ENVIRONMENT AGENCY

NATIONAL CENTRE FOR ECOTOXICOLOGY & HAZARDOUS SUBSTANCES

ALGAL MONITORING REPORT 1999

Report summarising freshwater (cyanobacterial) and marine microalgal monitoring during 1999

ENVIRONMENT AGENCY

CONTENTS

SUMMARY

- This report describes continuing work carried out by the Environment Agency of England and Wales, on monitoring and managing freshwater algal (primarily cyanobacterial) and marine microalgal incidents during 1999, and also discusses Regional differences and temporal trends during recent years. Data were collated from the National Algal Contacts Group by the National Centre for Ecotoxicology & Hazardous Substances.

- Freshwater algal monitoring indicated similar frequency and distribution of affected sites to past years. The majority of sites were in central and south-east England. Cyanobacteria were the dominant group, with two-thirds of water bodies sampled containing cyanobacteria. The warning threshold was exceeded in three-quarters of samples where cyanobacteria were present. In 1999 however, the total number of sites sampled was the lowest yet (256), primarily the result of fewer old sites being re-sampled (those sites containing cyanobacteria in past years). This may indicate that owners of affected sites, where problem have persisted annually, and the public, may be more aware of cyanobacterial problems, with fewer enquiries directed to the Agency.

- Toxicity analysis and assessment for cyanobacterial toxins continues by the University of Dundee for the Agency. In 1999, 38 samples were sent for toxicity analysis and assessment, similar in frequency to past years. Results affirm findings from past years, indicating high incidence of toxicity and demonstrating the need to regard all cyanobacterial species and strains as capable of producing toxins, and hence as a threat to animal and human health and safety. Research is continuing into cyanobacteria, namely into factors promoting their growth and factors influencing cell toxicity.

- Marine algal monitoring indicated similar frequency and distribution of affected sites to past years. The majority of bathing waters, coastal waters and estuaries sampled, stretched between Environment Agency Wales' coast, along the SW coast towards Southern Region. The total number of sites monitored however has continued to decline annually, from 615 in 1992 to 149 during 1999. The percentage of monitored sites containing nuisance algae remains high, with two-thirds of sites containing nuisance species, but only 3 incidences of potentially toxic algae were recorded during 1999, solely from SW Region.

- There is an evident decline in the Agency's algal monitoring efforts indicated by a reduction in the freshwater monitoring programme (decline in the number of 'old' sites resampled and number of sites sampled routinely), and by a reduction of the total number of sites sampled under the marine monitoring programme. The Agency's approach to algal monitoring is to be reviewed during 2000 and 2001 as part of a wider review of monitoring undertaken under the Agency's strategy on eutrophication.

- Many complex biological/chemical/physical factors influence frequency and distribution of algae, and which are unlikely to be mutually exclusive. Moreover, the monitoring programmes are based on a reactive nature rather than a comprehensive monitoring programme. Marine monitoring programmes and frequencies also vary regionally, and consequently, sites that do not have visible algal blooms present are unlikely to be monitored. Owners and the public may also indicate increased alertness and or awareness of algal blooms/scums; hence sites may be reported with varying frequencies. As a result, the use (in isolation) of these data as a robust indicator of the incidences of fresh and marine algae, and extent of eutrophication must therefore be treated with caution.

- Excessive growths of algae and cyanobacteria are exacerbated by eutrophication, which can cause adverse effects on the ecology and uses of affected waters. Moreover, the toxins produced by cyanobacteria and marine algae give rise to acute and chronic implications for human and animal health, especially for those whose condition may already be compromised. The Agency has therefore identified nutrient enrichment as one of its key issues to be tackled in respect of water quality in England and Wales, and has published its eutrophication management strategy to address such problems. This comprises national action to reduce nutrient inputs to water, complemented by local, catchment level efforts centred around eutrophication control action plans, to test and refine tools and techniques for assessing and managing eutrophication.

1. INTRODUCTION

A fundamental aspect of the Environment Agency's work is to monitor and assess the state of the environment. The Agency achieves this through a framework of 6 basic 'Viewpoints' (Land Use and Resources; Biological Populations, Communities and Biodiversity; Standards and Targets; Health of the Environment; Long Term Reference Sites; and Aesthetic Quality). These provide information on the state of the environment in order to answer questions and identify areas for further monitoring and surveillance. The monitoring programmes for freshwater and marine algae contribute to the data need in assessing the health of the freshwater and coastal environments (Environment Agency 1998, 1999a).

The potential toxic threat of blue-green algae (cyanobacteria) and their toxins, and their aesthetic impact on freshwaters, has wide implications for the Agency's activities, roles, and responsibilities (NRA, 1990a). Similarly, nuisance marine algae and the potential toxic threat of certain marine algal species (mainly dinoflagellates) has similar implications for the Agency, which maintains coastal water quality for three nautical miles offshore, monitors bathing water quality and assesses the aesthetic quality of beaches. Past reports have discussed issues in depth (Environment Agency, 1999b, 2000b).

The Agency, and its predecessor the National Rivers Authority, commenced an assessment of the incidence of potentially toxic and nuisance freshwater algae in 1989, and made recommendations for future monitoring and control measures (NRA, 1990b; NRA, 1991). Similarly, the Agency has routinely collated information since 1991 from all Regions regarding marine microalgal monitoring and management of incidents (Environment Agency, 2000b).

All information from the monitoring programmes is collated by Regional Algal Contacts and sent to the National Centre for Ecotoxicology and Hazardous Substances (NCEHS) for reporting via completed annual questionnaires. Data have been summarised into reports available from NCEHS (Environment Agency, 1999b; 2000b). Details of the monitoring programmes are available from the Algal Scientist, NCEHS and Regional Algal Contacts. Marine procedures are outlined in Lewis (1997).

1.2 Purpose of this report

Previous reports have reported separately on the annual freshwater and marine algal monitoring programmes and results (Environment Agency, 1999b, 2000b). This report summarises the results of the Agency's monitoring and management of freshwater and marine algal incidents during 1999, and discusses Regional differences and temporal trends in recent years.

2. FRESHWATER ALGAL AND CYANOBACTERIAL MONITORING

The Agency carries out algal monitoring in response to external enquiries received (from owners, water users and the general public from all freshwater habitats), as part of a reactive monitoring programme. Reactive monitoring is divided into 'new sites' that have no records of cyanobacteria being present, and 'old sites' where historically cyanobacteria were present (Environment Agency, 1999b). In addition to the reactive monitoring approach, certain sites are sampled routinely and as part of a long-term monitoring programme, to provide results in response to specific regional/area issues, and to attempt to provide a minimal national picture of geographical and temporal cyanobacterial population fluctuations, respectively.

2.1 Regional fluctuations between 1995-1999

Waterbodies sampled reactively for the first time (new sites), and those sampled reactively in the past which were subsequently re-sampled (old sites)

Results are shown below in Figure 1 corresponding to 'new' sites, and Figure 2 corresponding to 'old sites'. The total number of waterbodies are divided into those which contained cyanobacteria as the dominant group, and those where cyanobacteria were absent.

No discernible trends are evident in the regional variations in the number of sites sampled reactively for the first time, and in the number of sites that were subsequently re-sampled. The highest number of sites sampled are evident in Anglian, Midlands, South West and Thames Regions, and lowest in Southern Region. A complete list of the waterbodies sampled Regionally and their details are available from NCEHS on request.

2.2 Annual fluctuations

In 1989, initial monitoring resulted in 909 waterbodies sampled, although it was difficult to know precisely how often many waters were visited or how many samples were taken. In 1990, a total of 1,724 waterbodies were sampled, which consisted of a mixture of reactive and routine monitoring, hence a direct comparison with subsequent years is difficult (Environment Agency, 1999b).

Annual fluctuations between 1991-1999

Since 1991, a total of 3,001 sites have been sampled as part of the reactive monitoring programme, of which 2,082 were sampled for the first time (new sites) and 919 resampled in past years (old sites).

The annual fluctuations in the total number of waterbodies sampled by the Agency between 1991-1999, the total number of sites where cyanobacteria were present, and the total number where the warning threshold was exceeded is shown in Figure 3. The Agency warning thresholds are used as action levels above which there is risk of bloom formation, which indicate a likely risk to users of the waterbody.

Approximately three-quarters of the total number of sites sampled contained cyanobacteria, of which three-quarters exceeded the warning threshold.

Figure 1 below. Regional fluctuations in the total number of waterbody sites sampled reactively for the first time between 1995-1999 (new sites).

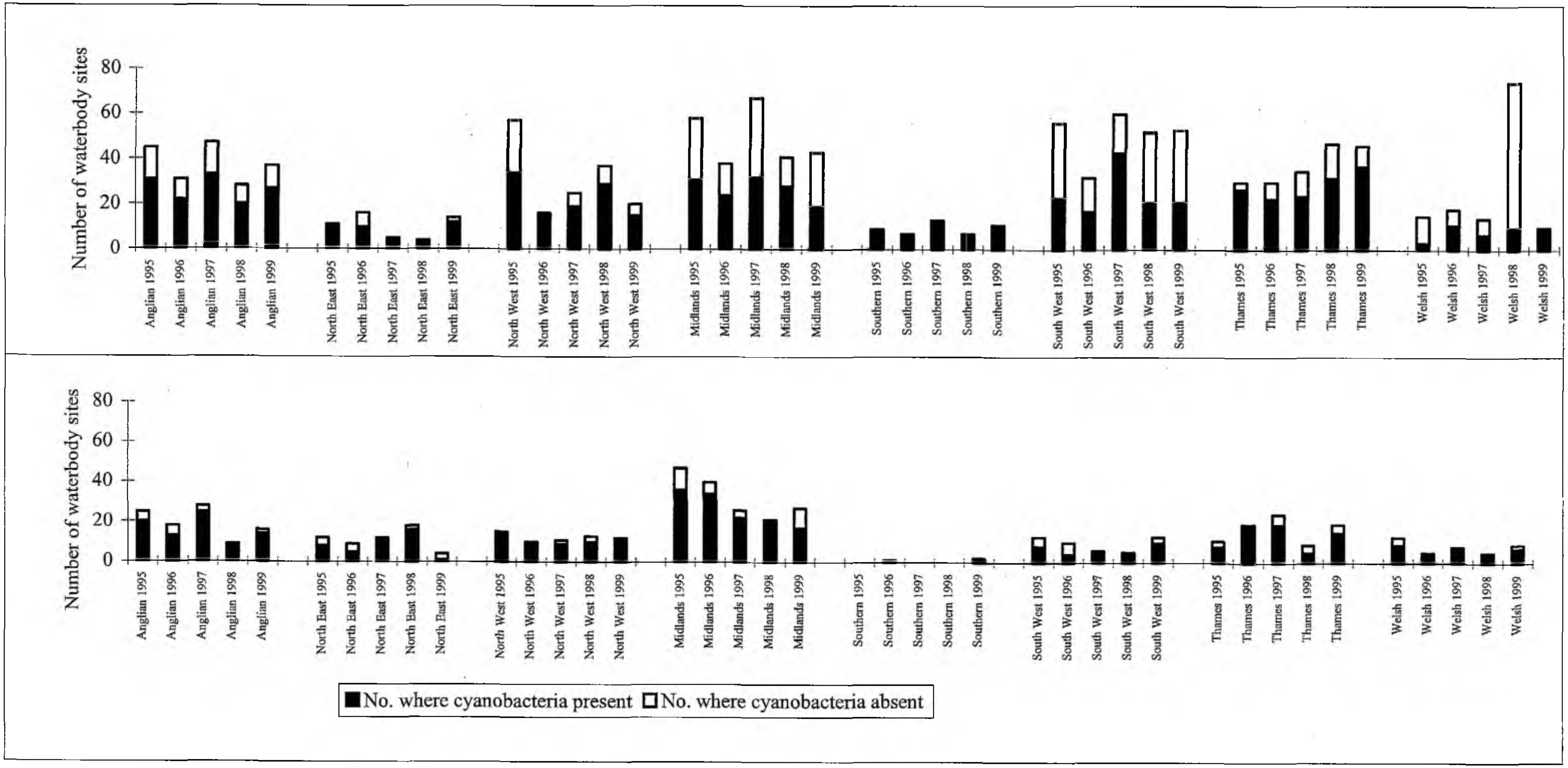


Figure 2 above. Regional fluctuations in the total number of waterbody sites sampled in the past that were subsequently resampled between 1995-1999 (old sites).

Figure 3. Total number of waterbody sites sampled in response to external enquiries as evident by visible algal problems between 1995-1999.

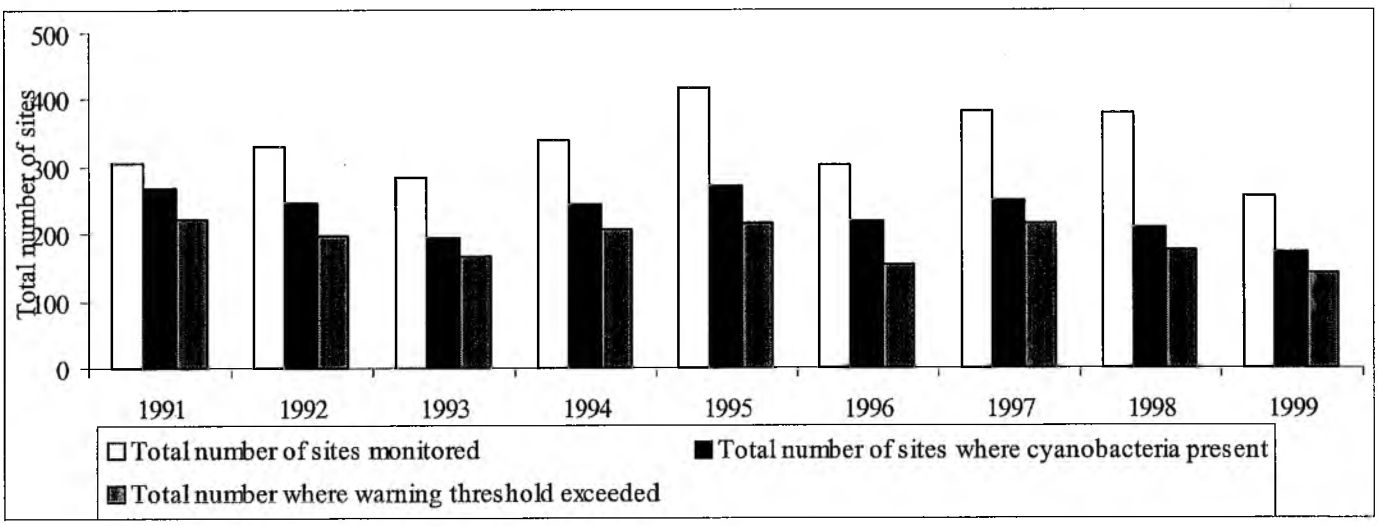


Table 1 below indicates split between the total number of sites sampled annually for the first time and those that were sampled before.

Table 1. Incidents of sites sampled reactively between 1991-1999.

Year	Total number of waterbodies sampled as part of the reactive monitoring programme	Total number of waterbodies sampled for the first time (and expressed as a percentage of the total), 'new sites'	Total number of waterbodies sampled in past years and re-sampled during the year, 'old sites'
1991	306	216 (71%)	90
1992	331	218 (66%)	113
1993	284	201 (71%)	83
1994	341	217 (64%)	124
1995	417	281 (67%)	136
1996	302	190 (63%)	112
1997	384	269 (70%)	115
1998	380	300 (79%)	80
1999	256	190 (74%)	66

The total number of sites sampled annually fluctuates between 300-400 sites per year, and those sampled for the first time represented the highest proportion. The lowest total number of sites sampled was recorded in 1999 however (256), which can be attributed to the lower number of sites sampled in the past that were subsequently re-sampled, which has continued to decline over recent years from 136 in 1995 to 66 in 1999.

2.3 Waterbodies sampled routinely

This includes waterbodies sampled as on-going investigations for specific regional and area requirements.

Similar trends are evident as recorded in the past, with continuing high incidences of cyanobacteria and a high proportion where warning thresholds were exceeded (Environment Agency, 1999b). Moreover, results indicate a continued decline in the number of sites sampled routinely from 137 in 1991 to 15 in 1999 (Table 2).

Table 2. Summary of the number waterbodies sampled routinely between 1991-1999.

Year	Number of waterbodies sampled	Number which contained cyanobacteria (and expressed as a percentage of the total)	Number where warning threshold exceeded (and expressed as percentage of those sampled)	Number where bloom/scum was present (and expressed as percentage of those sampled)
1991	137	101 (74%)	71 (70%)	44 (44%)
1992	69	43 (62%)	31 (72%)	23 (53%)
1993	80	61 (76%)	60 (98%)	40 (66%)
1994	70	50 (72%)	36 (72%)	46 (92%)
1995	44	35 (80%)	22 (63%)	16 (46%)
1996	39	26 (67%)	12 (46%)	20 (77%)
1997	33	27 (82%)	19 (70%)	21 (78%)
1998	21	18 (86%)	12 (66%)	6 (33%)
1999	15	8 (53%)	4 (50%)	5 (62%)

In Southern Region, no sites were routinely sampled, and in Anglian, extensive reservoir monitoring by the Region continued until the spring of 1999, but has subsequently been terminated.

In Midlands, monitoring is continuing at Colmere, The Mere, Whitemere and Crosmere between January-November. In North East, Green Lee Lough is monitored monthly, and is also the region's long-term monitoring site. In North West, Preston Docks continues to be monitored at a weekly frequency. In South West, Loe Pool (sampled between February-November) and Upper Tamar Lake (sampled between February-November) continue to be monitored. In Thames, following the Hungerford Incident (Johnson *et al.*, 1998), the Kennet & Avon canal (between locks 68 & 72) was sampled at a daily and weekly frequency between February – June 1999. In addition, fortnightly monitoring on the river Thames continues at 4 sites (Inglesham, Abingdon, Caversham and Windsor). In Environment Agency, Wales, Llyn Padarn and Llyn Tegid are monitored fortnightly.

A collaborative R&D project is continuing in Anglian at a series of gravel pits in Whisby Nature Reserve. This is due to complete in 2002. Biomanipulation is trialed by switching the fish populations in two of the gravel pits, in an effort to understand and explore 'top-down' control of the lake food web and to enhance the use of this technique in the management of eutrophication.

2.4 Long-term monitoring

Currently, each Region monitors one unmanaged site (defined as a site with no nutrient reduction or destratification measures) where cyanobacterial blooms have previously been recorded, in order to provide a minimal national picture of geographical and temporal change in terms of cyanobacterial populations. Long-term monitoring is monthly and continuous, whereas routine sampling is generally weekly or fortnightly (Environment Agency, 1999b)

The long-term monitoring programme is associated with programmes agreed at National level by the Agency and implemented in all Regions. Monitoring has continued in Anglian (Filby Broad); Midlands (Upper, Lower and Millshrub Bittell reservoirs); North East (Greenlea Lough); North West (Pennington Flash); Southern (Weir Wood reservoir); South West (Chilton Trinity Lake); Thames (Farmoor I reservoir); and Environment Agency Wales (Llyn Coron).

In addition, in South West, Combwich lakes, near Bridgewater have been monitored since 1999, and a site on the rive Frome, is sampled as part of the Environmental Change Network for an in depth study of diatoms. In Thames, two sites on the river Thames have also been monitored monthly since 1999, Littleton and Isleworth.

2.5 The extent of blooms and scums during 1999 compared to previous years

As past reports have indicated, this is very difficult to gauge with the available data.

North East, North West, Midlands, and Southern Regions reported similar frequency of blooms to past years, although North West reported that some blooms were recorded earlier in the year.

Anglian Region commented that the extent of blooms was average and similar to past years, and probably attributed to warm weather and low flows in rivers.

South West Region reported an increased frequency in blooms compared to previous years, and attributed this to increased number of reactive samples, particularly from rivers. Moreover, a bloom of *Gomphosphaeria* sp. was recorded in Wimbleball reservoir at the end of 1999, which persisted into early 2000.

Thames Region reported fewer incidents, attributing it to a relatively short season, and to fewer notifications by the public who appear to be better informed. In west area however, the number of incidents was highest, perhaps due to the high profile as a result of the Hungerford fish kill (Johnson *et al.*, 1998). In addition, a thick cyanobacterial scum was present for most of the year in sludge lagoons at Farmoor reservoir, and an extensive *Chroococcus* sp. scum/crust was recorded at Leatherhead Leisure Centre Boating lake.

Environment Agency Wales commented that incidents appeared to be more frequent than last year probably due to warmer, calmer weather, however, the total number of recorded incidents was lower than last year as shown from Figures 1 and 2. *Microcystis* was recorded at Bute East dock, Cardiff Bay, and the event featured in the national press. Similar blooms have been predicted to occur following the formation of the freshwater lake (Cardiff Bay Barrage), and various organisations have increased their awareness as a result.

2.6 Blooms in running waters

Planktonic cyanobacteria can occur in rivers under exceptional circumstances, during low flows or where they are seeded from upstream standing waters, however, they are unlikely to persist in flowing environments. Benthic cyanobacteria, forming microbial mats, may be more common than planktonic taxa in running waters.

Environment Agency Wales, reported mats of benthic *Oscillatoria* in small, pooled areas in Wonastow road Brook. Midlands Region reported an *Oscillatoria* mat in a ditch/tributary of Carrant brook.

Thames Region reported cyanobacterial presence at Filchamstead brook as a result of discharge from Farmoor WTW. A reoccurring problem was recorded at the Grand Union Canal, GUC, and cyanobacteria were also recorded in Salt Hill stream, originating from Stoke Park lake. Cyanobacterial blooms in the GUC were also recorded from Anglian Region.

South West Region reported unsightly brown algal mats at Mill Leat, Semington brook, and diatom blooms at various stretches of the river Stour, although they were less severe than in previous years

In North East Region, the river Coquet contained a short-lived *Aphanizomenon* scum, originating from Caistron gravel pits, whereas in Stainsby brook, *Aphanizomenon* was also recorded but levels were low. The latter originated from a small pond that contains regular cyanobacterial blooms.

2.7 Cyanobacterial toxicity

The University of Dundee continues to carry out R&D work for the Agency, on the fate and behaviour of cyanobacterial toxins, as part of the Technical Service Agreement whereby regions send samples to Dundee as and when deemed necessary (Codd, 1999).

2.8 Incidents as a result of toxicity

Samples from various regional waterbodies containing cyanobacteria, which were warranted for toxicity analysis and assessment, are summarised below (Table 3).

Table 3. List of waterbodies affected with cyanobacterial toxins during 1999.

Region and name of waterbody	Comments
Anglian	
Willowside lake, Woodridge, Suffolk	Water sample indicated positive toxicity and presence of 9.5µg/l microcystin-LR equivalent
Hintlesham lake, Suffolk	No toxicity indicated from water sample.
Needham Lake, Suffolk	No toxicity indicated from water and scum samples.
North West	
Caernwary Tarn	*Aphanizomenon* present – sample non-toxic.
Hollingworth lake	Microcystin found to be extremely toxic.
Clarence Park Lido	*Microcystis* and *Anabaena* were present, with acute hepatotoxicity detected, no signs of neurotoxicity detected.

Table 3 continued. List of waterbodies affected with cyanobacterial toxins during 1999

Region and name of waterbody	Comments
Southern	
Brooklands Lake	Toxicity indicated sub-lethal toxicity from benthic *Oscillatoria* present in lake. Although no swans died directly in lake, mortalities were thought to be attributed to cyanobacterial toxicity.
South West	
Mill Leat, Worton	No signs of cyanobacterial toxicity detected from benthic mat of *Oscillatoria*, although have not excluded possibility of trace levels of cyanobacterial toxins.
Chilton Trinity, Bridgewater	No indication of toxicity evident.
Thames	
Farmoor reservoir	Scum samples indicated acute toxicity from *Microcystis* sample.
Nature Discovery Centre, Thatcham	Scum sample indicated no toxicity
Cotswold Water Park	Water sample – no microcystins detected
Leatherhead Leisure Centre Boating lake	*Chroococcus* – sample was not toxic by bioassay and no microcystins were detected by HPLC-DAD.
Environment Agency Wales	
Llyn Tegid	*Anabaena flos-aquae* sample – microcystins detected that would present an acute health hazard.
Llwynfilly Lake	*Microcystis* scum indicated no toxicity.
Bute East Dock	Scum sample indicated positive result microcystins present. Dock inlet surface water also indicated presence of microcystin
Llys Y Fran reservoir	Sample was non-toxic.

2.9 Waters closed for recreational activities

Table 4 below, summarises information received concerning waterbodies known where activities (recreational and others) were suspended, or the site closed during 1999.

Table 4. Waterbodies where recreational activities were suspended or the site closed.

Region and name of waterbody	Comments
South West	
North Pond Dunwear	Fishing was suspended for a period during the summer months
North West	
Clarence Park Lido	Unknown what action was taken and over what the period.

Table 4 continued. Waterbodies where recreational activities were suspended or the site closed.

Region and name of waterbody	Comments
Midlands	
Hatfield Water Park Holme Pierrepont 2000m course Colwick Park West lake	Unknown duration frequency of closure
Southern	
Brooklands Lake Worthing	Local Borough Council still to decide whether to suspend rowing.
Environment Agency Wales	
Castle Ponds Pembroke	Algal bloom was flushed into Milford haven Waterway, although no complaints were received by EA, and unknown whether recreational activities were suspended
Bute East dock	Dragon boat racing was cancelled. Similar event organised for spring 2000, although unknown what action was taken by local council.
Thames	
Serpentine	Swimming was suspended until cyanobacterial concentrations declined below EA warning threshold limits.

3. MARINE MICROALGAL MONITORING

The occurrence of nuisance or potentially toxic marine algae is a natural phenomenon that has occurred throughout history, but there is an apparent trend of increasing frequency and distribution of marine microalgae world-wide (Hallegraef, 1998). This is generally attributed to a number of factors, namely, an increased scientific awareness of toxic species, increased utilisation of coastal areas for shellfisheries/fisheries, increased transport of cells, cysts and shellfish stock, and an increase in human activities and climatic conditions (exacerbated by eutrophication), which further stimulate blooms (Hallegraeff, 1995). These influences are unlikely to be mutually exclusive.

3.1 Monitoring frequency

In 1991, in response to increasing international concern over the effects of coastal eutrophication and the apparent increase of nuisance and potentially toxic marine algae around the UK coast, the Government accepted a review presented by the Marine Pollution Monitoring Management Group. This proposed a minimum core programme of marine monitoring for UK coastal waters. A phased programme of monitoring was subsequently introduced and adopted by the Agency consisting of two levels; 'Minimum Effort' and 'Best Endeavours' (Lewis, 1997; Environment Agency 2000b). This is not a comprehensive monitoring programme.

Furthermore, the monitoring programmes and frequencies vary regionally, and as such, sites are rarely investigated which do not have a visible algal bloom present. In addition, many complex biological/chemical/physical factors also influence frequency and distribution of marine algae (Hallegraeff, 1998; Reigman, 1998), hence the use (in isolation) of these data as a robust indicator of the incidence of marine algae, and extent of eutrophication, must be treated with caution.

The monitoring strategies and frequencies adopted regionally between 1996-1999 are summarised below (Table 5). No data are available prior to 1996.

Table 5. Regional summary of monitoring strategy and frequency.

Region	*Monitoring strategy*	*Monitoring frequency*
Anglian		
1996	Minimum effort + Sensitive areas	May-September
1997	Minimum effort + Sensitive areas	May-September
1998	Minimum effort + Sensitive areas	April-October
1999	Minimum effort + Sensitive areas	April-October
North East		
1996	Minimum effort + reactive monitoring	May-October
1997	Minimum effort + reactive monitoring	May-September
1998	Minimum effort + reactive monitoring	May-September
1999	Minimum effort + reactive monitoring	May-September
North West**		
1996	Minimum effort + reactive monitoring	April-September
1997	Minimum effort + reactive monitoring	May-September
1998	Minimum effort + reactive monitoring	February-November
1999	Minimum effort	June-September

Table 5 continued. Regional summary of monitoring strategy and frequency.

Region	Monitoring strategy	Monitoring frequency
Southern		
1996	Minimum effort	May-September
1997	Minimum effort	May-September
1998	Minimum effort	May-September
1999	Minimum effort	May-September
South West		
1996	Minimum effort	April-November
1997	Minimum effort + reactive	May-September
1998	Minimum effort + reactive monitoring	March-October
1999	Minimum effort	March-October
Thames		
1996	No monitoring	
1997	Minimum effort	May-September
1998	Minimum effort	Sites sampled for microbiology only – algal investigations not required
1999	Minimum effort	May-July
Wales		
1996	Best endeavours Minimum effort	April-July August-September
1997	Best endeavours Minimum effort	April- June July-September
1998	Best endeavours Minimum effort	April- June July-September
1999	Best endeavours Minimum effort	May-September

** Results from the Marine Biological and Chemical Consultants (MBCC, 1996; 1997; 1998).

In Anglian Region, phytoplankton samples have been collected since 1996 as part of the monitoring programme for the Urban Waste Water Treatment Directive (UWWTD). There are six Candidate Sensitive Areas on the Anglian coast. Plankton samples have been collected for cell counts and summary community analysis from these sites and adjacent coastal waters, in order to review the effects of hyper-eutrophication. Additional data have been collected from the Wash Embayment to support the UWWTD review and provide additional information for Habitats Directive requirements.

A degree of quality and comparability in measuring phytoplankton biomass, as chlorophyll *a*, and phytoplankton assemblages is required. In order to achieve these aims across Europe, BEQUALM project (Biological effects quality assurance in monitoring programmes) was set up in late 1998 amongst 12 European countries, including England and Wales. Within BEQUALM, inter-calibration exercises were set up, in order to set standard protocols that will help gain good and comparable data from sampling sites all over Europe. Certain Agency laboratories have taken part in this exercise, the results of which are yet to be reported. The project is scheduled to run until October 2001.

3.2 Regional fluctuations in monitoring between 1992-1999

No data are available prior to 1992. The total number of sites monitored in each Region between 1992-1999 and the number of sites with nuisance and potentially toxic algae are shown in Figure 4. Monitored sites included bathing and coastal waters, and estuaries. Information from Anglian region's Sensitive Areas work has been excluded from this analysis because the results are off-shore boat work and are not directly comparable with the on-shore bathing water sampling (details available in Patchell, 1999; 2000).

Potentially toxic marine algae include taxa as listed in Table 6.

Table 6. Notifiable toxic marine microalgal taxa.

CLASS	SPECIES
Bacillariophyceae	*Pseudo-nitzschia* spp.
Dinophyceae	*Alexandrium* spp., *Gymnodinium catenatum, Dinophysis acuminata, D. acuta, D. norvegica, Prorocentrum lima, Amphidinium carterae, Gyrodinium aureolum*
Haptophyceae	*Chrysochromulina polylepis, Prymnesium parvum*
Raphidophyceae	*Fibrocapsa japonica, Heterosigma akashiwo*

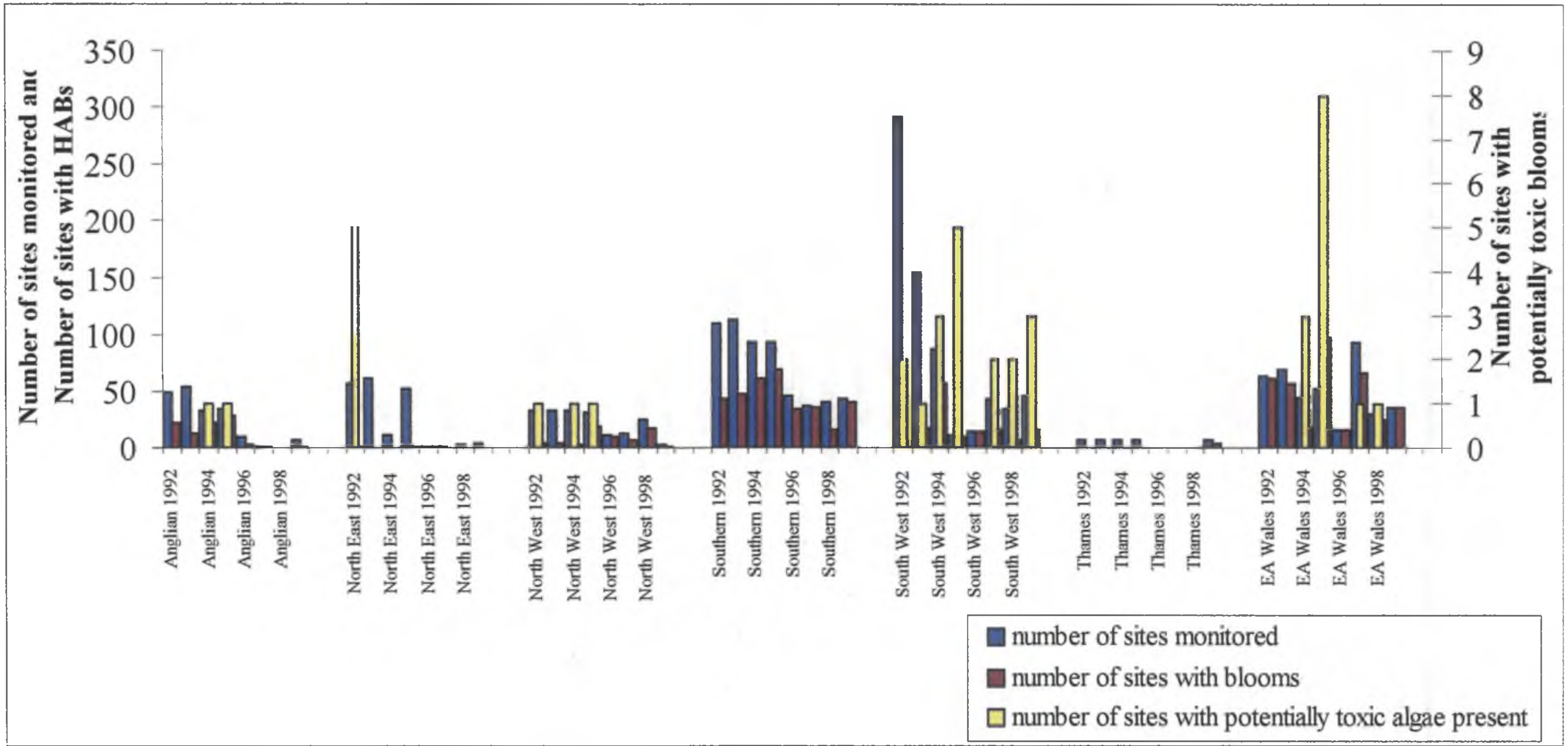
Although no discernible trend is evident regionally in the number of sites monitored, because of the variability in sampling strategies and frequencies, the highest number of sites monitored, and also the highest number of sites with nuisance algal blooms was indicated in Southern and South West Regions, and Environment Agency Wales. This may be attributed to a greater number of bathing waters and estuaries in these Regions than elsewhere, prolonged sampling periods and the use of the Best Endeavours monitoring programme. The lowest number of sites monitored, and hence sites with nuisance algae was indicated in Thames region, where there are very low number of bathing water sites and where the monitoring programme is also greatly reduced.

The distribution of selected nuisance and potentially toxic taxa and groups around the coast of England and Wales during 1999, from the minimum effort and best endeavours monitoring programmes, is shown in Figure 5. The selected taxa are:

- *Phaeocystis*, which forms nuisance foams, and was the most widespread,
- *Noctiluca*, which is also a nuisance species resulting in discolouration of the water and which may also be bioluminescent,
- *Alexandrium* and *Gymnodinium*, which are potentially toxic and cause paralytic shellfish poisonings (PSPs),
- *Gyrodinium*, which is ichthyotoxic and may result in death of marine organisms, and
- diatoms (including *Attheya*, *Chaetocerus*, *Asterionellopsis*), which are a nuisance, forming foaming on coasts, but which may also result in clogging and damage of fish gills, and hence cause fish mortalities.
- the remainder, including flagellates are recorded as Other.

Evidently, the most common taxa recorded was *Phaeocystis*. Potentially toxic algae (*Alexandrium* and *Gyrodinium*) were solely recorded in South West Region during 1999.

Figure 4. Regional summary of the total number of sites monitored, number of sites with marine algal blooms and the number of sites with potentially toxic algae, as reported by the Agency between 1992-1999.



In addition, SW reported macroalgae, Ulva (sea lettuce) from Holes Bay, Poole, and Ulva with Euglena from the Weymouth Sea Life Centre.

Figure 5. Distribution of selected taxa off the coast of England and Wales during 1999. Map provided by National Centre for Environmental Data and Surveillance.

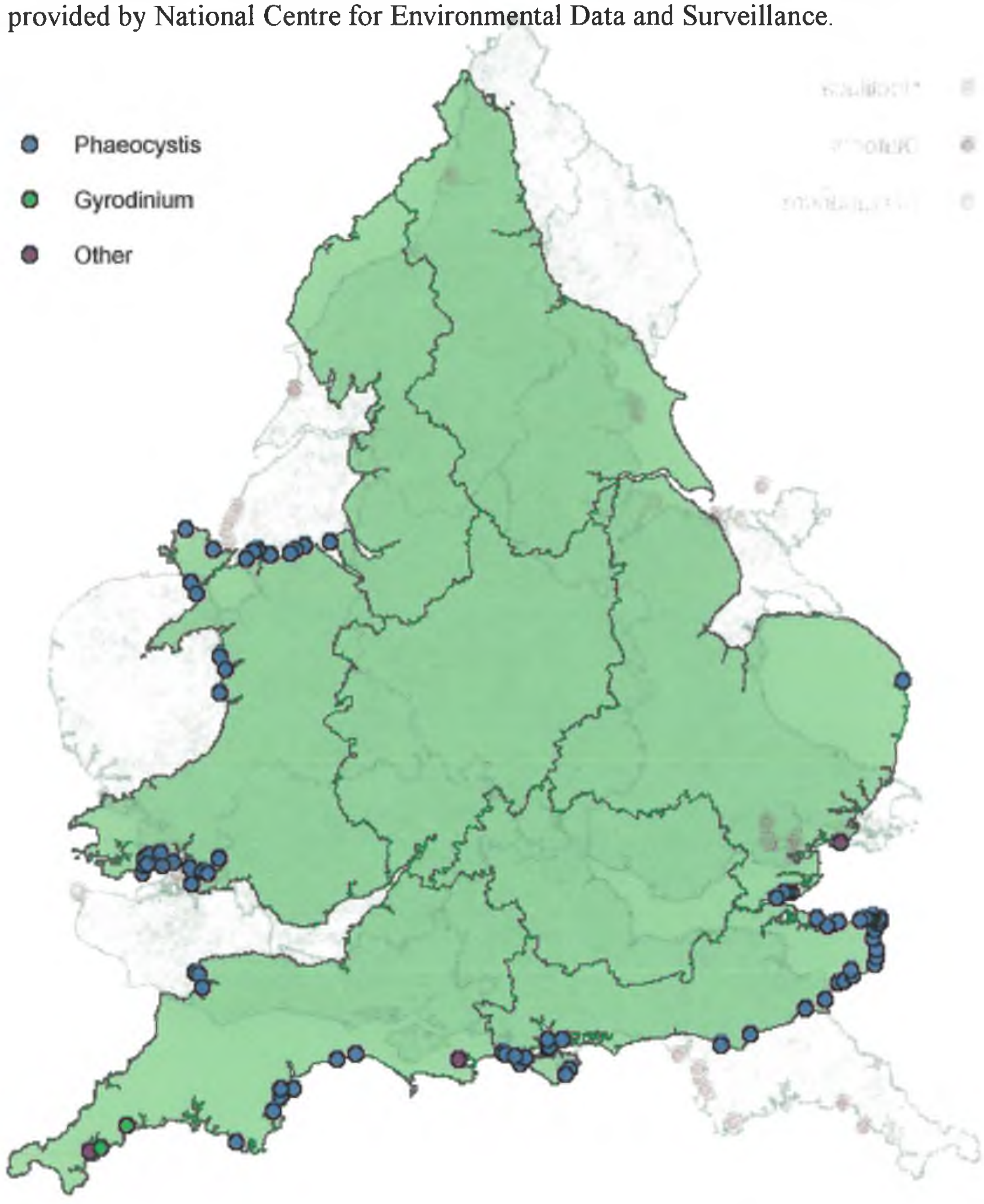
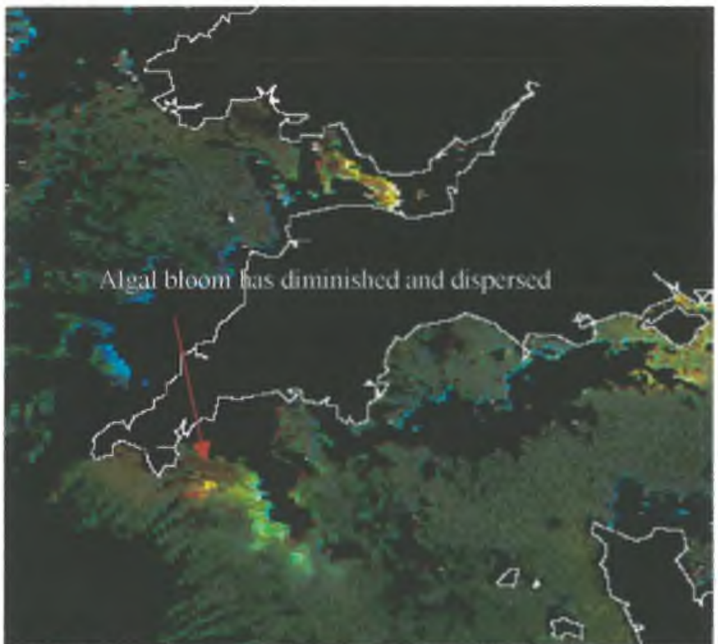


Figure 5 continued. Distribution of selected taxa off the coast of England and Wales during 1999. Map provided by National Centre for Environmental Data and Surveillance.

A significant bloom of the haptophyte *Emiliania huxleyi* was visible off the South west coast during 1999. Satellite imagery identified the bloom from the beginning of July, whereas by the end of August the bloom had dispersed (Figure 6).

Figure 6. Satellite imagery of the *Emiliania huxleyi* bloom from its maximum in 23 July, and its dispersal in 7 August, 1999.

Emiliania huxleyi bloom during 23 July, 1999



E. huxleyi bloom during 7 August, 1999.

SeaWiFS (sea-viewing wide field-of view satellite) images provided by the National Centre for Environmental Data and Surveillance. The off-shore black areas correspond to cloud cover.

3.3 Annual fluctuations between 1992-1999

The total number of sites monitored has continued to decline from a maximum of 615 in 1992 to 149 in 1999, and only 3 incidences of potentially toxic algae were reported during 1999 (Figure 7). Expressed as a percentage however, a high proportion of monitored sites were found to contain nuisance algae, as indicated in Table 7.

Figure 7. Annual fluctuations in the total number of sites monitored, the total number of sites with marine algal blooms and the total number of sites with potentially toxic algae, as reported by the Agency between 1992-1999.

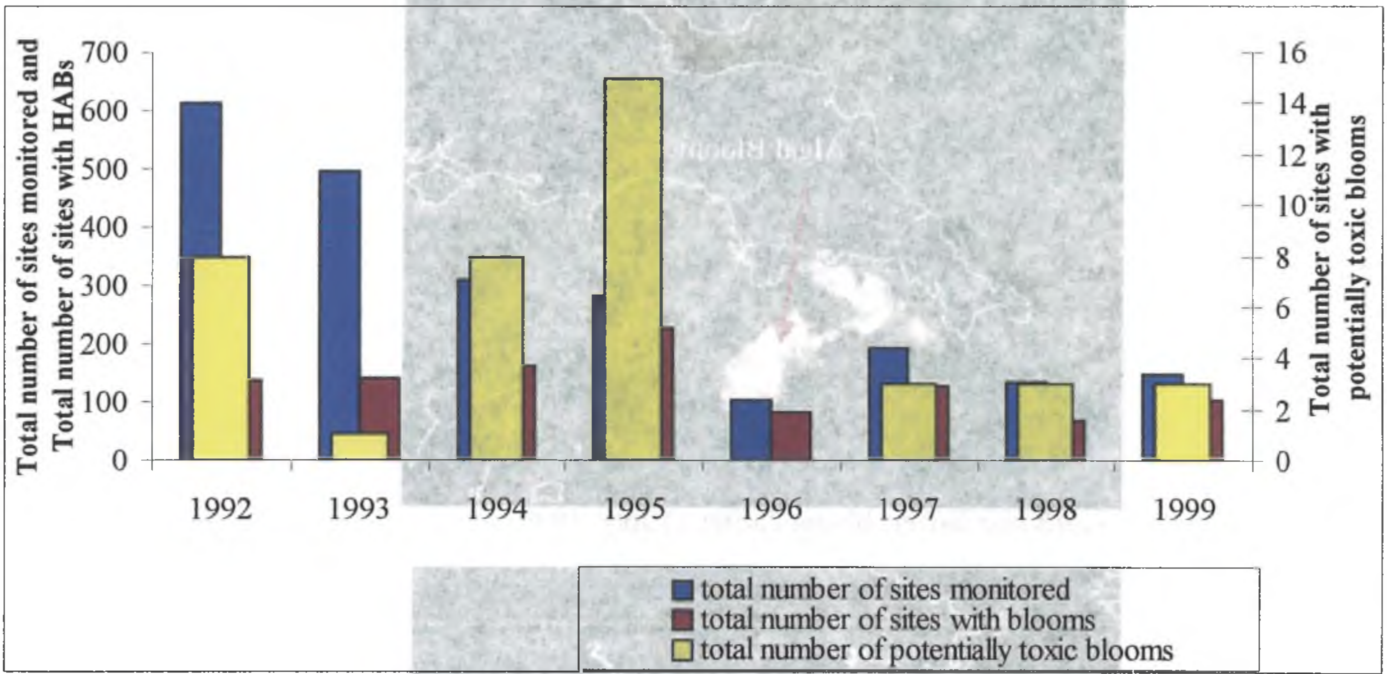


Table 7. Proportion of monitored sites containing nuisance algae.

Year	Percentage of sites monitored containing nuisance algae
1992	22
1993	29
1994	52
1995	80
1996	80
1997	65
1998	51
1999	68

3.4 The extent of blooms compared to past years

As past reports have indicated, this is very difficult to gauge with the available data (Environment Agency, 2000b). The collation of such data, and hence of sites affected by coastal eutrophication should however continue, since this is the best available national information.

Thames Region commented that results in species composition indicated temporal rather than spatial variation, whereas Anglian Region commented that the Sensitive Areas work will identify trends in marine algal frequency and extent of blooms.

North East Region reported increased media interest because of reported potential shellfish toxicity due to a marine bloom, and indicated that problems occur on smaller-scale and are becoming more frequent. The Region also reported that the Habitats Directive assessment provides an indication that eutrophication is becoming a bigger problem around the country, and therefore requires continued assessment.

In South West Region, the Fal estuary in Cornwall experienced exceptionally high cell counts this year, with the majority of samples taken in response to *Phaeocystis* blooms, which occur annually in spring. The region commented that marine blooms were less frequent in comparison to previous years.

North West Region reported an increased awareness of incidents this year and more were reported, although the results (Figure 4) indicated a lower frequency than last year.

Environment Agency, Wales reported a similar pattern in the frequency and duration of *Phaeocystis* blooms as indicated last year. Sites along the north Wales coast suffered a higher frequency of blooms than in Cardigan Bay. The Loughor estuary (Sensitive Waters Area) had a diatom bloom during spring, which was longer in duration than in past years. A diatom bloom was also recorded in Rhossili, and an exceptional *Noctiluca* bloom was evident in the Saundersfoot / Tenby area in June. A summary report detailing frequency of *Phaeocystis* and *Noctiluca* off north Wales's coastline is available from the Region (Environment Agency Wales, 1999).

Southern Region reported that, this year, marine algal bloom distribution and timing was typical of the pattern observed to many of previous years, although cell counts were lower. *Phaeocystis* developed around the Kent coastline during May and had extended up the Thames estuary 2 weeks later. The bloom had extended between the monitoring point at Sheerness and Hythe by the end of May. The *Phaeocystis* bloom also developed on the western approaches to the Solent during May, and to a lesser extent around the north and east coast off the Isle of Wight. Isolated blooms were recorded in Sussex. Last records were evident in June with dying colonies recorded. As an exception, *Asterionella* was not recorded around the Kent coast, although *Noctiluca* had been identified on one occasion.

3.5 Results of shellfish flesh monitoring

Requirements under the European Shellfish Hygiene Directive are met through a monitoring and surveillance programme in England and Wales, whereby water samples and samples of bivalve mollusc and other shellfish are collected from shellfish production areas and sites with recent histories of toxic algae problems. Monitoring and analysis of phytoplankton is carried out by Centre for Environment, Fisheries and Aquaculture Science, Lowestoft, whereas shellfish flesh analysis is carried out by Fisheries Research Services, Marine Laboratory, Aberdeen (CEFAS, 1999, Howard, 1999). This rolling monitoring programme was introduced in 1996 and currently covers all active shellfish harvesting sites and sites where toxic algal species were detected in recent years. Close liaisons take place between CEFAS and the Environment Agency.

The role of toxin production by some marine algae is not clear. Toxins may be produced as a protection against predation losses or as a survival strategy during periods of nutrient depletion. Resting spores of dinoflagellates for example may contain more toxin than the reproductive vegetative cells.

Marine biotoxin monitoring and surveillance results from the FRS MLA are presented in Howard (1999), and summarised below (Table 8).

Table 8. Summary of the total number of sites sampled for presence of PSP and DSP toxins in shellfish and fisheries areas in England and Wales between 1996-1999. ASP analysis commenced in 1999.

Year	Number of shellfish/fishing sites examined	Number of samples analysed for PSP, with positive results of PSP detected in parentheses	Number of samples analysed for DSP, with positive results of DSP detected in parentheses	Number of samples analysed for ASP, with positive results of ASP detected in parentheses
1996	22	214 (11)	110 (0)	
1997	28	269 (31)	146 (3)	
1998	30	254 (17)	184 (8)	
1999	30	287 (5)	200 (5)	255 (23)

4. EXTERNAL LIAISON AND COMMUNICATION

Algal blooms attract public attention resulting in the Environment Agency receiving enquiries about them. The Agency is not the competent authority for matters dealing with public health, therefore, liaison takes place between Environmental Health, Centre for Environment, Fisheries and Aquaculture Sciences, and the Ministry for Agriculture, Fisheries and Food when nuisance or potentially toxic algae are present. All queries were successfully dealt with, and there have been no complaints received concerning the Agency's approaches to dealing with algal incidents. Moreover, information on the Agency's approach to eutrophication and potentially toxic algae, and information detailing the responsibilities and actions of the organisations involved ensuring efficient implementation of duties, has been disseminated internally and to all relevant organisations. It has received positive feed-back.

The publicity material used by the Agency consists of information leaflets ('Blue-green Algae', 'Marine Algae', and 'Algae or Sewage – helping you to tell the difference'), and posters for Blue-green algae and Algae or Sewage. Regions commented that feedback is rarely received on the publicity material used.

Moreover, the Environment Agency's internet web site (environment-agency.gov.uk) is used to provide information on freshwater and marine algal and eutrophication issues, with similar information internally on the intranet.

5. REPORTED ALGAL CONTROL METHODS

Details have been reported from freshwater waterbodies. In Anglian, at Needham lake, artificial mixing was carried out, and various biomanipulation projects are continuing on the Norfolk Broads and at Whisby Nature Reserve, near Lincoln.

South West Region indicated that owners of small ponds have been advised on the use of barley straw, however, limited feedback is received on its effectiveness. Where feedback was received, ineffectiveness of barley straw was attributed to the incorrect placement of straw bales. Similarly, Southern Region reported limited success of barley straw use at Ferry pool, Sussex. North West Region also reported on unsuccessful use of barley straw in Preston docks. North East Region commented on the use of barley straw at Thryberg reservoir by the local council, with no cyanobacteria reported.

Biomanipulation and straw bales were used as part of Park Pools project in Midlands Region, in Stoke & Birmingham, and Sambourne trout pool continues to have straw bales although *Aphanizomenon* blooms continue to occur annually.

It is evident that use of barley straw is extensive, although it does not always seem effective. Agency staff should continue to follow guidelines as set out in the Policy on 'Blue-green algal monitoring and management of incidents', and advising, when required, that although barley straw has been shown to control algae in some waterbodies, it is not always effective and its mode of action is not yet fully understood.

6. THE EUTROPHICATION STRATEGY

Excess nutrient concentrations may lead to increased frequency of potentially toxic and nuisance algae, together with other adverse effects on the ecology and uses of waters, hence the need for control action. This process, termed eutrophication, was recognised by the Agency in its 1997 Environmental Strategy, is featured in the proposed Environmental Vision, and has been highlighted in the European Environmental Agency and Environment Agency state of the environment reports (European Environment Agency, 2000; Environment Agency 1998, 1999a). In response the Environment Agency has produced a eutrophication management strategy (Environment Agency, 2000a).

Existing Local Environment Agency Plans (LEAPS) have helped to identify eutrophication problems at local, catchment level, and building from this, the eutrophication strategy has selected a suite of pilot eutrophication control action plans (ECAPs), covering a variety of waterbody types, for managing local eutrophication issues at a catchment level. In addition, the eutrophication strategy will test and refine tools and techniques for assessing and managing eutrophication, which will be underpinned by national and international statutory drivers and commitments, namely the Urban Waste Water, Nitrates, and Habitat Directives, OSPAR, and the UK Biodiversity Action Plan (for mesotrophic and eutrophic standing waters). The Water Framework Directive will also, undoubtedly, influence the eutrophication strategy. Further details are available from the Agency, and the eutrophication management strategy document is available on the Internet (environment-agency.gov.uk), and so will not be discussed further.

Certain waterbodies sampled as part of the routine and the long-term monitoring programmes (and found to contain cyanobacteria), form part of the eutrophication control action plans. Llyn Tegid and Bittel reservoirs form part of the 'A' list where ECAPs will be introduced. The following waterbodies form part of the 'B' list, from which experience of eutrophication assessment and control action will be drawn from - Rutland, Grafham and Pitsford (where monitoring has ceased), Loe Pool, Llyn Padarn, Langstone and Chichester Harbours.

7. DISCUSSION AND CONCLUSIONS

Nutrients (their loadings and concentrations) are one of the main factors that influence algal growth, although there are many and complex biological/chemical/physical factors influencing algal development, as detailed in previous reports (Environment Agency, 1999b; 2000b).

It is evident that eutrophication is regarded as a priority water quality issue requiring action, and that algal growth is exacerbated by nutrient enrichment (eutrophication). Typically, excessive growths (blooms) consist of nuisance or potentially toxic algae, which are one of the visible symptoms of eutrophication. Cyanobacterial blooms are dominant in fresh waters but also occur in marine waters, whereas dinoflagellate blooms are dominant in marine waters. The Royal Commission on Environmental Pollution in the UK has also inferred the increased incidence of algal blooms, in particular cyanobacteria, to be widespread as a result of increasing cultural eutrophication (Royal Commission on Environmental Pollution, 1992), and English Nature indicated that eutrophication is adversely affecting many stillwater sites of special scientific interest, SSSIs (Carvalho and Moss, 1995). Increased incidents of marine algae are also attributed to eutrophication (Riegman, 1998).

The interpretation of the incidences of algal blooms as carried out under the Environment Agency monitoring programmes, and hence extent of eutrophication is however difficult. Results from freshwater algal and cyanobacterial monitoring are based on a reactive, selective procedure whereby mainly only new sites affected with algal blooms and scums are analysed in response to external enquiries. Sites are rarely investigated which do not have a visible algal bloom/scum present or which have had historical cyanobacterial problems. Results from the marine algal monitoring are influenced by Regional variations in the monitoring programmes, the number of bathing sites, and also by the number of reports received from the public.

For example, the number of external enquiries received has been highest from central and south-eastern areas of England (Anglian, Midlands and Thames Regions). These sites may be affected by eutrophication to a greater extent than sites elsewhere in England and Wales, and a more vigilant, aware public (whose population density is greater than elsewhere in the country) may be reporting the visible symptoms of eutrophication (algal blooms) more frequently. Conversely, although the public may be becoming more aware of cyanobacteria and their risks, they may not be reporting new sites affected by algal blooms and scums as frequently as in the past, possibly as water owners and managers are becoming more aware of their related problems.

The use of Agency data as a robust indicator of the incidence of algal blooms and the extent of eutrophication in England and Wales must be treated with caution. This is because of the range of influences on the frequency of blooms and because the data are from a primarily reactive monitoring programme. The collation of such data, and hence of sites affected by eutrophication should however continue, since this is the best available national information on the incidence of algal blooms. Further and better evidence can be obtained from more frequent monitoring at specific sites under the long-term and routine monitoring programmes, which should continue.

Results from Agency monitoring programmes indicate a continued reduction in sampling effort. This is evident by a decline in the number of 'old' sites resampled, a reduction in the number of sites sampled routinely, and a decline in the total number of sites sampled as part of the marine monitoring programme. The Agency's approach to algal monitoring is to be reviewed during 2000 and 2001 as part of a wider review of eutrophication-related monitoring. This will include consideration of new technologies, particularly for coastal waters, and how best to derive useful information from relatively limited data.

There continue to be high incidences of nuisance and potentially toxic algae, evident from the freshwater and marine monitoring programmes, hence the need to increase awareness of the health hazards presented by cyanobacterial and marine dinoflagellate toxins among water-users, associated organisations, water industry and public health professionals continues (Chorus and Bartram, 1999; Whitton and Potts, 2000).

There continue to be gaps in our knowledge base, that require further work, therefore, the Agency is continuing to sponsor R&D to achieve a better understanding of algal and eutrophication-related issues. This includes, with regards to coastal water quality, the use of new technology, novel monitoring techniques and use of data collected from aircraft. The eutrophication strategy will also drive further research to update monitoring and management for eutrophication control.

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