Understanding Chemical Pollution at Sea: A Learning Package

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Abstract

The chemical industry is today at the hub of the global economy and must often overcome vast distances between production and consumption areas. These geographical constraints require large volumes of hazardous substances to be transported, often by sea. Shipping generates risks which are steadily rising, due to the ever-increasing size of vessels, together with the pressure of world markets. In the event of an incident, these risks lead to different problems to those encountered in the case of oil spills. The threat of a chemical spill is a concern for many stakeholders (industry leaders, politicians, environmentalists and citizens).

It is therefore essential to have concise, comprehensive, educational information on this issue. Today, very few documents on this subject exist worldwide. Transport Canada and Cedre therefore decided to produce a learning guide on chemical pollution at sea. This learning package follows on from that on oil spills produced by Cedre in 2008 entitled "Understanding Black Tides" intended for 12 to 18-year-olds and their teachers, but also for journalists, those potentially involved in spill response and the general public.

Six major themes are developed in this new learning guide: an introduction to chemistry and a few examples of its uses; different aspects of shipping, such as the types of ships used and regulations; the main sources of chemical pollution at sea; spill prevention and preparedness; the different response techniques, systematically illustrated with examples of past incidents; the impact on human health, the environment and the economy.

1 Introduction

In the field of accidental marine pollution, oil spills bask in the limelight of media coverage due to their spectacular crowd-pulling nature. However, another threat is just as much of a reality: that of the dangers generated by chemical shipping. Today, the chemical industry is at the heart of the global economy and requires major flows of goods from production sites to consumption areas. Some 37 million chemicals are used by the world's population and 2,000 are regularly transported by sea. The volumes shipped are currently on the rise, with maritime chemical transport having more than tripled in the past 20 years.

The risks have become increasingly acute, in particular due to the growing number of ultra-large ships together with the high intensity imposed by global market pressure. The threat of a chemical spill at sea concerns many public and private interest groups as the pollution caused is often invisible and may appear difficult to manage.

Transport Canada is aware of this issue and strives to ensure more efficient, safer and more sustainable maritime transport through its Marine Safety Directorate. In order to

Quintin, K., A. Laflamme, J. Lamoureux, R. Rousseau, M. Gaillard, and S. Le Floch, and Understanding Chemical Pollution at Sea: A Learning Package, Proceedings of the Thirty-fifth AMOP Technical Seminar on Environmental Contamination and Response, Environment Canada, Ottawa, ON, pp. 116-125, 2012.

improve maritime safety, Transport Canada works in cooperation with various foreign experts, including the French Centre of Documentation, Research and Experimentation on Accidental Water Pollution (*Cedre*).

Through this cooperation, Transport Canada came to know of the learning guide produced by *Cedre* on oil spills entitled "Understanding Black Tides". Based on the observation that no such educational guide existed worldwide on chemical spills, Transport Canada produced this document in partnership with *Cedre* (Fig.1).

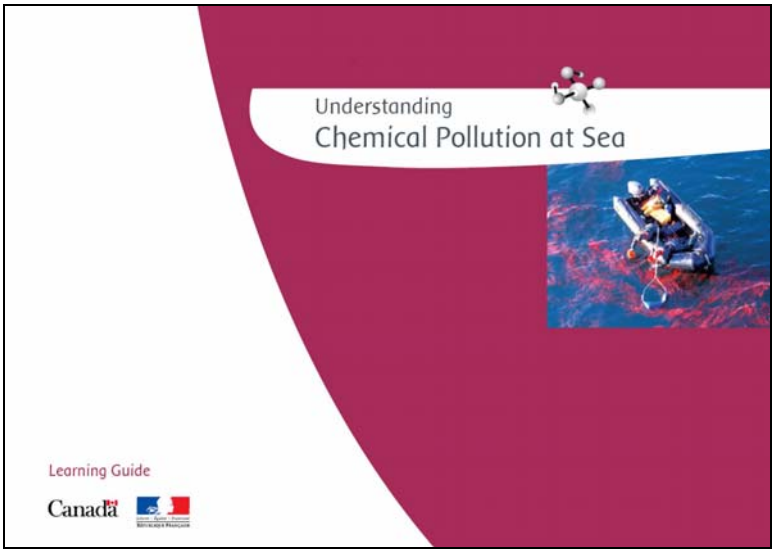

Figure 1: Front cover of the learning guide: "Understanding Chemical Pollution at Sea"

Because certain limits had to be set, we chose in this guide to address only accidental pollution at sea, in ports and estuaries, and to exclude chronic pollution and pollution of inland waters. Our approach focuses on pollution generated by ships, thus excluding coastal industrial facilities and offshore installations.

2 Background

Chemistry is a science that lays the foundations for a vast industrial sector involved in the production of virtually all the objects and products we use and consume on a daily basis. Chemistry contributes greatly to the fields of transport (automotive and aeronautical industries), safety (fire fighting), health (pharmaceuticals), clothing (textiles, dyes), food (agriculture, conservation, cookery), public works (concrete, paints, insulation), water management (controls, discharge treatment, water treatment, drinking water) and hygiene (perfumes, soaps, beauty products). The chemical industry is also, sadly, a major source of chronic and accidental pollution.

Chemical trade generates major traffic flows for the transport of products between extraction, processing and consumption sites, in particular by sea. Shipping can lead to spills in the marine environment. Studies on this subject often highlight the lack of available information. Feedback is limited due to the small number of listed and documented accidents and the vast number of products transported.

3 Materials and Methods

3.1 Project Development Phase

With this as a backdrop, *Cedre* initially began to gather relevant information, using operational guides produced by *Cedre*, *Cedre*'s website (www.cedre.fr) and a variety of other publications and websites as a foundation.

Once all the documentation required for the new guide had been gathered together, *Cedre* began to write the content of the document, in collaboration with all of its different departments. Because of this broad-based approach, the most experienced agents were able to contribute their knowledge of the management of some of the major past case histories. The content of this collection of educational documents was written by *Cedre* and subsequently approved by Transport Canada. The texts were drafted with a view to maintaining an objective attitude, presenting facts and not controversies, and putting forward all different points of view.

The participation of Canadian teachers in this project consisted of carrying out a review of the printed document. This stage of the project led to discussion on the design of the materials to ensure that they were as suitable as possible for teachers and pupils.

The photos used to illustrate the texts were mainly taken from *Cedre*'s picture library. The page layout of the printed document was created using Adobe InDesign at *Cedre*, based on a model produced by the chosen subcontractor. In parallel, around fifteen diagrams were produced to illustrate the various points.

To complete this guide, two posters were produced to illustrate two of the key themes in the guide (Fig. 2 & 3). These posters can be used for practical exercises and group work in class.

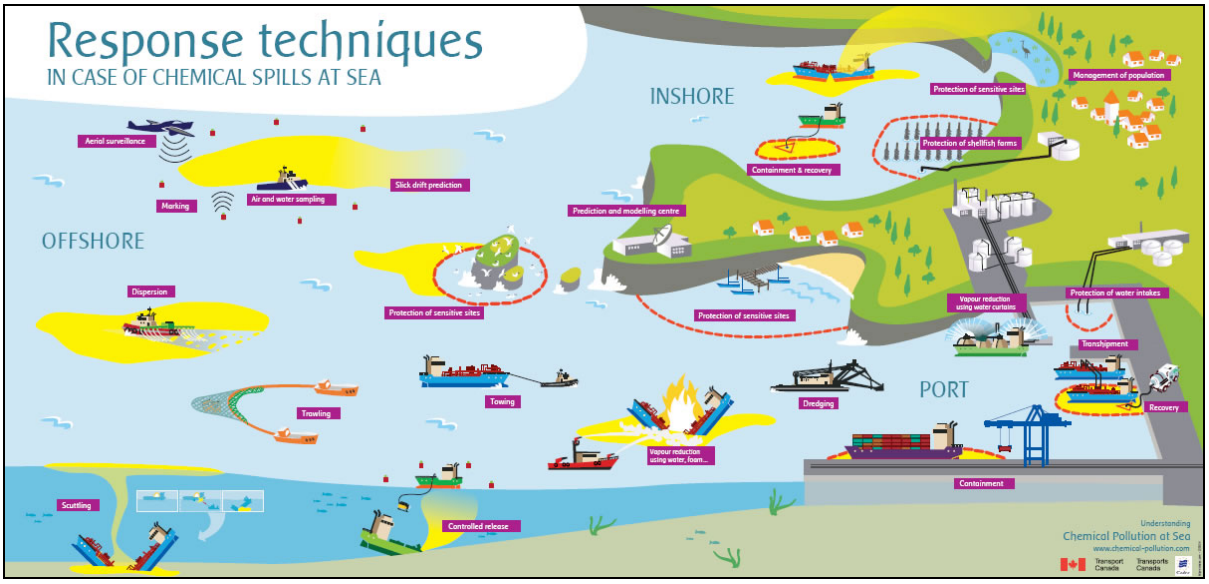

Figure 2: The poster: "Response techniques in case of chemical spills at sea"

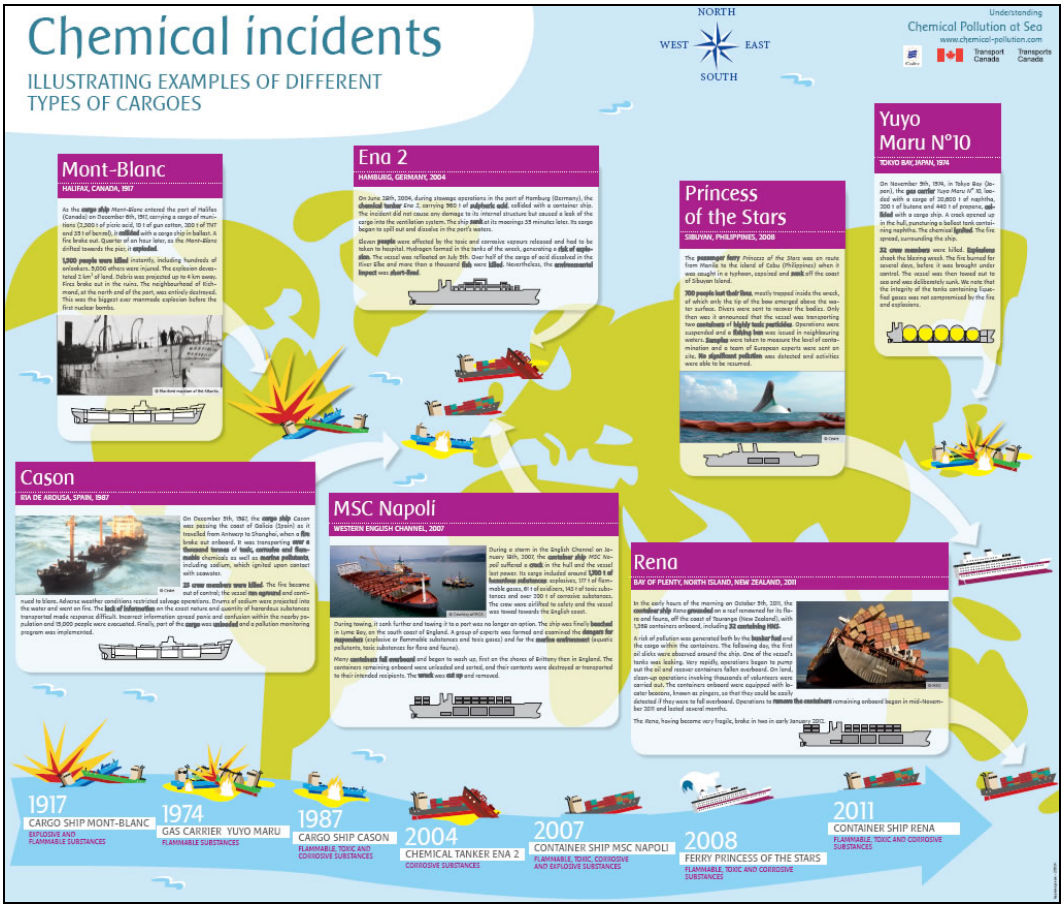

Figure 3: The poster: "Chemical incidents illustrating examples of different types of cargoes"

3.2 Target Audience and Intended Use

Environmental education has recently become a popular topic. It is important to raise young people's awareness about respecting and protecting the environment. At school, future citizens learn to understand the need to care for the environment.

The purpose of this learning package produced by *Cedre* was to raise the awareness of 12- to 18-year-olds on the issue of accidental chemical spills at sea and their impact on the environment.

The overall printed document was developed in order to provide materials for teachers preparing lessons (texts, diagrams, etc.) and the posters are intended to be used for group work in class on a particular theme.

4 Results

This learning package consists of a learning guide of more than 90 pages (Fig. 1) and two posters (Fig. 2&3). These documents have been published in both French and in English. Students can also test their knowledge through a set of quizzes.

The first chapter of the learning guide and website, entitled "Chemicals", provides an overview of the chemical industry, and the roles of chemicals in everyday life. It also covers the basics of chemistry, such as atoms and molecules. A section is devoted to the sourcing and manufacture of chemical goods, including refining and synthesis methods used in the industry. Different classes of chemicals are presented, along with examples of representative products. Information is provided on how to properly read the labels and material safety data sheets of dangerous goods.

The following chapter, “Shipping”, introduces the concept of hazardous and noxious substances (HNS) and presents major shipping routes for bulk chemical transportation. Detailed information is provided on the logistics of marine transportation, such as port terminals, types of vessels according to the chemicals transported and different forms of packaging. Sections on transporting gases, bulk liquids, bulk solids and containers explain the different challenges and technologies involved in their transport. A global picture of the most commonly transported chemicals is also provided to clearly define the major risks involved in transportation, based on past incidents and volumes transported. Emphasis is also placed on the safe transportation of dangerous goods through strictly enforced codes and regulations.

The third chapter, “Sources of pollution”, describes the various sources of chemical pollution, whether chronic or accidental. The section on chronic pollution raises awareness on the effects of low dose, ongoing pollution by chemicals on both human health and the marine environment. The causes of marine incidents resulting in the accidental release of chemicals are listed, with their contribution to the overall frequency of incidents. A map of notable incidents involving chemicals provides a valuable picture of the location of these events in relation to shipping routes and economic centres. The fate of spilt substances is explored to clearly explain the wide range of behaviours that can be encountered with chemicals in contact with water (Fig. 4). Historically significant incidents and the associated response efforts are summarized and analysed to provide insight on the challenges associated with chemicals spills, as well as the lessons learned from these incidents.

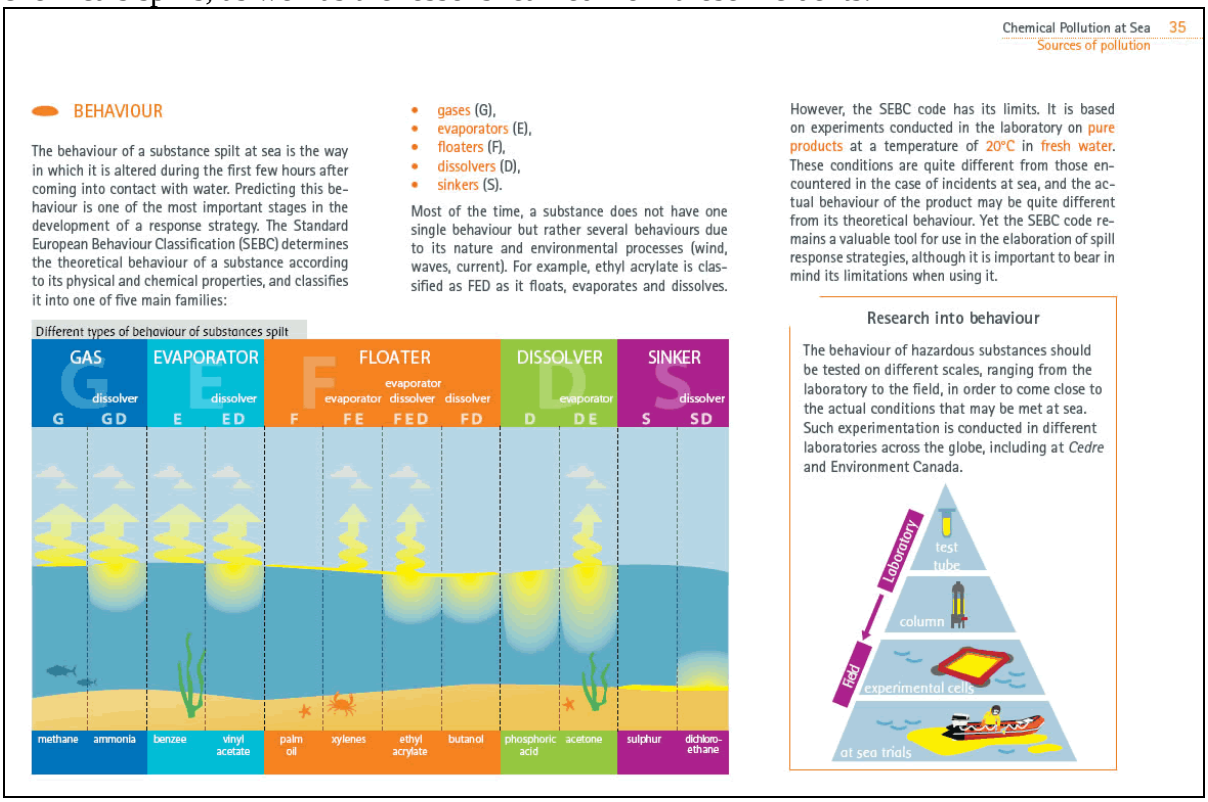

Figure 4: The printed guide is illustrated with photographs and other graphics to improve the learning experience: an example of a page from Chapter 3.

The activities related to prevention and preparedness for chemical spills are described in the fourth chapter. A section on the organizational framework explains the role and importance of various international initiatives and co-operation agreements aimed at supporting preparedness efforts. The logic behind the creation and implementation of contingency plans is clearly explained and illustrated to make this concept more tangible for those not directly involved in such activities. Valuable information is provided on the

specialized response associated with chemical incidents, covering topics such as personal protection equipment and response team training. A section on ship inspection highlights the importance of assessing the safety of sea-going vessels that transport dangerous goods in order to avoid incidents before they happen.

The fifth chapter, “Spill response”, covers both the logistical and technical aspects of chemical spill response. The general methodology of incident management is explained, including situation assessment, decision-making and emergency measures to be applied (Fig. 5). In-depth information is provided on response to bulk cargoes as well as to containers and packages, with emphasis on the very different problems that each type of shipment can exhibit. A breakdown of response techniques based on the location of the spill and the type of incident helps readers to better understand the appropriate actions to be taken according to the specific situation encountered. Monitoring and clean-up technologies and methods are explored, as well as waste management options.

Figure 5: “Decision-making process in the case of a spill”, an example of an illustration from Chapter 5.

The sixth and final chapter, “Impact”, deals with the economic, environmental and health effects caused by the release of a chemical. Practical information on the routes of entry of chemicals into the human body and basic toxicology concepts are explained in the first section. This information should enable readers to better understand the concepts of toxic doses, a subject little known to many individuals, which often leads to unjustified or misplaced fears and concerns. The fate and impact of chemicals on the environment is explained through the fate of spilt chemicals (where they ultimately will end up in the environment), bioaccumulation as well as the levels of harm observed in marine organisms following a pollution incident. Economic impacts and the measures in place to remedy them, such as liability funds, are also explained.

At the end of each chapter, there is a simplified summary of key concepts brought up in the text. This information is presented in a cartoon style, to appeal to younger readers, and features the story of an original character named Phosphacola (Fig. 6). The narrative is based on the use of phosphoric acid in soda and is focused on three main steps in the production

process: the extraction of rock phosphate, concentrated phosphoric acid and the finished product, a bottle of cola. Each storyboard uses these three forms to explore the main themes of the chapters, such as types of vessels for transport, effects of spills, etc.

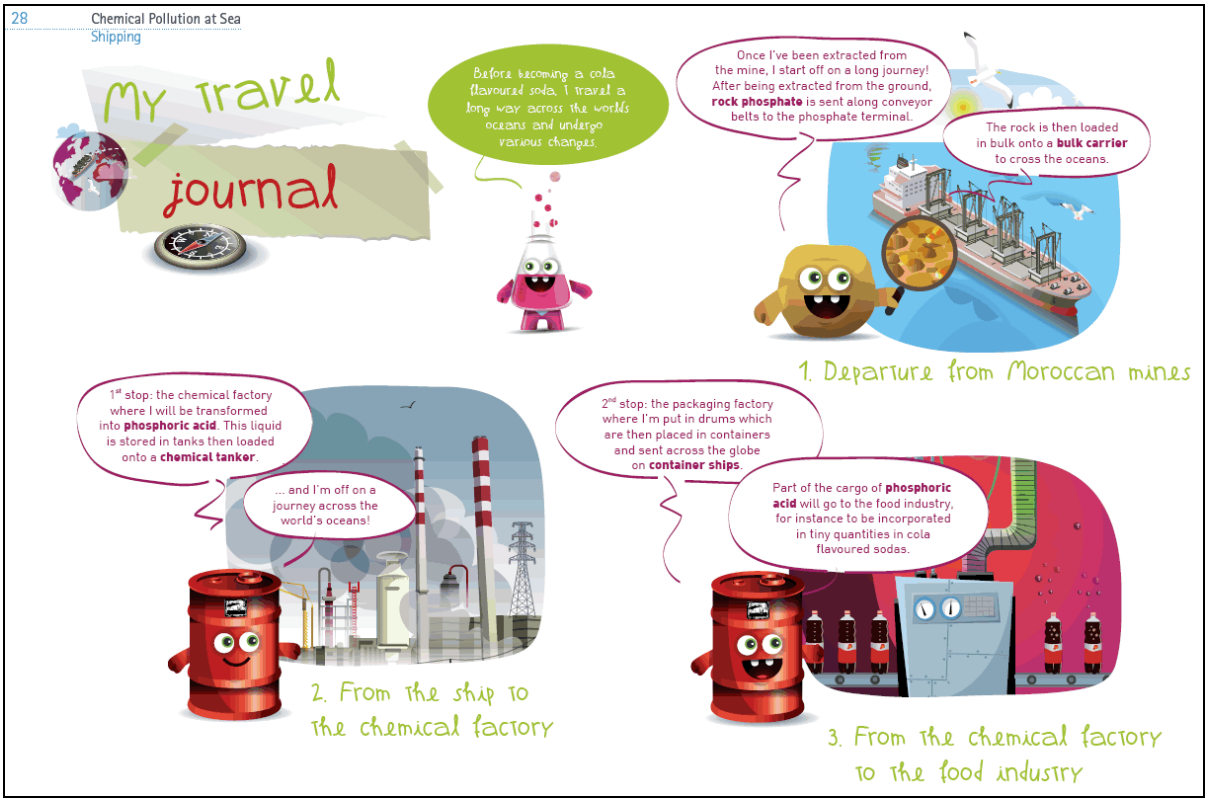

Figure 6: Phosphacola, an original character to explore the main themes of the chapter to make the learning experience more enjoyable for young readers.

To complete the learning experience, a quiz is included at the end of the document so readers can test their knowledge on chemical marine pollution (Fig. 7). Several questions are associated with each chapter, with three increasing levels of difficulty. The quiz can be used by teachers to assess reading comprehension and incite students to go back over the text to review certain concepts.

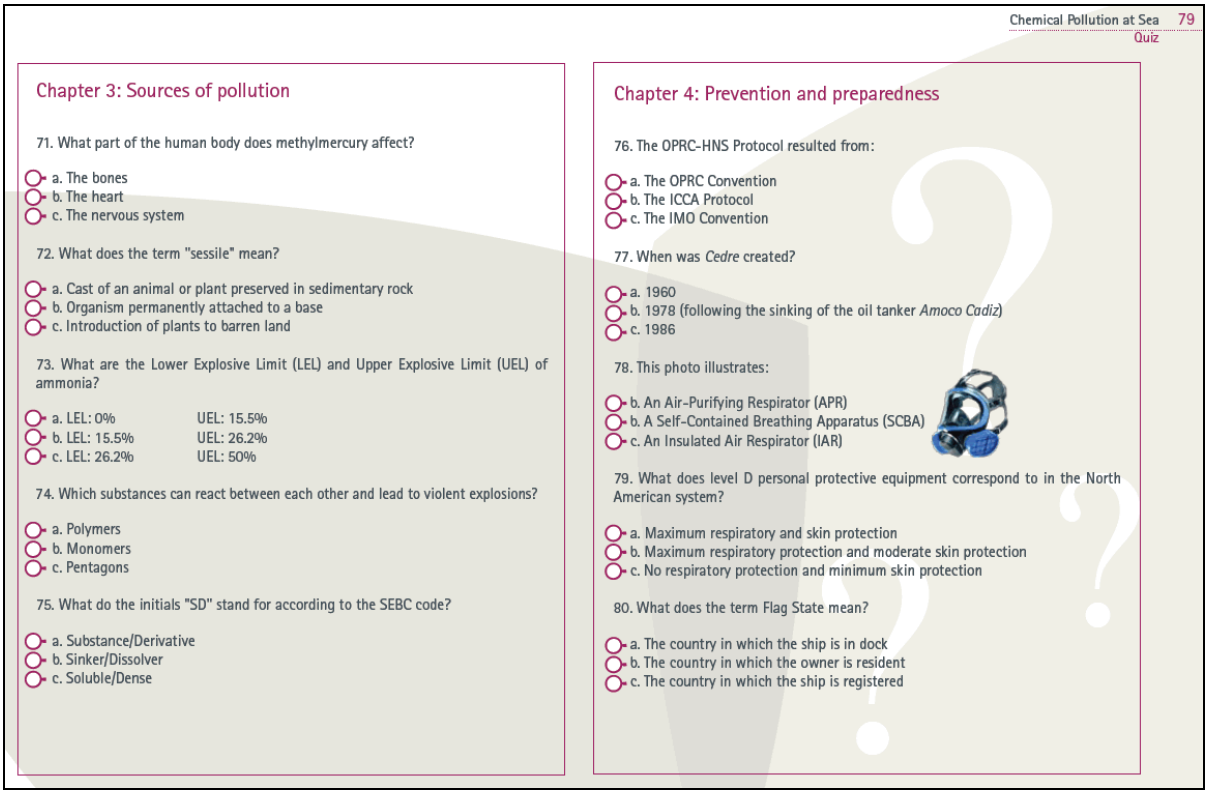

Figure 7: Example of part of a quiz.

5 Conclusion

It was felt by Transport Canada and Cedre an important and valuable task to explain to young generations the realities of HNS spills and their consequences objectively and not emotionally, as is too often the case with the media. It is important to present the facts of the matter clearly and simply.

The resulting guide presents current knowledge of the behaviour of Hazardous and Noxious Substances (HNS) at sea, the organisation in place to respond to a spill, response methods and resources and the medium- and long-term consequences of an HNS spill for the environment as well as maritime and economic activities.

Both fun and informative, the guide helps teachers to prepare their lessons and to combine many activities. Older pupils can use this document as a source of information for writing essays. The posters can be used by small groups of pupils for discussion on a particular topic and to learn to locate information.

The feedback from teachers who have received the learning guide has been extremely positive. Furthermore, in the event of a major HNS spill, a large number of journalists are expected to consult this learning package to find information to build into their reports or articles.

Today, the internet is a rapidly expanding medium, very well known to young people, which can be used to communicate important messages. To take this project further, a dedicated website is therefore being developed, and will be on line by the end of 2012 at www.chemical-pollution.com. This interactive website will present the entire content of the printed guide, as well as a large number of animations illustrating the different issues involved in the management of an HNS spill.

In conclusion, we can only effectively combat what we fully understand. We hope that this package will help younger generations to better understand chemical pollution and will arouse interest in more effectively combating it.

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6 References

Bonn Agreement, *Bonn Agreement Counter Pollution Manual, Hazardous Materials* [online]. Available at: http://www.bonnagreement.org/eng/html/welcome.html

CEDRE, *Chemical Response Guides,* Brest, Cedre, 2004-2011, (Chemical Response Guides) [online].
Available at: www.cedre.fr/en/publication/chemical/chem.php

CEDRE, *Understanding Black Tides. Learning Package,* Brest, Cedre, 118 p., 2007 [online].
Available at: www.black-tides.com

CSST (Commission de la santé et de la sécurité du travail), Service du répertoire toxicologique, *Le SIMDUT* [online]. Available at: www.reptox.csst.qc.ca/simdut.htm

De Lisi, S.M., *Hazardous Materials Incident Surviving the Initial Response,*Tulsa, PennWell Corp., 259 p., 2006.

EMSA, *Action Plan for HNS Pollution Preparedness and Response: HNS Action Plan,* Lisbon, European Maritime Safety Agency (EMSA), 73 p., 2007.

Environment Canada, *Environmental Damages Fund* [online].
Available at: www.ec.gc.ca/edf-fde/default.asp?lang=En&n=C5BAD261-1

GESAMP, *The Revised GESAMP Hazard Evaluation Procedure for Chemical Substances Carried by Ships,* London, IMO, 121 p., 2002 (Reports and Studies, 64) [online].
Available at: www.gesamp.org/publications/publicationdisplaypages/rs64

Helsinki Commission, Baltic Marine Environment Protection Commission, *HELCOM Manuals and Guideline, Response Manual, Volume 2 (Chemicals),* Annex 4, Figure a4-1 [online].
Available at: www.helcom.fi/manual/en_GB/cover/

International Maritime Organization (IMO), *Manual on Chemical Pollution. Problem Assessment and Response Arrangements. Section 1,* London, IMO, 111 p., 1999.

Kremer X., *Containers and Packages Lost at Sea. Operational Guide,* Brest, Cedre, 82 p., 2001. [online].
Available at: www.cedre.fr/en/publication/containers/containers.php

Le Floch, S., *Etude du comportement de produits chimiques déversés en mer, R.06.63.C.,* Brest, Cedre, 32 p., 2006.

Le Floch, S., and M. Marchand, *Comportement, devenir et impact des substances chimiques déversées accidentellement en mer. Etudes bibliographiques orientées prioritairement sur les produits flottants en vue de préciser les paramètres opérationnels. Analyse des principaux déversements accidentels de substances dangereuses en mer. Retours d'expérience, R.00.27.C.,* Brest, Cedre, 22 p., 2000.

Mamaca E., M. Girin, S. Le Floch and R. El Zir, Review of Chemical Spills at Sea and Lessons Learnt. IN: *Interspill Conference and Exhibition 2009,* Marseille, 12-14 May 2009.

The 4th IMO R&D Forum. A Key International Conference and Exhibition for Spill Prevention Preparedness, Response and Restoration, 2009, 40 p. [online]. Available at: www.itopf.com/information-services/publications/papers/documents/interspill09_hnsappendix.pdf

Rousseau, R., and Gaillard M., "Accidentologie et risque chimique en mer", *Bulletin d'information du Cedre*, n°27, pp. 4-9, 2010.

Struski, N., and X. Kremer, *Etat de l'art des techniques et procédures utilisées pour lutter contre les pollutions accidentelles par substances dangereuses en zones portuaires et littorales, R.03.34.C.*, Brest, Cedre, 79 p., 2003.