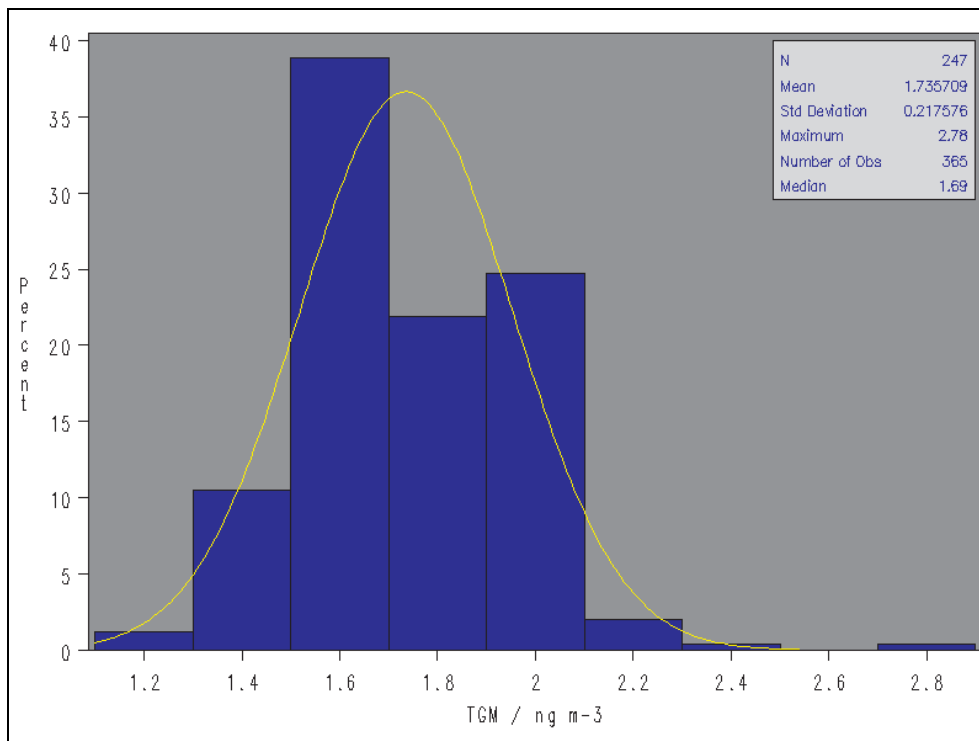
- The gap in data from January to April 1998 was due to the end of the original research funding.

#### Data Quality and Control

- The overall data capture rate was 68%. However, performance was excellent during the second half of the year.

**Table B5. Summary statistics for TGM at Mace Head, 1998.**

<b>Average daily mean</b>	1.74 ng/m <sup>3</sup>
<b>Standard deviation</b>	0.22 ng/m <sup>3</sup>
<b>Minimum daily mean</b>	1.13 ng/m <sup>3</sup>
<b>Maximum daily mean</b>	2.78 ng/m <sup>3</sup>
<b>No. days operation</b>	247



**Figure B7. Frequency distribution of daily mean values for 1998.**

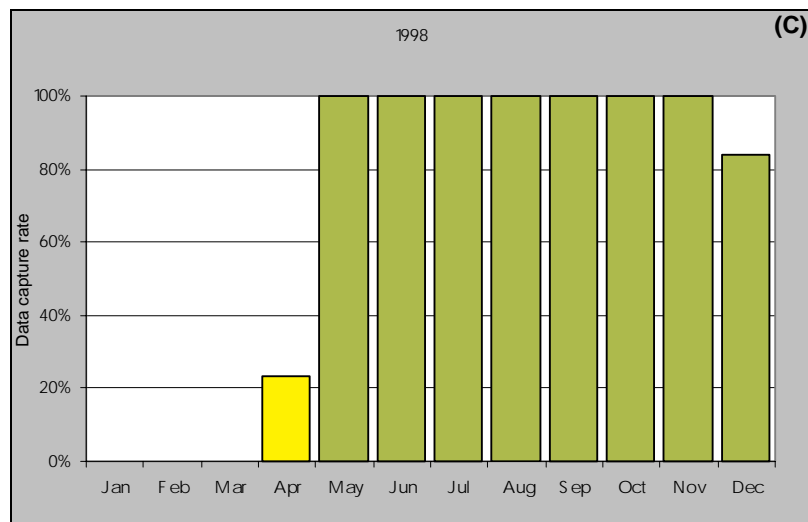
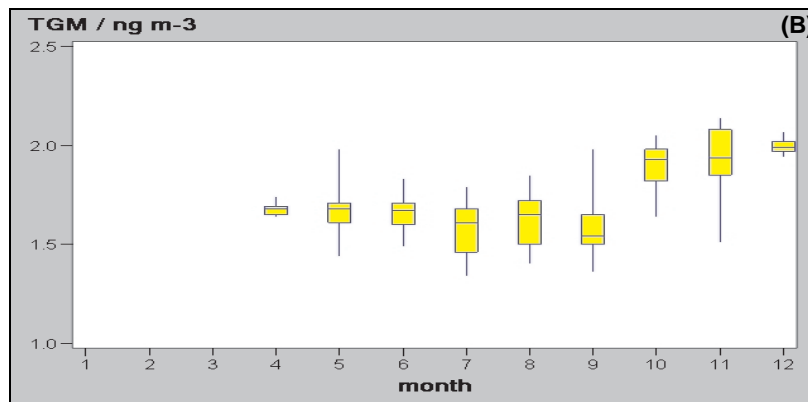
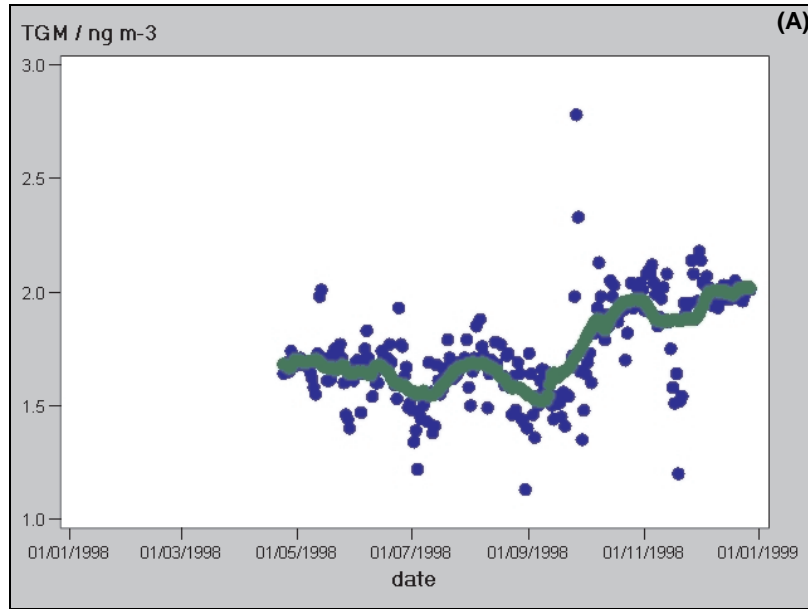


Figure B8. (A) Time series, daily values (blue) and 28-day running average (green) for total gaseous mercury (TGM). (B) Statistics for each month of 1998, with the mean, quartiles (box), and 5/95% quartiles (whiskers) for total gaseous mercury (TGM). (C) Data capture rate for each month (yellow indicates <80%).

**B5 Total Gaseous Mercury at Mace Head, 1999**

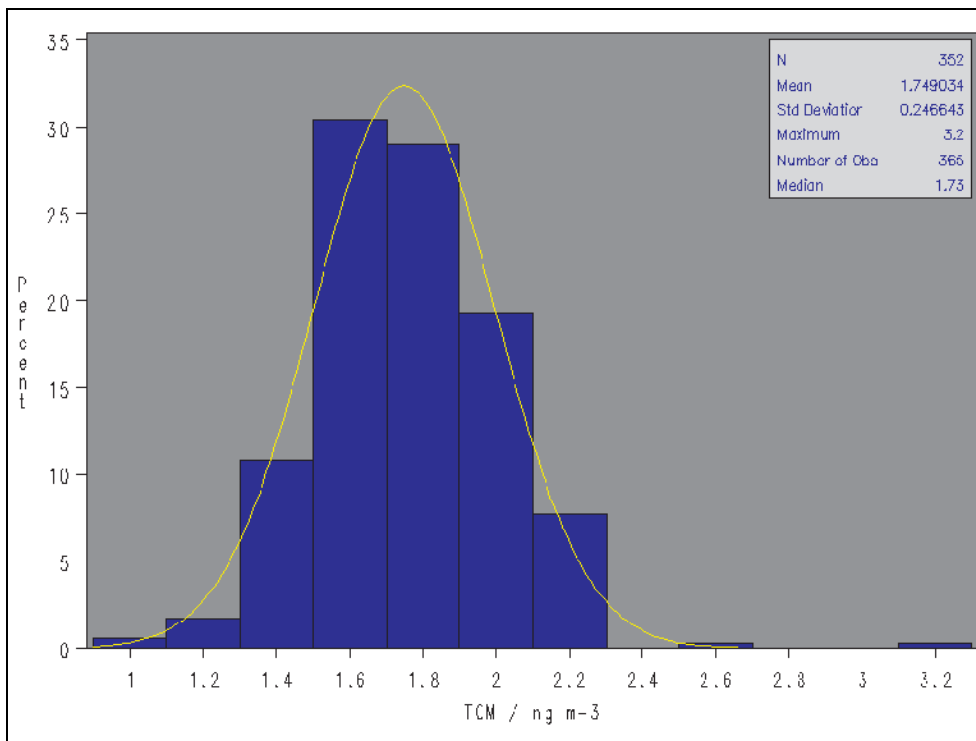
The distribution of daily averages is near normal. There is a high concentration event during October and two low concentration events during the late summer. Otherwise, the time series displays the typical winter high, summer low pattern for mercury concentrations at Mace Head.

**Table B6. Summary statistics for TGM at Mace Head, 1999.**

<b>Average daily mean</b>	1.75 ng/m <sup>3</sup>
<b>Standard deviation</b>	0.25 ng/m <sup>3</sup>
<b>Minimum daily mean</b>	1.06 ng/m <sup>3</sup>
<b>Maximum daily mean</b>	3.20 ng/m <sup>3</sup>
<b>No. days operation</b>	352

**Data Quality and Control**

- The overall data capture rate was 96%. No significant data outages occurred during the year. Scheduled maintenance and calibration procedures account for the few data gaps.



**Figure B9. Frequency distribution of daily mean values for 1999.**

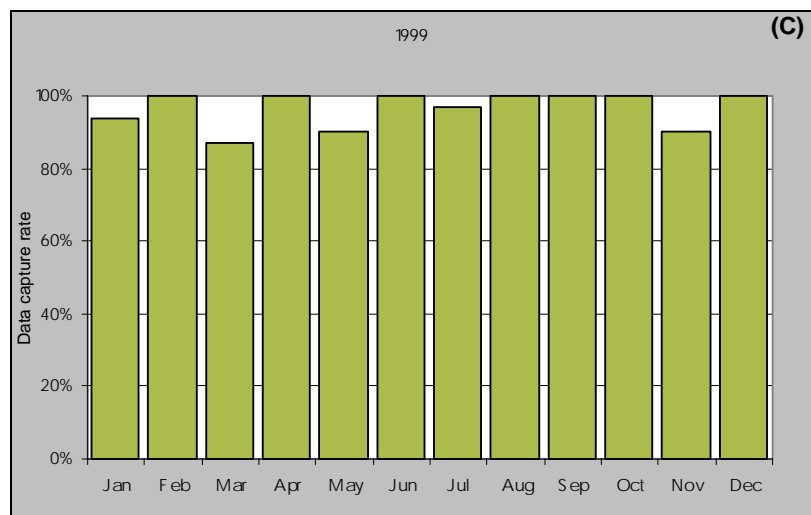
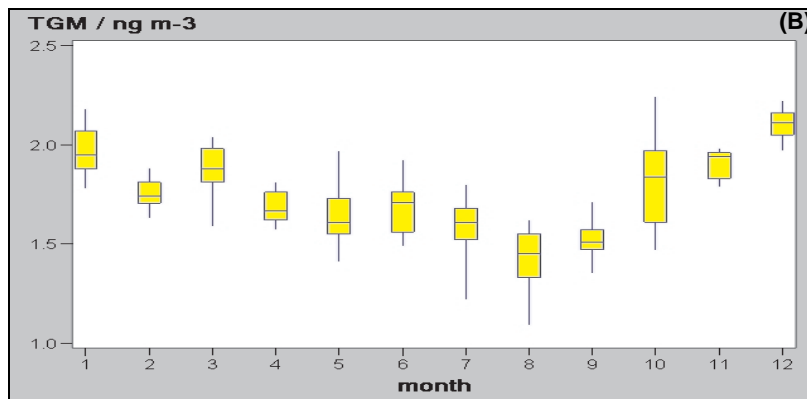
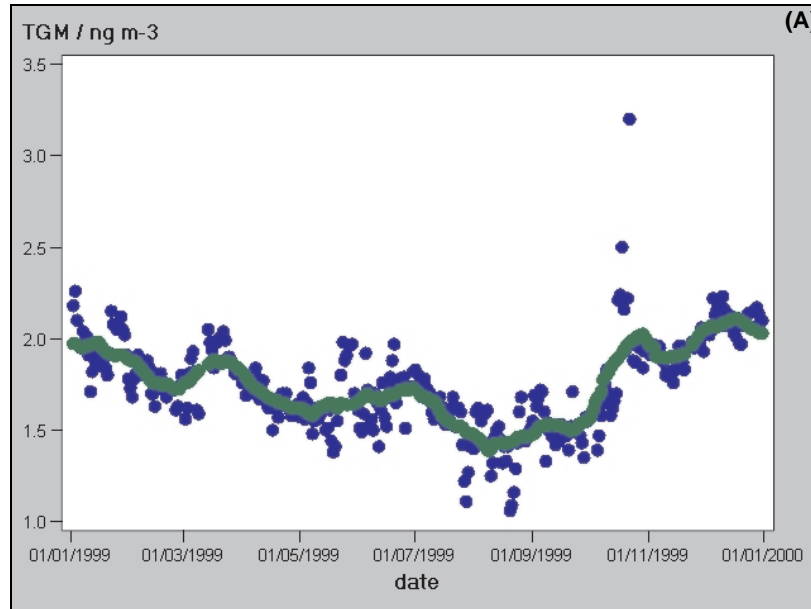


Figure B10. (A) Time series, daily values (blue) and 28-day running average (green) for total gaseous mercury (TGM). (B) Statistics for each month of 1999, with the mean, quartiles (box), and 5/95% quartiles (whiskers) for total gaseous mercury (TGM). (C) Data capture rate for each month (yellow indicates <80%).

**B6 Total Gaseous Mercury at Mace Head, 2000**

Continuous measurements of TGM at Mace Head, by GKSS, Germany.

The distribution of daily averages is unusually broad. The time series does not reflect the typical pattern, with unseasonably low concentrations of mercury persisting into winter. There is evidence of a number of high concentration events in the first half of the year, and no low concentration events observed.

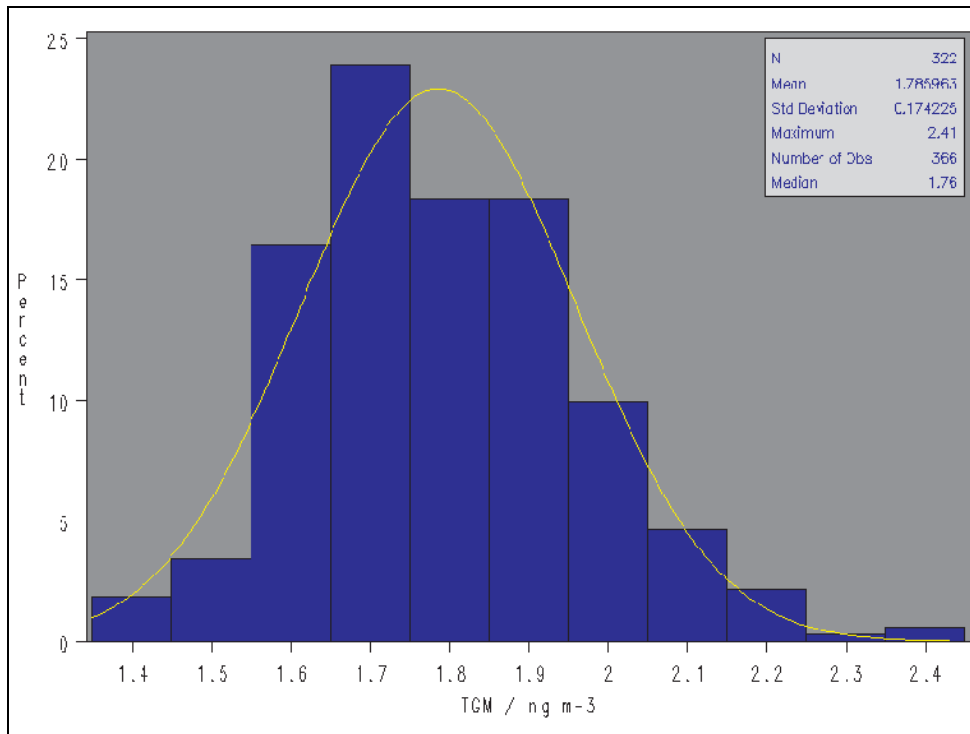
- Scheduled maintenance and calibration procedures account for the remaining few data gaps.

**Data Quality and Control**

- The overall data capture rate was 88%.
- A significant data outage occurred between April and May and again in September.

**Table B7. Summary statistics for TGM at Mace Head, 2000.**

Average daily mean	1.79 ng/m <sup>3</sup>
Standard deviation	0.17 ng/m <sup>3</sup>
Minimum daily mean	1.39 ng/m <sup>3</sup>
Maximum daily mean	2.41 ng/m <sup>3</sup>
No. days operation	322



**Figure B11. Frequency distribution of daily mean values for 2000.**

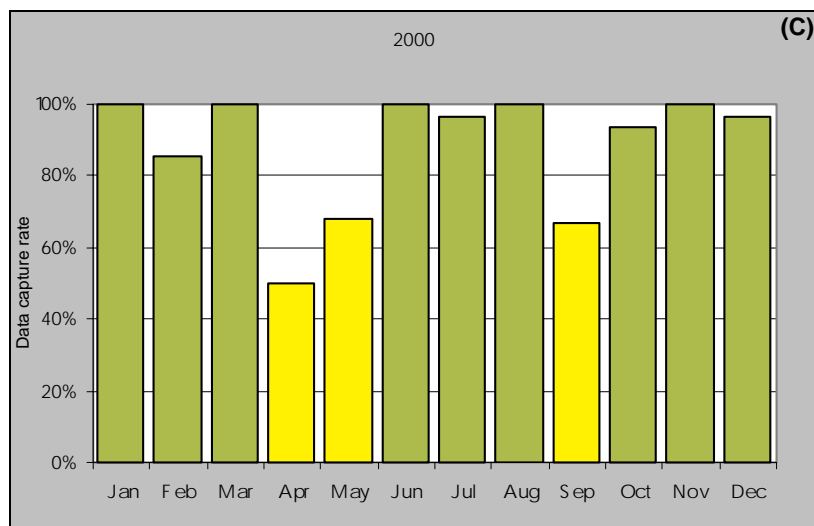
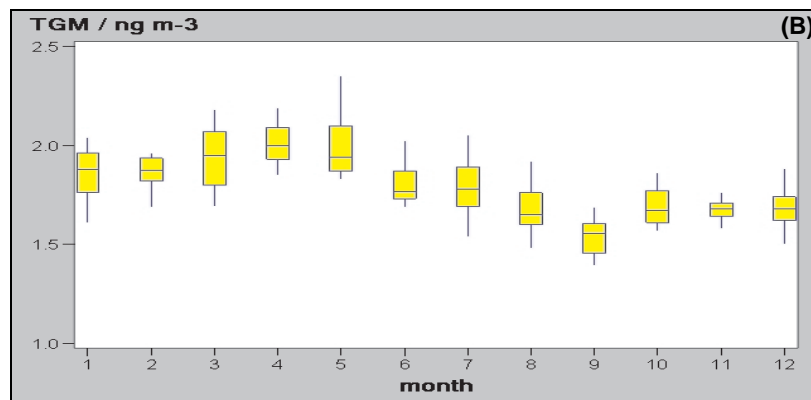
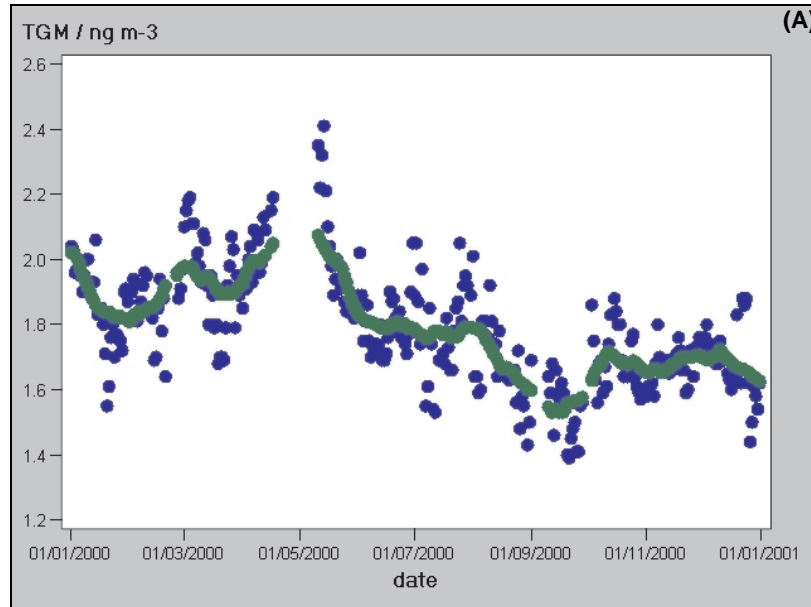


Figure B12. (A) Time series, daily values (blue) and 28-day running average (green) for total gaseous mercury (TGM). (B) Statistics for each month of 2000, with the mean, quartiles (box), and 5/95% quartiles (whiskers) for total gaseous mercury (TGM). (C) Data capture rate for each month (yellow indicates <80%).

## B7 Total Gaseous Mercury at Mace Head, 2001

Continuous measurements of TGM at Mace Head by GKSS, Germany, until September 2001; since October 2001, measurements have been carried out by GKSS on a contractual basis, funded by the EPA.

The distribution shows some bimodal characteristics, with additional structure at high concentrations. This probably reflects the long period of sustained elevated mercury concentrations during spring. There are numerous other high concentration events during the year, and one low concentration event.

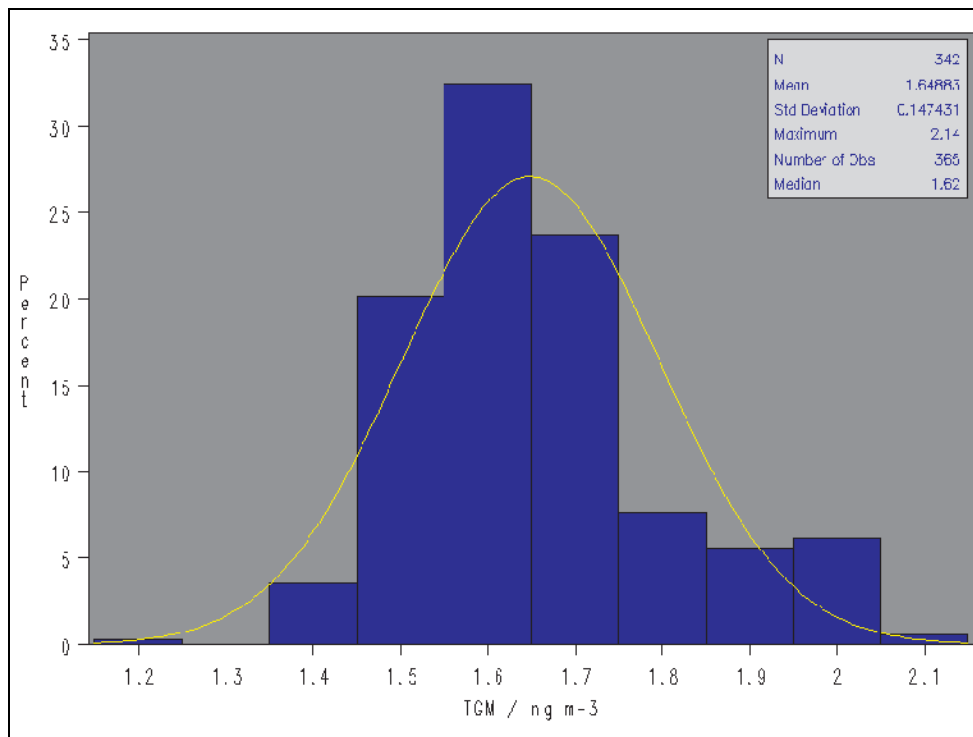
### Data Quality and Control

- The overall data capture rate was 94%.
- A significant outage occurred during March, which reduced data capture to just 71%.

- A shorter outage occurred between May and June, but the monthly capture rates did not fall below 80%.
- Scheduled maintenance and calibration procedures account for the remaining few data gaps.

**Table B8. Summary statistics for TGM at Mace Head, 2001.**

Average daily mean	1.65 ng/m <sup>3</sup>
Standard deviation	0.15 ng/m <sup>3</sup>
Minimum daily mean	1.19 ng/m <sup>3</sup>
Maximum daily mean	2.14 ng/m <sup>3</sup>
No. days operation	342



**Figure B13. Frequency distribution of daily mean values for 2001.**

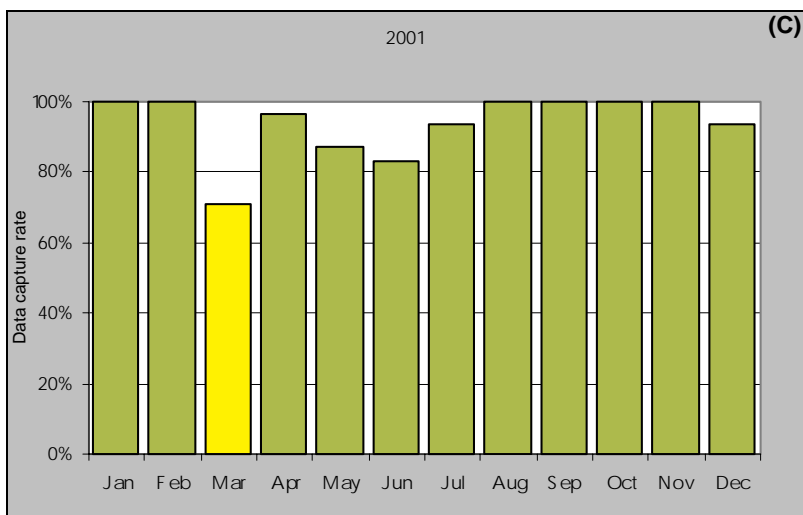
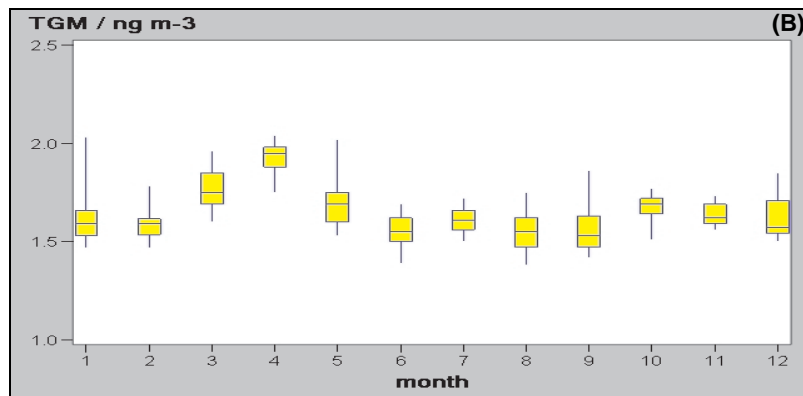
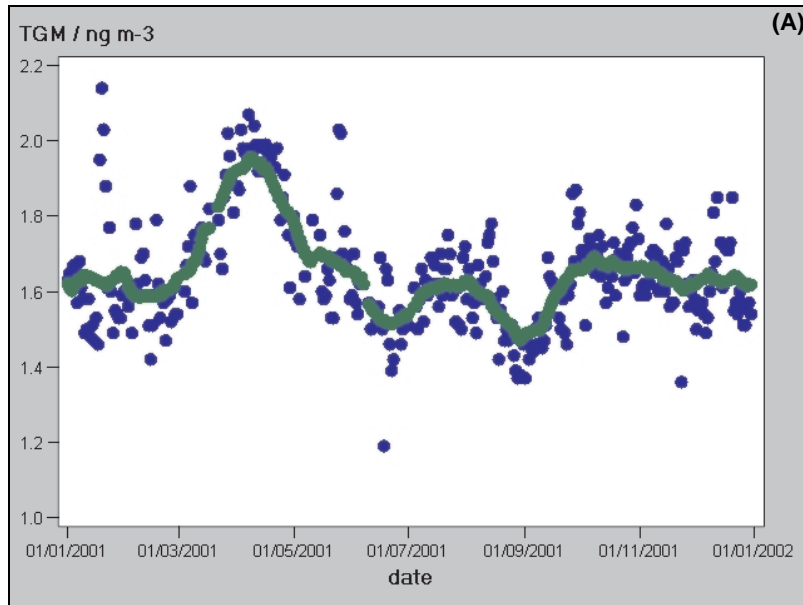


Figure B14. (A) Time series, daily values (blue) and 28-day running average (green) for total gaseous mercury (TGM). (B) Statistics for each month of 2001, with the mean, quartiles (box), and 5/95% quartiles (whiskers) for total gaseous mercury (TGM). (C) Data capture rate for each month (yellow indicates <80%).

### B8 Total Gaseous Mercury at Mace Head, 2002

The distribution of daily averages is near normal. The seasonal pattern during 2002 shows low variability, with a weak seasonal pattern. There were two high concentration events, during April and December. A short period of low concentrations was observed mid-summer.

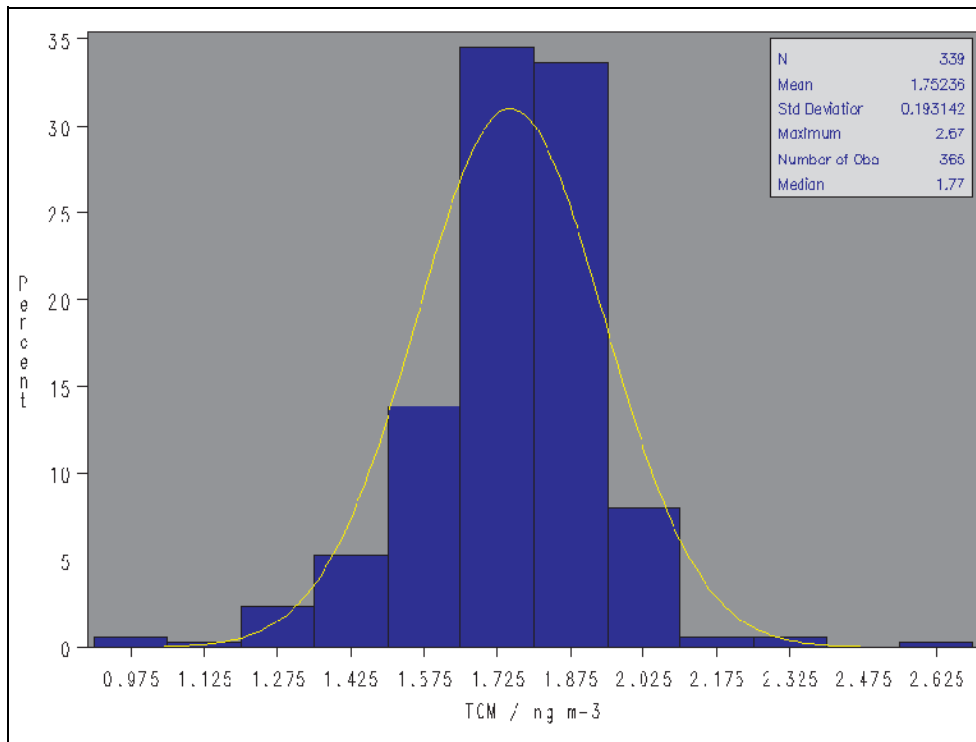
- Scheduled maintenance and calibration procedures account for the remaining few data gaps.

#### Data Quality and Control

- The overall data capture rate was 93%.
- A short outage occurred between May and June, when monthly capture rates fell to approximately 75%.

**Table B9. Summary statistics for TGM at Mace Head, 2002.**

Average daily mean	1.75 ng/m <sup>3</sup>
Standard deviation	0.19 ng/m <sup>3</sup>
Minimum daily mean	0.97 ng/m <sup>3</sup>
Maximum daily mean	2.67 ng/m <sup>3</sup>
No. days operation	339



**Figure B15. Frequency distribution of daily mean values for 2002.**

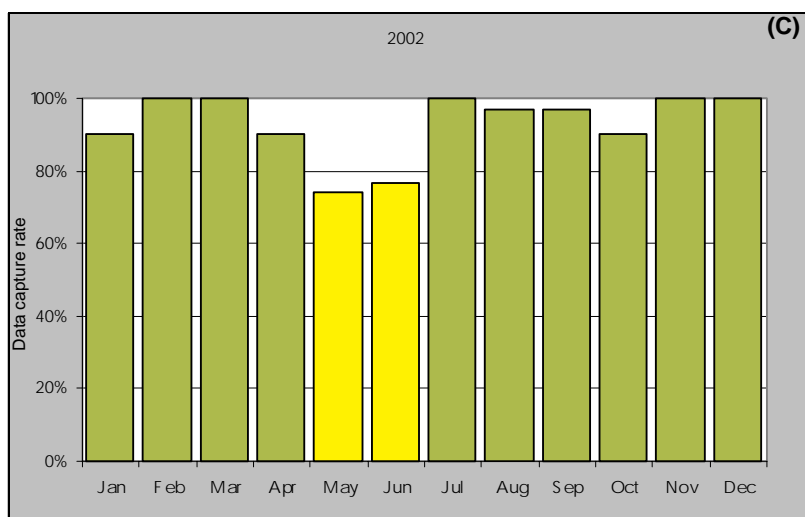
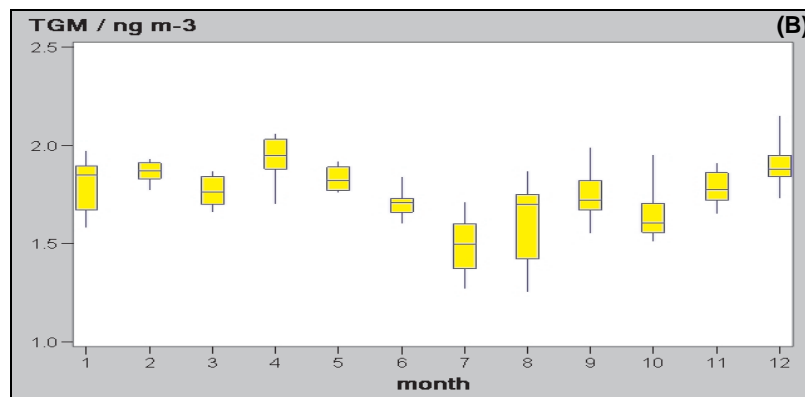
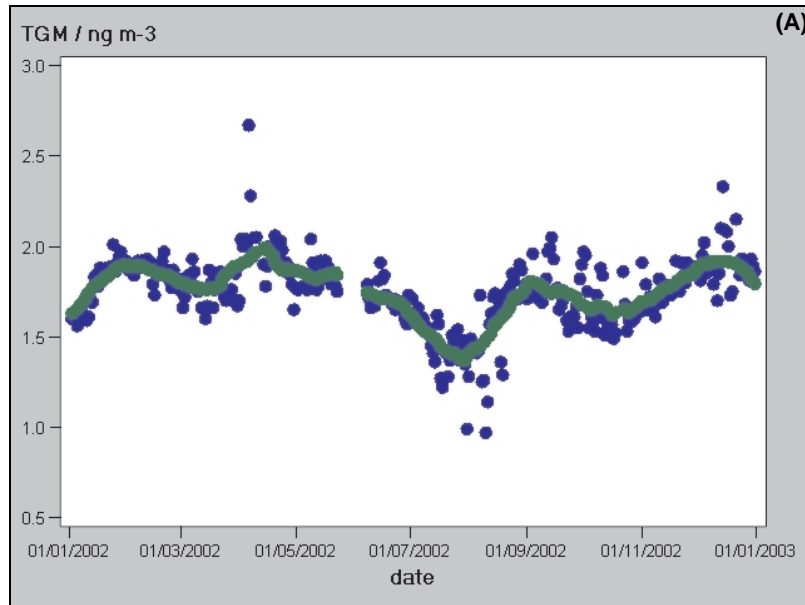


Figure B16. (A) Time series, daily values (blue) and 28-day running average (green) for total gaseous mercury (TGM). (B) Statistics for each month of 2002, with the mean, quartiles (box), and 5/95% quartiles (whiskers) for total gaseous mercury (TGM). (C) Data capture rate for each month (yellow indicates <80%).

**B9 Total Gaseous Mercury at Mace Head, 2003**

In strong contrast to the previous year, 2003 shows much higher variability. The distribution of daily averages is broad, though quite skewed towards lower concentrations. The normal seasonal pattern is obscured by the variability in the signal, probably influence by the exceptional weather conditions that prevailed over much of Europe during 2003.

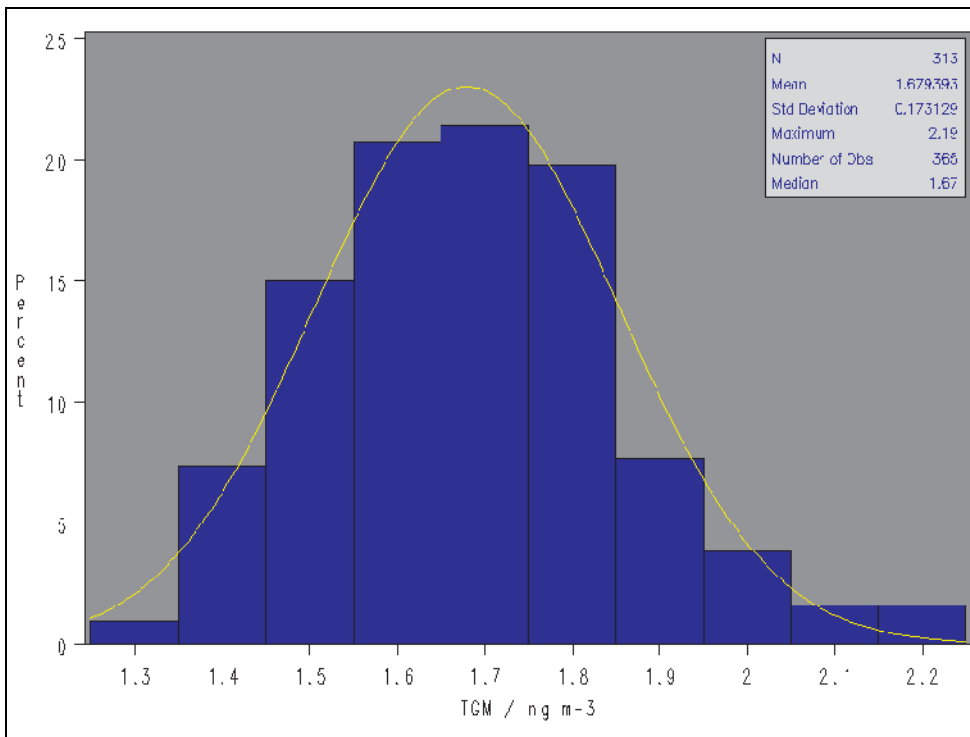
40%. Two outages were also recorded in February, but of shorter duration, and other events in June and August.

**Data Quality and Control**

- The overall data capture rate was 86%.
- However, a number of outages in data capture were recorded. Most notable were the problems seen in December, when capture rate fell to just

**Table B10. Summary statistics for TGM at Mace Head, 2003.**

<b>Average daily mean</b>	1.68 ng/m <sup>3</sup>
<b>Standard deviation</b>	0.17 ng/m <sup>3</sup>
<b>Minimum daily mean</b>	1.26 ng/m <sup>3</sup>
<b>Maximum daily mean</b>	2.19 ng/m <sup>3</sup>
<b>No. days operation</b>	313



**Figure B17. Frequency distribution of daily mean values for 2003.**

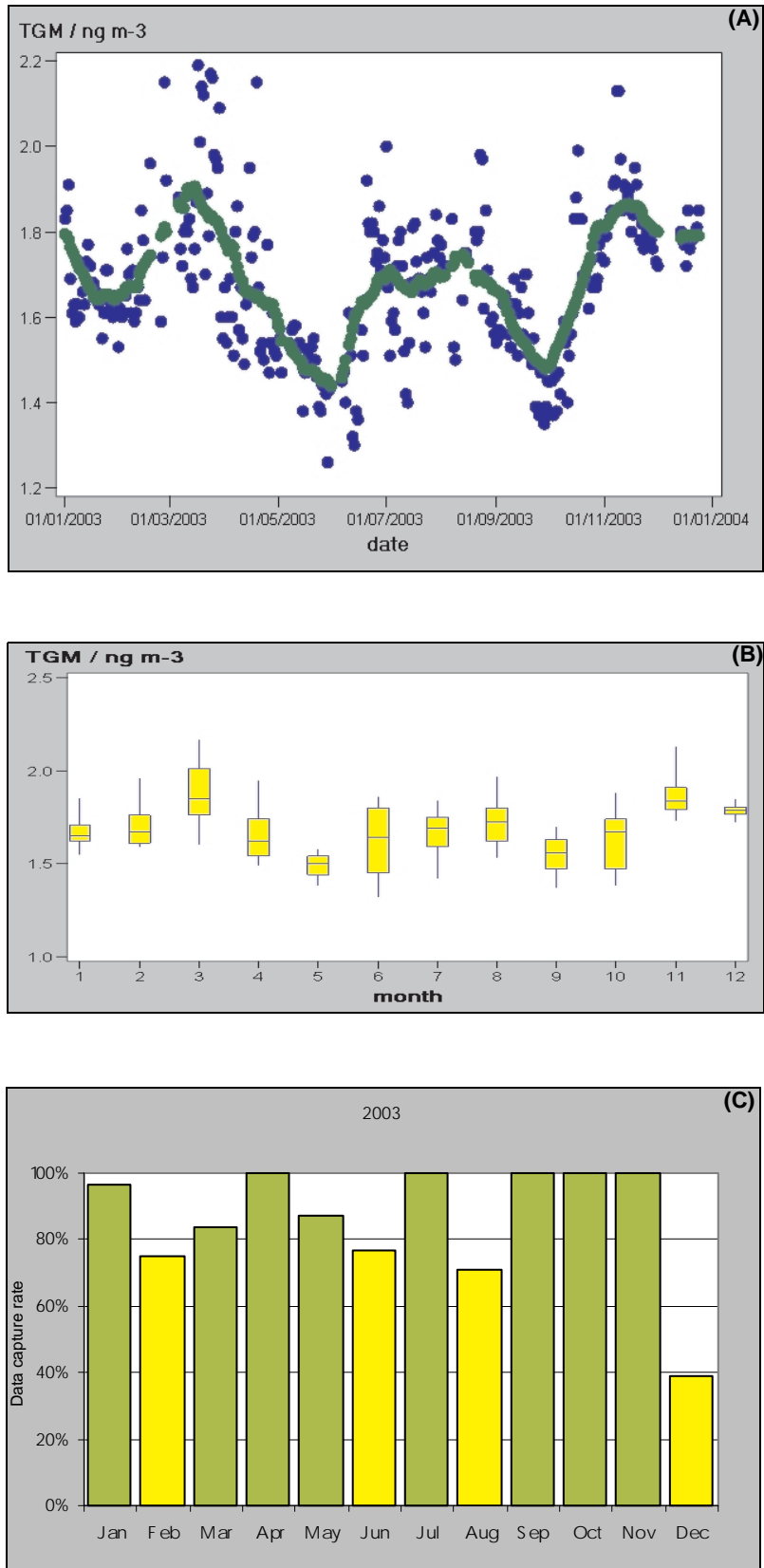


Figure B18. (A) Time series, daily values (blue) and 28-day running average (green) for total gaseous mercury (TGM). (B) Statistics for each month of 2003, with the mean, quartiles (box), and 5/95% quartiles (whiskers) for total gaseous mercury (TGM). (C) Data capture rate for each month (yellow indicates <80%).

### B10 Total Gaseous Mercury at Mace Head, 2004

There was a break in measurements at the end of December.

The distribution of daily averages is near normal. There were a number of high concentration events during the year, mainly during spring. The seasonal pattern is not strongly evident.

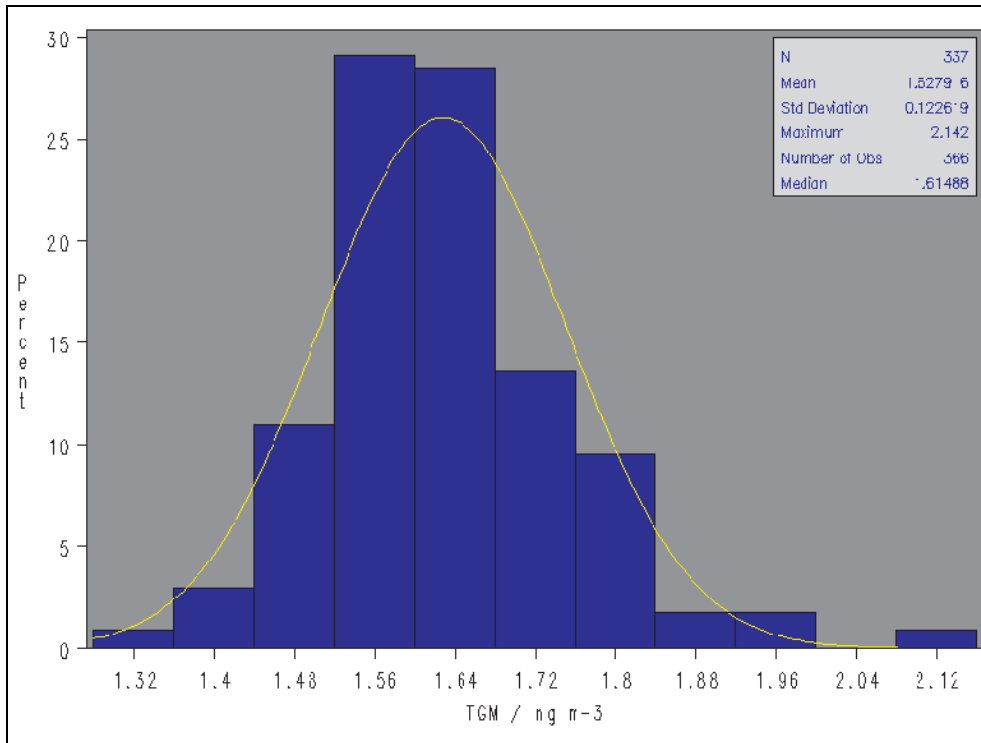
- August was another poor month, during which the system operated intermittently.
- Scheduled maintenance and calibration procedures account for the remaining few data gaps.

#### Data Quality and Control

- The overall data capture rate was 92%.
- A short outage occurred at the beginning of the year, which was a continuation of the problem from December 2003. The monthly capture rate was 67%.

**Table B11. Summary statistics for TGM at Mace Head, 2004.**

<b>Average daily mean</b>	1.63 ng/m <sup>3</sup>
<b>Standard deviation</b>	0.12 ng/m <sup>3</sup>
<b>Minimum daily mean</b>	1.29 ng/m <sup>3</sup>
<b>Maximum daily mean</b>	2.14 ng/m <sup>3</sup>
<b>No. days operation</b>	337



**Figure B19. Frequency distribution of daily mean values for 2004.**

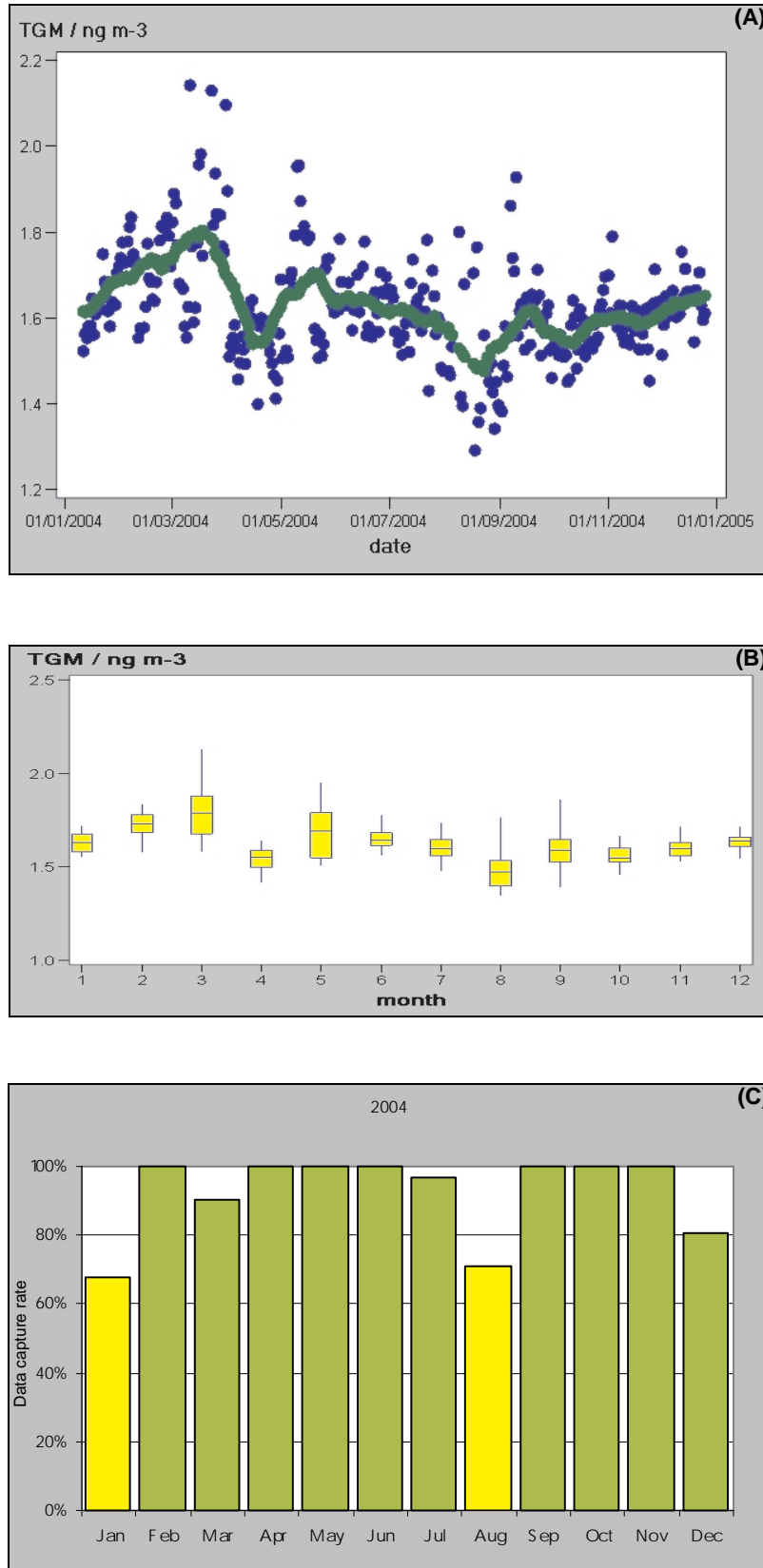


Figure B20. (A) Time series, daily values (blue) and 28-day running average (green) for total gaseous mercury (TGM). (B) Statistics for each month of 2004, with the mean, quartiles (box), and 5/95% quartiles (whiskers) for total gaseous mercury (TGM). (C) Data capture rate for each month (yellow indicates <80%).

### B11 Total Gaseous Mercury at Mace Head, 2005

Mercury measurements resumed in May 2005 with an upgraded instrument. There were some initial problems with argon supply, ageing of gold traps, etc.

Due to gaps in the data, the annual mean is not valid. There was one high concentration episode recorded during October. No low concentration events were observed, and little seasonal signal in the data.

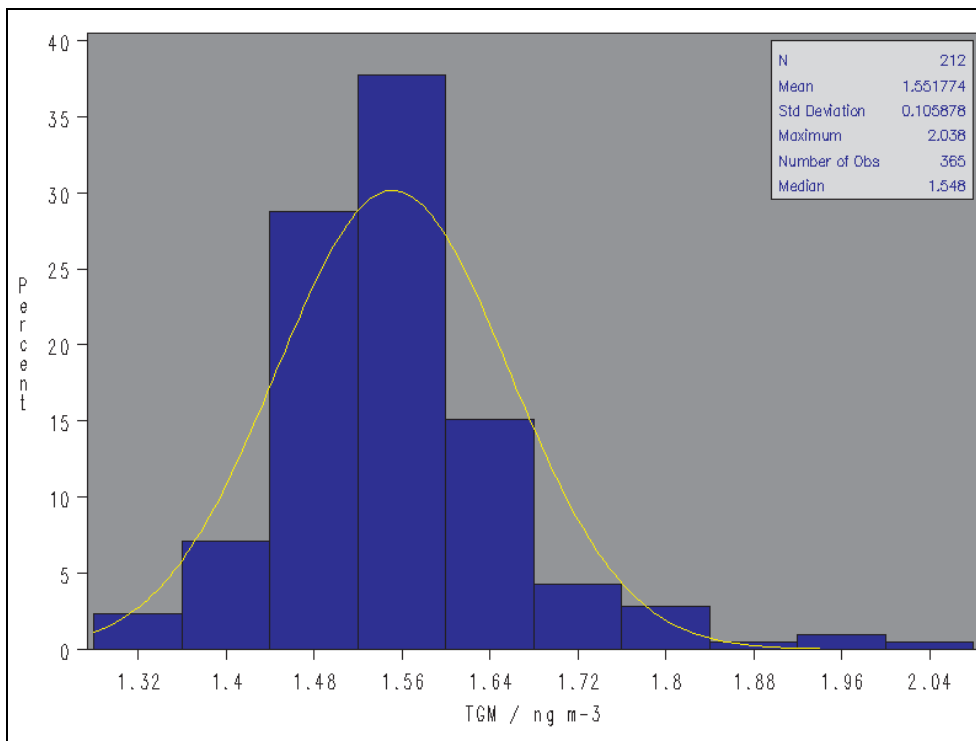
- From July onwards monitoring was again fully operational.
- Scheduled maintenance and calibration procedures account for the remaining few data gaps.

#### Data Quality and Control

- The overall data capture rate was 58%.
- A major break occurred from January to May. GKSS recalled the original instrumentation. A new system was commissioned.
- Recommencement of monitoring was short-lived, with a second break in June. This was due to problems with argon supply.

**Table B12. Summary statistics for TGM at Mace Head, 2005.**

Average daily mean	1.55 ng/m <sup>3</sup>
Standard deviation	0.11 ng/m <sup>3</sup>
Minimum daily mean	1.32 ng/m <sup>3</sup>
Maximum daily mean	2.04 ng/m <sup>3</sup>
No. days operation	212



**Figure B21. Frequency distribution of daily mean values for 2005.**

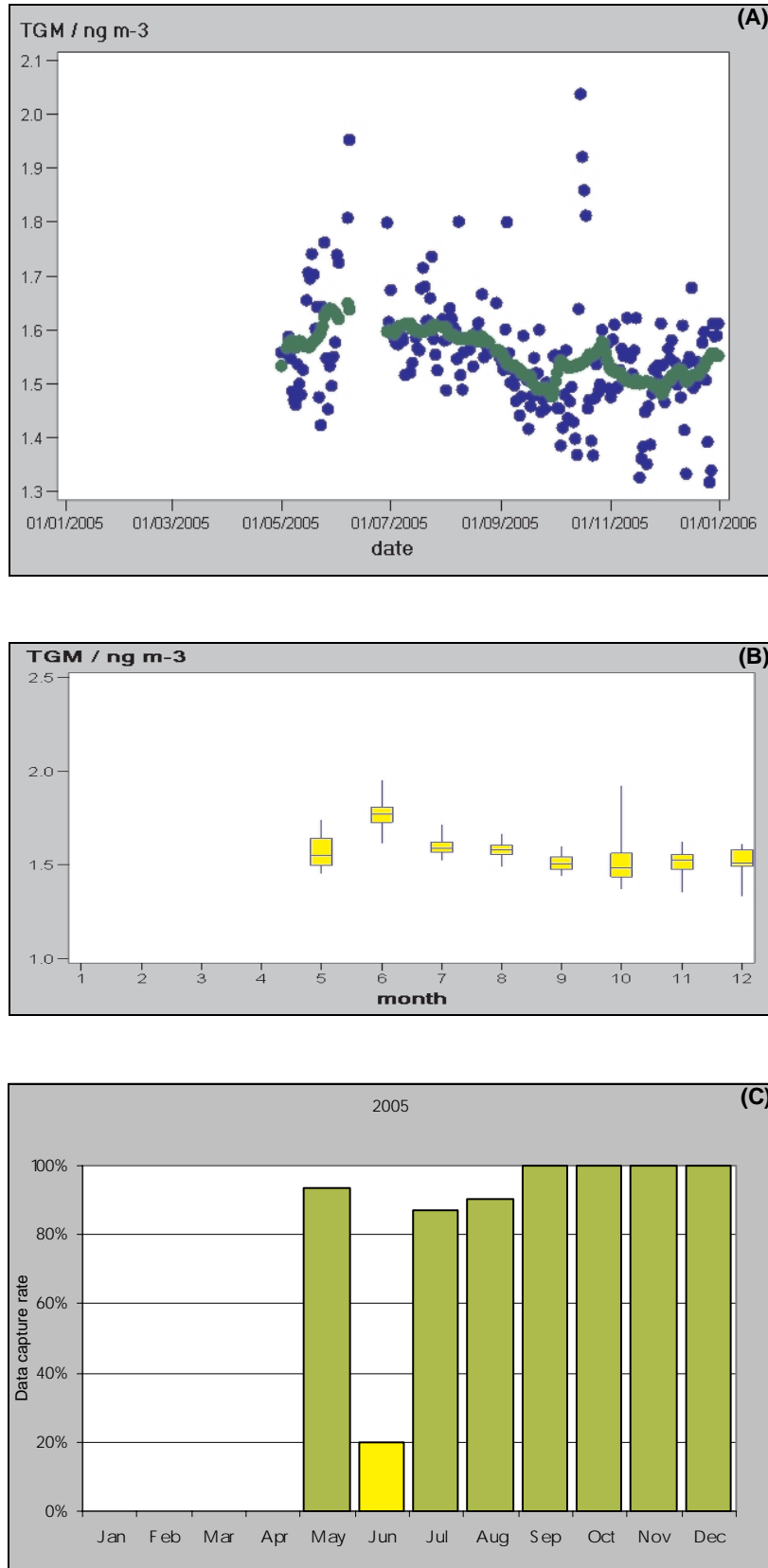


Figure B22. (A) Time series, daily values (blue) and 28-day running average (green) for total gaseous mercury (TGM). (B) Statistics for each month of 2005, with the mean, quartiles (box), and 5/95% quartiles (whiskers) for total gaseous mercury (TGM). (C) Data capture rate for each month (yellow indicates <80%).

## B12 Total Gaseous Mercury at Mace Head, 2006

There was a 3-week break in measurements late in the year.

The distribution of daily averages is somewhat skewed towards higher concentrations. There is a strong seasonal signal. A high concentration episode was observed in March, and low concentration events during June and September.

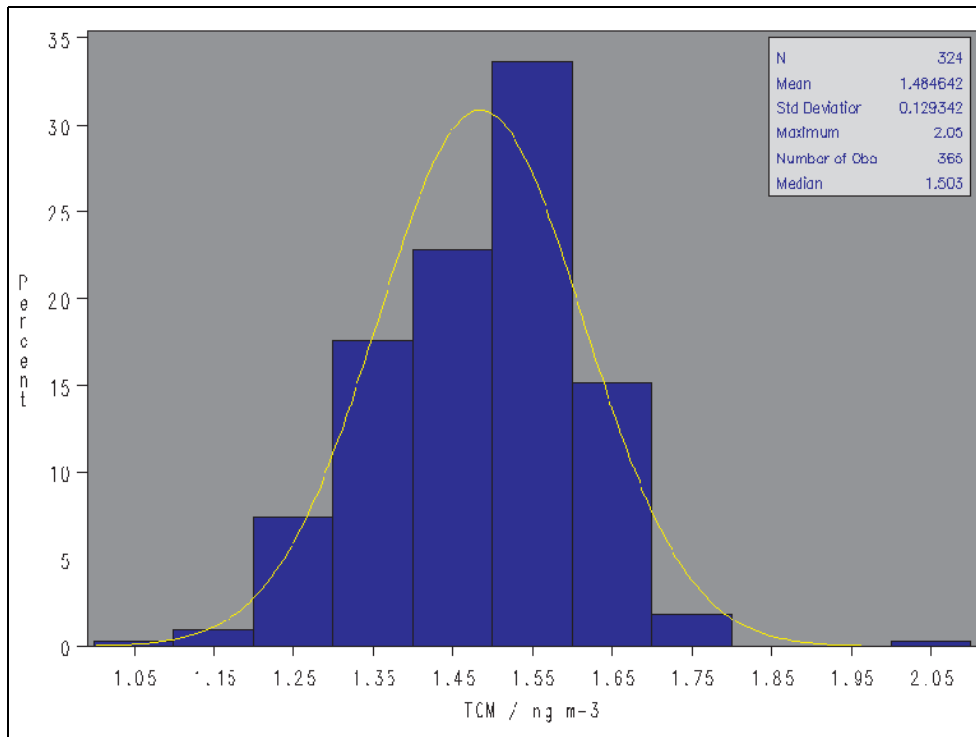
### Data Quality and Control

- The overall data capture rate was 89%.
- Operation was normal until September.
- Two separate data outages caused monthly capture rates for September to November to fall to between 60 and 70%
- 20 September–14 October: deactivation of gold trap led to some unreliable measurements.

- 17–27 October: some interruption for system upgrade, including new data acquisition software.
- 12–20 November: instability of internal power supply for UV light source caused problems.
- Scheduled maintenance and calibration procedures account for the remaining few data gaps.

**Table B13. Summary statistics for TGM at Mace Head, 2006.**

<b>Average daily mean</b>	1.48 ng/m <sup>3</sup>
<b>Standard deviation</b>	0.13 ng/m <sup>3</sup>
<b>Minimum daily mean</b>	1.07 ng/m <sup>3</sup>
<b>Maximum daily mean</b>	2.05 ng/m <sup>3</sup>
<b>No. days operation</b>	324



**Figure B23. Frequency distribution of daily mean values for 2006.**

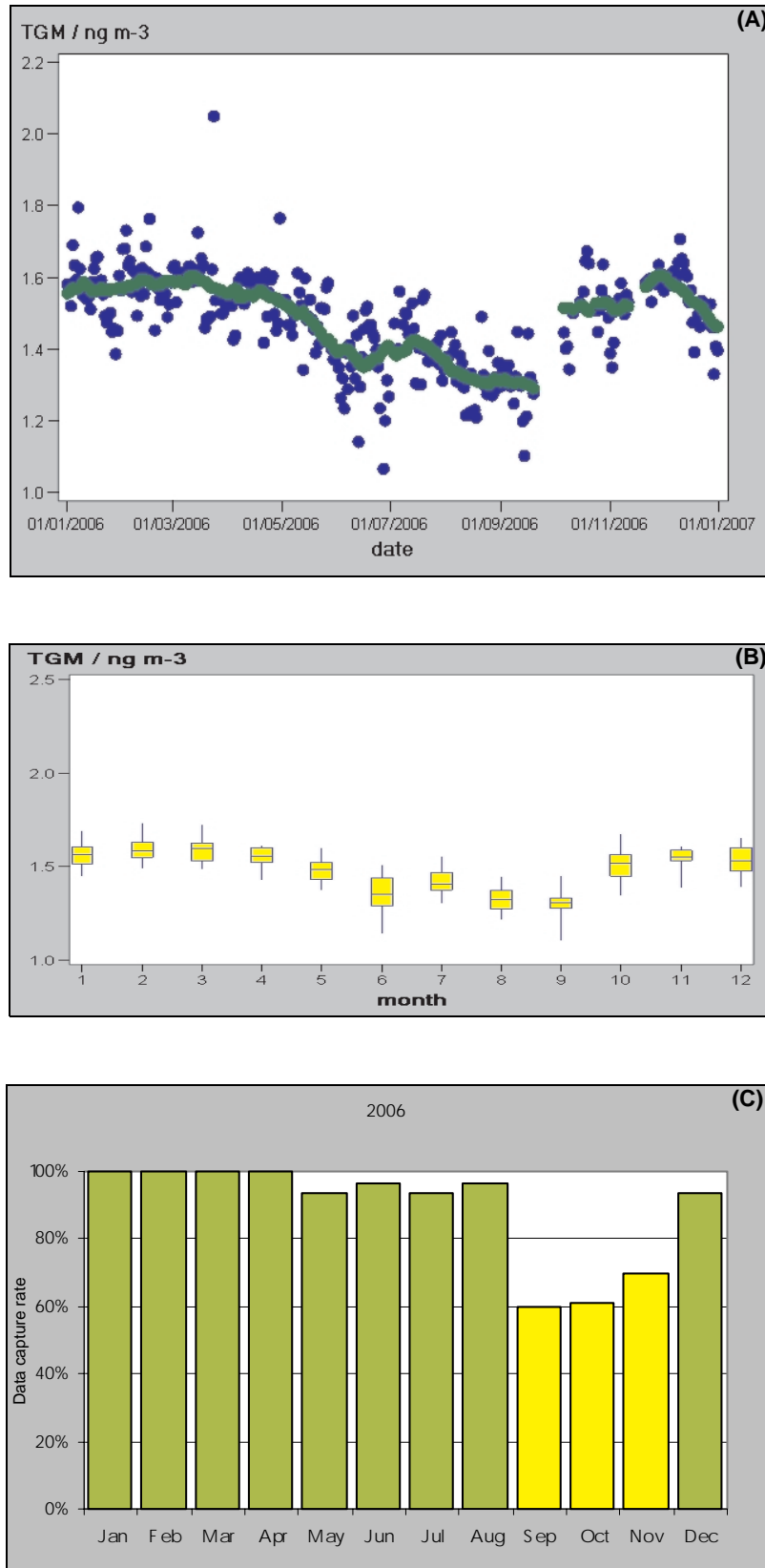


Figure B24. (A) Time series, daily values (blue) and 28-day running average (green) for total gaseous mercury (TGM). (B) Statistics for each month of 2006, with the mean, quartiles (box), and 5/95% quartiles (whiskers) for total gaseous mercury (TGM). (C) Data capture rate for each month (yellow indicates <80%).

## Appendix C Provisions of the Daughter Directive 2004/107/EC Relevant to Background Monitoring of Mercury

Article	Section	Provision	Comment
0	5	Disproportionate costs	Mace Head is an existing atmospheric research facility. The EPA supports the cost of measurement of mercury
3	5	Measurement scheme	Continuous measurement at fixed site
3	9	Background monitoring 1 site per 100,000 km <sup>2</sup>	Ireland requires 1 site
3	9	Co-ordination with EMEP	Yes
3	9	Site location Annex III Section I	Mace Head at a remote location with no known anthropogenic sources within several kilometres
3	9	Site location Annex III Section III	Mace Head is a Global Atmospheric Watch site. Most recent review of activities was published in 2006
3	12	Data quality objectives	Data capture is reported and recommendations have been made to ensure continued optimum site operation
3	13	Sampling methods Annex V Paragraph III	Atomic Fluorescence Spectrometry is used at Mace Head

# An Ghníomhaireacht um Chaomhnú Comhshaoil

Is í an Ghníomhaireacht um Chaomhnú Comhshaoil (EPA) comhlachta reachtúil a chosnaíonn an comhshaoil do mhuintir na tíre go léir. Rialaímid agus déanaimid maoirsiú ar ghníomhaíochtaí a d'fhéadfadh truailliú a chruthú murach sin. Cinntimid go bhfuil eolas cruinn ann ar threochtaí comhshaoil ionas go nglactar aon chéim is gá. Is iad na príomh-nithe a bhfuilimid gníomhach leo ná comhshaoil na hÉireann a chosaint agus cinntiú go bhfuil forbairt inbhuanaithe.

Is comhlachta poiblí neamhspleách í an Ghníomhaireacht um Chaomhnú Comhshaoil (EPA) a bunaíodh i mí Iúil 1993 faoin Acht fán nGníomhaireacht um Chaomhnú Comhshaoil 1992. Ó thaobh an Rialtais, is í an Roinn Comhshaoil agus Rialtais Áitiúil a dhéanann urraíocht uirthi.

## ÁR bhFREAGRACHTAÍ

### CEADÚNÚ

Bíonn ceadúnais á n-eisiúint againn i gcomhair na nithe seo a leanas chun a chinntiú nach mbíonn astuithe uathu ag cur sláinte an phobail ná an comhshaoil i mbaol:

- áiseanna dramhaíola (m.sh., líonadh talún, loisceoirí, stáisiúin aistriúcháin dramhaíola);
- gníomhaíochtaí tionsclaíocha ar scála mór (m.sh., déantúsaíocht cógaisíochta, déantúsaíocht stroighne, stáisiúin chumhachta);
- diantalmhaíocht;
- úsáid faoi shrian agus scaoileadh smachtaithe Orgánach Géinathraithe (GMO);
- mór-áiseanna stórais peitreal.

### FEIDHMIÚ COMHSHAOIL NÁISIÚNTA

- Stiúradh os cionn 2,000 iniúchadh agus cigireacht de áiseanna a fuair ceadúnas ón nGníomhaireacht gach bliain.
- Maoirsiú freagrachtaí cosanta comhshaoil údarás áitiúla thar sé earnáil - aer, fuaim, dramhaíl, dramhuisce agus caighdeán uisce.
- Obair le húdaráis áitiúla agus leis na Gardaí chun stop a chur le gníomhaíocht mhídhleathach dramhaíola trí chomhordú a dhéanamh ar líonra forfheidhmithe náisiúnta, díriú isteach ar chiontóirí, stiúradh fiosrúcháin agus maoirsiú leigheas na bhfadhbanna.
- An dlí a chur orthu siúd a bhriseann dlí comhshaoil agus a dhéanann dochar don chomhshaoil mar thoradh ar a ngníomhaíochtaí.

### MONATÓIREACHT, ANAILÍS AGUS TUAIRISCIÚ AR AN GCOMHSHAOIL

- Monatóireacht ar chaighdeán aer agus caighdeán aibhneacha, locha, uisce taoide agus uisce talaimh; leibhéal agus sruth aibhneacha a thomhas.
- Tuairisciú neamhspleách chun cabhrú le rialtais náisiúnta agus áitiúla cinntiú a dhéanamh.

### RIALÚ ASTUITHE GÁIS CEAPTHA TEASA NA HÉIREANN

- Cainníochtú astuithe gáis ceaptha teasa na hÉireann i gcomhthéacs ár dtiomantas Kyoto.
- Cur i bhfeidhm na Treorach um Thrádáil Astuithe, a bhfuil baint aige le hos cionn 100 cuideachta atá ina mór-ghineadóirí dé-ocsaíd charbóin in Éirinn.

### TAIGHDE AGUS FORBAIRT COMHSHAOIL

- Taighde ar shaincheisteanna comhshaoil a chomhordú (cosúil le caighdeán aer agus uisce, athrú aeráide, bithéagsúlacht, teicneolaíochtaí comhshaoil).

### MEASÚNÚ STRAITÉISEACH COMHSHAOIL

- Ag déanamh measúnú ar thionchar phleananna agus chláracha ar chomhshaoil na hÉireann (cosúil le phleananna bainistíochta dramhaíola agus forbartha).

### PLEANÁIL, OIDEACHAS AGUS TREOIR CHOMHSHAOIL

- Treoir a thabhairt don phobal agus do thionscal ar cheisteanna comhshaoil éagsúla (m.sh., iarratais ar cheadúnais, seachaint dramhaíola agus rialacháin chomhshaoil).
- Eolas níos fearr ar an gcomhshaoil a scaipeadh (trí cláracha teilifíse comhshaoil agus pacáistí acmhainne do bhunscoileanna agus do mheánscoileanna).

### BAINISTÍOCHT DRAMHAÍOLA FHORGHNÍOMHACH

- Cur chun cinn seachaint agus laghdú dramhaíola trí chomhordú An Chláir Náisiúnta um Chosc Dramhaíola, lena n-áirítear cur i bhfeidhm na dTionscnamh Freagrachta Táirgeoirí.
- Cur i bhfeidhm Rialachán ar nós na treoracha maidir le Trealamh Leictreach agus Leictreonach Caite agus le Srianadh Substaintí Guaiseacha agus substaintí a dhéanann ídiú ar an gcrios ózóin.
- Plean Náisiúnta Bainistíochta um Dramhaíl Ghuaiseach a fhorbairt chun dramhaíl ghuaiseach a sheachaint agus a bhainistiú.

### STRUCHTÚR NA GNÍOMHAIREACHTA

Bunaíodh an Ghníomhaireacht i 1993 chun comhshaoil na hÉireann a chosaint. Tá an eagraíocht á bhainistiú ag Bord lánaímseartha, ar a bhfuil Príomhstíúrthóir agus ceithre Stíúrthóir.

Tá obair na Ghníomhaireachta ar siúl trí ceithre Oifig:

- An Oifig Aeráide, Ceadúnaithe agus Úsáide Acmhainní
- An Oifig um Fhorfheidhmiúchán Comhshaoil
- An Oifig um Measúnacht Comhshaoil
- An Oifig Cumarsáide agus Seirbhísí Corparáide

Tá Coiste Comhairleach ag an nGníomhaireacht le cabhrú léi. Tá dáréag ball air agus tagann siad le chéile cúpla uair in aghaidh na bliana le plé a dhéanamh ar cheisteanna ar ábhar imní iad agus le comhairle a thabhairt don Bhord.

The EPA's Environmental Research Centre (ERC) was established as a centre of excellence under the National Development Plan 2000-2006. The ERC allows for a more structured approach to environmental research and provides for stronger environmental support to the NDP. The objectives of the ERC are:

- ◆ to allow for a more structured approach to environmental research,
- ◆ through the development of advanced innovative techniques and systems,
- ◆ and addressing priority environmental issues,
- ◆ thereby supporting environmentally sustainable development.

