MT

TNO Division of Technology for Society

Marine biological research

TNO

Marine biological research

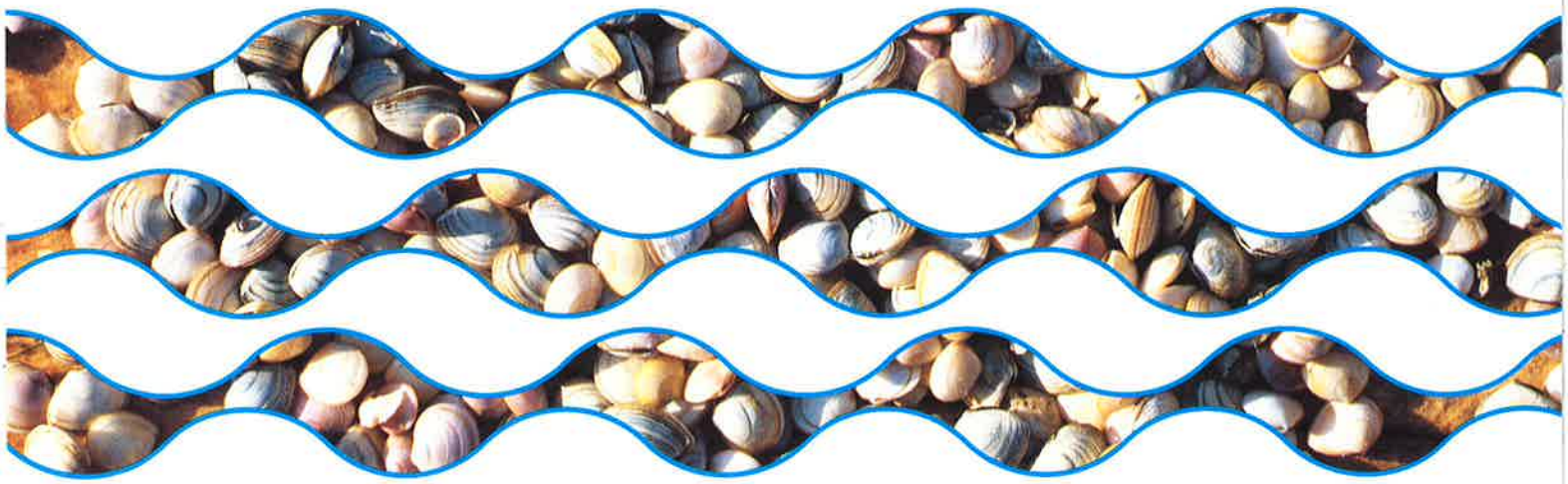
Model ecosystems and biological fieldwork

The Den Helder laboratory of the TNO Division of Technology for Society (MT-TNO) carries out various ecological field and semi-field experiments for industry and the government.
These experiments are often an essential supplement to the ecotoxicological laboratory research carried out by other MT departments; research which contributes to maintaining and improving the quality of water, soil, sediment and air.

Ecotoxicology is a relatively young science, mainly based on results of short-duration laboratory experiments. In these experiments small-scale toxicological tests are carried out with a small number of species of laboratory animals.
However, applying the results to problem situations in the field is not yet completely practicable in many cases. There is insufficient understanding of the interactions between organisms in natural communities on the one hand and the physical and (geo)chemical behaviour of pollutants in nature on the other. The semi-field experiments make a contribution to this understanding. A precondition, however, is that the model systems possess important characteristics of a natural ecosystem. Semi-field experiments provide a bridge between toxicological laboratory tests and ecological problems in nature that are caused by pollutants. The results of the semi-field experiments are used to validate mathematical models derived form smaller-scale experiments. On the other hand these results form the basis for mathematical models relevant to the field situation. The bridging function can also be seen here. Model ecosystems which possess many characteristics of a natural ecosystem are therefore ideal for obtaining a rapid first impression of the possible consequences of a pollutant, for instance, after an evironmental disaster. In the event of urgent environmental problems, the results often give direction to the further studies necessary, since the most sensitive organisms and processes can be identified. In addition to several smaller facilities, the laboratory has at its disposal the following three larger (semi-)aquatic model ecosystems, which will be discussed below.

- Model Plankton Systems
- Model Benthos Systems
- Model Tidal Flat Systems (in cooperation with the Netherlands Marine Research Institute (NIOZ) and the Research Institute for Nature Management (RIN).

These systems can be used for both fresh water and seawater research. Den Helder is ideally situated for studies involving seawater systems. In carrying out the research, the laboratory staff cooperates closely with other TNO specialists in the fields of biology, analytical chemistry, environmental technology and computer science who work in the laboratories in Delft and Apeldoorn.



Model Plankton Systems (MOPs)

System data

Double-walled plastic bags, with a diameter of 70 cm and a content of 1500 litres that are filled with natural seawater or fresh water in which planktonic organisms are present at natural densities.

Capacity

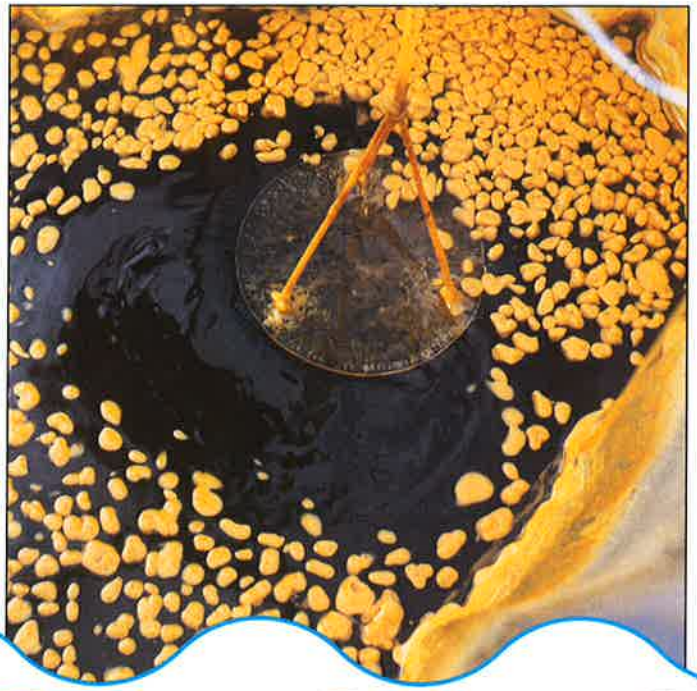
A maximum of 12 systems per experiment.

Location

Berghaven, Den Helder; the systems can be moved.

Parameters

- Abiotic environment: temperature, light, pH, oxygen tension, suspended particles, nutrient content and contaminant content.
- Microorganisms: number of bacteria, mineralization, biodegradation of contaminants.
- Phytoplankton: species composition, densities, primary production.
- Zooplankton: species composition, densities, composition of population, growth, production.



Research carried out

- Dose-effect relations of heavy metals (Hg, Cd, Cu) and of organic micropollutants (PCB's, phenols).
- Effects of various types of oil pollutants and oil combat methods.
- Optimization of bag dimensions and comparison with natural plankton systems in Norway (Ros-fjord).
- Relation between blooms of algea and metal speciation.
- Biodegradation of pollutants.
- Effects of polluted Rhine water and the dumping of dredged sediments on North Sea plankton.

Research planned

- The effect of atmospheric pollution.
- Types of bonding of micropollutants in relation to eutrophication.
- Development of algal cultures in oligotrophic waters.

Model Benthos Systems

System data

Plastic reservoirs with a surface area of 3 m^2 and a height of 80 cm, the bottoms of which are covered with a natural sediment layer up to a thickness of about 50 cm. The replacement rate of the water layer above it can be regulated. Laboratory animals can be introduced as required.

Capacity

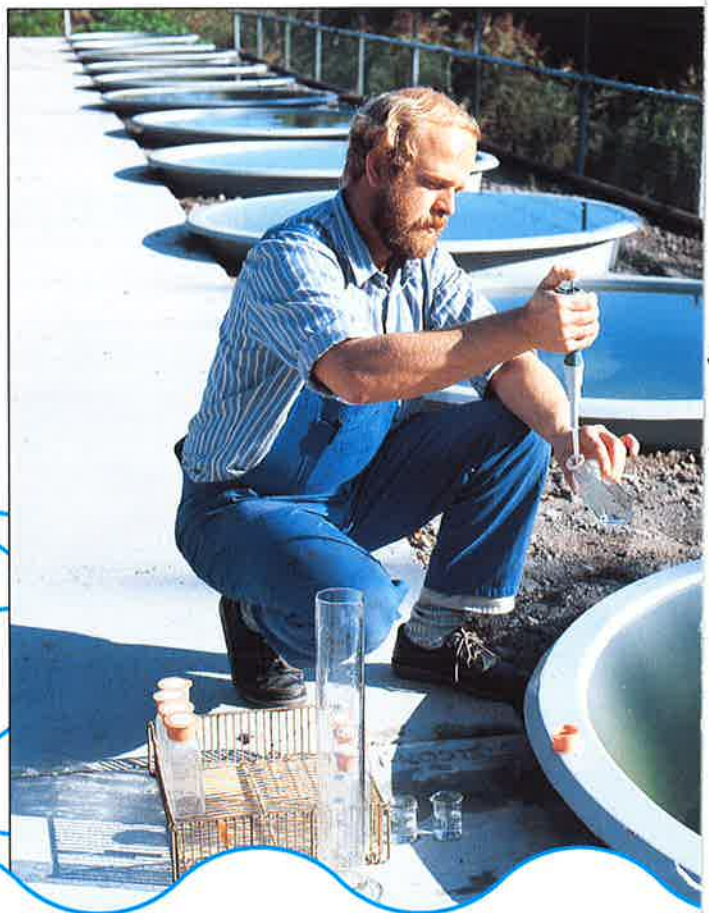
12 seawater systems and 12 fresh water systems.

Location

Seawater systems on the harbour site (Den Helder). Fresh water systems near the laboratory.

Parameters

- Abiotic environment: sediment analysis (behaviour of contaminants), redox profiles and water analysis (see MOPs).
- Growth, reproduction, physiology, biochemistry, histology and uptake of contaminants by the laboratory animals introduced, e.g. mussels, shrimps, young flatfish (seawater), zebra mussels, mosquito larvae and tubifex (fresh water).
- Growth and uptake of contaminants by higher plants introduced.
- Production and species composition of phytobenthos, phytoplankton and zooplankton.
- Microbial activities, mineralization, biodegradation of contaminants.



Research carried out

- Development of bio-assays for polluted underwater beds.
- Effect of bioturbation on the mobilization of contaminants from underwater sediments.
- Transfer of contaminants from fractionated or unfractionated dredged sediments to laboratory animals.
- Effects of polluted seepage water on bottom organisms around the Slufterdam, a large dumping site for dredged material.
- Cd absorption by plants under aerobic and anaerobic conditions.
- Sulphur balance and mobility of metals in small oligotrophic lakes which regularly dry out.

Research planned

- Biological classification of polluted underwater beds.
- Biodegradation of contaminants in underwater beds.

Model Tidal Flat Ecosystems (MOTIFs)

Research with these systems is carried out in cooperation with the Research Institute for Nature Management (RIN) and the Netherlands Marine Research Institute (NIOZ).

System data

Concrete basins with a surface area of 21 m^2 and a height of 120 cm. The bottom is covered with a 50 cm-thick layer of natural sediment. Seawater is pumped in and out to simulate ebb and flood.
Tidal movements and the rate of renewal of the seawater can be regulated.
Introduction of larger organisms as required; smaller organisms are introduced continuously via the replacement water.
The systems are managed by the Research Institute for Nature Management (RIN).

Capacity

8 basins.

Location

The island of Texel.

Parameters

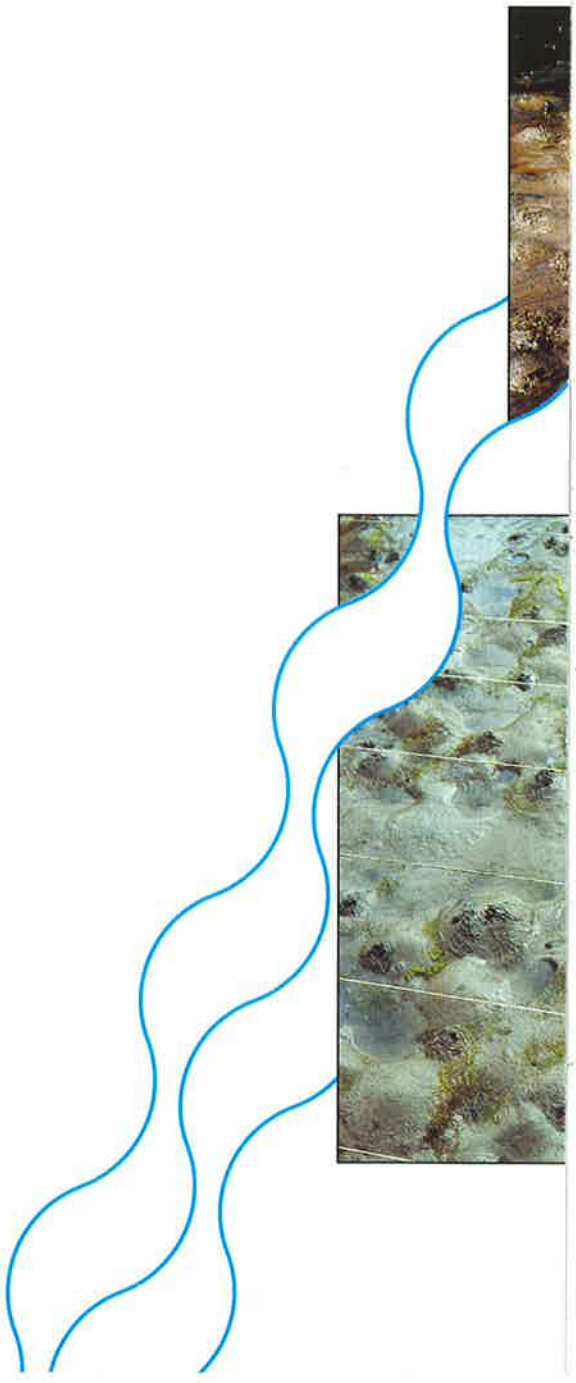
- Abiotic environment: behaviour of contaminants; oxygen tension; redox conditions, temperature, pH.
- Microorganisms: number of bacteria, mineralization and biodegradation of contaminants.
- Algae: species composition, densities and production of phytoplankton and phytobenthos.
- Meiofauna: species composition, densities, growth and production of zooplankton and meiobenthos.
- Macrofauna: density, growth, reproduction, intake of contaminants and, as required, physiological, biochemical, cytological characteristics of pelagic and benthic animals.

Research carried out

- Reproducibility of model tidal flat systems.
- Effects of various types of oil pollutants and oil containment methods in the Wadden Sea.

Research planned

- Effect of the dumping of dredging sludge in coastal waters on the Wadden Sea ecosystem.
- Effect of eutrophication of seawater on the tidal flat ecosystem.



Other key areas of research

Biomonitoring

By exposing laboratory animals for a certain period of time to the local environment, one can make an inventory of the extent of pollution caused by biologically available substances at given locations. Furthermore, one can establish by experiment the accumulation rates and levels of accumulated pollutants in the field situation and make comparisons between different locations (gradient studies). In addition, an insight is gained into the potential toxicological effects of the pollutants absorbed. This is done by measuring stress-inducing parameters related to the growth, physiology, cytology or biochemistry of the laboratory animals.

Research carried out

Exposure tests were carried out with mussels, Baltic Tellins (Macoma Balthica) and mud-flat clams in Dutch coastal water (Eems-Dollard Estuary, Western Scheldt, Eastern Scheldt and North Sea) and with zebra mussels in the large rivers (Rhine and Meuse) and their downstream fresh water basins (Lake IJssel and Haringvliet).

Specimen banking

Tissue homogenates from organisms, which are regularly collected in the field, are kept deep-frozen for retrospective studies. This is important if one wishes to gain an insight into pollution trends in recent decades - made possible by the refining of analytical techiques - or if attention falls on new contaminants.

Research on water birds

Dutch water areas are of major importance on the migration routes of significant numbers of European water birds. Many of these birds, including tens of thousands of diving ducks, use extensive fresh water basins, such as Lake IJssel and the Haringvliet, as a place to feed, moult and overwinter. Their food consists of a wide variety of organisms about which data on accumulated pollutants (e.g. PCB's) is known. This information has been obtained by means of biomonitoring studies and experiments in model ecosystems. This applies in particular to the zebra mussel (Dreissena polymorpha), a very important constituent of their diet. The experimental research with diving ducks concentrates on the transfer of contaminants from the food to the birds and on the consequences for their physiology and reproduction.

Research carried out

Measurements have been made of the effect of contaminated zebra mussels on the reproduction of tufted ducks which are kept in cages. In addition, an inventory has been made of the concentrations of pollutants in the organs and eggs of diving ducks and grebes.

Speciation research

The biological availability of micropollutants largely depends on the local surroundings.
The aim of speciation research is to try and determine the accumulation of micropollutants in laboratory animals, in relation to the types of chemical binding of metals. The research is carried out both in model ecosystems and in field situations. A mobile chemical laboratory is available for this purpose. The laboratory is housed in a road freight container, which can be placed on board a ship. The laboratory is also suitable for carrying out studies with ^{14}C.

Research carried out

- Metal speciation in relation to springtime blooms of algae in the North Sea.
- Metal speciation in estuaries and Dutch inland waterways.
- Metal speciation in model plankton systems.

Laboratory experiments

Following on the other research, experiments are carried out with laboratory animals in a special aquarium room in the laboratory. These experiments focus on physiological "scope for growth" (SFG) measurements and on measurements of the "valve movements" of mussels and various clam species. These parameters can often give an impression of the stress suffered by the laboratory animals in polluted (field) situations.

Research carried out

- Development of an automated system for the registration of valve movements of clams.
- SFG measurements with mussels from a pollution gradient in the Western Scheldt.
- SFG measurements with mussels from a pollution gradient near drilling platforms in the North Sea.

Research in preparation

SFG measurements with mussels from a pollution gradient near the "Loswal-Noord", an offshore dumping site for dredging sludge (North Sea).

Conclusion

The Den Helder Marine Research Laboratory of the TNO Division of Technology for Society has unique facilities for applied ecological (semi-)field research into both pelagic (water) and benthic (sediment) systems in seawater and fresh water environments. The staff has experience of the different aspects of this field of research.
There is a great deal of national and international interest in this research. The laboratory maintains many contacts with Dutch research institutes in the field of aquatic ecology. Major international cooperation projects have been carried out with, among others, the Umwelt Bundesamt (Federal Office for the Environment) in Hamburg, the Waterways Experimental Station in Vicksburg (U.S.A.), the Water Research Centre in England, and with various other European institutes.
The laboratory staff advises countries overseas (including India, Indonesia and the Dutch Antilles) on tackling aquatic-ecological problems.
To solve specific environmental-biological problems, the laboratory staff can draw upon the expertise in the field of environmental chemistry, environmental technology, toxicology, environmental biology, computer science, mathematics and public administration, which is present elsewhere within the TNO Division of Technology for Society. Should you have any questions about the field of work covered by the laboratory or about related problems, please contact.

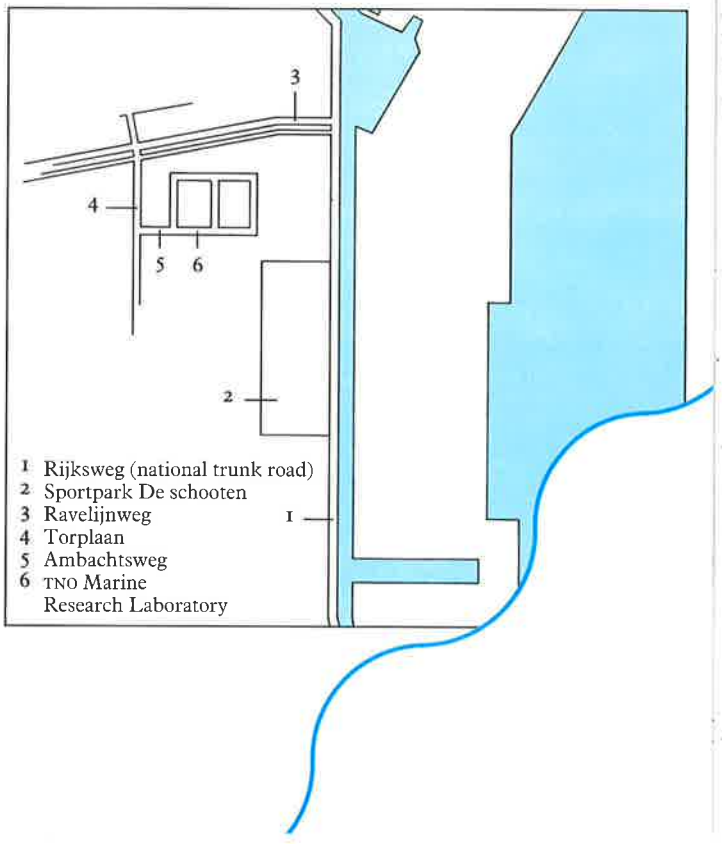
W. Chr. de Kock
TNO Division of Technology for Society
Applied Marine Research Laboratory
P.O. Box 57
1780 AB Den Helder
Ambachtsweg 8a
1785 AJ Den Helder
Phone +31 (0)2230 3 29 24
Fax +31 (0)2230 3 06 87

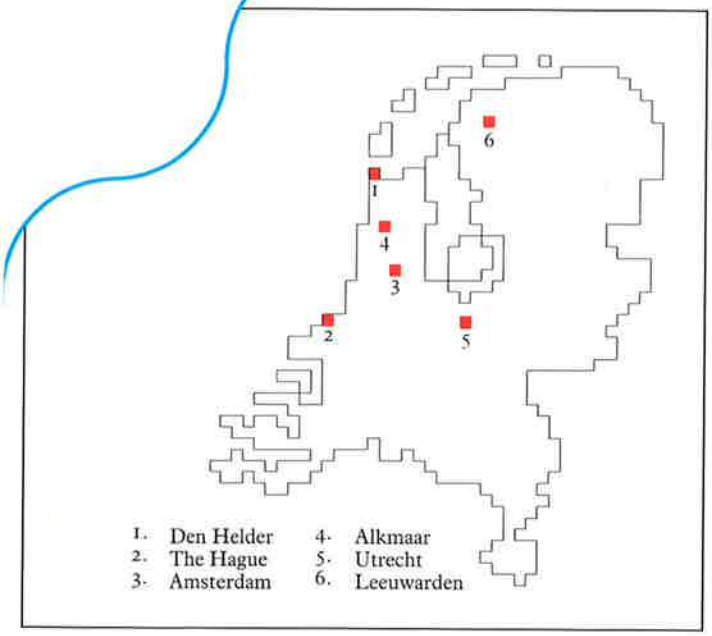
How to reach the Den Helder laboratory?

Coming from The Hague/Utrecht/Amsterdam (also from Schiphol International Airport) you take the A9 motorway to Alkmaar. From Alkmaar you follow the N9 to Den Helder.

Drivers coming from Leeuwarden had best take the A31 motorway heading for Harlingen. After the "Afsluitdijk" (A7), they must follow the N99 to Den Helder.

In Den Helder
Just before Den Helder you will be driving on the "Rijksweg" (national trunk road) with the canal on your right-hand side. Before the drawbridge you turn to the ("Westoever"). You are now on the Ravelijnweg. On this road you take the first road to the left; next you take again the first road to the left, which is the Ambachtsweg.





1. Den Helder
2. The Hague
3. Amsterdam
4. Alkmaar
5. Utrecht
6. Leeuwarden

Information about TNO*'s main fields of activities:*
TNO Liaison Officer
A.C. Lakwijk
Schoemakerstraat 97
2628 VK Delft
The Netherlands
Phone: (+31) 15 69 69 69

Colophon

Production and layout
TNO Corporate Communication Department

Photographs
TNO
Victor Scheffer, The Hague

Printed by
Drukkerij/Uitgeverij Lakerveld BV, The Hague

©TNO november 1987