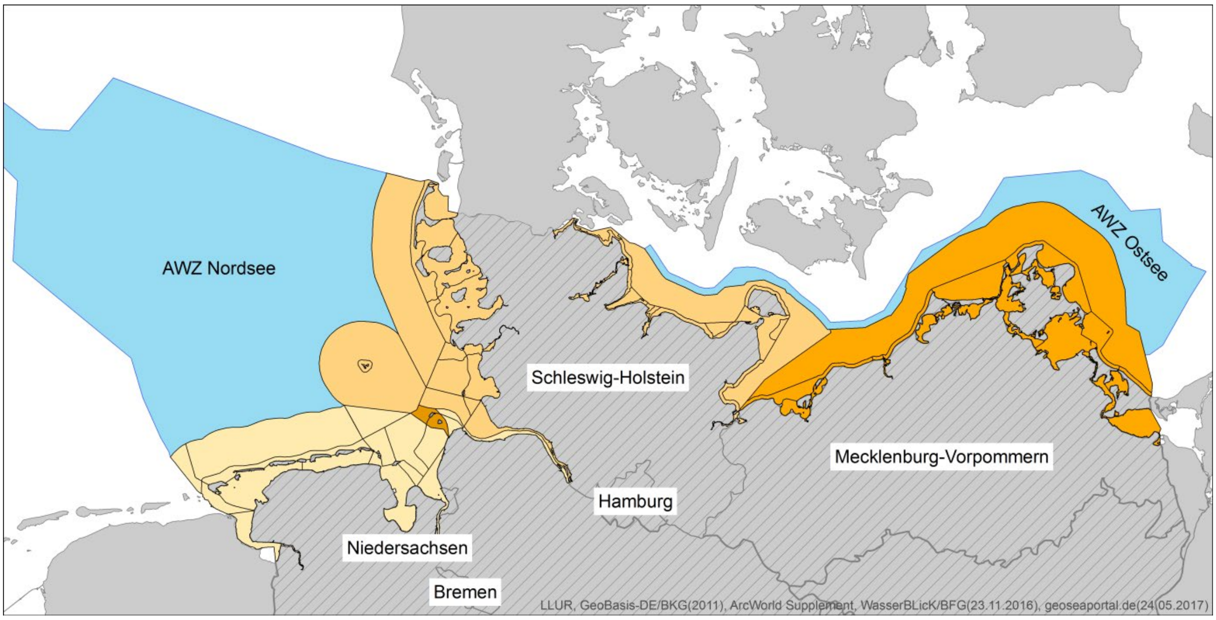
Guidelines for the examination of environmental impacts after pollution incidents in the German North Sea and Baltic Sea

(As of 31.05.2018)



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Citation:

UEG/CCME (2018): Guidelines for the examination of environmental impacts after pollution incidents in the German North Sea and Baltic Sea. 170 S. Havariekommando, Cuxhaven

Cover image

GIS-Grafik (Christoph Heinrich, LLUR) using GeoBasis-DE/BKG (2011), ArcWorld Supplement (ESRI), WasserBLicK/BFG (23.11.2016), www.geoseaportal.de (24.05.2017)

Foreword

On behalf of the Central Command for Marine Emergencies, the IfAÖ, under the leadership of UEG AG Monitoring, developed a proposal for an “examination concept for major pollutant incidents to determine the environmental impact in the German North and Baltic Seas” (IfAÖ 2016).

The guidelines presented here are a shortened and revised version of the research concept mentioned above by UEG AG Monitoring. It is designed for use in an emergency. Accordingly, the text is reduced to the essential aspects. Literature citations have been removed from the text, but the literature list of the research concept is included in the Appendix. The chapter numbering of the guide is based on that of the concept in order to make it easier to find the literature used as well as further information.

Acronyms and abbreviations

AMBI	AZTI Marine Biotic Index
AQS	Analytische Qualitätssicherung
BACI	Before/After-Control/Impact
BD	Birds Directive
BfG	Federal Institute of Hydrology / Bundesanstalt für Gewässerkunde
BLANO	Federal/State Committee North and Baltic Sea / Bund/Länder-Arbeitsgemeinschaft Nord- und Ostsee
BLMP	Federal/State Measurement Programme
BQI	Benthic quality index
BSH	Federal Maritime and Hydrographic Agency / Bundesamt für Seeschifffahrt und Hydrographie
CCME	Central Command for Maritime Emergencies / Havariekommando
DWD	National Meteorological Service / Deutscher Wetterdienst
EEZ	Exclusive economic zone
EPA	United States Environmental Protection Agency
EQS	Environmental quality standards
FAT-TW	Fish-based assessment tool – Transitional Waters
GC	Gas chromatography
GC-MS	Gas chromatography with mass spectrometry
GES	Good environmental status
HC	Hydrocarbons
HD	Habitats Directive
HD HT	Habitats Directive habitat type
HELCOM	Helsinki Convention
HK	Havariekommando / Central Command for Maritime Emergencies
HNS	Hazardous noxious substances
IOPC Funds	International Oil Pollution Compensation Funds
ITOPF	International Tanker Owners Pollution Federation
JAMP	Joint Assessment and Monitoring Programme (OSPAR)
LAWA	German Working Group on water issues of the Federal States and the Federal Government / Bund/Länder-Arbeitsgemeinschaft Wasser
M-AMBI	Multivariate AMBI
MarBIT	Marine Biotic Index Tool
MP	Monitoring programmes
MS	Mass spectrometry
MSFD	Marine Strategy Framework Directive
NLWKN	Lower Saxon Department for Water, Coastal and Nature Conservation / Niedersächsische Landesbetrieb für Wasserwirtschaft, Küsten- und Naturschutz

OSPAR	Convention for the Protection of the Marine Environment of the North-East Atlantic
PAH	Polycyclic aromatic hydrocarbon
pT	potentia Toxicologiae
QA	Quality assurance
OGewV	Surface Waters Regulations
SCAT	Shoreline Cleanup and Assessment Technique
TBT	Tributyl tin
THC	Total hydrocarbon
TWSC	Trilateral Wadden Sea Cooperation
UEG	Independent group of environmental experts
UVFS	Ultra violet fluorescence spectroscopy
VPS	Contingency Planning for Marine Pollution Control / VorsorgePlan Schadstoffunfallbekämpfung
WFD	Water Framework Directive

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1 Background and objectives

The German North Sea and Baltic Sea are marine areas with a very high volume of shipping traffic. Accordingly, some of the busiest shipping routes in the world are located here.

The increasing use of the seas, especially the increasing number of wind farms, also increases the risk of shipping accidents and the associated release of pollutants into the environment. Most often, mineral oil or oil derivatives end up in the sea. Despite the gratifying decline in tanker accidents, the risk of accidental oil pollution remains.

As part of the BE-AWARE I project (2012-2014), coordinated by the Bonn Agreement, a higher probability of the occurrence of shipping incidents/oil spills was determined for the southern **North Sea**, with its very busy shipping routes along the Belgian, Dutch, and German coasts, in comparison to other regions of the wider North Sea.

For the busy **Baltic Sea**, there has been a steady increase in shipping traffic over the past few decades. About 15% of the world's sea trade is here. After the construction of new oil terminals in Russia, a further increase in oil shipments can be expected in the future.

In the event of a pollution incident, there is a high probability that very sensitive habitats will be affected by pollution. Against this background, a **monitoring concept** for determining the environmental impact of major pollution incidents in the North and Baltic Seas is presented. The focus is on coastal and transitional waters and the immediately adjacent coastal habitats, since these regions are expected to have the greatest impacts from pollution with oil or other environmentally hazardous chemicals. Although the focus of the concept is on oil spills, the examination approaches can also be transferred to incidents involving other Hazardous and Noxious Substances (HNS).

The concept includes chemical, bioeffect, biological, and habitat monitoring with the requisite methodology. It differentiates between immediate monitoring for the first assessment of the magnitude of the incident, and long-term monitoring to determine damage and restoration of habitats and communities.

The necessity of creating a monitoring concept arises from recommendation 20 from the report of the independent expert commission "Havarie Pallas" ("Grobecker Commission", Berlin 2000) and the fifth milestone report on subproject 7 "Environment" of the project "Improving emergency preparedness and of emergency management in the North Sea and Baltic Sea". In the event of damage, such monitoring should, on the one hand, provide the scientific basis for describing and assessing the damage and, on the other hand, should be used to list costs in the context of insurance accounting.

2 Introduction

2.1 Oil as an environmental pollutant

Oils (mineral oil, crude oil) are extremely complex mixtures of thousands of substances, of which hydrocarbons (HC) make up by far the largest group of substances (usually > 75%). Relevant minor admixtures are nitrogen, sulphur, and oxygen-containing compounds and complexed metals (e.g., iron, nickel, vanadium).

Based on their chemical structure, HC are grouped into alkanes (paraffins), cycloalkanes (naphthenes), and aromatic compounds. The relative proportions of these components vary between crude oils of different origins and determine their physical properties. Alkanes and cycloalkanes make up the bulk of most crude oils. Depending on the number of their carbons and the temperature, they are highly- to non-volatile, liquid or solid compounds (waxes).

Most alkanes and cycloalkanes only have a low toxic potential towards aquatic organisms. Aromatics are partially water-soluble and are generally classified as the significantly more toxic and environmentally relevant components. They are therefore a particular focus of pollutant incident monitoring.

As soon as oil escapes onto the water surface as a result of an incident or other event, it is subject to various physical and chemical changes, which are known as *weathering processes*. The following weathering processes take place: dispersion, evaporation, spreading, emulsification, dissolution, photo oxidation, sedimentation, and biodegradation.

The speed and relevance of individual changes, which occur both at different times and parallel to one another, depend essentially on the type of oil and the prevailing hydrographic and meteorological conditions. In general, dispersion, evaporation, spreading, and emulsification are important in the initial phase after a spillage, while oxidation, sedimentation, and biodegradation are long-term processes that determine the ultimate fate of the oil.

2.2 Summary of monitoring studies after previous major oil and chemical incidents to date

The CEDRE and ARCOPOL studies showed that pollutant incident monitoring always includes the following three monitoring components:

- Chemical monitoring: determination of pollutant contamination in different compartments (water, sediment, biota).
- Bioeffect monitoring: reactions to exposure to pollutants at a sub-individual and individual level (bio tests, biomarkers).
- Biological monitoring: examination of harmful effects on population and/or community level (population dynamics, structural parameters).

In addition, further environmental compartments and components were regularly selected for environmental monitoring: pelagic, benthos, birds, and marine mammals.

Comparison of the monitoring programmes as part of the **CEDRE study** (Laruelle & Calvez 2005) revealed the following findings:

- The environmental components, which were examined more or less intensively depending on the pollutant incident, were the pelagic, the benthic area of the sublittoral and eulittoral, the supralittoral with the adjoining terrestrial area, as well as birds and marine mammals.
- The main focus was on monitoring activities in the benthic area and especially in the eulittoral, where drifting oil slicks ultimately stranded and the oil accumulated.
- The pelagic was examined more closely when local fishery or aquaculture was affected or threatened by oil pollution.
- In the event of a leakage of light oil or in the event of strong natural dispersion, monitoring was mostly focused on the sublittoral benthic area.
- Supralittoral and adjacent terrestrial areas were examined when these areas were polluted by the influence of wind and spray and when competent experts (botanists) were available.
- With regard to birds and marine mammals, interest in monitoring increased when significant local populations were present, when mortality was high, or when individual species were considered particularly worthy of protection.

As a result of the evaluation of the monitoring activities, the following deficiencies and monitoring priorities were identified within the framework of the **ARCOPOL project**:

- A general problem was the lack of coordination of monitoring programmes. According to the recommendation by Kirby & Law (2010), "environmental groups" should be set up to monitor and control all aspects of monitoring. At the national level, experts for individual components of a pollutant incident monitoring system should be named in advance. Instead of particular scientific interests, a multidisciplinary approach should have priority.
- The lack of reference data/preliminary data made it difficult to identify and assess the effects of pollutants. Long-term monitoring programmes are required to generate the necessary reference data. The implementation of the Water Framework Directive (WFD), the Marine Strategy Framework Directive (MSFD), and the Habitats Directive (HD) in national monitoring programmes should result in more usable preliminary data being available in the future.
- There were also frequent gaps in knowledge about the biology of selected bioindicators. This has a particularly negative impact when pollutant effects are to be recorded on a sub-individual (biomarker) and individual level. The choice should be of recognized and ecologically relevant species. Relevant selection criteria were determined as part of the EU project EROCIPS.
- In most cases, only short-term verifiable environmental damage was monitored after pollutant incidents and long-term effects were not examined or not recognized as such. In this respect, there is usually a fundamental lack of knowledge about long-term pollutant effects after incidents, although it can be assumed that these exist.
- The assessment of long-term effects can, however, be more difficult due to the natural variability of biological systems and chronic background pollution.
- The lack of standardized guidelines/procedures for implementing monitoring programmes is also widespread. These are considered to be absolutely necessary, also in view of the fact that programmes must always be flexibly adapted to the specific circumstances of a specific pollutant incident. The recommendations developed within the framework of the PREMIAM project in Great Britain can serve as a guideline for the development of monitoring guidelines in other countries.
- Furthermore, there is widespread ignorance about the environmental hazard caused by HNS after shipping incidents.

2.3 Dispersants

In addition to mechanical methods, chemical methods are also available for dealing with oil at sea. In terms of their mechanism of action, a distinction can be made between different product classes for chemicals. Oil herders and solidifiers increase the viscosity of the oil by contracting or solidifying it, thus facilitating mechanical removal. Demulsifiers and synthetic sorbents should ultimately increase the effectiveness of the absorption or skimming of oil. However, by far the most common dispersants used are those which promote the natural dispersion of oil and thus distribute it more firmly in the water column.

Effect of dispersants

When using a dispersant, the oil is broken up into tiny droplets and distributed in the water body from the surface of the sea. This results in a greatly increased surface area of the oil, which increases the bioavailability for microorganisms so that the oil can biodegrade more quickly.

Use of dispersants and NEBA

The use of a dispersant should always take place after carefully weighing the possible advantages and disadvantages in the specific individual case. A structured, step-by-step decision-making process is possible using the NEBA concept (net environmental benefit analysis), which is recommended by EMSA and IPIECA/OGP to weigh up the pros and cons of using a disperser. The NEBA process is based on the following four steps:

- Collecting and evaluating data: site examination; oil drift, weather conditions;
- Predicting what both non-intervention and the use of a dispersant would mean for threatened habitats;
- Weighing up different control measures with regard to ecological and socio-economic advantages and disadvantages;
- Choosing the best control measures that minimizes damage caused by the oil and at the same time promises the fastest regeneration of the marine environment.

2.4 Enforcement of costs for pollutant incident monitoring

Photo: H. Leuchs

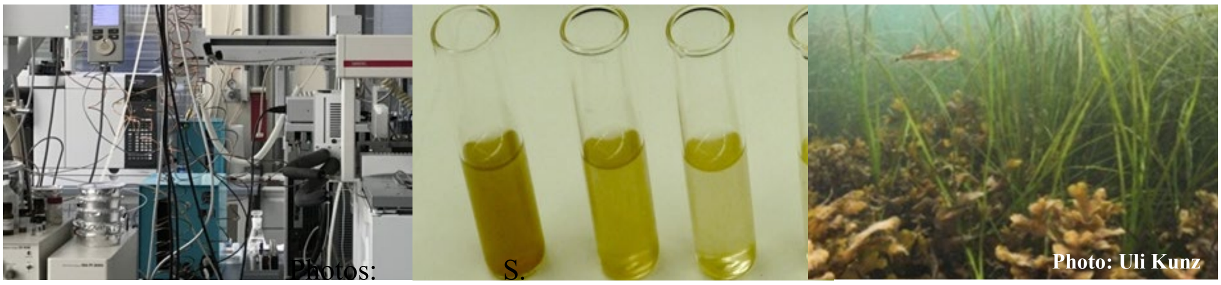
After an oil spill, the often very high costs for the necessary response and cleaning measures are the focus of claims for damages against the polluter. In addition, there are costs associated with recording and assessing environmental damage as part of more or less extensive pollutant incident monitoring.

In the first versions of the International Convention on Civil Liability for Oil Pollution Damage and the International Oil Pollution Compensation Funds (IOPC Funds) from 1992, environmental damage after oil incidents was not taken into account. Only current costs and economic losses were eligible for reimbursement.

With regard to claims for reimbursement for pollution incident monitoring, the following should be noted:

- The conditions under which compensation can be considered are very restrictive.
- In the first place, measures within the scope of immediate monitoring or in the acute pollution phase of an incident are reimbursable. Monitoring should accompany the oil response and cleaning measures as far as possible.
- Monitoring programmes are mainly classified as necessary in the event of major environmental damage. Criteria are, for example, a large area affected and the deterioration of commercial fish stocks and shellfish.
- The willingness to reimburse monitoring activities increases with increasing extent of the environmental damage.
- Environmental studies should primarily address the question of whether measures to restore the original state of the environment are necessary and feasible.
- The necessity of monitoring measures must be justified in detail. All measures must be documented in detail.
- International Tanker Owners Pollution Federation (ITOPF) experts should be involved in the design of a monitoring programme.

3 Relevant aspects of pollution incident monitoring



Guidelines for marine environmental monitoring after a pollution incident have been drawn up in various countries. Examples are the PREMIAM project carried out in Great Britain, the Oil Spill Monitoring Handbook (AMSA 2016) published by the Australian and New Zealand authorities for maritime safety, and recommendations for action to carry out pollutant incident monitoring from the French research and documentation centre for accidental water pollution CEDRE (Brest). Corresponding publications cited at various points in this report were, among others, also published by the regional marine protection conventions OSPAR and HELCOM, as well as ITOPF.

A comparison of the guidelines shows that the monitoring programmes are essentially the same with regard to the environmental components to be monitored. The following monitoring activities and environmental components are considered to be particularly relevant for pollutant incident monitoring.

- Chemical monitoring is used to determine the contamination of the environmental compartments water, sediment, and biota by the pollutant(s) that have escaped.
- Bioeffect monitoring records the toxic effects of pollutants on selected bioindicators.
- Biological monitoring should record the harmful effects on the biological ecosystem components benthos, fish, birds, marine mammals, and habitats.

An essential general goal of pollution incident monitoring is the decision as to whether there are environmental impacts and, if so, which measures are necessary to restore the environment to the state, which existed before the pollution incident.

3.1 Chemical monitoring

After a shipping incident with the escape of crude oil, oil derivatives, or other chemicals, the determination of the contamination of various environmental compartments is a central component of pollutant incident monitoring.

Objectives

- Chemical monitoring of water, sediment, and organisms primarily pursues the objective of determining the extent and intensity of pollution shortly after the release of pollutants as well as the decrease in pollution over time.
- The primary evaluation criterion of chemical analysis data is the restoration of the chemical reference state. This can be the condition immediately before the incident occurred or, in the case of long-term monitoring, the condition that is present in a representative reference area.
- It is used to clearly identify the polluter and thus to preserve evidence and assert claims for damages.

In addition, the results of chemical monitoring are an important decision criterion for whether and, if so, which measures are necessary to restore the original condition (reimbursement of costs).

3.2 Bioeffect monitoring

Objectives

Biological effect monitoring is used to record pollutant-related effects and/or effects on organisms as a result of pollution in the environment. In this respect, this type of monitoring is of particular relevance in the event of hazardous incidents, where a high level of exposure can be assumed.

A distinction must be made between biotests (bioassays) and biomarkers as monitoring tools for recording bioeffects:

- Biotests measure the ecotoxicity of environmental samples on selected test organisms under standardized laboratory conditions. A distinction is made between *in-vitro* and *in vivo* biotests. *In-vitro* tests mostly use cell lines as biological detectors, while *in vivo* tests are carried out with living organisms.
- Biomarkers are measurable biochemical, physiological, or morphological changes (so-called endpoints) that arise as reactions to physical and chemical environmental pollution. Biomarker studies are primarily carried out on organisms exposed in the field (bioindicators).

3.3 Biological monitoring

Objectives

Monitoring of benthos and the species groups fish, birds, and marine mammals serves to record and assess the damage to these relevant ecosystem components after a pollution incident. This is mainly done by comparing the condition caused by the pollution with the condition of the same biological components that are not affected by the pollution incident. In the course of pollution incident monitoring, the process of restoring the original condition or a comparable representative condition is monitored. An important objective of monitoring is the decision-making as to whether measures for restoration are necessary or not, and determination of the regeneration process in connection with the impairment of the ecosystems.

Primarily, the results of the species groups/habitats not affected by the pollution incident that were examined in parallel should be included in the assessment of the regeneration process. If necessary, a reference status can be defined using existing preliminary data with reference to affected species groups/habitats.

3.3.1 Benthos

As a component of the food web, benthic organisms are of considerable importance for the marine ecosystem. Because of this key role and the function of many organisms as indicators for changes in the surrounding environment, macrophytobenthos and macrozoobenthos are routinely examined as quality components in various monitoring programmes in German coastal waters.

Macrophytobenthos

Benthic macrophytes fulfil numerous ecological functions and are also of great economic importance. They serve many organisms (such as fish, crabs, and birds) as a habitat, a source of food and a substrate for spawning.

Eelgrass *Zostera marina* is an ideal bio-indicator for studying the effects of oil. The effect of oil on eelgrass varies from minor to severe, depending on water depth, type of oil, and surrounding local conditions.

Other macrophytes, such as bladderwrack *Fucus vesiculosus*, are less sensitive to oil exposure.

Macrozoobenthos

The term macrozoobenthos covers invertebrate organisms that live on or in the seabed and do not pass through a sieve with a mesh size of 1 mm.

An example of a trophic key group of macrozoobenthos (e.g., for benthophage seabird species) are mussels, which are particularly sensitive to a pollution incidents due to the predominantly sessile way of life of adults, their diet as a filter feeder, and their widespread use as bioindicators.

Most crustaceans are very sensitive to exposure to oil because they accumulate HC very quickly.

3.3.2 Fish

Fish can be harmed directly or indirectly by oil derivatives. Direct damage includes the absorption of oil droplets, absorption of dissolved oil components via the gills or other areas of the body surface, as well as impairment of the viability of fish eggs and larvae. Fish can also be indirectly affected by damage to their habitat and/or food sources caused by oil.

3.3.3 Birds

Birds are particularly noticeable victims of oil spills. They are therefore the focus of public attention in the event of such a spill. The harmful effects of oil on birds have two different levels:

- Individual birds are directly or, less noticeably, indirectly affected by oil pollution;
- Large concentrations of birds or breeding colonies of particularly sensitive species can be severely threatened locally after a pollution incident, or large parts of a population can be endangered (e.g., shelduck in the moulting season).

On the basis of expert judgements, Tasker & Pienkowski (1987) assigned an Oil Vulnerability Index (OVI) to various sea bird species in the North Sea. The index takes into account the length of time a species spends on the water surface, the importance of the North Sea population for the world population of the species, and the size of the total world population.

3.3.4 Marine mammals

Marine mammals, such as seals and whales, are among the species groups that enjoy particularly high public attention in the event of an oil incident. As potentially conspicuous victims of oil spills, like birds they have long been part of pollutant incident monitoring systems.

Harbour seal, grey seal, and harbour porpoise are the only marine mammals regularly occurring in large numbers in German waters. In the North Sea, the probability that these species will become victims of oil or chemical pollution is higher due to their significantly higher number of individuals than in the Baltic Sea.

3.3.5 Habitats

The most obvious environmental consequences of an oil spill do not include the chemical/toxic effects, but damage caused by direct contact between living organisms and habitats with oil or oil products. In habitats such as salt marshes, mussel beds, and eelgrass meadows, smothering with an oil slick leads to severe long-term damage.

Salt marshes that occur in the zone between land and sea are considered to be particularly sensitive habitats. If they are contaminated with oil, their regeneration is generally slow. This is especially true when oil penetrates deeper into the soil and leads to long-term contamination. Salt marsh plants show considerable differences in terms of their sensitivity and regenerative capacity. Annual herbs are predominantly the most sensitive to oil pollution, while grasses and perennial herbs are less sensitive. Persistent species with underground rhizomes and possibly vegetative reproduction have a comparatively high potential for regeneration.

4 Surveillance programmes in German marine monitoring

Long-term and routinely collected marine environmental data, such as those collected within the framework of regular marine surveillance, are a main source for the acquisition of preliminary or reference data, which represent an important tool for assessing the environmental damage caused by incidents. The core elements of maritime surveillance are monitoring programmes combined under the umbrella of the Federal/State Committee North and Baltic Sea (BLANO), the Federal/State Measurement Programme (BLMP). This means that relevant EU and national regulations are implemented, as well as obligations from regional marine protection agreements. The most important are the WFD, MSFD, Directive on environmental quality standards in the field of water policy, the HD, the Birds Directive (BD), and the OSPAR and Helsinki Conventions (HELCOM). In addition, the monitoring requirements from the Trilateral Wadden Sea Cooperation (TWSC) are part of BLMP. The current federal/state monitoring programmes are described in the monitoring manual with its data sheets (http://www.meeresschutz.info/monitoringhandbuch.html).

The separate Annex II of the monitoring concept (IfAÖ 2016) contains tabular lists of monitoring programmes (MP) that generate data that could be relevant as preliminary data/reference data for pollution incident monitoring. These are:

- Pollutants and bioeffects MP;
- Benthic habitats (fauna and flora) MP;
- Fish fauna MP;
- Bird fauna MP.

5 Deficiencies in marine monitoring in terms of advance data

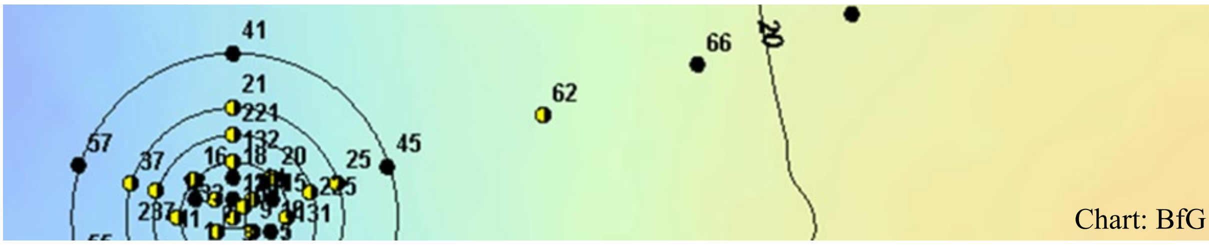
In principle, all environmental components identified as relevant for pollution incident monitoring are recorded as part of current marine environmental monitoring. However, there are definitely regional deficits with regard to spatial coverage and frequency of individual parameters.

According to the federal structure, coastal states are mainly responsible for monitoring in their own coastal waters; hence, the deficits identified and the recommended solutions are listed in the regional context and presented in tabular form in the study concept (IfAÖ 2016). In addition, there are even more extensive tables in Appendix II of the concept which contain the monitoring activities for the respective German coastal areas that are potentially relevant as sources of preliminary or reference data for the monitoring components of pollutant incident monitoring (Appendix II Tab. 8 - 11).

The following statements result from the **deficit analysis**:

- Overall, it can be stated that, in the context of monitoring the state of the German marine areas, the environmental components and parameters that are relevant for pollution incident monitoring, and that can potentially serve as preliminary data or reference data, are monitored.
- In general, greater spatial coverage is necessary of monitoring points in areas with a high risk of danger from the occurrence of pollution incidents as a result of a shipping incident. The priority is to monitor those habitats that are particularly sensitive and potentially suffer long-term damage (e.g., salt marshes, eelgrass stands, mussel beds).
- There is a shortage of preliminary data on macrozoobenthos communities in the eulittoral or sublittoral riparian zones. These marine compartments are particularly severely affected by oil and should be monitored particularly intensively in the context of pollution incident monitoring.
- Federal state monitoring programmes are inconsistent with regard to the frequency and season of sampling biota (mussels) to determine pollution. There should be harmonization in accordance with the monitoring recommendations of OSPAR and HELCOM.
- There is a general lack of reference data for selected bioindicators (bioeffect monitoring) in coastal waters.
- There are only limited preliminary data on marine pollution with oil-specific alkylated polycyclic aromatic hydrocarbons (PAHs) and alkanes (data available in the Federal Hydrography Agency (BSH)). There is hardly any knowledge available for HNS that are transported on a large scale by ships.

6 General monitoring principles



6.1 Monitoring design and strategy

Within the framework of monitoring, the effects of a pollution incident must be separated from natural variations in environmental conditions. If suitable preliminary data are available from the impaired area and from a reference area (which is as similar as possible to the affected area) that is not influenced by the damage event, this can be done according to the principle of the BACI model (Before/After-Control/Impact) or of the “Beyond BACI” model (Underwood 1992).

If preliminary data are not available or if reference studies cannot be carried out (e.g., due to the lack of suitable reference areas), environmental monitoring must inevitably be based exclusively on studies along a gradient of the pollutant concentration.

Each environmental impact assessment is usually based on the following characteristics:

- Biological components and key indicators;
- Pollutants in various environmental compartments;
- Physico-chemical environmental parameters that are characteristic of a habitat/biotope.

When designing pollutant incident monitoring, the following must be determined or specified (Law et al. 2011):

- Spatial and quantitative extent of damage;
- Issues and objectives of the monitoring programme;
- Most threatened/sensitive habitats/biotopes;
- Selection of monitoring parameters;
- Spatial scope of surveillance;
- Advance data from habitats/biotopes;
- Design and selection of evaluation and assessment procedures.

In principle, it should be possible to describe the condition of an affected area before a pollution incident as a starting point for its development over time using the most current data possible. For this purpose, the selected environmental components must be recorded in the short term in order to be able to carry out an initial assessment of environmental impact and resulting consequences. The subsequent recording of the temporal development of monitoring data is important because examination frequency must also be based on how quickly pollutant concentration decreases and the process of regeneration progresses. Development over time along the gradient of pollutant concentration must also be recorded so that anthropogenic changes after pollution can be distinguished from natural changes in view of the high spatial and temporal variability of the parameters.

As a measure for recording the effects, there are three approaches:

- Comparison with reference data / data from preliminary examinations in this area;

- Comparison with the development in the reference area;
- Comparison with areas of different pollution levels (gradient).

In practice, none of these approaches alone will allow satisfactory assessment of environmental impact after an incident. Usually a combination of all three approaches is appropriate.

The monitoring concept also provides for a distinction between immediate and long-term monitoring.

Immediate monitoring includes initial recording of the damage situation, examination of areas that have not yet been influenced or reference areas as starting values, as well as determination of habitats and communities that are mainly affected in order to be able to set up long-term monitoring.

Long-term monitoring, the "real" medium to long-term pollution incident monitoring, records the change in pollution in space and time. This monitoring also examines the pollution effect on biological components and habitats and the question of whether it is possible to restore the original condition which existed before the pollution incident occurred or a comparable reference condition.

Preliminary data from regular marine environmental monitoring or from individual studies are an important basis for assessing the environmental impact of a pollution incident. These data must come from long-term monitoring studies, which had been carried out in the damaged area before the incident ("temporal reference"), or data from comparable habitats ("spatial reference").

Reference samples are another important tool for assessing environmental damage after a pollution incident. They serve to assess and document the original condition of affected habitats and – in the course of pollutant incident monitoring – to assess the regeneration process of damaged habitats. The environmental conditions of the reference area should correspond as closely as possible to the natural conditions of the contaminated area (morphology, heights, exposure, sediments, communities, species). Areas/station grids for which advance data is available should be included as far as possible.

All examinations in the reference area should correspond in type and scope to examinations in the contaminated area and should be carried out at the same time. If possible, it must be ensured that all components that are documented in the contaminated area are also examined in the reference area.

If the polluted area is in an area with specific natural gradients, such as an estuary, it may not be possible to find a reference area with the same conditions as the polluted area. In this case, it should be checked whether several reference areas are to be identified that depict the natural gradient and thus include the polluted area.

The examination of selected **bioindicators**/types of indicators for chemical and/or bio-effect monitoring is a core element of any pollution incident monitoring. The selection of suitable species should be based on several criteria:

- Frequent occurrence in the affected area and in the wider geographic area;
- Sensitivity to oil or other pollutants;
- Species with a functional and/or structural key ecosystem function ;
- According to the WFD, sensitive taxa should be used for an impact assessment;
- The physiology and ecology of the species concerned must be known.

Theoretically, the **duration of pollution incident monitoring** should be determined by the objectives set at the beginning of monitoring and their achievement. In practice, however, a certain flexibility is required. Adjustments to the original programme design may be necessary due to current monitoring findings. There is no reason to start or stop all monitoring activities at the same time. Depending on the duration of regeneration, temporal monitoring requirements for different habitats or components differ.

In any case, a "**minimum programme**" should be considered if it is not necessary or possible to monitor all of the environmental components mentioned in Chapter 3. The selection of the components to be examined and definition of the scope of a minimum programme are made against the background of the specific pollution incident and the habitat(s) affected by pollution. In general, depending on the degree of sensitivity, protection status, and degree of natural spatial variability of a habitat, the requirements for a minimum programme can also vary.

Even with a minimal programme, regardless of the scope and general conditions of a pollution incident, chemical and biological test components must be examined.

In order to determine the restoration of the original state or a reference state of an area affected by pollution, long-term monitoring is also required as part of a minimal programme.

Conditions under which the implementation of a minimum programme can be considered justified and "sufficient" are, for example:

- The volume of oil that has leaked is relatively small;
- The oil is far from the coast at greater water depths (> 20 m) and eulittoral or near-shore habitats and the coast are not affected by pollution;
- Only a habitat of relatively low sensitivity and a high regeneration potential is affected.

Objectives that are followed with monitoring are:

- Preservation of evidence on the liability of the polluter;
- Pollutant characterization for the selection of measures;
- Assessment of environmental impact;
- Public information. In principle, relevant findings are also used for the topic of "occupational safety".

6.2 Sampling strategies and methods

Sampling

No generally valid recommendations can be given for the selection of sampling locations and number of samples. The parameters depend on conditions in the individual situation and the following variables:

- Amount of leaked oil/pollutant and type of oil;
- Weathering behaviour of the oil/pollutant;
- Topography and exposure of contaminated area;
- Heterogeneity of polluted area in terms of biotopes/habitats;
- Natural variability of components examined;
- In particular, gradients that exist in the area due to these anthropogenic and natural factors.

After this preliminary investigation, the entire examination area (polluted area plus reference area) should be divided into examination units (sub-areas), each of which is homogeneous in terms of natural and pollution-dependent parameters. For an individual, inherently homogeneous sub-area, it must then be decided which methodological approach (selective / random / systematic sampling) is to be followed when determining the sampling station network (AMSA 2003) (Table 1).

In practice, due to the limited number of samples, the seemingly homogeneous sub-area (see above) will be well covered spatially, with a network of sampling stations evenly distributed over it. If the determination of individual sampling positions takes place without detailed knowledge of local conditions, the principle of randomness with regard to the object of examination is largely preserved with this approach.

The above principles should be applied analogously in all habitats of the supralittoral (beaches and salt marshes), eulittoral, and sublittoral when defining the station network.

6.3 Assessment process

The status of marine waters is assessed within the framework of EU directives (WFD, MSFD, HD/BD) and regional agreements on marine protection (OSPAR, HELCOM, TWSC) against the background of a “reference status”. In the case of the WFD and MSFD, the statuses to be achieved are “good ecological status” / “good ecological potential” or “good environmental status (GES)”. The regional marine protection conventions OSPAR and HELCOM use their own assessment procedures for the holistic overall assessment of their convention areas. The assessment procedures differ.

Table 1: Approaches to the selection of sampling stations

Sampling approach	Characteristic	Potential application
Selective station selection	• Targeted selection of a relatively few stations/samples in contaminated and non-contaminated locations • Requires knowledge of distribution of environmental characteristics of relevant parameters • Documentation/justification of station selection (preservation of evidence)	• Preferably immediate monitoring • Monitoring in the event of low environmental pollution • Chemical monitoring (Oil characterization / chemical fingerprint)
Random station selection	• Large number of stations • Scientifically adequate • Adequate for legal examination	• Homogeneous sites such as offshore areas or long, uniformly structured sections of coast
Random layered /stratified station selection	• Large number of stations • Scientifically adequate • If necessary, adequate for legal examination • Division of inhomogeneous study areas into homogeneous sub-structures/habitats. Random station selection within delimited habitats	• In the case of extensive pollution of various habitats • If heterogeneously structured habitats are polluted • E.g., heterogeneous coastal areas with sampling transects perpendicular to the coast for each type of coast • Bays, inner coastal waters
Systematic selection of stations	• Station network or uniform pattern of sampling points distributed over a defined area • Taking samples at regular or defined intervals	• In large areas with unknown distribution of pollution • E.g., transect sampling from a ship to determine offshore pollution • With inconspicuous contamination (e.g., covered oil) • Salt marshes, possibly in different stages of development, sampling of transects / permanent squares
Sources: AMSA (2003), ITOPF (2012a), supplement IfAÖ		

With regard to oil contamination, the method of these assessment approaches has not yet been adequately examined (BLMP 2012c). Existing deficits should be remedied by the start of the second MSFD management cycle (2018 - 2024).

An assessment according to the MSFD and WFD must take into account the possibly very different sizes of the damaged area on the one hand, and water bodies or MSFD area on the other. In the absence of a standard procedure, this problem of different reference values must be carried out and will need to be discussed, taking into account the specific objectives.

Monitoring provides results on pollutant dispersion and on the various environmental impacts, which also change over time. Their assessment must show whether these are significant or serious, whether recovery measures (compensation) may also be necessary and, if so, to what extent.

As long as there are no adapted assessment procedures for this, existing procedures must be used.

Assessment of the consequences of the incident must therefore take into consideration the specific spatial and temporal reference to the incident using the parameters provided in this guide.

An assessment according to WFD and MSFD is, above all, in the case of major incidents, to be carried out in addition to this in order to check whether the consequences of the incident can be mapped using the WFD and MSFD instruments at the level of the water body or even the marine region.

6.4 Transport and storage

In principle, samples should be sent to the laboratory commissioned with the examination as soon as possible after taking the sample. For logistical and cost reasons, however, it is appropriate to collect a number of samples before they are dispatched. For longer transport times (e.g., by ship), refrigerators and freezers may be required.

It is possible that when the samples are collected it is not yet clear who will process the samples or when a laboratory can accept them. In these cases, the samples must be stored appropriately in order to ensure sample integrity. Recommendations for the storage of samples are given in Chapter 9 (methodological instructions).

6.5 Process and coordination of monitoring

Planning and implementation of monitoring examinations after an incident are very complex and require the cooperation of numerous participants from very different fields of work and from different organizations. A further complicating factor is that, immediately after an incident and at the beginning of a necessary immediate monitoring, there is particularly high time pressure because negative effects on the environment are the greatest and changes are highly dynamic. In order to get an overview of the measures to be taken, the main components of the monitoring are summarized in the flow chart in Figure 1. This is supplemented by Table 2, in which the same structure is used as in the figure, but more details are provided for explanation and supplementation. As can be seen from the illustrations, at the beginning of a “complex damage situation”, the Havariekommando / Central Command for Maritime Emergencies (CCME) has special tasks with regard to planning and decisions. It should be borne in mind, however, that not every “complex damage situation” automatically has to result in a monitoring programme; such monitoring should only be necessary in the event of incidents with the release of large quantities or particularly toxic pollutants.

Due to the urgency that is likely to prevail in the event of an incident, it is advisable to prepare the necessary organizational structures (monitoring coordinator, team of experts) in advance and to test them through occasional practice exercises.

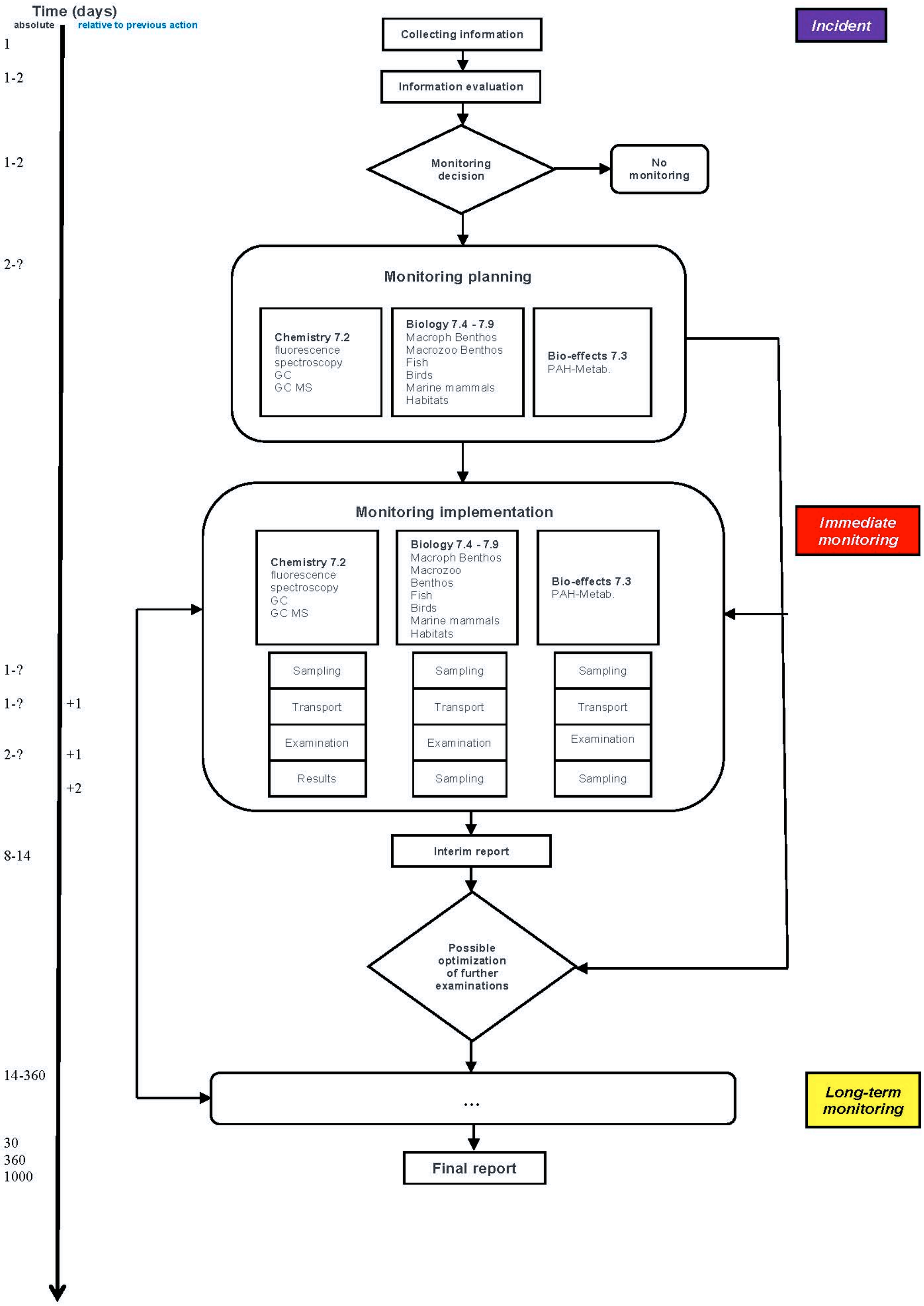


Figure 1: Schematic representation of the essential components of monitoring

Table 1: Summary of the essential components of monitoring

	Information required		Information evaluation	Examination planning				
	What	Who	Who	Who	What	Goals	Relevance; priority	Who, what, when, where, (detailed planning / coordination)
	Who: also see list of experts							
Information	**What**: crude oil, heavy fuel oil, diesel, chemicals	Ship, shipping company, port authorities	CCME M-Coordin. Team UEG?	M-Coordin. Team UEG?				
	How much: quantities, releases and kinetics	Regulatory authorities						
	Where incident site, expected drift; sensitivity	Supervisory authorities; Sensitivity mapping						
	"Visual" (*in situ*) observations: aerial surveillance; on-site observations	Navy, CCME, environmental and nature conservation associations			aerial surveillance	Survey of visible contamination		
	Weather	DWD						
	Currents	BSH						
	Modelling	BSH			Modelling	Optimization of sampling		
Monitoring			Monitoring decision: yes / no					
					Chemistry 7.2 fluorescence spectroscopy GC GC-MS	semi-quantitative and quantitative recording of the extent of pollution Preservation of evidence	*** ***	Coordinator; Team of experts; Laboratories
					Biology 7.4 - 7.9 Macroph Benthos Macrozoo Benthos Fish Birds Marine mammals Habitats	Recording the extent and effects of pollution	*** ** ** * *** ** ***	Coordinator; Team of experts; Laboratories
					Bio-effects 7.3 PAH-Metab.	Recording the extent and effects of pollution	* to ***	Coordinator; Team of experts; Laboratories
Time (days): absolute (relative to previous action)	0	1	1-2	2-?	2-?	2-?	2-?	2-?
	Incident							

Table 2: Continuation: Summary of the essential components of monitoring

Monitoring (implementation)						Further development, optimization, inclusion of further measured variables, placement of measured variables,	…	Final report
Sampling, field survey, mapping		Transport samples	Examinations (analyse samples & field data)	Results, evaluations	Interim report			
What, when	Who	Who	Who	Who	Who			Who
Who: also see list of experts								
		Aerial surveillance	Aerial surveillance					
			Modelling	Modelling				
						Decision		
9-10 water, beach, soil, biota - depending on the extent to which they are affected		Laboratories, possibly staff on site	Research laboratories, BSH		Laboratories, team of experts and coordinator	Observation of long-term effects and recovery		M-Coordin. Expert team UEG?
Depending on how affected they are		Laboratories, possibly staff on site	Research laboratories		Laboratories, team of experts and coordinator	Observation of long-term effects and recovery		M-Coordin. Expert team UEG?
Depending on how affected they are		Laboratories, possibly staff on site	Research laboratories		Laboratories, team of experts and coordinator	Observation of long-term effects and recovery		M-Coordin. Expert team UEG?
1 -? *(+1 - ?)*		1 -? *(+1)*	2 -? *(+1)*	*(+2 after receipt of samples)*	8 - 14	14 - 360		30; 360; 1000; …
Immediate monitoring						Long-term monitoring		

7 Monitoring of relevant components (data sheets)

Chapter 7 is the core of the guidelines. Instructions for chemical, bioeffect, and biological pollutant incident monitoring are given in 15 data sheets. Particular attention is paid to important components such as benthos or birds, as well as relevant habitats such as eelgrass or salt marshes. In the biological data sheets, an attempt has been made to maintain the same structure for better clarity by dealing with relevance, sensitivity, parameters, immediate and long-term monitoring, methods and evaluation in sub-chapters.

7.1 Data sheet for general instructions for pollutant incident monitoring

This data sheet contains instructions and activities that, regardless of the environmental components affected by an oil or other pollution incident, should always be carried out as part of pollution incident monitoring. Initial monitoring activities must be undertaken at an early stage while oil/pollution control is still ongoing. For example, situation surveys (which primarily serve to determine response and/or cleaning strategies) also provide relevant basic information for pollution spill monitoring. Overall, the activities carried out in the first hours to days after a pollution incident can make a decisive contribution to damage assessment and the conceptualisation of an adequate examination of a pollution incident.

The following list of instructions mainly relates to immediate monitoring, which covers the period from the first days to weeks after the occurrence of the pollution incident. In some cases, however, these are also general recommendations, which should be implemented at any time during the monitoring process.

Basically, every pollution incident requires an individual monitoring approach. After serious pollution incidents in particular, the activities required for an environmental impact assessment can usually not be determined with certainty at the beginning. In this respect, it is better to collect more extensive data and samples at an early stage than to leave out areas that might only be considered important at a later time.

Situation investigation

In the event of a pollution incident, the emergency team initiates various measures to examine the state of affairs, the results of which are also important for pollution incident monitoring. Additional data relevant to monitoring must also be recorded.

- Aircraft-based reconnaissance of the area involved in the incident. Large-scale coverage of the affected area.
- Use of oil drift models in order to obtain information on the dispersion and possible stranding of the oil.
- Aerial photos should be taken of both the affected and threatened coastal areas before oil is stranded there.
- Collection of weather and hydrographic data in order to evaluate the influence on the weathering process of the oil.

- Identification of particularly threatened and sensitive areas based on:

- exposure and geomorphology, possibly elevation model;
- VPS-sensi data (VPS: Contingency Planning for Marine Pollution Control);
- review of protected area status.

- Reconnaissance from the air should always be combined with a qualitative habitat survey and description of the oil-polluted areas through on-site inspection (see below).
- As part of the situation investigation, recording of information relevant to monitoring must be maintained until oil dispersion and/or oil landings no longer occur.

Chemical characterisation

Chemical analysis of the oil type is a measure that is part of regular oil spill response. Samples must first be taken on land, where the oil first reached the coast. The fresher a sample, the more substances it contains that have not yet volatilized. The analysis data are used for:

- Selection of suitable control and cleaning measures;
- Clear identification of the ship that caused the incident for the purpose of preserving evidence and making claims for damages;
- Evaluation of the toxicity and weathering behaviour of the oil. Both properties are important basic information for the conceptualisation of monitoring adapted to the specific pollution incident.

Coordination of pollution incident monitoring

- AG Monitoring suggests that the CCME, together with the responsible authorities and the UEG, form groups of environmental experts from various specialist areas for each federal state and for the exclusive economic zone (EEZ) in the event of a complex pollution incident / damage situation. This team of experts should be selected and named before any pollution incident occurs. Networking with the people responsible for national monitoring activities should be guaranteed. A monitoring coordinator and a deputy should be named in the team who coordinate all immediate monitoring activities.
- The monitoring coordinator should be authorized to initiate or commission the monitoring tasks to be carried out after consultation with the cost-bearers (CCME, federal states, or the federal government).
- The expert network should be able to select experts from specialist authorities, institutes, and consulting firms.
- It should be discussed whether the establishment of fixed regional “environmental groups” (equivalent to “Standing Environment Groups” in Great Britain) is a sensible measure to start immediate monitoring more quickly in the event of a pollution incident and to be able to carry it out more effectively.
- With regard to financial reimbursement of monitoring expenses, the insurance companies and, in the event of tanker incidents, ITOPF and the IOPC Funds must be informed about monitoring by CCME or the federal government.

Documentation

- Photos and possibly films are an important addition to the written damage documentation; they can illustrate the regeneration process of a habitat.
- For the documentation of on-site examinations, the available field recording sheets must be completed.
- All samples of water, sediment, and biota must be clearly and traceably labelled.
- All data should be stored in a location that can be quickly accessed for future inquiries.

On-site investigation

- On-site investigation to get an initial overview of the extent of the pollution. In the North Sea, the inspection must be carried out at low tide so that the extent of the pollution can be recorded as comprehensively as possible.
- Photos and notes of sensitive components that need primary protection. Detection of oil victims (birds, mammals, etc.) in the drift line.
- Prioritization of areas that are particularly vulnerable (if further oil landings are to be expected) or that are particularly sensitive to oil pollution.
- Detailed beach surveillance (as in a Shoreline Cleanup and Assessment Technique (SCAT) survey) is only useful when the landings of oil have come to a stop. In addition to recording oil distribution, the following points are important (more detailed information can be found in the data sheets):

- qualitative biotope mapping and description of oil polluted areas;
- first assessment of which parameters can be used for pollution incident monitoring;
- taking samples.

Preliminary data

Preliminary data from regular monitoring programmes or from individual studies are an important tool for assessing environmental damage after an oil spill. The quality of preliminary data has a decisive influence on the trustworthiness of conclusions drawn from a comparison with the findings of the pollutant incident monitoring. The following criteria must be set for the usability of preliminary data:

- Ideally, preliminary data are available from long-term monitoring studies in the pollution incident area or from comparable habitats;
- Preliminary data were collected only relatively shortly before the polluting incident and natural seasonal changes have not occurred since then.

If the following applies, preliminary data cannot be used or can only be used with considerable restrictions:

- Preliminary data are too old;
- Preliminary data were collected in a non-comparable habitat or in a non-comparable season.

Reference samples

Reference samples are a key element in the assessment of environmental damage and regeneration. The following aspects, among others, are important (for further information see Chapters 6.1 and 6.2):

- If possible, reference samples should be taken before the oil reaches the coast, primarily in areas that are particularly endangered due to their location and geomorphology and/or that represent a highly sensitive habitat.
- Landed oil is often only in patches. Reference samples can then be taken in representative, unaffected areas between the patches.
- Reference samples should document the status quo when the damage situation occurs. In doing so, they also define criteria for comparison that can be used to terminate monitoring or individual monitoring activities.

Collection of oil victims

- It is important to watch out for injured wild animals shortly after the release of oil or other pollutant.
- In the event of a pollution incident, drift line monitoring should be carried out for oiled birds, together with the removal of the corpses of oiled animals.

- Autopsy examinations of oiled dead birds should be carried out.

The decision tree shown in Figure 2 schematically summarizes the aforementioned general courses of action for pollution incident monitoring.

Table 3 contains brief information on vulnerability (risk) and sensitivity of habitats and biological species groups in the event of an oil spill, as well as an assessment of options for action available for monitoring. The categories of the columns are based on the following definitions:

Vulnerability (risk): is the ease with which oil can pollute a habitat and remain there for a long period of time.

Sensitivity: is the sensitivity to the chemical and physical properties of oil, the adverse effects of cleaning activities, and the potential for regeneration.

Monitoring options: take into account the existing monitoring methods, the availability of indicators for the detection of oil effects, and the practical and logistical difficulties of monitoring.

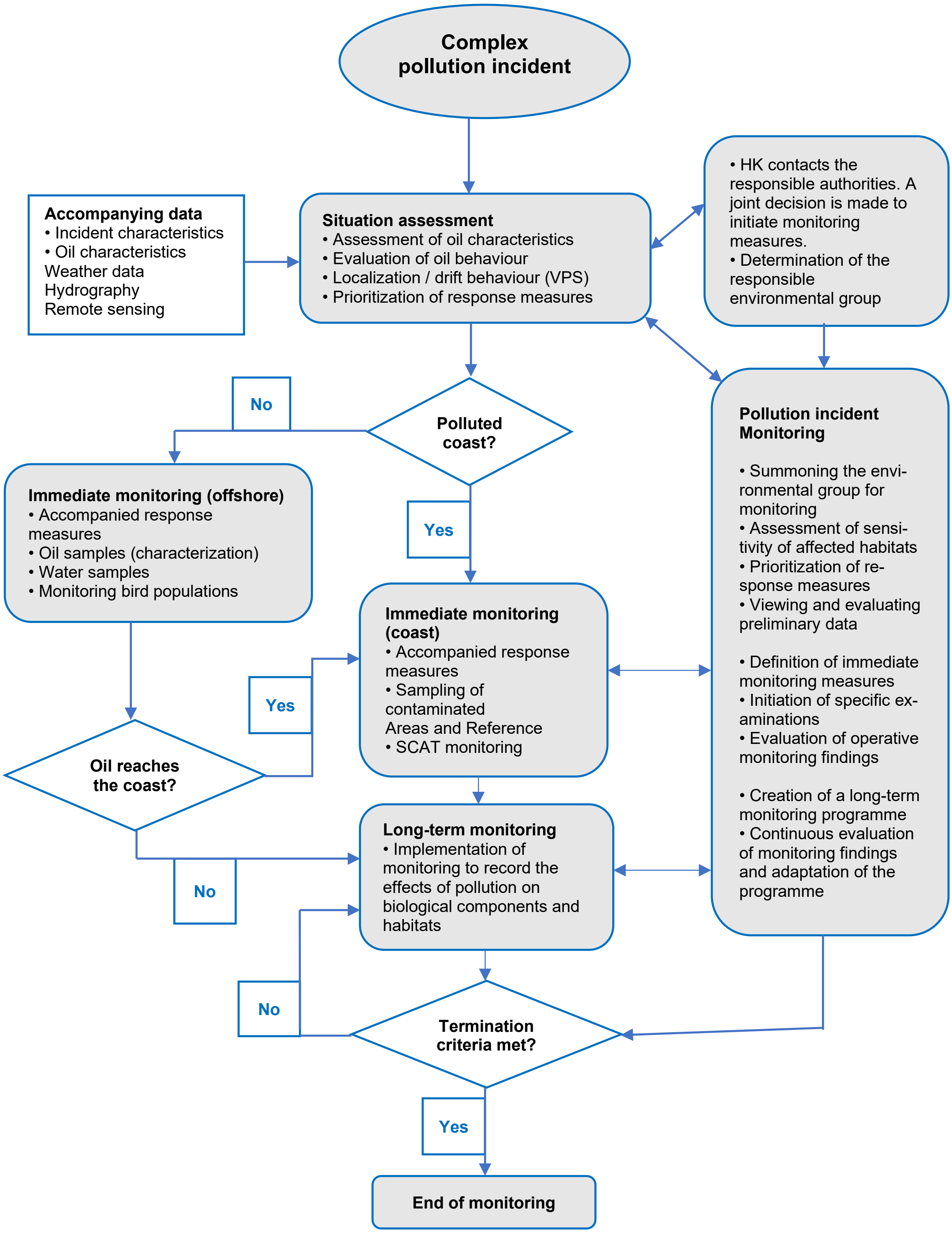


Figure 2: General courses of action and options in the context of pollution incident monitoring

Table 3: Vulnerability/risk, sensitivity and monitoring options of habitats and biological components

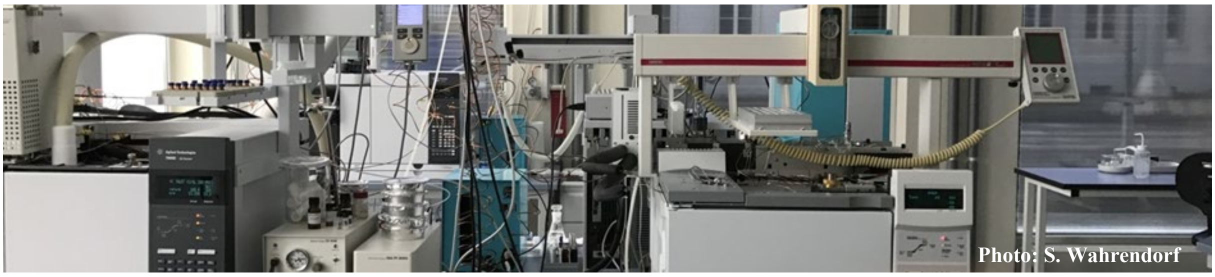
Habitat / Component	Vulnerability	Sensitivity	Monitoring options	Data sheet
Sandbanks which are slightly covered by sea water all the time	moderate	moderate – high	good	Sandbanks
Mudflats and sandflats not covered by seawater at low tide	moderate – high	~~low – high~~ moderate – high*	good	Eulittoral sand, mixed and mudflats, macrozoobenthos, bioeffect monitoring
Rocky coasts, artificial hard substrates in the tidal zone	moderate – high	low - high	possible	Macrophytobenthos, macrozoobenthos, riparian zones, and beaches, bioeffect monitoring
Eelgrass meadows – eulittoral	moderate	~~moderate~~ moderate – high*	possible	Macrozoobenthos, eelgrass meadows
Eelgrass meadows – sublittoral	low	low – moderate	possible	Macrozoobenthos, eelgrass meadows
Mussel banks – eulittoral	~~moderate~~ moderate – high*	~~moderate~~ high*	good	Mussel banks, bioeffect monitoring
Mussel banks - sublittoral	low	low – moderate	possible	Mussel banks, bioeffect monitoring
Benthos - sublittoral	moderate	moderate	good	Macrozoobenthos, reefs, Bioeffect monitoring
Glasswort (*Salicornia)* and other annuals colonizing mud and sand	high	moderate – high	low	Salt meadows
Spartina swards	high	moderate – high	good	Salt meadows
Atlantic salt meadows	high	~~moderate – high~~ high*	good	Salt meadows
Fish	low	low	difficult	Fish, Bioeffect monitoring
Birds	moderate – high	moderate – high	Breeding colony good - difficult at sea	Birds
Seals, porpoises	low	low	good	Marine mammals
Adapted from Moore et al. 2005 (CCW Impact Assessment Wales); partial changes and additions by IfAÖ; *Reassessment of vulnerability or sensitivity by UEG (original assessment crossed through).				

Quality assurance

Quality assurance (QA) is an essential part of marine environmental monitoring. It is intended to guarantee the accurate and standardized collection, processing, and evaluation of environmental samples and thus serves to ensure trustworthy and comparable test results. Within the framework of the BLMP, the quality assurance office (QAO) assigned to the Federal Environment Agency is responsible for coordinating QA. It advises coastal states and the federal government about QA issues and organizes, among others, training, workshops, and round robin tests and creates, for example, operating procedures.

To guarantee QA, the laboratories involved should, if possible, have quality management systems based on or in accordance with DIN EN ISO/IEC 17025. The applicable guidelines, standards, methodical instructions, etc. are listed on the monitoring data sheets of the BLMP manual.

7.2 Chemical monitoring data sheet



Relevance

After a pollution incident, the identification and determination of the leaked oil or other pollutants in the compartments water, sediment, and biota is a core element of pollution incident monitoring in order to quantify and evaluate its effects on the environment. Furthermore, the chemical analysis of environmental samples is used to clearly identify the source of pollution (e.g., to preserve evidence for claims for damages) and to estimate the effects on various environmental components (e.g., to optimize response measures).

For trace metals, HC, and numerous organic pollutants, extensive data sets exist from longstanding marine environmental monitoring in Germany, which can possibly be used for evaluating reference conditions. However, there is no such data for many of the goods and hazardous substances transported at sea because they are not measured in the monitoring programmes. For these substances it is of particular importance to obtain data from reference areas.

Chemical monitoring after an oil or pollution incident

Oil and other pollutants are quickly diluted in water, depending on hydrographic and meteorological boundary conditions, which is why initially high concentrations decrease in a short time. An analysis of water is therefore generally only relevant in the initial phase of monitoring. In sediment and biota, oil and numerous other (especially lipophilic) pollutants can be detected in higher concentrations for a significantly longer time because the substances accumulate here. Pollutant measurements are usually repeated at shorter intervals at the beginning of monitoring than during a later phase, in order to optimally record the kinetics of pollution. The measurements should finish when the pollutant load has fallen back to the level before the incident/event.

The volume of samples that should be collected after a pollutant incident can be large. It can include water from different depths, sediment and biota from the sublittoral and eulittoral zones, and beach areas. In order to optimize the effort, it may be useful to combine the various processes with one another and, for example, use data from remote sensing for planning the sampling of more specific processes. Remote sensing data can also be used for the spatial interpolation of specific point analyses. For the purpose of preserving evidence, it is appropriate to first take more samples and use some of them as reserve samples.

Following the escape of oil or oil derivatives, the most important chemical parameters to be analysed are the total hydrocarbon content (THC), n-alkanes, aromatic HC, and special biomarkers (steroids, triterpenes). These substance groups and their relevant monitoring parameters are summarized in Table 4.

Table 4: Chemical study groups and their relevant monitoring parameters

Parameter	Sampling	Matrix	Analytical method	Monitoring objective
THC (total hydrocarbon content)	Remote sensing *in situ* discreet	W W W, S, B	UV-vis spectroscopy	Immediate monitoring: determination of input and spread of oil pollution; detection of hot spots
n-Alkane	discreet	W, S, B	GC, GC-MS	Determine oil exposure in the environment and its development over time; main components of oil
Aromatic compounds **- BTX** **- EPA-PAK** **- alkyl. 2- and 3-ring aromatic compounds**	discreet	W, S, B	GC-MS	Determine oil exposure in the environment and its development over time; relevant toxic substances
Biomarker (steroid, terpene)	discreet	W, S, B	GC-MS	Identify culprit of the pollution; relevant for both immediate and long-term monitoring; relevant for preservation of evidence
W: water, S: sediment, B: biota				

Immediate monitoring

Immediately after an oil spill, and in the following days or weeks, the focus of chemical analysis is on the following:

- Determination of the extent of oil contamination on the water and on beaches by means of remote sensing (aircraft, satellite). Such data are also helpful for planning further sampling and the area-based interpolation of the results of the other analyses.
- Determination of the extent of the oil contamination in the water. For this, the THC in the water column and the horizontal spatial extent of the pollution, for example measured by means of UVF spectroscopy.
- When using a dispersant, the entry of oil into the water column must also be recorded. Sediment samples should be used to check whether the seabed is also contaminated.
- Detailed analysis of the chemical composition of leaked oil or oil derivatives (chemical fingerprint) provides:
  - information on whether, where, and in what concentration specific fractions of oil are transferred into the water column, into sediments, and biota; and
  - information that can be used to clearly identify the polluter and thus to preserve evidence and assert claims for damages.
- The collection of heavily oiled sediment or biota (e.g., mussels) for quantitative determinations is usually not necessary, as strong contamination can already be seen visually. However, it is appropriate to take such samples for preservation of evidence or as reserve samples for later use.
- If possible, reference samples should be taken in areas threatened by oil pollution.

Long-term monitoring

During long-term monitoring, chemical analyses must be carried out on relevant components, initially at short intervals, later at longer intervals. The following must be taken into account:

- The levels of aromatic compounds in the water should be measured along the drift route of an oil slick and in its vicinity in order to determine the entire impact zone.
- In the first year after the occurrence of an oil spill, the load of aromatic compounds in representative reference samples should be analysed in order to be able to take natural seasonal fluctuations into account. Possible regional differences must be taken into account.
- Whether the determination of PAH metabolites in fish bile is effective has to be decided on a case-by-case basis. It indicates whether it can be assumed that fish are impacted as a result of the pollutant incident.
- The method of sampling sediment and biota must follow the same methods that are used in regular pollutant monitoring and from which usable preliminary data are provided.
- The chemical analysis of components of a pollutant incident can be discontinued when the measured values are back to the level of reference ranges.

Methods

Sampling

Detailed instructions for taking samples of different matrices for subsequent chemical analysis are given in Chapter 9.1 (water), 9.2 (sediment), and 9.3 (biota). “Sampling” is understood here, as is common practice, to be the actual sampling in the field, storage of the samples, and the supply chain up to handover of the samples to the chemical analysis laboratory. The samples must be clearly labelled and all steps must be carefully documented (see Chapter 10). In all steps, it must be ensured that there is no direct or indirect contamination of the sample.

Water: Pollution of water with HC can be determined in the field *in situ* (see above) and by taking samples and then analysing them in the laboratory.

Sediment: When sampling surface sediment, the upper 2 cm of an undisturbed sample must be collected. To determine the depth spread of contamination, sediment cores should be cut into 2 cm layers and analysed separately.

Biota: Mussels are the preferred organisms for determining the load of aromatic compounds in biota (see Section 7.4).

In order to record the contamination of fish by PAHs, fish bile must be examined for PAH metabolites; this can only be done within the framework of fishery-biological monitoring programmes.

Analysis of oil-polluted feathers from dead birds can be an important means of securing evidence. Chemical analysis of bird eggs can be useful in order to demonstrate a chronic harmful effect of oil on birds in the context of long-term monitoring (see Section 7.6).

It is always important to procure **comparative samples** from the ship, which caused the pollution (tank samples, cargo samples, etc.).

Chemical analysis

Analysis methods for determining pollutants are very diverse and depend on the substances and the monitoring objectives. In general, one can differentiate between optical, spectroscopic, chromatographic, and coupled chromatographic-spectroscopic processes. In this order, the specificity of the analyses and results increases, but also the effort and thus the costs.

Optical-spectroscopic methods (e.g., ultraviolet fluorescence spectroscopy (UVFS)) are particularly suitable for rapid, semi-quantitative screening of THC. In addition to the examination of individual samples in the laboratory, they also allow, for example, continuous *in situ* measurements with portable UVFS measuring devices and are even used in remote sensing processes. Despite their limited specificity, they are therefore of great importance and are used – especially within the first days of an oil pollution incident– when viewing large areas, for semi-quantitative estimates of quantities, and for identifying hot spots. The method also enables different types of oil to be distinguished.

However, complex laboratory procedures are necessary to determine specific oil components in a sample. This requires individual samples that can show a high degree of variability.

A combination of gas chromatography with mass spectrometry (GC-MS) is the method of choice for the determination of aromatic HC, which, due to their environmental relevance, are a focus of chemical analysis. With it, the spectrum of individual HC contained in a sample can be recorded specifically and quantitatively. As part of regular environmental monitoring, the measurement of 16 PAHs selected by the United States Environmental Protection Agency (EPA) is customary. However, these PAHs are not very characteristic of oil. Therefore, the quantitatively more important alkylated 2- and 3-ring aromatics must also be recorded. In order to preserve evidence and for long-term monitoring, characteristic indicator compounds (biomarkers, PAHs) that are specific for the leaked oil must be analysed.

PAHs are usually not analysed in tissue samples from fish because they are not accumulated due to the effective metabolism of foreign substances. Instead, the detection of PAH metabolites in bile can be used as an indicator of PAH exposure.

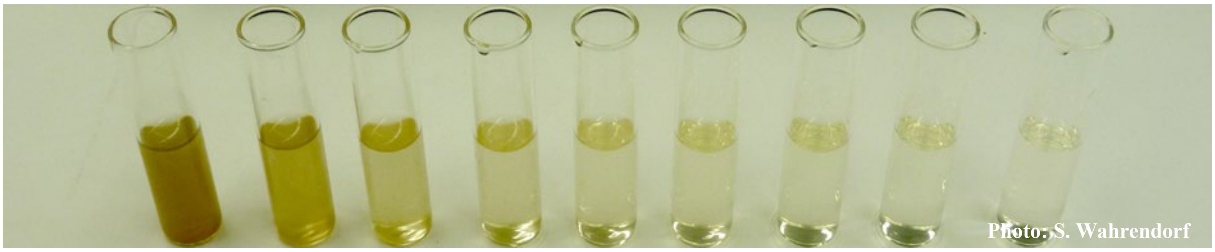
Pollutants other than oil may require different analytical methods. These must be agreed in each case with the assigned laboratories or other experts. Sampling should also be adapted specifically to the pollutant involved.

Evaluation criteria

The primary criterion for evaluating chemical analysis data is comparison with the reference status. This can be the condition prior to the occurrence of the incident or, in the case of long-term monitoring, also the condition that exists in a comparable, representative reference range.

Furthermore, criteria of the WFD or of OSPAR/HELCOM should be used for the evaluation of chemical data. According to the WFD, the chemical status of priority substances and certain other pollutants is assessed according to environmental quality standards (EQS) set out in the Surface Waters Regulations (OGewV 2016). Annex 7 of the OGewV lists, among others, the maximum permissible concentrations for some substances in transitional and coastal waters. Appendix 8 lists requirements for the assessment of measurement results.

7.3 Bioeffect-monitoring data sheet



Relevance

In the context of pollution incident monitoring, ecotoxicological methods can make an important contribution to recording and evaluating the effects of pollutants on various environmental compartments. Depending on the objective, a distinction must be made between bioassays and biomarkers as monitoring tools (see 3.2 Bioeffect monitoring). **Biotests** are used when the ecotoxicological effects of water and sediment samples are to be determined under laboratory conditions. As a rule, this is primarily appropriate in the acute phase of a pollution incident. **Biomarkers**, on the other hand, are suitable for recording pollution effects in the field (*in situ*) using suitable biota (bioindicators). With the range of established biomarkers available, stress-induced changes can be detected at different levels of biological organization. Bioeffect examinations, regardless of whether it is a biotest or a biomarker, should be accompanied by chemical analysis so that it can be seen if the determined toxic effects are related to the pollution.

Bioeffect monitoring after an oil or pollution incident

The decision as to whether and which bioeffect methods are used after a leakage of oil or other pollutants must be made case by case against the background of the specific environmental pollution. The following questions can help to choose the appropriate ecotoxicological investigation approach:

- Which chemical(s) has/have leaked? Is/are they potentially toxic or is there uncertainty about the toxicity?
- Where did the chemical(s) leak and where are they moving to?
- What is the physical behaviour of the chemical(s) in sea water?
- What are the key ecological and economic species in the vicinity of the incident site?
- Does the time of the leakage of the oil or the chemical(s) coincide with seasonally important biological processes (e.g., spawning season, main growth period)?
- Is/are the leaked substance(s) persistent and tend(s) to bioaccumulate?

Biotests

The ***use of biotests*** to determine the ecotoxicological effect potential of water and sediment samples is advisable under the following conditions:

Water samples

- If, after a major leak of oil, due to the type of oil (especially with a high proportion of easily soluble components) and based on model calculations, increased oil concentrations in the water can be expected.
- If the incident occurs in a relatively sheltered area, where there is little water exchange and little dilution of oil or other chemicals.
- If a dispersant is used and this results in an increased transfer of dispersed oil into the water column.

- When one ***or more*** chemicals are released and their toxicity is not known individually or in combination.

Sediment samples

- If the pollution incident occurs near the coast and oil comes into contact with sediment in shallow coastal areas.
- If the pollutant that has leaked is a "sinker" and/or the substance is hydrophobic and therefore binds particularly well to suspended matter and sediment.
- If, due to special circumstances (use of a disperser, hydrological/meteorological situation, wave action), contamination of sediment is to be expected.

Selection of biotests

Biotests used in the context of statutory monitoring tasks are based on the use of plants and animals as test organisms. In marine and brackish water areas, biotests are used in Germany for ecotoxicological assessment of dredged material. A test palette of organisms at different trophic levels is used.

Table 5 summarizes information on various common biotests. The Federal Institute of Hydrology (BfG) recommends the luminescent bacteria test and a marine algae and small crustacean test for ecotoxicological assessment of dredged material. This basic set of standardized *in vivo* biotests can also be used quickly in the context of pollution incident monitoring to test the toxic potential of water and sediment samples.

In order to record the interactions of toxic pollutants on different groups of organisms or trophic levels, a range of different biotests should always be used for examinations.

The final report of the CHEMSPILL project provides recommended information on the use of biotests and the selection of test organisms in connection with HNS pollution incidents. The use of biomarkers after a pollution incident is also dealt with there.

Table 5: Biotest procedure to determine the toxic potential of environmental samples

Test method	Organism	Toxicity	Terminal point	Test matrix	Time	Guidelines	Reference
Luminescent bacteria test	*Vibrio fischeri*	acute	Inhibition of bio-luminescence	Water, pore water, eluate	30 min	DIN EN ISO 11348-2	BfG (2011b) PREMIAM (Law et al. 2011)
Marine algae test	*Phaeodactylum tricornutum*	chronic	Growth rate	Water, pore water, eluate	72 hr	DIN EN ISO 10253	BfG
Small marine crustacean test	*Corophium volutator*	acute	Mortality, deformity	Sediment	10 days	DIN EN ISO 16712	BfG, PREMIAM
Small marine crustacean test	*Tisbe battagliai*	acute	Mortality	Sediment, pore water, eluate	48 hr	ISO 14669	PREMIAM
Oyster embryonic development	*Crassostrea gigas*	acute	Mortality, deformity	pore water, eluate	24 hr	ICES TIMES 11	PREMIAM

Biomarker

The use of biomarkers to detect the effects of pollutants on biota is appropriate under the following conditions:

- If the contaminated area has dominant species that can serve as bioindicators to determine toxic exposure. This applies, among others, to the widespread epibenthic blue mussel (*Mytilus edulis*), which, for example, occurs on mussel beds, reefs, sediment in the eulittoral and sublittoral, and in eelgrass meadows.
- If long-term pollution and serious biological damaging effects are to be expected.
- If commercially used species (fish, mussels) in or around the incident area are or could be affected.

Selection of biomarkers

The following mussels and fish are particularly suitable for biomarker studies in the German North Sea and Baltic Sea. They meet many of the criteria that bioindicators must meet (see Section 7.1). In addition, these species can also be used for accompanying chemical analysis.

- Mussel (*Mytilus* sp.)
- Baltic macoma/clam (*Macoma balthica*)
- Flounder (Platichthys flesus)
- Dab (Limanda limanda)
- Eelpout (Zoarces viviparus)

For the selection of suitable biomarkers, the advice of competent experts must be obtained (expert network). In the event of contamination with oil or oil derivatives, biomarkers must be selected that indicate exposure or effects of toxic HC. As with biotests, a combination of several biomarkers (biomarker palette) should be used if possible because this greatly increases the indicative significance of biomarker findings.

In previous large pollutant incidents, the focus was on biomarkers that indicate exposure to HC, especially PAHs. In addition, biomarkers were selected on various occasions which are used as indicators for general health status.

Table 6: Frequently used biomarkers for the detection of pollution effects

Biomarker	Organism group	Examination matrix	Indicator for	Monitoring timeframe
EROD activity	Fish	liver	Induction of detoxification	days - months
Lysosome stability	Mussel	haemocytes	Subcellular damage	days - months - years
ACHE inhibition	Mussel	gill	General indicator for physiological status	hours - months
DNA adduct micronuclei comet assay	Fish Mussel	blood, gill, liver	Genotoxic damage	days - months
Histopathology of liver tumours	Fish	liver	Neoplastic damage	months - years

Biomarker	Organism group	Examination matrix	Indicator for	Monitoring timeframe
Gonadal histopathology	Fish Mussel	ovary, testes	Reproductive disorder	months - years

Immediate monitoring

As part of the assessment of the situation after the occurrence of a pollution incident, the decision aids mentioned in the introduction must be used to check whether the use of biotests and/or biomarkers is justified. Since biotests are intended to provide information on acute ecotoxicity of the pollution, sampling is required as part of immediate monitoring, while sampling for biomarker examinations is usually only appropriate at a later point in time.

- If biotests are to be carried out, it must be decided whether only water samples should be examined or sediment samples as well. For logistical reasons, it is appropriate to sample both matrices first. Sediment samples can be examined if the result of the bioassay with water samples suggests sediment contamination.
- With the help of a biotest palette, the spatial extent of the toxicological effective area in the water body (impact zone) should be determined.
- Sampling for biotests should be carried out in connection with *in situ* measurement of oil contamination of the water body using UVFS (see 7.2 Chemical monitoring data sheet). This ensures that the samples actually come from a contaminated body of water. In addition, data from spectroscopic measurement can be related to the toxicological findings.
- When sampling water and sediment, it must be ensured that the samples are not contaminated with HC. Instructions for contamination-free sampling can be found in the Appendix (Chapter 10).
- If a dispersant was used to combat an oil spill, it is essential to determine the ecotoxicological potential of water samples with the help of biotests.

Long-term monitoring

- After a serious pollution incident, repeated sampling for biotests is advisable, even in the initial phase of long-term monitoring. The kinetics of the decrease in toxic potential in water and possibly in sediment can only be determined by taking multiple samples.
- Whether biomarkers can make a meaningful contribution to the assessment of spatial/temporal development of the environmental damage has to be decided on a case-by-case basis and with the help of experts. Factors such as, for example, the extent of pollution, habitat type, presence of suitable bio-indicators, and presumable regeneration time, should be considered in decision-making.
- Professional sampling of bio-indicators should be carried out by the institute/laboratory that is commissioned with the biomarker examinations (see file of expert network).

Methods and evaluation

Biotests: Biotests must be carried out as soon as possible because changes in bioavailable substances can occur even with proper storage. Prompt findings are required anyway to assess the toxic contamination of the pelagic and possibly the seabed. Samples must be refrigerated (4 ± 2 °C) until they are handed over to the analysis laboratory.

Determination of the ecotoxicological potential of water and sediment samples with the biotests mentioned is carried out using standardized test methods. In addition, the AQS leaflets published by the

Federal/State Working Group on Water (LAWA) should be used as supplementary methodological instructions.

Usually, the effectiveness of aqueous samples is examined. For sediment samples, pore water or eluates are used as the test matrix. The BfG uses the pT method (*potentia Toxicologiae*) for the evaluation and ecotoxicological classification of these environmental samples. The pT value indicates the number of times a sample has to be diluted in a ratio of 1:2 so that it no longer has any observed toxic effects. The toxicity classes are assigned to the handling categories “harmless”, “critical”, and “dangerous”.

The assessment of sediment samples is increasingly carried out using sediment contact tests, for example the small amphipod test with *Corophium volutator*. Since undiluted sediment samples are used, an assessment according to the pT method is not possible and an individual assessment must be made instead.

The following DIN procedures must be observed when taking samples for biotests:

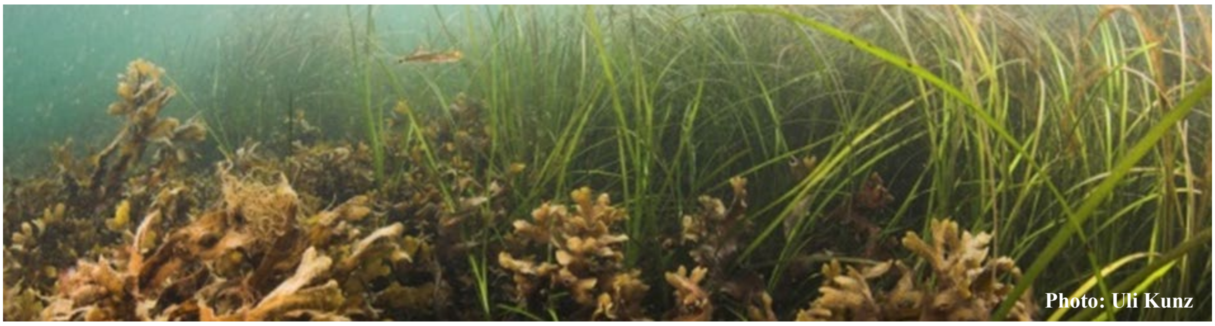
- DIN EN ISO 5667-16 [Feb. 1999] – Water quality — Sampling — Part 16: Guidance on biotesting of samples
- DIN EN ISO 5667-9 [Oct. 1992] – Water quality — Sampling — Part 9: Guidance on sampling from marine waters
- DIN EN ISO 5667-19 [Sep. 2004] – Water quality — Sampling — Part 19: Guidance on sampling of marine sediments

Biomarkers: There are good instructions for the use of many common biomarkers. JAMP (Joint Assessment and Monitoring Programme) operating instructions are available for the biomarkers recommended by OSPAR. Methods for various biomarkers are also described in the ICES TIMES series. Last but not least, the “Technical Report on Aquatic Effect-Based Monitoring Tools”, published by the EU in the context of the WFD, should be mentioned; in the annex there are various biomarker fact sheets with methodological information.

Preliminary data / data storage

- **Biotests**: Marine biotests are not part of regular marine environmental monitoring. However, they are used to assess the toxic potential of dredged material in the context of expansion and maintenance measures for shipping lanes or ports.
- **Biomarker**: With the exception of TBT effect monitoring commissioned by the NLWKN, bioeffect investigations are only routinely carried out by the Institute for Fisheries Ecology, Thünen Institute (TI). One focus of this monitoring is the occurrence of fish diseases and histopathological liver changes. The monitored areas are in the coastal waters and in the EEZ. For the German Baltic Sea, biomarker data are available from multi-year international research projects and from pilot studies commissioned by the LUNG. The data was mainly obtained from the eelpout (*Zoarces viviparus*), which has proven to be a bioindicator for toxic effects on reproduction.

7.4 Macrophytobenthos data sheet



Relevance

In the various national and international measurement programmes, macrophytes are some of the species that characterize habitat type and/or serve as a quality component for assessing the state of a water body or ecosystem. In particular, eelgrass (*Zostera marina*) and dwarf eelgrass (*Zostera noltei*) (see Eelgrass meadow data sheet, Chapter 7.9.1) on soft soils and bladder wrack (*Fucus vesiculosus*) are important indicator species for assessing the ecological status of a water body. Reed beds, brackish meadows, and salt marshes, which characterize the aquatic-terrestrial transition area and are used for the assessment, are dealt with in the Salt marsh data sheet (Section 7.9.7).

Sensitivity

Benthic macrophytes fulfil numerous ecological functions and are also of great economic importance. They serve many organisms (such as fish, crustaceans, and birds) as a habitat, a source of food, and a substrate for spawning. After extensive damage to a macrophyte population, these are no longer available in the long term. Oil can have negative effects on associated phytal fauna in and on the seabed as well as on macrophytes.

Eelgrass is particularly sensitive to oil pollution due to the long regeneration time after damage. The effect of oil on eelgrass varies from minor to severe, depending on water depth, type of oil, and surrounding local conditions. Eelgrasses are dealt with in a separate data sheet (see Eelgrass meadow data sheet, section 7.9.1).

Parameter

The following examination methods can be distinguished based on the nature of the substrate and the resulting macrophyte occurrence:

- Investigation of spermatophytes (seed-bearing plants) on soft substrates
- Investigation of macroalgae on hard substrates such as stones or other reef structures
- Investigation of the respective phytal fauna (see Macrozoobenthos data sheet, section 7.5)

Biotic parameter

In the event of a pollution incident, the following parameters of macrophyte vegetation must be examined:

- Species composition, extent (species), degree of coverage, biomass, location, depth dispersion

Hydrological parameters

- Temperature, salinity, oxygen concentration/saturation, and turbidity

Geophysical properties of surface sediments

- Samples of surface sediments
- On-site recording of colour, grain size, odour, inclusions, and any possible organic layers

Sampling strategies

Due to the dependence of macrophyte vegetation on prevailing substrate structures and water depth, all affected sub-areas within a contaminated area should be completely covered by a sampling station grid. In particular, any existing depth zonation in the area must be taken into account. When defining a network of stations for the examination of macrophyte communities, existing data for sensitivity mapping must be taken into account. Within the contaminated area, all existing differently sensitive areas must be examined.

In addition to fundamental considerations of the location (eulittoral or sublittoral) and nature of the substrate (soft or hard substrate) and the associated occurrence of Spermatophytes or adherent macroalgae, when choosing the sampling design it must be remembered that the results obtained from monitoring should be comparable to previous studies in the relevant area. Data on the occurrence of macrophytes in the German North Sea and Baltic Sea are regularly collected as part of BLMP monitoring, or mandatory examinations to examine the environmental impact of large-scale technical projects.

Investigation of suitable reference areas

In order to record the damage after a pollution incident and to monitor the regeneration process of contaminated macrophyte vegetation, it is essential to examine a suitable reference area at the same time. As part of the initial examination (immediate monitoring) of the affected area, a reference area unaffected by the pollution incident should therefore be identified and examined simultaneously. The environmental conditions of the reference area should correspond as closely as possible to the natural ancillary conditions of the contaminated area (substrate structure, sediment quality, water depth, species spectrum, individual density). Nearby stations that are already being sampled as part of existing measurement programmes (e.g., WFD, North Sea tidal flat mapping, or Trilateral Monitoring and Assessment Programme) should be examined here in particular.

All examinations in the reference area should correspond in type and scope to examinations in the contaminated area and be carried out at the same time. It should be noted that all macrophyte-covered substrates and depths that are documented in the contaminated area are to be examined.

Immediate monitoring

- As part of the investigation and assessment, a decision must be made as to whether there is a threat of contamination of the macrophyte community. The flat sublittoral, eulittoral and supralittoral are primarily at risk. For the examination of the upper eulittoral and the supra-littoral on soft-substate coasts, see the Salt marsh data sheet (Section 7.9.7).
- If there are reefs, they must be checked to see if they are at a depth that allows macrophytes to grow.
- In order to assess the damage caused by contamination and to monitor the regeneration process, suitable reference areas must be identified and examined at the same time.
- The initial examination of the macrophyte vegetation in the contaminated area and in a suitable reference area must always be carried out as early as possible after a pollution incident. If the coastal zone is expected to be contaminated by drifting oil, samples may need to be taken as a precaution in order to be able to characterize the initial state (temporal reference) of the area.

- If the macrophyte vegetation is only partially polluted, representative reference samples should be taken in non-polluted areas. Future contamination of possible reference sites or areas must be prevented.
- Heavily contaminated areas should be examined to document the degree of damage. Samples of adhering oil should be taken for chemical analysis to clearly identify the cause (chemical fingerprint or preservation of evidence, see Chemical monitoring data sheet, section 7.2).
- Contaminated areas or damage to macrophyte vegetation or macrozoobenthos organisms living there must be documented by photos or underwater video to secure evidence.
- In order to record the acute consequences of severe contamination on the macrophyte community and to assess the natural regeneration dynamics of the contaminated area, the examination following the initial examination, including sampling, should be repeated shortly afterwards (about 7-10 days after the pollution incident or the first examination).
- Bioindicators for chemical analysis require special treatment. The samples should be handed over without fixation to an analysis laboratory (see Appendix: "Treatment of samples for analysis").
- Analysis of macrophyte vegetation must be carried out by persons who have experience with the methodology of sampling and sample handling (see expert network).

Long-term monitoring

- Frequency and duration of macrophyte investigations are largely determined by the type of oil and type of contaminated habitat. These factors influence the persistence of the pollution and the regeneration capacity of the polluted area.
- Within the first year after contamination, examinations must be carried out at a higher frequency than in subsequent years. Depending on the time of year in which a pollution incident occurs, (control) examinations should, if possible, be carried out in spring/summer, during the main growth phase of macrophytes (between April/May and September).
- From the second year onwards, the contaminated area and representative reference areas must be examined at least once a year. Macrophytes should then be monitored in summer (July-September, preferably August-September).
- If sampling is carried out twice, spring and late summer or early autumn (to document possible recruitment) should be selected.
- Long-term monitoring can end if a) the macrophyte community of the formerly contaminated area corresponds to the reference area in terms of characteristics and species composition, or b) the condition of the macrophyte community of the formerly contaminated area is comparable with a documented reference condition of the area before the pollution incident.

Methods

The test method or sampling device to be used is largely determined by local conditions and can vary with time and season (e.g., due to tides, ice).

More detailed methodological instructions and evaluation procedures can be found in the respective underlying monitoring programmes:

<u>General:</u>

- BLMP: Macrophyte data sheet (4) (2015-07-03), German Marine Monitoring Programme (Bund-Länder-Messprogramm)
- BSH (2013): Untersuchung der Auswirkungen von Offshore-Windenergieanlagen auf die Meeresumwelt [Examination of the effects of offshore wind turbines on the marine environment] (StUK4)

North Sea:

- OSPAR: JAMP Eutrophication Monitoring Guidelines: Benthos, OSPAR Agreement 2012-12 Technical Annex 1 (Hard-bottom macrophytobenthos, soft-bottom macrophytobenthos and hard-bottom macrozoobenthos)
- Common Wadden Sea Secretariat: TMAP monitoring handbook
- Eutrophication – Macroalgae (version 15.12.2009)
- Tidal Area – Seagrass (version 16.09.2009, TMAG 09-2)

Baltic Sea:

- HELCOM: Guidelines for monitoring of phytobenthic plant and animal communities in the Baltic Sea Annex for HELCOM COMBINE programme (Bäck 1999).

Evaluation

The primary criterion for assessing monitoring results after a pollutant incident is the restoration of the reference state. In particular, results of the reference areas examined in parallel should be included in the evaluation because the extent and coverage as well as the species spectrum and the biomass of the species are partly subject to pronounced seasonal and/or annual fluctuations between the various examination times (see general principles). In addition, the reference status can, if necessary, be defined using existing preliminary data from existing monitoring programmes in the relevant area.

Various evaluation and classification systems for the ecological quality component macrophytes are available for the German North Sea and Baltic Sea; they are used within the scope of existing monitoring programmes for the implementation of the WFD and MSFD. The examination method is geared towards the calculation of indices, which are regularly calculated within the framework of existing monitoring programmes in order to enable comparison with reference values (preliminary data). Further information on this can be found in the Macrophytes monitoring data sheet of the federal-state measurement programme (BLMP 2012b).

Table 7: Presentation of the common methods and parameters for examining macrophytes in the event of a pollutant incident

Note: reed beds, brackish meadows, and salt marsh – see Salt marshes data sheet (Chapter 7.9.7)

	Methods and parameters	
	Eulittoral	**Sublittoral**
Examination done	from land and/or from the air (possibly with a small boat)	by sea (small boat or ship)
Soft substrates (including sand banks, sand flats, mixed mudflats, silty mudflats)	**North Sea** Aerial mapping (and *in situ* ground mapping (ground truthing), also see Eelgrass meadow data sheet): – area-wide recording of eelgrass meadows and, if present, green algae mats *Parameters*: – location – depth limit – degree of coverage of eelgrass and, if present, green algae mats Surface mapping – Analysis of affected eelgrass areas or permanent monitoring stations on	**Baltic Sea** Coastal waters Dive mapping – Transect mapping with a frame at defined depth levels (0.25; 0.5; 0.75; 1; 1.5; 2 m; further in 1 m steps down to the lower distribution limit at selected measuring points) – 5 parallels with an area of 1 m² per depth – Distance between the areas 5-10 m – Sampling of vegetation and sediment Inner coastal waters

	Methods and parameters	
	Eulittoral	**Sublittoral**
	foot – Analysis of transects (density and composition of species) *Parameters*: – surface area – species extent – species composition – degree of coverage of eelgrass and opportunistic green algae – biomass – epiphytes on *Zostera* – location – depth limit *In addition:* – Analysis of the macrozoobenthos of affected eelgrass and reference stocks (see data sheet macrozoobenthos)	– S-H: 9 transects – M-V: 16 transects Outer coastal waters – S-H: 20 transects – M-V: 9 transects *Parameters:* – percentage coverage – depth limits for Charophyceae and spermophytes – definition of plant communities *Supplementary information* – density – biomass – species number
Rocky coast (Helgoland)	Surface mapping – Macrophyte recording using geo-referenced grid mapping squares/frames (50 x 50 cm) along a transect and (permanent squares) *Parameters*: – Species composition through 1 x inspection according to the Reduced species list (RSL) index by Wells et al. (2007)): Species richness, proportion of green and red algae, proportion of opportunists – Coverage (%) with *Fucus serratus* – Abundance of *Ulva lactuca*	Dive mapping – Three underwater transects to record *Laminaria hyperborea* and four species of red algae *Parameters*: – Reduced species List (RSL, after Wells et al. 2007): species richness, proportion of green algae and red algae, proportion of opportunists – Depth limits of sublittoral algae: 3 types of red algae and *Laminaria hyperborea* – also see rocky Eulittoral (Helgoland)
Hard substrates (mussel beds, rock, reefs) Artificial hard substrates (e.g., groynes, embankments)	Surface mapping – Macrophyte recording by means of geo-referenced grid mapping (squares/frame 50 x 50 cm) along a transect – Sampling (50 x 50 cm) to determine biomass *Parameters:* – coverage – biomass – Species composition (as with Eulittoral rock coast, incl. proportion of green and red algae and opportunists)	Outer coastal waters (EEZ): habitat type "reefs" – Area-wide recording of macrophytes by means of an underwater video camera and frame samples – Underwater examination: along transects through frame sampling (scratch samples; 50 x 50 cm). 12 nm zone – Extension of the measurements of the outer coastal waters to the 12 nm zone to record the lower limit of distribution. – Methods like outer coastal waters *Parameters:* – coverage – density – species populations – Depth limit of *Fucus spp.*
Inclusion of additional parameters • Documentation of hydrographic (temperature, salinity, oxygen, turbidity) and meteorological data • Recording of geophysical sediment parameters (also see Macrozoobenthos data sheet) • Recording of phytal fauna		

7.5 Macrozoobenthos data sheet

Relevance

The term macrozoobenthos covers invertebrate organisms that live on or in the seabed and are retained in a sieve with a mesh size of 1 mm. The macrozoobenthos represents an important component of the marine food web and is therefore of considerable importance for the marine ecosystem.

Sensitivity

An important group of macrozoobenthos are, for example, mussels, which are particularly sensitive in the event of a pollution incident due to the sessile lifestyle of adult specimens and their diet as a filter feeder, as well as their widespread use as bioindicators. These characteristics and the wide distribution of the mussels make them particularly suitability as bio-indicators.

Most crustaceans are very sensitive to exposure to oil because they accumulate HC very quickly.

Biotic parameters

In principle, when monitoring benthic invertebrate fauna, especially with regard to the selection of sampling method, a distinction must be made between:

- Investigation of the benthic soft substrate fauna (epifauna and infauna)
- Investigation of the epifauna on hard substrates, such as stones or other reef structures
- Investigation of the phytal fauna

The main aspects of the monitoring of benthic invertebrate fauna:

- Recording changes in the benthic settlement structure, and
- Recording pollution within trophic key groups (especially of mussels)
- Species composition, density of occurrence of individuals (abundance) and biomass
- Size ranges of specific mussel species
- Contamination of suitable bioindicators (usually mussels)

Hydrological parameters

- Temperature, salinity, oxygen concentration/saturation close to the ground and on the water surface

Surface sediment properties

When examining benthic soft-substrate fauna, a sample of the surface sediment must be taken from each station to determine geophysical sediment parameters. The sample should be described in terms of colour, grain size, odour, inclusions, and any existing layers. The sediment sample is taken with a core sampler (e.g., penetration depth 6 cm, diameter 4.5 cm), in the eulittoral directly from the seabed, in the sublittoral from an undisturbed grab sample. The sediment samples are transferred to suitable sample containers and frozen in the laboratory (- 20 °C) until analysis. The sediment type is determined in accordance with DIN EN ISO 14688-1, the determination of grain size distribution in accordance with DIN 18123 (mesh sizes in accordance with DIN ISO 3310-1).

Sampling strategies

Due to the strong dependency of the benthic colonisation on the existing sediments and habitat structures, all affected sub-areas within the contaminated area must be completely covered by the sampling station grid. In particular, any existing depth zones in the area must be taken into account. When defining a network of stations for sampling the macrozoobenthos, existing data for sensitivity mapping and, if necessary, current biotope maps must be used. Within the contaminated area, all areas with different sensitivity to the pollutant must be examined.

In addition to basic considerations (land-side/sea-side sampling, soft substrate fauna/epifauna), when selecting the sampling device, it is important to note that the results obtained during the monitoring process should be comparable to those of previous examinations in the relevant area. Data on benthic invertebrate fauna of the German North Sea and Baltic Sea are regularly collected as part of BLMP monitoring or mandatory sampling to examine the environmental impact of major technical projects.

Investigation of suitable reference ranges

For the identification of damage after a pollution incident and for monitoring of the regeneration process of a contaminated benthic habitat, a parallel investigation of a suitable reference area is an essential aspect. As part of the initial investigation of the affected area, a reference area unaffected by the pollution incident must therefore be examined at the same time.

The natural conditions, the reference area should correspond as closely as possible to the affected area (habitat structure, sediment properties, water depth, species spectrum, density of individuals). Especially nearby stations that are already regularly sampled within the scope of existing measurement programmes should be examined.

All investigations in the reference area should correspond in type and scope to the examinations in the contaminated area and should be carried out simultaneously.

Immediate monitoring

- During the assessment of the situation, a prognosis of where and when the contamination of the benthos can be expected is necessary. When assessing the risk, factors such as the type of oil and natural dispersion caused by the impact of waves and currents (drift models) must be taken into account (see VPS). Benthic communities in the area of the landing zones of an oil slick, coastal areas including the eulittoral are at risk.
- The initial examination of the benthos in the contaminated area and in a suitable reference area must always be carried out as early as possible after a pollution incident. If the coastal zone is expected to be contaminated by drifting oil, benthos samples may have to be taken here in order to be able to characterize the initial state (temporal reference) of the area.
- Photographic documentation of visible contamination or damage to macrozoobenthos organisms must be carried out in order to preserve evidence. Photographs of the contaminated areas (drift line/mudflats) should be taken in the littoral. Contaminated areas in the sublittoral must be documented using underwater video or photographic recordings.
- Samples are also to be taken from heavily oiled benthic organisms for the purpose of preserving evidence. The polluting oil must also be sampled in order to identify the cause of the oil pollution by means of chemical analysis.
- In order to record acute consequences of pollution on the benthic community and to be able to assess the natural regeneration dynamics of the area, new sampling has to be carried out about one to two weeks after the initial examination.

- During initial investigation of the affected area, contamination of a sample caused by the sampling process must be avoided if possible. For example, bringing pollutants (oil slick) floating on the water surface into contact with soil samples during use of the sampling equipment (van Veen grab/dredge, etc.) must be avoided. This is particularly important if the macrozoobenthos sample also serves to obtain organisms for chemical pollutant analysis.
- Bioindicators for chemical analysis require special treatment. They should be handed over without fixation to an analysis laboratory (Appendix: Treatment of samples for analysis).

Long-term monitoring

- The frequency and duration of benthos surveys are largely determined by the type of oil and the type of contaminated habitat. These factors have an impact on the persistence of the pollution and the regeneration capacity of the polluted area.
- Benthos surveys should be carried out more frequently within the first year of contamination than in later years. In the first year, sampling two to four times seems appropriate. Ultimately, however, the time of year at which a pollution incident occurs also determines whether sampling is appropriate. An examination is more useful during the growth phase and the reproduction phase of benthic organisms than in winter.
- From the second year, based on monitoring in comparable areas, examinations of the contaminated area and representative reference areas should be carried out at least once a year. If sampling is carried out twice, spring (standing stock) and autumn (recruitment) should be selected.
- On the basis of the assessment criteria explained in the relevant section (see below), benthos examinations should be terminated if a benthos community has re-established itself in the formerly polluted area, which in terms of its species spectrum, dominance structure, and, in the case of long-lived species, population structure and biomass is comparable to the benthos at reference sites.

Methods

The sampling method or sampling device to be used depends primarily on local conditions, but can also vary with time or season (e.g., due to tides, ice drift).

More detailed methodological instructions can be found in the respective underlying monitoring programmes:

<u>General:</u>

- BLMP 2012c: Macrozoobenthos monitoring data sheet, German Marine Monitoring Programme (Bund-Länder-Messprogramm)
- BSH 2013: Untersuchung der Auswirkungen von Offshore-Windenergieanlagen auf die Meeresumwelt [Examination of the effects of offshore wind turbines on the marine environment] (StUK4). Hamburg and Rostock

<u>North Sea:</u>

- OSPAR Commission 2012: JAMP Eutrophication Monitoring Guidelines: Benthos, OSPAR Agreement 2012-12
- Technical Annex 1 (Hard-bottom macrozoobenthos)
- Technical Annex 2 (Soft-bottom macrozoobenthos)
- TMAP 2009a: TMAP handbook Tidal Area – Macrozoobenthos

<u>Baltic Sea:</u>

- HELCOM 2015: Manual for Marine Monitoring in the COMBINE Programme of HELCOM, Part C:
- Annex C-8, Soft bottom macrozoobenthos
- Annex C1, Tables listing sample stations

Evaluation

The primary criterion when assessing monitoring results after a pollution incident is restoration of the reference state. In particular, results from parallel monitoring of the reference areas be included in the evaluation, because individual densities and biomasses of the species are partly subject to pronounced fluctuations in time. In addition, the reference status can, if necessary, be defined using existing preliminary data from existing monitoring programmes in the relevant area.

Various evaluation and classification systems for the ecological quality component macrozoobenthos are available for the German North Sea and Baltic Sea; they are used within the scope of existing monitoring programmes for the implementation of the WFD and MSFD. For coastal waters of the Baltic Sea, MarBIT (Marine Biotic Index Tool) is an assessment procedure for the ecological quality component of macrozoobenthos. The settlement structure, density of individuals, and proportion of taxa that are sensitive and that are tolerant to environmental influences (contamination) in the examined area serve as indicators. The modified BQI (benthic quality index) index is available as an evaluation index for the EEZ of the Baltic Sea. For the coastal and transitional waters of the North Sea, the M-AMBI assessment procedure, and the estuarine type procedure (Ästuartypie-Verfahren (AeTV)), or the underlying indices (M-AMBI, AeTI) are available. According to the specifications of the WFD, the MarBIT evaluation procedure was adapted for the Helgoland water body and the biological quality component macrozoobenthos was evaluated with the help of the MarBIT index (Helgoland-MarBIT module).

In general, the examination methods should be geared towards calculation of indices that are regularly used in the context of existing monitoring programmes in order to enable comparison with reference values (preliminary data). However, since the applicability/suitability of the above-mentioned assessment systems in connection with oil contamination has not yet been sufficiently proven, they only need to be taken into account in the context of pollution incident monitoring. The state of regeneration is assessed for each area on the basis of all recorded parameters (see above). Further information on this can be found in the BLMP Macrozoobenthos data sheet.

7.6 Fish data sheet

Relevance

Fish can be found in all regions of the North Sea and Baltic Sea. Therefore, fish are potential victims of marine pollution after an incident. Monitoring practice has shown, however, that after oil spills it was often not possible to provide concrete evidence of damage to fish stocks. Even if damage occurs, large, often commercially used, fish stocks can recover relatively quickly from harmful effects.

From a nature conservation perspective, the species listed in the HD and the Red List would be particularly relevant for monitoring after a pollution incident. These include river lamprey, sea lamprey, allis shad, twait shad, houting, and sturgeon. However, due to their rare occurrence, monitoring of these species is not practicable. Examinations seem appropriate only in exceptional cases, for example when a local spawning habitat (e.g., twait shad) is contaminated by oil. Of the species mentioned, twait shad is most commonly found in coastal waters.

Sensitivity to a pollution incident

After an oil spill, fish can be directly affected by:

- ingestion of oil droplets and/or contaminated food organisms
- absorption of dissolved HC via the gills or other organs (e.g., skin)
- impairment of the viability of fish eggs and the survival rate of fish larvae.

In addition, fish can also be indirectly affected by:

- pollution-induced changes in the habitat used (e.g., loss of spawning substrate such as macrophytes or stones/blocks)
- loss of benthic or pelagic food organisms.

In the event of a pollution incident in offshore and open sea areas with greater water depth (> 20 m), it can be assumed that mobile fish species will avoid a polluted area. Large scale fish mortality is not to be expected. Special fish monitoring is therefore usually not justified. In shallow or sheltered marine areas, however, sublethal to acute damage is to be expected.

Juvenile fish, larvae, and eggs are the most sensitive to oil and other pollutants. However, it is difficult to record damage at these life stages.

Many fish species produce a large number of eggs and are therefore able to adapt to suddenly changing environmental conditions as well as to pollutant-induced population losses. Even if larvae or juvenile stages are affected by increased mortality due to a pollution incident, this does not necessarily have to have an impact on the population of adult fish or be recognized as a change in the adult population.

Parameters

Standard parameters:

- total individual density per unit (time or area)

- total biomass per unit (time or area)
- individual density per species of fish
- biomass per fish species (individual weights, if applicable)
- length distribution per fish species.

Additional parameters (depending on the monitoring issue):

- age structure (ageing based on otoliths, scales or gill covers)
- gonad index (degree of maturity according to ICES standard)
- liver somatic index
- stomach analysis.

Immediate monitoring

Immediate monitoring specifically geared towards the ecosystem component fish is not required. Nonetheless, as part of the situation assessment and drift-line monitoring, it is important to see whether an unusual number of dead fish are washed ashore. In the case of dead fish washed ashore, the fish species should be determined and sample specimens collected for a veterinary pathological examination, if necessary, and a chemical analysis of pollutants. This should be followed by a check of the availability of preliminary or reference data on the area affected by pollution as a criterion for the decision on the implementation of long-term monitoring.

Long-term monitoring

For each individual case it should be assessed whether fish monitoring can reveal a causal relationship between the population parameters determined and the pollution incident. For decision-making, experts should be called in who evaluate fishing-related preliminary data, information about affected habitats, etc.

Fish monitoring appears to be justified under the following conditions (examples):

- The pollution incident occurs in an estuary/transitional water during a period in which spawning migration or spawning activity is occurring (special focus on protected species).
- Spawning habitats of substrate spawners (e.g., macrophytes, stones, and blocks) are polluted or no longer suitable for successful spawning. Species (e.g., herring, twait shad) that only occur in a locally limited area would be particularly affected by pollution.
- Oil pollution affects a shallow, relatively protected marine area with restricted water exchange. Harmful effects at the population level are to be expected, especially at times when sensitive developmental stages occur (eggs, larvae, young fish).

Methods

As part of various regular monitoring programmes, the status of predominantly commercially used fish stocks in the North Sea and Baltic Sea is comprehensively recorded and assessed. In the transitional waters of the North Sea, the range of fish species is examined as a biological quality component according to the WFD.

In the case of pollutant incident monitoring, all monitoring methods (fishing gear, time and area required, sample processing) must be adopted in accordance with the standards of existing monitoring programmes. An overview of the current methodological standards is listed in Table 8.

Table 8: Summary of national standards of existing monitoring programmes

Application area	Acquisition method	Extent	Frequency
North Sea			
Coastal (transitional waters)	– Stow net fishery (Ankerhamen, Steerthamen with 50 mm mesh size decreasing to 6 mm)	– 1 hr before or after the tide change, but at least 2 - 3 hr haul time, 1x for low and 1x for high tide phase	2x year in spring and autumn
Coastal (mudflats)	– small beam trawler (StUK4 standard with 10 mm mesh size inner cod end)	– 15 min towing time at 3-4 kn	
Offshore	– large beam trawl (StUK4 standard with 20 mm mesh size inner cod end) – pelagic trawl (standard: PSN205 with 20 mm mesh size inner cod end)	– 30 min towing time at 3 - 4 kn	
Baltic Sea			
Coastal (inner and outer coastal waters)	– Beach seine (1-5 mm mesh size) – Multi-mesh gill net (HELCOM standard) – for the inner waters of the Bodden and lagoons small bottom trawl (2-3 m opening width, 0.5-1 m back height, ≤ 20 mm mesh width in the cod end)	– 3 parallel hauls per 1 km of beach section with 50-100 m towing length – Layer of 3 multi-mesh gauze nets – 10-15 min towing time at 3-4 kn, the number of stations must cover the examination area representatively	2x year in spring and autumn
Offshore	– demersal wind farm trawl (StUK4 standard with 20 mm mesh size inner cod end) – pelagic trawl (standard: PSN205 with 20 mm mesh size inner cod end)	– 30 min towing time at 3-4 kn, the number of stations must cover the examination area representatively	

Evaluation

Evaluation of fish communities and fish populations is based on status indicators such as abundance, biomass, and length and size distributions. In addition, distribution areas and patterns are used. The effects of human activities (here the oil or pollution spill) on specific ecosystem components such as fish are described and assessed using the relationship between pressure and state indicators. This approach is also followed by the MSFD.

The WFD prescribes the monitoring of the fish quality component in the transitional waters of the North Sea by means of stow net fishery. The assessment is based on the “FAT-TW” assessment approach specially developed for transitional waters.

7.7 Bird data sheet

Relevance

Sea birds and shorebirds are conspicuous victims of oil spills and are particularly suitable as bioindicators for pollution incident monitoring at sea and along the coast.

Sensitivity

The sensitivity of sea birds and their habitats to an oil spill is generally great. The level of sensitivity varies depending on the species/species group and habitat.

Table 9: Sensitivity of North Sea seabird species to acute oil pollution (modified from Tasker & Pienkowski 1987)

Very highly sensitive	Highly sensitive	Moderately sensitive
divers	gannet	fulmar
eider	cormorant	little gull
common scoter	kittiwake	black-headed gull
other seaducks	skua	common gull
shelduck	little auk	lesser black-backed gull
guillemot	shore birds in summer	herring gull
razorbill		great black-backed gull
other auks		terns
		shore birds in winter

Immediate monitoring

In the case of birds, it is important to initiate immediate monitoring as soon as possible because birds are the most obvious and usually the first visible victims of an oil spill. This group of animals is therefore of particular interest to the public.

Immediate monitoring measures and references to protocols are based on Camphuysen et al. (2007, http://www.oiledwildlife.eu/birds/publications/handbook-oil-impact-assessment-seabirds).

Table 10: Sensitivity of habitats used by birds to pollution with oil and oil derivatives..

Habitat characteristic	**Winter** (Dec-Feb)	**Spring** (Mar-May)	**Summer** (Jun-Aug)	**Autumn** (Sep-Nov)
Wintering areas for sea and coastal birds	4	3	0	2
Feeding grounds for migrating sea and shorebirds	2	4	2	4
Breeding areas for sea and coastal birds	2	4	4	1
Moulting areas for sea birds	0	0	4	0

Assessment levels				
4 = very high sensitivity	3 = high sensitivity	2 = moderate sensitivity	1 = low sensitivity	0 = no sensitivity

In the context of immediate monitoring, measures are essentially relevant that deal with recording of oiled birds, recording of bird populations potentially threatened by oil, and collection of oiled birds for autopsy examinations:

Situation assessment to estimate the spatial and temporal scope of work in the following days as well as the planning of immediate monitoring measures.

Recording the number of birds present in the area through ground-based and possibly aircraft-based mapping.

Recording the number of breeding and/or roosting birds in the polluted area and in peripheral areas. Existing survey results can be used here, if they were collected shortly before the incident.

Recording the number of affected birds on the coast (dead birds and oiled birds) through beached bird monitoring, possibly supplemented by aircraft-based counts (e.g., ''Außensände'' – the outer sandbanks in the Wadden Sea National Park)

- The federal states are responsible for beached bird monitoring, in Schleswig-Holstein the LKN-SH, in Lower Saxony the NLWKN. Mecklenburg-Western Pomerania does not yet have its own set of rules.
- The drift line must be checked daily and the number of dead and oiled live birds recorded in accordance with the requirements of the responsible authorities. In this case, existing roosting flocks of birds (as potential future oil victims) can also be recorded.
- Any bird rings (metal or coloured) should be recovered and the ring data to be noted in order to determine the origin and age of the animals concerned. Ring data must be sent to Beringungszentrale Hiddensee (Hiddensee ringing centre) (in Mecklenburg-Western Pomerania) or (outside Mecklenburg-Western Pomerania) to Beringungszentrale Helgoland (Helgoland ringing centre). The exact placement of coloured rings (which leg, arrangement of the rings) must be noted (and a proof photo taken if possible).

Estimation of the actual number of affected birds through drift experiments

- In order to estimate the extent of birds actually affected, a drift experiment with marked fake birds or other marked floating bodies should be carried out immediately after the pollutant incident has occurred. The dummies should be deployed by plane or ship and recorded along a defined stretch of coast as part of drift line monitoring.

Collection of oiled birds (including data acquisition)

- Daily collection of oiled dead birds and bodies from the drift experiment; recording of basic data in the field (at least date and coastline area).
- In order to ensure comparability with preliminary data, predefined beach sections, e.g., from TMAP beached bird monitoring.
- Dead or weakened oiled birds can drift fly actively considerable distances before they reach the coast. Therefore, a large-scale search of coasts must be organized and, if necessary, the procedure must be coordinated with neighbouring states.
- To secure evidence that birds really died as a result of the pollution incident, samples of oiled plumage must be taken from stranded birds for chemical analysis of the oil. The laboratory responsible for the chemical identification of those responsible for oil pollution is assigned to the BSH.

Autopsy including data acquisition

- An autopsy of a representative sample of affected bird species provides important information about the cause of death and is used to determine sex and age distribution and, if applicable, the population the birds originate from.
- If there is a large number of oil victims, there should be sufficient freezer capacity to store the carcasses.
- An oil sample should be taken from each carcass that is intended for autopsy.
- The following must be documented for each examined carcass: date / location / type / age / sex / cause of death / coverage with oil / condition / moulting state / stomach contents / biometric data / possible population affiliation / oil sample.
- Templates for forms and identification aids can be found as technical documents in Camphuysen et al. (2007): http://www.oiledwildlife.eu/birds/publications/handbook-oil-impact-assessment-seabirds)

Long-term monitoring

Long-term monitoring is intended to evaluate the effects of a pollution incident on the population of affected bird species. With one exception (***measuring PAH content in bird eggs***), all of the programmes listed below have already been established and are being implemented in regular international monitoring programmes. The data collected in these programmes can be used as preliminary data after an oil spill.

Measuring PAH content in bird eggs

As part of the TMAP and Biota-Monitorings der Umweltprobenbank (biota monitoring of German Environmental Specimen Bank), pollutant levels in bird eggs are measured at a few stations on the North Sea and Baltic Sea coast. Aromatic HC are not included in the scope of the examination. After a pollutant incident it is therefore recommended to determine the content of aromatics, primarily PAH, in eggs taken from already monitored and possibly new colonies of breeding birds.

Existing monitoring programmes:

- Drift line monitoring
- Roosting bird monitoring
- Breeding bird monitoring
- Monitoring of breeding success

More detailed information on the content of individual monitoring programmes for birds can be found in the tables (Tab. 7, Tab. 13 - Tab. 19) contained in Appendix II of the study concept (IfAÖ 2016).

Ongoing international monitoring programmes

The status of birds in the North Sea and Baltic Sea is already being recorded and assessed as part of various supraregional monitoring programmes. More detailed information on the implementation of the individual monitoring programmes in Germany can be found in the Long-Term Monitoring section and in Annex II (separate) (Tab. 7, Tab. 13 - Tab. 19) of the monitoring concept (IfAÖ 2016).

MSFD

- Abundance and distribution of seabirds and coastal birds (North Sea)
- Breeding success of sea and coastal birds in the North Sea
- Abundance and distribution of seabirds and coastal birds (Baltic Sea)

Further information on MSFD monitoring can be found at http://mhb.meeresschutz.info/de/monitoring/uebersicht.html

HELCOM

- Sub-programme: Marine breeding birds abundance and distribution
- Sub-programme: Marine wintering birds abundance and distribution

Further information on monitoring under HELCOM can be found at http://helcom.fi/action-areas/monitoring-and-assessment/monitoring-manual/birds/

OSPAR

- EcoQo 3.1. Proportion of oiled common guillemots among those found dead or dying on beaches
- EcoQo 3.2. Mercury and organohalogen concentrations in seabird eggs

(http://www.ospar.org/documents/dbase/publications/p00307/p00307_ecoqo%20handbook%202009%202nd%20edition.pdf)

- OSPAR also has breeding success and abundance indicators that can be used for assessment if necessary (e.g., see ICES (2016)).

Further information on monitoring under OSPAR can be found at http://www.ospar.org/work-areas/cross-cutting-issues/cemp

TMAP

- Breeding success
- Number and distribution of breeding birds
- Contaminants in bird eggs
- Numbers of migratory birds
- Beached Bird Surveys

Further information on monitoring under TMAP can be found at http://www.waddensea-secretariat.org/monitoring-tmap

Rehabilitation

When live oiled birds are transferred to a rehabilitation centre, the type and number of birds admitted, treated, released, and post release survival must be recorded. The determination of post-release survival is carried out by ringing the birds and, if necessary, telemetry examinations.

Evaluation

Evaluation of immediate monitoring

Drift line monitoring carried out as part of immediate monitoring to record oiled birds offers the fastest way to assess the severity of the impact on individual species. Drift line monitoring can be used in connection with veterinary pathological examinations and a drift experiment.

Evaluation based on red lists

By comparing the estimated number of oiled birds of a species after an oil spill with the endangered classifications according to the Red List of Breeding Birds in Germany / the Federal States and the Red List of Migratory Birds in Germany (Hüppop et al. 2013), an assessment of the severity of the consequences for the populations of species can be estimated.

Evaluation based on the number of birds in relation to the biogeographic populations (1% criterion):

A wetland is of international importance if it regularly accommodates 1% of the biogeographical population of a waterbird species. If an area, which meets the 1% criterion for a given bird species, is affected by a serious pollution incident, it can be assumed that this waterbird species is particularly endangered.

Evaluation of long-term monitoring

In order to evaluate the effects of an oil spill on seabirds and shorebirds, data from various monitoring programmes before the spill must be compared with data after the incident.

7.8 Marine mammal data sheet

Relevance

After a pollution incident, substances released represent an immediate and, in some cases, longer-term threat to marine mammals. This applies at the individual level (immediate effect), but can also spread to the population level (long-term effect). In German waters, the dominant marine mammal species are harbour porpoise, harbour seal, and grey seal.

Sensitivity

Marine mammals are long-lived, reproduce slowly, provide a relatively high level of care for their young, and are at the top of the food web. Therefore, they are threatened by pollution incidents, especially at the population level. Grey seals and harbour seals tend to be more prone to oil contamination than harbour porpoises.

Parameters

In the event of a pollution incident, the following parameters should be examined in relation to marine mammals:

- Number and spatial distribution of marine mammals at species level
- Number and spatial distribution of contaminated marine mammals at species level
- Number and spatial distribution of dead marine mammals on the drift line, including the degree of pollution contamination
- Condition, sex, age, cause of death, degree of oiling, stomach contents, biometric data, state of health, pollution load, and population affiliation of dead marine mammals
- Chemical composition of pollutants adhering to fur or skin

Immediate monitoring

After a pollution incident occurs, the focus should be on the following measures:

- Estimation of the overlap of contamination with the current distribution of marine mammals: aerial counts, consultation of experts, and reference data to delimit the regional-seasonal distribution
- Recording of dead animals and those weakened by pollutants on the coast (can be combined with the beached birds monitoring if necessary)
- Recording of visibly contaminated animals through aerial surveillance or possibly ship-based recording of the population at haul-out sites
- Examination of the extent to which areas are affected in which concentrations of foraging marine mammals are known to occur: Sylt Outer Reef, Borkum Riffgrund, and Dogger Bank
- Veterinary pathological examination of dead animals. The following must be documented for each carcass: date of discovery / location / species / age / sex / cause of death / degree of oiling / condition / stomach content / biometric data / possible population affiliation / oil samples.

Long-term monitoring

- Inventory surveys (aircraft or possibly ship-based counts as well as land-based counts, e.g., on Helgoland). In the case of seals, counts during the pupping season are particularly important in order to detect effects on reproduction.
- Assessment of pollutants in body tissues through veterinary pathological examinations of dead animals and sampling of living animals
- Radio tagging of animals (harbour seal, grey seal) and acoustic monitoring (harbour porpoises) to determine changes in habitat use
- Measurement of pollutant concentrations in the diet of marine mammals

Ongoing monitoring programmes

MSFD:

- Line transect surveys of marine mammals (North Sea and Baltic Sea) to determine distribution and population size
- Stationary, acoustic monitoring to determine the distribution and population size of harbour porpoise
- Recording dead marine mammals, partly also veterinary pathological examinations

Further information on marine mammal monitoring within the framework of the BLMP can be found at http://mhb.meeresschutz.info/de/kennblaetter/neue-kennblaetter/details/pid/30.html

TMAP:

- Internationally coordinated surveys of grey seals and harbour seals are carried out in the Wadden Sea by various institutions and coordinated by the TSEG.

Further information on monitoring under TMAP can be found at http://www.waddensea-secretariat.org/monitoring-tmap

Other monitoring programmes:

- Grey seal studies (recolonisation) in the Baltic Sea (Landesamt für Umwelt, Naturschutz und Geologie in Mecklenburg-Vorpommern [State Office for the Environment, Nature Conservation and Geology in Mecklenburg-Western Pomerania]).
- Recording of the seal populations on Helgoland by seal hunters, Verein Jordsand, and the municipality.

Methods

- Inventory counts from airplanes, ships, or from land
- Telemetry
- Long-term hydrophone recordings
- Biometrics
- Veterinary pathological examinations
- Toxicological tests on tissue samples (including blood)

Evaluation

After a pollutant incident, basic data from relevant institutions can be used to estimate the environmental impact. In synthesis with monitoring data collected after a pollution incident limited interpretation is possible with regard to the assessment of the effects of the incident. Due to methodological restrictions, data from aerial- and ship-based counts as well as acoustic recordings only allow limited assessments of the effects of a pollution incident. At most, only major fluctuations in population size can be detected.

Interpretation is limited by the fact that the exact delimitation of the different mammal populations involved and their migratory movements are not yet completely known.

In particular, monitoring dead animals can be used in connection with veterinary pathological examinations to assess the effects on individuals. Oil contamination of dead animals can be detected and can be linked to increased mortality in the population.

Therefore, dedicated monitoring of dead animals and comprehensive veterinary pathological examinations after an incident can be the methodological focus of mammal monitoring.

7.9 Habitat data sheets

The following data sheets deal with pollutant incident monitoring in different habitats of the North Sea and Baltic Sea. The selection includes widespread habitat types, which are also important for nature and species protection. According to the HD, all of these habitats are of community interest, so that the areas they occur in are also designated as HD sites. Some of the selected habitats also belong to the threatened habitats identified by OSPAR and/or HELCOM (Table 11).

As a supplement to the habitat-related data sheet, the data sheet General Instructions for Use in Pollution Incident Monitoring (Section 7.1) and, depending on the examination parameters, the component-specific data sheet (7.2 – 7.8) must be used as monitoring instructions.

Table 11: Habitats Data sheet – Occurrence in North Sea and Baltic Sea and protection categories

Data sheet	North Sea		Baltic Sea		Protection category
	Habitat/Comments	Maritime zone	Habitat/Comments	Maritime zone	
Eelgrass meadow	Mostly in the Wadden Sea under the influence of tides	Coastal waters, transitional waters	Mostly close to the shore below the waterline	EEZ coastal waters	§30 BNatSchG OSPAR HELCOM
Mussel banks	Eulittoral and sublittoral mussel beds in the Wadden Sea	Coastal waters, transitional waters	Sublittoral mussel banks	EEZ coastal waters	§30 BNatSchG (Reefs as defined in HD) HD HT 1170 (only sublittoral Mussel banks) OSPAR
Sandbanks (constantly covered by water)	Sandy to gravelly elevations from the seabed; typical macrozoobenthos community	EEZ coastal waters,	Sandy to gravelly elevations from the seabed; typical macrozoobenthos community	EEZ coastal waters	§30 BNatSchG HD HT 1110 HELCOM
Eulittoral tidal flats (Sand, silt, mixed mudflats)	Wadden Sea	Coastal waters, transitional waters	Wind flats, spits, etc.	Coastal waters	§30 BNatSchG HD HT 1140 plus HD HT 1310 & 1320 OSPAR HELCOM
Reef	Mineral or biogenic hard substrates in the Eulittoral or sublittoral	EEZ coastal waters, transitional waters	Mineral or biogenic hard substrates in the sublittoral; often with macrophytes	EEZ coastal waters	§30 BNatSchG HD HT 1170 (with biogenic hard substrates only defined sublittoral as HD HT 1170) HELCOM
Shore area/beaches	May contain annual drift lines Gravel and pebble beaches	Coastal waters, transitional waters	Annual drift lines, Gravel and pebble beaches (Cliffs)	Coastal waters	§30 BNatSchG (if occurring as a beach wall) HD HT 1210 HD HT 1220

Data sheet	North Sea		Baltic Sea		Protection category
	Habitat/Comments	**Maritime zone**	**Habitat/Comments**	**Maritime zone**	
					plus (if there is a cliff) HD HT 1230 can be included
Salt marshes	Salt-tolerant vegetation transition intertidal zone to land; Zoning	Coastal waters, transitional waters	Salt-tolerant vegetation Land – sea transition; small-scale distribution	Coastal waters	§30 BNatSchG HD HT 1330, 1320 & 1330

7.9.1 Eelgrass meadow data sheet

Relevance

Eelgrass meadows are very susceptible to deterioration in the environment around them, and they can recede or disappear completely. Eelgrass meadow are therefore useful indicator communities for the health and sustainability of a coastal ecosystem. They are the habitat for a large number of associated organisms, which, under certain circumstances, react more sensitively to oil spills than the eelgrass itself and should therefore be considered.

Two Eelgrass species occur in the German North Sea and Baltic Sea: dwarf eelgrass (*Zostera noltei*) and common eelgrass (*Zostera marina*). In the **North Sea** these form more or less dense meadows in the Wadden Sea. The largest and densest eelgrass beds in terms of area grow in the North Frisian part of the Wadden Sea; eelgrass beds in Dithmarschen and Lower Saxony are smaller and less dense. In the **Baltic Sea**, common eelgrass grows in the sublittoral almost along the entire coastline of Schleswig-Holstein and Mecklenburg-Western Pomerania in water depths of <1 m to 10 m. Common eelgrass grows mainly between 1 and 3 m water depth. Dwarf eelgrass is distributed along the Schleswig-Holstein Baltic Sea coast, usually in shallow bays and sheltered coastal areas. On the outer coast of Mecklenburg-Western Pomerania, dwarf eelgrass only occurs sporadically, but more strongly in inner coastal waters of over 1 m depth (especially Wismar Bay, Salzhaff, Greifswalder Bodden).

Sensitivity

Common eelgrass is often used as a bioindicator to determine the harmful effects of oil exposure. The effects can be minor to severe, depending on water depth, type of oil, and surrounding local conditions. However, the majority of studies document only a minimal influence on the plant itself, with the exception of black coloration of the leaves and a reduction in growth rates. However, oil can have a significant effect on the associated eelgrass fauna in and on the seabed as well as on the eelgrass leaves.

The eelgrass meadows in the intertidal zone of the Wadden Sea, which fall dry periodically, are potentially most threatened by a pollution incident. In the event of an oil spill, eelgrass can die off from acute exposure to toxic oil components or from being smothered by oil. The same applies to the associated fauna and flora. The effectiveness of a possible “flushing effect” caused by the tidal currents is determined by the location of the eelgrass meadow. In sheltered coastal areas with a low energy input, oils can act over a longer period of time. If oil penetrates the sediment, toxic contamination through uptake via the eelgrass roots is to be expected. Birds (such as brent goose and wigeon) that feed on eelgrass are also indirectly affected. Cleaning activities in contaminated areas can cause physical (mechanical) damage to eelgrass meadows.

In sublittoral eelgrass communities of the Baltic Sea, the potential for damage from the oil depends to a large extent on the movement of the water (wave action), the flow rate of the water through the eelgrass meadow (flow intensity), the depth of the water and the way in which the oil is distributed. The risk to eelgrass decreases with increasing water depth, since naturally dispersed oil is mainly concentrated in the upper pelagic zone.

Parameters

Aerial photographs, especially those taken directly from above, and georeferenced aerial photographs, help with assessing the affected area and the selection of the area to be monitored.

In order to determine the effects on eelgrass meadows, monitoring should be carried out in the affected meadows as well as in comparable reference meadows using the corresponding WFD method (spread, density, species composition in the North Sea; depth limit and competition from opportunists in the Baltic Sea). Reference data from previous years is available for this purpose. By comparing the development of polluted meadows with that of reference meadows, effects can be assigned to the pollutant incident. In addition, further parameters are measured/documented in the affected meadows and compared with values in similar, unaffected reference meadows:

- The nature and condition of the eelgrass (description of eelgrass sprouts and leaves, such as discoloration or leaf loss)
- Collecting/counting (including dead) benthic organisms (including mussels) for qualitative recording of affected species and for documentation/evidence of damage
- Abundance of epifauna (especially mud snails and periwinkles)
- Abundance of infauna (especially occurrence of cockles and opportunistic bristle worms), sampling using core sampler

Immediate monitoring

- Reconnaissance and evaluation of whether eelgrass meadows in the eulittoral and shallow sublittoral are directly or potentially threatened
- Simultaneous identification and analysis of suitable reference areas (see Macrophytobenthos data sheet) to assess the damage caused by contamination and to monitor the regeneration process
- In the event of impending contamination, the first sample should be taken as early as possible, i.e. if possible before an oil spill reaches the eelgrass meadow in order to obtain the necessary reference data for comparison with data from monitoring after contamination.
- Sampling of the infauna and epifauna in polluted and reference meadows
- Documentation of the degree of damage in contaminated areas
- In the case of severe pollution, sampling, should be repeated relatively quickly after immediate monitoring (about 7-10 days after the pollution incident), in order to assess acute toxic damage (e.g., death of mussels and other biota).
- The extent of damage should be documented with photos.

Long-term monitoring

- The development of the affected eelgrass should be documented in subsequent years using the federal state monitoring method (sampling in summer, in the mudflats by aerial and ground surveys three times a year, in the Baltic Sea with underwater video and diving examinations). The results should be compared with the development of reference areas monitored using the same methods. The parameter set must be supplemented with additional parameters (see above “Additional parameters” and Table 12).
- The frequency and duration of the monitoring studies are largely determined by the type of oil and type of contaminated habitat.

- During the sampling in the second year, samples of sediment should be taken for chemical analysis and grain size analysis. In the event of persistent sediment contamination, the pollutant content in biota (preferably blue mussels, possibly also mussel species living in the sediment) must be determined.
- From the second year onwards, the contaminated area and a representative reference area must be examined at least once a year.
- If sampling is carried out twice a year, the development of the eelgrass and associated fauna should be examined in spring (May) and summer (August).

Long-term monitoring to document possible effects of a pollution incident on an eelgrass meadow community can be discontinued if a) the eelgrass community of the contaminated area corresponds to the reference area in terms of characteristics and species composition, or b) the condition of the eelgrass community of the contaminated area is comparable with a documented reference state of the area before the pollution incident.

Methods

Due to the different characteristics, distribution and depth distribution of eelgrass beds in the North Sea (Eulittoral) and Baltic Sea (Sublittoral), different monitoring methods are used in the event of a pollution incident (cf. Table 12).

Table 12: Description of methods, parameters, examination frequencies as well as the evaluation procedures for the examination of eelgrass populations in the event of a pollution incident

<table>
<tr><th></th><th>Eulittoral (North Sea)</th><th>Sublittoral (Baltic Sea)</th></tr>
<tr><td>Methods and Parameters</td><td>Aerial surveys in connection with ground mapping
<u>aerial mapping</u>
Parameters:
– Location
– Eelgrass coverage: recorded in coverage classes
> 5% and > 20% eelgrass cover of the considered tidal flats in SH,
> 5% in Lower Saxony
– Coverage by opportunistic algae mats, recording in coverage classes
> 20% green algae cover in SH,
> 1% in Lower Saxony
<u>Surface mapping</u>
– Analysis of affected eelgrass areas or permanent monitoring stations by circulation of the area outline with GPS points
– Walking along transects through the meadow (density and composition of Z. marina & Z. noltei)
Parameters:
– surface area
– species composition
– degree of coverage recorded in coverage classes, > 20 -60%, > 60% eelgrass cover. in SH, <1, 1 – 4, 5 – 20, 21 – 40, 41 – 60, 61 –</td><td><u>Underwater video mapping</u>
– Recording of the depth distribution of Zostera marina (at least 5 video transsects per station or coastal section)
– Recording of eelgrass cover of the seabed (%)
<u>Diving examinations</u>
– up to the limit of distribution in defined depth sections 0.25; 0.5; 0.75; 1.0; 1.5; 2.0 m; continue in 1 metre steps. 5 quadrats (1 m²) which are located at a distance of 5 to 10 m from one another, are surveyed per depth unit.
Parameters:
– species composition
– degree of coverage (%)
– biomass
– biomass fraction of opportunistic algae species
– depth limit
In addition:
– Analysis of macrozoobenthos in affected and reference eelgrass meadows (see Macrozoobenthos data sheet)</td></tr>
</table>

	Eulittoral (North Sea)	**Sublittoral (Baltic Sea)**
	100% in Lower Saxony) – epiphytes on *Zostera* – location – description of the condition of Eelgrass (black colouration) *In addition:* – Analysis of the macrozoobenthos in affected and reference eelgrass meadows (see data sheet macrozoobenthos)	
Frequency	aerial mapping At least 3 times a year during the vegetation period (June – September) to record the annual maximum in Schleswig-Holstein Ground mapping (additional program) – Monthly analysis of the affected meadows or permanent monitoring points in the first year after an incident to describe the eelgrass status as well as the infauna and epifauna – annual inspection / mapping of the affected eelgrass populations from the second year after an incident	– annual video mapping and diving examination in the main vegetation period (June to September)
Evaluation/ Procedure	– primary criterion is restoration of the reference state – procedures according to WFD and TMAP should be used in addition (Dolch et al. 2009; NLWKN 2010)	– primary criterion is restoration of the reference state – the procedures according to WFD (BALCOSIS procedure, Fürhaupter et al. 2015b) and HELCOM as well as MSFD Art. 9 "Good environmental status" (GES) should be used in addition.

Evaluation

The extent and density of Eelgrass meadows in affected areas are assessed against the development in comparable reference areas against the background of long-term developments from WFD monitoring. Proof of damage is determined by comparing the further development of infauna and epifauna of eelgrass meadows in affected areas with the fauna in reference eelgrass meadow communities; comparative data from previous years is usually missing here. In addition, the condition of eelgrass plants themselves and their further development over shorter periods of time are assessed in affected meadows and compared with plants in reference areas.

As long as affected meadows show a different (negative) development in their extent and density, as well as in their associated fauna and flora, and as long as the eelgrass is obviously damaged in affected meadows (black coloration, general degradation), a pollutant effect can be assumed.

7.9.2 Mussel bank data sheet

Relevance

Occurrences of mussel banks in the EU and sublittoral areas on the German coasts of the North Sea and Baltic Sea are of great ecological and sometimes also economic importance. These reef-like biogenic hard substrate structures are characterized by a significantly increased diversity of species, a high filtering capacity, and a breakwater function, which is why the preservation of the mussel bank habitat is of particular importance. Mussel banks in the sublittoral are in some cases defined as HD HT 1170 Reef.

The mussel banks of the **North Sea** are important biogenic structures in the Helgoland Felswatt (rocky flats) and in the Wadden Sea ecosystem, which serve numerous invertebrates and birds as habitats and food sources. Due to their associated fauna and flora, as well as the high total biomass, mussel banks are the most biodiverse and most productive communities in the Wadden Sea. They are formed in variable proportions by the blue mussel and, in recent years, also by the Pacific oyster.

In the **Baltic Sea**, blue mussels occur regionally in very high densities. Many reefs and other hard substrates are often densely overgrown with blue mussels, which form larger mussel banks. On soft substrates, blue mussels can occur as aggregated clumps or multi-layer blue mussel banks with a high density of individuals and a broad age structure. The mussel banks on hard and soft substrates offer marine invertebrates a habitat (e.g., for small crustaceans, especially gammarids) and substrate (e.g., for periphyton organisms such as hydrozoan, barnacles, tunicates, encrusting organisms such as bryozoans).

Sensitivity

Mussel banks in the intertidal zone of the Wadden Sea, which periodically fall dry, are potentially the most threatened by a pollution incident. In the event of an oil spill, the mussels can die through acute exposure to toxic oil components or from being covered by oil, depending on the type of oil/oil derivative or the degree of weathering of the oil,. The same applies to the associated fauna and flora of a mussel bank. If oil penetrates the mussel bank substrate (soft substrate under a mussel bank, shell remains, cavities between the shells of living mussels – hereinafter referred to as “sediment”), chronic contamination of the mussels due to long-term exposure to HC is to be expected. Animals that feed on mussels are also indirectly affected, for example, birds

In comparison with other marine habitats, a long regeneration time can be assumed if eulittoral mussel banks are polluted. This is particularly true in the event of sustained contamination of the underlying sediment.

Parameters, sampling strategy

- Determination of the area, coverage and proportion (percentage of mussel-occupied areas on the mussel beds) of the mussel bank or the mussel beds

- Determination of the abundance, biomass, condition, and cohort distribution (length-frequency distribution) of the mussels on the banks by means of core samplers
- Analysis of the structure and dynamics of associated fauna (endobenthos and epibenthos fauna) and vegetation. The associated fauna and vegetation of a mussel bank are good indicators of the condition of a mussel bank. They should therefore be recorded as part of pollution incident monitoring. Lists of the characteristic species are available in the evaluation scheme for HD HT 1170 "Reef".
- https://www.bfn.de/fileadmin/MDB/documents/themen/natura2000/marin_11.pdf).
- Examination of sediment properties (grain size analysis / chemical properties / degree of contamination) and occurrence of mussel shell material
- Examination of chemical contamination of the mussels

Immediate monitoring

- As part of the monitoring and evaluation, it is primarily necessary to check whether mussel banks in the eulittoral or shallow sublittoral are directly or potentially threatened. The extent to which deeper sublittoral mussel banks are threatened must also be examined although the immediate risk of contamination of these banks is lower.
- To assess damage caused by contamination and to monitor the regeneration process, it is necessary that the monitoring of suitable reference areas takes place in parallel (see 7.5 – Macrozoobenthos data sheet).
- In the event of impending contamination, a first sample should be taken as early as possible, i.e. before an oil spill hits the mussel bank, in order to obtain the necessary reference data for subsequent post-contamination monitoring.
- Contaminated areas should be documented in order to prove the extent of damage. Samples of adhering oil must be taken for chemical analysis in order to clearly identify the polluter (chemical fingerprint or preservation of evidence, see 7.2 – Chemical monitoring data sheet).
- In the case of severe contamination, a second examination including sampling should be carried out relatively quickly (about 7-10 days) after the incident in order to record acute toxic damage (e.g., death of mussels and other biota). The extent of damage should be documented with photos.
- In general, sediment and biota samples should be taken at different points on a contaminated bank, as it cannot be assumed that pollution of a mussel bank is homogeneous.

Long-term monitoring

- As part of follow-up examinations, samples of sediment located under a mussel bank must be taken for chemical analysis and grain size analysis.
- Externally undamaged mussels should also be sampled in order to determine their level of contamination. Since accumulation of pollutants takes a certain amount of time, maximum pollutant levels are only reached about two to three weeks after the start of exposure to pollutants.
- An important period for further examination is the time after mussel spat settles (autumn). This can be used to check whether and how successfully the affected mussel bank was re-colonized by mussel spat.
- When determining the intervals for follow-up examinations, the following essential factors should be taken into account (expert network):
    - Extent of the initial acute or fatal damage to the mussel bank community
    - How heavily is the sediment contaminated?
    - Is there a source of continued contamination for biota?
    - Progress/decrease in contamination in sediment and in mussels

  - Successful colonisation during the time of the first spat settlement

- If the examination findings and the kinetics of the contamination indicate long-term regeneration, monitoring can be carried out at intervals of several years.

Methods

In the event of oil pollution in sublittoral mussel banks, monitoring is more difficult and will be carried out with different equipment than in the eulittoral. However, the fundamental aspects to be taken into account with regard to the components to be recorded, sampling times, and intervals are the same as with eulittoral mussel banks. In the event of a pollution incident, the following parameters for the affected mussel banks and the suitable reference areas must therefore be recorded:

Eulittoral:

- In general, mussel banks in the eulittoral are made up of so-called mussel beds and more or less mussel-free mudflats in between. A bank or sub-bank includes all beds that are within a maximum of 25 m of each other. If there are distances of more than 25 m between the beds, these are measured as separate banks.
- Determination of the surface area and inventory of the affected mussel banks, as well as the reference mussel banks, by digital evaluation of aerial photographs and/or mapping of the outline through on-foot inspections of banks in the mudflats.
- Mapping of the coverage (“Bedeckung”) (the percentage of a whole bed covered by mussels) and the proportion (“Besatz”) (the percentage of the patches occupied by mussels).
- Sediment properties, occurrence of mussel shell remains, relief height [cm], fucus cover on the mussel beds [%], balanid growth (barnacles) [%].
- Annual monitoring is carried out at representative locations because the distribution, extent, abundance, biomass, condition, and cohort distribution of the mussels, as well as the structure of the associated fauna and vegetation of mussel banks, can show large annual fluctuations. The method of mapping the eulittoral mussel banks of the North Sea and the list of parameters to be recorded are specified by the “Trilateral Monitoring and Assessment Programme” (TMAP).

Sublittoral:

- Determination of the area and inventory of the affected mussel banks and reference mussel banks by acoustic remote sensing in combination with underwater video recordings, grab/dredge sampling and diving operations.

Evaluation

The primary criterion of the evaluation should be the condition of a mussel bank before it became polluted. However, since contaminated mussel banks generally require a long regeneration time and their status is also subject to natural annual fluctuations, in addition to the original condition, current reference samples (representative mussel banks) must be taken into account when evaluating the above parameters. In addition, it should be checked whether suitable reference data is available from the regular surveillance monitoring (see Chapter 7.1 KB General Instructions for Pollution Incident Monitoring). For the mussel populations in the Lower Saxony and Schleswig-Holstein Wadden Sea, extensive data exist from a monitoring programme to examine population development in the eulittoral.

7.9.3 Sandbanks data sheet

Relevance

Sandbanks are elevations off the sea floor in the sublittoral area, which can reach just below the sea surface but do not fall dry at low water levels. Their permanent water cover distinguishes sandbanks from coastal tidal areas (see muddy, mixed and sandy mudflats data sheet) and outer sands. They are free of vegetation or have only sparse macrophyte vegetation. As an HD habitat type, sandbanks have a special protection status (HT 1110).

Macrozoobenthos can be composed of a species- and individual-rich sandy bottom fauna, with mussels being particularly important as food for fish and benthophage sea ducks. Due to the lower water depth compared to the surrounding seabed, sandbanks are an easily accessible food source for diving sea birds. In addition, sandbanks are often located in regions with little shipping traffic and comparatively low levels of disturbance, which makes them generally very attractive as stopover sites for passage migrants and as wintering areas for numerous species of sea birds. The fish fauna includes various types of flatfish and sandeels.

Sensitivity

The particular sensitivity of sandbanks to oil contamination is primarily derived from the high concentration of seabirds which normally occur on the water surface (see Relevance). Direct contamination of benthic habitat or the sediment is to be expected, especially if oil/pollutants sink or occur at very shallow water depths (coastal area/surf zone). The risk of contamination varies depending on natural factors such as drift and wave action.

Parameters, Sampling strategy

The methods to be used to examine the resident benthic soft substrate fauna (epifauna and infauna) are based on the general requirements for immediate and long-term monitoring of macrozoobenthos after pollution (Macrozoobenthos data sheet). Using the monitoring data sheets Chemistry, Birds, Mammals, Fish and Macrozoobenthos, the examinations on the various ecosystem components in sandbank areas, such as birds or zoobenthos, must be precisely coordinated in an overall monitoring concept. The following notes on immediate and long-term monitoring are specified in more detail in the above-mentioned data sheets.

Immediate monitoring

- Reconnaissance and evaluation of whether sandbanks are directly or potentially threatened
- Determination of the direct or potential impact on seabird populations
- Immediate monitoring specifically geared to the fish ecosystem component is not required
- Simultaneous identification and analysis of suitable reference areas
- In the event of a threat of contamination to the benthic habitat/sediment, the first sampling of benthic soft substrate fauna and sediment should be carried out as early as possible in order to obtain reference data (see Macrozoobenthos data sheet).

- If there is recognizable oil pollution, samples of oil or oil-contaminated sediment must be chemically analysed with regard to their specific composition as part of the preservation of evidence.
- Contaminated areas in the sublittoral should be documented with underwater video (preservation of evidence)
- Implementation of drift line monitoring on neighbouring coasts (recording of affected fish, birds, mammals, invertebrates)
- If necessary, aircraft-based remote sensing to locate affected animals or to estimate the number of victims
- Recovery of oiled birds from the coast for autopsy

Long-term monitoring

- The progression of the contamination in time should be documented through the analysis of pollutants in sediment and biota samples (mussels).
- The requirements for monitoring benthic soft substrate fauna should follow the Macrozoobenthos data sheet: from the second year onwards, the contaminated area and representative reference areas must be monitored at least once a year. If sampling is carried out twice a year, spring (standing stock) and autumn (recruitment) should be selected.
- Repeat documentation of contaminated areas with underwater video
- Benthos examinations should be terminated when a benthos community has re-established itself in the formerly polluted area, which is comparable, in terms of its species spectrum, its dominance structure, its population structure (in the case of long-lived species, e.g., some mussel species), and its biomass, with the benthos community before the pollution incident occurred or with the benthos communities of representative reference locations.
- Checking the availability of preliminary or reference data on fish from the affected area, as a decision criterion for carrying out long-term monitoring
- Depending on the extent to which birds are affected, the monitoring programmes listed on the Birds data sheet must be used.

Methods/Evaluation

The scope and methodology of the investigations to be carried out, as well as the evaluation of their results, should be extracted from the handbook data sheets Chemistry, Macrozoobenthos, Fish, Birds and Mammals and agreed upon within the overall monitoring concept.

7.9.4 Eulittoral sand flats, mixed flats and mud flats data sheet

Relevance

Eulittoral tidal flats include tidal flats with sand, mud, or mixed substrate which regularly dry out at low tide. Higher plants are missing on sand, mixed and mud flats, apart from the more or less extensive eelgrass beds and – in the upper Eulittoral –the pioneer zone and lower salt meadows. The area that regularly dries out is demarcated between the LAT (lowest astronomical tide) recorded on nautical charts and the line of the MHWL (mean high water level), which includes the eelgrass beds and mussel banks located there. Shallow water zones on the Baltic Sea coast, which fall dry temporarily, are known as wind flats. In contrast to the periodic tidal rhythm of the North Sea, they are subject to weather-dependent, aperiodic water level fluctuations. Pronounced wind flats occur on deposition coasts (spits, sand spits), in shallow water zones and on wave cut platforms of the inner and outer coastal waters.

Mudflats and sandflats not covered by seawater at low tide are designated as HD HT 1140. They border on Atlantic salt meadows (1330), Glasswort mudflats (1310), Spartina swards (1320), and large shallow inlets and bays (1160) and overlap with Estuaries (1130).

Due to its species-rich seabed fauna, tidal flats provide habitat for a number of marine fish species in their juvenile stages. They are also an important feeding ground for water birds and are of particular importance for migratory birds (moulting, resting, and wintering area). These functions are also performed by the wind flats in the Baltic Sea.

Sensitivity

Overall, particularly high potential for damage should be assumed in the case of pollutant contamination in the mud flats, especially for the macrozoobenthos and bird fauna. In addition, in the event of a pollution incident near the coast, it must be assumed that the pollutants will spread over a large area within the tidal flats due to the changing water levels and the associated transport of contaminated sediments. Long-term consequences are to be expected, especially for mud flats less exposed to wind and wave action.

Parameters

The parameters to be recorded as part of a pollution incident monitoring in eulittoral sand, mixed and mud flats are based on the generally applicable requirements for protected habitats and can be found in the corresponding data sheets (Macrozoobenthos, Macrophytobenthos, Mussel banks, Eelgrass meadows, birds, fish). The immediate and long-term monitoring of the macrozoobenthos should be based on the BLMP methods and, if necessary, take into account existing preliminary data. All longer-term monitoring measures must be coordinated within the scope of the concept of pollution incident monitoring.

Immediate monitoring

- Determination of the hazard potential for the benthic habitat/sediment: oil/pollutant must be chemically analysed immediately or the hazard assessed on site.

- Initial sampling of the sediments and the benthic communities based on hazard analysis must be carried out as early as possible in the affected area and in a suitable reference area (see Macrozoobenthos data sheet). During the examinations, the amount of pollutants transported into the mudflats or stranded oil should have reached its maximum extent. Taking into account the tides and drift of the oil/pollutants, multiple sampling phased out over time may be necessary, possibly in different areas. The aim of the initial investigation is to characterize the maximum acute effects of the pollution incident on the tidal flats.
- To be able to estimate the horizontal and vertical transport of pollutants and the associated acute consequences for the benthic community, all examinations at the stations sampled for the first time must be repeated at the earliest possible point in time.
- If the coastal zone is expected to be contaminated by floating oil/pollutants, benthos and sediment samples may have to be taken as a precaution in order to be able to characterize the initial state of the area (see Coastal zone and Beaches data sheet).
- Contaminated areas must be documented photographically during each examination (preservation of evidence).
- In the littoral zone, investigations of the macrozoobenthos are carried out with the help of a cylindrical core sampler (see Macrozoobenthos data sheet), the recommended diameter of which is 10-15 cm (corresponding to a surface area of about. 80-180 cm²). The recommended depth is 30 cm; for penetration depths ≤ 20 cm, the number of deeper-living macrozoobenthos species (e.g., *Mya arenaria*, *Arenicola marina*) might be underestimated.
- The number and location of the stations, as well as the number of replicas per station, depends on the density and distribution pattern of macrozoobenthos in the areas to be investigated and must be coordinated within the pollution incident monitoring programme.
- If necessary, as part of the initial investigation, oiled birds should be recorded and recovered for autopsy; aerial remote sensing could be carried out to localize affected animals or to estimate the number of victims (see Birds data sheet).

Long-term monitoring

- Sampling times and duration of long-term monitoring depend largely on the type, scope, and time of the contamination. Guidelines are given in the data sheets on Macrozoobenthos, Macrophytobenthos, Mussel banks, and Eelgrass meadows. Depending on the specific conditions of the pollution incident and the area to be monitored, long-term monitoring must be coordinated in agreement with competent experts.
- The duration of long-term monitoring is determined by the point in time when the reference state was restored and it is therefore dependent on the duration of pollution or the persistence of the stranded oil/pollutant. In addition to the specific properties of the affected tidal flats, the amount of oil/pollutant, the type of oil/pollutant, and the type of control measures play an important role. For exposed tidal flats, it is assumed that the duration of the effects of pollution will be one to two years. A pollution period of over five years is assumed for mudflats on sheltered coasts.
- Long-term monitoring measures in the tidal flats should be carried out in accordance with the respective data sheets (Macrozoobenthos, Macrophytobenthos, Mussel banks and Eelgrass meadows, birds).

Methods/Evaluation criteria

The scope and methodology of the investigations as well as the evaluation of their results, should follow the data sheets Macrozoobenthos, Macrophytobenthos, Mussel banks, Eelgrass meadows or Birds in agreement with the expert network (see above). The primary criterion in assessing the results of monitoring after a pollution incident is the restoration of the reference state. Preliminary data or data on the sensitivity of the affected coastline must be taken into consideration in the evaluation of the monitoring results.

7.9.5 Reef data sheet

Relevance

Reefs are hard substrates rising from the seabed, either geogenic (rock, boulders, glacial drift, marl or chalk blocks) or biogenic hard substrates (e.g., mussel banks) which are permanently covered with water. They are protected under the HD HT 1170. Due to their genesis, there is a close association between reefs and sandbanks (HD HT 1110, see Sandbanks data sheet) and coarse sand, gravel and shell habitats, which are protected under the Federal Nature Conservation Act (§ 30 BNatSchG). Often these marine habitat types alternate on a small-scale.

Depending on the depth of the water and the availability of light, reefs are often colonized by marine macrophytes. For this reason, the associated fauna of molluscs, small crustaceans, polychaetes, and other species groups characteristic of macrophytes is often just as much a component of typical macrozoobenthos communities of reefs as are numerous epibiontic/sessile species that rely on hard substrate (e.g., cnidarians, bryozoa, tunicates, barnacles). The structurally rich habitat provides food, spawning and refuge for numerous fish species. Due to the high productivity and the good availability of food, reefs are also very attractive for marine mammals and (depending on the water depth) for sea birds.

Sensitivity

Due to the particularly high biodiversity and the function as a regeneration reservoir for rare and threatened species, there is a particularly high potential for damage to the local flora and fauna in the event of oil/pollutant contamination.

Parameters (Monitoring requirements)

Monitoring investigations in reef areas are particularly time-consuming due to the fact that sampling with beam trawls/dredges or grabs is not available or is only available to a limited extent in a restricted number of areas. The examination of epibenthos on hard substrates is generally carried out by research divers. In the case of contamination that allows the use of research divers, scratch samples should be taken in the affected areas as part of immediate monitoring. Contaminated biogenic reefs (mussel banks) that have formed over sandy substrate (soft substrate) can also be examined selectively with a grab in order to obtain information about the pollution of the underlying sediment (see Mussel banks data sheet). Depending on the type and extent of the pollution or the possibility of divers being deployed, immediate monitoring measures may have to be limited to the documentation of the affected areas using underwater video. Nearby soft substrate habitats (sandbanks, coarse sand/gravel) should be examined with a Van Veen grab sampler or core sampler.

According to the monitoring Macrozoobenthos, Macrophytes and Mussel banks data sheets, the measures to be taken in reef areas monitoring must be coordinated with competent experts as part of the overall monitoring programme.

Immediate monitoring

- Determination of the hazard potential for the benthic habitat as part of the initial assessment of the situation: the pollutant/oil must be chemically analysed immediately. On geogenic hard substrates (rock), where there is a lack of soft material (sediment) in which oil can penetrate causing longer-lasting pollution, only acute effects of dispersed oil on epibenthic organisms are to be expected.
- The often close association of reefs and sandbanks and/or species-rich gravel, coarse sand and shell habitats, as well as eelgrass meadows (see section Relevance), may require a small-scale alternation of examination methods (see data sheets on Sandbanks, Coastal zone/Beaches, Macrozoobenthos, Macrophytes, Eelgrass meadow).
- In accordance with the risk analysis in the affected area (see Macrozoobenthos data sheet) sampling must be carried out as early as possible. If contamination by floating oil is expected, examinations of the macrozoobenthos and macrophytes should be carried out as a precautionary measure to be able to characterize the initial state of the area. To record acute consequences of contamination on the benthic community, a new sample must be carried out about one week after the first contamination.
- Contaminated areas of the sublittoral should be examined with underwater video (preservation of evidence). An evaluation of the condition of the benthos is, to a limited extent, possible with video recordings. In addition, this will supply knowledge on the occurrence and distribution of benthic fauna and, if necessary, of eelgrass stocks or algae growth on stones.
- Soil grabs (e.g., Van Veen grab sampler) or trawls are unsuitable for the investigation of areas with hard substrates: if diving is possible, scratch samples should be taken from the reef structures for quantitative recording of the epifauna. An area of 20 x 20 cm must be examined in each case. The samples are scraped off with the help of a spatula and transferred to a mesh bag. When determining the sampling locations, any depth zonation must be taken into account. At least three scratch samples should be taken from each depth level.
- Small-scale soft substrate areas within a reef or biogenic reef (mussel banks) must be examined with a grab. In doing so, sub-samples for grain size analysis and chemical analysis must be ensured (see Macrozoobenthos and Mussel banks data sheet). The number of samples depends on the extent of the pollution or the local conditions and must be agreed with experts when determining the scope of the investigation.

Long-term monitoring

- Sampling times and duration of long-term benthic monitoring depend largely on the type, scope, and time of the contamination over the course of the year and must be agreed within the expert network. Guidelines are given in the Macrozoobenthos, Macrophytes and Mussel banks data sheets.
- Examinations of pollution should be carried out on suitable epibenthic bioindicators (e.g., mussels) and to repeated at intervals until the contamination has subsided.
- Follow-up examinations of epibenthic flora and fauna should be carried out in the immediate vicinity of the stations examined as part of the immediate monitoring; renewed sampling of the areas where scratch samples were taken should be avoided.
- Long-term monitoring should be terminated when a biological community begins to grow, which is comparable to the reference locations in the contaminated area, or when the pollution of indicator organisms has dropped to the background value (see evaluation, section 7.5).
- Long-term monitoring of other components of reef systems must be carried out according to the data sheets on Macrophytes, Fish, Birds, Mammals.

Methods/Evaluation

The scope and methodology of the investigations to be carried out, as well as evaluation of their results, should be taken from the data sheets on Macrophytes, Macrozoobenthos, Mussel banks (biogenic reef) and chemical monitoring in agreement with the expert network (see above).

7.9.6 Coastal zone and beaches data sheet

Relevance

In the event of an oil incident, the coastal zone and beaches are particularly threatened by pollution. A large part of leaked oil often drifts to the coast due to wind and currents and it accumulates there. As a result, control and cleaning measures are primarily carried out on the coast.

In the North Sea, the outer coasts of North Sea Islands that are exposed to wave action, are dominated by sandy beaches with comparatively coarse sediment material. Wave action, tidal currents, and storm surges lead to a constant movement and mixing of sediment. In less exposed and sheltered coastal sections, such as the mainland-oriented side of islands, in estuaries, and on the mainland coast sheltered by the tidal flats of the Wadden Sea, the coastal zones are characterized by finer sediment with varying proportions of silt. These coastal zones are often biologically highly productive and thus serve as an important source of food for birds and fish larvae.

Large parts of the German North Sea coast have sea dykes. There are often salt meadows directly in front of the dykes (see Salt meadow data sheet, chap. 7.9.7).

In the German North Sea, rocky coasts with rocky tidal flats occur exclusively around Helgoland.

In the Baltic Sea, sandy beaches are widespread in front of flat coastal areas, whereas gravel, boulder, and pebble beaches are mostly found below moraine or chalk cliffs.

The HD lists "Annual vegetation of drift lines" (HD HT 1210), "Perennial vegetation of stony banks" (1220), "Vegetated sea cliffs of the Atlantic and Baltic Coasts" (1230) and "Embryonic shifting dunes" (2110) as habitat types worthy of protection in the coastal zone.

Sensitivity

The extent and duration of oil pollution stranded in the coastal zone are largely determined by the exposure and the sediment composition of the coast. Exposed, steeply rising sandy beaches are relatively quickly cleaned of oil by wave action. Extensive, level beaches, on the other hand, are more prone to prolonged oil pollution. Grain size composition influences the penetration of oil into the sediment and thus partly also its persistence. In coarse-grained sediment, oil can penetrate deep into the pore system due to the easier water exchange, but it can also be washed out more easily. In fine-grained sediment with little water exchange, oil can penetrate through the burrows of infauna species and persist there for a long time. Penetration also depends on the type of oil. Light crude oils and diesel oil penetrate deeper sediment layers more easily than viscous oils and mousse (water-in-oil emulsions). Rocky coasts exposed to waves usually show hardly any traces of oil after a short time. On sheltered rocky coasts, however, the pollution can last 2 to 5 years. A combination of these factors determines the pollution duration of the coastal zone (see table 14 in section 6.1 of the monitoring concept (IfAÖ 2016)). Depending on the extent of oil pollution, more or less serious and long-term damage to the meiobenthos and macrozoobenthos community in the coastal zone is to be expected.

Parameters

With pollution incident monitoring, the extent and duration of contamination of sediment and biota should be recorded, as well as the colonisation structure of macrozoobenthos in the coastal zone. Salt meadows are not taken into account in this data sheet. The monitoring of this very sensitive habitat is described in a separate data sheet (see Section 7.9.7). The procedure in rocky flats should be carried out analogously to the procedure for Reefs (see data sheet, section 7.9.5).

Immediate monitoring

- In the event of an impending contamination, samples of sediment and biota should be taken as soon as possible in order to obtain the reference data required for later long-term monitoring. If possible, the sampling should take place along a transect at different vertical levels (e.g., drift line, surf zone, shallow water zone near the shore).
- If oil has washed ashore, it is often irregular and patchy. This makes it possible to take representative reference samples in unpolluted beach/shore areas.
- In the North Sea, samples should preferably be taken in the coastal zone at low tide. Samples of sediment and biota can then easily be taken by hand.
- When oil landings are no-longer expected, the extent of the pollution must be determined by monitoring the beach (SCAT monitoring). Different stretches of beach should be divided into sectors and assessed with regard to their vulnerability and sensitivity.
- Photographic documentation of the pollution (coastal zone/beach).
- Dead mussels, crabs, and other invertebrates that have washed up or are conspicuous in the shallow water area should be documented (text, photo) and sampled (preservation of evidence).
- If necessary, initiation of drift line monitoring (recording of affected fish, birds, mammals)

Long-term monitoring

- The contamination of the beach and coastal zone should be confirmed by chemical analysis of terrestrial and aquatic sediment samples. Based on the findings, the examination area for long-term monitoring can be determined.
- During long-term monitoring, the breakdown (ageing) of the oil in the contaminated sediment must be registered by means of chemical analysis. The findings can show whether degradation is taking place or whether “fresh” and thus more toxic oil is persisting. This could delay the recovery of the benthic fauna.
- The pollution load of biota must be determined for selected bio-indicators.
- Chemical analyses of sediment and biota should be repeated at intervals until the pollution level has fallen to the background value.
- Examination of macrozoobenthos (see data sheet section 7.5) along transects aligned perpendicular to the shoreline. Sampling should cover the depth range in which contamination of the sediment was detected. The georeferenced transects are to be sampled repeatedly. The examination must also be carried out in representative adjacent, non-polluted coastal sections.
- Monitoring of the macrozoobenthos should continue until the benthic community structure that existed before the pollution has re-established itself, or until it matches the structure of representative reference locations.
- In the terrestrial area of a beach, the vegetation can take on an important indicator function for the regeneration of a contaminated area. More species-rich vegetation is usually only found in areas that are rarely used by tourists.

- In the course of the response and cleaning work, additional, unavoidable damage to the coastal zone and beaches can occur. The regeneration of this habitat should be monitored, especially in the case of natural beaches with vegetation that was originally largely undisturbed.

Methods/Evaluation

The primary criterion when assessing the results of monitoring after a pollution incident is the restoration of the reference state. The results of the reference areas must be included in the evaluation. Since the density and biomasses of the species are sometimes subject to pronounced temporal fluctuations, the reference areas must be examined at the same time as the polluted areas.

As a rule, no advance data is available for the shallow water areas immediately in front of the coastal zone because these are not monitored as part of regular marine monitoring. Reference data are therefore to be collected as part of pollution incident monitoring.

Methodological notes on the sampling of sediment and biota for chemical analyses and the examination of macrozoobenthos are given in the data sheet in Chapter 7.2 “Chemical monitoring” and Chapter 7.5 “Macrozoobenthos”.

The following data sheet of the BLMP manual contains information on the methodology for the monitoring of the following structures in the coastal zone, which are designated as HD habitats:

1210 – HD HT Annual vegetation of drift lines

1220 – HD HT Perennial vegetation of stony banks

1230 – HD HT Vegetated sea cliffs of the Atlantic and Baltic Coasts

Evaluation criteria for these three habitat types were determined by Krause et al. (undated). The primary evaluation parameters are habitat structures, inventory of typical species, and damage.

In the terrestrial area, the state of the vegetation is the primary evaluation criterion for near-natural beach areas. Standardized botanical methods should be used here, such as the examination of vegetation along transects or in randomly distributed squares (also see Salt meadows data sheet (Section 7.9.7)).

7.9.7 Salt marshes data sheet

Relevance

In the salt marshes of the North Sea and Baltic Sea coasts, various aquatic, semi-aquatic, and terrestrial habitats interlock in relatively small areas. Salt marshes are of high ecological as well as socio-economic importance.

Typical locations of salt marshes on the North Sea are the areas in front of sea dykes of the mainland coast, on the Halligen, and the sheltered coasts of the islands.

On the Baltic Sea, salt marshes have developed, for example, around coastal lagoons and coastal flood marshes, in bays such as Wismar Bay and the Darss-Zingster Bodden chain.

Salt marshes are particularly at risk of pollution in the event of an oil incident at sea, similar to other coastal zones and beaches.

Sensitivity

Salt marshes are one of the habitats with the highest sensitivity to oil pollution. In the event of an oil incident, they must therefore have priority in protection against oiling. Once oil covers the vegetation and the ground of a salt marsh, the area often takes a long time to recover. It is also difficult to clean oiled areas without doing more damage. When choosing a cleaning method, it is therefore important to consider whether it leads to more serious damage than the oiling itself.

The damage to soil, vegetation, and fauna is largely determined by the type of oil, the degree of weathering of the oil, the exposure and geomorphology of the area, and the timing of the incident (time of year). As a rule of thumb, the length of time of oil remains will increase as the influence of tides and currents decreases. Oil can penetrate deeper into the salt marsh via creeks or ditches, if present. At the same time, differences in relief make cleaning difficult.

The probability of long-term (> 2 years) damage occurring is particularly high under the following conditions:

- The oil reaches the salt marsh shortly after the pollution incident and is hardly weathered.
- The marshy soil becomes heavily oiled, either through thick layers of oil on the surface or penetration of the oil into the ground.
- Plants are completely covered in oil during the growing season.
- Aggressive response and/or cleaning measures are carried out, which damage plant roots and introduce oil into the soil.
- There is chronic re-pollution with oil.

Parameters

Salt marshes house a variety of morphological structures, habitats, life forms and species in a small area. This requires a correspondingly diverse monitoring programme that is specifically tailored to the individual components and at the same time well-coordinated. The following aspects must be included:

- Exposure and geomorphology
- Habitat distribution and disturbance
- Contamination and regeneration of soil, fauna, and flora (Sections 7.2, 7.4, 7.5)
- Properties of surface sediments or soils, in aquatic habitats additional hydrological parameters (Section 7.4, 7.5)
- In the case of biota, species composition and – depending on the group/taxa – (individual) density, cover, extent/distribution, biomass
- Vegetation; if necessary, in-depth examination of individual plant species where different sensitivity to contamination with oil is expected
- Endobenthic and epibenthic fauna in water bodies (for details see Section 7.5), endogean and epigeic fauna, and phytal fauna in terrestrial areas
- Breeding and roosting birds (for details see Section 7.7)
- Control and cleaning options

Sampling strategy

- The diversity of the habitat and the salt marsh communities of flora and fauna must be taken into account in the monitoring design. This means that elevation, soil, genesis, and utilisation must be taken into account as well as annual cycles of the individual components. Monitoring design and sampling strategy must therefore be planned particularly thoroughly in salt marshes, taking into account the specifications in Section 6.1 and Section 6.2.
- When developing the sampling strategy, data from sensitivity mapping from the VPS-sensi module and – if available – data from other previous investigations in the area (preliminary data) must be taken into account. It must be ensured that the data obtained within the scope of the monitoring can be compared with previous data.

Immediate monitoring

Characteristics of salt marshes, recording of general concepts

- Evaluation of exposure and geomorphology, zoning, identification of threatened and less threatened areas, affected and less affected areas, as well as areas worthy of protection and less worthy (local protection measures possible?)
- To be able to estimate the scope of monitoring, it is necessary to check which habitats are represented in the area. Consideration of the different depth zones, stages of succession, determination of monitoring sectors, transects and survey points, permanent areas for the evaluation and sampling of the relevant components. The more heterogeneous an oil-polluted area, the more samples have to be taken.
- Data on sensitivity and shore type from VPS-Sensi, aerial photographs and, if necessary, an elevation model will help with classification and planning.

Chemical analysis

- Samples of landed oil and oil-contaminated plant material must always be collected and analysed with regard to their specific composition as part of the preservation of evidence (Section 7.2).

Flora, Fauna

Recording the extent and intensity of oil pollution in the vegetation is one of the priority tasks of immediate monitoring.

The following parameters should be recorded:

- Distribution of the oil on the vegetation. Which parts of the plants are oiled?
- General composition of the vegetation. What is the proportion of short-lived herbaceous plants and perennial species? Are there any conspicuous, dominant species?
- Do the plants have well-developed rhizomes or rosettes from which the vegetation can regenerate?
- Photographs of vegetation along transects in representative reference areas.
- Macrozoobenthos must be recorded in strongly aquatic habitats (pioneer zone, tidal creeks, ditches, wet hollows) (see Immediate monitoring in the macrozoobenthos data sheet, Section 7.5).

Soil/Sediment

- For an initial assessment of the pollution, it is sufficient to assess soil exposure on the basis of the vegetation cover.
- A visual evaluation of profiles of the topsoil provides an initial indication of whether oil has penetrated the soil.
- Early information on the extent and intensity of oil pollution of the soil can serve as a decision-making aid for choosing the most suitable response or cleaning method.

Long-term monitoring

Chemical analysis

- From the early phase of long-term monitoring, samples should be taken to analyze the chemical composition of the oil to determine its weathering status and to be able to forecast further development. The result of the analysis can, if necessary, serve as a decision-making aid when choosing cleaning methods.
- The focus of monitoring the kinetics of pollution with mineral oil products is on chemical analysis of sediment or soil samples.
- In habitats with pioneer vegetation that are regularly flooded or in tidal creeks, the PAH contamination of mussels living in the sediment should also be recorded.
- For the methodology of sampling, sample handling, and transportation, see Section 7.2.

Vegetation

- Initially aerial monitoring of the affected area by means of multispectral photogrammetry should take place at different times of the year (growth phase, rest phase) and later at annual intervals during the vegetation period.
- At the beginning of long-term monitoring, detailed recording of vegetation damage must be carried out.
- If oil has penetrated the soil, the degree of damage to the plant roots or rhizomes must also be assessed.
- In order to follow vegetation regeneration, spatially defined transects and examination areas should be defined. Changes should be examined at fixed time intervals, taking seasonal aspects into account.
- If necessary, representative individual species that represent different groups of life forms/sensitivity are to be examined in depth.

Soil/Sediment

- The properties of surface sediments should be examined at representative stations, usually in connection with an examination of flora and fauna (soil sample for laboratory analysis; on-site recording of colour, grain size, odour, inclusions, water cover, type of cover with organic material – also see Sections 7.4 and 7.5).
- Even if oil pollution is not visible, soil samples should be taken for chemical analysis to check whether the soil is contaminated.
- Depending on vegetation density, soil can be more or less well protected from the ingress of oil. The oil penetration depth must be determined and soil samples taken at locations with different vegetation cover and different layers of organic litter.
- If control/cleaning work has been carried out in a salt marsh, check whether oil has penetrated the soil. Penetration depths can vary depending on the density of the protective vegetation cover.

Fauna

- In order to follow the regeneration of fauna, spatially defined transects and examination areas should be defined.
- Samples of local macrozoobenthos (infauna, epifauna, e.g., mud snails and periwinkles) should be examined in regularly flooded pioneer zones (glasswort, cord grass), creeks, ditches, and wet hollows.
- In lower and upper salt marshes, in brackish marshes or in grassland, various arthropod taxa (e.g., true bugs, beetles, butterflies and moths) should be examined (specialist literature, expert network) which represent different life forms and forms of exposure.
- Changes should be assessed at fixed time intervals. For the timing of macrozoobenthos investigations, see Section 7.5; in the case of the endogean, epigeic, and phytal fauna of the lower and upper salt meadows, smaller intervals should be selected depending on the annual cycle of the taxa examined (see specialist literature).

Birds

- Monitoring in accordance with instructions in Birds data sheet (Section 7.5)

Methods

For information on methods, see the specific data sheets on Chemical analysis (Section 7.2), Macrozoobenthos (Section 7.4), Birds (Section 7.7), Macrophytes in the aquatic area (Section 7.4) and especially on Salt marshes in the monitoring concept (IfAÖ 2016), Tab. 32.

Detailed methodical instructions can also be found in the respective current monitoring programmes (see Monitoring Manual http://www.meeresschutz.info/monitoringhandbuch.html, in particular the sheets Chemical monitoring pollutants; Macrophytes, Macrozoobenthos, Birds, HD HT 1310 Salicornia and other annuals colonizing mud and sand, 1320 Spartina swards (*Spartinion maritimae*), HD HT 1330 Atlantic salt meadows).

The methods for monitoring the epigeic, endogean, and phytal fauna in salt marshes have not yet been laid down in the "BLMP Monitoring Manual". Here specialist literature and the network of experts should be referred to.

Evaluation criteria

The primary criterion for assessing monitoring results after a pollution incident is restoration of the reference state. In particular, results of the reference areas examined in parallel should be included in the evaluation. In addition, the reference status can, if necessary, be defined using preliminary data from existing monitoring programmes in the relevant area.

For the German North Sea and Baltic Sea, various evaluation and classification systems are also available for evaluating pollution and the condition of various groups of biota, which are part of existing monitoring programmes of the WFD, MSFD, and HD.

8 Monitoring in Focus Regions

8.1 Wangerooge to Alte Weser lighthouse with maritime waterways towards Wilhelmshaven and Bremerhaven

Photo: W. Heiber

The Wangerooge/Wilhelmshaven/Bremerhaven focus region is part of the German Bight – one of the busiest sea areas for shipping in the North Sea. Shipping traffic moves through the area to the ports in Wilhelmshaven as well as Bremerhaven, Nordenham, Brake, and Bremen (Figure 3).

A large part of the focus region Wangerooge/Wilhelmshaven/Bremerhaven is taken up by the Habitat Directive area "Lower Saxony Wadden Sea National Park". Furthermore, in the areas of the river Weser and Weser estuaries, there are the Habitat Directive areas "Unterweser" and "Weser near Bremerhaven". In addition to the HD areas, the BD areas "Lower Saxony Wadden Sea and Adjacent Coastal Sea", "Unterweser", "Luneplate", "Marschen am Jadebusen" and "Butjadingen" are located in or adjacent to the focus region (Figure 3).

The boundaries of the respective protected areas can be found in the VPS. Valuable habitats are also located outside the protected areas in the shallow and deep sublittoral areas of Jade Bay and the Outer Weser.

The spatial overlap of important marine protected areas with very heavily frequented shipping routes involves an increased risk potential for the areas concerned.

Habitats

The focus region includes such different sub-areas as the tidal flats in Jade Bay, the tidal flats behind the barrier island Wangerooge, the deep channels of the Jade and Weser, the funnel estuary of the Weser with tidal flats, and the open tidal flats off the Wurster coast. Furthermore, several islands occur in the focus region i.e. Wangerooge, Minsener Oog, Mellum, and Knechtsand. At 360 cm, Jade Bay has the highest tidal range in the German Bight.

The extensive mud flats of the focus region include channels and tidal creeks as well as muddy, sandy, and mixed sediment mudflats in various forms. Jade Bay has a high proportion of mud flats, especially in its western part, which is sheltered from wave action; in contrast, there are the exposed sand floodplains and plateaus in the Outer Weser. Other important habitats that are also particularly sensitive to oil pollution are eelgrass meadows and mussel banks, salt meadows, and the aquatic-terrestrial transition zones characterized by glasswort and cord grass.

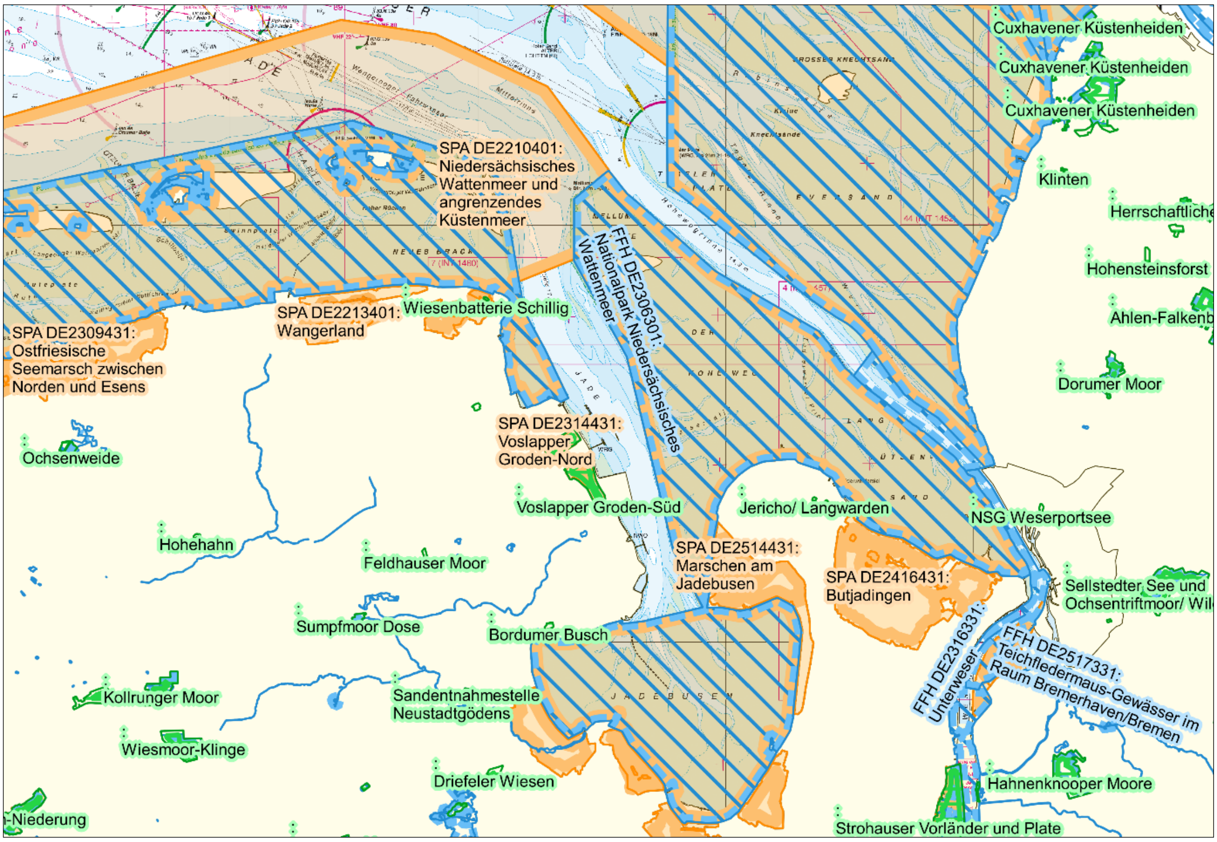


Figure 3: Wangerooge - Wilhelmshaven - Bremerhaven Study area: depiction of the electronic nautical chart with Habitat Directive, bird protection, and nature protection areas (IfAÖ 2016)

Estuaries such as the Weser represent the link between limnic and marine habitats and are highly productive ecosystems. Characteristic for this habitat is the ebb and flow of seawater, which leads to constant fluctuations in the salt content. The focus region thus covers a wide range of salinity, from the oligohaline area of the Lower Weser south of Bremerhaven to the mesohaline and polyhaline zones of the outer Weser; the Jade and Jade Bay system borders on the region to the west, which is characterized by euhaline conditions (> 30 ‰).

Chemical monitoring

Chemical monitoring includes examination of the water, sediment, and selected biota.

In soft sediments, depending on prevalence, mostly the Baltic macoma and/or common cockle species can be used as bioindicators for measurements of pollutant levels in biota ; blue mussels are an ideal species for this on hard substrates and mussel banks.

The flounder, which is widespread in the focus region, and the relatively locally occurring eelpout are particularly suitable for determining pollution levels in fish. The latter species has been used for many years in the focus area by the German Environmental Specimen Bank as an pollution accumulation indicator.

In specific cases, it must be considered whether sea bird eggs should also be examined for relevant pollutants after a pollution incident. Eggs from the herring gull colony on the island of Mellum are taken annually in May by the German Environmental Specimen Bank for the analysis of pollutants. In addition, as part of the TMAP, oystercatcher eggs on Mellum and common tern eggs on Minsener Oog are sampled annually.

Bioeffect monitoring

Oiled sediments can be a long-term source of pollution for benthic organisms. The ecotoxic potential of sediment samples should be examined with bio tests.

If possible, the same bioindicators should be selected for a biomarker examination as for chemical analysis (mussel and fish species, see above). The eelpout, which is widespread in the area under consideration, is recommended by OSPAR and HELCOM for pollutant effect examination; since it is viviparous, the eelpout is particularly suitable for recording disorders in reproduction and development.

Biological monitoring

Benthos

The environmental parameters for salinity, depth, sediment, exposure to currents and wave action, i.e. location factors that decisively determine the settlement of benthic organisms, vary widely in the focus region. This means that a large variety of habitats and their respective macrozoobenthos communities occur in the region.

Characteristic species of the Eulittoral **soft substrate communities** in Jade Bay include Baltic macoma (*Macoma balthica*) and common cockle (*Cerastoderma edule*), the snail species *Hydrobia ulvae* and *Retusa obtusa*, the amphipod *Corophium volutator* and other Amphipoda (including *Urothoe poseidonis*) as well as numerous species of polychaetes (including *Caulleriella killariensis*, *Pygospio elegans*, *Scoloplos armiger*, the ringworm *Hediste diversicolor*). The communities on the different types of tidal flats (mud flats, mixed mud flats and sand flats) do not differ noticeably in terms of species composition. However, different species dominate in the different tidal flat types.

The extensive tidal flats of Hohe Weg and Wurster Watt, consisting primarily of sand flats, are home to a rich community of macrozoobenthos. Common species include the lugworm *Arenicola marina*, the ragworm, as well as Baltic macoma, common cockle, and sand gaper clam *Mya arenaria*.

The salinity gradient essentially determines the composition of the macrofauna communities in the Weser estuary. With decreasing salinity, the marine species gradually recede until finally different types of oligochaetes and the polychaete *Marenzelleria viridis* (neobiont) dominate. In the inner area of the funnel estuary near Bremerhaven, Baltic macoma, sand gaper, polychaetes such as the lugworm, the ragworm, and the Amphipoda species *Alitta succinea* are in the mud flats, from the sand hoppers the mud shrimp Corophium and, on the sandy surfaces of the sublittoral, various species of the genus *Bathyporeia* (*B. elegans*, *B. pelagica*, *B. pilosa*).

Banks of blue mussel *Mytilus edulis* cover about 1.2 to 1.8% of the area in Jade Bay. In the Weser estuary the area covered by mussel banks is up to 0.6%. Extensive mussel banks can also be found in the sublittoral. Today, eulittoral and sublittoral blue mussel banks are overlaid with Pacific oyster *Magallana gigas* (neobiont). In the Weser estuary the occurrence of both species extends to the inner area of the funnel mouth. Mussel banks form the habitat for a species-rich associated fauna and flora. The distribution of the eulittoral Blue mussel banks in Lower Saxony Wadden Sea can be found in the NUMIS environmental portal

(http://www.numis.niedersachsen.de/trefferanzeige?cmd=doShowDocument&docuuid=73867463-3428-4c52-a2b2-160ad76ff0e0&plugid=/ingrid-group:iplug-csw-dsc-nokis-admin).

Further focal points of benthic colonization with species-rich fauna (e.g., sea anemones) are geogenic hard substrates (marl/stone fields, clay and peat) and patches of the sand mason worm (*Lanice conchilega*) in the sublittoral of the Jade and Weser.

The focus region houses a large part of Lower Saxony's **eelgrass beds**. Extensive beds are found mainly in the east and southwest of Jade Bay (Stollhammer and Seefelder Watt, Arngaster Sand – stands of dwarf eelgrass *Zostera noltei*) as well as off the Wurster coast (Eversand, Knechtsand –mainly stands of the common eelgrass *Z. marina*). Larger stands can also be found along the sheltered mainland coast between Harlesiel and Horumersiel and along the coast in front of Butjadingen.

Salt marshes

There are extensive salt meadows along the coast between Harlesiel and Schillig and around Jade Bay. The areas in the east of Jade Bay are characterized by relatively dense populations of beach aster and sea lavender, so that the salt meadows here appear unusually rich in flowers for the mainland coast of Lower Saxony. On the Budjadingen peninsula, salt marshes occur in and in front of Langwarder Groden and further south-east up to Bremerhaven. On the eastern bank of the Outer Weser, extensive salt meadows and grassland areas extend from Bremerhaven to Cuxhaven in front of the dyke. Larger, particularly natural, salt meadows of occur on the islands of Wangerooge and Mellum.

Fish

The focus of fish monitoring is primarily on **sedentary and demersal species**: flatfish species are potentially much more affected by harmful effects of pollutants, as oil contamination of the sediment is to be expected if oil is released in the Wadden Sea region. Substrate spawners must be taken into account if their spawning substrates (macrophytes, hard substrates) are potentially affected by oil.

During spring, the focus region is of particular importance for the growth of young stages of plaice, sole, and herring. After a pollution incident increased juvenile fish mortality and thus an influence at the population level cannot be ruled out. As a first approximation, the effects can be monitored in the context of juvenile fish monitoring in the EEZ and territorial waters.

It can be assumed that an increased risk potential and thus a need for examination of the fish fauna exists if a body of water with low water exchange rates, such as Jade Bay, is affected by oil.

During the spring months, spawning migrations of diadromous **migrating fish species** take place in the Weser estuary and in the Jade. This includes several HD species, such as the Twait shad, as well as the river lamprey and sea lamprey. In the event of an extensive oil incident, these fish species would experience a barrier effect on their way to (adult individuals) and from (juvenile individuals) their spawning areas and suffer a related reduction in their spawning success. It is to be expected that the effects of an oil incident would also be detectable at the population level of diadromous migratory fish species. Thus long-term monitoring is necessary for fish species that are strictly protected in accordance with the HD (e.g., twait shad, allis shad, North Sea houting).

As part of the monitoring of benthic habitats, their degree of restoration and their potential for re-colonization by fish species can be assessed.

Birds

The dune islands of Wangerooge, Mellum, and Minsener Oog have ***breeding populations*** of many bird species. In particular, breeding bird colonies of various terns and gull species achieve the highest numbers of breeding populations on the islands in the Wadden Sea. Other breeding birds on the islands include different types of shorebirds, shelduck, eider, red-breasted merganser, cormorant, and spoonbill (http://www.mellumrat.de). The salt marsh forelands (Außengroden) of Wangerland, the mouth of the Weser, and Jade Bay are breeding grounds for various bird species, especially shorebirds, gulls, and terns. For example, the salt marshes of the Jade Bay are among the most important breeding areas for the Redshank in the entire Wadden Sea. About 15% of the entire Wadden Sea population or the German breeding population breed here.

In the event of an oil incident, the breeding populations of the islands are endangered because their breeding grounds are mostly on flat dune islands at a low elevation above sea level. The same applies to the unprotected salt marshes in front of the dykes. For this reason, in the event of an oil incident, there is a high probability that the immediate vicinity of nest sites and feeding areas will be contaminated by oil. Landwards of the dykes, on the other hand, breeding birds are not likely to be directly affected, because the dykes would prevent the flow of oil into the breeding sites. However, some species that breed landwards of the dykes forage off the coast or in offshore waters, and are thus more endangered.

A large number of **passage migrant birds** use the extensive mudflats in the area to forage. Shore birds dominate. For example, Jade Bay, as part of the Lower Saxony Wadden Sea, is the most important moulting and feeding sites for avocets in Germany in late summer. The same applies to the tidal flats of the Lower Weser, where another large avocet feeding area is situated. The numbers of on-passage dabbling ducks (especially teal) in the Lower Weser should also be emphasized, as well as important moulting populations of the eider duck in the region of the island of Mellum.

In the event of an oil incident, birds feeding or roosting in the mudflats may be immediately endangered by direct contact with oil. If, as a result of an oil incident, there is large-scale mortality of benthos organisms, which are a food source for birds, negative consequences for the fitness of birds and even their death can be expected (loss of food or/and poisoning from contaminated food).

The bird populations of offshore waters within the focus area are of species typical to the North Sea. In the event of an oil incident in the offshore area, birds occurring there may be affected by oil pollution. In general, divers, grebes, auks and sea ducks are considered to be the species groups with the highest sensitivity to oil pollution.

Marine mammals

Three marine mammals – harbour seal, grey seal, and harbour porpoise - occur all year round along the East Frisian Islands, and give birth to their young there too. For harbour porpoise, there is only a low risk of falling victim to a pollution incident due to its low abundance in the area of the focus region. However, harbour porpoises do move into Jade Bay, especially in spring.

Harbour seals occur along the entire German Wadden Sea coast and on Helgoland. They mainly use haul-out sites along the East Frisian Islands, including Wangerooge and the neighbouring islands of Spiekeroog, Minsener Oog, and Mellum. Harbour seals are also found in high numbers in the Wadden area of Hohe Weg and on the outer sands off the Wurster coast. In Jade Bay the density is relatively low. Current data from seal counts of the last few years can be retrieved from the homepage of the Lower Saxony Wadden Sea National Park Administration (http://www.nationalpark-wattenmeer.de/nds/service/publikationen/1134_harbour seal-von-borkum-bis-cuxhaven-karten). During the breeding and rearing season, as well as during moulting, between May and September, harbour seals spend a lot of time at haul-out sites and are particularly endangered by a pollution incident during this period.

Grey seals are also widespread along the East Frisian Islands, where they are mainly seen at haul-out sites on Wangerooge, Spiekeroog, Minsener Oog, and Mellum. During the rearing season (between November and February) and when they moult (mid-February to mid-May), grey seals spend less time in the water than during the rest of the year, which means that, in case of a pollution incident, they can potentially be endangered not only at sea but also on the sandbanks they use as haul-out sites.

Recommendations for action in the event of a pollution incident

Guidelines for the monitoring of components and habitats in the focus region “Wangerooge to Alte Weser lighthouse” after an oil incident, are listed in Table 13. Further information on methods can be found in the data sheets specified in this table. Response measures and immediate monitoring measures are to be carried out in the areas considered most sensitive in VPS at the time of action. In particular, the zones where the oil is predicted to land and the coastal regions must be monitored, since this is where the most massive environmental damage is to be expected. If oil escapes into the water column, it must be taken into account that the tidal flats can also be threatened by oil pollution at low tide. If oil is released in tidal creeks or in shipping channels, depending on the drift of the oil slick, shallow water areas and beaches near the banks are at risk of oil pollution at high tide.

Table 13: Recommended actions for Habitats/components in the Großraum Wangerooge –Alte Weser lighthouse – Wilhelmshaven focus region

	Recommended actions	Parameters to be recorded	Data sheet	Habitats/Components in the focus region
Chemical monitoring				
– **Water** – **Sediment** – **Biota**	– Water: analytics are particularly relevant as long as oil is drifting on the water surface – Sediment: analysis compulsory because its pollution is always to be expected in the eulittoral-dominated focus area – If oil has landed, determine the penetration depth of the contamination in the shore/beach area or in salt marshes – Biota: depending on the habitat, mussels from the epibenthos or infauna – Evaluate HC contamination of fish by analysing PAH metabolites in the bile of, for example, flounder or eelpout – Sea bird eggs (if the contamination occurs before the breeding season)	– Total hydrocarbons (THC) – Aromatic HC/PAH – PAH metabolites in fish bile – HC/PAH in sea bird eggs	Chemical monitoring	– Water column: spatial spread of contamination – Sediment: priority examination near the coast and in the oil landfall area – Biota (mussels): should be analysed together with sediment samples – Blue mussel: hard substrate, mussel bank, eelgrass meadow – Mussels of the infauna: vegetation-free mud, sand, and mixed flats – Eelpout: eelgrass meadow, tidal creeks – Dab, flounder: sandy mudflats, tidal creeks, large channels
Bioeffect monitoring				
– **Biotests** – **Biomarker**	– Determination of the toxic potential of sediment samples – When large areas of tidal flats are contaminated, bioeffects are recorded using flounder. – Examination of reproductive disorders in eelpout in the event of extensive damage to eelgrass meadow or contamination of creeks, flat sublittoral (habitat for eelpout)	– Biotest range – Reproduction disorders and other biomarkers	Bioeffect monitoring	– Oil-contaminated flats and creeks, contaminated soil from salt meadows – Eelgrass stands in Jade Bay, Wurster Watt and in the Knechtsand/Eversand area
Biological monitoring				

	Recommended actions	**Parameters to be recorded**	**Data sheet**	**Habitats/Components in the focus region**
Macrozoobenthos	Sublittoral soft substrates: – Examination of benthic soft substrate fauna using Van Veen grab sampler – At least 20 grab samples per habitat, these can be distributed over a large area if necessary, number of sites according to the size of contaminated area and type of habitat, at least 4 sites – Beam trawl / dredge (5 min per transect) – Documentation of the sublittoral areas using UW video / ROV – Take suitable reference samples	– Species composition – Individual density (abundance) and biomass – Size spectra of mussel species found – Pollution levels for bioindication of suitable mussel species (see above) – Geophysical properties of surface sediments – Hydrological parameters	Macrozoobenthos, Sandbanks	– Sublittoral, deeper areas (muddy and fine sandy soft substrates) – Soft substrates in the Jade and Weser shipping channels – Soft substrates in the area of the Weser estuary
	Eulittoral soft substrate: – Examination of benthic soft substrate fauna using a core sampler – At least 20 core samples per habitat, these can be distributed over a large area if necessary, number of sites according to the size of contaminated area and type of habitat, at least 4 sites – Photographic documentation – Take suitable reference samples	Parameters as for sublittoral soft substrate	Eulittoral sand-, mixed flats and mud flats, coastal zone and beaches, macrozoobenthos	– Muddy and fine to coarse sandy soft substrate of the eulittoral of the outer coasts and Jade Bay

	Recommended actions	**Parameters to be recorded**	**Data sheet**	**Habitats/Components in the focus region**
	Hard substrates, mussel banks: – Scratch samples for quantitative recording of the epifauna (20 x 20 cm) on foot or diver – Consideration of any depth zones that may occur (at least 3 scratch tests per depth level) – If available, sampling of small-scale soft-substrate areas within reefs using core samplers – Photographic documentation, contaminated areas in the sublittoral are documented with underwater video (preservation of evidence), status evaluation using underwater video – Mussel banks: examination of the area and inventory of affected mussel banks as well as reference mussel banks by evaluating aerial photographs and/or on-foot inspections in the mudflats	Parameters as for sublittoral soft substrate	Reef, Mussel banks, Macrozoobenthos	– Artificial hard substrates (e.g., groynes and dams, sheet piling in the ports of Wilhelmshaven and Bremerhaven) – Blue mussel banks in the Wadden Sea parts of the study area
Macrophytobenthos	Macrophytes on soft substrate: – Widespread recording of eelgrass meadows and green algae mats by means of remote sensing (aerial mapping) and in situ surface mapping (ground truthing) – If necessary, selective examination of permanent monitoring stations (if reference data is available)	– Surface area – Species distribution – Species composition – Degree of coverage > 5% – Biomass – Epiphytes on Zostera – Location – Depth limit – Covering of opportunistic algae mats	Eelgrass meadow, Macrophytes, Macrozoobenthos	Muddy and fine to coarse sandy soft substates of the eulittoral of outer coasts and Jade Bay
	Macrophytes on hard substrate: – Macrophyte monitoring using a sampling quadrat (50 x 50 cm) along a transect (possibly establishing permanent quadrats)	– Species composition – Amount of green and red algae – Number of opportunists – Coverage (%) with fucus	Macrophytes, Mussel banks	– Blue mussel banks in the eulittoral of the observation area, artificial hard substrates (see above)
Salt marshes	– Recording of vegetation in selected permanent plots / quadrats and/or transects – Recording of invertebrate fauna at monitoring stations	Vegetation: – Surface area – Species composition	Salt marshes	– Salt meadows along the entire mainland coast as well as on the islands of Wangerooge and Mellum, including

	Recommended actions	**Parameters to be recorded**	**Data sheet**	**Habitats/Components in the focus region**
	– Recording of seasonal changes – Aerial photos for first extensive recording of damaged vegetation and vegetation regeneration – If necessary, recording of oiling of the soil and weathering / degradation of oil over time	– Density, spread – Proportion of annual and perennial plants – Habitat-typical invertebrate fauna (representative groups of endogean, epigeic, and phytal fauna): – Species spectrum – Abundance If necessary, recording of benthic fauna in aquatic areas (see Macrozoobenthos eulittoral soft substrate) – If necessary, recording avifauna (see Birds)		grassland areas and aquatic-terrestrial transition zones characterized by glasswort and small cord grass
Fish	– Optional drift line monitoring to record dead and washed up fish – Optional examinations with stow net fishery and/or a small beam trawl, or with gill nets in creeks in salt marshes	– Species composition – Species abundance – Species biomass – Age and length recording	Fish	– Mudflats – Small fish fauna of Jade Bay salt marshes
Birds	– Carrying out drift line monitoring in combination with drift experiments – Collection and disposal of dead birds, autopsy of sample of dead birds – Potential rehabilitation of oiled birds – If necessary, samples of eggs for PAH content – Monitoring of breeding success and number of breeding pairs	– Roosting birds: number of oiled birds as part of drift line monitoring, – Abundances – Breeding birds: breeding success, number of breeding pairs, content of PAHs in bird eggs	Birds	– Offshore waters – Sandbanks – Dune islands – Shallow bays – Mudflats – Salt marshes

	Recommended actions	Parameters to be recorded	Data sheet	Habitats/Components in the focus region
	– Monitoring of bird populations based on ship, land, and air surveys			
Marine mammals	– Monitoring of haul-out sites in the Outer Weser / Outer Jade using ship and aircraft-based methods – Recording of injured / dead animals as part of drift line monitoring.	– Populations on traditional haul-out sites – Corpses (dissection to clarify the cause)	Marine mammals	– Wangerooge – Minsener Oog – Mellum – Wadden areas Hohe Weg and – Robbenplate

8.2 Elbe estuary - Outer Elbe to Kiel Canal

The Elbe estuary is subject to diverse uses and sometimes competing interests such as shipping, water management aspects, nature conservation, and flood defences. As part of the German Bight, it is one of the busiest areas in the North Sea for shipping traffic, which runs to and from Hamburg and the Kiel Canal.

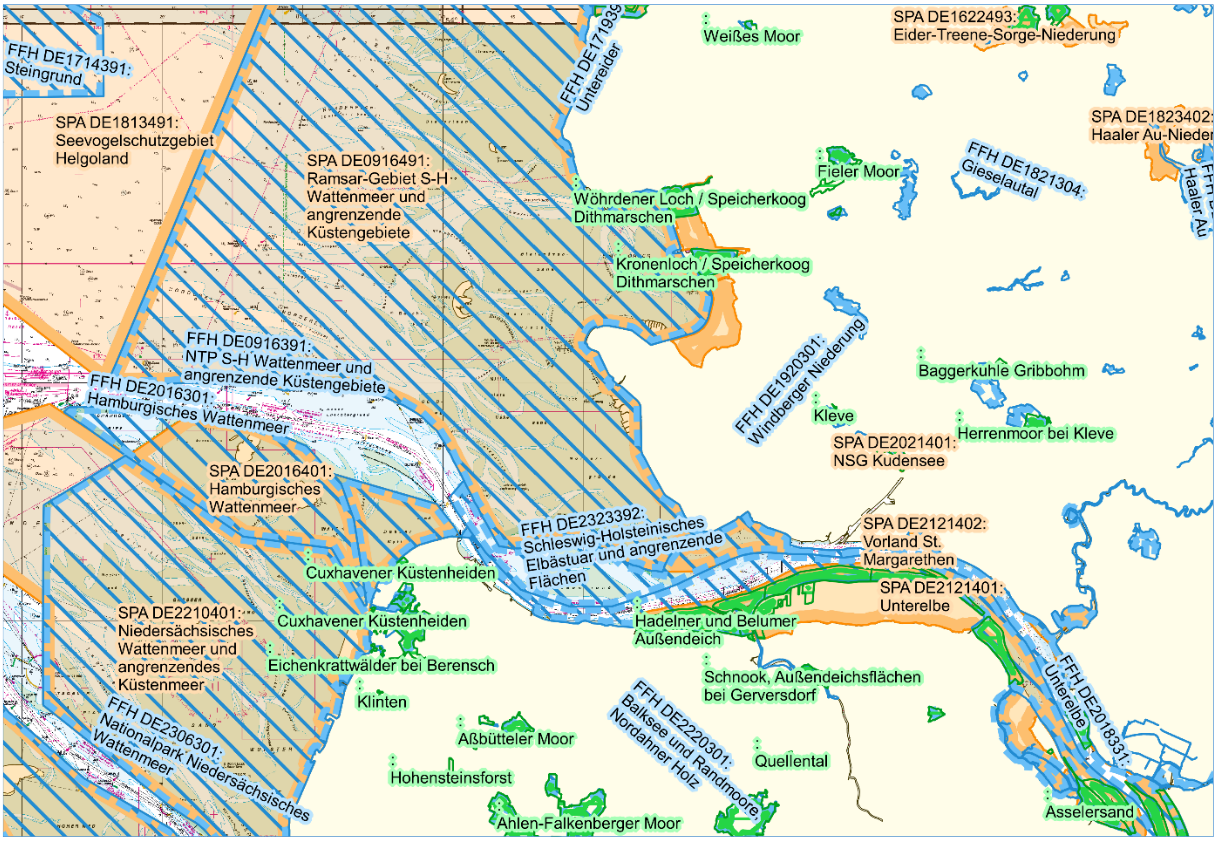


Figure 4: Greater Elbe estuary: depiction of electronic nautical chart with Habitats Directive, Birds Directive, and nature conservation sites (IfAÖ 2016)

Almost the entire estuary of the Elbe is designated as a protected area in accordance with the BD and HD. For the most part, these protected areas are also part of the Wadden Sea National Parks of Lower Saxony, Hamburg, and Schleswig-Holstein.

Habitats

The Elbe estuary is a dynamic system of shallow and deep-water areas, tidal flats, terrestrial areas, islands, and streams with strong tides and currents.

The dominant habitat types in the "Outer Elbe to Kiel Canal" study area are the Wadden Sea and the estuary with its main channel, side channels and creeks. In the eulittoral a distinction must be made between muddy, mixed, and sandy tidal flats.

The intertidal zone makes up the largest part of the study area at 20 - 36%.

Estuaries represent the link between limnic and marine habitats. Characteristic for this habitat is the ebb and flow of salt water, which leads to a constant fluctuation in salinity.

Other significant parts of the habitat in the "Elbe estuary" focus area are mussel banks, glasswort mudflats, cord grass stands, salt meadows, and annual drift lines. Salt meadows are among the habitats with the highest sensitivity to oil pollution.

Chemical monitoring

The extensive tidal flats in the outer and inner Elbe estuary are especially threatened by contamination. In the event of an oil incident, mud flats (flats and creeks) are most likely to be affected by pollution. Using sediment and biota samples, the spatial distribution and the temporal course of the contamination can be assessed.

In areas free of surface vegetation and fauna, pollutants should be measured in mussels of the infauna (Baltic macoma, common cockle).

Flounder and eelpout, which occur extensively, are suitable for examination of contamination of fish by oil-based HC. The latter species is particularly widespread on the Schleswig-Holstein side of the Elbe estuary. In the main creek system of Meldorf Bay, eelpout are taken annually in May by the German Environmental Specimen Bank for pollutant investigations.

In individual cases, it must be checked whether sea bird eggs should also be examined for relevant pollutants after a pollution incident. Eggs from herring gulls in a colony on the island of Trischen are sampled every two years in May by the environmental specimen bank. As part of the TMAP, oyster catcher eggs from Hullen and Trischen as well as common tern eggs from Neufelder Koog and Trischen are sampled annually.

Bioeffect monitoring

In the case of severe environmental pollution, it is advisable to use biotests to evaluate the ecotoxic potential of contaminated water and sediment, in addition to chemical analysis.

Flounder or eelpout are suitable species for the examination of biomarkers.

Biological monitoring

Benthos

In the "Elbe estuary" focus area, macrozoobenthos communities are dominated by different species, depending on the sediment type and salinity. In the transition between salt and fresh water, the characteristic species are the Polychaetes (Bristleworms) *Boccardiella ligerica* and *Marenzelleria* spp. Hard substrate in this area is predominantly populated by hydrozoans (cnidarians) and the blue mussel *Mytilus edulis*. Colonisation of tidal flats depends on sediment composition. The mud flats are mainly populated by the Polychaetes *Eteone longa* and the mud shrimp *Corophium volutator*. While the typical inhabitants of the sandflats include the Polychaetes Sc*oloplos armiger, Scolelepis squamata* and the Sand mason worm *Lanice conchilega* as well as the Common cockle *Cerastoderma edule*, the Polychaetes *Pygospio elegans* and *Nephtys hombergii* and the Baltic macoma *Macoma balthica* show no clear preference and are common to all the mudflats represented. In the transition to the Weser estuary there are a limited number of blue mussel banks on the mud flats and in the channels. In the area of the Elbe shipping lane, at least one larger sublittoral mussel bank is known. The study area's macrozoobenthos is the primary food source for various fish species as well as for numerous passage migrants and breeding bird species. The distribution of the eulittoral Blue mussel banks in the Lower

Saxony Wadden Sea can be found in the NUMIS environmental portal (http://www.numis.niedersachsen.de/trefferanzeige?cmd=doShowDocument&docuuid=73867463-3428-4c52-a2b2-160ad76ff0e0&plugid=/ingrid-group:iplug-csw-dsc-nokis-admin.).

The development of **macrophyte vegetation** of the tidal Elbe is determined tidal regime, flow speed, salinity, bank morphology, substrate, and exposure.

Various macrophyte taxa (both algae and angiosperms) can be found in more saline parts of the Elbe estuary. Permanent beds of Eelgrasses (*Zostera spp.*) have been documented on the tidal flats of Dithmarschen from Westerkoog (north of Büsum) northwards along the coast.

The transitional waters of the Elbe estuary are dominated by reed species, such as the sea clubrush *Bolboschoenus maritimus*, which grow parallel to the banks, partly bordered by salt marshes. Buttonweed and cord grass grow between the groynes.

On the water side of the reed beds, there is a patchy Glasswort area and a mixed area of Glasswort and cord grass.

Salt marshes

Along the coastline of Dithmarschen salt marshes occur in front of the dykes. In the area of Friedrichskoog there is a particularly wide salt marsh area. In the north of the Friedrichskoog peninsula / southwest of the Meldorfer Bucht there is another, particularly broad saltmarsh area. Other extensive salt marshes are located in the Elbe estuary on the east of the island of Trischen, in front of the dykes on the island of Neuwerk, between the islands of Scharhörn and Nigehörn, and in the transition to the Weser estuary along the coast of Cuxhaven and Nordholz.

Fish

The fish community in the tidal Elbe includes about 34-40 species and is largely characterized by a few euryhaline migratory fish species. Smelt is by far the most common species, alongside ruffe, herring, lesser pipefish, three-spined stickleback, and flounder.

Extensive spawning migrations by diadromous **migratory fish species** mainly take place in the Elbe estuary in spring. These include several HD species, such as twait shad, allis shad, European sturgeon, river lamprey, sea lamprey, and houting. In addition, the species listed as endangered according to the Red List of endangered fish species in Germany, such as European eel, Atlantic salmon and sea trout, would be affected by an oil incident during spring. An oil pollution incident could form a barrier preventing these fish species movements on the way to (adult individuals) and from (juvenile individuals) spawning areas, which could lead to a related reduction in spawning potential or success. Another direct impairment due to increased mortality would be on egg and larval drift (or their growth) during early summer, especially for twait shad. Indirect effects due to the damage of spawning habitats cannot be ruled out in the event of an oil incident. It is to be expected that the effects of an oil incident would also be detectable at the population level of diadromous migratory fish species. Thus long-term monitoring is necessary for fish species that are strictly protected in accordance with the HD.

In addition, **fish species such as flounder** are important **biological indicators** for recording chemical pollution and the effects of biological pollutants. As part of the monitoring of benthic habitats, their degree of restoration and their potential for re-colonization by fish species can be assessed.

Birds

There are ***high numbers of breeding*** birds on the islands (Neuwerk, Scharhörn, Nighörn, Trischen). The populations of seagulls and terns are important there. Other breeding bird species on the islands are cormorant, spoonbill, shelduck, various species of waders, eider, dabbling ducks and geese. The salt marsh in front of the dykes on the outer coasts and the Elbe estuary are breeding habitats for various species, in particular waders, seagulls and terns. The only colony of the gull-billed tern in north-western Europe occurs on the Schleswig-Holstein side of the river, in the saltmarshes near Neufeld. The 30-40 breeding pairs of this population, which is threatened by extinction, would be affected. Some polder areas within the focus area (for example Dithmarscher Speichererkoog) also house a large number of breeding bird species.

In the event of an oil or chemical incident in the greater Elbe estuary, breeding bird populations on the islands are at risk because the breeding grounds are mostly on flat dune islands at a low height above sea level. The same applies to the exposed salt marshes in front of the dykes. The risk that the immediate vicinity of the nest sites and feeding areas will be contaminated by washed-up oil is high. The breeding populations of the polder areas are at risk if the birds move from the polders to the coast or to offshore waters for foraging.

A large number of ***passage migrant birds*** use the extensive tidal flats in the focus area for foraging. Particularly large populations of shore birds occur in summer in the Elbe estuary area between Brunsbüttel and Meldorfer Speicherkoog. Particularly noteworthy are the flocks of the Afro-Siberian knots in spring, which comprise 90% of the total population. Another important species is the shelduck (Red List of Migratory Birds in Germany, “threatened with extinction”). Shelduck moult on the mud flats in the Trischen / Elbe estuary area in July and August in internationally significant numbers. Due to their inability to fly, when they moult, they cannot avoid an oil slick at this time. In the event of an oil incident, the entire population would be endangered.

The bird areas in the offshore waters within the study area accommodate the typical range of species of the North Sea. In the event of an oil incident in the greater Elbe estuary, sea- and water-birds, which occur in the offshore area may be particularly affected by oil pollution. In general, divers, grebes, auks, and sea ducks are considered to be the species groups with the highest sensitivity to oil pollution. The eider duck may be particularly at risk. Important moulting sites for this species are situated in the areas of the outer sands and near Trischen, as well as around the islands of Scharhörn and Nigehörn.

Marine mammals

Harbour porpoise and harbour seal occur in the Elbe estuary funnel at different frequencies. Harbour porpoise is usually found in the North Sea in water depths of over 10 m. Therefore it occurs in lower densities along the coasts and in the study area than in the rest of the German Bight.

The period between April and August is considered to be particularly sensitive because **harbour porpoise** then occur in higher densities due to mating (July - August), calving (May - July), and rearing. Young animals, which would be particularly sensitive to a pollution incident, occur mainly in areas remote from the coast. Overall, the risk of harbour porpoise of falling victim to a pollution incident should be assessed as low due to its low abundance in the study area and its high mobility.

Harbour seal occur along the entire German Wadden Sea coast and on Helgoland. In the Elbe estuary, harbour seals can be found on Neuwerk and Scharhörn. Occasionally they are also seen further up the river Elbe. In general, sightings in the Elbe are very rare. During the breeding and rearing season (May - July) and during moulting between June and September, harbour seals spend a lot of time on haul-out sites. Due to the intensive use of haul-out sites from May to September, harbour seals are potentially at risk from a pollution incident not only at sea, but also on the eulittoral sandbanks they use to rest on. Current data with the results of the seal censuses of the last few years can be retrieved from the homepage of the Lower Saxony Wadden Sea National Park Administration (http://www.nationalparkwattenmeer.de/nds/service/ publikationen/1134_seehunde-von-borkum-bis-cuxhaven-karten).

Because of their relatively high population, seals have a higher risk of falling victim to a pollutant incident compared to harbour porpoise. However, the risk is limited to the area of the Outer Elbe with its islands and mud flats. In the event of a pollutant incident above Brunsbüttel, the risk of pollution is low as long as there is no major oil drift due to wind, currents, and tides.

Recommendations for action in the event of a pollution incident

Guidelines for the monitoring of components and habitats in the focus region "Elbe estuary" after an oil incident, are listed in Table 14. Further information on methods can be found in the data sheets specified in this table. Response measures and immediate monitoring measures are to be carried out in the areas considered most sensitive in VPS at the time of action. In particular, the zones where the oil is predicted to land and the coastal regions must be monitored, since this is where the most massive environmental damage is to be expected.

Due to the tides, if oil escapes within the water column, it must be taken into account that the low-tide zone can also be threatened by oil pollution at low tide. If oil should leak into the creeks and in the nautical channel of the Elbe near the water surface, shallow water areas and beaches near the shore are primarily at risk of oil pollution during high tide, depending on the drifting of the oil slick.

Table 14: Recommended action for habitats / components in the Elbe estuary focus area

	Recommended actions	Parameters to be recorded	Data sheet	Habitats/Components in the focus region
Chemical monitoring				
Water **Sediment** **Biota**	– Chemical analysis of water is particularly relevant as long as oil is far from the coast. The analysis should show whether there is a deeper contamination of the water column and whether benthic habitats are threatened. – If oil threatens to land or has landed, sediment and biota (mussels) in the coastal shallow water area must be sampled. – To determine the HC contamination of fish, PAH metabolites can be analysed in the bile of, for example, flounder or eelpout. – Analysis of sea bird eggs for hydrocarbon exposure	– Total hydrocarbons (THC) – Aromatic HC/PAH – PAH metabolites in fish bile	Chemical monitoring	– Water column: in the early phase of an oil incident, if possible, screening of contamination using ultraviolet fluorescence spectrometry. – Sediment: priority examination near the coast and in the oil landfall area. – Mussels: should be analysed together with sediment samples.
Bioeffect monitoring				
Water **Sediment** **Biota**	– Bioeffects are optional, especially to be examined in the event of a major pollution incident. Biotests should be used to check whether water and sediment samples have toxic potential. – Biomarker examinations can optionally be carried out on mussels (infauna/epifauna) – Flounder and eelpout are particularly suitable for biomarker examinations on fish	– Bio tests with bacteria, unicellular algae, small crustaceans – Biomarker examinations	Bioeffect monitoring	– Biotests on water samples may be particularly relevant in areas remote from the coast in order to detect water column. Examination of sediment primarily in coastal areas with shallow water depths because contamination potential is particularly high there. – Biomarker: blue mussels as bioindicators for reef and hard substrates. In soft soils, the macoma and cockle species can also be used as bioindicators close to the shore

	Recommended actions	Parameters to be recorded	Data sheet	Habitats/Components in the focus region
Biological monitoring				
Macrozoobenthos	Sublittoral Soft substrates: – Examination of the benthic soft substrate fauna using Van Veen grab sampler – At least 20 grab samples per habitat, these can be distributed over a large area if necessary, number of sites according to size of the contaminated area and type of habitat, at least 4 sites – Beam trawler / dredge (5 min per transect) – Take suitable reference samples	– Species composition – Individual density (abundance) and biomass – Size spectra of mussel species found – Pollutant load for bioindication of suitable mussel species (see above) – Geophysical properties of the surface sediments – Hydrological parameters	Macrozoobenthos	– Sublittoral, deeper areas (silty and fine sandy soft substrates) – Soft substrates in the Elbe nautical channel – Soft substrates in the area of the Elbe estuary
	Eulittoral Soft substrates: – Examination of the benthic soft substrate fauna using a core sampler – At least 20 core samples per habitat, these can be distributed over a large area if necessary, number of sites according to the size of the contaminated area and type of habitat, at least 4 sites – Photographic documentation – Take suitable reference samples	Parameters as for sublittoral soft substrates.	Eulittoral sand, mixed and mud flats, coastal zone and beaches, macrozoobenthos mussel banks	– Silty and fine to coarse sandy soft substrates of the eulittoral of the outer coasts and Elbe estuary

	Recommended actions	**Parameters to be recorded**	**Data sheet**	**Habitats/Components in the focus region**
Macrozoobenthos	Sublittoral Soft substrates: – Examination of the benthic soft substrate fauna using Van Veen grab sampler – At least 20 grab samples per habitat, these can be distributed over a large area if necessary, number of sites according to size of the contaminated area and type of habitat, at least 4 sites – Beam trawler / dredge (5 min per transect) – Take suitable reference samples	– Species composition – Individual density (abundance) and biomass – Size spectra of mussel species found – Pollutant load for bioindication of suitable mussel species (see above) – Geophysical properties of the surface sediments – Hydrological parameters	Macrozoobenthos	– Sublittoral, deeper areas (silty and fine sandy soft substrates) – Soft substrates in the Elbe nautical channel – Soft substrates in the area of the Elbe estuary
	Eulittoral Soft substrates: – Examination of the benthic soft substrate fauna using a core sampler – At least 20 core samples per habitat, these can be distributed over a large area if necessary, number of sites according to the size of the contaminated area and type of habitat, at least 4 sites – Photographic documentation – Take suitable reference samples	Parameters as for sublittoral soft substrates.	Eulittoral sand, mixed and mud flats, coastal zone and beaches, macrozoobenthos mussel banks	– Silty and fine to coarse sandy soft substrates of the eulittoral of the outer coasts and Elbe estuary

	Recommended actions	Parameters to be recorded	Data sheet	Habitats/Components in the focus region
	Hard substrates, mussel banks: – Scratch samples for quantitative recording of the epifauna (20 x 20 cm) by inspection / diver – Consideration of any depth zoning that may occur (at least 3 scratch tests per depth level) – If available, sampling of small-scale soft substrate areas within reef areas using core sampler	Parameters as for sublittoral soft substrate	Reef, Mussel banks, Macrozoobenthos	– Blue mussel banks in the Wadden Sea parts of the study area – Artificial hard substrates (e.g., sheet piling in the neighbouring ports)
Macrophytobenthos	Macrophytes on soft substrates: – Widespread recording of eelgrass meadow and opportunistic green algae mats by means of remote sensing (aerial mapping) and in situ surface mapping (ground truthing) – If necessary, selective examination of permanent monitoring stations (if reference data is available)	– Surface area – Extension species – Species composition – Degree of coverage > 5% – Biomass – Location – Covering opportunistic algae mats	Macrophytes, Macrozoobenthos	– Silty and fine to coarse sandy soft substrates of the eulittoral of the outer coasts and Elbe estuary
	– Survey of emerging reed beds (according to "macrophyte" site type index STIm).	– Species composition – Colonisation – Vegetation zoning – Vitality/health	Macrophytes	– Soft substrates in the Elbe nautical channel – Soft substrates in the area of the Elbe estuary
	Macrophytes on hard substrates: – Macrophyte detection by means of a frame (50 x 50 cm) along a transect (possible establishment of permanent quadrats)	– Species composition – Amount of green and red algae – Number of opportunists – Coverage (%) with fucus	Macrophytes, mussel banks	– Blue mussel banks in the eulittoral of the study area, artificial hard substrate (see above)

	Recommended actions	Parameters to be recorded	Data sheet	Habitats/Components in the focus region
Salt marshes	– Vegetation survey on selected permanent areas / squares and/or transects – Recording of seasonal changes – Survey of invertebrate fauna at monitoring stations – Aerial photos for the first extensive recording of damaged vegetation and overall recording of vegetation during salt meadow regeneration – If necessary, recording the oiling of the soil and weathering / degradation over time	Vegetation: – Surface area – Species composition – Density, spread – Proportion of annual and perennial plants – Habitat-typical invertebrate fauna – (representative groups of endogean, epigeic, and phytal fauna): – Species spectrum – Abundance If necessary, recording of benthic fauna in aquatic areas (see Macrozoobenthos eulittoral soft substrate) – If necessary, recording avifauna (see Birds)	Salt marshes	– Salt marshes along the coastline of Dithmarschen and in the transition to the Weser estuary – Salt marshes in the transitional tidal Elbe – Salt marshes in the foreland of the island of Neuwerk – Salt marshes on the east of the island of Trischen
Fish	– Optional implementation of drift line monitoring to record dead and washed-up fish – Optional examinations with stow net fishery and/or small beam trawler	– Species composition – Species abundance – Species biomass – Age and length recording	Fish	– Transitional waters, coastal waters
Birds	– Implementation of drift line monitoring in combination with a drift experiment – Collection and disposal of dead birds, autopsy of a sample of dead birds – Potential rehabilitation of oiled birds – Monitoring of breeding success and number of	– Roosting birds: number of oiled birds as part of drift line monitoring, abundance – Breeding birds: breeding success, number of breeding pairs, content of PAHs in	Birds	– Offshore waters – Sandbanks – Dune islands – Flats – Salt meadows – Koogs / marshes

	Recommended actions	Parameters to be recorded	Data sheet	Habitats/Components in the focus region
	breeding pairs – Monitoring of resting sea and water bird populations based on ship, land, and aircraft survey	bird eggs		
Marine mammals	– Monitoring of harbour porpoise and grey seal not relevant – Haul-out sites for resting and pupping of harbour seal locally available and to be monitored	– Haul-out sites on traditional sandbanks – Mapping of distribution patterns – Injured / dead animals	Marine mammals	– Harbour seal May-Sept more common on sandbanks – Sandbanks in the mouth of the Outer Elbe – Medemgrund

8.3 Kieler Förde to Kiel lighthouse with adjacent habitats and shallow water areas

Photo: J. Voß

Kieler Förde extends over a length of 17 km from the southern tip in Kiel city centre to the outer fjord, where Kiel Bay begins. At its mouth it is about 6.5 km wide. The narrowest point, “Friedrichsorter Enge”, is about 1.9 km wide. It separates the outer fjord from the inner fjord. As an approach to the Kiel Canal and the Kiel ferry and cargo port, the Kieler Förde is of great importance for shipping. The entrance to the Kiel Canal is on the west side of the inner fjord, on the opposite side to the mouth of the Schwentine. Ship traffic is regulated by a traffic separation zone south-east of Kiel lighthouse. In the Friedrichsorter Enge area, the main nautical channel narrows to just 450 m.

From Schilksee to Neumühlen, the Kiel city area extends on both sides of the inner fjord, with dense urban development and industrial areas in the southern part of the inner fjord. Here the coastline is characterized over large areas by embankments, flood protection systems, and port facilities. The shore areas of the outer fjord mostly have sandy beaches.

With the exception of the outer, northern sea areas, only terrestrial protected areas, which area mostly landscape protection areas, are designated in the Kieler Förde. Areas of the outer fjord are part of the Natura 2000 network of Habitat Directive and BD sites (Figure 5). Soft substrates predominant on the seabed of the fjord. Increased proportions of silt occur in deeper areas and dredged channels. Hardly any natural hard substrates occur in the area. Eelgrass meadows are widespread in sandy shallow-water areas.

Overall, the Kieler Förde is a potentially accident-prone sea area due to the heavy shipping traffic in connection with a nautical channel, which is partly narrow, and the entrance to the Kiel Canal.

Habitats

The Kieler Förde is a coastal body of water that has been significantly modified by anthropogenic influences. In the coastal shallow-water areas, mostly sandy sediments occur, bordering on sandy beaches, which extend inland. In order to replace the past loss of hard substrates due to the removal of boulders for human use, stones were deposited onto the Falkensteiner Beach. According to the WFD classification, three main water-body types can be assigned to the study area. The inner Kieler Förde to Heikendorf is designated as a mesohaline inner coastal water (B2). The coastal areas of the outer fjord on the north (Bülk) and south side (Probstei) are classified as mesohaline open coastal waters (B3), while the central outer fjord is a meso-polyhaline open coastal water (B4).

Chemical monitoring

The contamination of the environment with oil/oil derivatives should be determined by chemical analysis of water, sediment, and biota. On reef and hard substrate structures, blue mussels can be used as bioindicators. Depending on the occurrence, the Baltic macoma and/or common cockle species can be used in soft substrates. When sampling close to the shore, smaller sand gapers that are not buried deep in the sediment, may also be suitable for the analysis.

Flounder and eelpout are particularly suitable for recording the contamination of fish by oil-based HC. Flounder can be found on the sandy bottoms of the fjord, while eelpout is an inhabitant of the eelgrass meadow/macrophyte stands.

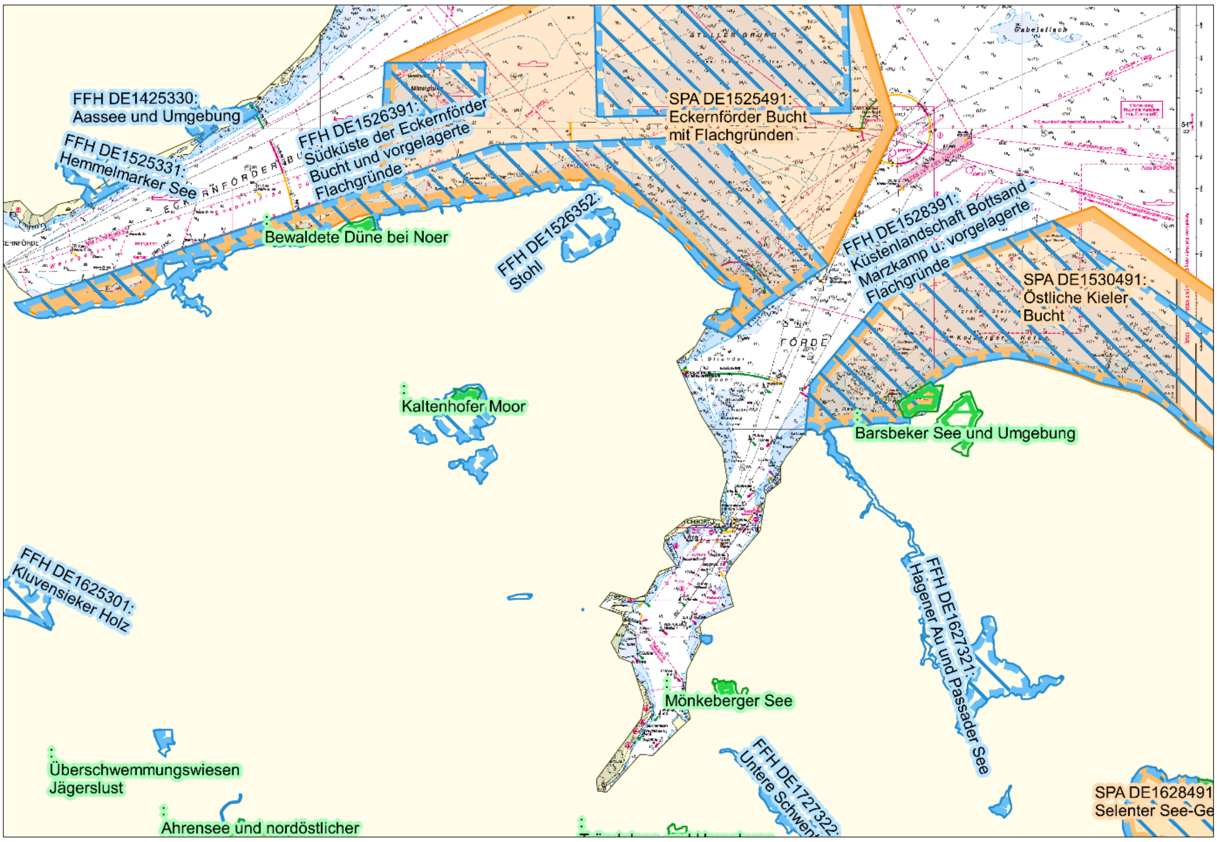


Figure 5: Greater Kieler Förde: depiction of electronic nautical chart with Habitats Directive, Birds Directive, and nature conservation sites

Bioeffect monitoring

In the event of severe environmental pollution, it is advisable to use bio-tests to evaluate the ecotoxic potential of contaminated water and/or sediment, in addition to chemical analysis.

Flounder or eelpout are suitable for the examination of biomarkers. As residents of eelgrass meadows, eelpout have a special indicator function for this habitat.

Biological monitoring

Benthos

Typical marine-euryhaline benthic **sand-bottom communities** of the southern Baltic Sea can be found on the predominant soft substrates in the Kieler Förde. In areas with an increased proportion of silt (in slow-flowing deeper areas or near the navigable channel), high abundances of characteristic polychaete species such as *Scoloplos armiger* and *Heteromastus filiformis* and other taxa such as oligochaetes and nematodes can be seen. Epibenthic taxa (barnacles, blue mussels, bryozoans, and cnidaria) are primarily found in the area where anthropogenic structures exist (port and industrial facilities, sheet piling, rock embankments). In some areas in sandy shallow-water areas, eelgrass meadows with a typical phytal fauna (for example *Gammarus salinus*, *G. oceanicus*, or *Idothea balthica*) occur. The dominant predatory epifauna species are the common starfish and the common shore crab. Due to the high anthropogenic character of the area, numerous benthic neophyte species are resident (for example *Rhithropanopeus harrisii*).

In the event of a pollution incident, pollution of the shallower coastal areas of the Kiel Fjord is to be expected. The macrozoobenthos species that settle here are the basic food for resident fish and seabird species.

Macrophytes in the Kieler Förde include angiosperm communities consisting of eelgrasses and spiral ditchgrass. As part of a permanent monitoring point on the eastern bank of Kieler Förde around Heikendorf, Fucus spp. are recorded in the shore area and eelgrass down to a water depth of about 3.70 m.

Salt marshes

Remnants of salt marshes only occur in the study area at the eastern exit of the fjord in the area of the Bottsand nature reserve.

Fish

The Kieler Förde is heavily influenced by human structures and activities such as embankments, port facilities, and shipping traffic, but shows a very heterogeneous habitat structure (e.g., eelgrass meadow and extensive stone fields). This means that at least 30 different fish species use the fjord as a habitat. **Permanent residents** are, for example, the shorthorn sculpin (bull-rout) and eelpout as well as various goby species, but also salt-tolerant freshwater species such as perch. Sea stickleback and three-spined stickleback are typical inhabitants of eelgrass meadows. For cod and herring, the fjord primarily serves as a nursery for larvae and young fish, but is also an important spawning area for the herring. The varied habitat structures offer them good hiding places and a sufficient food base. Lured by the river water of the Schwentine, sea trout come to Kieler Förde on their spawning migrations.

The mouths of the Strander Au, Fuhlenau, Hagener Au, and Barsbeker Au tributaries are designated as fishery free zones.

In the event of an oil/chemical incident, especially the shallow coastal areas of the Kieler Förde would be at risk. These serve various flatfish species (for example flounder), but especially cod and herring as **nursery and spawning areas** (only the herring) and are an important habitat for other small shallow-water fish species.

Birds

The main **breeding bird population** in the study area is concentrated on the "Bottsand" nature reserve on the Outer Kieler Förde. On its sand spit, red-breasted merganser, eider, shelduck, mute swan, common gull, and various shorebirds, terns, and dabbling duck species breed. In the event of an oil incident in the Kiel Bay, the breeding birds on "Bottsand" would be at risk, because their breeding grounds are located on the low-lying sand spit directly on the outer coast of the Baltic Sea. For this reason, the probability is very high that the spit itself (and thus the immediate vicinity of the nest sites) will be contaminated by oil. The breeding population of the little tern is of special interest. The species is listed in Appendix I of the BD (79/409/ EEC). The population of this species (which is threatened with extinction in Germany and classified as critically endangered in Schleswig-Holstein) has been increasing on Bottsand since 2007, and in 2014 reached 27 breeding pairs.

The study area includes parts of Birds Habitat site DE1525-491 "Eckernförder Bucht mit Flachgründen" and DE1530-491 "Östliche Kieler Bucht". The outer areas of Kieler Förde (in particular the shallow water area Stoller Grund) are one of the **most important wintering areas** for sea ducks (eider, common scoter, long-tailed duck) and great crested grebes. Little grebe regularly overwinter in large numbers in the sheltered port areas of Kiel. At Heikendorf, large gatherings of herons and occasionally greater scaup regularly occur. There is a regularly occupied cormorant roost near Friedrichsort. Razorbills and red-throated divers occur regularly stay off the coast.

In the event of an oil incident, sea- and water-birds in the offshore area may, under certain circumstances, be particularly affected by pollution. In general, the species groups divers, grebes, auks, and sea ducks are considered to be the species groups with the highest sensitivity to oil pollution.

"Bottsand" nature reserve has one of the largest wind induced tidal flats on the Schleswig-Holstein Baltic Sea coast. It is used by numerous water birds and waders for foraging. If an oil spill occurred in the Kieler Förde, however, direct pollution of the tidal flat area can be assumed to be light because the oil can only enter the area where the tidal flats are situated through the narrow channel to Wendtorf Marina.

Marine mammals

Harbour porpoise occur all year round in the Kieler Förde. They are part of the Baltic Sea population, which migrates from the Great Belt towards the Pomeranian Bay in summer. The period between June and August is considered to be a particularly sensitive time for harbour porpoise, due to mating (July - August), calving (June - July), and rearing, as well as the higher densities, which occur in spring and summer,. Young animals, which would be particularly endangered in the event of a pollution incident, are rarely seen in the Kieler Förde. Overall, the risk of harbour porpoise of falling victim to a pollution incident in the area under consideration can be classified as low.

Harbour seals do not have any firmly established haul-out sites for resting and breeding along the entire German Baltic Sea coast. In the Kieler Förde they only appear as visitors.

Grey seals occur along the German Baltic Sea coast, mainly in the eastern coastal waters. In recent years, grey seals have been sighted more and more frequently in the coastal waters of Mecklenburg-Western Pomerania, so that a recolonisation of the German Baltic Sea by this species is probably just beginning. However, to this day there are no firmly established haul-out sites with regular reproduction on the German Baltic Sea coast. Grey seals only appear as rare visitors in the Kieler Förde and Kiel Bay.

Overall, in the event of a pollution incident in the focus area, there is no significant risk for harbour seals and grey seals. The closest mixed colony of harbour seals and grey seals is on Rødsand south of the Danish island of Falster (Dietz et al. 2003). If individual oil victims occur, it cannot be ruled out that they are individuals from this colony.

Recommendations for action in the event of a pollution incident

Guidelines for the monitoring of components and habitats in the focus region "Kiel Förde to Kiel Lighthouse" after an oil incident, are listed in Table 15. Further information on methods can be found in the data sheets specified in this table. Response measures and immediate monitoring measures are to be carried out in the areas considered most sensitive in VPS at the time of action (see VPS-sensi). In particular, these include the shore areas of the outer fjord and the BD sites "Eckernförder Bucht mit Flachgründen" and "Östliche Kieler Bucht". In particular, the landing zones of the oil and the coastal regions should be monitored, since this is where the most massive environmental damage is to be expected. The information stored in the VPS must be used to coordinate monitoring measures (shore types, land photos and orthophotos, sensitivity, etc.). Insofar as near-natural beach sections, which are generally rarely used for tourism, are affected by oil contamination, the beach vegetation that may be present there must also be recorded as a monitoring component.

Table 15: Recommended action for habitats / components in the Kieler Förde focus area

	Recommended actions	Parameters to be recorded	Data sheet	Habitats/Components in the focus region
Chemical monitoring				
Water **Sediment** **Biota**	– Chemical analysis of water is particularly relevant as long as oil is far from the coast. The analysis should show whether there is a deeper contamination of the water column and whether benthic habitats are threatened. – If oil threatens to land or has landed, sediment and biota (mussels) in the coastal shallow water area must be sampled. – To determine the HC contamination of fish, PAH metabolites can be analysed in the bile of, for example, flounder or eelpout.	– Total hydrocarbons (THC) – Aromatic HC/PAH – PAH metabolites in fish bile	Chemical monitoring	– Water column: in the early phase of an oil incident, if possible, screening of contamination using ultraviolet fluorescence spectrometry. – Sediment: priority examination near the coast and in the oil landfall area. – Mussels: should be analysed together with sediment samples.
Bioeffect monitoring				
Water **Sediment** **Biota**	– Bioeffects are optional, especially to be examined in the event of a major pollution incident. Biotests should be used to check whether water and sediment samples have toxic potential. – Biomarker examinations can optionally be carried out on mussels (infauna/epifauna) – Flounder and eelpout are particularly suitable for biomarker examinations on fish	– Bio tests with bacteria, unicellular algae, small crustaceans – Biomarker examinations	Bioeffect monitoring	– Biotests on water samples may be particularly relevant in areas remote from the coast in order to detect water column. Examination of sediment primarily in coastal areas with shallow water depths because contamination potential is particularly high there. – Biomarker: blue mussels as bioindicators for reef and hard substrates. In soft soils, the macoma and cockle species can also be used as bioindicators close to the shore – In eelgrass meadows the eelpout is suitable for biomarker examinations.

	Recommended actions	Parameters to be recorded	Data sheet	Habitats/Components in the focus region
Biological monitoring				
Macrozoobenthos	Sublittoral soft substrates: – Examination of benthic soft substrate fauna using Van Veen grab sampler – At least 20 grab samples per habitat, these can be distributed over a large area if necessary, number of sites according to the size of contaminated area and type of habitat, at least 4 sites – Beam trawl / dredge (5 min per transect) – Documentation of the sublittoral areas using UW video / ROV – Take suitable reference samples	– Species composition – Individual density (abundance) and biomass – Size spectra of mussel species found – Geophysical properties of surface sediments – Hydrological parameters	Macrozoobenthos, sandbanks	– Sublittoral soft substrates in deeper areas of Kieler Förde
	Eulittoral soft substrates: – Examination of benthic soft substrate fauna using a core sampler – At least 20 core samples per habitat, these can be distributed over a large area if necessary, number of sites according to the size of contaminated area and type of habitat, at least 4 sites – Photographic documentation – Take suitable reference samples	Parameters as for Sublittoral Soft substrates	Eulittoral sand-, mixed flats and mud flats, coastal zone and beaches, macrozoobenthos	– Fine to coarse sandy soft substrates of the Eulittoral (shore area) – Wind flats in the Bottsand area

	Recommended actions	**Parameters to be recorded**	**Data sheet**	**Habitats/Components in the focus region**
	Hard substrates, mussel banks: – Scratch samples for quantitative recording of the epifauna (20 x 20 cm) by inspection / diver – Consideration of any depth zoning that may occur (at least 3 scratch tests per depth level) – If available, sampling of small-scale soft substrate areas within reef areas using core samplers – Photographic documentation, contaminated areas in the sublittoral are documented with underwater video (preservation of evidence), condition evaluation with underwater video	Parameters as for sublittoral soft substrates	Reef, mussel banks, macrozoobenthos	– Sublittoral hard substrate / rock embankment in the Falkensteiner Strand area – Artificial hard substrates (e.g., sheet pile walls in the area of the Inner Kieler Förde, Wendtorf Marina)
Macrophytobenthos	Macrophytes on soft substrates: – Underwater video to record the depth distribution of eelgrass (*Zostera marina*) and macroalgae; 5 video transects/ sites or coastline. – Recording of seed-bearing plant species (angiosperms) and coverage by frame sampling (diver) along a depth transect – Sampling of macrophytes and sediment up to the limit of distribution in defined depths of (0.25; 0.5; 0.75; 1.0; 1.5; 2.0; further in 1 m steps). – For each depth level, 5 mapping areas (1 m²) are recorded, which are located at a distance of 5 to 10 m from one another.	– Species composition – Vegetation boundary – Spermatophyte depth limit – Characeae depth limit – Share of opportunists in Zostera stands – Biomass – Extent (species) – Surface area	Eelgrass meadow, macrophytobenthos, macrozoobenthos	– Sublittoral soft substrates in the outer area of the Kieler Förde
	– Diving examinations at different depths – Sampling of macrophytes and sediment up to the distribution limit in defined depth sections (0.25; 0.5; 0.75; 1.0; 1.5; 2.0; further in 1 m steps). – For each depth level, 5 mapping areas (1 m²) are recorded, which are located at a distance of 5 to 10 m from one another.	– Species composition – Definition of plant community – Spermatophyte depth limit – Characeae depth limit – Extent (species) – Surface area	Eelgrass meadow, macrophytes, Macrozoobenthos	– Fine to coarse sandy soft substrates Kieler Förde – Wind flats in the Bottsand area

	Recommended actions	Parameters to be recorded	Data sheet	Habitats/Components in the focus region
	– Recording of the species, surface area, and biomass			
	Macrophytes on hard substrates: – Underwater / video to record condition – Scratch frame sampling along transects by divers – Recording the density and determining species population	– Species composition (occurrence and frequency of macrophytes) – Degree of coverage – Density – Depth limit for Fucus spp.	Macrophytes reef	– Sublittoral hard substrate
Salt meadows	– Vegetation survey on selected permanent areas / squares and/or transects – Recording of seasonal changes – Aerial photos for the first extensive recording of damaged vegetation and overall recording of vegetation during salt meadow regeneration – If necessary, recording the oiling of the soil and weathering / degradation over time	– Surface area – Species composition – Proportion of annual and perennial plants – Habitat-typical invertebrate fauna – If necessary, recording of habitat-typical avifauna	Salt meadows	– Salt meadows around Bottsand nature reserve
Fish	– Optional drift line monitoring to record dead and washed up fish – Optional examinations with beach seine (3 parallel hauls) and/or multi-mesh net	– Species composition – Species abundance – Species biomass – Age and length recording	Fish	– Coastal waters of the fjord – Small fish fauna of the salt meadows
Birds	– Implementation of drift line monitoring in combination with a drift experiment – Collection and disposal of dead birds, autopsy of a sample of dead birds – Analysis of oil contamination (preservation of evidence) – Potential rehabilitation of oiled birds – Monitoring of breeding success and number of breeding pairs – Monitoring of -sea- and water-bird populations based on ship, land, and aircraft surveys	– Roosting birds: number of oiled birds as part of drift line monitoring, abundance – Breeding birds: breeding success, number of breeding pairs, content of PAHs in bird eggs	Birds	– Outer coast and wind flats in the Bottsand area – Offshore waters (e.g., Stollergrund) – Spit

	Recommended actions	Parameters to be recorded	Data sheet	Habitats/Components in the focus region
Marine mammals	– Recording of dead animals (harbour porpoise, seals) as part of drift line monitoring	– possibly dead animals (section / cause of death)	Marine mammals	Grey seal/Harbour seal: – No known resting areas within focus area – Extended catchment area – Wismar Bay (Lieps, Langenwerder) – Rødsand (Denmark / Falster)

8.4 Kadetrinne to Rostock Port (Kadetrinne and approaches to Rostock and adjacent Graal-Müritz and Darß nature reserves)

The “South of Gedser” traffic separation scheme and approaches to Rostock are among the busiest shipping routes in the southern Baltic Sea. In particular, the Kadetrinne is considered to be a difficult and therefore accident-prone nautical channel with heavy ship traffic, which is forecast to increase.

The “South of Gedser” traffic separation scheme overlaps in the EEZ to a large extent with the approximately 100 km² of the “Kadetrinne” HD site (Figure 6). The channel system located here has an important function for the exchange of different groups of species and is of crucial importance for the supply of the Baltic Sea with oxygen-rich, salty Kattegat waters. The water exchange, current, and associated good oxygen ratios, as well as sediment diversity (occurrence of the FFH habitat type “reef”), create a very high biodiversity in this small protected area, which is very important for the Baltic Sea ecosystem[1].

The “Darßer Schwelle” Habitat Directive site (384 km²) occurs in the eastern part of the area within German territorial waters. This marine area between the coast of the Darß (“West Strand”) and the EEZ is made up of a mosaic of sandbank and reef protected habitat types. In its eastern part, there are erosion and deposition areas at Darßer Ort and Prerowbank.

In addition, coastal stretches of several national protected areas, which partially overlap with international protected areas (e.g., Stoltera nature reserve), would be threatened by a pollution incident. The boundaries of the respective protected areas can be found in the VPS.

The spatial overlap of important marine protected areas with one of the world's most heavily frequented shipping routes entails a high risk potential for the areas concerned. In the event of a pollutant/oil incident, this requires an extant, immediately applicable marine environment monitoring plan.

Habitats

Darßer Schwelle, which dominates the focus area, is a submarine glacial till ridge between the Danish islands of Falster and Mön and the German peninsula of Fischland-Darß, which separates the Baltic Sea from the Arkonasee or the central Baltic Sea. The Kadetrinne cuts through the Darßer Schwelle and consists of numerous channels that are up to 32 m deep. Up to 70% of the water exchange between the Baltic Sea and the North Sea takes place through the Kadetrinne. It is therefore of crucial importance for supplying the Baltic Sea with salt and oxygen-rich North Sea water. The Kadetrinne is an important link between Mecklenburg Bay and the central Baltic Sea with an ecological networking function as a partial habitat or migration route for harbour porpoise, for fish migrating from rivers to spawn, and for other marine organisms such as the larvae of marine invertebrate species.

[1]https://www.bfn.de/fileadmin/BfN/presse/2015/Dokumente/2015-08-04_Schutzgebiet_Kadetrinne-PM.pdf

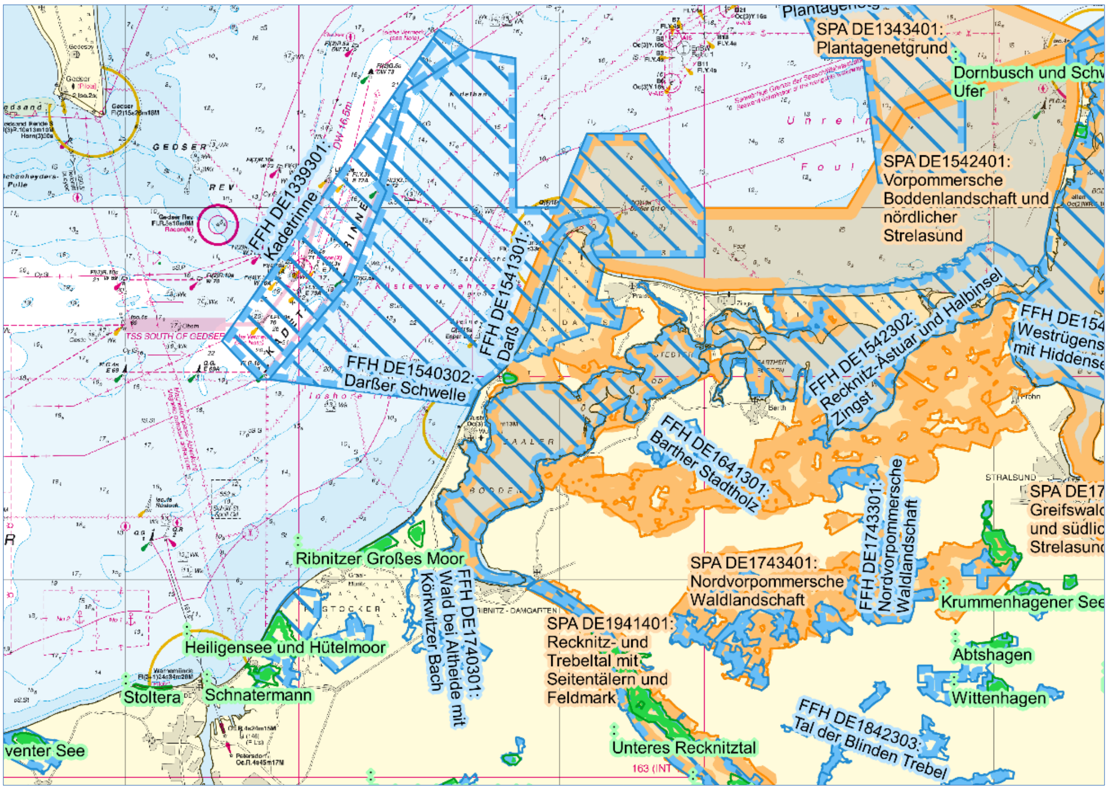


Figure 6: Greater Rostock/Graal-Müritz/Darß: nautical chart with Habitats Directive, Birds Directive, and nature conservation sites (IfAÖ 2016)

The sea floor in the Kadetrinne is made up of very different sediment types, which occur in a very small space. They consist of coarse sand and gravel, in which glacial till and a high concentration of boulders (reef habitat type) are scattered. Sandy silt is deposited in the deepest parts of the channels.

In the "Kadetrinne" area, several reefs occur as habitat types (HT 1170) from Annex I of the HD (92/43/EEC) which extend into the actual channel from the German part of the Darßer Schwelle. Other extensive reefs are also located in the area of the approaches to Rostock ("Warnemünder Reef"), west of Rostock ("Stoltera") and in the area of Plantagenetgrund. In particular, due to the genesis of this area, there is often a small-scale alternation of sandbanks (HT 1110) and the habitat type "Species-rich gravel, coarse sand and shell habitats in marine and coastal areas"[2].

Chemical monitoring

Contamination of the environment with oil/oil derivatives should be determined by chemical analysis of water, sediment, and biota. Blue mussels can be used as bioindicators on reef and hard substrate structures. Depending on its occurrence, Baltic macoma (*Macoma balthica*) and/or common cockle species (*Cerastoderma* sp.) can mostly be used in soft substrates. In the case of sampling close to the shore, smaller sand gaper clams (*Mya arenaria*), which do not sit deep in the sediment, are also suitable for analysis.

The widespread fish species flounder and eelpout are particularly suitable for recording the contamination of fish by HC.

[2] https://www.bfn.de/fileadmin/MDB/documents/themen/meeresundkuestenschutz/downloads/Marine-Biotoptypen/Biotoptyp-Kies-Sand-Schillgruende.pdf

Bioeffect monitoring

In the case of severe environmental pollution, it is advisable to use bio-tests to evaluate the ecotoxic potential of contaminated water and/or sediment, in addition to chemical analysis.

Flounder or eelpout are suitable for the examination of biomarkers. As residents of eelgrass meadows, eelpout have a special indicator function for this habitat.

Biological monitoring

Benthos

Since the marine habitats in the Kadetrinne area are little-disrupted by human activities, and the effects of the general eutrophication of the Baltic Sea have not led to structural changes, it has high biodiversity. It is a marine-euryhaline benthic community that is, for the southern Baltic Sea, very species-rich. Large densities of blue mussels (*Mytilus edulis*) occur in the **numerous reef areas**. Epibenthic taxa such as sponges, anthozoa, bryozoa, balanids, tunicata, the polychaetes *Nereimyra punctata* and *Nymphon brevirostre* are typical colonisers of reefs in the Kadetrinne area. In the Plantagenetgrund area, where habitats (sandbanks, reef, coarse sand) alternate on a small scale, characteristic soft substrate species such as the sand gaper clam (*Mya arenaria*), coarse sand species (Polychaetes *Ophelia rathkei*, *Travisia forbesii*) and typical reef inhabitants can be found. Blue mussel banks and sand gaper clams form the food basis for numerous benthophage sea bird species (for example long-tailed duck, common scoter). In the Kadetrinne area, brown and red algae predominantly grow on rocks and form the basis for a species-rich phytal community. Notable **occurrences of macrophytes** are to be expected in particular in the reef areas of the "Kadetrinne" Habitat Directive site and within the adjoining "Darßer Schwelle" Habitat Directive site to the west. In particular, larger occurrences of red algae (e.g., *Ceramium rubrum*, *Delesseria sanguinea*) and brown algae (e.g., *Chorda filum*, *Laminaria saccharina*) are to be expected. Dense stands of eelgrass (*Zostera marina*) grow in the outer coastal waters, especially off the Zingst peninsula or west of the island of Hiddensee.

Salt marshes

Salt marshes are found in the Rostock Heath area in the "Hüttelmoor/Rostocker Heide" nature reserve and in Darß-Zingster-Boddenkette. Both areas are not directly endangered by a potential pollution incident occurring on the outer coast.

Beach vegetation

Large parts of the study area have no natural beach vegetation due to intensive human use. Significant natural beach vegetation can only be expected in less frequented or closed beach areas. Usually stranded oil does not threaten vegetation.

Damage to the vegetation in near-natural beach areas is more likely to come from response and cleaning measures than from the oil itself. The regeneration of vegetation damaged by response measures should be monitored.

Fish

No fishery-free areas are designated in the study area. Cod spawn in the deeper areas of Mecklenburg Bay, so its reproduction is not likely to be endangered by oil pollution. The coastal areas, which are potentially threatened by oil pollution, serve as a habitat and nursery area for flounder and turbot in particular as well as other non-commercial fish species. Due to the very high number of offspring and the associated potentially rapid repopulation of contaminated sea areas, it is to be expected that harmful effects at the population level cannot be clearly demonstrated. Fish monitoring is, therefore, not a priority. Individual fish species such as flounder and eelpout are important as bio-indicators for recording chemical pollution and the effects of biological pollutants.

Marine mammals

Harbour seal and Grey seal are visitors to the study area. There are no permanent haul-out or rearing sites. Potential haul-out sites are sandbanks and unused stretches of beach in the National Park "Vorpommersche Boddenlandschaft" . At the southern tip of the Danish island of Falster, there is a mixed colony of harbour seal and grey seal on Rødsand.

Harbour porpoise occur in relatively high abundance, as regular acoustic monitoring surveys have shown. At most, a direct contact with oil when breathing on the water surface could occur in the case of a large oil slick. Targeted monitoring of potential harmful effects from oil is not possible with harbour porpoise. Increased mortality would be reflected in increased records of dead animals.

Birds

The main **breeding bird populations** in the focus area are concentrated in two regions: the islands of Kirr, Barther Oie, and Schmidt-Bülten, in the Darß-Zingster chain of lagoons, regularly host mute swan, greylag goose, Egyptian goose, shelduck, tufted duck, red-breasted merganser, different types of dabbling duck, shorebirds, seagulls and terns as breeding birds. The second main breeding area is Pagenwerder. The island is located in Breitling, directly on the Warnemünde main channel and the navigable channel of Rostock Port. Mute swan, greylag goose, Egyptian goose, red-breasted merganser, various types of dabbling duck, shorebirds, seagulls and terns regularly breed there.

In the event of an oil incident in Kadetrinne, the breeding population of the Darß-Zingst chain of lagoons are only slightly threatened because they are protected from direct oil influence by the land masses of Darß-Zingst. The land-locked Pagenwerder breeding grounds are hardly at risk in the event of an oil incident, because the narrow entrance to Warnemünde can be secured against any oil ingress. By contrast, an oil incident in the Rostock Port area during the breeding season, would be a great threat to the breeding birds of Pagenwerder. The main channel and the navigable channel to the industrial harbour, which branches off from this, are less than 200 m from Pagenwerder, and the oil harbour is less than 1.5 km away.

Passage migrant bird populations in the offshore waters within the focus area comprise the typical spectrum of Baltic Sea species. Of particular importance are the occurrences of eider, long-tailed duck, common scoter, divers, red-necked grebe, and Slavonian grebe. In the event of an oil incident in the Kadetrinne, sea- and water-birds in the offshore area may be particularly affected by oil pollution. In general, divers, grebes, auks and sea ducks are the species groups considered to have the highest sensitivity to oil pollution.

Recommendations for action in the event of a pollution incident

Guidelines for the monitoring of components and habitats in the focus region "Rostock/Graal-Müritz/Darß" after an oil incident, are listed in Table 16. Further information on methods can be found in the data sheets specified in this table. Response measures and immediate monitoring measures are to be carried out in the areas considered most sensitive in VPS at the time of action (cf. VPS). These include, in particular, the outer coast of the Darß as well as the Stoltera nature reserve and Unterwarnow (Breitling/Pagenwerder/Schnatermann nature reserve). The Kadetrinne reefs are not directly threatened by oil because of the water depth of 18-32 m, as long as oil escapes on the surface of the water. Reef structures and the sublittoral sea floor are potentially exposed to a pollution risk if oil leaks from a damaged ship at greater water depths, for example if the oil is a result of a grounding or collision, and is potentially drifted by sea bed currents.

In the areas of sublittoral hard substrate or geogenic/biogenic reef (Warnemünder Reef, Kadetrinne, Darßer Schwelle, Plantagenetgrund), which are numerous in the area, scratch samples and samples taken manually by divers as well as visual assessment using underwater video can be used for biological monitoring. Further methodological information is given in the data sheets in Table 16.

Table 16: Recommended action for habitats / components in the Rostock/Graal-Müritz/Darß focus area

	Recommended actions	Parameters to be recorded	Data sheet	Habitats/Components in the focus region
Chemical monitoring				
Water **Sediment** **Biota**	– Chemical analysis of water is particularly relevant as long as oil is far from the coast. The analysis should show whether there is a deeper contamination of the water column and whether benthic habitats are threatened. – If oil threatens to land or has landed, sediment and biota (mussels) in the coastal shallow water area must be sampled. – To determine the HC contamination of fish, PAH metabolites can be analysed in the bile of, for example, flounder or eelpout.	– Total hydrocarbons (THC) – Aromatic HC/PAH – PAH metabolites in fish bile	Chemical monitoring	– Water column: spatial determination of the contamination. – Sediment: priority examination near the coast and in the oil landfall area. Depending on the threat or damage situation, sensitive areas / HD sites (Kadetrinne, National Park) – Mussels: should be analysed together with sediment samples.
Bioeffect monitoring				
Water **Sediment** **Biota**	– Bioeffects are optional, especially to be examined in the event of a major pollution incident. Biotests should be used to check whether water and sediment samples have toxic potential. – Biomarker examinations can optionally be carried out on mussels (infauna/epifauna) – Flounder and eelpout are particularly suitable for biomarker examinations on fish	– Bio tests with bacteria, unicellular algae, small crustaceans – Biomarker examinations	Bioeffect monitoring	– Biotests on water samples may be particularly relevant in areas remote from the coast in order to detect water column. Examination of sediment primarily in coastal areas with shallow water depths because contamination potential is particularly high there. – Biomarker: blue mussels as bioindicators for reef and hard substrates. In soft soils, the macoma and cockle species can also be used as bioindicators close to the shore – Eelpout is suitable for biomarker examinations in the areas at Darßer Ort and Warnemünde
Biological monitoring				

	Recommended actions	Parameters to be recorded	Data sheet	Habitats/Components in the focus region
Macrozoobenthos	Sublittoral soft substrates: – Examination of benthic soft substrate fauna using Van Veen grab sampler – At least 20 grab samples per habitat, these can be distributed over a large area if necessary, number of sites according to the size of contaminated area and type of habitat, at least 4 sites – Beam trawl / dredge (5 min per transect) – Documentation of the sublittoral areas using UW video / ROV – Take suitable reference samples	– Species composition – Individual density (abundance) and biomass – Size spectra of mussel species found – Contamination load for bioindication of suitable mussel species (see above) – Geophysical properties of surface sediments – Hydrological parameters	Macrozoobenthos, sandbanks	– Sublittoral soft substrates of the outer coasts and Breitling, sandbanks in the Darßer Ort / Darßer Schwelle area
	Eulittoral soft substrates: – Examination of benthic soft substrate fauna using a core sampler – At least 20 core samples per habitat, these can be distributed over a large area if necessary, number of sites according to the size of contaminated area and type of habitat, at least 4 sites – Photographic documentation – Take suitable reference samples	Parameters as for sublittoral soft substrates	Eulittoral sand-, mixed flats and mud flats, coastal zone and beaches, macrozoobenthos	– Fine to coarse sandy soft substrates of the eulittoral of the outer coasts (Warnemünde, Markgrafenheide, Rostock Heath Beach, Graal-Müritz, Neuhaus, Dierhagen, Hohes Ufer Ahrenshoop, Weststrand Darß, Darßer Ort, Nordstrand Prerow, Zingster Strand, Nordstand Sundische Wiese östlich Zingst) – Wind flats in the Bock area
	Hard substrate, mussel banks: – Photographic documentation, contaminated areas in the sublittoral are documented with Scratch samples for quantitative recording of the epifauna (20 x 20 cm) by inspection / diver – Consideration of any deep zoning that may occur (at least 3 scratch tests per depth level) – If available, sampling of small-scale soft substrate areas within reef areas using core samplers – Underwater video (preservation of evidence), condition evaluation with underwater video	Parameters as for Sublittoral Soft substrates	Reef, mussel banks, macrozoobenthos	– Eulittoral boulder / pebble beach in the Stoltera / Hohes Ufer (Wustrow) area – Sublittoral hard substrate / Reef / Mussel banks: Warnemünder Reef east of the Approaches to Rostock, Reef in Kadetrinne area, Darßer Schwelle, Plantagenetgrund – Artificial hard substrate (e.g., sheet pile walls in the Breitling / Unterwarnow / Nothafen Darßer Ort area, Dierhagen / Wustrow breakwater areas)

	Recommended actions	Parameters to be recorded	Data sheet	Habitats/Components in the focus region
Macrophyto-benthos	Macrophytes on soft substrates: – Recording of seed-bearing plant species (angiosperms) and coverage by frame testing (diver) along a deep transect – Sampling of macrophytes and sediment up to the limit of distribution in defined depths of (0.25; 0.5; 0.75; 1.0; 1.5; 2.0; further in 1 m steps). – For each depth level, 5 mapping areas (1 m²) are recorded, which are located at a distance of 5 to 10 m from one another.	– Species composition (occurrence and abundance of macrophytes) – Extent (species) – Surface area – Location – Depth distribution (limits of distribution) – Size spectra of the mussel species	Macrophytes macrozoobenthos reef	Sublittoral soft substrates of inner coastal waters (e.g., Breitling, Nordrügensche Bodden waters, waters around the northern part of Hiddensee)
	– Underwater video to record the depth distribution of eelgrass (Zostera marina) and macroalgae; 5 video transects/ sites or coastline. – Diving surveys at different depths (dense eelgrass stands 0-2 m, 5-7 m) to determine the species, degree of coverage, and biomass		Macrophytes macrozoobenthos	Sublittoral soft substrates of outer coastal waters (e.g., off the Zingst peninsula and west of the island of Hiddensee)
	Macrophytes on hard substrates: – Underwater / video to record the condition, frame sampling by divers to record the density and determine species population	– Species composition (occurrence and frequency of macrophytes) – extent (species) – Degree of coverage – Location	Macrophytes macrozoobenthos reef	Reef / reef structures of outer coastal waters (e.g., Kadetrinne, Plantagenetgrund)
Fish	– Optional drift line monitoring to record dead and washed up fish – Optionally network examinations with beach seine (3 parallel hauls) and / or multi-mesh (3 layers) – Optional examinations with a small bottom trawl (inner Bodden waters)	– Species composition – Species abundance – Species biomass – Age and length recording	Fish	– Inner / outer coastal waters
Birds	– Implementation of drift line monitoring in combination with a drift experiment – Collection and disposal of dead birds, autopsy of a sample of dead birds	– Resting birds: number of oiled birds as part of drift line monitoring, abundance	Birds	– Outer coast and wind flats in the Bock area – Offshore waters (e.g., Plantagenetgrund) – Breitling

	Recommended actions	Parameters to be recorded	Data sheet	Habitats/Components in the focus region
	– Potential rehabilitation of oiled birds – if necessary, sampling of eggs for PAH content – Monitoring of breeding success and number of breeding pairs – Monitoring of resting sea and water bird populations based on ship, land, and aircraft survey	– Breeding birds: breeding success, number of breeding pairs, content of PAHs in bird eggs		
Marine mammals	– Recording of dead finds (harbour porpoise, seals) as part of drift line monitoring	– possibly dead finds (section / cause of death)	Marine mammals	– No known resting areas within focus area – Large Harbour seal colony on Rødsand (Denmark / Falster)

9 Methodological instructions

9.1 Water sampling

Sample volume for determination of:

- BTEX/volatile HC: 50 ml (GC-MS in "scan mode")
- THC and individual hydrocarbon components (alkanes, aromatics, biomarkers): 1 – 4 litres (depending on the analytical limit of quantification)

Devices/sample container

- If possible, water samples should be taken directly with a sample container to avoid the risk of cross-contamination.
- Samples for determination of THC and detailed analysis of oil components (e.g., PAHs, chemical fingerprints) must be collected in glass containers that are free from organic residues. Because of the sensitivity of carbons to photodegradation, brown glass bottles should preferably be used.
- Samples of highly volatile oil components (BTEX) should be taken in special, tightly closing sample vessels (VOA glass).
- If a water sampler is used, it should be possible to open and close it at the sampling depth.
- If oil components are present, sampling devices must be cleaned or decontaminated before each use.
- Decontamination:
    - Mechanically remove any adhering oil residues with paper or fabric (wipe off).
    - Wash with water with a detergent (washing-up liquid or similar), then with clean water.
    - Rinse with methanol or acetone, then with hexane and allow the solvent to evaporate
    - Pay attention to personal protective equipment and proper disposal of chemicals.

Carrying out the sampling

- Taking samples near the water surface in the range of 0 – 1 m water depth. Samples close to the ground are taken 1 m above the sediment.
- Water samplers must be brought into position in the closed state and opened and closed *in situ*.
- Samples should be taken first from a reference area, then from the least contaminated area, and then from increasingly contaminated sites.
- Before using the device, the water surface must be cleaned of any oily deposits. This has to be done carefully so that no oil gets into the water. Absorbent materials can be helpful here.

Storage/transport

- Storage of volatile organic substances (VOA) in VOA tubes: they can be stored for up to 14 days at 4 °C in the dark without loss of sample integrity.
- THC and PAH analysis: samples can be acidified with 1 ml 6N HCL/litre.
- Immediately after sampling, water samples should be stored in a cooling container.
- At 4 °C and in the dark, water samples can be stored for up to 7 days without loss of sample integrity.

Notes

Factors that can lead to the contamination of water samples must be avoided and possibly documented (oil film, weather conditions, swell, etc.). Potential sources of contamination are, for example, exhaust gases, lubricants, oiled surfaces, etc.

9.2 Sediment sampling

Sample volume for the determination of:

- THC and aromatics/PAH: 500 ml
- Grain size analysis: 100g/100ml

Devices/sample container

- A Van Veen grab sampler, an Ekman Birge grab or a box grab are suitable for sampling sediments from a ship.
- In the Eulittoral and in the shallow water zone near the shore, sediment cores can be extracted with a core sampler.
- In dry sediment areas, a relatively undisturbed sediment core can also be extracted with a spade/shovel.
- Aluminium bowls and lids should be used for the analysis of oil components (THC, PAH). Alternatively, glass container can also be used; their lids should have Teflon seals. (Alternatively, the glass opening can also be covered with an aluminium foil before the lid is screwed on.)
- Samples for grain size analysis can be collected in Ziploc bags.

Carrying out sampling

- In oiled areas, the collection devices must be decontaminated at the beginning and between samplings.
- Contamination of samples with oil on the water surface should be avoided.
- In the intertidal zone and in the shallow coastal zone, sediment samples can be taken by hand with a core sampler or an Ekman Birge grab, and at easily accessible places with a shovel.
- When taking samples in the sublittoral, the sampling device (Van Veen grab sampler, box grab) should only penetrate the sediment by its own weight. Avoid disturbing the surface by lowering it too quickly.
- Three successful samples should be taken at each location.
- A grab sample is successful if:
    - the grab is not over-filled and the contents have not been pushed against the top.
    - there is a layer of water on the sediment and the surface is undisturbed.
    - the grab closes tightly and does no sample material washes out.
- Sampling of the grab contents:
    - Carefully pour off excess water to the side.
    - With a spoon, take a sample from the top 2 cm sediment layer.
    - A composite sample for chemical analysis should be formed from the three sediment samples from a location. It must be ensured that the mixed sample is made up of equal proportions of all partial samples (aliquots).

Storage/transport

- Immediately after sampling, sediment samples should be stored in a cooler bag at about 4 °C.
- The samples must be frozen (-20 °C) on the evening of the sampling day. Frozen samples do not lose their sample integrity even over a number of years.
- Samples for grain size analysis should be stored in the refrigerator at 4 °C and must be analysed within 2 weeks.

Notes

- If possible, samples should be collected first from the least contaminated and last from the most polluted location.
- When sampling in easily accessible places, such as mudflats or beaches, sampling with a small shovel is sufficient.
- Possible sources of contamination must be taken into account when taking samples from a ship. These can be, for example, exhaust gases, lubricants, oiled surfaces.
- In uncontaminated areas, samples should be taken to determine background levels.
- Sampling along a pollution gradient should be done at regular spatial intervals with respect to the polluted area.
- Chemical findings should be based on dry weight as this reduces the variability between samples.

9.3 Sampling of biota (mussels) for pollutant analysis

Sample size

- The number of mussels required for analysis depends on their size and soft body weight. At the time of reproduction, with developed gonads, the soft body weight is greater than after spawning.
- For PAH analysis using GC/MS, at least 30 g of soft body mass should be available.

Devices / sample container

- Dredges (for epifauna sampling)
- Grab/shovel (for infauna sampling)
- Sieve for obtaining the infauna from grab samples
- In the presence of oil: water and reagents for decontamination of the sampling devices

Carrying out the sampling

- Sublittoral. Epibenthic blue mussels are collected using a dredge. Further epibenthic mussels can be collected with dredges, infauna species with sediment grabs.
- Mussel banks in the sublittoral. Samples should preferably be taken by divers.
- Eulittoral. Mussels can be taken directly from the sediment surface or by digging from the sediment with a shovel.
- Mussel banks in the Eulittoral can be sampled by hand. Disposable gloves should be worn and changed between different samples.
- A sample should consist of individuals of similar shell length. When comparing different samples, they should consist of individuals of similar mean length.

Storage/transport

- The mussels should preferably be handed over to the analytical laboratory alive or, if previously agreed, frozen. There, the soft bodies are sectioned with subsequent preparation and analysis.
- Live mussels should be handed over to the analytical laboratory within one day. Until then they should be kept moist (not in water) and cooled (<10 °C). Individual samples can be transported in Ziploc bags or glass containers, for example.

Notes

- A mussel species with a wide distribution in the polluted area and in reference areas should be selected.

- At the beginning of the sampling, it must be decided whether mussel samples should be handed over to the analytical laboratory alive or, if necessary, frozen (-20 °C). A comparison of the pollutant contents is only useful if the analysis is carried out on a uniformly processed sample matrix.
- The section of mussels must be carried out by the analytical laboratory. The mixed soft body samples should preferably be obtained by dissection from living animals.
- If possible, more than the minimum number of individuals should be collected to allow for retention samples.
- At least three samples must be collected within an area of similar pollution. In the event of an exposure gradient, samples should be taken along a transect.
- The determined pollutant contents should be related to dry weight, as this reduces variability between samples.

9.4 Operating instructions to ensure sample integrity of environmental samples for chemical analysis

Operating instructions to ensure integrity of environmental samples for chemical analyses (water, sediment, biota)

Aim

Environmental samples should be treated, stored, and transported in such a way that they are free of contamination, intact, and suitable for the intended examination without restriction. Handling of samples must be documented in order to prove their integrity.

<table>
<tr><th colspan="4">Methodological instructions</th></tr>
<tr><td rowspan="8">1</td><td colspan="3">Sample containers must not leak or break. Avoid direct contact between sample and plastic.</td></tr>
<tr><th>Sample type</th><th>Sample container</th><th>Note</th></tr>
<tr><td>Oil</td><td>Glass bottle 50 ml</td><td rowspan="4">– clean glass bottles provided by the analytics laboratory
– preferably dark glass for water samples
– cover bottle opening with aluminium foil under the cap</td></tr>
<tr><td rowspan="2">Water</td><td>Glass bottle 1 l
(visible oil contamination)</td></tr>
<tr><td>Glass bottle 1 l, if necessary 2 l
(without visible oil pollution)</td></tr>
<tr><td>Sediment
(fine, gravel)</td><td>Aluminium bowls or glass containers
500 ml</td></tr>
<tr><td>Sediment
(coarse, pebble)</td><td>Wrap in aluminium foil</td><td>Samples wrapped in aluminium foil can be stored in plastic bags</td></tr>
<tr><td rowspan="2">Biological samples</td><td>Glass container</td><td>as above</td></tr>
<tr><td></td><td>Wrap in aluminium foil</td><td>Whole individuals can be stored in plastic bags after being wrapped in aluminium foil</td></tr>
</table>

2	Fill the container as full as possible to displace air. Otherwise there is a risk of the loss of light HC through evaporation.	
3	Sample labelling. All samples should be labelled immediately.	
	3.	Labelling of the container depends on the type of sample. At the end of the work instructions there is an example of sample identification.
	3.2	Sample notes should not be placed in the sample container.
	3.3	Sample labels should only be attached after the sample has been closed and the outside of the sample container has been cleaned.
4	Sample protocol. A list of all samples is necessary in order to:	
	4.1	to check that no sample has been lost
	4.2	compare sample labels with the sample log in order to identify errors or omissions
5	Sample preservation in the field. Most samples can be preserved in the field by cooling them to about 4 °C. Use cool boxes and cooling pads for this. Then preserve the samples as follows:	
	Sample type	**Conservation method**
	Sediment	cool < -20 °C – freeze
	Oil	cool < 4 °C – do not freeze
	Benthos (e.g., mussels)	cool < 4 °C (max. 24h)
	Fish	freeze for longer interim storage
	Crustaceans	Preferably freeze large fish and Crustaceans (>10cm)
6	Protection of samples from contamination. All areas where samples must be handled or stored must be:	
	6.1	decontaminated before and after use
	6.2	designated non-smoking areas
	6.3	isolated from internal combustion engines, exhaust pipes, or other sources of hydrocarbon contamination
7	Sample storage	
	If samples have to be stored overnight or longer, this should be done under suitable conditions (refrigerator, freezer)	
8	Sample transport	
	8.1	Samples must be brought to the examination laboratory or institute within the time specified by the laboratory or the work instructions
	8.2	Sample containers should have a “sample transport chain” sticker. It should document the treatment steps and transport process of the sample.

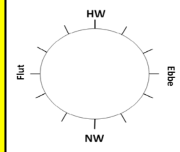
10 Appendix

10.1 Examples of field recording forms

The two tables show examples of how the forms to be used should be set up and structured. The tables are provided separately as Excel tables by CCME. They will be updated as necessary. The templates should be adapted to the special circumstances in the event in question.

Legend: Yellow fields are mandatory, white fields are optional.

Table 17: Recording form for water Top of form

HAVARIEKOMMANDO	Felderfassungsprotokoll				UEG AG 2 Monitoring
	Wasser				
Version: 1.4	Schadstoffunfall/Schadstoff				Stationsblatt Nr.
Gültig ab: 01.01.2018					Seite 1 von 2
Gebiet	**Station**	**Koordinaten WGS 84 [gg° mm,mmm]**		**Datum**	
		Sollkoordinaten	Istkoordinaten	**Uhrzeit**	
		Breite	Breite	**Uhrzeit HW**	
		Länge	Länge	**Tidephase** (bitte ankreuzen)	
Probenehmer	**Organisation**	**Probenahme vom**	**Schiffsname bzw. Fahrzeugtyp**		
		Schiff □ **Helikopter** □ **Land** □ ………………………. □			

Umgebungsbedingungen							
Wassertiefe [m]		**ICES Wettercode [Code]***		**Windstärke [Bft.]**		**Optischer Eindruck des Wassers nach BAOAC**, sichtbare Verunreinigungen**	
		Lufttemperatur [°C]		**Windrichtung [Kürzel]**			
		Luftdruck [mbar]		**Wellenhöhe [m]**		**Probe für chemische Analyse**	**nein** □ **ja - Wasser** □ **Sedim.** □ ……………..□

Methodik Probenahme			
Gerät	**Beprobtes Volumen [L]**		**Konservierung**
	(für jede Probe getrennt eingeben)		□ **kühl lagern (4°C) und dunkel** □

Table 18: Recording form for water samples

HAVARIEKOMMANDO		Felderfassungsprotokoll							UEG AG 2 Monitoring
		Wasser							
Version: 1.4		Schadstoffunfall/ Schadstoff							Stationsblatt Nr.
Gültig ab: 01.01.2018									Seite 2 von 2
Proben									
Probe Nr.	Beprobungstiefe [m]	Probenvolumen [L]	Wasser-temperatur [°C]	Salinität [PSU]	sichtbare Öl-Mengen	Geruch	Anzahl Proben-gefäße (wenn > 1)	Unter-suchungs-parameter	Bemerkungen

* Wettercode ICES	
0	Klar
1	Teilweise bewölkt
2	Geschlossene Wolkendecke
3	Sand- und Schneesturm
4	Nebel, starker Dunst
5	Sprühregen
6	Regen
7	Schnee, Schneeregen
8	Schauer
9	Keine Beobachtung

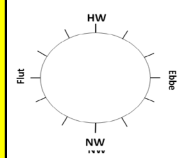
** Bonn Agreement Oil Appearance Code (BAOAC)

Code	Beschreibung, Aussehen	Schichtdicke (µm)	Volumen (m³) per km²
1	glänzend (silbergrau)	0,04 bis 0,30	0,04 bis 0,3
2	regenbogenfarbig	0,3 bis 5,0	0,3 bis 5,0
3	metallisch	5,0 bis 50,0	5,0 bis 50,0
4	Öleigenfarbe, ungleichmäßig	50,0 bis 200,0	50,0 bis 200,0
5	Öleigenfarbe, gleichmäßig	mehr als 200,0	mehr als 200,0

Table 19: Recording form for macrozoobenthos (soft substrate) in Sublittoral and Eulittoral

Top of form

HAVARIEKOMMANDO	Felderfassungsprotokoll	UEG AG 2 Monitoring
	Makrozoobenthos Weichboden	
Version: 1.4	Schadstoffunfall/Schadstoff	Stationsblatt Nr.
Gültig ab: 01.01.2018		Seite 1 von 2

Gebiet	Station	Koordinaten WGS 84 [gg° mm,mmm]				Datum	
		Sollkoordinaten		Istkoordinaten		Uhrzeit	
		Breite		Breite		Uhrzeit HW	
		Länge		Länge		Tidephase (bitte ankreuzen)	

Probenehmer	Organisation	Probenahme vom	Schiffsname bzw. Fahrzeugtyp
		Schiff □ Helikopter □ Land □ .... □	

Umgebungsbedingungen

Wassertiefe [m]		ICES Wettercode [Code]*		Windstärke [Bft.]		Optischer Eindruck des Wassers nach BAOAC**, sichtbare Verunreinigungen	
Wassertemperatur [°C]		Lufttemperatur [°C]		Windrichtung [Kürzel]			
Salinität [PSU]		Luftdruck [mbar]		Wellenhöhe [m]		Probe für chemische Analyse	nein □ ja - Wasser □ Sedim. □ ....□

Umgebungsbedingungen - Zusatzangaben bei Probenahme im Eulitoral

Wasserbedeckung [%]	Lebensspuren Fauna an der Bodenoberfläche	Bewuchs mit Algen und höheren Pflanzen	Auffälligkeiten

Methodik Probenahme

Gerät	Beprobte Fläche [cm²]	Maschenweite Sieb [µm]	Fixierung
			Formalin 4% □ .... □

Table 20: Recording form for macrozoobenthos (soft substrate) in the sublittoral and eulittoral

Examples

HAVARIEKOMMANDO

UEG
AG 2 Monitoring

Felderfassungsprotokoll

Makrozoobenthos Weichboden

Version: 1.4	**Schadstoffunfall/ Schadstoff**		**Stationsblatt Nr.**
Gültig ab: 01.01.2018			Seite 2 von 2

Proben

Probe Nr.	Probe-nahmetiefe [cm]	Foto-nummer	Sedimentansprache***	Farbe	Geruch	anoxisch [ja/nein]	Oxidations-schicht [cm]	Zusatzprobe für Sedimentanalyse [ja/nein]	Bedeckungs-grad Öl [%]	Anzahl Proben-gefäße	Bemerkungen (z.B. Totfunde von Muscheln etc.)

*** Wettercode ICES**

0	Klar
1	Teilweise bewölkt
2	Geschlossene Wolkendecke
3	Sand- und Schneesturm
4	Nebel, starker Dunst
5	Sprühregen
6	Regen
7	Schnee, Schneeregen
8	Schauer
9	Keine Beobachtung

**** Bonn Agreement Oil Appearance Code (BAOAC)**

Code	Beschreibung, Aussehen	Schichtdicke (µm)	Volumen (m^3) per km^2
1	glänzend (silbergrau)	0,04 bis 0,30	0,04 bis 0,3
2	regenbogenfarbig	0,3 bis 5,0	0,3 bis 5,0
3	metallisch	5,0 bis 50,0	5,0 bis 50,0
4	Öleigenfarbe, ungleichmäßig	50,0 bis 200,0	50,0 bis 200,0
5	Öleigenfarbe, gleichmäßig	mehr als 200,0	mehr als 200,0

***** Sedimentansprache**

Stein	Kies			Sand			Schlick	Ton	Detritus	Schill (Art)
	Grobkies	Mittelkies	Feinkies	Grobsand	Mittelsand	Feinsand				

Differenzierung Feinsand-Schlick-Fraktion nach Ragutzki		
Sedimenttyp	**Anteil < 63µm [%]**	**Watt**
heller, mittelsandiger Feinsand	≤ 8	helles Sandwatt
dunkler, schlickiger Feinsand	> 8 - ≤ 12	dunkles Sandwatt
Schlicksand	> 12 - ≤ 40	Mischwatt
Schlick	> 40	Schlickwatt

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