

Available IMARES generated ecotoxicological data with relevance to petroleum related chemicals

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Summary

The work done at IMARES (formerly TNO Den Helder) mainly focused on model ecosystem communities (multi-species). Some single species (*V. fischeri*, *C. volutator* and *E. cordatum*) tests were performed by TNO Den Helder. Additional single species (*C. marinus*), and single substance experiments listed in this document are performed at TNO Delft, which is not part of IMARES. The suitability of this data for the use in the planned SYMBIOSES project will be discussed during the workshop at Trondheim of February and March 2011.

1 Introduction

This document provides an overview of ecotoxicological tests of oil and oil-related chemicals performed by IMARES (formerly TNO Den Helder). This meta-data overview was generated for the potential use of its underlying data in the ecotoxicological models in the SYMBIOSES model system.

At IMARES, experiments were performed with crude oil (treated and untreated with dispersants) mostly model ecosystem and (semi-)field experiments.. Additionally, some single species tests were performed by TNO Den Helder but also by TNO Delft; the latter is currently not part of IMARES.

Several desk studies on the ecotoxicological effects of crude oil were also performed by IMARES (e.g., [1-3]), these are not included in the present overview, as most of the data gathered in those studies are generated by third parties.

2 Single species tests

2.1 Chaetogammarus marinus

Single species ecotoxicological tests were performed by Adema at TNO Delft [4-6]. Please note that TNO Delft is currently not part of IMARES, availability of data therefore has to be discussed with the rightful owners. The table below summarises the experimental conditions.

Table 1 Selection of single species and single substance tests performed by TNO Delft [4-6]

Species and life-stage:	<i>Chaetogammarus marinus</i> , young, about 5 mm long, grown in laboratory culture in seawater
Exposure type:	Daily renewal
Exposure temperature and medium:	15 ± 1 °C, filtered 28‰ natural seawater (Eastern Scheldt, Netherlands)
Exposure concentrations:	Geometric series of at least 5 test concentrations (apart from blank) after range finding tests, 2 1L beakers for each concentration, each containing 10 animals
Feeding:	Small piece of <i>Fucus spec.</i> is added to prevent cannibalism
Target effect:	Mortality monitored after 24, 48, 72 and 96h
Type of data available:	LC50 with confidence intervals for all time steps. NOEC only after 96h.
Selection of tested chemicals:	1,3-pentadiene 1,3,5-triethylbenzene 2-methylpentene 2-pentene 2,5-dimethylphenol 3,5-dimethylphenol 4-dodecylphenol 4-nonylphenol nonene p-dodecylphenol Tetradecene Tridecene

2.2 Contaminated sediments

Experiments with (oil) contaminated sediments were performed under both laboratory and field conditions by De Kock [7]. Experimental conditions are summarised in the table below.

Table 2 Experimental conditions of sediment tests performed by TNO Den Helder [7]

Species and life-stage:	<i>Cerastoderma edule</i> , collected near the coast at Wierum, the Netherlands <i>Macoma balthica</i> , collected in the Balgzand area near Den Helder, the Netherlands <i>Crangon crangon</i> , collected in the Balgzand area near Den Helder, the Netherlands
Exposure type:	Lab: static Field: natural tidal refreshment of water
Exposure temperature and medium:	Lab: 12.5 °C natural Eastern Scheldt seawater Field: variable local conditions Nieuwe Diep at Den Helder, the Netherlands
Exposure concentrations:	Contaminated sediment from Koopvaarders-Schutsluis at Den Helder: 8400 µg oil/g dry wt Contaminated sediment from Loswal North Sea: 290 µg oil/g dry wt Reference: No detectable oil levels
Feeding:	in situ
Target effect:	Mortality
Type of data available:	Cumulative mortality as a function of exposure time (39 days)
Tested chemical:	Oil contaminated sediments from Koopvaarders-Schutsluis and Loswal
Chemical verification:	Chemical analysis performed by RIZA, Lelystad, the Netherlands

2.3 Spiked sediments

Some single species tests with oil spiked marine sediments were conducted by TNO Den Helder [8-10]. The experimental conditions are summarised in the tables below.

Table 3 Experimental conditions of *V. fischeri* test performed by TNO Den Helder [8-10]

Species and life-stage:	<i>Vibrio fischeri</i> (commercially obtained freeze-dried)
Exposure type:	Static
Exposure temperature and medium:	15°C, solid-phase
Exposure concentrations:	DMA gasoil: 19, 40, 87, 178, 680, 1707 mg/kg dry wt Oesterput sediment HV46: 78, 170, 372, 811, 2708, 7448, 18957 mg/kg dry wt Oesterput sediment
Feeding:	-
Target effect:	Reduction of luminescence
Type of data available:	10 min. effect levels (no data for other time indices)
Tested chemical:	DMA gasoil and HV46
Chemical verification:	GC with flame ionization

Table 4 Experimental conditions of *C. volutator* test performed by TNO Den Helder [8-10]

Species and life-stage:	<i>Corophium volutator</i> between 0.5 and 1 mm in length collected from the Oesterput area
Exposure type:	Static
Exposure temperature and medium:	15°C, natural Oesterput seawater and sediment
Exposure concentrations:	DMA gasoil: 19, 40, 87, 178, 680, 1707 mg/kg dry wt Oesterput sediment HV46: 78, 372, 811, 2708, 7448 mg/kg dry wt Oesterput sediment
Feeding:	No feeding reported
Target effect:	Mortality
Type of data available:	10d survival (no data for other time indices)
Tested chemical:	DMA gasoil and HV46
Chemical verification:	GC with flame ionization

Table 5 Experimental conditions of *E. cordatum* test performed by TNO Den Helder [8-10]

Species and life-stage:	<i>Echinocardium cordatum</i> collected from North Sea 3 km west of Castricum, the Netherlands
Exposure type:	Refreshment of water by dripping 10 L per day
Exposure temperature and medium:	15°C, Eastern Scheldt seawater
Exposure concentrations:	DMA gasoil: 19, 87, 255, 554, 1601 mg/kg dry wt Oesterput sediment HV46: 328, 734, 1068, 4163, 20916 mg/kg dry wt Oesterput sediment
Feeding:	No feeding reported
Target effect:	Mortality and reburial
Type of data available:	14 d survival and reburial after 30 min. (no data for other time indices)
Tested chemical:	DMA gasoil and HV46
Chemical verification:	GC with flame ionization

Kaag and colleagues did similar tests with *C. volutator* and *V. fischeri* on oil contaminated sediments from the North Sea Canal, in order to derive maximum permissible risk levels for mineral oils in sediments [11].

3 Model ecosystem experiments

3.1 Planktonic model ecosystems

Effects of oil were studied intensively by Kuiper and others in model ecosystems [12-19]. Some of these studies are performed for the industry and the results are in principle confidential [13, 16], and are therefore not included in this report. Work done for the government does not suffer from confidentiality issues.

Some studies were performed with planktonic model ecosystem such as shown in Figure 1. Table 6 and Table 7 list the experimental conditions of such studies.

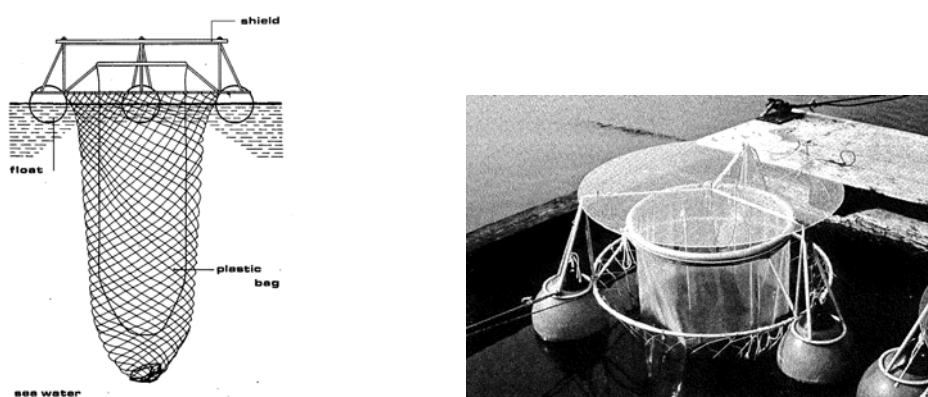


Figure 1 Left: diagram of the model ecosystem; right: picture of the model ecosystem

Table 6 Summary of experimental conditions as reported by Kuiper [12, 14]

Species and life-stage:	Nonspecific phytoplankton, zooplankton and decomposers
Exposure type:	Static
Exposure temperature and medium:	Natural seawater at experiment location (North Sea average temperatures vary between 6 and 17°C)
Tested chemicals and exposure conditions:	Nigerian light crude oil: 200 mL oil on top (0.5 mm) and 60, 120, 300 and 500 µg oil/L initial WSF for 40+ days North sea oil, Forties field: 390 mL oil on top (0.5 mm) for 20+ days
Feeding:	in situ
Target effect / Type of data available:	Following parameters were determined 3-5 times a week. Phytoplankton: chlorophyll, phaeopigments, number of algal cells Zooplankton: number of organisms, species distribution, egg production Decomposers: total number of bacteria, respiration
Chemical verification:	TOC

Table 7 Summary of experimental conditions as reported by Kuiper [17]

Species and life-stage:	Nonspecific phytoplankton, zooplankton and decomposers
Exposure type:	Static
Exposure temperature and medium:	Natural seawater at experiment location (North Sea average temperatures vary between 6 and 17°C)
Tested chemicals and exposure conditions:	Forties field crude oil (with light components partly removed) (200 mL on top, 0.5 mm) Idem with dispersant (Different mixing regimes)
Feeding:	in situ
Target effect / Type of data available:	Following parameters were determined on a regular basis. Phytoplankton: chlorophyll, phaeopigments, number of algal cells Zooplankton: number of organisms, species distribution, egg production Decomposers: total number of bacteria, respiration Oil concentration in water
Chemical verification:	TOC

3.2 Benthic model ecosystems

Kuiper et al. [15, 16, 18] and Scholten et al. [19] used model tidal flats ecosystems (Figure 2) to study effects of oil on micro-organisms, meiofauna and macrofauna. Experimental conditions used in these experiments are summarised in Table 8.

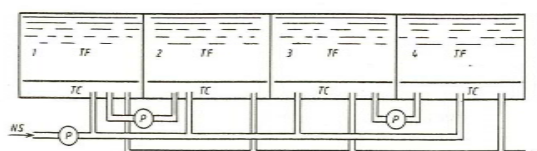


Figure 2 Left: diagram of mesocosm facilities; right: picture of test facilities as used in [15, 16, 18, 19]

Table 8 Summary of experimental conditions as reported by [15, 16, 18, 19]

Species and life-stage:	Nonspecific phytoplankton, zooplankton and decomposers Nonspecific meiobenthos Mokbay, Texel Wadden Sea <i>Cerastoderma edule</i> , Roggeplaat Eastern Scheldt Corphium volutator <i>Macoma balthica</i> , Balgzand Wadden Sea <i>Arenicola marina</i> , Schorren, Texel Wadden Sea <i>Nereis diversicolor</i> , Mokbay, Texel Wadden Sea <i>Hydrobia ulvae</i> , Mokbay, Texel Wadden Sea <i>Littorina littorea</i> , Marsdiep, Dyke Texel Wadden Sea <i>Mytilus edulis</i> , Huisduinen, North Sea
Exposure type:	Static (tidal cycles were simulated by pumping the same water into and out of the system); experiments ran from April through February (next year).
Exposure temperature and medium:	Natural seawater available at experiment location (North Sea average temperatures vary between 6 and 17°C)
Tested chemicals and exposure conditions:	Oil from F3 block 0.3 L/m ² Burning of oil from F3 block Simulated mechanical removal of oil from F3 block Forties field oil (0.1 and 0.5 L/m ²) Forties field oil + dispersant Dispersant
Feeding:	in situ
Target effect / Type of data available (selection):	Following parameters were determined at regular intervals: Phytoplankton: chlorophyll, phaeopigments, number of algal cells Zooplankton: number of organisms, species distribution, egg production Decomposers: total number of bacteria, respiration <i>C. edule</i> , <i>M. baltica</i> : Mortality as a function of time, shell growth as a function of time, AFDW at limited time indices <i>M. edulis</i> : recruitment rate, length and weight <i>A. marina</i> : nr of casts, AFDW as a function of time <i>N. diversicolor</i> , <i>C. volutator</i> , <i>H. ulvae</i> : AFDW as a function of time <i>L. littorea</i> : Shell length for limited time indices
Chemical verification:	GC

4 Field experiments

Van het Groenewoud and others have monitored long-term effects of discharged oil-contaminated cuttings in the field [20-29]. However, at this moment, that work does not seem to be relevant for the planned SYMBIOSES project. Therefore, a more detailed description of their work is not included in the present document.

Another experiment involved a controlled spill 35 km west of IJmuiden in the North Sea [30]. Two spills were generated with two types of oil. Both were sprayed with the same dispersant after 1 hour. Samples were also collected from a 'clean' location nearby. Samples were collected prior to the spill, directly after and one a few hours after the treated spill. Conditions are summarised in the table below.

Table 9 Summary of experimental conditions of the simulated oil spill in the field as reported by [30]

Species and life-stage:	Nonspecific phytoplankton, zooplankton and decomposers
Exposure type:	Controlled spill in the field (North Sea 35 km west of IJmuiden)
Exposure temperature and medium:	Local conditions (North Sea average temperatures vary between 6 and 17°C)
Tested chemicals and exposure conditions:	Crude Statfjord oil (2 m ³) Light fuel oil (2 m ³)
Feeding:	in situ
Target effect / Type of data available (selection):	Phytoplankton: Chlorophyll, phaeopigments and primary production Zooplankton: number of organisms, species distribution Decomposers: total number of bacteria, respiration
Chemical verification:	In situ fluorometric measurements

5 Quality Assurance

IMARES utilises an ISO 9001:2008 certified quality management system (certificate number: 57846-2009-AQ-NLD-RvA). This certificate is valid until 15 December 2012. The organisation has been certified since 27 February 2001. The certification was issued by DNV Certification B.V. Furthermore, the chemical laboratory of the Environmental Division has NEN-AND-ISO/IEC 17025:2005 accreditation for test laboratories with number L097. This accreditation is valid until 27 March 2013 and was first issued on 27 March 1997. Accreditation was granted by the Council for Accreditation.

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Justification

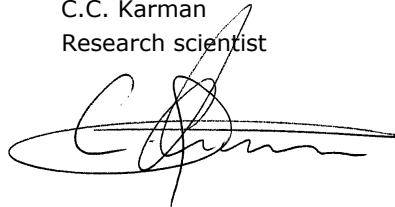
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The scientific quality of this report has been peer reviewed by the a colleague scientist and the head of the department of IMARES.

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Approved: J.H.M. Schobben
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