Science Series
Aquatic Environment Monitoring Report no. 62

Monitoring of the quality of the marine environment, 2006-2007

Cefas

Science Series
Aquatic Environment Monitoring Report no. 62

Monitoring of the quality of the marine environment, 2006-2007

This report should be citied as: Cefas, 2009. Monitoring the quality of the marine environment, 2006-2007. Sci. Ser. Aquat. Environ. Monit. Rep., Cefas Lowestoft, 62:33pp.

This report was compiled and edited by Robin Law and Clare Adams of the Cefas Lowestoft Laboratory, Pakefield Road, Lowestoft, Suffolk NR33 0HT. A copy can be obtained by downloading from the Cefas website www.cefas.co.uk.

Contents

Foreword

Aquatic Environment Monitoring Report No. 62 collects together work carried out in 2006-07 by Cefas scientists in support of our monitoring and surveillance duties (see overleaf). The information presented covers both environmental surveillance at offshore and coastal sites and site-specific work carried out in support of risk assessments and regulatory procedures. Some of the science reported here forms part of wider efforts to integrate data from Departments and Agencies in the UK to provide a comprehensive picture of the quality of the marine environment within the UK's nationally co-ordinated marine monitoring programme. Other components are unique to Cefas due to our requirement to understand ecosystem response resulting from potential pressures from deposit, extraction and discharge activities. The strategy for the national monitoring programme is described in publications commissioned by the Marine Environment Monitoring Group (MEMG). The programme manual, known as the Green Book, is available in downloadable format from http://www.cefas.co.uk/publications/scientific-series/green-book.aspx. The programme seeks to develop time trend data for a number of sites around the UK and this work is augmented by special surveys of compounds likely to pose specific risks, or for which few data exist.

The Defra report Safeguarding our Seas (Defra, 2002) set out a vision for "clean, healthy, safe, productive and biologically diverse seas". It started a process which has changed the UK's approach to monitoring and assessment of our seas. The next stage in this process was the preparation of the first integrated assessment of our seas, Charting Progress (Defra, 2005). This provided a baseline for the state of our marine environment at that time, and much was learnt from the process of its preparation. Charting Progress outlined a number of actions, including the development of a UK Marine Monitoring and Assessment Strategy (UKMMAS). Within this strategy, three evidence groups have been established to collate data on the themes of:

- Clean and Safe Seas
- Healthy and Biologically Diverse Seas
- Productive Seas

So as to make explicit the links between the topics covered in this report and the aims of the UKMMAS, the topics have been grouped under these headings. This process is now being taken further with the preparation of a second integrated assessment report, currently known as Charting Progress 2, due for publication in 2010. This will be followed by an OSPAR Quality Status Report for the NE Atlantic area, also in 2010.

This report, earlier reports in the AEMR series and other publications are also available in downloadable format from the Cefas website: www.cefas.co.uk.

Robin Law
Lindsay Murray

Background to the work

As an Executive Agency of the Department for Environment, Food and Rural Affairs (Defra), Cefas carries out work in support of Defra's strategic priorities, all of which underpin the overarching aim of ensuring that everyone can live within their environmental means.

Public Service Agreements are key cross-government priorities, each of which has a designated lead department. Defra leads on one Public Service Agreement:

- *Secure a healthy natural environment for everyone's well being, health and prosperity, now and in the future*

Within this framework, environmental work at Cefas is directed at research, monitoring and assessment of the impact of potentially harmful substances or activities on the quality of the marine, coastal and estuarine environments. We are involved directly in advising on UK and international legislation and in developing policy relating to management of the aquatic environment. We provide advice to Governments, enforcement agencies and policymakers throughout the world on the development and implementation of monitoring and assessment programmes and control measures.

An important component of our work is to provide advice to Defra Ministers and other Government Departments on all aspects of non-radioactive contamination of the aquatic environment. Specifically under Part II of the Food and Environment Protection Act (1985) (FEPA) (Great Britain Parliament, 1985a & b), Defra (through the Marine and Fisheries Agency (MFA)) has the responsibility to licence and control the deposit of material to sea and constructions in the marine environment, notably for windfarms and port developments. Currently, licensed materials disposed of to sea are predominantly sediments, derived from maintenance and capital dredging activities in coastal waters. We provide advice to the MFA concerning all of these activities. Disposal at sea is also regulated internationally by OSPAR, and our work enables the UK to fulfil its obligations as a Contracting Party to the Convention.

The Cefas Regulatory Advice Team evaluates scientific and technical aspects of licence applications and makes regular visits to licence holders to ensure that any stipulated conditions are being met. Conducting monitoring programmes in support of risk assessments enables Defra to ensure the effectiveness of the assessment process and provides a basis for decisions on future policy for the management of marine resources. Cefas scientists monitor the environmental conditions at marine disposal sites and compare the results with those obtained during more general monitoring studies, allowing action to be taken if unexpected impacts should occur. This also provides a feedback loop which ensures that risk assessments undertaken within the licensing process incorporate the most recent research findings.

Under the Water Resources Act (1991) (Great Britain Parliament, 1991), Defra is a statutory consultee for all discharges to controlled (tidal) waters. Cefas scientists assess the fishery implications of applications for consent to discharge permits. Consideration is given to resources in the area, the toxicity of the effluent, local hydrographic conditions and any standards set out in national policy or EU Directives.

Under the requirements of the EU Marine Strategy Framework Directive, member states are required to assess their waters with respect to demonstrating or moving towards "good environmental status" in relation to eleven descriptors. The EU have established a process, led by the International Council for the Exploration of the Sea and the EU Joint Research Centre, intended to facilitate the development of methods and criteria which will allow status to be assessed for each of the descriptors. Cefas are involved in this process, particularly for descriptors 4 and 8 relating to the functionality of food webs and effects due to contaminants, respectively, where we chair the task groups.

We also provide advice to the Department of Energy and Climate Change (DECC) and other departments concerning the control of pollution in other areas affecting the marine environment including the extraction of offshore oil and gas and marine aggregate. The statutory Offshore Chemical Notification Scheme and The Environmental Impact Assessment and Natural Habitats (Extraction of Minerals by Marine Dredging) (England and Northern Ireland) Regulations 2007 on the winning of aggregates, respectively, control these activities.

On Defra's behalf, Cefas is responsible for monitoring intermediate and offshore stations within the UK Clean Seas Environmental Monitoring Programme (CSEMP), which seeks to integrate national and international monitoring programmes for all relevant UK agencies. Each year, we collect samples of seawater, sediment and biota for chemical analysis and deploy a number of biological effects techniques, including water and sediment bioassays and fish disease surveys. The current phase of the monitoring programme is focused on the detection of long-term temporal trends in contaminant concentrations and the development and deployment of a wider range of biological effects techniques studying organism response at a variety of cellular and subcellular levels. The CSEMP allows us to ascertain the effectiveness of regulatory measures taken to reduce the inputs of hazardous substances to UK seas. In addition, it contributes to the UK's international monitoring obligations to demonstrate UK compliance with various EU Directives: Dangerous Substances Directive (76/464/EEC); Shellfish Waters Directive (79/923/EEC); Shellfish Hygiene Directive (91/492/EEC); Fishery Products Directive (91/493/EEC); the Commission Decision 93/351/EEC concerning maximum mercury limits in fishery products, and similar requirements under OSPAR. Currently, a group led from within Cefas is working to redesign the CSEMP so as to ensure that it meets current requirements and, as far as possible, to dovetail with proposed monitoring to be undertaken under the EU Water Framework Directive (2000/60/EC) in rivers, estuaries and coastal waters from 2008.

In order to ensure that the advice provided to Defra and other regulators is always based on the most up-to-date knowledge and techniques, Cefas carries out a wide range of research and development to provide for the future needs of monitoring and surveillance programmes. For example, we have developed new and more sensitive bioassay techniques, analytical methods and unattended sampling and monitoring devices. Within these programmes we have made a number of significant contributions to environmental protection and as a consequence of our work have established a worldwide reputation in the field of aquatic environmental research.

More information on our research programmes is available on the Cefas website: www.cefas.co.uk.

Glossary of terms

AEMR	Aquatic Environment Monitoring Report
BEQUALM	Biological Effects Quality Assurance in Monitoring Programmes
BFRs	Brominated Flame Retardants
BNFL	British Nuclear Fuels Limited
CSOs	Combined Sewer Overflows
CEMP	Co-ordinated Environmental Monitoring Programme (of OSPAR)
CP2	Charting Progress 2
CSEMP	Clean Seas Environmental Monitoring Programme
CSIP	Cetacean Strandings Investigation Programme
DECC	Department of Energy and Climate Change
DEFRA	Department for Environment, Food and Rural Affairs
EA	Environment Agency
EARP	Enhanced Actinide Removal Plant (at BNFL Sellafield)
EU	European Union
FCA	Foci of cell alteration
FEPA	Food and Environment Protection Act 1985
HBCD	Hexabromocyclododecane
HELCOM	Helsinki Commission
ICES	International Council for the Exploration of the Sea
LC/MS	Liquid Chromatography / Mass Spectrometry
MAFF	Ministry of Agriculture, Fisheries and Food
MEMG	Marine Environment Monitoring Group
MFA	Marine and Fisheries Agency
NAD	No Abnormalities Detected
NIEA	Northern Ireland Environment Agency
OPRA	Operator & Pollution Risk Appraisal
OSPAR	Oslo and Paris Convention
QSR	Quality Status Report
RIFE	Radioactivity in Food and the Environment
SEERAD	Scottish Executive Environmental & Rural Affairs Department
SFPA	Scottish Fisheries Protection Agency
SIXEP	Site Ion Exchange Effluent Plant (at BNFL Sellafield)
STW	Sewage Treatment Works
TBBP-A	Tetrabromobisphenol-A
THORP	Thermal Oxide Reprocessing Plant (at BNFL Sellafield)
UK	United Kingdom
UKMMAS	UK Marine Monitoring and Assessment Strategy
UV	Ultra-violet
WGPDMO	The ICES Working Group on Pathology and Diseases of Marine Organisms

Clean and Safe Seas

1. Radioactivity in UK coastal waters

Authors: Carol Smedley and Kins Leonard

Demonstrates that the UK is on track to meet the UK Government's aim to reduce concentrations of radioactive substances in the marine environment to "close to zero"

1.1 Introduction

The UK Government is committed to preventing pollution of the marine environment from hazardous substances, which includes ionising radiation. The ultimate aim is to reduce concentrations in the environment to close to background values for naturally occurring radioactive substances, and close to zero for artificial radioactive substances (Defra, 2002). A long-term programme of surveillance into the distribution of key radionuclides is maintained using research vessels, and other means of sampling. The results obtained from the seawater surveys reported here provide evidence of progress towards achievement of the Government's vision. Summary data are also used in reports to evaluate the state of the seas (e.g. Marine Environment Monitoring Group, 2005), this information can also be used to distinguish different sources of man-made radioactivity (e.g. Kershaw and Baxter, 1995). In addition, these surveys support international studies concerned with the quality status of coastal seas (e.g. OSPAR, 2000). In 2006 OSPAR adopted the Periodic Evaluation of the Progress in Implementing the OSPAR Radioactive Substances Strategy (concerning progressive and substantial reductions in discharges of radioactive substances, as compared with the agreed baseline) (OSPAR 2006). The programme of radiological surveillance work provides the source data and therefore the means to monitor and make an assessment of progress in line with the UK's commitments towards OSPAR's 1998 Strategy for Radioactive Substances target for 2020 (OSPAR, 1998). Data are also compiled (on an annual basis), and an assessment is reported in the ongoing RIFE (Radioactivity in Food and the Environment) report series (e.g. RIFE-13 (UK Environment Agencies, 2008)).

Detailed historical data for ^{134}Cs and ^{137}Cs in seawater have been published in a series of reports so as to aid model development (Camplin and Steele, 1991; Baxter *et al.*, 1992; Baxter and Camplin, 1993a-c) and have been used to derive dispersion factors for nuclear sites (Baxter and Camplin, 1994). The data have also been used to examine the long distance transport of activity to the Arctic (Kershaw *et al.*, 1999) and long-term trends in Northern European seas (Povinec *et al.*, 2003).

Discharges from Sellafield peaked in the mid 1970s. A number of counter-measures were introduced, including the Site Ion Exchange Effluent Plant (SIXEP, in 1986), which controlled Cs discharges, and the Enhanced Actinide Removal Plant (EARP, in 1994). EARP allowed the treatment of medium-active, stored liquors, which also contained ^{99}Tc – not treated by EARP – and consequently these discharges (which are of limited radiological significance) rose in 1994. However, following a successful trial of new abatement technology, discharges once again decreased in 2003 (Mayall, 2005). Discharges of ^{129}I, ^{90}Sr, ^{14}C, ^{60}Co, and ^{3}H also increased in the mid 1990s, as a result of operational changes at the site, including the starting up of the Thermal Oxide Reprocessing Plant (THORP) in 1995.

Studies of the migration behaviour of ^{99}Tc have afforded opportunities to substantiate and extend the information obtained from earlier similar studies of ^{137}Cs. The distribution of ^{99}Tc in waters around the British Isles prior to, and immediately after, the increased ^{99}Tc discharges (in 1994) indicated a rapid advection of ^{99}Tc within and from the Irish Sea to the north of Scotland as compared to previous estimates (Leonard *et al.*, 1997a,b; McCubbin *et al.*, 2002). The subsequent transport rate out of the North Sea and northwards with the Norwegian Coastal Current and West Spitsbergen Current slowed markedly, in apparent correspondence with variations in the North Atlantic Oscillation (NAO) winter index (Kershaw *et al.*, 2004).

1.2 Methods

1.2.1 Sampling

The research vessel programme on radionuclide distribution currently comprises an annual survey of the Bristol Channel together with biennial surveys of the Irish Sea and the North Sea. Large volume surface seawater samples (50 litres) are collected, using the ships pumped supply, during cruises of the research vessels, *Cefas ENDEAVOUR* and *CORYSTES*. Surveys of the Bristol Channel, Irish Sea and the western English Channel were carried out by Cefas between March and October 2007.

1.2.2 Sample analysis

Samples were filtered (0.45 µm) to separate dissolved and particulate phases. Analyses of dissolved ^{137}Cs involved pumping filtered seawater, acidified with nitric acid, through cartridges filled with ASG resin (ammonium duodeca-molybdophosphate on silica gel) to extract caesium. Analyses of ^{3}H involved double distillation of water samples under alkaline conditions and in the presence of holdback carriers to ensure chemical separation from all gravimetric and radiometric interference. Subsamples of distillate were assayed for ^{3}H using a Packard Tri-Carb 2700 TR/LL liquid scintillation counter.

1.3 Results and discussion

The results of the seawater surveys are given in Figures 1.1a to 1.1f inclusive.

1.3.1 ^{137}Cs distributions

The 2007 ^{137}Cs data for the Irish Sea (Figure 1.1a) show a similar range of levels to those observed from sampling in recent years; the general distribution being one of falling concentrations as the distance from Sellafield increases. Concentrations of ^{137}Cs were reasonably uniform (< 0.5 Bq kg^{-1}) in a large proportion of the Irish Sea. Slightly increased levels, from the most recent discharges, were observed along the Cumbrian and southern Scottish coastline. Relatively higher ^{137}Cs concentrations south of the Isle of Man were most likely due to the variability of circulation patterns, largely driven by meteorological conditions (McCubbin *et al.*, 2002). The maximum discharge of ^{137}Cs occurred at Sellafield in 1975 and ^{137}Cs concentrations of up to 0.5 Bq kg^{-1} were measured in the late 1970s. Due to significantly decreasing discharges after 1978, remobilisation of ^{137}Cs from contaminated sediments appears to be the dominant source of water contamination for much of the Irish Sea (McCubbin *et al.*, 2002). Consequently, levels in seawater have shown near exponential decrease with time since the commissioning of the SIXEP waste treatment process in the mid 1980s, as illustrated by the data provided in Figure 1.1b for shoreline seawater at St Bees (~10 km to the north of Sellafield).

Concentrations in the western English Channel (average activity 0.002 Bq kg^{-1}) were within experimental error, similar to the background level resulting from global fallout (Figure 1.1c).

1.3.2 ^{3}H distributions

The concentrations of tritium observed in the Irish Sea (Figure 1.1d) were below the limit of detection (~2 Bq kg^{-1}) over a large proportion of the survey area. Some evidence of the impact of discharges from the Heysham nuclear power plant and Sellafield was apparent along the Morecambe Bay and southern Scottish coastline. The overall distribution of tritium in the Irish Sea was similar to that observed from recent discharges of caesium-137 (Figure 1.1a).

In the Bristol Channel, the extent of the combined effects of discharges from Cardiff, Berkeley, Oldbury and Hinkley Point is evident (Figure 1.1e) however elevations in ^{3}H con-

Figure 1.1a. Concentrations (Bq kg^{-1}) of caesium-137 in filtered surface water from the Irish Sea, June 2007

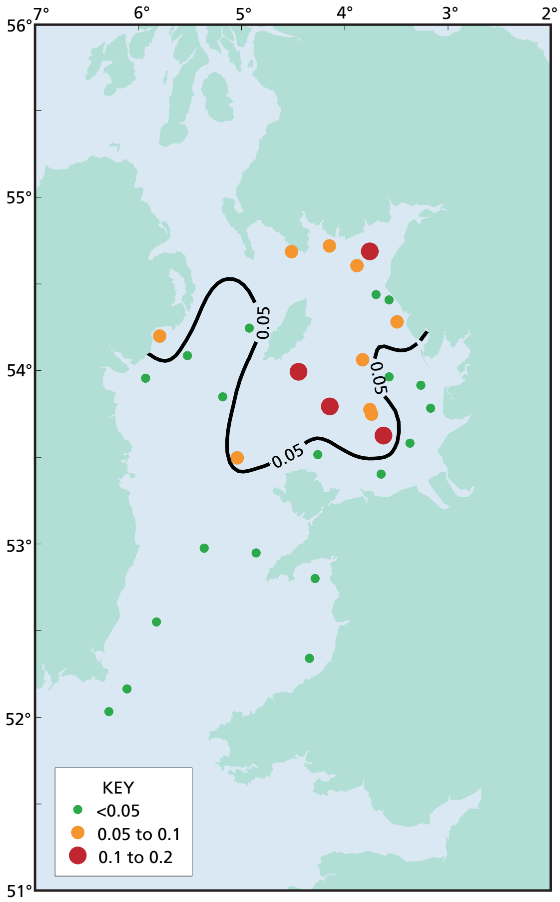


Figure 1.1b. Temporal variation of dissolved caesium-137 in shoreline seawater close to Sellafield (at St Bees), 1986-2007

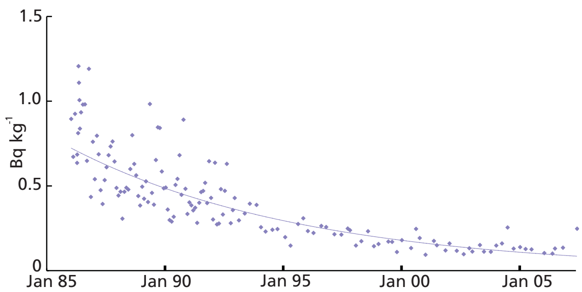


Figure 1.1c. Concentrations (Bq kg^{-1}) of caesium-137 in filtered surface water from the western English Channel, March 2007

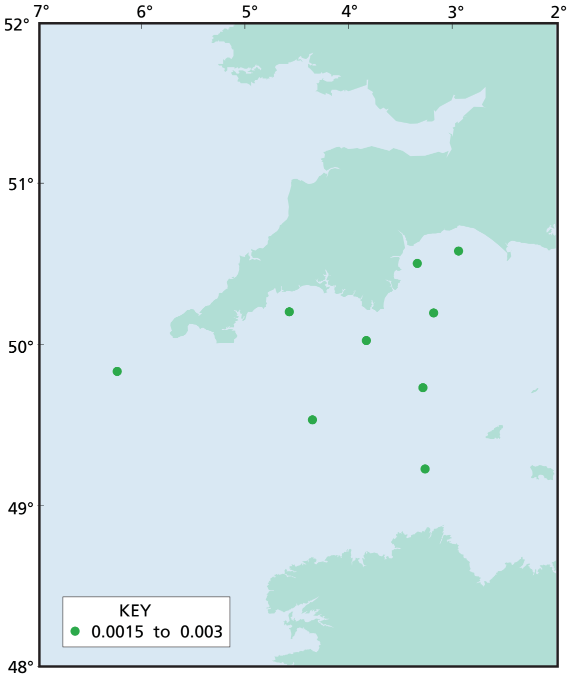


Figure 1.1d. Concentrations (Bq kg^{-1}) of tritium in surface water from the Irish Sea, June 2007

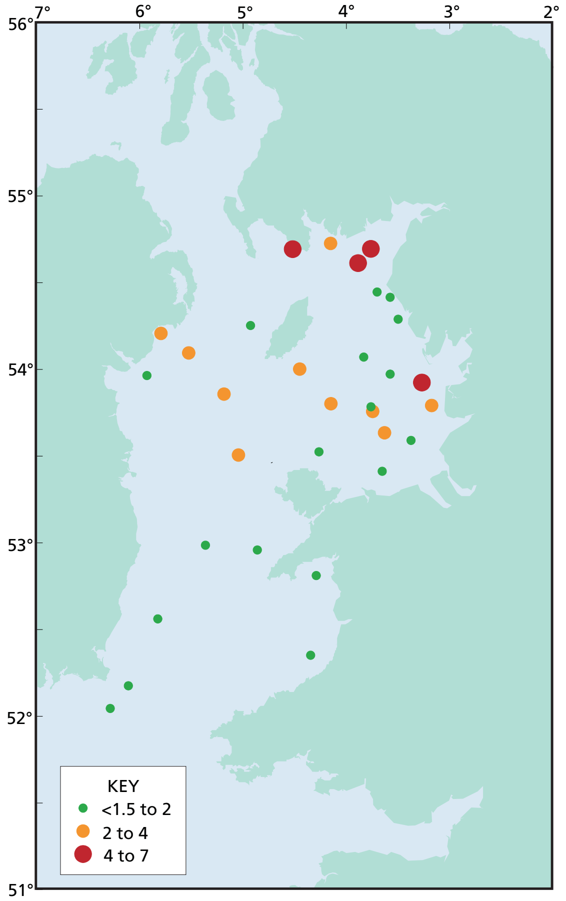


Figure 1.1e. Concentrations (Bq kg^{-1}) of tritium in surface water from the Bristol Channel, October 2007

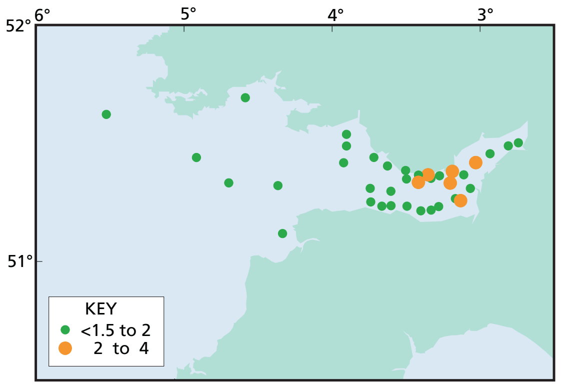
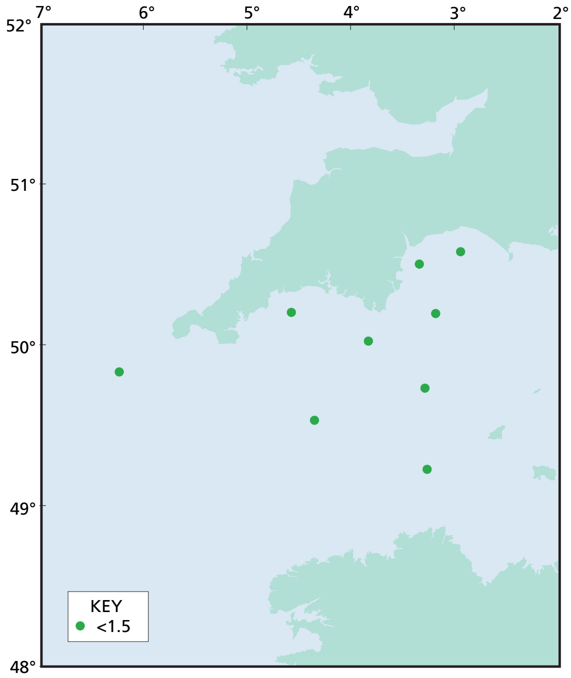


Figure 1.1f. Concentrations (Bq kg^{-1}) of tritium in surface water from the western English Channel, March 2007



centrations close to the Hinkley nuclear power plant and the Amersham radiopharmaceutical plant at Cardiff decreased rapidly with distance downstream of the points of discharge (i.e. in a westerly direction). Concentrations at the mouth of the Bristol Channel were below the limit of detection (2 Bq kg^{-1}). The spatial distribution is consistent with conservative dispersion behaviour in the macrotidal Severn estuary. Tidal current speeds generally exceed 1.5 m s^{-1} at springs and 0.75 m s^{-1} at neaps, meaning water parcels can move up to 25 km during a flood or ebb tide (Uncles, 1984). Levels of ^{3}H in the western English Channel were below detection (Figure 1.1f).

1.3.3 Other radionuclides

Concentrations of ^{99}Tc in seawater are continuing to decrease, following the installation of new effluent treatment procedures at Sellafield. The results of research cruises involving studies of this radionuclide have been published by Leonard *et al*. (1997a and b, 2001, 2004) and McCubbin *et al*. (2002). Trends in plutonium and americium concentrations in the seawater of the Irish Sea have been considered by Leonard *et al*. (1999). A full review of the quality status of the north Atlantic has been published by OSPAR (2000).

Healthy and Biologically Diverse Seas

2. Contaminants in marine mammals

Author: Robin Law

Shows that an earlier trend of rising concentrations of the brominated flame retardant hexabromocyclododecane (HBCD) in porpoise blubber has been reversed

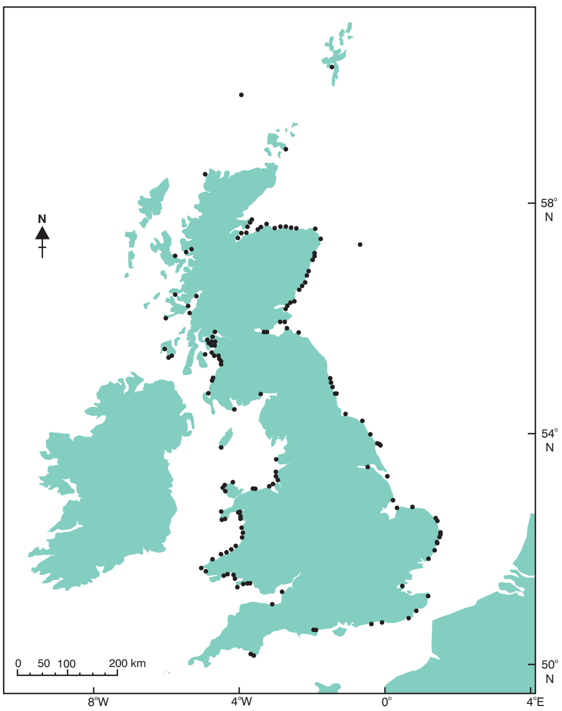
Investigations into the cause of death of cetaceans stranded around the coasts of the UK are undertaken within the UK government-funded Cetacean Strandings Investigation Programme (see http://www.ukstrandings.org/csip_web4/). The aim of the CSIP is to collate, analyse and report data for all cetacean strandings around the coast of the UK; determine the causes of death in stranded cetaceans, including by-catch and physical trauma; and undertake surveillance on the incidence of disease in stranded cetaceans in order to identify any substantial new threats to their conservation status. Within this programme, tissue samples are taken from selected animals (those that are freshly dead or only slightly decomposed) at post mortem for contaminant analysis. Since the inception of the programme in 1990, this analysis has been conducted by Cefas. The results have been reported in the open literature, summarised in earlier copies of these reports, and the data have been published in two technical reports (Law, 1994; Law *et al*., 2006a).

The field of brominated flame retardants (BFRs) remains one of intense research activity, as shown by the most recent review of environmental information from Europe and Asia (Law *et al*., 2008a). In 2006, we published a study of the concentrations of two high-production volume BFRs, hexabromocyclododecane (HBCD) and tetrabromobisphenol-A (TBBP-A) in the blubber of harbour porpoises from the UK (Law *et al*., 2006b). The tissue samples analysed in that study derived from animals stranded or dying due to physical trauma (mostly bycaught in fishing gear) during the period 1994-2003. Investigation of possible time trends indicated a sharp increase in HBCD concentrations from about 2001 onwards, which was significant at the 1% level. Concentrations of TBBP-A, in contrast, were low. As a result of the concern raised by this sharp increase, we have conducted further analyses of these two BFRs in blubber samples collected during 2003-2006, in order to investigate any later time trends. This study and its findings are presented in full in Law *et al*. (2008b) and are summarised below.

Analysis was undertaken using LC/MS and LC/MS-MS on a diastereoisomer-specific basis (Law *et al*., 2008b). 138 samples were analysed for both HBCD and TBBP-A, raising the number of animals which could be assessed for temporal trends in HBCD concentrations to 223 in total (including the 85 animals from the earlier study; Law *et al*., 2006b). The locations from which the porpoises were collected are shown in Figure 2.1. The α-HBCD isomer dominated over the other isomers (Law *et al*., 2005) and was detected in all but one of the samples, at concentrations ranging from 34 to 11,500 µgkg^{-1} wet weight (12,800 µgkg^{-1} lipid weight). The highest concentration occurred in blubber from an animal from 2003, and was about half of the highest value seen in the earlier study (21,400 µgkg^{-1} lipid weight), again in an animal from 2003. All of the data are given in the Electronic Supplementary Information accompanying Law *et al*. (2008b), which is available on the web at http//:pubs.acs.org

In the recent study, low concentrations of TBBP-A were detected using the LC/MS technique used for quantification, similar to those determined previously. However, none of these positive values were confirmed using a newly developed LC/MS-MS confirmatory method and so they were classified as nondetects (limit of detection using LC/MS < 5 µgkg^{-1} wet weight for each isomer). This does call into question the positive TBBP-A data reported previously, although we cannot categorically say they were overesti-

Figure 2.1. Locations from which the porpoises were collected.



mates. Stored extracts from the earlier study will be reanalysed using LC/MS-MS in the future in order to resolve this question.

The technique used to investigate possible time trends in HBCD concentration was the same non-parametric statistical approach used previously, with a null hypothesis of no trend. Table 2.1 lists the summary statistics for the HBCD data. The results of this investigation confirmed the statistically significant increase reported from the earlier study and indicated a statistically significant decrease between 2003 and 2004, which was significant at the 5% level (Figure 2.2). The apparent decreases seen in later years in Figure 2.2 were not sufficiently large to be statistically significant.

Because our study was not balanced in terms of a number of factors which may also influence HBCD concentrations (area, season, bycaught or stranded, sex, age class, blubber thickness) we also investigated these factors. Overall, we concluded that none of these factors confounded the observed decline, although it suggested that the timing of the decline was not uniform across the country (Law *et al.*, 2008b).

The bromine industry provided us with UK sales data for HBCD, previously unavailable, for the years 1997-2006. In Figure 2.3, these sales figures are plotted against the mean sum HBCD concentrations in porpoise blubber. There does seem to be some correlation between the two, with a time lag of 2 – 4 years. This suggests that the food-chain response to changing concentrations is relatively rapid for HBCD, although further monitoring will be necessary to confirm this. It should also be noted that sales figures do not necessarily correspond with actual emissions. It is possible to fairly reliably estimate point-source emissions, but the magnitude and trend of inputs to the environment from diffuse sources such as flame-retarded consumer products in use or in landfill is unknown.

The downturn seen in porpoise blubber HBCD concentrations is likely to have resulted from reductions in inputs from industrial sites to the marine environment, as a result of two factors. Firstly, the closure in 2003 of the HBCD manufacturing plant at Newton Aycliffe close to the NE coast of England. This site had had considerable historic emissions of HBCD to the environment during its working lifetime, with annual emissions of more than 5 tonnes (European Chemicals Bureau, 2008). In addition, a plant in NW England manufacturing expanded polystyrene (to which HBCD is added) closed in 2002. Secondly, in recent years, the bromine industry has developed initiatives intended to reduce emissions from the manufacture and use of HBCD and other BFRs. Initially focussed on the deca-mix PBDE (polybrominated diphenyl ether) formulation, the same voluntary controls are now being extended to TBBP-A and HBCD. These initiatives did not, however, formally begin in the UK until 2006.

Table 2.1. Summary statistics for the HBCD data (Concentrations are given in $\mu g kg^{-1}$ lipid weight; the frequency is the number of animals sampled in each year).

	frequency	mean ∑HBCD concentration	median ∑HBCD concentration	mean ln(∑HBCD) concentration
1994	1	73	73	4.29
1995	2	30	30	3.14
1996	7	71	40	3.99
1997	2	283	283	5.29
1998	6	83	61	4.01
1999	5	249	246	5.20
2000	13	178	219	4.95
2001	15	1620	649	6.49
2002	18	5140	1220	7.44
2003	32	5450	1860	7.51
2004	31	1360	487	6.40
2005	63	1180	456	6.14
2006	28	817	379	5.96

Figure 2.2. Plot of (ln sum HBCD concentration) values against year of stranding or bycatch. Also marked are yearly means.

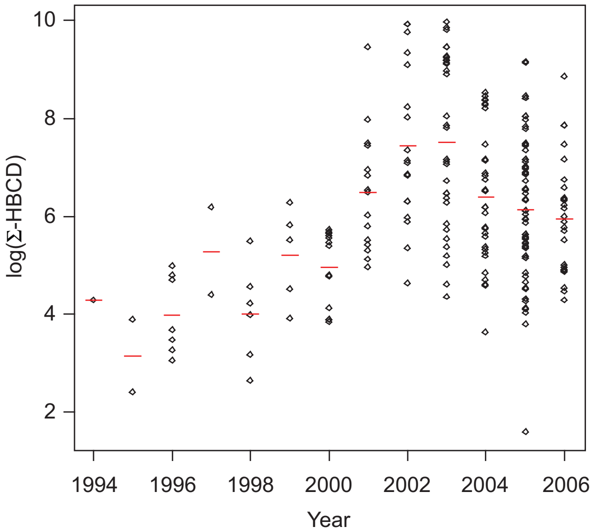
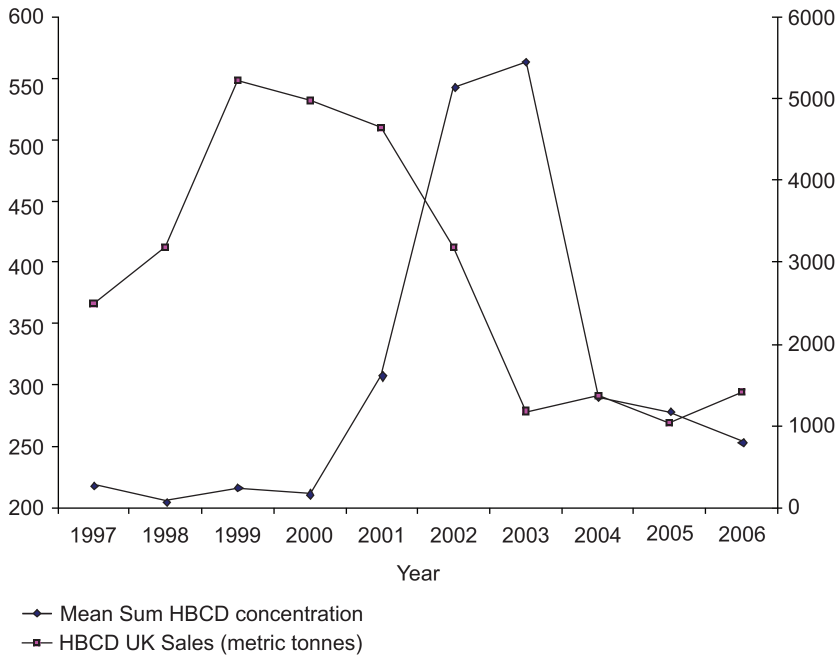


Figure 2.3. Indicative plot of mean sum HBCD concentrations in blubber of harbour porpoises vs. UK sales of HBCD in metric tonnes, 1997-2006.



3. Fish health status in the North Sea and Irish Sea 2007

Authors: Stephen W. Feist, Brett Lyons, John P. Bignell and Grant D. Stentiford

Trends in the incidence of fish disease provide indicators of marine environmental health, and demonstrate geographical variability

3.1 Introduction

The use of fish health parameters, including overt disease and the presence of organ pathology provides a robust tool for the assessment of health status, both at the organism and population levels in marine fish. In this way pathology provides an important component of the UK Clean Seas Environmental Monitoring Programme (CSEMP), linking effects of environmental contaminants inducing biomarker responses to larger scale assessment of population health.

Assessments of fish disease and organ pathology are applicable for any species. However, under the CSEMP the principal target species are the dab (*Limanda limanda*) for offshore sites and the flounder (*Platichthys flesus*) for inshore or intermediate sites. An important component of this assessment is the presence of liver pathology, including cancer (Stentiford *et al*., 2003; Feist *et al*., 2004). Round fish species such as cod (*Gadus morhua*) and whiting (*Merlanguis merlangus*) are also included as a monitoring species, with guidelines for disease assessment provided by ICES (Bucke *et al*., 1996).

The fish disease monitoring programme also seeks to gather information on the health status of commercial species where conditions present may have human health implications i.e. zoonotic potential or to render the fish unsightly or unmarketable. This chapter provides information on the disease status of a variety of fish species in the North Sea, English Channel and Irish Sea from data obtained during 2007.

The utility of this approach is recognised internationally and is included in the Oslo and Paris Commission (OSPAR) Co-ordinated Environmental Monitoring Programme (CEMP) (OSPAR, 1995) where it is currently accorded CEMP 1 voluntary ranking. The ICES WORKING GROUP on Pathology and Diseases of Marine Organisms (WGPDMO) has developed assessment tools for fish disease measurements. With these in place it is possible that fish disease information will be elevated to CEMP 1 mandatory status.

Fish disease data have been used for environmental assessments for the North Sea and more widely for the north-east Atlantic under the auspices of the North Sea Task Force and its Quality Status Report (QSR) (North Sea Task Force, 1993), the OSPAR Quality Status Report 2000 (OSPAR, 2000) and the 3rd and 4th Helsinki Commission (HELCOM, 1996, 2002). Currently, assessments are underway via the UK initiative Charting Progress 2 (CP2) and the OSPAR QSR for the north-east Atlantic, both due for publication in 2010.

This chapter provides information on the results obtained from the 2007 monitoring programme and provides a summary of how long-term fish health data is being used for CP2 assessment.

3.2 Materials and methods

Monitoring was undertaken as part of the integrated biological effects monitoring cruises that take place annually during the summer (June and July). In 2007 a total of 22 sites were assessed for external fish disease and the presence of macroscopic liver nodules and 24 sites were sampled specifically for liver pathology (for site locations see Table 3.1).

Sampling protocols followed those established by ICES (Bucke *et al*., 1996) for external diseases. Target species were dab and cod (*Gadus morhua*) for offshore sites and dab and flounder at inshore locations. Where sufficient numbers of other species were caught, a disease assessment was undertaken. Species sampled included plaice (*Pleuronectes platessa*), haddock (*Melanogrammus aeglefinus*) and whiting (*Merlangius merlangus*). For each a careful assessment of external condition and parasite presence was made. Internal examination was also undertaken, with emphasis on the condition of the visceral organs and the liver in particular. The degree of infection with nematode parasites and the presence of melanomacrophage aggregates on the liver surface were recorded. Specimens exhibiting undiagnosed lesions were removed and placed in fixative for histological examination in the laboratory.

From all dab examined for external disease that harboured liver nodules greater than 2mm in diameter, a section of the liver incorporating the suspected tumour was taken for confirmatory histological analysis. Samples were fixed in neutral buffered formalin for between 24 and 48 hours and stored in 70% alcohol prior to further processing. Samples for other fish species requiring histological confirmation were treated similarly. In addition, standard sections of liver and gonad tissue were sampled from 50 dab greater than 20 cm in length for the assessment of pathological changes. At each site sampled, the first 20 fish were also sampled for other biomarkers. The otoliths were also removed from each of these fish for age assessment (data not reported here). Histological methods and diagnostic criteria followed those developed by ICES and were undertaken according to the quality assurance requirements required under the Biological Effects Quality Assurance in Monitoring

Table 3.1. Summary catch data and disease prevalence in dab (Limanda limanda) by size category on stations sampled during 2007

CSEMP	AREA	LAT	LONG	SIZE	M	F	LY	U	EP	HYP	LN	X	ST	LP	AC	GL
244	Amble	55.3052	1.2418	15-19	66	35	5	1	1	9	0	0	33	4	2	0
				20-24	83	64	8	4	2	40	3	1	66	3	4	1
				25>	0	2	0	0	0	1	0	0	0	0	0	0
706	Inner Liverpool Bay	53.4466	-3.4407	15-19	143	46	0	11	1	4	0	0	14	45	0	1
				20-24	37	104	0	14	3	7	8	0	3	83	3	29
				25>	0	23	0	6	1	2	2	0	1	19	1	7
616	Carmarthen Bay	51.548	-4.5997	15-19	76	19	0	6	1	0	0	0	2	3	0	2
				20-24	6	28	1	4	0	0	0	0	0	7	1	6
				25>	1	29	0	1	1	1	0	0	0	9	0	4
287	Dogger Central	54.5282	2.6832	15-19	52	48	1	4	2	9	0	0	35	9	1	0
				20-24	22	98	0	15	4	60	7	0	26	75	6	5
				25>	0	7	0	0	1	4	0	0	0	5	0	0
284	North Dogger 2	55.0685	2.0937	15-19	28	23	0	2	0	8	0	0	17	0	1	0
				20-24	22	33	0	6	0	26	5	0	18	6	4	0
				25>	1	49	0	11	0	26	9	0	8	15	1	1
283	North Dogger 1	55.2916	2.904	15-19	59	41	5	13	2	10	0	0	67	1	2	0
				20-24	29	100	7	22	6	27	6	1	67	18	5	0
				25>	5	93	9	24	0	43	9	0	48	22	4	1
286	West Dogger	54.7747	1.3005	15-19	72	28	3	7	0	20	0	0	54	3	1	0
				20-24	37	107	2	17	1	69	7	0	79	25	1	2
				25>	0	26	1	3	0	15	6	0	14	14	2	0
344	Flamborough	54.2343	0.5323	15-19	47	53	3	2	3	7	0	0	8	0	1	1
				20-24	79	69	3	5	2	54	2	0	29	5	1	2
				25>	0	4	0	1	0	3	1	0	4	1	1	1
377	Off Humber	53.1499	0.5724	15-19	36	64	6	2	2	5	0	1	35	6	1	0
				20-24	41	104	2	5	6	33	5	0	63	11	3	3
				25>	0	22	1	0	0	5	1	0	7	9	5	1
378	Indefatigable Bank	53.5667	2.0784	15-19	27	73	0	1	0	2	0	0	0	5	5	0
				20-24	34	100	1	4	6	31	1	0	2	31	4	5
				25>	5	111	1	9	5	47	9	0	0	59	3	7
715	Liverpool Bay	53.4723	-3.6996	15-19	41	25	0	4	0	0	1	0	2	16	2	12
				20-24	15	47	0	5	0	4	2	0	2	41	1	11
				25>	0	53	0	9	3	5	2	0	0	33	1	19
534	Lyme Bay	50.6151	2.9381	15-19	0	1	0	0	0	0	0	0	0	0	0	0
				20-24	11	21	0	0	0	0	0	0	0	0	0	0
				25>	0	17	0	0	0	0	0	0	0	0	0	0

Table 3.1 continued. Summary catch data and disease prevalence in dab (Limanda limanda) by size category on stations sampled during 2007

CSEMP	AREA	LAT	LONG	SIZE	M	F	LY	U	EP	HYP	LN	X	ST	LP	AC	GL
796	Morecambe Bay	53.9145	-3.3929	15-19	54	49	0	6	0	0	0	0	10	31	1	1
				20-24	18	156	0	5	5	1	1	0	18	100	2	19
				25>	1	27	0	0	1	0	1	0	0	19	2	3
494	Off Newhaven	50.7587	0.0206	15-19	1	0	0	0	0	0	0	0	0	0	0	0
				20-24	10	33	0	0	0	2	0	0	0	5	0	0
				25>	0	6	0	0	0	0	0	0	0	2	0	0
649	North Cardigan Bay	52.7113	-4.5142	15-19	8	4	0	0	0	0	0	0	0	4	0	0
				20-24	2	5	0	1	0	0	0	0	1	4	0	2
				25>	0	1	0	0	0	0	0	0	0	1	0	0
805	SE Isle of Man	54.0666	-3.8759	15-19	4	2	0	0	0	0	0	0	4	0	0	0
				20-24	6	0	0	1	0	0	2	0	3	2	0	2
				25>	0	0	0	0	0	0	0	0	0	0	0	0
654	South Cardigan Bay	52.1964	-4.4808	15-19	106	105	0	1	4	9	1	0	3	85	1	0
				20-24	3	59	0	2	1	6	8	0	2	33	3	6
				25>	0	0	0	0	0	0	0	0	0	0	0	0
584	South Eddystone	50.108	-4.1205	15-19	13	2	0	0	0	0	0	0	0	0	0	0
				20-24	15	19	0	0	0	1	0	0	0	1	0	0
				25>	1	0	0	1	0	0	0	0	0	0	0	0
769	St Bees Head	54.5164	-3.7984	15-19	146	64	0	4	3	0	1	0	156	82	1	1
				20-24	26	54	1	2	4	0	10	0	58	51	3	1
				25>	1	23	0	4	1	0	5	0	10	7	1	1
294	Tees Bay	54.7426	1.136	15-19	50	50	4	1	0	3	0	0	26	0	0	0
				20-24	43	77	4	4	1	11	0	0	45	4	4	0
				25>	0	0	0	0	0	0	0	0	0	0	0	0
776	Red Wharf Bay	53.3587	-4.157	15-19	64	47	0	1	2	1	0	0	9	12	0	0
				20-24	19	146	1	6	3	2	5	0	8	41	3	10
				25>	0	13	0	1	0	1	2	0	0	6	0	3
486	Rye Bay	50.8145	0.7125	15-19	48	45	0	2	0	1	0	0	0	5	1	5
				20-24	25	50	0	0	1	1	0	0	2	7	1	2
				25>	1	31	0	1	0	3	1	0	0	8	0	

Key:

M = Male
F = Female
LY = Lymphocystis
U = Epidermal ulceration
EP = Epidermal papilloma
HYP = Hyperpigmentation
LN = Liver nodules
MLN = Multiple liver nodules
MA = Macrophage aggregates
X = X-cell disease
ST = *Stephanostomum* sp.
LP = *Lepeophtheirius pectoralis*
AC = *Acanthochondria* sp.
NM = Nematodes
GL = *Glugea* sp.

(BEQUALM) programme (Feist *et al.*, 2004). Pathological changes to the liver are presented here under the broad categories of 1) non-specific inflammatory lesions, 2) non-neoplastic toxicopathic lesions, 3) foci of cellular alteration (FCA), 4) benign neoplasms and 5) malignant neoplasms. Fish displaying no liver pathology are reported as 'No Abnormalities Detected' (NAD).

3.3 Results

3.3.1 Dab diseases

Disease prevalence data according to size category are presented in Table 3.1. For several sites visited, the overall disease prevalence levels are similar to previous years. Increases in the prevalence of hyperpigmentation were again recorded for dab from most North Sea locations sampled and the Dogger Bank region in particular. Levels of this condition in Cardigan Bay and the Irish Sea more generally have reduced compared to 2006 and the condition remains significantly lower in Irish Sea dab than in North Sea dab populations. The prevalence of ulceration was reduced at several Irish Sea sites, Rye Bay and on the Dogger Bank. In contrast, the prevalence of ulcerated dab increased slightly in Cardigan Bay compared to 2006. Dab from other locations showed similar levels to previous years. Other disease conditions were at similar levels to those recorded in recent years.

A sample of fifty flounder from Rye Bay was screened for the presence of intersex and liver pathology. Two cases of vacuolated foci of cellular alteration were detected. No other liver pathology was detected and none of the fish exhibited intersex.

3.3.2 Progress in the use of fish disease data to classify Good Ecological Status

In recent years we have made considerable advances in the multivariate analyses of fish disease data collected from offshore sites in the UK. This progress has enabled us to identify patterns in disease profiles across wide geographical scales and to identify specific 'Site Types' that broadly classify the health of a specific site or region. These Site Types are now being utilised for initiatives such as Charting Progress 2 and will be utilised for more extensive assessments under the OSPAR QSR in 2010. Site typing is based upon the quality assured measurement of 5 grossly visible disease categories (Fig 3.1) and 5 liver pathology categories, including those associated with cancer formation (Fig 3.2). By considering the prevalence of each of these categories at a given site, a 'harm score' is generated that equates to the aforementioned Site Types (Table 3.2). The harm score delivers a definitive means to assess the past, current and future status of a given site and will prove instrumental in assessing disease trends and the effects of intervention strategies (Stentiford *et al.* 2009).

3.3.3 Disease status of other species

As in previous years only few sites yielded sufficient numbers of commercial species for disease evaluation, particularly of cod. Disease levels were low and mainly restricted to the occurrence of parasites (Table 3.3). A notable exception being the occurrence of liver tumours in bib *(Trisopterus luscus)* from Lyme Bay. Sufficient whiting were collected at four sites. All fish obtained from the Farne Deep were found to harbour nematode infections (as was the case in 2006). A range of other parasite species was detected, including the copepods *Lernaeocera branchialis* and *Clavella adunca* and 'black spot' disease caused by the host reaction to infection with metacercariae of trematode parasites in the skin. All haddock from the site off Tees harboured nematode parasites. In all of the cases of parasitism detected, there was little evidence of adverse host reaction and in most cases the fish appeared to be in good condition. Cases of skeletal deformity and superficial lesions, including tumours, were not detected in the fish examined.

3.4 Conclusions

- The continued increase in prevalence of hyperpigmentation in dab from the North Sea and Cardigan Bay requires further investigation. Various causes have been postulated, including exposure to UV radiation and contaminants, viruses and other prokaryote organisms. Collaborative investigations have been able to provide new data on the pathology and ultrastructure of the condition and attempts to isolate bacterial or viral agents have been unsuccessful, suggesting that infectious agents are not involved in the pathogenesis of the condition (Bruno pers. comm.).
- Site typing is being utilised in the current Charting Progress 2 initiative.
- Although some data on the health status of commercial species have been obtained, this is insufficient to provide an assessment at other locations for those species examined and for other commercially important fish and shellfish species. Occasional reports from the public augment our knowledge of disease occurrence and are invaluable in providing information from a variety of locations around the UK and are used to draw attention to disease occurrence that may be followed up during subsequent monitoring wherever this is possible.

Figure 3.1. Representative images of grossly visible diseases of dab (*Limanda limanda*) according to ICES criteria (Bucke *et al.* 1996). (A) No visible external diseases. (B) Epidermal papilloma (EP) on skin (arrow). (C) Skin hyperpigmentation (HYP). Multi-focal hyperpigmented regions on skin (arrows). (D) Skin ulceration (U) (arrow). (E) Lymphocystis (LY). Cluster of infected subepidermal fibroblasts (arrow). (F) Single large liver nodule (LN) (arrow) and adjacent apparently normal liver (asterisk).

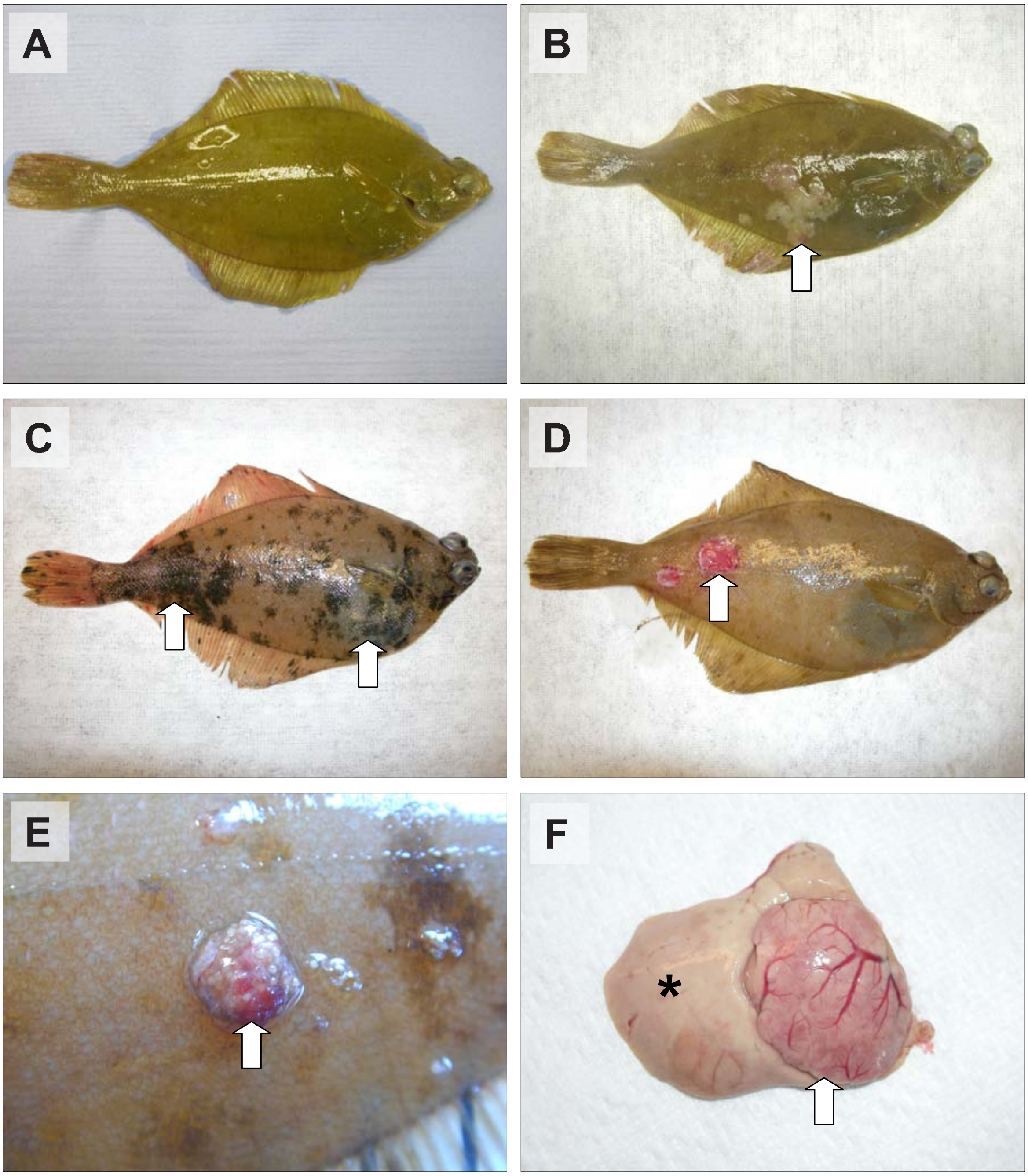


Figure 3.2. Representative liver lesions and pathology categories according to Feist *et al*. (2004) (pathology category and abbreviation in italics and parentheses). (A) Normal liver *(NAD, No Abnormality detected)*; Bar = 100 µm. (B) Nuclear pleomorphism (white arrows) *(NNT, Non-neoplastic toxicopathic lesion)*; Bar = 100 µm. (C) Granuloma (white arrow) and melanomacrophage centres (black arrow) *(NSI, non-specific inflammatory lesion)*; Bar = 200 µm. (D) Focus of cellular alteration (white arrow) *(FCA, Foci of cellular alteration)*; Bar = 50 µm. (E) Hepatocellular adenoma (white arrow) *(BN, Benign neoplasms)*; Bar = 200 µm. (F) Hepatocellular carcinoma with atypical cellular and nuclear profiles (white arrow) *(MN, Malignant neoplasms);* Bar = 50 µm. All H&E staining.

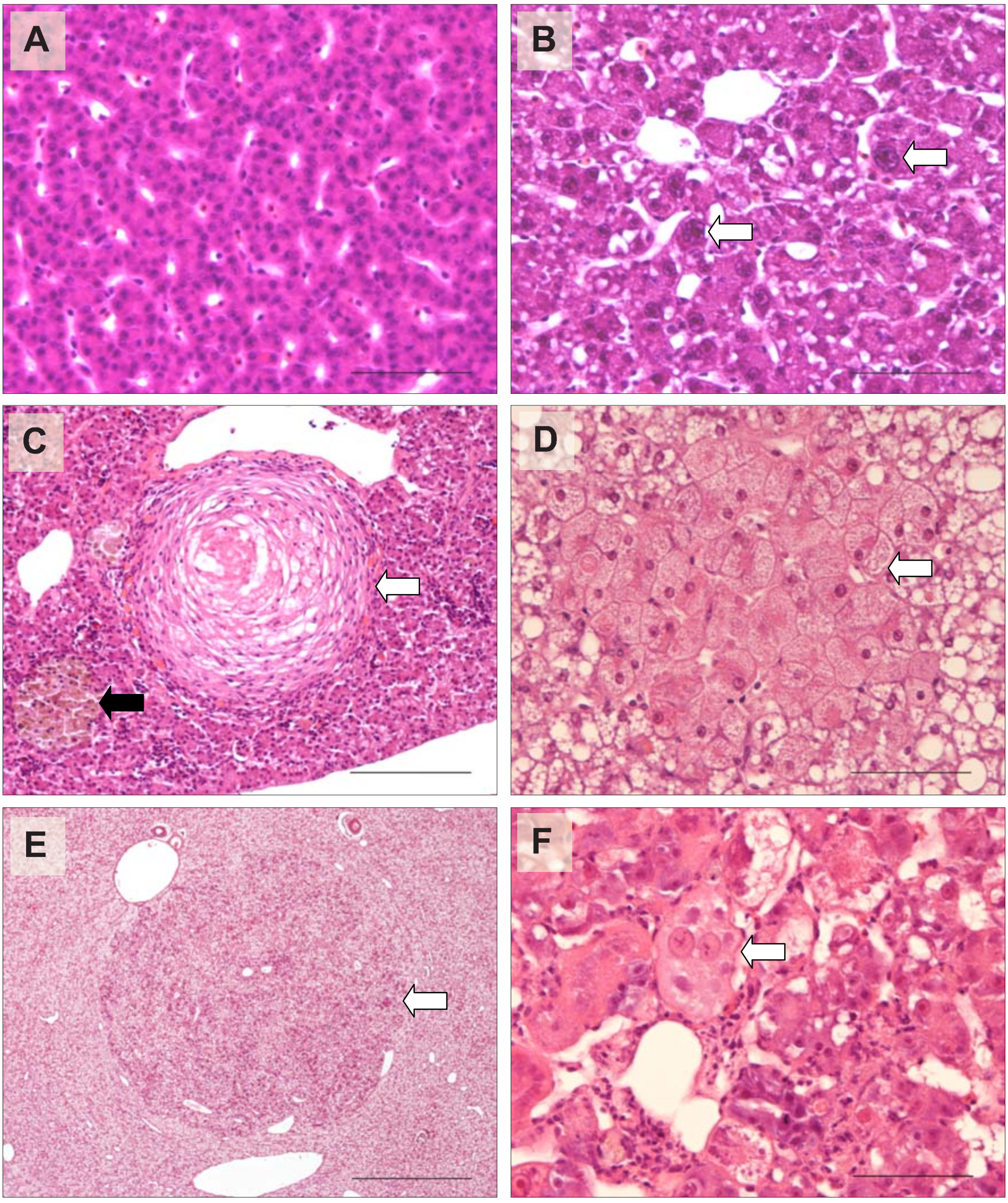


Table 3.2. Simple marine site classification scheme based upon disease profiles and derived harm scores in populations of dab (*Limanda limanda*) captured at those sites. Free text provides a broad outline of the likely disease profile within each site type.
Key: NAD (no abnormality detected in liver), NNT (non-neoplastic toxicopathic lesion in liver), FCA (foci of cellular alteration in liver), BN (benign neoplasm in liver), MN (malignant neoplasm in liver), NSI (non-specific inflammatory lesion in liver), LY (lymphocystis, external disease), U (ulceration, external disease), EP (epidermal papilloma, external disease), HYP (hyperpigmentation, external disease).

Type A	Type B	Type C
Generally low prevalence (<10%) of ICES external diseases and almost complete absence of HYP	Appearance of higher prevalence of ICES external diseases (incl. LY, U and HYP)	Highest levels of ICES external diseases (including up to 50% prevalence of HYP
Up to 50% of fish with no indication of BEQUALM liver pathology categories (NAD)	Less than 30% of fish with no indication of BEQUALM liver pathology categories (NAD)	Less than 20% of fish with no indication of BEQUALM liver pathology categories (NAD)
Low prevalence (<5%) of fish with NNT liver lesions and approximately 50 % prevalence of NSI liver lesions	Low prevalence (<10%) of fish with NNT liver lesions but an elevated prevalence of NSI liver lesions (up to 90%)	Similar prevalence of NNT liver lesions to Type B sites but a consistently high prevalence (up to 100%) of NSI liver lesions
Low prevalence of fish with liver FCA (<10%) and BN liver tumours (<5%). MN liver tumours very rare or absent.	Prevalence of FCA can exceed 15%. BN liver tumour prevalence around 10%. MN liver tumours more common than in Type A (up to 6%)	High prevalence (up to 50%) of FCA with BN liver tumour prevalence often exceeding 15%. MN liver tumours still comparatively rare though generally comprise a larger proportion of observed liver tumours than Type B (up to 8%).
Liver pathology score <5 and/or External disease score <5	**Liver pathology score >5<10 and/or External disease score >5<10**	**Liver pathology score >10 and/or External disease score >10**

Table 3.3. Disease status of commercial species from locations in the North Sea and Irish Sea sampled in 2007.

Species	No. examined	Size range(cm)	Location	Parasites/Pathology (No. affected)
Cod	31	21-38	Amble	NM(26), CLV(1)
Whiting	58	19-32	Thames Gabbard	NM(2), CLV(2), CR(5)
"	76	14-37	Farne	NM(76), CLV(2), LB(2), LP(1)
"	100	23-44	Eddystone	CLV(4), LB(4), CR(3)
"	45	16-33	West Lundy	NAD
Haddock	100	23-41	Off Tees	NM(100), LB(5)
"	200	22-26	West Lundy	CLV(3), LB(10)
Bib	100	27-45	Lyme Bay	NM(6), LB(18), CR(11) Liver tumours (10)

Key: NAD = No abnormalities detected; NM = Nematodes (*Anisakis* spp.); CLV = *Clavella adunca*; LP = *Lepeophtheirus pectoralis*; LB = *Lernaeocera branchialis*; CR = *Cryptocotyle*

4. Licensing of deposits in the sea

Author: Chris Vivian

Provides annual information on licensing and enforcement activities undertaken in relation to deposits in UK seas.

4.1 Introduction

This section gives information about the licensing of deposits in the sea around the coasts of England and Wales in 2007 under Part II of the Food and Environment Protection Act 1985 (as amended) (FEPA) (Great Britain Parliament, 1985a & b). In order to provide a complete picture for the UK as a whole, licensing statistics for Scotland and Northern Ireland are also included in this section.

4.2 Legislation and licensing authorities

The deposit of substances and articles in the sea, principally the disposal of dredged material (as opposed to discharge into the sea via pipelines) and the use of material during marine construction and coastal defence works, is controlled by a system of licences issued under Part II of FEPA. Certain operations (e.g. the deposit of scientific equipment or navigation aids) are exempt from licensing under the Deposit in the Sea (Exemptions) Order 1985 (Great Britain Parliament, 1985a & b).

Following devolution in 1999, Defra (then MAFF) continued to license deposits in the sea around the Welsh coast on behalf of the Welsh Assembly Government. In Scotland, the licensing function became the responsibility of the Scottish Executive (then SEERAD). In Northern Ireland the issuing of licences remained the responsibility of the Environment and Heritage Service, an agency of the Department of the Environment for Northern Ireland.

4.3 Enforcement

Scientists from Cefas have the powers to enforce Licence provisions. Visits are made to construction sites and disposal vessels. Samples are taken and records, including logbooks, are checked. Scientific staff carried out 6 inspections in 2007.

Officers of the Department's Marine and Fisheries Agency (MFA) are charged with enforcing the provisions of FEPA (Part II) and undertake regular inspections from a network of port offices in England and Wales. The MFA carried out 146 inspections in 2007 in relation to construction works and the disposal of waste materials (dredged materials and a small amount of shellfish waste) at designated disposal areas. Further details are given in Table 4.1.

In England and Wales, 5 written warning or advisory letters were issued for apparent breaches of licensing controls in 2007.

In England and Wales in 2007 there were no successful prosecutions for illegal marine works.

In Scotland, certain authorised staff of the Fisheries Research Services (FRS), Marine Laboratory, Aberdeen and the Scottish Fisheries Protection Agency (SFPA) hold similar enforcement powers. The FRS made 14 enforcement visits in 2007.

In Northern Ireland the Environment and Heritage Service made 20 enforcement/investigation visits in 2007 which resulted in 3 warning letters being issued to terminate the unlicensed activities.

4.4 Licensing of dredged material disposal

Table 4.2 gives details for the period 2003 to 2007 of the number of sea disposal licences issued, the quantity of waste licensed and the quantity actually deposited, together with information on those contaminants in the wastes which the UK is required to report internationally to meet obligations under the OSPAR and London Conventions. A proportion of the trace metals in this dredged material is natural, but the mineral structure is such that it will not be available to marine organisms.

Figure 4.1 shows the main disposal sites used in 2007 and the quantities disposed of at each site. Although applications for licences are required to show evidence that they have considered alternative disposal options including ben-

Table 4.1. Inspection activity by the MFA during 2007.

District	No. of Inspections		No. of Infringements
	Construction	Disposal	
Central	12	8	0
Eastern	15	4	2
London	1	0	0
Northern	8	2	0
South Eastern	32	3	5
South Western	3	3	0
Western	46	3	3
Wales	6	0	0
Annual Total	**123**	**23**	**10**

Table 4.2. Summary of dredged material licensed and disposed of at sea in 2007.

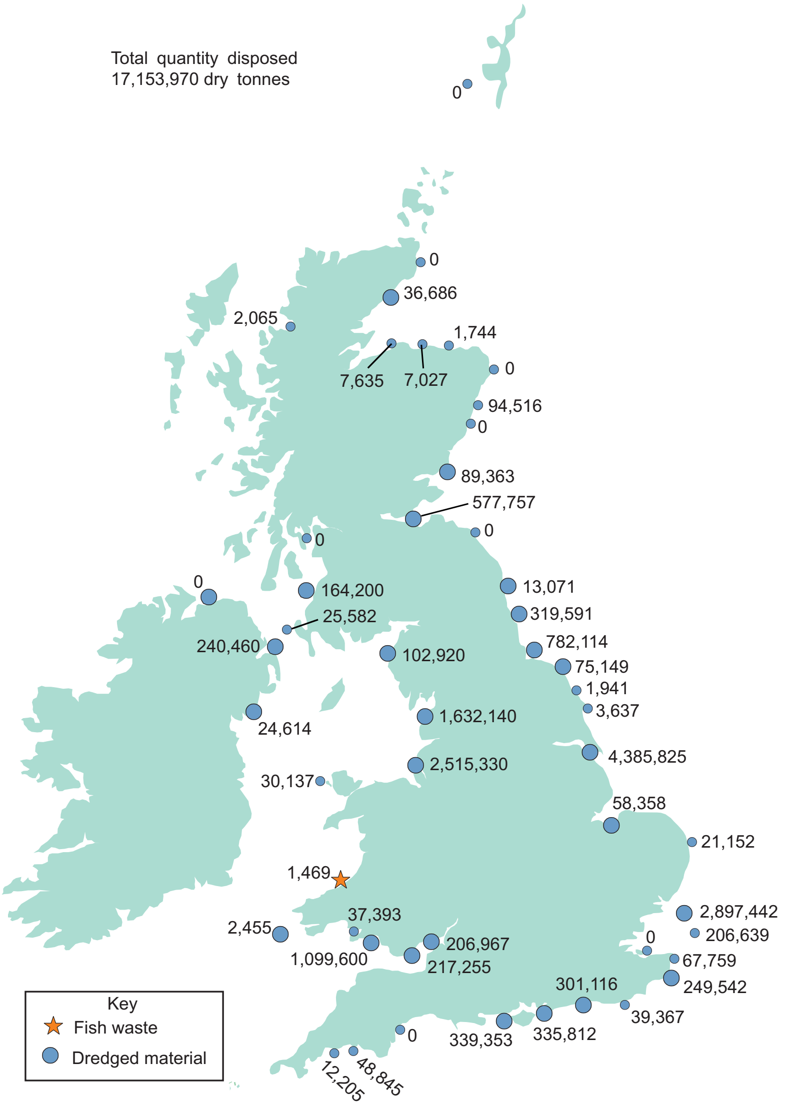
Country	Year	Licences issued	Licensed quantity (tonnes)	Wet tonnage deposited	Dry tonnage deposited	Quantities of metal contaminants in wastes deposited (tonnes)						
						Cd	Cr	Cu	Hg	Ni	Pb	Zn
England and Wales	2003	97	31,836,123	29,526,580	15,800,897	5.41	950	498	4.29	443	1,183	2,694
	2004	80	44,790,919	28,516,645	14,949,123	5.27	886	513	4.35	412	1,190	2,648
	2005	87	37,483,750	27,729,366	14,774,821	4.91	759	571	4.28	419	1,031	2,594
	2006	65	21,076,535	26,833,340	13,989,803	4.41	622	422	3.55	362	914	2,085
	2007	76	40,174,335	30,617,428	15,882,324	4.93	713	498	3.76	408	1,053	2,364
Scotland	2003	29	3,573,981	2,764,020	1,647,881	0.61	70	57	1.40	41	101	175
	2004	23	2,412,670	1,484,408	742,204	0.19	27	19	0.51	14	31	54
	2005	20	5,293,220	2,723,703	1,376,334	1.23	181	112	1.59	69	174	360
	2006	24	4,566,531	1,701,046	850,523	0.21	58	36	0.88	29	62	124
	2007	22	3,006,279	2,018,862	1,032,455	0.09	41	21	0.34	25	34	73
Northern Ireland	2003	2	189,900	115,404	73,382	1.47	8	4	0.06	3	2	12
	2004	4	432,904	111,208	79,135	0.04	3	1	0.06	1	1	7
	2005	3	37,800	585,187	308,111	0.11	23	10	0.03	13	14	47
	2006	3	176,999	833,426	507,942	1.01	68	49	0.33	42	59	209
	2007	3	454,000	429,285	265,074	0.07	21	8	0.07	13	9	34
U.K. total	2003	128	35,600,004	32,406,004	17,522,159	7.50	1,027	559	5.75	487	1,286	2,881
	2004	107	47,636,493	30,112,261	15,770,462	5.50	917	533	4.92	427	1,223	2,709
	2005	110	42,814,770	31,038,256	16,459,266	6.25	963	692	5.89	501	1,219	3,000
	2006	92	25,820,065	29,367,812	15,348,268	5.63	748	508	4.76	433	1,034	2,418
	2007	101	43,634,614	33,065,575	17,179,852	5.09	775	527	4.17	446	1,096	2,471

Notes: Tonnages deposited relate to quantities in the calendar year 2006, which may be covered by 2 or more licences, including one or more issued in previous years.

Table 4.3. Other categories of licences issued in 2007.

Licence category	England and Wales	Scotland	Northern Ireland	Total
Construction – new and renewal	205	73	16	294
Tracers, biocides etc.	8	0	0	8
Burial at sea	16	0	0	16

Figure 4.1. Amount of dredged material disposed of at sea in 2007, in dry tonnes.



eficial use, the problems of having silty materials for disposal, and matching the timing of dredging campaigns and the demand for sediments, have meant that most of the finer materials, in particular, are deposited at sea.

4.5 Other licensed activity

Under Part II of FEPA, licences are also required for certain other activities or deposits made below the mean high water springs mark for construction purposes. Each licence application is carefully considered, in particular, to assess the impact on the tidal and intertidal habitat, hydrological effects, potential interference to other users of the sea and risk to human health. Details of these licences issued in 2007 are shown in Table 4.3.

Further activities involve the use of tracers, the application of biocides, and burial at sea. Generally, the anticipated environmental impact from these deposits is minimal and little or no monitoring is required. Details of these licences issued in 2007 are also shown in Table 4.3.

Licences have also authorised the disposal of a small amount of fish waste, details are given in Tables 4.4(a) and (b).

Table 4.4a. Fish waste licensed for disposal at sea in 2007 (1).

Country	Licensed Quantity (tonnes) [1]	Company and source of waste	Disposal sites	Quantity deposited (wet tonnes)	Quantity deposited (dry tonnes)
England and Wales	0	Quay Fresh and Frozen Foods Ltd, New Quay	New Quay	1,469	1,469

Notes: (1) No Fish Wastes were licensed or disposed of in Scotland or Northern Ireland during the period covered by this report.
For information on licensed quantities and tonnages deposited see footnote to Table 4.2.

Table 4.4b. Summary of fish waste licensed and disposed of at sea in 2007.

Country	Year	Licences issued	Licensed quantity (tonnes)	Wet tonnage deposited	Dry tonnage deposited
England and Wales	2003	1	6,000	953	953
	2004	0	0	1,834	1,834
	2005	0	0	1,988	1,988
	2006	0	0	1,203	1,203
	2007	0	0	1,469	1,469
Scotland	2003	0	0	0	0
	2004	0	0	0	0
	2005	0	0	0	0
	2006	0	0	0	0
	2007	0	0	0	0
Northern Ireland	2003	0	0	0	0
	2004	0	0	0	0
	2005	0	0	0	0
	2006	0	0	0	0
	2007	0	0	0	0
U.K. Total	2003	1	6,000	953	953
	2004	0	0	1,834	1,834
	2005	0	0	1,988	1,988
	2006	0	0	1,203	1,203
	2007	0	0	1469	1469

Notes: For information on licensed quantities and tonnages deposited see footnote to Table 4.2.

5. Advice on fishery implications of pipeline discharges

Authors: Simon Kershaw & Richard Acornley

Seeks improvement and protection of shellfish waters and growing areas and supports sustainable inshore fisheries

5.1 Overview

This section gives a brief summary of activities carried out during 2006-2007 in connection with the provision of advice on fishery implications of pipeline discharges.

Cefas appraisal of applications for pipeline discharges involves consideration of fishery resources in the area, the toxicity of the effluent, the local hydrographic conditions and any standards set out in national policy or European Union (EU) Directives. This includes the impact of discharges on marine fauna, including fish nurseries and shellfish populations, and specific interactions of chemicals and the marine environment. One important issue in relation to sewage discharges is the microbiological contamination of bivalve mollusc shellfisheries and the associated human health concerns. The reduction of sewage contamination at source is the most effective way of reducing the health risk. It also reduces the burdens on the industry and increases acceptability of product to supermarkets and other markets.

5.2 Summary of pipeline discharge applications

During 2006-2007 Cefas assessed applications for a total of 185 individual discharges; of these a total of 129 (69.7%) were assessed for their potential to impact on shellfish waters and/or production areas. Shellfish hygiene issues therefore continued to be the most common concerns addressed. Table 5.1 shows the types of discharge application commented on in 2006-2007. The majority of applications were for discharge of domestic or combined domestic and industrial sewage, including storm and emergency sewage overflows.

During periods of prolonged or heavy rainfall, surface water run-off will add to the domestic and industrial sewage, substantially increasing the volume of wastewater entering the sewerage system. Although the sewerage networks and sewage treatment works are designed to store and treat multiples of the flows experienced in dry weather it is not feasible to treat all flows from these combined foul and surface water sewer systems, Combined Sewer Overflows (CSOs). In pipe-full conditions storm overflows are required to allow a proportion of the untreated dilute sewage to discharge from the sewerage system. Intermittent discharges from storm tanks and CSOs may therefore by-pass the treatment works with the potential to impact on receiving waters.

Applications for 81 storm overflow discharges were received in 2006-2007 of which 65 were identified as potentially impacting on shellfisheries. Where water company discharge improvements are identified to benefit shellfish waters, Environment Agency (EA) policy requirements restrict overflow operation to a maximum of ten spills per annum (in aggregation with other impacting storm discharges averaged over a ten year period). Previously this requirement had to be negotiated by Cefas on a case-by-case basis. Where applications are received for discharges that are not funded to specifically benefit shellfish waters, but still have the potential to impact on shellfisheries, Cefas may require restrictions on overflow operation in order to protect public health.

Cefas continues to request that the water companies provide an annual report of spills from each of these overflows and where necessary asked for clarification that discharges had been considered in aggregation with others impacting on the same fishery. The review of annual spill reports is important for evidence-based decision-making, proving useful in identifying problem discharges that require further improvement. It has also highlighted the (often large) discrepancies between predicted and actual spill frequencies.

Emergency overflows only come into operation when there is a major failure at the sewage treatment works or pumping station. If this should occur, it may cause severe contamination of fisheries in the area. Applications for 37 emergency discharge applications were received, of these 28 had the potential to affect shellfisheries. In advising on such applications Cefas therefore requested urgent notification of emergency events to the local food authority so that appropriate action could be taken to protect public health.

A total of 31 applications were received for continuous discharges of secondary (biologically treated) effluent (17 affecting shellfisheries); these included upgrading of existing works and new treatment works, and package plants. In addition, 7 applications were received for sewage discharges receiving tertiary treatment (ultra-violet disinfection or membrane filtration) in order to reduce microbiological contamination. Two of these benefited shellfish areas.

Trade discharges were assessed for impacts of any chemicals, suspended solids or other inorganic components on fisheries and the marine environment generally.

5.3 Impact of discharge improvements on bivalve mollusc shellfisheries

The Government has set a target for all commercially harvested shellfish beds in England and Wales to achieve a microbiological classification for bivalve mollusc shellfish of at least Class B as categorised under Regulation (EC) No. 854/2004, see Table 5.2. The proportion of Class B beds increased from 45.9% in 1992 to 88.4% in 2007 (Figure 5.1). The proportion of Class C areas decreased from 38.4% in 1992 to a low of 7.1% in 2007. Numbers of prohibited areas decreased from 5.0% to 1.8% in the same period. This increase in Class B areas and decrease in Class C and prohibited areas in this period, largely reflects water company investment targeting discharges to tidal waters, and in particular those improvements identified as benefiting shellfish waters.

Despite significant improvements in water quality as a result of investment in discharge improvements, in 2007, fewer than 3% of shellfish production areas in England and Wales achieved the 'Class A' standard which reflects water quality clean enough to allow marketing of shellfish direct for human consumption without further processing. A decrease in the proportion of Class A areas is also of concern as Class A confers benefits of access to markets and premium market prices for the fishing industry. To achieve Class A status for many fisheries it is likely that a combined programme of additional discharge improvements and/or measures to tackle diffuse pollution issues would be required in the future.

5.4 Case studies

Advice was provided to the EA following consultation on an application for temporary relaxation of consent conditions during refurbishment of Colchester STW, a large sewage treatment works at the head of the Colne Estuary. Whilst improvement works were necessary, Cefas suggested approaches to management of shellfish hygiene issues that might arise during the refurbishment period and encouraged engagement with local stakeholders. As a result of consultation, the EA agreed to monitor microbiological parameters in the effluent during and for a period after the refurbishment works. The consent for the upgraded works included a requirement for telemetry on the storm and emergency overflows.

Two separate discharge consent applications were made to the EA in relation to new discharges to the Dart Estuary that had the potential to adversely impact on shellfisheries. Cefas raised concerns over the increased microbiological load to the water in the shellfish production areas, which might compromise the classification status, and suggested that higher levels of treatment may be appropriate. Following our response, one applicant withdrew their application and the discharge was made to a cesspool instead. The other discharge was made to the ground, thereby avoiding new pipeline discharges to the estuary.

Table 5.1. Numbers of applications of various types commented on within 2006-2007

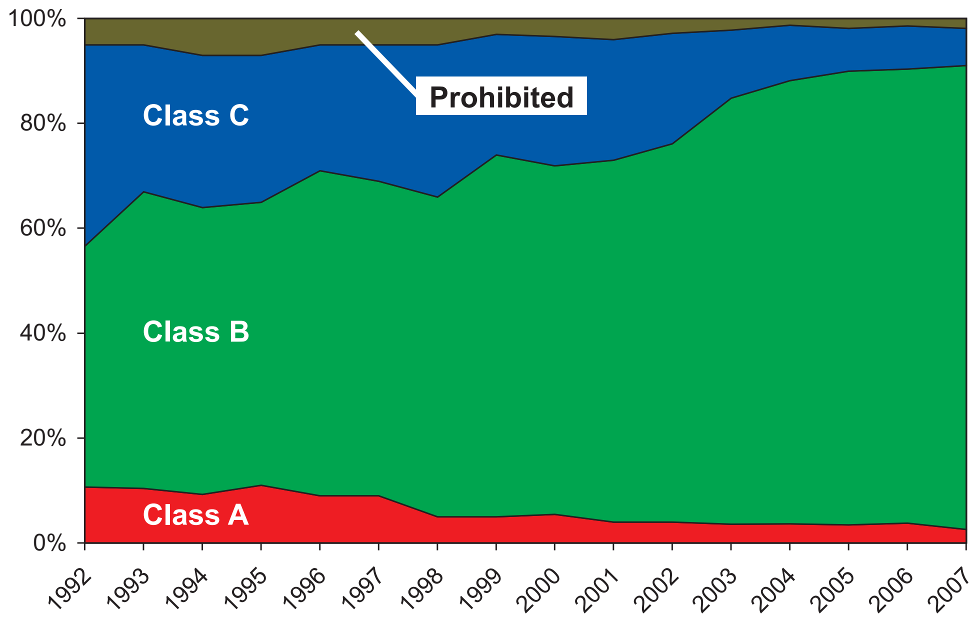
Type of application	Total	Shellfish – related
Continuous sewage discharges		
Primary treatment	2	0
Secondary treatment	31	17
Tertiary treatment	7	2
Intermittent sewage discharges		
Storm overflow	81	65
Emergency overflow	37	28
Trade discharges	14	13
Other discharges	13	4
Total	**185**	**129**

Table 5.2. Classification categories under EU Regulation 854/2004

Class	Criteria	Requirements
A	<=230 E. *coli* /100g of flesh and intravalvular liquid	May be consumed without treatment
B	<=4,600 E *coli* /100g of flesh and intravalvular liquid in 90% of samples	Purification or relaying for 2 months* (or heat treatment by approved process)
C	<=46,000 E. *coli* /100g of flesh and intravalvular liquid	Relaying for 2 months* or heat treatment by approved process
	>46,000 E. *coli* per 100g of flesh and intravalvular liquid. Does not conform to requirements of class A, B, or C (or at discretion of member State) Harvesting not permitted.	

• *The competent authority may agree a shorter period on basis of food business operator's risk analysis*

Figure 5.1. Percentage of shellfish production areas in England and Wales in each hygiene classification category, 1992-2008



Consultation took place on a first time rural sewerage scheme in the Plymouth area in which crude discharges were to be transferred to a sewage treatment works for treatment. However, this would result in increased flows at a pumping station and potentially increase the frequency of spills. Cefas requested emergency notification and spill reporting for discharges from this pumping station and although South West Water maintained that the outfall was not near a designated Shellfish Water, the EA encouraged the protection of shellfisheries above minimum requirements by proposing clauses requiring spill reports on request.

Discussions took place with the EA in relation to planned improvements at Chichester Wastewater Treatment Works which impacts on a shellfish production area in Chichester Harbour currently reflecting Class C under microbiological hygiene monitoring. UV disinfection will be required for the continuous discharge, which should be of benefit to the water quality and hence shellfisheries. However, Cefas expressed concerns regarding the frequency of storm discharges and the decision not to limit the number of spills to 10 per year (on average). Cefas stressed that these improvements might therefore not be sufficient to result in a significant improvement in the classification status (consistent with Government aims) for nearby shellfish harvesting areas.

5.5 General advice

In addition to assessment of applications for consent to discharge, a variety of other advice relating to pipeline discharges was provided during the year.

General support was provided for water quality liaison with the EA regions, highlighting local and topical discharge issues prior to meetings. This has proved effective in championing the consideration of the marine environment and fisheries interests and influencing scheme outcomes, prior to any formal discharge consent application.

Advice was given to the EA in relation to an appeal by United Utilities against the consent conditions for several intermittent discharges in Preston that had the potential to impact on shellfisheries in the Ribble Estuary. Representation was also made to the Secretary for State in relation to this appeal. Cefas advised that event monitoring and annual reporting should be required to inform future investment and management decisions on shellfisheries issues. The EA won this appeal, retaining these consent conditions in the discharge consents.

Spill summaries for monitored intermittent discharges in South West and Southern Regions were received from the EA. Cefas provided comment on these and it is noted that a number of discharges were exceeding their predicted average spill frequencies, thereby potentially contaminating shellfish production areas. Investment made within the Water Companies investment period 2000-2005 (AMP3) with the aim of improving Shellfish Waters may not therefore be delivering the intended improvements.

On request, advice was given to the shell fishing industry regarding the potential impacts of individual discharges on their activities.

Cefas provided comments to the EA in response to their proposal to apply the national risk-based Operator and Pollution Risk Appraisal (OPRA) system to the regulation of discharges to water. Several aspects of the proposed system were highlighted where Cefas considered that the risks discharges posed to shellfisheries had not been given sufficient weight.

5.6 Database maintenance

All applications, consents and authorisations continue to be entered onto a database that contains details of discharges to saline waters in England and Wales. This provides unique intelligence and is a strategic tool used alongside other Cefas tools to underpin impact assessments and policy decisions in the marine environment.

A bespoke data management system has been developed, which incorporates several databases relevant to shellfish hygiene work carried out by Cefas. This facilitates interrogation of data across the different areas, providing a more coherent understanding and giving a more useful tool for assessment of discharge applications and for co-ordinating the provision of advice

6. References

BAXTER, A.J. and CAMPLIN, W.C., 1993a. Radiocaesium in the seas of northern Europe: 1970-74. Fish. Res. Data Rep., MAFF Directorate of Fisheries Research, Lowestoft, (30): 111pp.

BAXTER, A.J. and CAMPLIN, W.C., 1993b. Radiocaesium in the seas of northern Europe: 1962-69. Fish. Res. Data Rep., MAFF Directorate of Fisheries Research, Lowestoft, (31): 69pp.

BAXTER, A.J. and CAMPLIN, W.C., 1993c. Radiocaesium in the seas of northern Europe: 1985-89. Fish. Res. Data Rep., MAFF Directorate of Fisheries Research, Lowestoft, (32): 179pp.

BAXTER, A.J. and CAMPLIN, W.C., 1994. The use of caesium-137 to measure dispersion from discharge pipelines at nuclear sites in the UK. Proceedings of the Institution of Civil Engineers. Water, Maritime and Energy, 106, 281-288.

BAXTER, A.J., CAMPLIN, W.C. and STEELE, A.K., 1992. Radiocaesium in the seas of northern Europe: 1975- 79. Fish. Res. Data Rep., MAFF Directorate of Fisheries Research, Lowestoft, (28): 166pp.

BUCKE, D., VETHAAK, A. D., LANG, T., and MELLERGAARD, S., 1996. Common diseases and parasites of fish in the North Atlantic: Training guide for identification. ICES Techniques in Marine Environmental Sciences, (19) : 27pp.

CAMPLIN, W.C. and STEELE, A.K., 1991. Radiocaesium in the seas of northern Europe: 1980-84. Fish. Res. Data Rep., MAFF Directorate of Fisheries Research, Lowestoft, (25): 174pp.

DEFRA, 2002. Safeguarding Our Seas – A Strategy for the Conservation and Sustainable Development of Our Marine Environment, Department for Environment, Food and Rural Affairs, 80pp, ISBN 0 85521 005 2.

DEFRA, 2005. Charting Progress: an integrated assessment of the state of UK seas. http://www.defra.gov.uk/environment/water/marine/uk/stateofsea/chartprogress.pdf

EUROPEAN CHEMICALS BUREAU, 2008. http://ecb.jrc.it/esis ; accessed February 25, 2008

FEIST, S.W., LANG, T., STENTIFORD, G.D. and KÖHLER, A., 2004. The use of liver pathology of the European flatfish, dab (*Limanda limanda* L.) and flounder (*Platichthys flesus* L.) for monitoring biological effects of contaminants. ICES Techniques in Marine Environmental Science, (28): 47pp.

GREAT BRITAIN PARLIAMENT, 1985a. Food and Environment Protection Act, 1985. Chapter 48. Her Majesty's Stationery Office, London

GREAT BRITAIN PARLIAMENT, 1985b. Marine Pollution. The Deposits in the Sea (Exemptions) Order, 1985. Her Majesty's Stationery Office, London. Statutory Instrument, 1985, No. 1699

GREAT BRITAIN PARLIAMENT, 1991. Water Resources Act, 1991. Chapter 57. Her Majesty's Stationery Office, London, 259pp

HELCOM, 1996. Third Periodic Assessment of the State of the Marine Environment of the Baltic Sea, 1989-1993; Background Document. Baltic Sea Environment Proceedings N0 64 B. 252pp.

HELCOM, 2002. Environment of the Baltic Sea area 1994-1998. Baltic Sea Environment Proceedings N0 82 B. 215pp.

KERSHAW, P.J. and BAXTER, A.J., 1995. The transfer of reprocessing wastes from north-west Europe to the Arctic. Deep-Sea Research II, 43, 1413-1448

KERSHAW, P.J., HELDAL, H.E., MORK, K.A. and RUDJORD, A.L., 2004. Variability in the supply, distribution and transport of the transient trace ^{99}Tc in the NE Atlantic. Journal of Marine Systems, 44, 55-81.

KERSHAW, P.J., MCCUBBIN, D. and LEONARD, K.S., 1999. Continuing contamination of north Atlantic and Arctic waters by Sellafield radionuclides. Science of the Total Environment, 237/238, 119-132

LAW, R.J. (compiler), 1994. Collaborative UK Marine Mammal Project : summary of data produced 1988-1992. Fisheries Research Technical Report, MAFF Directorate of Fisheries Research, Lowestoft, (97): 42pp.

Available for download at: http://www.cefas.co.uk/publications/techrep/tech97.pdf

LAW, R.J., BERSUDER, P., ALLCHIN, C.R. and BARRY, J., 2006b. Levels of the flame retardants hexabromocyclododecane and tetrabromobisphenol A in the blubber of harbor porpoises (*Phocoena phocoena*) stranded or bycaught in the U.K., with evidence for an increase in HBCD concentrations in recent years. Environmental Science and Technology, 40, 2177-2183.

LAW, R.J., BERSUDER, P., BARRY, J., WILFORD, B.H., ALLCHIN, C.R. and JEPSON, P.D., 2008b. A significant downturn in levels of hexabromocyclododecane in the blubber of harbor porpoises (*Phocoena phocoena*) stranded or bycaught in the UK: an update to 2006. Environmental Science and Technology, 42, 9104-9109.

LAW, R.J., HERZKE, D., HARRAD, S., MORRIS, S., BERSUDER, P. and ALLCHIN, C.R., 2008a. Levels and trends of HBCD and BDEs in the European and Asian environments, with some information for other BFRs. Chemosphere, 73, 223-241.

LAW, R.J., JEPSON, P.D., DEAVILLE, R., REID, R.J., PATTERSON, I.A.P., ALLCHIN, C.R. and JONES, B.R., 2006a. Collaborative UK Marine Mammals Strandings Project: summary of contaminant data for the period 1993-2001. Science Series Technical Report, Cefas Lowestoft, (131) : 72pp.

Available for download at: http://www.cefas.co.uk/publications/techrep/tech131.pdf

LAW, R.J., KOHLER, M., HEEB, N.V., GERECKE, A.C., SCHMID, P., VOORSPOELS, S., COVACI, A., BECHER, G., JANÁK, K. and THOMSEN, C., 2005. Hexabromocyclododecane challenges scientists and regulators. Environmental Science and Technology, 39, 281A-287A.

LEONARD, K.S., MCCUBBIN, D., BLOWERS, P and TAYLOR, B.R., 1999. Dissolved plutonium and americium in surface waters of the Irish Sea, 1973-96. Journal of. Environmental Radioactivity, 4, 129-158

LEONARD, K.S., MCCUBBIN, D., BROWN, J., BONFIELD, R. and BROOKS, T., 1997a. A summary report of the distribution of technetium-99 in UK Coastal Waters. Radioprotection, 32, 109-114.

LEONARD, K.S., MCCUBBIN, D., BROWN, J., BONFIELD, R. and BROOKS, T., 1997b. Distribution of technetium-99 in UK coastal waters. Marine Pollution Bulletin, 34, 628- 636.

LEONARD, K.S., MCCUBBIN, D., BROWN, J., BONFIELD, R. and PEAK, T., 2001. Accumulation of 99Tc in the Irish Sea. RL7/01. CEFAS, Lowestoft.

LEONARD, K.S., MCCUBBIN, D., MCDONALD, P., SERVICE, M., BONFIELD, R. and CONNEY, S., 2004. Accumulation of technetium-99 in the Irish Sea. Science of the Total Environment, 322, 255-270.

MARINE ENVIRONMENT MONITORING GROUP 2005, Marine Environment Quality, Report 1 of 5 contributions to Charting Progress: an Integrated Assessment

MAYALL, A., 2005. A fine balance: multifactorial decision making and the regulation of Tc-99 discharges at Sellafield. Proceedings of the Seventh International Symposium of the Society for Radiological Protection, Cardiff. pp. 291-297.

MCCUBBIN, D., LEONARD, K.S., BROWN, J., KERSHAW, P.J., BONFIELD, R.A. and PEAK, T., 2002. Further studies of the distribution of 99Tc and 137Cs in UK and European coastal waters. Continental Shelf Research, 22, 1417-1445.

NORTH SEA TASK FORCE 1993. North Sea Quality Status Report 1993. Oslo and Paris Commissions, London. Olsen and Olsen, Fredensborg, Denmark. 132pp.

OSPAR, 1995. Assessment and Monitoring. The Joint Assessment and Monitoring Programme. ISBM 094695541 7.

OSPAR, 1998. SINTRA statement. Summary Record OSPAR 98/14/1, Annex 45. Oslo and Paris Commission, London.

OSPAR, 2000. Quality Status Report 2000. Oslo and Paris Commission, London.

OSPAR, 2006. Agreement on a monitoring programme for concentrations of radioactive substances in the marine environment. Annex 14, ref 9.8c, Malahide (Ireland): 27 June-1 July 2005. OSPAR, London.

POVINEC, P.P., BAILLY DU BOIS, P., KERSHAW, P.J., NIES, H. and SCOTTO, P., 2003. Temporal and spatial trends in the distribution of 137Cs in surface waters of Northern European Seas – a record of 40 years of investigations, Deep-Sea Research II, 50, 2785-2801.

STENTIFORD, G. D., LONGSHAW, M., LYONS, B. P. and FEIST, S. W., 2003 Histopathological biomarkers in estuarine fish species for the assessment of biological effects of contaminants. Marine Environmental Research, 55, 137-159.

STENTIFORD, G.D., BIGNELL, J.P., LYONS, B.P. and FEIST, S.W., 2009. Discriminating offshore sites by use of fish disease profiles and context for the use of disease data in marine environmental monitoring. Marine Ecology Progress Series (in press).

UK ENVIRONMENT AGENCIES, 2008. Environment Agency, Environment and Heritage Service, Food Standards Agency and Scottish Environment Protection Agency, 2008. Radioactivity in Food and the Environment, 2007. RIFE 13. Environment Agency, Bristol, Belfast, London and Stirling.

UNCLES, R.J., 1984. Hydrodynamics of the Bristol Channel. Marine Pollution Bulletin, 15, 47-53.

Head Office
Centre for Environment,
Fisheries & Aquaculture Science
Pakefield Road, Lowestoft,
Suffolk NR33 0HT, UK

Tel +44 (0) 1502 56 2244
Fax +44 (0) 1502 51 3865
Web www.cefas.co.uk
Cefas is an executive agency of Defra

ISSN 0142-2499