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SID 5 Research Project Final Report

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2. Project title
3. Contractor organisation(s)
4. Total Defra project costs (agreed fixed price)
5. Project: start date.....
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6. It is Defra's intention to publish this form.
Please confirm your agreement to do so YES NO

(a) When preparing SID 5s contractors should bear in mind that Defra intends that they be made public. They should be written in a clear and concise manner and represent a full account of the research project which someone not closely associated with the project can follow.

Defra recognises that in a small minority of cases there may be information, such as intellectual property or commercially confidential data, used in or generated by the research project, which should not be disclosed. In these cases, such information should be detailed in a separate annex (not to be published) so that the SID 5 can be placed in the public domain. Where it is impossible to complete the Final Report without including references to any sensitive or confidential data, the information should be included and section (b) completed. NB: only in exceptional circumstances will Defra expect contractors to give a "No" answer.

In all cases, reasons for withholding information must be fully in line with exemptions under the Environmental Information Regulations or the Freedom of Information Act 2000.

(b) If you have answered NO, please explain why the Final report should not be released into public domain

Executive Summary

7. The executive summary must not exceed 2 sides in total of A4 and should be understandable to the intelligent non-scientist. It should cover the main objectives, methods and findings of the research, together with any other significant events and options for new work.

On 18th January 2007 the container ship *MSC Napoli*, outward bound from Europe to South Africa in heavy weather, began to take in water through cracks in the engine room walls. The crew abandoned ship and were airlifted to safety, and two emergency towing vessels maintained on station in the Western Approaches by the French and UK governments took her in tow. The intention was to tow her to Portland Harbour on the south coast of the UK as a place of refuge where problems with the ship and her cargo could be tackled in safety. On the morning of the 20th January the ship suffered a serious structural failure and she was beached in Lyme Bay, off Branscombe in Devon, to prevent her from sinking. The ship was carrying 2,318 containers, 159 of which contained more than 1,600 tonnes of chemicals classified as dangerous goods by the International Maritime Organisation and around 4,000 tonnes of oil as fuel. It was considered that to have allowed the ship to sink in deep water would lead to a serious risk of chronic pollution with little or no ability to intervene. A salvage operation was then begun with the aim of removing the oil and cargo from the ship. As a quantity of oil and approximately 100 containers had been lost during and immediately following the grounding of the *MSC Napoli*, Defra decided to implement a monitoring programme in Lyme Bay in order to assess any environmental impact and to provide information which would allow the Food Standards Agency to protect the human food chain. The monitoring programme was designed and co-ordinated by Cefas.

The cargo carried by the *MSC Napoli* was very diverse, including many non-hazardous goods (cars, gearboxes, paper, personal effects etc) and a wide variety of hazardous materials (including chemicals, solvents, personal care products and pesticides). Of particular concern were the pesticides lambda-cyhalothrin, profenofos, glyphosate, carbendazim, propaquizafop, and dibutyltin oxide and a broad range of other chemical products.

The monitoring programme which was developed was therefore based on three main assumptions:

1. oil has been lost and may affect the local environment and so hydrocarbons should be monitored.
2. during the salvage operation any of the chemicals aboard may be lost and monitoring for those compounds may be necessary in water, sediments and biota.
3. as Lyme Bay is of major nature conservation importance, there will be a need to assess the damage to the local flora and fauna.

Initially, the Environment Agency augmented their routine water quality monitoring programme around Lyme Bay, both by adding additional stations to improve the data coverage and by implementing a screening procedure for chemicals in the water samples using coupled gas chromatography-mass

spectrometry. In addition, the Plymouth Marine Laboratory undertook a survey of the waters across Lyme Bay at various distances from shore (along the 10m, 20m and 40m depth contours) to assess the levels of hydrocarbon contamination in subsurface waters and the surface microlayer. Also, Cefas and the Marine and Fisheries Agency instigated a programme of sampling commercial shellfish (crabs, scallops and mussels) from Lyme Bay and Portland Harbour. These were analysed for polycyclic aromatic hydrocarbons, toxic components of oil which can affect the human foodchain and whose concentrations may require fishery closures to be put in place. Natural England organised necropsies of a proportion of the oiled seabirds which was conducted by members of the British Trust for Ornithology to establish species affected and their condition prior to oiling, and Cefas conducted analyses of oil from the feathers of a number of birds in order to confirm that the oil was from the *MSC Napoli*. In preparation for analysis of any of the chemicals aboard the vessel if lost, Cefas and the Environment Agency collected sediment samples from around the shoreline of Lyme Bay and from the Fleet and Portland Harbour, and the Plymouth Marine Laboratory also collected surface sediment samples from all the stations of the cruise mentioned above. All of these sediment samples were stored frozen at -20°C in order that they could provide baseline data against which any future contamination by any of the chemicals could be assessed.

Both the Plymouth Marine Laboratory (seawater) and Cefas (shellfish) studies showed elevated concentrations of PAH only in the area immediately outside the exclusion zone established around *MSC Napoli*. None of the shellfish showed PAH concentrations higher than the Food Standards Agency's guideline values ($10\ \mu\text{g kg}^{-1}$ wet weight for benzo[a]pyrene and $15\ \mu\text{g kg}^{-1}$ wet weight for benz[a]anthracene and dibenz[a,h]anthracene) and so no fishery closures were imposed. Studies undertaken by the University of Plymouth showed limited sublethal biological effects in limpets from Branscombe, close to the *MSC Napoli*. Benthic surveys undertaken on behalf of Natural England found evidence of damage to the benthic environment surrounding the *MSC Napoli*, but it could not be established that this was a result of the grounding of the vessel. Oil spilled from the *MSC Napoli* resulted in over 3,000 seabird casualties. Necropsies of approximately 10% of these (306 birds) were undertaken in order to assess the impact on populations of seabirds affected. Of these, 168 were guillemots and 104 razorbills (55% and 34%, respectively). Of the guillemots that could be aged, 77% were adults, 20% were young adults and only 3% were sub-adults. The effects of the removal of breeding adults will impact on the southern populations that breed in Iceland, the F eroes, Britain, Ireland and France. Analysis of solvent swabs from oiled feathers from 13 birds was undertaken at Cefas, and fingerprinting studies confirmed that the oil on 12 of the feathers was fuel oil from the *MSC Napoli*. Samples of seawater from the holds and engine room of the *MSC Napoli* were screened for chemicals by the Environment Agency and toxicity tested by Cefas against an alga and a crustacean. This showed low concentrations of chemicals and toxicity initially, which reduced in the holds as container of cargo were removed. By the time all of the water was pumped out of the ship (58,000 tonnes over a single tide) so that she could be refloated the level of toxicity was very low, so there was no concern regarding potential toxic impacts.

Overall, the impact of the *MSC Napoli* incident, as established during this monitoring programme, was less than initially feared from the first Cefas assessment of the hazardous goods manifest listing the chemicals and their quantities carried by the ship. Almost all of the oil fuels aboard were safely transhipped and removed and no dangerous goods containers were lost into the sea. All of the containers remaining aboard following the grounding were transferred to Portland Port for processing and onward transfer, recycling or disposal of both containers and contents.

Of the elements of the overall monitoring programme undertaken in Lyme Bay in response to the *MSC Napoli* incident, the following were funded by Defra under ME1308:

Design and co-ordination of the programme by Cefas.

Sampling and analysis of seawater samples collected by PML and the collection and storage of sediment samples from the same survey.

The collection and storage of sediment samples from around Lyme Bay and in the Fleet and Portland Harbour by Cefas.

Collection and analysis of shellfish samples by Cefas.

Seabird necropsies undertaken by the British Trust for Ornithology undertaken on behalf of Natural England and the analysis of oiled feathers at Cefas. ME1308 also paid for the hire of a mobile freezer in which carcasses could be stored prior to the necropsies being performed.

Two benthic surveys of areas of nature conservation in Lyme Bay undertaken on behalf of Natural England.

Project Report to Defra

8. As a guide this report should be no longer than 20 sides of A4. This report is to provide Defra with details of the outputs of the research project for internal purposes; to meet the terms of the contract; and to allow Defra to publish details of the outputs to meet Environmental Information Regulation or

Freedom of Information obligations. This short report to Defra does not preclude contractors from also seeking to publish a full, formal scientific report/paper in an appropriate scientific or other journal/publication. Indeed, Defra actively encourages such publications as part of the contract terms. The report to Defra should include:

- the scientific objectives as set out in the contract;
- the extent to which the objectives set out in the contract have been met;
- details of methods used and the results obtained, including statistical analysis (if appropriate);
- a discussion of the results and their reliability;
- the main implications of the findings;
- possible future work; and
- any action resulting from the research (e.g. IP, Knowledge Transfer).

On 18th January 2007, severe storms and huge waves battered the container ship *MSC Napoli* en route from Antwerp to South Africa. Eighty km south of the UK coast at Lizard Point, in the English Channel, severe cracks developed in both sides of the hull and flooded the engine room. The crew abandoned ship and were airlifted to safety; the ship was taken in tow by two emergency towing vessels maintained on station by the UK and French governments and set off for Portland Harbour. Unfortunately the condition of the ship worsened and, amid fears that she may sink offshore, was beached 1 km off Branscombe Beach in Devon, within Lyme Bay. This area is part of Britain's first World Heritage Site (the Jurassic Coast) and is of high nature conservation importance.

The *MSC Napoli* was carrying over 40,000 tonnes of cargo in 2,318 containers. Of these, 159 contained 1,684 tonnes of dangerous goods as classified by the IMO criteria. These included a wide variety of industrial and agricultural chemicals such as pesticides, fumigants, solvents and personal care products. The vessel also carried around 3,500 tonnes of heavy fuel oil (IFO380) and 500 tonnes of marine diesel oil as bunkers. Initially, this was considered to present a greater risk to the local environment than elements of the cargo.

As the ship grounded and over the next few days, approximately 100 containers were lost overboard from the deck cargo. Of these, 76 came ashore and were dealt with on the beach and the remainder were presumed sunk. These were recovered later using sonar surveying to locate the containers and divers to attach lifting gear. None of these containers carried dangerous goods as all of those containers were carried in the holds of the vessel. Work began to remove the fuel oils and containers from the vessel. The oils were transferred to a lightening tanker and the containers taken by barge to Portland Port, where a system had been set up to handle them. This involved assessing the state of both the containers and their contents, and either recovering, recycling or disposing of them, depending upon their condition. By 26 February all of the oil and all the containers above deck had been removed. The final container from the hold cargo was removed on 17 May, four months after the start of the incident. On the 9 July, the ship was refloated with the intention of towing her to a port for recycling. However, a diver survey showed that the ship's condition was too poor for her to survive a tow and she was regrounded on 13 July a short distance from the original grounding site. On 20 July, shaped explosive charges were used to separate the ship into two parts. The floating bow section was towed to Belfast for recycling, leaving the flooded stern aground. At the time of writing, work continues to dismantle parts of the stern. By mid-November 2007, the accommodation block, hold covers and other materials had been removed and the intention is to lift and remove the final remaining section beginning in April 2008.

Monitoring activities

The cargo carried by the *MSC Napoli* was very diverse, including many non-hazardous goods (cars, gearboxes, paper, personal effects etc) and a wide variety of hazardous materials (including chemicals, solvents, personal care products and pesticides). Of particular concern were the pesticides lambda-cyhalothrin, profenofos, glyphosate, carbendazim, propaquizafop, and dibutyltin oxide and a broad range of other chemical products.

The monitoring programme which was developed was therefore based on three main assumptions:

1. oil has been lost and may affect the local environment and so hydrocarbons should be monitored.
2. during the salvage operation any of the chemicals aboard may be lost and monitoring for those compounds may be necessary in water, sediments and biota.
3. as Lyme Bay is of major nature conservation importance there will be a need to assess the damage to the local flora and fauna.

Immediately following the grounding, it was apparent that a significant quantity of oil had been lost from the vessel and, with a continuing threat of the release of toxic chemicals from the cargo, it was decided to initiate a monitoring programme across Lyme Bay. This involved Cefas, the Environment Agency, Natural England, the Plymouth Marine Laboratory and the University of Plymouth; with overall co-ordination by Cefas. Each of these organisations had their own focus, based on their individual environmental responsibilities, but these were complementary and built into a comprehensive monitoring programme. A full report of the monitoring activities is

being prepared and will be available from the Cefas website. Defra's agreement was sought for each of the components of the monitoring programme which they were to fund, which included subcontracts to the Plymouth Marine Laboratory and Natural England. Initially, monitoring focussed on the spilled oil, but plans to allow monitoring of any lost chemicals against a sediment baseline were also put in place early on. As it was not possible to know which chemicals would need to be monitored until they were lost to sea, it was decided to collect and archive surface sediment samples at -20°C against future need. Cefas and the Environment Agency collected these coastal sediment samples, around the whole of Lyme Bay from Teignmouth to Portland Harbour. The Plymouth Marine Laboratory collected offshore samples during the cruise described below. The Environment Agency also collected sediment samples close to the position of the grounded vessel. Figure 1 shows the sampling locations.

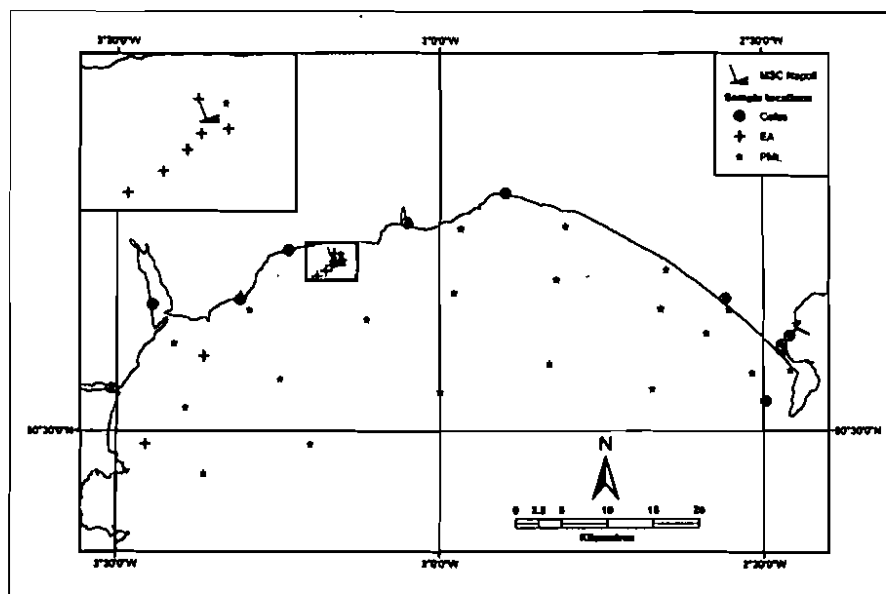


Figure 1. Sampling locations for baseline sediments to be archived frozen.

Environment Agency

The Environment Agency based their sampling programme on a routine bathing water quality scheme, which was already in operation, supplemented by additional stations in order to enhance the coverage. Seawater samples were analysed for a series of routinely determined target compounds, including hydrocarbons and polycyclic aromatic hydrocarbons (PAHs) and additionally conducted screening analyses using coupled gas chromatography-mass spectrometry in order to detect and quantify non-target chemicals. A large number of chemicals were identified at trace concentrations (low or sub- μg per litre levels). These included one-ring aromatic compounds (benzene, toluene and xylenes), bisphenol A, other phenols, bromoform, caffeine, iso-propyl alcohol and other alcohols, tributyl phosphate, trichloroethylene and a range of phthalate esters. Most were not, however, included within the cargo aboard *MSC Napoli*, and these findings probably largely reflect low-level coastal pollution normally present in the area. As part of the control activities associated with the incident, water samples were taken routinely from the holds and engine room of the vessel. These were also analysed by the Environment Agency. A number of chemicals were identified at concentrations an order of magnitude or more higher than the relevant EQS (environmental quality standard, based on continuous exposure), and these were contained within the cargo. Parallel toxicological studies undertaken by Cefas generally indicated low levels of acute toxicity to an alga and a crustacean, and dispersion modelling suggested that this toxicity would be reduced rapidly following release of water from inside the ship to the wider marine environment. Surface sediments, limpets and mussels were collected from sites between Brixham and Portland Bill and archived as above. The Environment Agency are also preparing a stand-alone report of their activities which will be made available via their website.

Cefas

Sediment samples to be archived were collected during the last week of January 2007. The major part of Cefas' activities were focussed on the determination of hydrocarbon and PAH concentrations in commercial shellfish across Lyme Bay and in Portland Harbour, locations which could be affected by spilled oil or chemicals from the *MSC Napoli*. Sampling began on 24 January, with shellfish being purchased from commercial catches. The species studied were edible and spider crabs, mussels and scallops. Sampling locations across Lyme Bay are shown in Figure 2. Tissue samples were analysed using well-established methodology with appropriate analytical quality control. Briefly, tissue samples were subjected to alkaline digestion followed by liquid-liquid extraction and alumina clean-up, with analysis of a suite of PAH (both parent and alkylated) using coupled gas chromatography-

mass spectrometry. A number of internal standards (deuterated PAH) were added at the start of the digestion, and both procedural blanks and laboratory reference materials (LRMs) were analysed within each sample batch. The results obtained for the LRMs were used for acceptance or rejection of the results for each sample batch and also to construct quality control charts to allow the day-to-day performance of the method to be assessed.

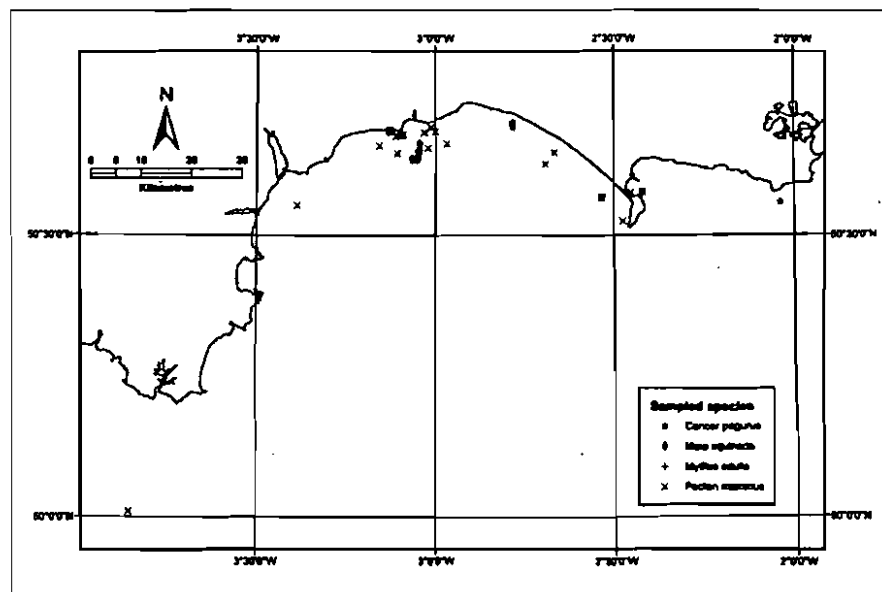


Figure 2. Sampling locations for the commercial shellfish samples analysed for hydrocarbons and PAH by Cefas.

Over 50 individual shellfish samples were analysed. Summed PAH concentrations ranged from 7 to 568 $\mu\text{g kg}^{-1}$ wet weight, with the highest concentration observed in scallops collected off Branscombe. Concentrations in scallops and in one sample of mussels were slightly higher than those in crabs, but only samples collected very close to the wreck (but outside the 500m exclusion zone) showed signs of contamination from the spilled oil. Even in these samples, concentrations were only slightly elevated relative to the general background. The UK Food Standards Agency has set guideline values for three individual PAH compounds in order to protect human health (10 $\mu\text{g kg}^{-1}$ wet weight for benzo[a]pyrene and 15 $\mu\text{g kg}^{-1}$ wet weight for both benz[a]anthracene and dibenz[a,h]anthracene) and these limits were not breached in the scallops or mussels. These three compounds were not detected in any of the crab samples.

There are few comparative data against which to assess the level of contamination. In 1996-97, we undertook a survey of PAH concentrations from commercial shellfish beds around England and Wales. No scallops were analysed but, in mussels, summed PAH concentrations ranged from 40 to 11,500 $\mu\text{g kg}^{-1}$ wet weight. The concentrations observed in Lyme Bay in 2007 are at the lower end of this range, although the earlier samples were exposed only to diffuse pollution and local point sources. Following the oil spill from the Sea Empress in Wales in 1996, mussels from many sites within the fishery closure area showed summed PAH concentrations above 1,000 $\mu\text{g kg}^{-1}$ wet weight and the highest concentrations observed, within Milford Haven, were > 100,000 $\mu\text{g/kg}$ wet weight. In comparison, the concentrations in shellfish from Lyme Bay were only slightly elevated.

Plymouth Marine Laboratory

Once oil had been spilled in Lyme Bay following the grounding of *MSC Napoli* it became necessary to conduct a survey aimed at assessing the degree of contamination and its spread. The Environment Agency were analysing water samples taken from the coast, but it was decided to supplement this by mounting a dedicated offshore cruise. Scientists from the Plymouth Marine Laboratory conducted this cruise on 30 - 31 January 2007. A series of samples of subsurface water and of the sea surface microlayer were taken at sites across the whole of Lyme Bay, approximately along the 10 m, 20 m and 40 m depth contours (Figure 3). In addition, samples of surface sediment were taken and stored frozen at $-20\text{ }^{\circ}\text{C}$ as baseline samples, in case sediment monitoring was to be conducted at a later stage. Samples from the sea surface microlayer were obtained using a surface slick sampler, and the subsurface water samples were obtained at 2 meters depth with 2.5 litre Winchester amber glass bottles using a custom-made stainless steel and Teflon sampling device. Analyses were conducted using coupled gas chromatography-mass spectrometry following solvent extraction and clean-up.

In general, the PAH concentrations observed in the subsurface seawater samples were low and probably represented the normal background in Lyme Bay. The highest concentrations was observed at the station closest to the grounded *MSC Napoli*, where a modestly elevated concentration was seen. In the surface microlayer samples a similar pattern was observed, reflecting a clear (though localised) petrogenic contamination due to the

oil released from the ship. Beyond the localised area of the spill, PAH from pyrolytic sources were more dominant in the subsurface waters, reflecting the general background contamination of Lyme Bay.

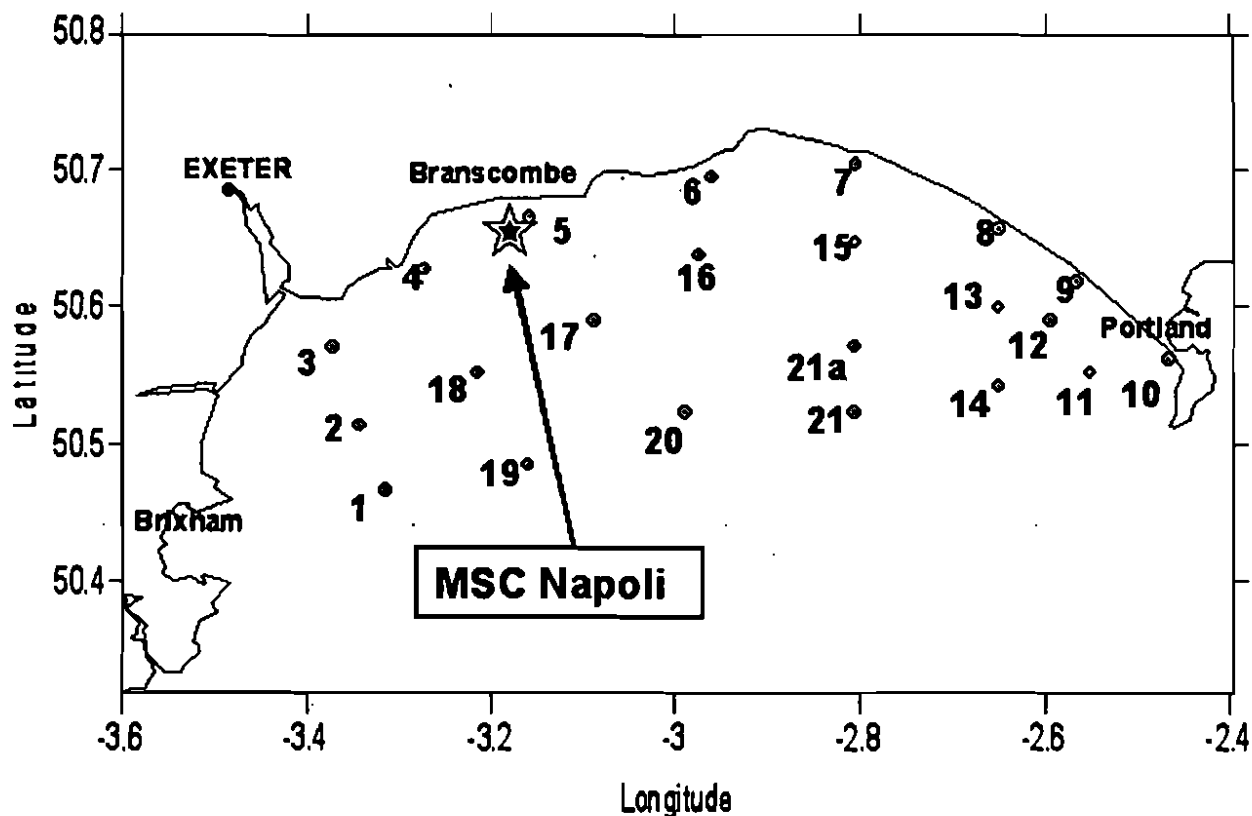


Figure 3. Samples of subsurface water and of the sea surface microlayer taken at Lyme Bay

Natural England

Lyme Bay is an area of high nature conservation importance, particularly in relation to subtidal reef habitats and species such as the pink sea fan (*Eunicella verrucosa*), a soft coral. In order to protect the seabed, scallop dredging has been voluntarily discontinued in a number of areas within the bay. There was a concern that the ship and/or the lost containers may damage important seabed features, and Natural England commissioned two benthic surveys in order to assess possible impacts. The first of these was undertaken during June 2007. Four sites were surveyed by divers (Beer Home Ground, West Tennants Reef, Dogleg Reef and Sunset Ledge). Beer Home Ground was assessed as highly degraded due to earlier scallop dredging activities. The other three sites showed much more diverse fauna and showed no signs of recent impacts when compared to earlier studies undertaken in 2004 or 2006. The second survey was undertaken during August 2007, and involved the use of a drop-down video system to survey the seabed. The area surveyed included the immediate vicinity of the *MSC Napoli* and four adjacent reef areas (Beer Home Ground, West Tennants Reef, Eastern Heads and Pinhay Settle). No obvious signs of contamination or physical damage from the *MSC Napoli* could be seen on any of the reefs. Some physical damage was noted on West Tennants Reef, but this was thought to be due to the earlier use of mobile fishing gear. Some debris was observed on the seabed relatively close to the *MSC Napoli*, but no signs of physical damage from this debris moving around could be seen on the video images. Some oiling of static fishing gear was also observed.

Oil spilled from the *MSC Napoli* resulted in over 3,000 seabird casualties. Natural England contracted the British Trust for Ornithology to undertake necropsies of approximately 10% of these (306 birds) in order to assess the impact on populations of seabirds affected [7]. Of these, 168 were guillemots and 104 razorbills (55% and 34%, respectively). Of the guillemots that could be aged, 77% were adults, 20% were young adults and only 3% were sub-adults. The effects of the removal of breeding adults will impact on the southern populations that breed in Iceland, the Færoes, Britain, Ireland and France. Analysis of solvent swabs from oiled feathers from 13 birds was undertaken at Cefas, and fingerprinting studies confirmed that the oil on 12 of the feathers was fuel oil from the *MSC Napoli*. Chromatograms are shown in Figures 4a and 4b.

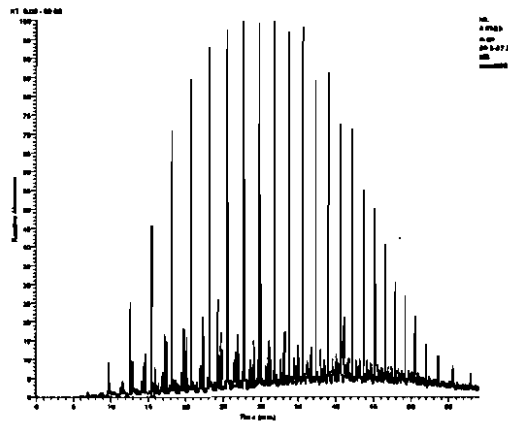


Figure 4a. GC-MS total ion chromatogram of a solvent swab of an oiled feather from seabird number 65.

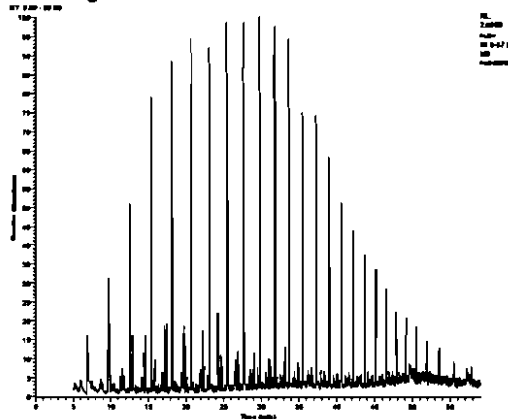


Figure 4b. GC-MS total ion chromatogram of IFO380 heavy fuel oil from *MSC Napoli*.

Lyme Bay represents one of only three UK sites at which the endangered scaly cricket (*Pseudomogoplistes vicentae*) can be found. These animals inhabit shingle above the high-water mark, and are associated with the seaweed strandline. Obviously, they will have been at risk from both beached oil and containers and debris which came ashore, and from recovery activities on the beaches. Once the *MSC Napoli* has been removed and all other related operations have ceased, a survey of the scaly cricket will be conducted.

University of Plymouth

In collaboration with the Plymouth Marine Laboratory, the University of Plymouth used combined biological effects monitoring techniques and chemical fingerprinting to undertake a rapid assessment of the impact of spilled oil and chemicals on the adjacent coastline. During January 2007, although oil contamination appeared to be restricted to a surface slick in the vicinity of the wreck, biomarkers of cytotoxicity and immunotoxicity (cell viability and phagocytosis, respectively) were reduced in samples of common limpets from Branscombe beach, close to the wreck. For this study, three locations within Lyme Bay were studied, and two reference sites in Cornwall and Devon were sampled for comparative purposes. A second collection of limpets and winkles was made during July, around the time when explosives were used to break the vessel into two parts. Ecotoxicological testing showed further impairment of cellular function in these animals, and chemical fingerprinting using GC-MS indicated that oil swabbed from their shells matched the IFO380 heavy fuel oil carried by the *MSC Napoli*. This study was conducted within an EU-funded research programme.

Assessment of impact

All of the ship's bunker fuels (diesel and heavy fuel oil IFO 380; totalling just under 4,000 tonnes) were removed by transfer to another vessel. Within about 4 months (by 17th May) all of the containers remaining aboard had also been removed and taken to Portland Port for disposal or recovery of both the cargo contained and the containers themselves. The ship was refloated on Monday 9th July, following the discharge of 58,000 tonnes of water from within the patched hull. She was then rebeached on Thursday 12th July following an inspection by divers which concluded that she was too badly damaged to be towed further without a serious risk of her breaking in two. On the 17th and 18th July, explosives were used to separate the vessel into two parts, the bow section floating and the stern section upright on the seabed. Following examination for potentially invasive species by Cefas, the bow section was towed to the Harland and Wolff shipyard in Belfast for recycling, arriving in late August. Subsequently, plans were also made to lift the stern section onto a submersible barge for removal and

recycling. Work was proceeding and the accommodation block had been cut free and removed, when a serious storm upset the balance of the ship and she took on a 30° - 40° degree list to starboard. This made the lightening of the stern section much more problematic, and plans are being revised. Further salvage work is likely to begin in April 2008.

In the event, none of the containers of dangerous goods were lost from the vessel and all were recovered to Portland Port and dealt with on land. Trace quantities of some chemicals carried aboard were detected in the waters within the holds of the vessel, and contributed to low levels of toxicity detected in the same locations. Both declined with time as containers were removed and, by the time the vessel was refloated, had effectively fallen to zero. This meant that the discharge of 58,000 tonnes of water into Lyme Bay during the refloating caused no concern regarding effects in the wider environment. Losses of oil caused pollution of beaches in both Lyme Bay and North Brittany. Over 3,000 seabird casualties were found around Lyme Bay, which will have some impact on the southern breeding populations. Somewhat elevated concentrations of PAH were observed in both subsurface waters, the surface microlayer and shellfish samples collected close to the wreck, but these elevations were modest and very localised. Overall, the impact of the incident was less than feared initially from study of the cargo manifest and toxicity assessment of the chemicals carried aboard the *MSC Napoli*. One note of caution though for future incidents is that, although the *MSC Napoli* was a large container ship when constructed in 1991, she is now of a modest size at 4,419 TEU (twenty-foot equivalent units). Coping with a casualty from the largest class of vessels currently afloat, which are 14,500 TEU, would be a vastly more difficult undertaking.

References to published material

9. This section should be used to record links (hypertext links where possible) or references to other published material generated by, or relating to this project.

Links can be added here to a number of other reports:

Aquatic Environment Monitoring Report prepared by Cefas

A report of monitoring studies undertaken by the Environment Agency

Other references:

Grantham, M.J. & Newson, S.E.. Post-mortem analysis of bird corpses from the grounding of the MSC Napoli. Research Report 466, British Trust for Ornithology, Thetford, Norfolk, 2007.

Readman, J.W., Guitart, C., Frickers, T. and Law, R.J. (2007). An assessment of chemical pollution from the MSC Napoli. *Marine Pollution Bulletin*, **54**, 501-503.

Kirby, M.F., Devoy, B., Law, R.J. & Ward, A. The use of a bioassay based approach to the hazard/risk assessment of cargo derived toxicity during shipping accidents: a case study – the MSC Napoli. *Marine Pollution Bulletin*, in press 2008.

Guitart, C., Frickers, P., Horillo-Carballo, J., Law, R.J. & Readman, J.W. Characterisation of sea surface chemical contamination after shipping accidents. *Environmental Science and Technology*, in press 2008.

Kelly, C., Law, R.J., Baker, K.L., Lunn, M.M.E. and Mellor, P.K. PAH in commercial shellfish following the grounding of the *MSC Napoli* in Lyme Bay, UK, in 2007. In preparation.