Snapshots of the Environment
The National Centre for Environmental Data and Surveillance
Environment Agency

Understanding Coastal Water Quality

1.0 Introduction

1.1 The "Snapshots of the Environment" series has explored some of the issues related to each of the nine themes identified in the Environment Agency's '**An Environmental Strategy for the Millennium and Beyond**' (Environment Agency, 1997a). Each Snapshot has used the **Viewpoints on the Environment** (Environment Agency, 1997b) and the **Stresses and Strains** frameworks to look at some of the pressures on the Environment.

1.2 This seventh Snapshot takes a cross-thematic approach to consider issues of interest to the Environment Agency related to the marine environment. Given the breadth of this topic and the restricted space, this Snapshot can only touch upon some of the issues rather than providing an extensive review. As more information becomes available, or new issues develop, they will be covered in future Snapshots.

1.3 A guide to the acronyms used is provided at the end of this document. An electronic version of this document may be found on the World Wide Web at **www.environment-agency.gov.uk**. This website also allows access to information on UK Bathing Water quality via the "Your Backyard" section of Your Environment.

2.0 Background

2.1 The Environment Agency has responsibilities for a small but highly significant part of the marine environment: the coastal zone. Responsibilities extend to five kilometres for pollution protection and ten kilometres for freshwater fisheries management.

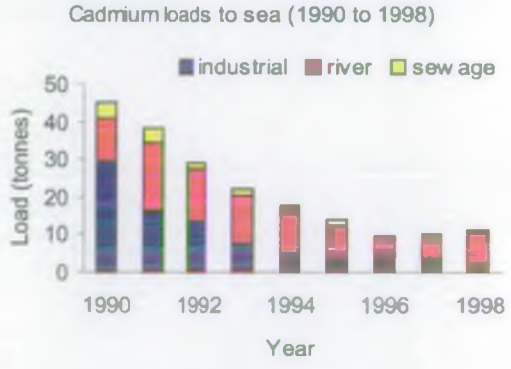
2.2 The coastal zone of England and Wales represents a key environmental and economic resource. Some 40% of manufacturing industry and 26% of the population are sited close to the coast, which will directly affect the water quality of this region. Wider use is now being made of coastal waters, particularly in terms of increased recreation, increasing the pressures on environmental resources such as protected areas and certain species (DoE, 1996).

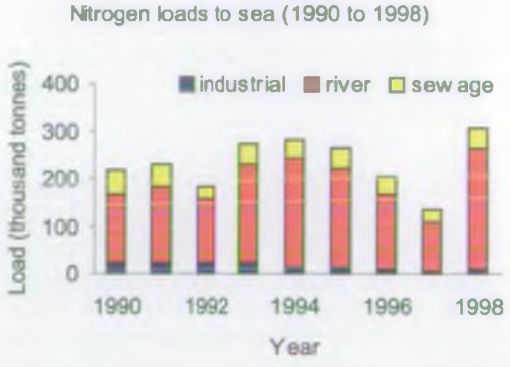
2.3 In addition to pressures from the land, the water quality of the coastal zone is affected by mixing with offshore waters which in turn affects the quality of these waters. The UK government is thus a signatory of the Oslo and Paris Conventions (OSPAR). In 1998 OSPAR produced two key strategies, one of which was on hazardous substances, eutrophication and radioactive substances in the marine environment. This committed the signatories to "achieve concentrations in the marine environment near background values for naturally occurring substances and close to zero for man-made synthetic substances by the year 2020".

2.4 This Snapshot discusses some of the monitoring carried out to measure inputs of contaminants into the coastal waters of England and Wales. It then highlights potential problems in relating inputs from the land to concentrations measured at sea. This leads to suggestions on how to develop a better understanding of coastal water quality to aid in our commitment to continually improve our sea water quality. Further information may be gained from the Environment Agency report on the "State of the Environment of England and Wales: Coasts".

3.0 Current assessment techniques

3.1 The Agency measures inputs to the sea of a range of hazardous substances from direct, indirect and riverine sources and reports to the Department of the Environment, Transport and the Regions (DETR).





These data provide direct information on progress in reducing the inputs of these substances into the sea for reporting to OSPAR. Determinands measured include both those occurring naturally such as nutrients and certain hazardous substances which are bi-products of manufacturing and farming (Pentreath, 1999).

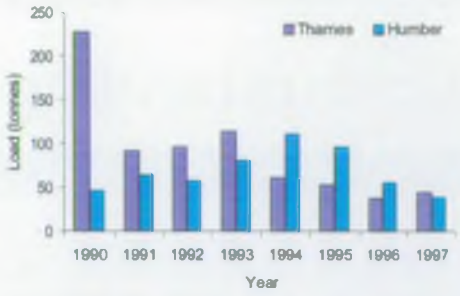
3.2 In general the input of many of the monitored substances have reduced significantly over the last decade. For example, the cadmium load in the period 1991 to 1997 shows a reduction of greater than 50%. An even more marked reduction is seen in total lindane load. Nutrient load reductions are less marked. The scale of reduction has decreased in more recent years, with increases in 1998 due to high river flows. The more ambitious reductions set in 1998 will probably require changes in policy over forthcoming years.

3.3 The Marine Pollution Monitoring Management Group (MPMMG) recognised in the late 1980s the absence of consistent information on measuring the water quality of coastal waters. They established the National Marine Monitoring Programme (NMMP) which set out to measure the spatial distribution of selected substances both within and between selected sites. The sampling for this programme was carried out by the Agency in England and Wales within the 5km coastal zone and the Centre for Environment, Fisheries and Aquaculture Science (CEFAS) further offshore. The spatial survey for England and Wales was completed in 1995 (MPMMG, 1998).

Distribution of lindane from NMMP spatial survey

3.4 For example, lindane concentrations measured in the NMMP spatial survey have been related to the OSPAR loads from those estuaries monitored. The results broadly agree, with highest loads and measured concentrations in the Thames and Humber estuaries. The temporal resolution of the NMMP data do not however allow the reductions seen in the OSPAR data to be reflected.

Lindane loads to the Humber and Thames estuaries (1990 to 1997)



3.5 The requirement for temporal data has been recognised in the establishment of the second phase of the NMMP which commenced in 1999. The data collected for this will provide a valuable long-term data set to reflect changes in sediment and ecological quality in addition to water quality in selected estuaries and coastal waters.

3.6 The Environment Agency National Coastal Baseline Survey (1993-1998) monitored the levels of metals, nutrients and organic contaminants in water samples taken at 15km intervals around the entire coast of England and Wales. More spatially intensive measurements were taken for nutrients, fluorescence and transmission using electronic monitors. These data provided an invaluable indication of those areas of the coastal zone consistently high in the parameters measured, but lacked the temporal resolution to fully understand the water quality of the coastal zone.

3.7 The newly developed NMMP temporal survey goes a long way towards monitoring the levels of contaminants in coastal waters. The survey is, however, geographically constrained, with sampling at set points and does not describe the entire coastal zone. Methods must be developed therefore which allow monitoring of the wider coastal zone.

4.0 Developing a better understanding

4.1 In order to establish whether our seas are getting cleaner, we need to develop a better understanding of two key aspects. Firstly, we need to understand the fate of hazardous substances within the marine environment. Results clearly show that the levels measured in the water column are different from the loads recorded at the source, but what processes do the contaminants undergo to cause these differences?

4.2 Secondly, we need to be able to measure the levels of eutrophication in the coastal zone at a high temporal resolution consistent with biological processes.

4.3 There are a number of recent developments in marine monitoring which together can help to address

these two key areas. When used effectively in combination they will allow us to develop a better understanding of coastal water quality and enable us to make informed decisions on the state of pollution of our seas.

5.0 Automatic monitoring buoys

5.1 Traditional marine monitoring techniques such as those used for the NMMP spatial survey and the coastal baseline survey do not offer the required temporal coverage for investigating changes in water quality in such a highly variable environment. The Environment Agency, amongst others is investigating the use of continuous monitoring buoys to address the responsibility to form an opinion on the state of pollution of the marine environment. The National Centre for Environmental Data and Surveillance has developed such a buoy (Proteus) for estuarine deployment and is currently investigating the use of alternative platforms (Matthews *et al.* 1999). The photograph shows the Proteus buoy moored in Poole Harbour. The telemetry and sensors are currently being ported to a Trinity House buoy to provide the stability and security required offshore.

The Proteus buoy operating in Poole Harbour

5.2 The Proteus buoy holds sensors for temperature, salinity, dissolved oxygen, pH, fluorescence, transmission and nitrate. Further developments are being made to integrate sensors for additional nutrients. In order to investigate the fate of OSPAR monitored hazardous substances it would be necessary to collect water samples for analysis onshore. The current telemetry system allows for both automatic and responsive sampling and various water sampling systems are being investigated. These may take the form of water bottles, used previously, or may make use of modified blood bags for storage of water as used by the CEFAS Smart Buoy (Mills, 1999).

5.3 Other organisations are investigating the development of buoys for water quality monitoring. These organisations will meet together, under the auspices of the National Marine Monitoring Programme, to discuss a common approach to buoy development. The NMMP has recognised the high temporal variability in water chemistry and has recommended the use of such technology for this element of the temporal survey.

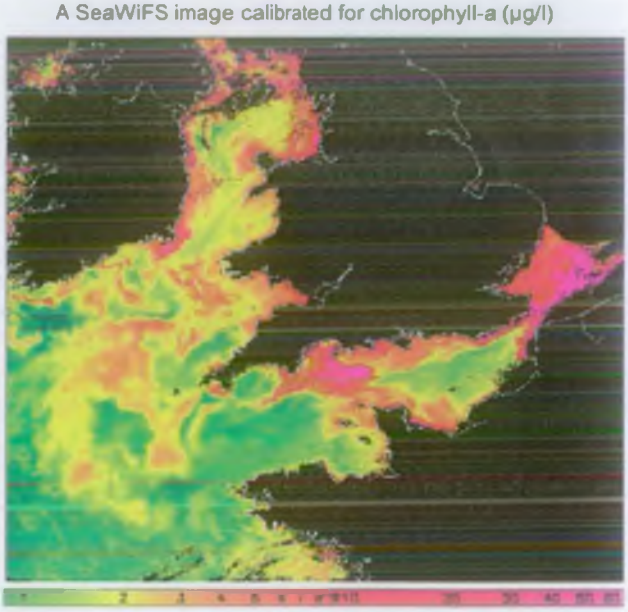
5.4 The advantage of continuous monitoring buoys is the collection of temporally rich data sets. The data are still, however, collected at set geographical positions and do not represent wide spatial coverage.

6.0 Earth observation data

6.1 Satellite sensors offer the potential to provide this information over a wide spatial scale. Satellite sensors measure the upwelling electromagnetic radiation from the ground or water surface at selected wavelengths. This may be used to infer certain parameters, and in particular chlorophyll-*a* concentration which in turn is an indicator of the presence of eutrophication. The image shows data from the Sea-viewing Wide Field-of-view Sensor (SeaWiFS) satellite provided by NASA via Plymouth Marine Laboratory, calibrated for chlorophyll-*a* concentration.

6.2 These data are currently being received by the National Centre for Environmental Data and Surveillance in order to develop an operational tool for the notification of areas of high chlorophyll-*a* concentration to Regional customers. Problems

A SeaWiFS image calibrated for chlorophyll-a (µg/l)



currently exist with the accuracy of the calibration in waters optically dominated by inorganic sediment known as Case 2 waters. Research is ongoing both in-house and externally to improve the calibrations.

6.3 The compilation of this data set over a long time period will also allow a measure of the eutrophic state of the coastal zone to be established. Typically data are received once each day, which, even allowing for the presence of cloud cover, will clearly show which areas were subject to high chlorophyll-*a* concentrations throughout the year. This information may then be combined with data on nutrient loadings from the OSPAR data and *in-situ* nutrients data from continuous monitoring buoys. This combination of data sources should prove to be highly superior to spot water samples of chlorophyll-*a* and nutrients in assessing eutrophication.

7.0 Numerical models

7.1 The most promising way forward for investigating the fate of OSPAR monitored hazardous substances in the coastal environment is the use of numerical models. Models may be used to simulate the movement of water bodies and thus water-borne contaminants.

7.2 Numerical models may also be used to simulate the removal of contaminants from the water column through attachment to sediments and take up by algae. This is potentially one of the main sources of the discrepancies seen between the measured sources and in-water measurement of hazardous substances.

8.0 The way forward

8.1 The use of the three techniques described above will allow more integrated monitoring of water chemistry in the coastal environment. This will enable more informed decisions to be made on reductions of contaminant loadings and the manner in which these are reflected in the receiving waters.

8.2 In the future it will be important to develop an understanding of the effects of changes in water chemistry on the ecological quality of the coastal zone, particularly in response to the proposed European Union Water Framework Directive. This requires that the competent authorities assess the ecological status of all waters, including estuarine and coastal, up to one mile offshore. Further research and monitoring is required to develop suitable methods for systematic assessment of the ecological quality of coastal waters to meet the requirements of this Directive.

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Acronyms

CEFAS Centre for Environment, Fisheries and Aquaculture Science
DoE Department of the Environment
DETR Department of the Environment, Transport and the Regions
MPMMG Marine Pollution Monitoring Management Group
NASA National Aeronautics and Space Administration
NMMP National Marine Monitoring Programme
OSPAR Oslo and Paris Convention

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