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Guidelines for environmental monitoring of petroleum activities on the Norwegian continental shelf

COLOPHON

Executive institution

Norwegian Environment Agency

Project manager for the contractor

Contact person in the Norwegian Environment Agency

Mihaela Ersvik

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Guidelines for environmental monitoring of petroleum activities on NCS

Summary

Companies operating on the Norwegian continental shelf are required to carry out environmental monitoring in order to obtain information on the actual and potential environmental impacts of their activities and to provide authorities with a better basis for regulation. These guidelines are a result of the cooperation between the Norwegian Environment Agency, an expert advisory group appointed by the Agency, oil and gas companies and consultancy firms.
The guidelines contain detailed requirements on how to carry out and report from the monitoring activities. They cover the expected scope of monitoring activities, which parameters must be analyzed, and which methods must be used, as well as provide requirements on necessary accreditation and templates for reporting.

5 emneord

Miljøovervåking, petroleumsvirksomhet, vannsøyle, prøvetaking, visuelle undersøkelser

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Environmental monitoring, petroleum activities, water column, sampling, visual mapping

Front page photo

Foreword

Companies operating on the Norwegian continental shelf are required to conduct environmental monitoring in order to obtain information about the actual and potential environmental impacts of their activities and to provide the environmental authorities with a better basis for regulating discharges and emissions. These guidelines are a result of a collaboration between the Norwegian Environment Agency (the Agency), an expert advisory group appointed by the Agency, oil and gas companies, and consultancy firms. Their purpose is to function as detailed requirements for conducting and reporting on the monitoring.

It is crucial for results of the monitoring and the use to which they are put that monitoring is conducted within a standardised framework. Results must be comparable over time. In addition, the monitoring must, to a large extent, be conducted in the same way across the whole continental shelf, to make it possible to compare fields and regions. This is also important because results are reported internationally.

Detailed requirements for environmental monitoring on the Norwegian continental shelf have previously been laid down in the Regulations relating to the conducting of petroleum activities (the Activities Regulations). These detailed requirements were removed from the Activities Regulations with effect from 1 January 2010 and incorporated in the present guidelines. The guidelines (publication M-300 in Norwegian) have been updated on several occasions and translated into English (these guidelines).

The main aim of this revision is to include more detailed requirements for surveys related to decommissioning activities (see new chapter 5). The need for and the scope of environmental surveys before, possibly during and after decommissioning will vary, and depends, among other things, on the area's discharge history and vulnerability, results of previous surveys and the extent of planned decommissioning activity.

The deadline for delivery of program draft for seabed surveys has also been changed in line with the amendment to the management regulations § 34 (point 4.1. Timetable).

Norwegian Environment Agency, Oslo, October 2023
Signe Nåmdal

Director of the Industry and Marine Environment Department

Content

1. Introduction

1.1 Purpose of offshore environmental monitoring

The purpose of the offshore environmental monitoring is to provide an overview of the environmental status and trends over time seen in relation to offshore oil and gas activities. Monitoring is intended to indicate whether the environmental status on the Norwegian continental shelf is stable, deteriorating or improving, due to operators' activities. In addition to identifying trends, the results are to as far as possible provide a basis for projections for future developments.

Overall, the environmental monitoring is to contribute towards describing to what degree a station or a wider area around a facility or in a region is impacted because of discharges from oil and gas activities. It is important that results from the environmental monitoring offshore can be used to verify predictions and conclusions og the environmental impact assessment study for the respective field or for the region.

Environmental monitoring of offshore oil and gas activities includes monitoring of the water column and of benthic habitats (sediments, soft-bottom fauna, and hard-bottom fauna). Operators and authorities use monitoring results as

- a source of information and as grounds for decision making regarding new measures to be implemented offshore.
- input for developing and reporting on national environmental indicators for the offshore oil and gas industry.
- information for the Norwegian Ministry of Climate and Environment and to international bodies such as OSPAR.

1.2 Monitoring requirements

Pursuant to section 49 of the Act of 13 March 1981 No. 6 concerning protection against pollution and concerning waste (Pollution Control Act), any person that causes pollution has a duty "to provide the pollution control authority or other public bodies with any information necessary to enable them to carry out their tasks pursuant to this Act". Further, under section 51 of the Act, the Agency as well as the Norwegian Radiation and Nuclear Safety Authority (DSA) have the power to order investigations to "determine whether and to what extent the activity results in or may result in pollution".

Specific requirements relating to environmental monitoring are set out in sections 52-56 of Regulations relating to conducting petroleum activities (the Activities Regulations), which deal with environmental surveys of the water column and benthic habitats, and cooperation between operators within the same region. The scope of the monitoring must be proportional to the expected risk.

Detailed requirements for environmental monitoring on the Norwegian continental shelf were previously included in the Activities Regulations. As part of the legislation simplifying process and in order to provide more flexibility when changes were needed, the detailed descriptions of monitoring procedures have been transferred from the regulations to the present guidelines. The regulations now contain general requirements, while the guidelines provide more detailed instructions on how the requirements can best be met. The guidelines describe the expected scope of the monitoring activities, provide the parameters that must be analysed and the methods that must be used, as well as requirements regarding necessary accreditation and templates for reporting.

Additional monitoring surveys and auditing

If the Agency or DSA deems it necessary, further or other types of surveys may be required to investigate the environmental condition and effects of emissions, cf. Sections 52, 54 and 55 of the Activity Regulations. The Agency and operators will agree on the scope and nature of such investigations.

Authorities may carry out inspections and controls of environmental monitoring activities, in the same way they do for other activities regulated by environmental legislation. This applies to all stages, from planning of the surveys to the use of the results by individual operators to improve their environmental performance.

Mapping of marine growth on facilities

Regulation relating to alien organisms, section 18 establishes general requirement to exercise due care for those who take measures that may lead to the unintentional spread of alien organisms in the environment. Handling of marine growth in connection with the removal of petroleum facilities is a measure covered by this duty of care. Section 24 also sets requirements relating to measures that could lead to accidental spread of alien organisms. The Agency therefore recommends that the operators carry out surveys to determine which species occur on the facilities before they are moved, if moving may entail a risk of spreading alien species (see chapter 5).

1.3 Planning and cooperation

Operators in a region where monitoring is planned are responsible for drawing up draft programmes for monitoring of the water column (either field surveys or method development) and of the benthic habitats in the region. Operators are required to build their environmental monitoring programmes on the requirements of the activities regulations, on the instructions given in these guidelines, on results from previous surveys and based on the risk and discharge status on a felt or in a region. The draft programmes are presented and discussed at annual planning meetings, where the Agency, an expert advisory group appointed by the Agency, DSA, Offshore Norge and relevant operators participate. Operators make the necessary corrections and send the final programme to the Agency.

A forum for offshore environmental monitoring is held annually. This is a meeting place where operators and consultants are invited to present the most recent results (from the previous year's surveys), as well as plans for future monitoring. The forum also provides an

opportunity for lectures and discussions around current issues related to offshore environmental monitoring. The forum is organised alternately by the Agency and Offshore Norge.

As part of the environmental monitoring regime, operators are required to contribute to method development, cf. § 52 of the Activities Regulations and this must be carried out in collaboration with the Agency and DSA.

1.4 Description of the monitoring regimes

Monitoring of the water column

Section 55 of the Activities Regulations stipulates that monitoring of the water column must be carried out in connection with offshore oil and gas activities. The monitoring is intended to document whether and to what extent organisms in Norwegian waters are affected by pollution generated by oil and gas activities.

Water column monitoring shall consist of field studies and method development (see Chapter 3 on monitoring of the water column). The field surveys are conducted every three years, and shall as a minimum include oceanographic measurements, analysis of chemical parameters and investigations of organisms placed in cages (mainly mussels) and of wild caught organisms (mainly fish). The period between two field studies will be used for further development and qualification of methodology for future water column monitoring.

Water column monitoring shall also include investigations og radioactivity.

Monitoring of benthic habitats (sediments and soft- and hard-bottom fauna)

According to sections 53 and 54 of the Activities Regulations, monitoring of benthic habitats consists of two main elements:

- Baseline surveys, which are required before exploration drilling in new areas, in areas where vulnerable benthic species and habitats occur or in areas where there is reason to believe these may occur, and before production drilling.

- After production drilling has started, must new fields be included in the regional monitoring surveys and normally be monitored every three years.

Monitoring of benthic habitats consists mainly of taking samples of the seabed with an approved grab type and analysing the sediment samples for heavy metals, oil compounds and other relevant substances, as well as describe the composition and condition of soft bottom fauna (see Chapter 4 on grab sample surveys).

Other monitoring

Environmental surveys must be carried out **before, possibly during and after decommissioning activities** to an extent that will vary from field to field (see Chapter 5 on Decommissioning-related environmental surveys).

In areas where **vulnerable bottom habitats** might be present or where conventional sampling equipment is not appropriate, customized investigations should be done as a substitute or in addition to taking sediment samples using a grab (see Chapter 6 on visual surveys).

Environmental monitoring will also cover **investigations of radioactivity**. Plans for this are prepared by the operators in consultation with the Norwegian Radiation and Nuclear Safety Authority.

1.5 Quality assurance

Quality assurance and control is essential for the success of the environmental monitoring. Quality assurance should be anchored with both consultant and oil company. The consultant's quality assurance system (QA-system) should be presented in the tender and required in the final report. Operators must assess the quality/suitability of this system continuously and discuss this with the Agency and DSA when needed, for example in connection with the annual planning meetings.

The QA-system should include a verification of sampling, a plan for using reference samples, reviewing analytical methods and results and performing the quality control of the report. A standard QA-system must be used, for example ISO 9000 or CEMP 2002-15. Quality assurance of the various analyses, both in terms of type and frequency, should be presented as part of the method description in the report. There is a minimum requirement that analyses are verified against reference samples run in the same test series as the real samples. The results from the reference samples must be discussed in the report from the monitoring surveys.

Quality control of the methods applied in connection with the monitoring, for example by means of external calibration, blind testing, or use of reference samples, must be carried out when possible.

All suppliers of services for monitoring programs (analyses, fieldwork) must have EN ISO/IEC 17025 accreditation, or an equivalent for the methods they use, whenever an accreditation scheme is available. Service suppliers must also document their own quality assurance and control routines. The latest and valid version of the method standards and guidelines must be used, and reference must be made to the year when these standards were established when reporting from monitoring surveys.

2. Definitions and abbreviations

Alkylphenols
phenols with varying carbon chain and structure. Alkylphenols are naturally found in crude oil and are water-soluble, so they are discharged together with produced water from the oil industry.

Background levels:
Concentrations of selected parameters (hydrocarbons, metals, radioactive substances) at the regional stations in each region. They should be as close as possible to the natural concentrations in the area.

Baseline survey:
The first environmental survey in an area or locality to obtain information on its chemical and biological status before a new activity starts.

Biological impact:
Found in an area if the fauna in a sample is significantly different from that at comparable regional stations in the same region. Calculations of biological impact are based on an overall evaluation of all the statistical analyses carried out on the biological material.

CEMP (Coordinated Environmental Monitoring Programme):
an international program run by OSPAR with the goal of providing comparable data from all OSPAR marine areas. The program develops common guidelines for planning, implementation, analysis and reporting (formerly known as JAMP guidelines).

Chemical contamination:
Present in areas where the levels of the selected metals, radioactive substances and/or hydrocarbons are significantly higher than the expected background level (see the latter and LSC).

Diversity
measurement of species diversity in a benthic community, here as a function of the number of species and how specimens are distributed among these species. Described by diversity indices.

DP system (dynamic positioning system):
Computer-controlled system that automatically ensures the maintenance of the vessel's position, orientation, and possibly also speed. Positioning is done by using the vessel's own propulsion and positioning systems. Classified as DP1, DP2 or DP3 system according to IMO’s standards for accuracy and redundancy (DP3 is the best, but DP1 is most often sufficient for visual surveys).

Grab sampler load:
One sediment load collected by a grab sampler.

Facility:
Installations, plants, and other equipment for petroleum activities, however, not supply and support vessels or ships that transport petroleum in bulk. Facility may also comprise pipeline and cable when applicable. .

Juvenile:
young, sexually immature specimens.

Kurtosis:
a measure of how peaked or flat the distribution of data is relative to a normal distribution. High kurtosis indicates that the data distribution has a narrower peak than expected for a normal distribution. Used in evaluating grain size distribution.

LSC (Limit of significant contamination)
a statistically calculated limit for chemical contamination, based on background levels from regional/ subregional stations.

Macrofauna
Organisms larger than 1 mm (i.e. that are retained on a 1 mm sieve).

Megafauna
Organisms larger than 20 cm.

Meiofauna
Organisms in the size range of 0.063–1 mm. The term generally refers to specific groups of organisms (foraminifera, nematodes, harpacticoid copepods, etc.).

MOD (Environmental Monitoring Database):
A database containing data from the environmental monitoring programmes for the Norwegian continental shelf. It can be accessed at http://mod.dnvgl.com/.

Multivariate analyses
Statistical analyses that handle more than one variable in the same analysis and look for trends across several dimensions at once.

Naturally occurring radioactive substances:
Radium-226 (Ra-226) and Radium-228 (Ra-228) are naturally occurring radioactive substances that are discharges together with produced water. Lead-210 (Pb-210) is a by-product of Ra-226. Thorium-228 (Th-228) is a by-product of Ra-228.

NPD
The sum of naphthalene, phenanthrene, dibenzothiophene and their C1-, C2- and C3 alkyl homologues.

PAHs (Polycyclic aromatic hydrocarbons)
All hydrocarbons in which the molecule contains two or more aromatic rings (see appendix III).

Plankton
Organisms that spend all or part of their life cycle floating or drifting in the water and that have little or no independent mobility.

Radial transects
Preferred station design around a facility. It consists of two axes placed perpendicularly on each other and the facility at the origin, with the main axis in the prevailing current direction in the area.

Region
A delimited area of the continental shelf defined by geographical coordinates. The boundary towards the shore follows the coastal baseline.

ROV
Remotely Operated underwater Vehicle carrying a video camera, which can often be equipped with extra gear such as sonar, sensors, a manipulator arm and sampling equipment.

Satellites:
facilities producing towards a mother platform, mainly underwater structures.

THC (Total hydrocarbon content)
Content of all hydrocarbons in the material within a particular range of carbon chain lengths (n-C12 – n-C35), both those formed biologically and those originating from oil and other sources of pollution.

TOC
Total organic carbon (applies to sediment).

TN:
Abbreviation for total nitrogen in sediment.

Transect:
A continuous axis in the field-specific station network.

Transponder:
Equipment used in underwater acoustic navigation. Mounted on the ROV and communicates with transceiver / HIPAP system so that the position of the ROV can be displayed in a mapping software and logged.

UCM-fraction (Unresolved Complex Mixture)
Includes components in that fraction of the produced water that are not identified.

USBL system (Ultra Short Baseline):
Method for acoustic positioning most frequently used on offshore vessels where a transceiver mounted under the vessel communicates with a transponder mounted on ROVs.

Water column
The marine environment from the water surface to the surface of the sediment.

3. Water column monitoring

The monitoring of the water column shall document whether and to what degree marine organisms in Norwegian waters are impacted by pollution generated by offshore petroleum activities, no matter whether the source of the discharges is produced water with its complex composition, old drill cuttings piles, leaks from the seafloor/old wells or other relevant discharges. Unless otherwise agreed upon, the monitoring must as a minimum include oceanographic measurements, analysis of chemical parameters and investigations of organisms placed in cages and of wild caught organisms. For wild-caught organisms, measurements of radioactivity must also be performed. The areas to be monitored are decided by the Agency in consultation with the relevant operators.

The water column monitoring consisted previously of yearly surveys (called condition monitoring and effect monitoring). Since 2015 the Agency has requested that a more comprehensive field study be conducted every three years. This may entail that a wider area with several facilities is covered or/and that several analytical parameters are included.

As part of the environmental monitoring regime, the operators are expected to contribute to developing improved methods for monitoring of the water column, cf. Section 52 of the Activity Regulations. The period between two field studies shall be used to develop and qualify new methodology (see Chapter 3.9).

The Agency and DSA may require further investigations of the water column, both with regard to the environmental condition and the effects of discharges in the fields' surrounding areas, cf. sections 52 and 55 of the Activity Regulations. Such investigations shall be initiated in agreement with the Agency and relevant operators.

3.1 Programme for the field surveys

Drafting a programme

Operators for the area where monitoring is planned are responsible for drafting programmes for the field survey monitoring of the water column. The programme must be based on the requirements of the Activities Regulations, on the instructions given in these guidelines, on results from previous surveys as well as the environmental risk and discharge status at the filed/region to be investigated. Deviations from existing requirements must be stated and justified.

The program proposal for water column monitoring shall be submitted to the Agency and DSA no later than February 1st the year the field survey is to be conducted, The Agency, together with its advisory group, relevant operators, Offshore Norge and DSA get together and discuss the programme proposal. The operators make the necessary revisions and submit the final program by April 1st of the same year, cf. section 34 of the Management Regulations.

Content of the program for field surveys

The monitoring program for the field surveys shall contain descriptions of the area(s) to be monitored. The choice of areas must be justified. Assessments of the discharge components, discharge spreading area, the recipient's conditions and the environmental risk associated with the discharges shall be documented in the program.

The program shall also give information about:

- The planned station design and analytical programme (kap. 3.2)
- Description of the species planned to be used/investigated (kap. 3.3)
- Detailed description of sampling and handling of samples (kap. 3.4)
- Detailed description og sample types and proposed analytical parameters (kap. 3.5)
- Detailed description of planned quality assurance procedures and statistical methods to be used (kap. 3.6 og 3.7)
- Description of potential new methods/equipment to be tested/qualified during the field survey.

3.2 Planning of the field surveys

Monitoring period and frequency

Field surveys must be scheduled in a most suitable period in terms of spawning status for mussels and the fish species expected to be found in the investigated area(s). Furthermore, the field surveys shall be carried out at the best possible time considering:

- relevant local conditionsm, for example vertical density stratification in the water column
- practical and logistical considerations
- facilitating, if reasonable, comparison of results if surveys take place in the same area more than once

In accordance with NS *9434 Water quality - Monitoring of environmental contaminants in blue mussel (Mytilus spp.) - Collection of caged or native mussels and sample treatment* and CEMP Guidelines for Monitoring Contaminants in Biota (OSPAR Agreement 1999-2), exposure of mussels should take place outside their spawning period. Mussels to be used in the field studies in the water column monitoring must have gonads at an early stage of development, so that the likelihood of the mussels spawning during the exposure period is low. If purchased from farms that keep mussels in various stages of development, mussels that are not expected to spawn during the exposure period must be used. It is also not desirable to use mussels that have spawned just before they are used for monitoring purposes.

Survey design

The field survey must include at least one suitable reference area both when using instrument rigs/mussel cages and when investigating wild caught organisms.

The positioning of the rigs equipped with monitoring instruments (among others passive samplers and caged organisms) in the target area must be chosen based on knowledge of the physical characteristics of the area and on dispersal models for relevant discharge components, including added chemicals. The operator must ensure that consultants carrying out the survey are provided with relevant information on production and discharges at the field(s) being

investigated, including information about discharge components, volume of teh discharges and DREAM modelling data for the produced water plume.

The number and position of the instrument rigs are a to be chosen so that the field surveys provide the best possible picture of the environmental situation in the selected area(s). This may mean 15 stations or more, depending on the number of facilities and the size of the surveyed area.

The number of rigs to be deployed and where in the water column they are to be placed depends to a large degree on the local conditions in the investigated area(s), but relevant planning advice is given in OSPAR Agreement 1999–2 and in NS 9434. Mussels are to be deployed for a period of 6 weeks. Another exposure length can be accepted by the Agency if there are special considerations, but these need to be documented and justified in the draft program.

3.3 Organisms to be monitored

Wild caught fish

Collection of wild caught organisms must be based on updated information on the occurrence, distribution and migration patterns of relevant fish stocks in the area(s).

The Agency requires the collection and analysis of tissues from 30 (+/- 5) individuals of at least three different fish species from the monitoring area and the reference area. Availability of the different fish species will vary widely with location and season, but the same species must be examined in both the monitoring and reference areas in one and the same field study. Relevant species are cod, haddock, pollock, flatfish (dab or long rough dab), tusk and ling. Fish used for sampling should be within a relatively narrow size range for both sexes, to reduce variation in measured endpoints. For further information and recommendations on collection and species selection, see OSPAR Agreement 1999–2 and JAMP Guidelines on Contaminant-Specific Biological Effects Monitoring (OSPAR Agreement 2008-09).

Blue mussels for caging

The Agency requires deployment of blue mussels in cages for monitoring of exposure and effects. The deployment should be in accordance with NS 9434. *Mytilus edulis* should be the dominant species in such deployment studies[1].

It is important to document that the mussels to be deployed are free of known diseases and outside active spawning. Pre-exposure samples must be taken from the mussels to determine their pollution status, cf. NS 9434. Prior to deployment, the mussels should be acclimatized in clean water with the same temperature and salinity as in the area they will be deployed in.

Food availability for the caged mussels must be documented, especially if these are placed deep in the water column. Food availability must be documented both at monitoring stations and at reference stations.

[1] In previous versions of the guidelines at least 90% of the population was required to be *M. edulis*. This proved to be difficult to achieve. The proportion of *M. edulis* was 88% in WCM2012 and 82% in WCM2015. therefore from 2020 we recommend following NS 9434 which also states that *M. edulis* should be the dominant species.

3.4 Sample collection and processing

Biological samples must be collected, handled and preserved in accordance with OSPAR Agreement 1999-2, OSPAR Agreement 2008–09 and NS 9434. Working surfaces used for sample processing must be clean, and the samples must be handled in such a way as to minimise the risk of sample contamination on board the vessel.

Fish to be used for analyses must be kept alive until samples are taken for biochemical, physiological or histological analyzes.

The possibility to carry out analyses blindly using sample anonymization must be facilitated where necessary.

3.5 Analytical parameters

Oceanographic parameters

The field survey shall include the following measurements:

- conductivity, temperature and density (CTD) on a sufficient number of stations so that conductivity, temperature and salinity vertically in the water column are documented for the area. To be measured as a minimum when deploying and retrieving the cages.
- current direction and speed from at least two stations no more than 1000 meters away from the platform
- temperature at all stations, continually.

Chemical parameters measured in the recipient

Passive samplers must be used at all stations with caged organisms to quantify exposure of these organisms. Passive samplers shall monitor dispersal of pollution/discharges to the environment and to validate dispersal models. Deployment of passive samplers for these purposes shall include sampling at several stations and at several depths.

Passive samplers shall as a minimum be used to analyse the content of THC, PAH, NPD and alkylphenols (AP).

Chemical analyses of the biological material are described in the following section.

Parameters measured in biological material

The Agency expects that the monitoring as a minimum includes analysis of the parameters provided in Table 3-1 for mussels and Table 3-2 for fish.

Chemical analyses are to be done by pooling four samples from mussels at each station. Effect analyses are to be done on minimum 15 mussels from each station. As mentioned above, effect parameters and metabolites should be investigated on 30 fish from each species and from each area.

Performing analyses blindly shall be facilitated where appropriately, in addition to MN-scoring, cf. tables 3-1 and 3-2.

Table 3-1: Parameters to be analyzed in mussels		
Parameter	**Type of tissue/matrix**	**Method**
Size and condition (CI)	Whole mussel	Length of the mussel Dry weight of soft tissue on representative sub-sample shall be used to calculate condition index.
Speciation	Representative subsample. Individual level.	Distribution of mussels at different stations shall be done so that one can expect the same species composition at all stations. Determination of species / subspecies / hybrid composition is carried out on a representative subsample.
Reproductive maturity & spawning status	Whole mussel, internal organs, gonad products (histology sample to be taken as transverse incision)	A histological sample must be taken of all individuals being tested. Maturity and spawning status must be validated after the survey.
General health status	Whole mussel	«stress on stress»
PAH	Soft tissue	GC-MS A reference sample must be used when measuring PAH in mussels.
Metals (Hg, Pb, Cd, Ba)	Soft tissue	ICP A reference sample must be used when measuring metals in mussels.
Micronuclei (MN) Chromosome damage	Non-granular haemocytes. Alternatively, cells extracted from enzymatically treated gill tissue.	Manual or automatic quantification of micronuclei formation. Manual MN-scoring must be performed blindly by anonymizing and randomizing samples
Lysosomal membrane stability (LMS)	Digestive gland	Histology of cryostat sections of the digestive gland

Table 3-2: Parameters to be analyzed in fish		
Parameter	**Type of tissue /matrix**	**Method**
Size	Whole fish	Weight, length
Gender	Whole fish and gonads	Macroscopic assessment, possibly Lupe
Age	Otolith	Microscopical assessment
Liver somatic index (LSI)	Whole fish and liver	Liver weight/body weight

Table 3-2: Parameters to be analyzed in fish		
Parameter	**Type of tissue /matrix**	**Method**
Gonad somatic index (GSI)	Whole fish and gonads	Gonad weight/body weight
Condition index (CI)	Whole fish	Weight/length
PAH/NPD	Liver[2]	GC-MS
Concentration of PAH metabolites	Bile	GC-MS/LC-FD Stomach content shall be registered (full/empty)
Tissue changes, including lysosomal changes	Liver	Histology
CYP1A1-induction	Liver S9 or microsomes	EROD-activity
		CYP1A ELISA
		qPCR: AH-receptor gene and CYP1A1-gene
DNA damage	Liver	DNA adducts
	Lymphocytes	DNA strand breaks (comet)
Chromosome damage	Red blood cells	Manual or automatic quantification of micronuclei formation. Manual MN-scoring must be performed blindly by anonymizing and randomizing samples
Acetylcholine esterase (AChE) inhibition	Muscle	AChE-activity
Ra-226, Ra-228, Pb-210 and Th-228	Bones and muscle	Gamma spectrometry *Samples must be large enough (ca 1 kg wet weight).* *Detection limit:* *Ra226 = 5Bq/Kg* *Ra228 = 10Bq/Kg*

3.6 Quality control

Requirements regarding quality assurance are given in Chapter 1.5.

3.7 Statistical analysis of data

As a minimum, the following analyses must be carried out:

- comparisons of endpoints measured at all stations against T0 (pre-exposure measurements)
- comparisons of endpoints measured at monitoring stations against reference stations
- comparison of endpoints against the exposure

[2] Previously were concentrations of NPD / PAH analyzed in the fish fillet out of food safety considerations. However, concentrations have been found to be very low, and rarely above the detection limit. In 2020 the requirement was therefore changed to apply to liver. This is an important support parameter for bile metabolites.

Consultants must be sure to check for any effects of temperature, gender, size, age, food access, and more on the results. These are variables that can influence the measured response of each organism.

Data collected during the field surveys of the water column monitoring have traditionally been analysed using ANOVA, Kruskal-Wallis and Mann-Whitey U Test. The Agency recommends identifying other statistical methods that can contribute to better data utilization and a clearer environmental status at the investigated area(s). There may come clearer requirements on statistical analysis in later editions of these guidelines.

3.8 Reporting

A quality assured draft report from the field survey together with associated analysis results shall be submitted to the Agency no later than April 1 st the year after the survey was carried out, cf. section 34 of the Management Regulations. The Agency, DSA and the Agency's expert group will evaluate the report. Any potential comments to the report will be sent by the end of June. The comments from the evaluation must be answered. The deadline for delivering the final report is October 1 st. the year after the survey was carried out, cf. section 34 of the Management Regulations.

The Agency must be informed as soon as possible if during the investigations, or during the preparation of the tests, results are found that entail significant deviations from the expected environmental condition or trend, cf. section 34 letter a of the Management Regulations.

The target group for the report includes oil and gas companies, environmental authorities, research institutions and consultancy firms. The survey and results must be presented in such a way that they also make sense for professionals who have not participated in the actual monitoring.

The report is to be submitted electronically. Final reports from conducted field surveys/monitoring are published on www.miljodirektoratet.no once the Agency and DSA has approved them. Results from the field surveys are presented at the annual *Forum for Offshore Environmental Monitoring.*

All unprocessed data and results shall always be available be for the Agency and DSA, preferably in a central database and in appendices to the report.

Contents of the report

The final scientific report shall contain a complete documentation of the completed survey, focusing on:

- sampling design / field activities
- analytical parameters
- analytical methods and quality assurance
- results and conclusions of the survey
- main trends in the region or sampling area (if data is available)
- issues to be given priority in future monitoring

A description of method development work carried out in connection with the field survey, as well as information on when the results are expected to be available must be included in the report.

Summary

The summary shall not exceed five pages and must be submitted both in Norwegian and English. The target group for the summary is the same as for the main report, but also the general public. We expect therefore that the summary is clear and reader friendly.

A summary must include the following:

- a brief description of the goals of the survey;
- a short description of the field work;
- a short description of any deviations from the program that may affect the results
- the main results and discussions of these
- main trends and comparison with any relevant earlier surveys
- conclusions and recommendations.

Introduction

The following shall be described:

- a description of the area(s) to be investigated, including maps with visible map scale and depth contours showing the position of the monitoring stations and facility(s);
- discharge history at the investigated platform(s), if possible, with concentrations of the different components in the discharge and other activities that may have affected chemical and biological conditions at the time of the survey;
- earlier surveys
- goals and priorities for the field survey in question, in relation with the program for the water column monitoring.
- reasons for the choice of sampling areas and sampling stations.

Methods

The methods section shall include:

- information on the origin of organisms used in the field survey and how they were treated prior to field deployment;
- description of the completed field work, including the period, number of stations/instrument rigs, and any deviations from the proposed program, with reasons;
- brief description of the laboratory procedures for physical, chemical and biological analyses, including description of any deviations, with reasons, and an evaluation of whether/how results are affected;
- information on where and how the processed samples are stored, with a contact person able to provide access on demand;
- information on how and where the unprocessed data is stored, with a contact person able to provide access on demand;
- information on quality assurance routines in the field and in the lab, including accreditation status and any documented participation in intercalibration exercises for relevant methods;
- description of statistical methods used, including reasons for choosing them.

Results and discussion

This chapter presents and discusses the results of the survey.

The observations and results obtained for all the parameters analysed shall be described. This includes background levels in test organisms before deployment in cages. Other characteristics of the station or sampling area of significance for the result discussion should also be presented.

As a minimum, the following results must be presented:

- comparison of results between stations and between stations and background levels. Stations with significantly elevated values must be highlighted.
- results must be presented as a function of available information about exposure, e.g. measured PAH values in biological material and simulated or measured concentrations in the water column.

The results of the surveys must be assessed and discussed in the light of previous environmental conditions and discharge history at the current field(s).

The questions listed below shall be discussed:

- What is the significance of the detected biological responses?
- How do biological responses correspond with exposure parameters and with gradients in natural and anthropogenic environmental variables?
- How do the results relate to those of earlier surveys in the same area, if any?
- How do the results relate to those of relevant surveys of nearby areas?
- Do the results reflect the discharge history in the area(s)?

Overall evaluation and conclusions

To the extent that the available data allow it, the chapter shall contain concluding considerations on the state of the environmental condition and development at the individual field(s) and in the region.

The report shall provide both a detailed and a comprehensive interpretation of the results from the field survey with the intention to describe to which degree the organisms included in the study have accumulated hydrocarbons or other petroleum-related substances and whether they show evidence of exposure and/or stress from the discharges in the area.

The report should also provide an assessment of the significance of biological responses for the individual and the population in time and space.

Recommendation for future monitoring

Any recommendations for changes in the design of future field surveys must be described in the report.

Any recommendations for further development of methods in the periods between two field surveys should be included in the final report from the field survey, see chapter 3.8.

Appendices

The report must include the following appendices:

- the final monitoring program decided upon in cooperation with the Agency;

- survey report (field logs) with date, time, position (GMS and UTM, and which reference grid is used; grid zone must be specified), depth, number of samples and weather conditions presented in table format for each station or area(s) being investigated;
- analysis report including tables with analytical data;
- any documentation on accreditation;
- documentation on control results.

3.9 Further development and validation of methods

The operators shall, as part of the environmental monitoring, contribute to developing new methods for monitoring the water column, cf. § 55 in the Activities Regulations.

There is still a need for development of water column monitoring methods because the range of qualified methods is currently very limited and new methods can help to strengthen the monitoring. The period between two field studies must be used for testing, further development and qualification of methodology.

The Agency considers the method development program as an ongoing program where new projects come in and may take several years to complete. Different stages of a development program may be literature studies, lab studies and field studies. Final reports from the various development projects will be reviewed when revising the method requirements in these guidelines.

3.9.1 Topics for further development

The Agency and DSA will give priority to developing/qualifying methodology in order to:

- monitor several representative species with different ecological functions and from several trophic levels
- gather more information on effects by means of other endpoints/biomarkers for effect
- gather more information on pollution from added chemicals, both in terms of dispersal and effects
- gather more information on potential sedimentation of components in produced water
- gather better exposure information, including logging of hydrocarbon concentrations by means of fluorescence
- gather information on potential effects of naphthenic acids
- gather information on potential effects of the UCM-fraction.
- gather information about potential effects of naturally occurring radioactive substabces
- gather information on any synergistic effects of pollutants including radioactive substances.

Appendix I lists identified methods that may be relevant for the water column monitoring, but which need further development and validation before they can be used. The appendix provides information on the status of the follow-up of the methods identified as relevant for water column monitoring. Examples of follow-up status may be "literature study initiated", "lab trial initiated" or "field study". The Agency's intention is to update this appendix regularly.

3.9.2 Criteria for method validation

Before a new method can be used in field surveys, the following should as a minimum be done:

- An assessment of appropriateness and suitability of the method being considered (including sensitivity and assessment of species differences)
- Adequate qualification under controlled laboratory conditions. For biological endpoints this will involve exposure to real or man-made produced water, specific components in the produced water, or to extracts of real produced water.
- Qualification of new methods in the lab must include an assessment of the relevant exposure period necessary.
- A verification in field conditions. This can be done in relation to regular fieldwork carried out for monitoring purposes.

The Agency does not require publication of results in scientific papers as part of the method validation, but we expect the work carried out in development projects to hold a similar standard.

3.9.3 Program for method development work

Operators on NCS must submit a description of potential new projects in the method development program, and the status of ongoing projects by February 1st, cf. 3.9.4.

The Agency arranges annual planning meetings where the proposals are discussed together with operators, Offshore Norge, DSA and the Agency's advisory expert group. Operators review the program in accordance with the conclusions from the meeting and submit the final work program for the current year to the Agency. Appendix I is updated based on the final program for method development.

Contents of program proposals for method development

The method development program shall contain descriptions of submitted project proposals, the operators' evaluations of these and the operators' proposals for candidates to be financed.

Descriptions of submitted project proposals shall include the following:

- The goal of the projects: what issues shall be addressed?
- Relevance to the water column monitoring: what is the knowledge status, what knowledge gaps will the project fill, how will the new knowledge be used in the water column monitoring? Is it a completely new method/concept?
- Implementation plan: what experiments, what methods, what species/life stages, etc. Schedule. When will the results be available? If one ends up with a new or improved method: when will it ready to be used in the water column monitoring?

3.9.4 Reporting

Operators shall report from the method development projects as they report from the field surveys.

Status reporting underway in multi-year projects takes place in connection with the preparation of a program for method development work, cf. 3.9.3. For this type of reporting, we require a brief description of:

- results so far,
- further work,
- brief status update for the table in Appendix I.

The final reports from the various development projects shall give a clear recommendation on whether the method should be rejected, needs further qualification and what the next step would be, or whether the method can be implemented in the field surveys. Furthermore, issues from the planning phase must be answered. If the method is recommended to be implemented, the recommended protocol for use in the water column monitoring, including a description of quality assurance, must be attached.

Final reporting from development projects is done as soon as possible after the projects are completed.

4. Monitoring of benthic habitats (grab sampling surveys)

In soft bottom areas the surveys will consist of grab sampling of the seabed before exploration drilling in particular cases (see chapter 4.2), before and during production drilling and production, and after decommissioning of the field. Sediment composition, chemical parameters and soft bottom fauna are to be investigated.

The Norwegian continental shelf is divided into eleven geographical regions for monitoring of benthic habitats (see Figure 4.1). As a general rule, each region is surveyed every third year with surveys alternating between regions each year (see Table 4-1). The scope of the monitoring programmes must be proportional to the level of offshore activity in the region. Monitoring of new activities is additional to and must be adapted to existing monitoring activities. If large variations in depth and/or type of sediment indicate that it is necessary, regions should be divided into subregions. The subregional divisions established in regions that have already been surveyed should not be changed without good reason.

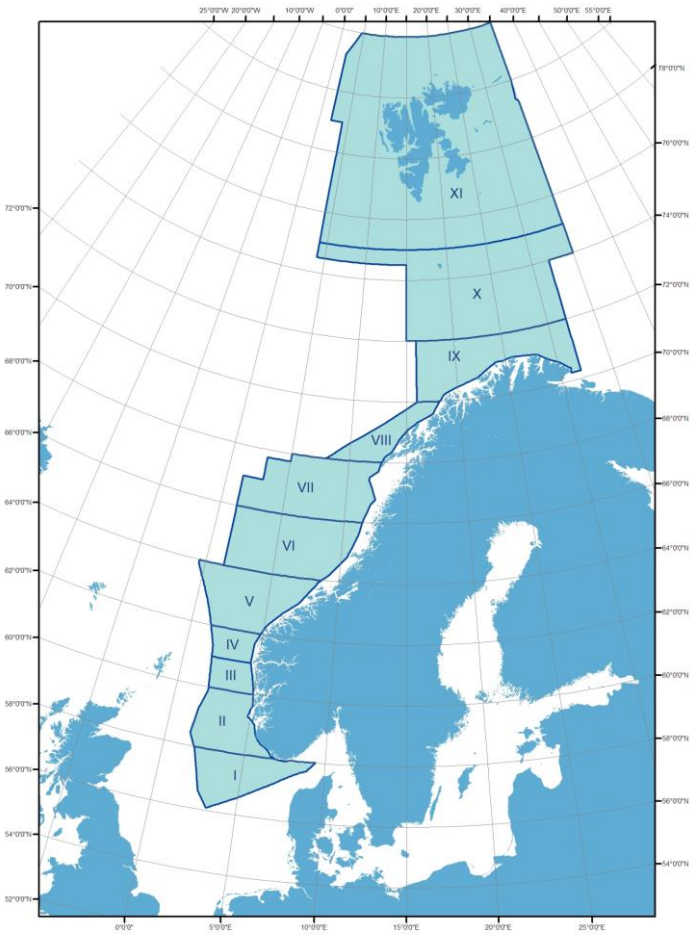


Figure 4-1. Overview of regions to be used for offshore environmental monitoring of benthic habitats

Table 4-1: Monitoring of benthic habitats in the different regions in the period **2022-2024**[1]			
Region/field[1]	Year for planned regional survey		
North Sea			
I **Ekofisk region** *56-58 °N* *Brynhild*[2]*, Ekofisk, Eldfisk, Embla, Gyda, Hod, Oselvar*[2]*, Tambar, Tor, Trym, Ula, Valhall, Yme.*	2023		
II **Sleipner region** *58-60°N* *Alvheim, Atla, Balder, Byggve, Bøyla, Edvard Grieg, Gaupe*[2]*, Gina Krog, Grane, Gudrun, Hanz, Heimdal, Ivar Aasen, Jette*[2]*, Johan Sverdrup, Jotun*[2]*, Ringhorne Øst, Sigyn, Skirne, Skogul, Sleipner Øst og Vest, Solveig, Svalin, Utgard, Vale, Varg, Vilje, Volund, Volve.*		2024	
III **Oseberg region** *60-61°N* *Brage, Fram, Fram H-Nord, Huldra*[2]*, Martin Linge, Oda, Oseberg, Oseberg Sør og Øst, Troll, Tune, Veslefrikk*			2025
IV **Statfjord region** *61-62 °N* *Duva, Gimle, Gjøa, Gullfaks, Gullfaks Sør, Knarr, Kvitebjørn, Nova, Snorre, Statfjord, Statfjord Nord og Øst, Sygna, Tordis, Valemon, Vega, Vigdis, Visund, Visund Sør.*	2023		
Norwegian Sea			
V **Møre-region** *62-64 °N* *Ormen Lange*		2024	
VI **Haltenbanken-region** *64-66 °N* *Alve, Bauge, Draugen, Dvalin, Fenja, Heidrun, Hyme, Kristin, Maria, Marulk, Mikkel, Morvin, Njord, Norne, Skarv, Skuld, Trestakk, Tyrihans, Urd, Yttergryta, Ærfugl, Åsgard.*		2024	
VII **Nordland-region** *66-68 °N* *Astaa Hansteen, Snefrid Nord*		2024	
VIII **Troms region** *68-70 °N*			
Barents Sea			
IX **Finnmark region** *70-72 °N* *Snøhvit, Goliat*			2025
X **Barents Sea South** *72-75 °N* *Johan Castberg*			2025
XI **Barents Sea North** *North of 75 °N*			

[1] The list is not complete. [2] Shut down.

4.1 Time frame

Program

Draft programmes for monitoring surveys of benthic habitats must be submitted to the authorities by March 1st of the year in which the surveys are to be carried out, see section 54 of the Activities Regulations. Final programs should be submitted to the Agency by April 1st, cf. section 34 of the Management Regulations, and latest two weeks before field work starts. Deadlines for the submission of draft programmes for baseline surveys are established together with the Agency on a case-to-case basis.

Execution

Fieldwork in connection with monitoring of sediments and soft-bottom fauna should be carried out in the period May 1st– June 15th in regions I–VIII (58–70°N). For regions IX–XI (North of 70°N) the period is extended until July 1st. The reason behind this is to avoid capture of juvenile stages.

In special cases, operators may carry out sampling at other times, but this must be well justified in the programme submitted to the authorities.

Reporting

The deadline for delivering verified draft reports from baseline surveys and regional monitoring surveys to the Agency and DSA is 1st April of the year after the surveys were carried out. The Agency, DSA and the Agency's expert group will evaluate the reports. Comments to the reports will be sent by June 15th. The evaluation comments must be answered. The deadline for delivering final reports is October 1st, cf. section 34 of the Management Regulations. The reports will then be made available on the Agency's website before the "Forum for offshore environmental monitoring" takes place.

If results obtained during the surveys or sample processing deviate substantially from the expected status or trend, this must immediately be reported to the Agency.

4.2 Survey frequency and sampling design

Baseline surveys

Baseline surveys are part of the benthic habitat monitoring and consist of taking samples of the seabed, describing the sediment composition, analysing the samples for heavy metals and oil compounds, as well as describing the composition and condition of the soft bottom fauna. In areas defined as vulnerable or where the presence of vulnerable species or habitats is probable visual surveys are required in addition to traditional monitoring (see chapter 5).

The scope of baseline surveys should be shaped by the need to obtain new knowledge.

The purpose of baseline surveys is to establish background data for the various parameters, as well as a 'robust' average value that will represent the basis for a local LSC (Limit of Significant Contamination).

There is no LSC established for radioactivity, as the components being analysed also occur naturally and there is natural variation. However, background data is needed to be able to assess whether the level of naturally occurring radioactive substances in the environment is increasing (in relation to the natural background level). Therefore, some baseline surveys must include taking sediment cores, for which several sediment depths must be dated through established lead-210 methods. The purpose is to be able to say something about the change in background levels over time, both levels of radioactive substances and the relationship between different nuclides.

Section 53 of the Activities Regulations requires baseline surveys to be carried out:

- before exploration drilling in new and previously unsurveyed areas (depending on existing knowledge about the characteristics of the seabed and of the benthic fauna in the area);
- before exploration drilling in areas where vulnerable species and habitats have been shown to exist, or where their existence is probable;
- before production drilling.

Regional stations must be established as soon as possible and latest by the time production drilling starts.

A baseline survey is valid for six years unless the Agency decides otherwise after consultation with the Agency.

Operators must contact the Agency if they’re unsure whether conducting a baseline survey in connection with new activity is required cf. Activities Regulations § 53.

Operators must have and provide an overview of existing monitoring data for the area of interest and state why they do not consider that a baseline survey is necessary. The area(s) in question should be well investigated, and information that vulnerable benthic fauna is not present in the area must be made available in order for the Agency to be able to grant an exemption.

Field-specific surveys

In general, the same survey frequency is required for all types of fields and developments.

- Monitoring of a field starts with the first regional survey for the relevant region.
- After the first survey, field-specific monitoring surveys are as a general rule conducted every three years, as part of the regional monitoring surveys. Changes in the frequency of field-specific surveys must receive prior approval from the authorities.
- After the production phase has ended, further environmental surveys are carried out as described in chapter 6.

The scope of field-specific surveys must reflect the results of previous surveys and the level of activity and discharges registered on the field in question. This means that certain stations or analyses may be omitted, and new ones included in consultation with the

Agency and DSA. The final scope of these surveys is decided during annual planning meetings as described in chapter 1.3.

Regional surveys

The Norwegian continental shelf has been divided into eleven geographical regions for the regional monitoring of benthic habitats (see Figure 4.1). Table 4-1 provides further details on the location of each region, which fields are included in each region and the schedule for regional surveys. Benthic habitats in each region should, as a rule, be surveyed every three years. A regional survey includes both the regional and the field-specific stations in the region.

Samples from the regional and field-specific stations in one region are to be taken during the same survey. The regional stations are intended to provide information on general background levels in the area for the parameters that are monitored and to function as reference stations for the expected normal situation. The field-specific stations are intended to provide information on the environmental status near the facilities in each region. Samples should primarily be analysed for petroleum hydrocarbons, metals, naturally occurring radioactive substances, as well as sediment and fauna composition.

4.3 Station network

The monitoring of benthic habitats has both a local and a regional focus. Within each region, the objective of field-specific monitoring is to reveal any impacts of individual facilities on the surrounding area, while a set of regional stations is intended to reflect normal benthic conditions in the region and make it possible to detect whether oil and gas activities have more widespread impacts in the region. Previously established reference stations, where no impacts have yet been detected, must from now on be classified as regional stations. All changes in regional stations must be corrected in environmental monitoring database (MOD).

The locations of regional stations must be coordinated with the locations of the field-specific stations in the same region. The positioning of both types of stations must be based on information about:

- depth and topography;
- currents and dispersal patterns in the area in question;
- sediment characteristics and sedimentation patterns;
- discharge history of the fields;
- pipelines and other facilities on the fields.

It is the operators' responsibility to make use of this information to revise a station network or establish a new one. Data on currents must cover a range of depths and the different seasons of the year. It is particularly important to obtain data for the depths immediately above the seabed as well as those where discharges are planned/ expected. Further elements to be considered when selecting either field-specific or regional stations are described below.

4.3.1 Selection of stations for baseline surveys

Regional stations

When a first regional survey is to be carried out, a representative selection of at least 10 regional stations should be established to provide a general picture of background benthic conditions in the region. The regional stations should therefore be located in areas that are not expected to be affected by discharges from the offshore oil and gas industry, either at the time or later. The Agency, in agreement with the Institute of Marine Research in Norway, considers that several of the stations used by MAREANO can be used as future regional stations. A new regional station must be established if a regional station proves to be affected by a later field development.

The following elements should be taken into consideration when positioning regional stations:

- they should cover all the main types of seabed (sand, clay, etc.), with main emphasis on sedimentation areas;
- if the water depth in the region varies, the stations should be located in such a way that typical depth intervals can be described;
- the stations should cover all parts of the region where there are field developments or where developments are expected.

When a baseline survey is carried out before production starts on a field, a minimum of three of the regional stations should be associated with the field in question. For a baseline survey carried out before an exploration drilling it may be enough to include only one regional station. These stations should be as representative as possible of background conditions on the field. They should be reasonably close to the oil or gas field in question and have similar sediment type and depth. If necessary, more regional stations can be established near the field/exploration drilling location area for this purpose. The same regional stations must be used from year to year both in the baseline survey and for later monitoring surveys of the field. Results from the regional stations are to be used as reference values for assessing possible effects observed at nearby field-specific stations.

Field-specific stations

Field-specific stations for a baseline survey before production drilling should preferably be established using a radial transect design that is expected to be permanent for subsequent monitoring surveys of the field. The stations are to be placed at increasing distances from the discharge point (according to the geometric series 250 m, 500 m, 1000 m etc). Transect length with increasing distance from the discharge point should be decided upon on a case-to-case basis. Stations less than 250 m from the facilities should be established if practically possible and acceptable in terms of safety. If the final position of the oil or gas field centre has yet not been determined, a grid design may be used for station positioning across the field. A system with three parallel transects placed 1 km apart, with three to four stations in each transect is often used.

If the geographical characteristics of a field development indicate that a radial transect design will not be optimal, another design may be selected and used in subsequent monitoring surveys. The operator should inform on the reasons for doing this, and the station network should be designed in agreement with the Agency. The stations should

cover as much as possible of the entire area that will later be included in the monitoring programme. The orientation and surface of the station network should be determined based on the expected area of influence estimated with the help of prognoses on discharge quantities and dispersal modelling (using the same assumptions as the EIA carried out for the field).

The operator should be able to document the reasons for the selected station positioning, based for example on water current patterns, depth intervals etc. The stations should be located so that it is possible to determine the degree to which benthic habitats are affected by discharges from the oil or gas field. Each station must be given a unique designation consisting of a maximum of seven characters (including both letters and numbers). The same designation must be used on maps, in tables and in the text. If a station is later moved by more than 50 m, it must receive a new designation. Any such changes must be specified in the report and the station history must be shown in a table. These changes must also be recorded in MOD.

During a baseline survey before production drilling, samples should be taken from a minimum of three regional stations (including existing stations. These stations are expected to become the regional stations associated with the field in subsequent monitoring surveys.

It can be difficult to maintain a radial transect or grid design of the stations when carrying out baseline surveys in deep water (>500 metres). In such cases, the stations should be positioned as optimally as possible in relation to the discharge pattern, expected dispersal patterns and benthic conditions.

In connection with baseline surveys before exploration drilling one should follow the rule of establishing a radial transect if the drilling location is known, or a grid design if the drilling location is not known. The number of stations may depend on depth, seabed conditions and proximity to other fields / formerly investigated areas. The number of stations may often be reduced but must be brought back to the standard number when conducting a baseline survey before production drilling.

4.3.2 Selection of stations for follow-up monitoring surveys

After drilling and discharges to the sea have started, the station network used for the first monitoring survey of a field should as a general rule be the same as that used for the baseline survey. However, depending on the overall monitoring activity in the region in question, certain stations may be omitted, and new ones added in consultation with competent authorities. The monitoring programme should reflect the discharge pattern on the examined field. To make it possible to compare results between years, the positions of specific stations should not be changed. The deviation in position should not exceed ±50 meters. If a station is later moved by more than 50 m, it must receive a new designation. Any such changes must be specified in the report and the station history must be shown in a table. These changes must also be recorded in MOD.

If it is difficult to collect representative samples at a station, for example due to high content of stones, sponge spicules or the like, the person responsible for the survey may decide to leave the station without taking samples. Any such deviations must be described

in the monitoring report (see chapter 6.1 under methods). If necessary, authorities may also require the establishment of new stations in transitional zones between oil and gas fields.

Regional stations

As a general rule, a regional monitoring survey must include all the established regional stations. In new regions where there are few fields to be monitored, regional surveys may in special cases be limited to the regional stations that are associated with fields. A gradual reduction of the number of stations originally established as reference stations may also be considered in areas where fields are being closed down.

In the case of regional stations, all replicates of the chemical samples should be analyzed for calculating LSC. This should be done at least during three surveys (ca. 10 samples).

Field specific stations

When a final decision is made regarding the location of the facility(s) and discharge points, a permanent network of monitoring stations can be established using the baseline survey as a starting point.

In the case of single facilities, a radial transect design should preferably be used, with one axis along the prevailing direction of current flow just above the seabed and the other perpendicular to this. This is the preferred design even in cases where a grid pattern was used for the baseline survey. In such cases, as many stations as possible from the grid should be retained. In the case of a complex field development (many subsea facilities, for example) it may be necessary to deviate from this design, as stations must be located in a way that makes it possible to monitor the scale of the impacts of the facilities. Most of the stations should be located downstream of the facilities with respect to the prevailing current direction. One of the two radial transects should run North-South if no prevailing current direction can be identified.

Regardless of whether a grid or radial transect design is used, the station network should always include at least one station in each of the four main directions, even if there is no indication of chemical contamination or biological impact on the field. If the chemical contamination (for Ba 2xLSC is used as the limit) or biological impact on a field extends beyond the outermost stations in the network, new stations must be established outside these for the next monitoring survey. The new stations should be placed along the axes, at geometrically increasing distances. If later surveys (after the baseline survey and first follow-up monitoring survey) show elevated values for any of the parameters analysed at the first two stations downstream of the discharge point/facility, chemical analyses should as a minimum be carried out at all the innermost stations (along the other three radial transects) in addition to the three downstream stations. Analyses of THC and Ba (or the equivalent weighting agent) should be performed at all stations.

The scope of the monitoring surveys in each region and each field should reflect the level of activity, discharge history, and the results of the previous survey. As a general rule, the outermost stations sampled should always be unaffected (no biological impact or chemical contamination). If there is no measurable biological impact or chemical contamination, the station network can be reduced when the next benthic survey is carried out. For the same

reason and provided discharges are low in the meantime, it may also be possible to extend the period between surveys of a field to six years.

4.4 Analytical parameters

This chapter describes what parameters or group of parameters should be analyzed in the collected sediment samples. Table 4.2 below provides an overview of requirements regarding numbers of samples, analytical parameters, sample storage, etc. The Agency may request analysis of additional parameters (screening of new substances) on the basis of information on discharges in a region or an individual field.

Table 4-2: Sediment samples, sample depth, size and storage

Parameter	Sample depth	Baseline and first follow-up survey	Subsequent surveys	Sample storage and size
TOC/TN	0-5 cm	Mixed sample from 3 grab samples for all stations	Mixed sample from 3 grab samples for stations where fauna is analyzed	≤ -20°C[1] 100 g
Grain size	0-5 cm	Mixed sample from 3 grab samples for all stations	Mixed sample from 3 grab samples for stations where fauna is analyzed	300 g
THC	0-1 cm 1-3 cm[2] 3-6 cm[2]	3 samples 1 sample 1 sample	3 samples 1 sample 1 sample	≤ -20°C[1] 300 g
Drilling fluid	0-1 cm			≤ -20°C[1] 300 g
NPD and PAH	0-1 cm	1-2 samples	1-2 samples	≤ -20°C[1] 300 g
Metals Ba[3], Cd, Cr, Cu, Pb, Zn, Hg, As	0-1 cm	3 samples	3 samples	≤ -20°C[1] 50 g
Core samples Radioactivity Ra-226, Ra-228, Pb-210, Th-22	0-1 cm 1-3 cm 3-6 cm		3 samples 3 samples 3 samples	200 ml dry weight Detection limit: Ra-226= 5 Bq/Kg Ra-228 = 15 Bq/Kg

Table 4-2: Sediment samples, sample depth, size and storage				
Parameter	Sample depth	Baseline and first follow-up survey	Subsequent surveys	Sample storage and size
				Pb-210 = 20 Bq/Kg Th-228 – 10 Bq/Kg
Sediment cores with lead dating[4] Radioactivity Ra-226, Ra-228, Pb-210, Th-228	0-10 cm (with 1 cm distance)	1-2 samples	1 sample from regional stations 1 sample from selected stations. Otherwise, regular core samples	200 ml per sediment depth dry weight
Macrofauna		5 samples	5 samples	10 % formalin[5] Bengal red / Eosin
Meiofauna[6]				

[1] As stated in ISO 5667-19:2004 and ISO 16665:2013.

[2] Profile samples to be taken only on a selection of fields/stations.

[3] And/or equivalent main component in the weighting agent (*e.g.* ilmenite contains titanium-iron, Ti).

[4] There are several methods for lead dating. Choice of method depends on local conditions. Both Institute for Marine Research (HI) og Geological Survey of Norway (NGU) can provide good method descriptions.

[5] Formalin may be replaced by less harmful stabilization liquids when testing of these is in place.

[6] This can be relevant in areas where conventional sampling equipment cannot be used.

Monitoring of the vertical extent of contamination should be done when necessary, after consultation with the Agency and DSA. Vertical sectioning of the sediment samples should provide an estimate of how deep into the sediment drilling waste is present at selected stations and whether a natural recovery process is underway.

4.4.1 Sediment appearance on sampling

The characteristics of a sample should be described immediately after collection. Use procedure described in NS-EN ISO 16665. See also *JAMP Guidelines for Monitoring Contaminants in Sediments* (JAMP 2002-16). Such characteristics may include:

- the presence of drill cuttings, empty shells or other objects;
- the presence (or absence) of conspicuous fauna;
- smell (for example H_2S or oil);
- sediment description (sand, clay, gravel etc.) and stratification of layers;
- color (according to Munsells color charts for soils and sediment).

It is also recommended to log the number of unsuccessful grab loads.

4.4.2 Physical and chemical sediment analyses

Total organic carbon (TOC)/ total nitrogen (TN)

TOC is to be determined in samples from all stations in baseline surveys and first follow-up monitoring surveys. TOC should subsequently be determined in samples from stations where biological analyses are carried out. The same applies to TN-analyses, if these are included. The Agency may require continued analysis of TOC/TN if this is considered necessary.

Grain size distribution

Analysis of grain size distribution is required for all stations in baseline surveys and first follow-up monitoring surveys, and subsequently at stations where biological analyses are carried out. As a minimum, the percentages of silt/clay (<63 µm), sand (63-2000 µm) and gravel should be presented for all biological surveys as a supporting parameter for interpretation of soft-bottom fauna data.

Hydrocarbons and synthetic drilling fluids

As a general rule, analyses should include the groups of substances specified below. Certain analyses may be omitted if the operator can document that there have been no discharges of the substances in question. The operator should also take into account the discharge status on the field and in the region and assess whether other parameters should be analysed.

The following analyses should be done on samples collected from all stations in baseline surveys and first follow-up monitoring surveys:

- THC
- main components of synthetic drilling fluids (if used)
- NPD and PAHs (see appendix III).

Depending on the degree and extent of contamination, the analytical programme for field-specific stations can be reduced from the second monitoring survey onwards:

- THC (and possibly synthetic drilling fluids): all stations
- NPD and PAHs: all regional stations and as a minimum, the two downstream field-specific stations closest to the discharge point/facility. Also, on stations
    - where significantly high values were found in the previous survey
    - where the concentration of THC (mean value of three grab samples, including olefins) is higher than 50 mg/kg
    - where biological impacts have been registered.

If significantly high values for THC or NPD/PAHs are found at the two closest downstream stations in one monitoring survey, NPD/PAH analysis should be reintroduced in the next survey for the three downstream stations and the inner stations around the facility in the three remaining directions.

Sediment samples from different soil layers (0-1, 1-3 and 3-6 cm) should be taken for THC analyses on a few fields. These may include fields where drilling with oil-based fluids was previously conducted, fields where leakages from injection wells were registered and fields

where dredging operations have been carried out. Particularly which fields and what number of stations are to be investigated is determined after consulting with the Agency. Taking profile samples is not required when conducting baseline studies unless there are suspicions of past contamination from previously drilled exploration wells in the area.

Metals

For baseline and first follow-up monitoring survey, analyses of the following metals should be done for all stations: Ba or the equivalent main component in the weighting agent, As, Cd, Cr, Cu, Pb, Zn and Hg. Depending on the degree and extent of contamination, the analytical programme can be reduced from the second monitoring survey onwards. Metals should be analysed in samples from all regional stations and as a minimum in samples from the two downstream stations closest to the discharge point/facility. Metals should also be analysed in samples from stations:

- where significantly high values were found in the previous survey (2xLSC is used as the limit for Ba);
- where the concentration of THC (mean value of three grab samples, including olefins) is higher than 50 mg/kg;
- where biological impacts have been registered.

If significantly high values are found at the two closest downstream stations in one monitoring survey, all metals should be analysed in the next survey for the three downstream stations and the inner stations around the facility in the three remaining directions.

If the previous monitoring survey has not found elevated metal concentrations, these analyses can rest as long as no drilling activity was undertaken since, and there are no other relevant factors of importance for metal concentrations in the sediments.

Radioactivity

The number of samples for analyzing naturally occurring radioactive substances and station selection are assessed on a year-to-year basis based on data available for the field and the size of the discharge.

Baseline surveys: Sediment cores must be taken during baseline surveys before start-up of oil fields with expected discharges of produced water and before start-up of subsea production units. Samples shall be taken at the point of discharge. For subsea units this will be the point of discharge at the mother facility. Sediment cores are not required before exploration drilling. In connection with the baseline surveys, sediment cores must be dated at different sediment depths by using established lead-210 method in order to say something about changes in background levels over time, both individually for the naturally occurring radioactive substances Ra-226, Ra-228, Pb-210 and Th-228 and the ratio between these.

Field specific stations: If core samples are taken, they must be analysed for Ra-226, Ra-228, Pb-210 and Th-228 at minimum 3 different distances from the petroleum facility in order to be able to interpret the results along a gradient. Samples must be taken as close as possible to the platform (eg, 250, 500 and 750 m), and 3 different sediment depths must be

analysed for each sampling point (at 0-1, 1-3 and 3-6 cm depth). Where cores are taken in different directions, at least two shall be downstream in the main sea current direction. Taking core samples around facilities that do not discharge produced water is not relevant.

If there are indications of accumulation og radioactive substances in core samples at a field, sediment cores must be taken in accordance with established lead-210 method at stations with elevated values. These are in addition to the sediment cores taken for the individual baseline surveys.

Regional stations: Background data is needed for each region in order to be able to assess whether the level of naturally occurring radioactive substances in the environment is increasing (in relation to the natural background level). Sediment cores must therefore be taken at regional stations every 9 years.

4.4.3 Biological characterisation

A thorough analysis of the soft-bottom macrofauna, including taxonomical identification and number of specimens belonging to each species should be carried out. The purpose of the investigation is to reveal potential impacts on the fauna as a result of discharges and contamination on the field. Calculations of biomass are not required.

In some cases, it may be needed to investigate meiofauna in the sediment samples in addition to or instead of macrofauna. This may be relevant in areas where conventional sampling equipment cannot be used. Where such analyses are appropriate, the methodology and relevant fauna groups should be discussed with the Agency.

Samples for biological analyses are taken at all stations during baseline surveys and first follow-up regional surveys. In subsequent surveys, biological analyses should be included for the regional stations and the field-specific stations closest to each facility, preferably at a distance of 250 m. If biological impacts or values of THC > 50 mg/kg are found at field-specific stations, the minimum requirement for the subsequent survey is to take samples at each station where a biological impact was found and the next station in the transect (further out from the facility).

4.5 Sample collection and processing

For sample collection and processing in the field (including requirements regarding the vessel, keeping field logs, choice of sampling equipment, collection procedures, etc.), please refer to NS-EN ISO 5667-19 for sediments, NS-EN ISO 16665 for soft-bottom fauna and NS-EN 16260 for visual surveys.

If a laboratory is seeking approval of a new accredited method, the company should provide documentation that the results achieved with the new method are as good as or better than those achieved with the old method.

4.5.1 Sample collection

For baseline surveys of soft-bottom habitats, there should be chosen appropriate quantitative sampling equipment that can be used for the collection of both biological and

chemical samples. The equipment must sample a minimum area of 0.1m^2. The use of a different type of sampling equipment in subsequent surveys requires approval from the Agency.

Benthic samples should be taken with suitable equipment to avoid sediment compression. The equipment used to subtract subsamples for metal and hydrocarbon/drilling fluid analysis should not contaminate the samples (see NS-EN ISO 5667-19).

In shallow areas (<500 meters) one should as a rule use a modified van Veen grab (see Appendix IV). Heavier equipment such as boxcorer can be used in deep areas (*e.g.* Ormen Lange). The most important is that the same type of equipment is used in subsequent surveys.

In some cases, a grab sampler may not be suitable, for example:

- in areas where there are cold water corals or sponge communities;
- in areas where the seabed habitat is heterogeneous – a mixture of rock, stones and gravel with some soft-bottom areas;
- when monitoring discharges from the top-hole section after drilling; in such cases, there is so little dispersal that traditional sampling methods cannot convey the extent of the impacts;
- potentially at big depths (> 500 m)

If necessary or desirable, other types of equipment may be used after consultation with and approval from the Agency. In such cases, parallel use of both types of equipment during field work may be necessary on a temporary basis within a predetermined area. The purpose of such a trial is to determine whether there are differences in the results of significance for data interpretation and time trend analysis.

Separate samples should be taken from the upper 0–1 cm of the sediment (optionally from several depths) in each grab sample for analysis of metals and hydrocarbons/drilling fluid. Each sample is to be packaged, stored and analyzed separately.

Samples for chemical and biological analyses are to be taken from separate grab loads, collected in accordance with NS-EN ISO 16665. This does however not exclude the use of modified van Veen grab sampler because chemical and biological samples taken with such devices are to be regarded as separate samples. For sieving of macrofauna samples in the field, see the same standard. Sieves should have round openings and a mesh opening of 1mm.

The samples collection methodology for meiofauna analyses needs to be discussed with the Agency. It is preferable to take separate core samples, but it is also possible to collect partial samples from the grab loads for such analyses.

4.5.2 Sample storage

Sediment samples to be analysed for grain size distribution, hydrocarbons, synthetic drilling fluids and metals are to be stored at a minimum temperature of -20 °C until they are analysed.

For preservation of biological samples in the field and sample storage, see NS-EN ISO 16665.

4.5.3 Establishment and storage of biological reference material

Accurate species identification is of fundamental importance for the reliability of the statistical analyses of the fauna. Experience has shown that quality control of species identification of the macrofauna needs to be improved. Consultants should insofar as possible use the same species identification literature.

One way of improving the situation is to build up a reference collection by retaining selected biological material from the surveys (specimens of genus and species). External taxonomists should validate the reference collection at regular intervals. It is important that the contractors/institutions carrying out the surveys use the services of the same external taxonomists. It is also important to be aware of the fact that reference collections and specimen samples from the surveys have different purposes and shall not include the same material.

It would be best to assign the responsibility for the storage and curation of the material to experts, for example within natural history museums. The Agency encourages oil companies/contractors to enter into agreements with suitable museums/institutions to ensure that the same procedures for sample selection, storage and curation are used in all surveys. Relevant museums are affiliated to the Universities of Bergen, Trondheim, Tromsø and eventually Bodø.

4.5.4 Analytical methods

One should use analytical methods described in updated Norwegian or international standards.

All results of the chemical analyses of sediment are to be standardised using kg dry weight of sediment.

4.5.5 Physical and chemical sediment analysis

All stones larger than 5 mm should be removed from the subsamples before chemical analyses are performed.

TOC/TN

There is no Norwegian or international standard for analyzing TOC in sediments. Common to the methods in use today is the removal of inorganic carbon with acid and subsequent combustion. Detection is however different. We recommend that analysis of TOC is performed with instruments that have a hot wheel detector (HWD). In this way, TN can also be determined in the same batch, without significant additional costs.

Grain size distribution

The methodology for determining grain size distribution in the range 2000 to 63 µm is described in Bale & Kenny (2005). No further subdivision of the fraction < 63 µm is required.

The weight of each fraction is determined (to the nearest 0.01 g) and cumulative percentages by weight are calculated for each station. The results are further used to determine the median particle diameter and standard deviation, together with the skewness and kurtosis of the grain size distribution.

Hydrocarbon analyses

Hydrocarbons are to be determined in all samples from all stations, in accordance with Chapter 4.4.2. Methods with a high hydrocarbon extracting efficiency from sediment samples must be used. The analytical laboratory must be able to document this on request.

THC should be determined using a gas chromatography/flame ionisation detector (GC/FID) in the retention window C12 to C35. A reference oil sample will be used as an internal standard for the quantification. The reference oil in use is EDC 95/11[3]. If this is replaced, intercalibration exercises using equivalent reference oils are required. NPD and PAHs should be determined by means of gas chromatography / mass spectroscopy (GC/MS), and results should be reported for both individual components, sum NPD and sum PAH. If the drilling fluid used contains organic components (ethers/esters), the samples must also be analysed for these substances.

Detection limits should meet the following minimum requirements:

- THC: 1 mg/kg dry sediment (the quantification limit to be given in the report);
- NPD/PAHs, individual components: 1 µg/kg dry sediment.

Assessment of development trends over time of THC concentrations and size of contaminated area should be carried out based on field-specific data. Similarly, analyses of development trends over time at the regional stations should be done. These analyses are to be carried out using a suitable statistical tool. Data sets from earlier surveys can be found in the MOD database.

Synthetic drilling fluids

The sediment samples are to be analyzed for the main component in synthetic drilling fluids. The analytical method needs to be adapted to the relevant substances. Where appropriate extraction and further processing of the sediment samples for these analyses may be conducted together with those for hydrocarbon analyses.

[3] HDF-200, previously used as a referance oil, is no longer being produced.

Metal analyses

The samples are to be analyzed after digestion with nitric acid, HNO_3. The following metals should be determined: Ba, Cd, Cr, Cu, Pb, Zn, Hg and As[4]. If other weighting agent except Ba was used during drilling (*e.g.* Ti) the relevant parameter must also be analyzed. For determination of Hg, the samples should be freeze-dried or dried at 40 °C before sieving and digestion.

All parameters should be analyzed using ICP-MS or other well documented instrumental methods of high sensitivity that provide sufficient accuracy of the results. This needs to be documented in the laboratory's quality assurance system. Hg may be determined using cold vapor technique/Hg-analyzer. Detection limits for metals are shown in appendix V.

Analyses of development trends over time should be carried out for any metals with recorded values exceeding the background level. Metals with values below LSC may be left out in the illustrations included in the report.

Limits of significant contamination (LSC) and interpretation

LSCs are calculated based on the results recorded at regional stations. Before LSC values are calculated, a principal component analysis (PCA) of the chemical data should be carried out, both for the current year alone and for all available data (as a minimum data from the three last surveys in the regions). The results of the PCA will clarify whether it is necessary to split the region into subregions. If subregions are used, they must be the same for THC and for the weighting agent used (*e.g.* barite or ilmenite). LSC values are to be calculated both for the current year's data set alone and using the complete data set from all surveys in the region.

The values obtained with different calculation methods are compared and assessed to choose the relevant LSC (for the whole region or subregions).

LSC values are calculated from mean values, using a unilateral t-test and a significance level of 5 %. LSC values must contain a significant number of digits. The formula for calculating LSC values is given in the appendix VI.

As a general rule, the LSC values obtained on the basis of all available data are quite robust and vary only slightly from one survey to another.

Radioactivity and interpretations

All samples must be analyzed for Ra-226, Ra-228, Pb-210 and Th-228 using quality assured methods. Uncertainty (2 sigma) must be stated in the analyses stated in Bq/l (water) and Bq/kg (sediment or biota). Detection limits must be provided. If a radionuclide is not detected in a sample, then half the detection limit is to be used as a result. Samples with values below the detection limit can be omitted in the figures.

Results from analysis of core samples are to be interpreted by comparing values in sediment layers (lead-dated) from the time before and after production start in the area

[4] Analyses of arsenic in sediment are carried out for the first time in 2017.Same method to be used as for Cd.

where such data is available. Results must also be analyzed along a gradient from the nearest stations to the platform and further away to assess whether there are concentrated substances in the area closest to the platform.

Results from core samples of Ra-226, Ra-228, Pb-210 and Th-228 shall be presented separately in figures showing the gradient from the platform and the three different depths and compared with results from the regional stations. When visualizing data the prominent current direction in the area should also be shown. The presented results must include measurement uncertainties (2 sigma).

Results from sediment cores must be presented with concentration of Ra-226, Ra-228, Pb-210 and Th-228 in each sediment depth, age (lead-dated), and sedimentation rate.

An assessment of the temporal development of concentrations / contaminated area on the field-specific data and on results from the regional stations must be made. For previous datasets, go to the MOD database.

4.5.6 Biological characterization

Special guidelines for the analysis of benthic fauna samples are given below. Otherwise, use NS-EN ISO 16665 for species identification. As a rule, taxonomic resolution should be at species level.

Organisms belonging to Porifera, meiofaunal groups such as the *Harpactoida*, planktonic organisms such as copepods and mysids, and fish may be identified and recorded if wished, but they should be excluded from calculations of community indices and from multivariate analyses.

For some groups (for example *Oligochaeta*, Cnidaria, Solenogastres and Phoronida), it may be necessary to operate with morphological forms only, since species identification requires special expertise and fixation techniques. This will fulfil the requirements for the subsequent numerical analyses. Solitary hydrozoans should be identified down to species level, but this is not necessary for colonial species. As an exception, larger species of *Foraminifera* may be identified. Statistical analyses are to be performed both with and without such species.

The taxonomic resolution should as a minimum be the same in the follow-up monitoring surveys as in the baseline survey.

Newly settled juveniles of benthic species should be identified and included in the data set, with the exception of newly settled larva of *Echinoidea*. If juveniles appear among the ten most abundant organisms in the data set, the statistical analyses should be performed both with and without these in order to illustrate their influence on the benthic community.

Only professionally qualified personnel should perform species identification. Documentation of quality control procedures, as well as species identification literature should be available on request. Taxonomic identification should be done using up to date, authoritative literature and digital identification tools. As a general rule, taxonomic resolution should be at species level.

Databases like Worms (World Register of Marine Species) or ERMS (European Register of Marine Species) should be used to provide consistency in terms of species identification so that data is comparable.

4.5.7 Processing of biological data

The following data is required for each station:

- complete lists of recorded species (species name and number of specimens of each species),
- total number of species,
- total number of specimens standardized to a sediment surface area of 0.5 m^2,
- table with the ten most abundant species (species name, number of specimens and percentage from the total number of specimens at the station), also showing the total number of species found at the station,
- H' (species diversity as Shannon Wiener index on a log2 base),
- ES_{100} (expected number of species per 100 individuals),
- NSI,
- ISI,
- NQI1

H' and ES_{100} are indexes for species diversity. NSI and ISI are sensitivity indexes recently updated and adapted to Norwegian soft bottom fauna (Rygg og Norling 2013). They describe the extent to which the soft bottom community consists of tolerant or sensitive species. NQI1 is an index that provides an overall indication of species diversity and sensitivity. It is based on the AMBI index for faunal disturbance (Borja & Muxika 2005) and the number of species and individuals in a sample.

All the results above should be standardized to a sediment surface area of 0.5 m^2.

The following analyses should be done at all stations on a field, including the regional stations associated with the field, and in addition for all the regional stations as a group:

- cluster analyses based on the Bray-Curtis dissimilarity index (Bray & Curtis 1957), followed by Group Average Sorting,
- ordination by non-metric multidimensional scaling (MDS).

The multivariate analyses should be carried out based on the values obtained by summing up the five samples from each station. Multivariate analyses should also be used to investigate the correlation between chemical and biological parameters. It is important that the results are presented and interpreted in a satisfactory manner, given the aim of the survey.

The method used to identify stations with disturbed fauna should be described in the report's chapter on method description, as do the reasons for choosing it.

Other analytical methods than those specified above may also be used, provided that they come in addition to those listed above.

4.5.8 Estimation of affected area

A conservative estimate of the maximum area with THC-contaminated sediment (as defined by LSC) is required. In addition, the maximum area with THC over 50 mg/kg[5] and the area with disturbed bottom fauna are to be estimated. The calculations are based on the assumption that affected areas are elliptical, and that the entire area within the innermost unaffected stations is considered contaminated. The calculation method is described in appendix VII. The calculated surface should be compared with those of previous surveys. This can be done provided that information is given on which wells and facilities are used in the calculations, for example in a table. If stations are omitted from a survey, resulting in the impossibility to calculate the affected area, it is assumed that the results of the previous year's survey are still valid.

4.6 Reporting

The purpose of offshore environmental monitoring is to provide an overview of the environmental status and of trends over time seen in relation to offshore oil and gas activities. It is important therefore that the survey results are assessed taking into account the state of the marine environment as registered in previous investigations as well as the discharge history in the area. Keeping this in mind, one should assess the condition of and potential impacts on the environment as part of the reporting process.

The results are to be presented in a technical report and a summary report with the authorities and the general public as the main target groups. A more detailed description of the expected report design follows below. The report is to be delivered in electronic format[6].

Final reports from conducted monitoring surveys are made available on www.miljodirektoratet.no after approval from the Agency and DSA.

The Agency expects one report for each regional survey. The report should provide an overview of the main environmental trends in the region and on the individual fields investigated. All raw data and results derived from these should be available to the authorities at all times in the centrally established MOD and in the form of electronic appendices to the reports. Consistency between the database and the reports, for instance in terms of results, variables and station names is very important. We recommend using MOD actively when retrieving and analysing data so that this functions as free quality control for the database and give the possibility to correct any errors that might be identified in the process.

Two separate reports from the monitoring surveys should be delivered: a summary report in English and Norwegian, and one main report in Norwegian. The raw data files, including the cruise log, must be provided as appendices to the reports.

[5] Commonly used lower limit for impact on benthic fauna due to chronic exposure.

[6] During the past few years a new tool for digital reporting has been devloped, where existing data in MOD has gradually been included alongside newly acquired data *https://viewer.dnv.com/EnvironmentalRiskManagement*. A summary report is published on the Agencys website as well. The reporting requirements in these guidelines will be adjusted accordingly later.

4.6.1 Summary report

The summary report should be maximum 20 pages long and be delivered in both Norwegian and English. The target group for the report includes the oil and gas companies, environmental authorities, and the general public.

The summary report should include the following elements:

- A one-page summary with a brief goal description, with tables or figures showing environmental status and trends in the region.
- a brief description of the fieldwork.
- presentation and discussion of the most important results (illustrated with figures and tables).
- main trends and comparison with earlier surveys, as well as uncertainty aspects connected to that.
- illustrations of seabed areas where contaminated sediments and biological impacts have been found should be included for each field and for the region as a whole.
- conclusions and recommendations.

4.6.2 Main report

The target group for the report includes oil and gas companies, environmental authorities, research institutions and consultancy firms. The survey and results must be presented in such a way that they also make sense for professionals who have not participated in the actual monitoring. The final scientific report should contain a complete documentation of the completed monitoring survey, focusing on:

- analytical parameters
- analytical methods and quality assurance the results and conclusions of the survey
- trends within individual fields and the region as a whole
- issues that should be given priority in future surveys.

The main report should include the elements described in the following.

Summary

A brief description (no longer than one page) of the purpose of the survey, an overview of the state of the environment and trends in the region in the form of a table or/and a graph.

Introduction

The following should be described for each field and, if relevant, for the region as a whole:

- the area expected to be affected by discharges from oil and gas activities, according to the EIA,
- drilling and discharge history and other activities that may have affected chemical and biological conditions up to the time of the survey,
- earlier surveys (table),
- main trends in pollution levels up to the moment of the current survey,
- specific goals and priorities for the current survey.

Methods

The methods section should include the following:

- map of stations showing coordinates, map scale, depth contours, existing facilities,
- reasons for the choice of stations (if any changes from earlier surveys),
- table with overview over station changes,
- brief description of the completed field work, including time frame for conducting the survey, number of stations, positioning system, sampling programme at each station and any problems or deviations from the programme and these guidelines, with reasons (complete field log in appendix),
- the report should mention whether sampling was not performed at a station or whether samples were rejected due to high stone or sponge spicule content in the sediment. Include a discussion on whether and /or how results were affected.
- brief description of the laboratory procedures (physical, chemical and biological analyses): description of any deviations, with reasons, and an evaluation of how they affect the results,
- detection limits, quantification limits and LSC must be reported for chemical analytical methods,
- principles for quality assurance routines in the field and laboratory, including details on participation in intercalibration exercises for relevant methods,
- accreditation status and proof, together with documentation of quality control of the results (chemical analyses) should be included in an appendix,
- which formulae for indices and which statistical methods were used, etc.,
- procedure and criteria for identifying stations with disturbed fauna,
- information about any supplementary analyses and reasons for conducting them,
- where and how the processed material (samples, reference collections, databases) is stored, responsibility for the material and results and their availability.

Results and discussion

This chapter presents and discusses the results of the survey. The elements to be included are summed up in Table 4-3 and discussed below.

Table 4-3: Physical/chemical and biological parameters to be included in the report

Physical/chemical characterizationn	Biological characterization
• grain size distribution divided as a minimum in silt/clay (< 63µm), sand (63-2000µm) og grus, • for grain size, median particle diameter and standard deviation should be provided, • color smell appearance, • total organic carbon (TOC), total nitrogen (TN) - voluntary, • table with average value of all parallel samples as well as standard deviations of chemical results from all previous surveys	• number of species and specimens standardized to a sediment surface area of 0.5 m^2 sediment (per station) • community indices (H', ES_{100}, NSI, ISI NQI1), • the 10 dominant species with density and percentage of total, • similarity between stations, grouping by means of multivariate analyses, • geographical distribution of station groups, • description of station groups based on: - depth

Table 4-3: Physical/chemical and biological parameters to be included in the report

Physical/chemical characterizationn	Biological characterization
• graphs showing relevant chemical data against year, presented with mean values (any high standard deviations to be marked with * and commented upon in the text), • LSC calculated based on results from regional stations for the current year's data set alone and for the entire data set (at least the three last surveys) i order of priority, for one of the following: - the whole region (all regional stations) - subregions if used (based on selected regional stations) - a selection of regional stations associated with each field in the region, • concentrations that are significantly different from background levels, • THC-contaminated areas for the fields and the region (both significantly over background level and over 50 mg/kg). • results from core samples of Ra-226, Ra-228, Pb-210 and Th-228 shall be presented in figures showing the gradient from the platform as well as the three different depths • results from field specific core samples shall be compared with results from the regional stations • sediment cores are presented in figures with a concentration of Ra-226, Ra-228, Pb-210 and Th-228 at each depth, age (lead-dated), and sedimentation rate.	- sediment characteristics - content of organic matter - content of hydrocarbons - content of metals - biological parameters, • analysis of correlation between community indices, density of selected species, physical properties of the sediment, and hydrocarbon and metal content (the significant correlations should be further analyzed to identify potential cause-effect relationships), • area with recorded faunal disturbance.

Similarities and differences in terms of chemical condition and faunal structure between field-specific and regional stations should be scientifically assessed on the basis of the biological results and multivariate analyzes. It is important that the results from the reference samples and the uncertainty estimations are considered in the discussion. This provides important information about the extent to which trends can be identified or whether identified changes are within acceptable uncertainty limits for the methods used.

Description of individual stations

Tables and figures should so far as possible be used to present the observations and the average results obtained for all physical, chemical, and biological parameters and all indices required. Any classification of these should be explained and reasons for its use given. Other characteristics of the station that are of significance for the discussion should also be presented. All relevant information given in figures and tables should also be mentioned in the discussion. The same results should however not be illustrated in both tables and figures.

Description of individual fields

- mean values, range (min.–max. and SD[7] or SE), geographical gradients of concentrations, and biological indices across the field.
- comparison with corresponding characteristics for the associated regional stations
- results of multivariate analyses on the similarity between groups of stations (Clarke et al. 2008).
- to what degree the physical/chemical characteristics could explain the observed biological pattern.
- specification of the areas where chemical contamination and biological impacts have been recorded.
- trends over time on the individual field for the characteristics listed in the bullet points above.

Description of the region

- mean values, range (min.–max. and SD[6] or SE[8]), geographical gradients of concentrations, and biological indices across all regional stations.
- results of multivariate analyses on the similarity between groups of stations, facilities, etc.
- to what degree the physical/chemical characteristics could explain the observed biological pattern.
- specification of the total areas in the region where chemical contamination and biological impacts have been recorded.
- changes in any of the points above since the previous survey.

The points listed in Table 4.3 should be included in the results and discussion chapter. They should also provide the starting point for answering the questions listed below.

- Can one group stations across the field or in the region based on a geographical or other pattern?
- How far from the discharge point/facility are chemical contamination (above LSC) and biological impacts statistically detectable?
- How big is the area with measured THC-concentrations above 50 mg/kg?
- How do the responses correspond with gradients in natural and anthropogenic environmental variables?
- How do the results correspond with those of earlier surveys?

[7] Standard deviation
[8] Standard error of the mean

- How do the results correspond with those of relevant surveys in nearby areas?
- Are the effects correlated with the discharge history of the field or region?

The extent of the area with chemically contaminated sediments and the area with disturbed fauna should be illustrated both in tables (km^2 for chemical contamination and biological disturbance) and in maps for the field/region in question.

Overall evaluation and conclusions

This chapter should contain concluding remarks on the environmental status and trends on individual fields and in the region, discussed in relation to EIA predictions and results of previous surveys. The most important trends regarding the benthic habitat both on individual fields and in the region should be described. The chapter must also identify areas where there are problems.

If visual surveys were carried around the same time as the benthic habitat survey or relatively recently, the results of these should be taken into account in the evaluation and interpretation of the survey results.

Recommendations

The report should include thoughts on future environmental monitoring based on this year's work:

- suggestions for future surveys based on current results.
- suggestions for improvement, modernization, and rationalization of the monitoring methodology.

4.6.3 Appendices

The appendices to the report should be delivered electronically and should as a minimum include the following:

- final program for the surveys as established together with the Agency.
- complete field logs: date, time, position (GMS and UTM, which reference grid is used; grid zone must be specified), depth, number of grab samples and weather conditions presented in table format for each station.
- analysis report.
- tables of all analytical data.
- raw data files in Excel format.

5. Decommissioning-related environmental surveys and further monitoring

The purpose of this chapter is to provide some general guidelines for what Norwegian Environment Agency expects related to environmental surveys of offshore oil & gas decommissioning activities. The need for and the scope of environmental surveys before, possibly during and after decommissioning will vary, and depends, among other things, on the area's discharge history and vulnerability, results of previous surveys and the extent of planned decommissioning activity.

Offshore petroleum decommissioning activities normally require a permit under the Pollution Control Act. The Agency has the authority to set further requirements for specific activities if needed, beyond what is described in these guidelines.

5.1 General considerations about methods and reporting

Except for marine growth mapping, environmental surveys of offshore petroleum decommissioning activities must mainly be based on the monitoring methodology described in these guidelines and supplemented with other analyses and methods where applicable.

For surveys comprising sediment samples, we refer to the chapter 4.4 Analysis parameters, 4.5. Sampling and processing and 4.6. Reporting. In general, it will be necessary to carry out both chemical and faunal analyses to an extent that is adjusted to fit the purpose of the surveys. In areas with vulnerable benthic fauna, there may be a need for acoustic and visual surveys. In these cases, we refer to Chapter 6. Visual and acoustic surveys of the seabed, for guidance. Acoustic and visual surveys can also be used to gain knowledge about the condition, location, and extent of oil-contaminated drill cuttings piles.
According to §52 of the activity regulations, the operators must, as an integral part of the environmental monitoring, contribute to developing new methods for monitoring. Decommissioning activities on the NCS have been few so far but will increase considerably in the coming years. There will be a need for method development so that monitoring of decommissioning activities will be more accurate and provide the best possible basis for decision-making, for example when it comes to estimating the hydrocarbon leakage potential from oil-contaminated cuttings piles or mapping of marine growth and invasive species.

When possible and appropriate, results from decommissioning surveys shall be made available in the MOD-database and in the Agency's database for visual surveys carried out in relation to petroleum activities offshore (https://visuell.miljodirektoratet.no/). This

applies regardless of whether the surveys are carried out in connection to the regional monitoring or as separate field-specific surveys.

5.2 Environmental surveys before decommissioning

The operator must have sufficient knowledge of the pollution situation and the presence of vulnerable habitats and species in the area before decommissioning can start. The purpose is to be able to plan and carry out decommissioning activities in a way that minimizes the spreading of pollution and environmental impacts in the area.

If the presence of contaminated sediments is to be expected based on the known discharge history (for example, discharge of oil-contaminated drilling cuttings, oil-based drilling fluid, PFASs, major accidental discharges or leaks from injection wells), environmental survey must be carried out before decommissioning activities may start. The scope of these surveys, including the number and location of stations, must be adjusted based on the extent of the expected pollution and whether vulnerable species or habitats are present in the area.

In areas where oil-contaminated drill cuttings were discharged, the Agency expects that the cuttings piles are characterized regarding size, distribution, and degree of contamination. Surveys must be carried out for each individual cuttings pile and include analyses for total hydrocarbon content (THC), heavy metals and any other relevant compounds. Testing or assessments must be carried out to say something about the leakage potential from these cuttings piles in relation to the disturbance potential from the planned decommissioning activities. Offshore Norge has developed its own guidelines for the characterization of cuttings[9] based on the OSPAR Recommendation 2006/5 (OSPAR, 2009).

Results from previous surveys may be used if they are deemed sufficient at documenting the pollution situation in the relevant area. Environmental survey results must be used as a basis for choosing the method, technology, and disposal solution for the planned decommissioning activities, as well as when assessing the need for and choosing measures to prevent or limit spreading of pollution.

If no vulnerable benthic fauna is registered in the area, and there is no suspicion of contaminated sediment based on the discharge history and other knowledge of the area, including information provided by previous surveys, the decommissioning activities can be started without further surveys.

5.3 Mapping of marine growth on petroleum facilities

Mapping of marine growth on petroleum facilities that are planned to be removed may be relevant in some cases. The purpose of such mapping is to identify any invasive alien species, so that measures can be implemented to prevent further spreading of these species.

[9] OFFSHORE NORGE, 2016. Guidance document for characterization of offshore drill cuttings piles

The spreading of non-indigenous species is considered one of the biggest threats to species diversity in nature but has not been given much consideration when removing petroleum facilities, and our knowledge on the topic is insufficient. Keeping the precautionary principle in mind, mapping, and a subsequent risk assessment of the spreading potential of invasive alien species should therefore be carried out. Mapping, risk assessment and any measures to prevent spreading of alien species must be taken before moving the facility.

As of today, there are no specific requirements related to methods or technology for mapping, risk assessment and measures to be taken, but the general requirement for the use of BAT is also applicable here. Until now, completed surveys of this type have been based on visual surveys using ROVs. As a preparation for these surveys, a screening of relevant species was carried out based on the Norwegian Blacklist of alien species developed by the Norwegian Biodiversity Information Centre. A probability analysis of which species were relevant to look for was made based on known habitat types for the species in question, with regard to depth, salinity, temperature, substrate preference, life cycle and way of life.

The need for this type of mapping must be considered for each individual case, and will depend, among other things, on how the facility are transported to land and the risk of spreading of invasive alien species. For facilities that are dismantled offshore and transported dry to land, such mapping will be less relevant.

5.4 Environmental surveys during decommissioning

In many cases, environmental surveys before and after decommissioning activities can be sufficient. In other cases, however, it may also be relevant to carry out surveys during ongoing decommissioning activities. This may be the case in areas with known presence of contaminated sediment or drill cuttings, where there is a particular risk of spreading contamination due to the planned activities. For example, when digging in or relocating oil-contaminated drill cuttings and contaminated sediments. Surveys during decommissioning may also be relevant in areas with vulnerable benthic fauna located close to where the planned activities will take place, where there is a risk of physical impact in the form of direct damage or smothering.

Which type of surveys are relevant must be considered in each individual case. Measurements of water currents, turbidity, hydrographic data (conductivity, temperature, and density) and particle sedimentation may, for example, be relevant to have an idea of the extent and dispersion of particles caused by decommissioning activities, and thus contribute to knowledge about the impact of such activities both in the water column and on the seabed in the area.

5.5 Follow-up surveys after decommissioning

When the petroleum operations, including decommissioning, have ended and the facilities have been removed, follow-up survey(s) must be carried out to describe the environmental

status of the area after decommissioning. The surveys must describe the pollution status /chemistry and biology for the entire area that has been affected by the activity and come as close as possible to previous discharge point(s). This includes locations where sampling was not possible during the production phase. The results of the follow-up survey will be used to determine whether further environmental monitoring of the area is needed.

The scope of the follow-up survey will vary. In areas where there is no suspicion of contaminated sediment, it may be sufficient to use the 250m stations of the existing station network and include additional stations closer to the field center and where facilities previously were located. The number of new stations and their location may vary in each individual case.

When planning follow-up survey in areas with contaminated sediment, it will be natural to use surveys carried out prior to or during decommissioning as a starting point, as well consider any implemented clean-up measures. Surveying and sampling must be done in a way that does not entail a significant risk of additional spreading of pollution.

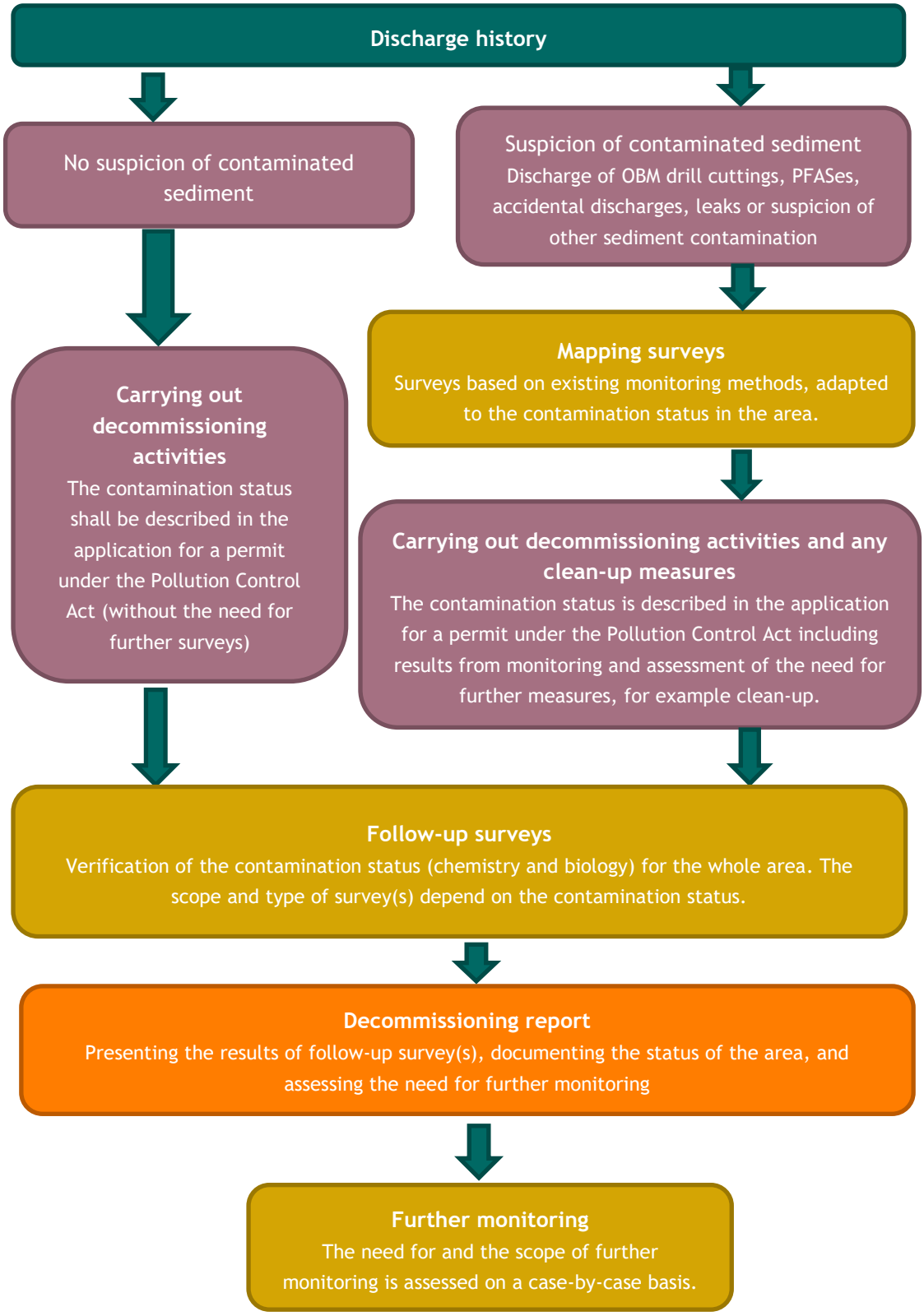
5.6 Environmental monitoring beyond decommissioning

The need of further environmental monitoring after decommissioning is completed must be decided based on the results of the follow-up survey and on recommendations for further monitoring presented in the operator's decommissioning report.

In some cases, for various reasons, further monitoring of the area will be needed. Reasons for this may be a high level of pollution in sediment, the nature of the pollution, proximity to vulnerable areas, or the area's suitability to be used for other purposes.

In areas where the follow-up survey shows little or no pollution or impact on fauna, it is not necessary to carry out further environmental monitoring.

Figur 5-1 Flow diagram for environmental surveys related to decommissioning activities.



6. Visual and acoustic surveys of the sea floor

Visual or acoustic methods, or a combination of the two, can be used in areas with a hard sea bottom where conventional sampling is impossible, or in areas where vulnerable benthic habitats may exist. Visual surveys are conducted instead of or in addition to grab sampling surveys of the sea floor.

These surveys should primarily be carried out prior to exploration or production drilling and in connection with field decommissioning. It may also be advisable to conduct visual monitoring (i.e. repeat visits) during the production period in areas with particularly widespread vulnerable benthic habitats.

Appendix IX provides a description of what must be surveyed and classified, and of how to report from these surveys.

The purpose of visual surveys

The purpose of visual surveys in connection with petroleum activities is to map the presence and extent of species and habitats that are on the Norwegian 'red list' of endangered species (Norwegian Biodiversity Information Centre (Artsdatabanken) 2018) or on the OSPAR list of threatened and/or declining habitats (OSPAR, Agreement 2008-6), see § 53 of the Activity Regulations.

The Norwegian red list shows which species and habitats are threatened with extinction in Norway. The following habitats are on the Norwegian red list:

- Hard-bottom coral gardens
- *Radicipes* coral garden
- soft-bottom bamboo coral gardens
- sponge spicule seafloor in the south Barents Sea

The Oslo-Paris (OSPAR) Convention for the Protection of the Marine Environment of the North-East Atlantic has identified species and habitats of great environmental value which are regarded as threatened and/or in decline https://www.ospar.org/documents?d=32794). These include:

- Coral gardens
- Coral reefs
- Deep-sea sponge aggregations (mainly aggregations of *Hexactinellida* and *Demospongia*).
- Sea pens and burrowing megafauna

6.1 Programme

Operators are only required to send draft programmes to the Norwegian Environment Agency in connection with repeat visits. The programme is to be treated in the same way as the programme for monitoring of sediments: see Chapter 4.1 for further information.

6.2 Methodology and quality requirements

The starting point for visual mapping is often based on an assessment of a previously performed site survey with multibeam echo sounding or side scan sonar. The methodology for visual surveys largely adheres to the Norwegian standard for visual surveys of the seabed using remotely operated and/or towed observation gear for collection of environmental data (NS-EN 16260). See also the Offshore Norges handbook *Species and Habitats of Environmental Concern. Mapping, Risk Assessment, Mitigation and Monitoring in Relation to Oil and Gas Activities*[10] (Offshore Norge Handbook).

6.2.1 Qualification requirements

Surveys must be planned and conducted by experienced personnel with appropriate training. Species identification must be performed by qualified personnel as described in NS-EN 16260. Documentation of quality control procedures and species identification literature must be available on request.

6.2.2 Recommended equipment

The following equipment is necessary for carrying out acoustic surveys:

- Multibeam echo-sounding or side scan sonar with a minimum resolution of 0.5 x 0.5 m.
- Software package for interpreting data.

See Appendix VIII for equipment recommended for visual surveys.

6.2.3 Logging of metadata and data storage

All necessary metadata and data, including photos and videos, for each individual survey must be logged and reported to the Agency as described in Appendix IX.

6.2.4 Mapping scope and requirements regarding image quality/coverage

Transect length and area must be large enough to yield a representative sample from the location and area of influence of the activity. The scope of the surveys and the density of transect lines will vary, depending on the activity to be undertaken, how heterogeneous the seabed in the area is assessed as being, the dominant fauna communities and the extent to which vulnerable habitats are present in the area.

[10] Offshore Norge Handbook. Species and Habitats of Environmental Concern. Mapping, Risk Assessment and Mitigation and Monitoring - in Relation to Oil and Gas Activities

During mapping, the velocity of the ROV should be limited to a maximum of 1 knot, and its height above the sea floor should be 1–3 m.

It is recommended that continuous analysis be performed, i.e. continuous registration from the video of individual specimens or colonies of coral, sea pen and sponge along a transect. Classified data points must be generated along the transects. The data points must be representative of the variation along the transect.

It is recommended that still photos be taken at least every 30 meters, and more often if there are special objects that require further photos.

6.3 Survey pattern

The survey pattern will vary, depending on which fauna are expected to be found and which operation is planned, whether it is a mapping survey or repeat visit, and whether a drilling location is known or not. If it is a repeat visit, a targeted survey pattern must be established, based on information from mapping and the purpose of the monitoring; see under programme.

Systematic acoustic surveys using multibeam echosounding or side scan sonar can be used as a basis for deciding on a survey pattern and must be used in areas where coral reefs are expected or likely to be found.

In areas where there are expectations of finding species and habitats that are not necessarily detected by acoustic surveys, for example sponges and sea pens, a 25 m^2 area should be surveyed. We therefore recommend that a dual visual survey be conducted. If the first survey detects species/habitats that are on the Norwegian Red List (Artsdatabanken 2018) or on the OSPAR list of threatened or declining habitats, the survey should be expanded.

The survey methods for the various groups of fauna are briefly described below. For more detailed descriptions, please see the Offshore Norge handbook.

Corals

Surveys to detect the presence of corals requires that areas that may potentially contain such structures have been identified in advance. From the operators' site survey, which is performed on each field, acoustic surveys can be used to identify areas that may consist of either cold water coral reefs or stone formations that may harbour non-reef-forming coral species. These areas should be classified as potential coral areas and examined visually. Please see the Offshore Norge handbook for guidance in mapping and classifying coral occurrences.

Coral gardens that are mapped should be classified into the following groups:

- Hard-bottom coral garden
- *Radicipes* coral garden
- Soft-bottom bamboo coral garden
- Other soft-bottom coral gardens

The dominant and secondary species in each transect line must be reported.

Sponge communitites

Sponge communitites should be mapped continuously along the transect lines. Still photos should be taken every 30 m as a minimum (and preferably every 20 m) and used to quality check the quantitative estimations. If still photos alone are used to obtain quantitative estimations, it is important that the photographs are not taken too close to the seabed. Multiple photos should preferably be used to indicate average quantities for a given area. The sponge aggregations that are mapped should be classified into the following groups:

- Soft-bottom sponges
- Hard-bottom sponges
- Glass sponges

The dominant and secondary species in each transect line must be reported.

The coverage of the different sponge categories along the survey transects must be classified according to the following criteria:

- <1% of the seabed is covered (single specimens/rare)
- 1–5% of the seabed is covered (scattered)
- 6–10% of the seabed is covered (common)
- >10% of the seabed is covered (high density)

This is described in more detail in the Offshore Norge handbook.

Sea pen communities

Sea pen communities must be mapped. The habitat 'Sea-pen and Burrowing Megafauna Communities' is defined as an endangered habitat (OSPAR, 2010b). The habitat includes deep water sea pen communities consisting of *Umbellula encrinus* and aggregations of for example *Kophobelemnon stelliferum* or other sea pen species which can be found in both the Norwegian Sea and the Barents Sea (*Funiculina quadrangularis*, *Virgularia mirabilis*, *Pennatula phosphorea*). The following semi-quantitative distribution should be used for sea pen communities:

- 1–5 individuals per 25 m^2
- 6–10 individuals per 25 m^2
- 11–15 individuals per 25 m^2
- >15 individuals per 25 m^2

The dominant and secondary species should be reported for each data point, or as a minimum for each transect line.

'Red-listed' species

In addition, red-listed coral and sea pen species must be reported. The species should be reported as individual observations (points) and reported in addition to the specified habitats. Red-listed sponges are not included in the database because there are large numbers of species registered with the category 'data deficient', and many species may be

difficult to tell apart on video. Individual specimens of species that are easy to identify can be reported as 'other' in the database (see Appendix IX).

6.4 Video and photo analysis

Guidelines for analysis and registration of photos and video collected during visual surveys are described in NS-EN 16260.

6.4.1 Registration of fauna

The fauna analyses involve counting individuals/colonies of corals, sponges and sea pens, and measuring the size of *Desmophyllum pertusa*.

Fauna diversity should be calculated based on semi-quantitative density measurements of the individual species/types of fauna. Differences in fauna characteristics should be compared with available information on the physical/chemical conditions at the same localities, e.g. sediment type, areas of hard bottom and presence of trawl tracks.

6.5 Reporting

Data, metadata, photos, videos and reports must be submitted to the Agency via this website https://visuell.miljodirektoratet.no/. Information on how data are to be submitted is also available here. Data must be reported as soon as possible after the completion of a survey, and three months after the survey has been conducted at the most.

The report will be more comprehensive for repeat visits than for mapping surveys. The report must contain the following if relevant:

- objective of the survey
- field methodology and execution
- data analysis methods used
- quality control
- brief description of important findings, including any differences in fauna characteristics as described under "registration of fauna"
- conclusions of the survey
- issues that should be given priority in any future monitoring
- evaluation of the analytical methods and proposals for improvements
- list of all red-listed species observed

References

Appleby, P G & Oldfield, F. (1978). *The calculation of lead-210 dates assuming a constant rate of supply of unsupported 210pb to the sediment*. Catena. Vol 5, pp. 1-8.

Artsdatabanken (2018). *Norsk rødliste for naturtyper 2018*. [Norwegian Red List for habitat types 2011]. https://www.artsdatabanken.no/rodlistefornaturtyper ,Trondheim.

Bakke, T., Klungsøyr, J. & Sanni, S. 2013. Environmental impacts of produced water and drilling waste discharges from the Norwegian offshore petroleum industry. Marine Environmental Research.

Bale, A.J. & Kenny, A.J. 2005. Sediment analysis and seabed characterisation. In: Eleftheriou, A.; McIntyre, A.D. *"Methods for the study of marine benthos«*. 3rd edition. Blackwell Science. Oxford, UK. ISBN 0-632-05488-3. pp. 43-86.

Baršienė, J. *et al*. 2013, Environmental genotoxicity and cytotoxicity levels in fish from the North Sea offshore region and Atlantic coastal waters, Marine Pollution Bulletin 68, 106–116

Bjerkeng, B. 2000. *Miljøovervåking på norsk sokkel - sammenligning av konsentrasjoner i sediment mot bakgrunnsnivåer. Begrepet "Limits of Significant Contamination" (LSC).* NIVA notat O-99218. 36s.

Borja A. & Muxika I. 2005. *Guidelines for the use of AMBI (AZTI's Marine Biotic Index) in the assessment of the benthic ecological quality*. Marine Pollution Bulletin 50(7):787-9.

Bray, J.R. & Curtis, J.T., 1957. *An ordination of the upland forest communities of Southern Wisconsin*. Ecol. Monogr., Vol. 27, pp. 325-349.

CEMP Guidelines for Monitoring Contaminants in Biota. OSPAR Agreement 1999-2 (revised 2018).

CEMP Guidelines on Quality Assurance for Biological Monitoring in the OSPAR Area. OSPAR Agreement 2002-15 (revised 2018-2019).

CEMP Guidelines for Monitoring Contaminants in Sediments. OSPAR Agreement 2002–16 (revised 2018).

Clarke, K.R., Somerfield, P.J., Gorley, R.N, 2008. Testing of null hypothesis in exploratory community analyses: similarity profiles and biota-environment linkage. J. Exp. Mar. Biol., 336, 56-69.

Dias et al. (2013). Validation of 226Ra, 228Ra and 210Pb measurements in soil and sediment samples through high resolution gamma ray spectrometry. INAC 2013: international nuclear Atlantic conference, Brazil.

EPA, Test method 610 – Polynuclear Aromatic Hydrocarbons. Environmental Protection Agency.

Hansson, T., Thain, J., Martínez-Gómez, C., Hylland, K., Gubbins,M., Balk, L. 2017. *Supporting variables for biological effects measurements in fish and blue mussel*. ICES Techniques in Marine Environmental Sciences. No. 60. 22 pp.

Henriksen S. og Hilmo O. (red.) 2015. *Norwegian red list for species 2015*. Artsdatabanken, Norge.

JAMP Guidelines for General Biological Effects Monitoring. OSPAR Agreement 1997-7. Technical annexes revised in 2007. Technical annex 6 revised in 2013

JAMP Guidelines on Contaminant-Specific Biological Effects Monitoring. OSPAR Agreement 2008–09 (replaces Agreement 2003-10).

JAMP Guidelines for the integrated monitoring and assessment and their effects. Agreement 2012-9

IAEA 2011. International Atomic Energy Agency, Analytical Methodology for the Determination of Radium Isotopes in Environmental Samples, Analytical Quality in Nuclear Applications Series No. 19.

Offshore Norge. 2019*. Handbook. Species and Habitats of Environmental Concern Mapping, Risk Assessment, Mitigation and Monitoring - In Relation to Oil&Gas Activities*. Report No. 2019-007.

OSPAR 2006. *OSPAR recommendation 2006/5 on a Management Regime for Offshore Cuttings Piles*

NS 4764. *Water analysis - Total residue, and total fixed residue in water, sludge and sediments* [in Norwegian]. Standard Norge

NS-EN ISO/IEC 17025. General requirements for the competence of testing and calibration Laboratories. Standard Norge

NS 9434. *Water quality - Monitoring of environmental contaminants in blue mussel (Mytilus spp.) - Collection of caged or native mussels and sample treatment* [in Norwegian]. Standard Norge

NS-EN ISO 12846. *Water quality - Determination of mercury - Method using atomic absorption spectrometry (AAS) with and without enrichment (ISO 12846:2012).* Standard Norge

NS-EN 16260. *Water quality - Visual seabed surveys using remotely operated and/or towed observation gear for collection of environmental data.* Standard Norge

NS-EN ISO 5667-19. *Water quality - Sampling - Part 19: Guidance on sampling in marine sediments (ISO 5667-19:2004).* Standard Norge

NS-EN ISO 16665. *Water quality - Guidelines for quantitative sampling and sample processing of marine soft-bottom macrofauna (ISO 16665:2014)*. Standard Norge

OSPAR Guidelines for monitoring the Environmental Impact of Offshore Oil and Gas activities. Agreement 2017-02.

OSPAR 2008. *Descriptions of Habitats on the OSPAR List of Threatened and/or Declining Species and Habitats*. OSPAR Agreement 2008-7.

OSPAR 2010a. *Background document for Deep Sea Sponge Aggregations*. OSPAR Commision biodiversity series Publication Number: 485/2010.

OSPAR 2010b. *Background document for Sea Pens and Burrowing megafauna*. OSPAR Commision biodiversity series Publication Number: 481/2010.

OSPAR 2010. *Background document for Coral gardens*. OSPAR Commision biodiversity series Publication Number: 486/2010.

Pielou, E.C., 1966. *The measurement of diversity in different types of biological collections*. Journal of Theoretical Biology, Vol. 13, pp.131-144.

Rygg B., Norling K., 2013. *Norwegian Sensitivity Index (NSI) for marine macroinvertebrates, and an update of Indicator Species Index (ISI).* NIVA-rapport 6475-2013, 46s.

Thain, J., Fernandez, B. & Martinez-Gomez, C. 2019. *Biological effects of contaminants: stress on stress (SOS) response in mussels*. ICES Techniques in Marine Environmental Sciences, No. 59.

7. Appendices

7.1 Appendix I – Overview of method development work

Requirements related to method development and validation are given in chapter 3.9.

Table 6-1: Suggested parameters and methods than need further development and /or validation before they can be taken in use in the water column monitoring

Parameter/ method	Tissue type/matrix	Method	Follow-up	Status
Micronucleus, chromosome damage. Counting automatization.	*Mytilus* spp. Fish	Robotics could make this method more robust by avoiding bias introduced by the laboratory personnel. At the same time, the number of registered cells could increase significantly with automatization. Therefore, automatization should be developed and validated for use in the WCM.		
Acetylcholin-esterase (AChE) inhibition	*Mytilus* spp.	Many WCM-reports contain data. This was last measured in 2017, when the lowest AChE inhibition was measured in the zero-group The parameter needs better validation for produced water or other exposure relevant for WCM.		
qPCR	Mytilus spp. Fish Selected tissues, expression of selected genes.	New endpoints should be evaluated in order to include this in the list over required parameters for WCM if they are proven suitable for WCM. Potential areas are hormone disruptive effects.		
Oxidative stress (GR, GSH-PX, SOD, GSH/GSSG)	Fish Enzyme activity, concentration	Methods lack validation for use in the WCM.		

Table 6-1: Suggested parameters and methods than need further development and /or validation before they can be taken in use in the water column monitoring				
Parameter/ method	**Tissue type/matrix**	**Method**	**Follow-up**	**Status**
Concentration of alkylphenol metabolites GC-MS	Fish Bile	Can provide an early warning of effects from other compounds than PAH metabolites. Useful to look at this in relation to effect parameters (for example vitellogenin or qPCR of relevant genes). The method should be prioritised for validation so that it is qualified for use in the WCM.		
Potential new species	*Calanus* spp. Lumpfish (egg and larvae) Scallops Sponges Earlier life stages of various species (fish, invertebrates) Planktonic organisms	For Calanus: the field survey in 2017 was of a limited scope. Consultants were clear on the fact that the method should be prioritized for validation/qualification for use in the WCM. Suggestions on other relevant species were put forward in working meeting of 14th June 2019.		
Differences in responses between different *Mytilus*-species and their hybrids	*Mytilus edulis* *Mytilus trossulus* *Mytilus galloprovincialis* Hybrids	It should be investigated whether the biomarker responses on the "must include"-list are different for the different species.		
Peroxisomal proliferation	*Mytilus* spp. Fish	More information is needed on how exposure to PV leads to peroxisomal proliferation.		
Cellular energy allocation (CEA)	*Mytilus* spp.	More information is needed on the suitability of CEA in field surveys, as well as which responses one can expect after exposure to PV.		
ALA-D-activity	Fish, red blood cells	It is recommended that ALA-D's suitability is documented		

Table 6-1: Suggested parameters and methods than need further development and /or validation before they can be taken in use in the water column monitoring				
Parameter/ method	**Tissue type/matrix**	**Method**	**Follow-up**	**Status**
	Enzyme activity	by means of controlled dose-effect studies, as well as testing and validation at a relevant offshore location (for example downstream for the PV discharge point for Ula, a field with highest reported discharge of lead on NCS in 2018)		
Vitellogenin	Fish Protein concentrations	Previously evaluated as relevant because it can give information on effects of exposure to naphthenic acids. The parameter has given limited information previously but is no longer in use.		
eDNA		This is expected to be a method/approach with high potential for use in future WCM.		
Detection of chemicals released in the water column	Water samples or other appropriate sampling methods	Methods for analysis and sampling are needed to detect components of added chemicals in the water column or in exposed mussels. Deployment of sampling equipment shall be done according to the present guidelines in what concerns spreading and risk analyses.		
In situ fluorescence	Water Sediment	Measurement of aromatic hydrocarbons from PV, as well as leakage of aromatic hydrocarbons from old drill cutting piles, by means of in situ fluorescence is desired.		
Automatization of biological measurements	Image analysis (digital) Flow cytometry	Faster results, lower costs. Increase the number of observations/hits. More objective assessments.		

Table 6-1: Suggested parameters and methods than need further development and /or validation before they can be taken in use in the water column monitoring				
Parameter/ method	**Tissue type/matrix**	**Method**	**Follow-up**	**Status**
General measurements for health status	Blue mussels	As per today is stress on stress used. However it is recommended to find another method that is more appropriate in terms of animal wellfare.		
Morphological changes	Whole fish (haddock, cod)	Morphological changes in adult fish are interesting. See Jawad et al. (2018), Journal of fish diseases 41:1909-1915		
Histopathology	Blue mussels, fish	Can uncover changes at organ-level.		
Filtering activity	Blue mussels	Valve opening		
Methods for quantifying exposure	Water, sediment	In situ fluorescence Other principles could also be relevant		

7.2 Appendix II – Method archive

This appendiks gives an overview of:

- Methods that have been used previously, but which have either been replaced or turned out to be unsuitable for the WCM-programme
- Methods that have been atempted validated/qualified for use in the field surveys of WCM but found to be unsuitable.

Table 6-2: Parameters that are no longer relevant to be used for water column monitoring			
Parameter/method	**Type of tissue/matrix**	**Reason**	**Year og archiving**
Volume of the mussels	*Mytilus* spp., Whole mussels	Other supporting parameters are considered sufficient to assess condition of the blue mussels. There are no historical data from WCM and therefore no time series to be maintained.	2020
Respiration	*Mytilus* spp., Whole individuals	Respiration is no longer on the list of biomarkers used in WCM due to time and technical	2020

Table 6-2: Parameters that are no longer relevant to be used for water column monitoring			
Parameter/method	**Type of tissue/matrix**	**Reason**	**Year og archiving**
		constraints related to measuring this in the field offshore.	
Lysosomal membrane stability, NRRT	*Mytilus* spp. Hematocytes	This parameter has been used earlier and is now replaced by a newer method. NRRT has a higher risk of bias than the alternative newer method but could potentially be more sensitive.	2020
General health status: *Clearance rate*	*Mytilus* spp., Whole individual	The use of this parameter in WCM has been limited due to challenges in terms of the time required to measure this in the field offshore.	2020

7.3 Appendix III – Analysis parameters

Table 6-3: US Environmental Protection Agency (US EPA) list over the 16 most important PAH-components when looking at pollution		
Parameter	**STORET No[1]**	**CAS No[2]**
Acenaphthene	34205	83-32-9
Acenaphthylene	34200	208-95-8
Anthracene	34220	120-12-7
Benzo (a) anthracene	34526	56-55-3
Benzo (a) pyren	34247	50-32-8
Benzo (b) fluoranthene*	34230	205-99-2
Benzo (ghi) perylene	34521	191-24-2
Benzo (k) fluoranthene*	34242	207-08-9
Chrysene**	34320	218-01-9
Dibenzo (a, h) anthrasene	34556	53-70-3
Fluoranthene	34376	206-44-0
Fluorene	34381	86-73-7
Indeno (1,2,3-cd) pyrene	34403	193-39-5

Table 6-3: US Environmental Protection Agency (US EPA) list over the 16 most important PAH-components when looking at pollution		
Parameter	**STORET No[1]**	**CAS No[2]**
Naphthalene	34696	91-20-3
Phenanthrene	34461	85-01-8
Pyrene	34469	129-00-0

[1] Storage and Retrieval number (US EPA)

[2] Chemical Abstract Service registry number (American Chemical Society)

* Figures for benzo (b, j, k) fluoranthenes are reported together

** Chrysene is reported together with triphenylene

7.4 Appendix IV Modified van Veen grab for collecting sediment samples

Traditional sampling in connection with monitoring of petroleum activities offshore generally involves taking 8 grab loads (5 biology samples + 3 chemistry samples). In shallower water, as is the case in the southern parts of the Norwegian continental shelf, a regular van Veen grab is most appropriate. A modified van Veen grab (combined) is however also used to carry out environmental monitoring offshore. When using a slow winch and/or at bigger sampling depths (> 100m), the use of this grab sampler saves time, because the sampler's residence time in the sea is decreased. By utilizing the modified grab sampler chemistry and biology samples can be obtained from the same grab load, the number of necessary loads being thus reduced. One achieves at the same tine a more direct relationship between biology and chemistry data. An important objective of these surveys is to find any correlations between measured chemical parameters and the composition of the soft-bottom fauna in an area.

The modified grab sampler is 0.05 m^2, larger than a conventional van Veen grab sampler of 0.1 m^2. Biology and chemistry samples may be taken from the same grab load since a divider splits the load in two. The inner walls of this model have two slots, so that the divider can be manually pressed down when the grab sampler comes on deck (Figure 6-1). As is the case with a conventional van Veen grab, the area for the biology samples is identical with 0.1 m^2, while the area for the chemistry samples is 0.05 m^2. The sampler satisfies requirements for water flow so that to avoid a "frontal wave" when it hits the bottom (ISO 16665: 2014). The screens have a 0.5 mm perforated mesh which constitutes 60% of the grab top surface.

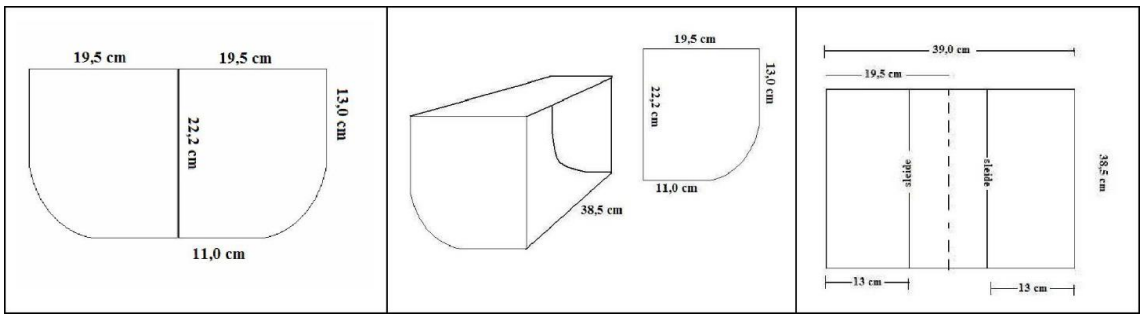
Figure 6-1. Illustrations of sliding tracks and grab sampler with divider

The sampler's shape, along with the requirement that the area for biology samples must be 0.1 m^2, means that the sediment sample must be at least 9 cm deep. The volume of sediment in liters at this depth will be 8 liters, thus meeting the requirement of having at least 7 liters in the sediment sample.

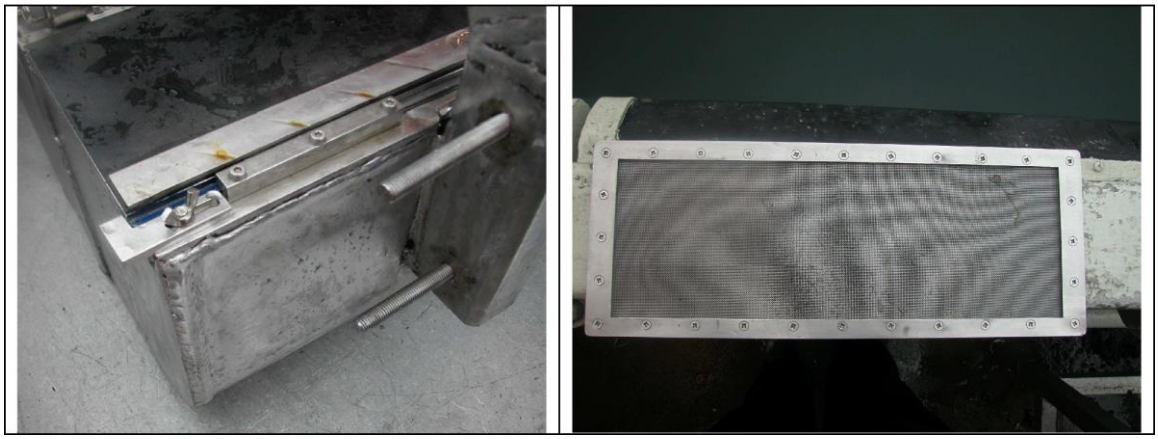
Table 6-4: Overview over number of litres in a sample at various sampling depths

cm	litre	cm	litre	cm	litre	cm	litre	cm	litre
1	0,7	6	5,1	11	10,0	16	15,0	21	20,0
2	1,5	7	6,1	12	11,0	17	16,0	22	21,0
3	2,4	8	7,1	13	12,0	18	17,0	22,2	21,2
4	3,3	9	8,1	14	13,0	19	18,0	-	-
5	4,2	10	9,0	15	14,0	20	19,0	-	-

Drawings and photographs



Dimensions and design of grab sampler. Left and center: from the side. Right: topside



Left side: locking mechanism for the screen. Right side: screen with 0,5 mm mesh

The divider splits the sample in two so that samples can be processed independent of each other.

7.5 Appendix V – Detection limits for metals

The detection limits are established with regard to both the sensitivity of the measuring instruments and the background values registered in the sediments in the North Sea. These detection limits (mg/kg dry sediment) depend on the quantities of sediment that are weighted. The values provided in the table below are valid for a quantity of weighted sediment of minimum 1 g.

Tabell 6-5: Detection limits for different metals

Element	Detection limit mg/kg dry sediment
Arsenic (As)	0,5
Barium (Ba)	1,0
Cadmium (Cd)	0,03
Chromium (Cr)	0,5

Tabell 6-5: Detection limits for different metals	
Element	**Detection limit mg/kg dry sediment**
Copper (Cu)	0,6
Mercury (Hg)	0,01
Lead (Pb)	0,5
Zinc (Zn)	2,0

7.6 Appendix VI – Formula for calculating LSC

$$LSC > \bar{R}_{\bullet\bullet} + t_{\alpha(1),\nu} \cdot s \cdot \sqrt{1 + \frac{1}{N_r}}$$

$\bar{R}_{\bullet\bullet}$ = average of the station mean values for the regional stations

$t_{\alpha(1),\nu}$ = critical value from the t-distribution with one-sided t-test with level of significance α (=0.05) and v = Nr -1 degrees of freedom

s = standard deviation of sedimentation between station averages

N_r = number of regional stations

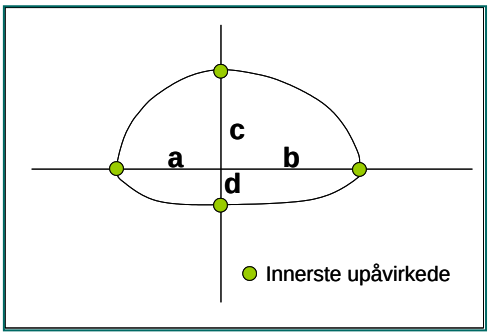
The standard deviation s is calculated as $$s = \sqrt{\frac{\sum_{i=1}^{N_r} \left(\bar{R}_{i\bullet} - \bar{R}_{\bullet\bullet}\right)^2}{N_r - 1}}$$

where $\bar{R}_{i\bullet}$ = mean values on the parallels of regional station nr. *i.*

7.7 Appendix VII - Methods for delimitating affected areas

Two affected areas are to be calculated for each field: one where there is significant chemical contamination by THC (as defined by LSC values, to be calculated for THC and THC higher than 50 mg/kg if possible), and one where there are impacts on the benthic fauna. The areas should be given in km^2. The calculations are based on the assumption that the affected areas are approximately elliptical. The radii of the ellipse depend on the distance along each transect where effects can be detected. The calculations are conservative, *i.e.* they give an estimate of the maximum area affected. The radii must therefore be calculated as the distance from the center of the ellipse to the innermost station where no effect is found. In many cases, this will result in an asymmetrical ellipse (see the figure below). The area is calculated in the same way in both cases:

Area = π * (a+b)*(c+d)/4



If no stations have been sampled along a transect, the radius is defined as the distance from the center to the nearest station where no effects were found in the most recent survey that covered the transect in question.

If a transect has never been surveyed, the radius is defined as the average of the other radii.

If a previous station is omitted one year its values from the last time the station was investigated may be used.

On complex fields where there are many facilities and overlapping station networks, such as Gullfaks, one common elliptical area should be defined for the entire field. The radii should normally be the distance from the center to the nearest station where no effect is found, but in most cases some assessment will also be needed to define the most suitable area.

The calculation method (chosen ellipse and how the axes are defined) must be documented in the report.

7.8 Appendix VIII – Recommended equipment for carrying out visual surveys

The following equipment is necessary to carry out visual surveys:

- Suitable survey vessel with dynamic positioning system (DP system)
- ROV suitable for the purpose (see below)
- Underwater navigation system/ USBL system
- Data communication (fiber optic connection between the bottom and the surface)
- High resolution video (preferably HD) (video equipment that records at a higher resolution than the standard resolution. Requires fiber cable for real-time transmission from ROV. Minimum resolution is 720p (that is, 720 horizontal lines in video), while 1080p ("full HD resolution") is the most common format.)
- Camera for still images
- Lasers to measure distances/dimensions

General requirements for the ROV

- Enough thruster capacity for the purpose (adjusted depth, current velocity and so on).
- Sufficient power source to operate the equipment to be used (described below).
- Sufficient light, possible to adjust depending on the seawater conditions (particles etc.).

Navigational equipment

Depending on the survey type there will be different requirements connected to the accuracy of the underwater positioning system. The standard NS-EN 16260 should be observed. For mapping purposes, the accuracy should not be less than 2 m + 5% of water depth with continuous recording of positions and depths. All positions and depths must be logged together with the time reference. It is also an advantage to log additional data such as the ROV's heading, altitude, pitch and roll, and the vessel's position.

Still image camera

During mapping a still photo should be taken for every 30 meters of the seabed in addition to video, for other details see NS EN 16260. Still images are important for species identification, while video is better suited to calculate the quantitative distribution over larger areas.

Minimal requirements for the camera:

- Camera with a resolution of 2 megapixels or higher is recommended. For mapping the camera should be able to capture objects larger than 5 mm.
- A blitz/"flashgun" should be connected to the system so that it is possible to take clearer pictures.
- Possibility to choose between automatic or manual focus, as well as light sensitivity (ISO).

Advice: a camera with rapid focus and higher ISO values is recommended for taking pictures of moving organisms. Other camera features may be prioritized if the targets are mostly still ("sessile").

Video camera

Minimal requirements:

- Pan-tilt
- Zoom
- Overlay with positon, time, depth, name of survey line etc.
- Possibility to choose between automatic or manual focus

It is an advantage that the observation gear has different cameras available with different light sensitivity and zoom.

Laser distance meters

There are several types of laser distance meters, both bar code and dot types. The devices' measurements are used to calculate the sizes of objects and fauna.

Description of equipment when reporting

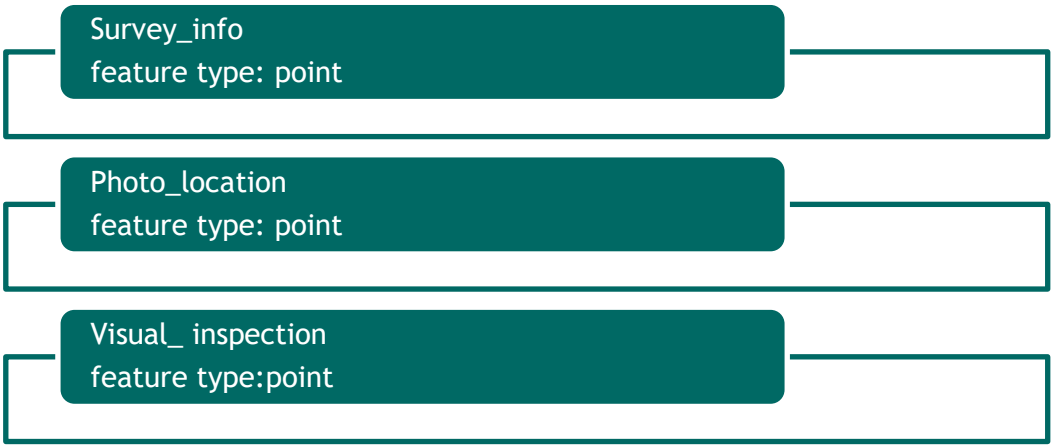
- ROV
  - ROV specifications and supplier
  - Additional equipment, maybe also its assembly (for example light positions etc.)
  - Number and type of lights (halogen, LED or other)
  - Lasers (line- or point type, as well as distance)
  - Still image camera and video camera
  - Speed, height above the bottom, camera tilt, dimming etc.
- Survey
  - Supplier
  - Navigation system and bottom accuracy
  - Event logging/ event fix
  - Navigational screen and accompanying software
  - Utilized map datum
- Any additional equipment
  - For example, ROV-samplers

7.9 Appendix IX –- Data structure for reporting from visual surveys

In this appendix we describe what must be reported in the database. The data structure can be divided into three tables as shown below:

- information about the survey ("survey_info")
- visual observations ("visual_inspection")
- photos and video from the survey ("photo_location").

The data structure form is shown in the figure below. More information about data submission and the data model is available here https://visuell.miljodirektoratet.no/.



7.9.1 Visual observations

Visual observations of sediment, seabed structures, human influence and drilling cuttings if any, and visual observations of habitats and species on the Norwegian red list for species must be reported.

The following habitats must be reported in the database:

- Coral reef
- Coral gardens
    - coral_garden_type: bamboo, hard_bottom, pig_tail, other
- Sponge aggregations
    - Sponge_type: hard bottom, soft bottom, glass sponges
- Sea pen communities
- Other aggregation-forming fauna

Red-listed species must also be reported.

Habitats and species that are registered in the database must be reported as present or absent from the survey area.

For coral gardens, sponge aggregations and sea pen aggregations the most dominant species must be reported under 'dominating species' and the next most dominant species must be reported as 'secondary species'. These should be reported for each data point, but must as a minimum be reported for each transect line.

Other categories in the database are:

- 'Unidentified' – used if a dominant species cannot be identified at either species or genus level
- 'Other' – used if the observation can be identified as a species or genus that is not present in the data structure

There are three comment fields for fauna:

- Comment on the habitat/aggregation
    - Used if there are special comments associated with the observed habitat
- Comment on fauna
    - Used to comment on observations in the category 'other aggregation-forming fauna'
- Comment on species.
    - Used if a species or genus is known, but not registered in the database. The reason(s) why the species/genus has been reported must be included.

The comment field is also used if there have been changes in the taxonomy. Special observations such as damage, coverage by sediment or petroleum products etc. may also be included in the most relevant comment field.

Habitats must also be classified. The classification of the various habitats is described in more detail in the Offshore Norge handbook *Species and habitats of environmental concern.*

Observation of the seabed

Visual observations of the seabed must be reported as described in the table below.

Type	Description
Substrate	mud and sand, sand, gravel, cobbles and boulders mud and sand with gravel, cobbles and boulders, bedrock or consolidated sediments, shell hash, coral rubble, coral framework
Seabed structure	bacterial mats, gas seep, MDACs, hydrothermal vents, iceberg ploughmark, mound, coral mound, pockmarks, ridge, ripples, sand waves and other current features, slide, slide block, cliff, slope, wreck, cable, cobbles, boulders, hole, crack
Anthropogenic impact on the seabed	Trawl marks, fishing nets, plastic, other fishing litter, other marine litter, shipwreck, comments on anthropogenic impact
Drilling cuttings	Present, partial, complete cover

Habitats – coral reef

Presence

Coral reefs must be reported as observed or not observed in the area surveyed.

Coral reefs must be mapped as individual coral colonies. A colony is characterised by the presence of one end with living coral polyps facing into the current and behind that dead reef with a tail of coral rubble. It is most important to survey the living portion of the coral colony.

If coral reefs are observed, the species that forms the reef must also be reported. There are two species that form reefs in Norway: the stony coral, *Desmophyllum pertusum*, and the zigzag coral, *Madrepora oculata*. These species are red-listed and must therefore be reported as either present or absent if the coral reef is observed in the survey area. This is described in more detail under red-listed species.

If a new/another species is suspected, 'other species' must be noted in the comment field.

Classification

The density of living polyps at the front of the coral must be reported for the following ranges:

- < 5%
- 5–20%
- 20–40%
- 40–60%
- >60%

In addition, the radius, length and height (m) of the reef must be reported if data are available. This is described in more detail in the Offshore Norge handbook.

The status of the coral colony, i.e. the estimated size of the area with living *Desmophyllum* polyps at the front of the colony and the density of living polyps at the front must also be reported.

For further descriptions of classification, please see the Offshore Norge handbook.

The terms are not the same as those used in the Offshore Norge handbook. The relationship is shown below.

Terms in the data structure	Terms in the Offshore Norge handbook
Dead	Dead
Scattered	Poor
Low density	Fair
High density	Good
Very high density	Excellent

Habitats – coral gardens

Presence

It must be reported whether coral gardens were observed in the area surveyed or not. It must also be registered whether the coral garden that was observed can be identified as hard-bottom coral garden, soft-bottom bamboo coral garden (dominated by the bamboo coral *Isidella lofotensis*), *Radicipes* coral garden (*Radicipes gracilis*)) or other (other types of soft-bottom coral gardens).

The dominant species and second most dominant species should be reported for each data point and must as a minimum be reported for each transect line as 'Dominating species in coral gardens' and 'Secondary species in coral gardens'.

The species that can be reported under dominant and secondary species are shown in the table below with the appurtenant sub-group. Some genus names have also been entered. Genus names must be used if a specimen is difficult to identify at species level.

Hard-bottom coral garden

• Gorgonian corals
  • *Paragorgia arborea*
  • *Primnoa resedaeformis*
  • *Paramuricea placomus)¤¤*
  • *Muriceides kuekenthali*
  • *Anthothela grandiflora*
  • *Lateothela grandiflora*
  • Swiftia sp.
• Cauliflower coral forest
  • *Drifa glomerata*
  • *Duva florida*
  • *Duva multiflora*
  • Gersemia sp.
• Other soft corals
  • *Alcyonium digitatum*
  • *Alcyonium norvegicum*
  • *Alcyonium glomeratum*
  • *Anthomastus grandiflorus*
  • *Anthelia fallax*
  • *Clavularia borealis*
  • *Clavularia arctica*
  • *Sarcodictyon roseum*
  • Neptheidae
• Hydrocorals
  • *Stylaster norvegicus*
  • *Stylaster gemmascens*

Soft-bottom coral garden

• Gorgonian corals
  • *Radicipes gracilis* (pigtail corals)
  • *Isidella lofotensis* (bamboo corals)
  • *Caryophyllia smithii**
  • Caryophyllia sp*
  • *Desmophyllum dianthus**
  • *Fungiacyathus fragilis**
  • *Flabellum macandrewi**
  • *Stenocyathus vermiformis*
  • *Soft-bottom cup corals (can be used if species marked with an asterix are difficult to identify*

Classification

Coral gardens are classified according to the following individual density per 25 m^2:

- 1–5
- 6–10
- 11–15
- >15

Habitats – sponge aggregations

Presence

It must be reported whether sponge aggregations are registered in the area surveyed or not.

In addition, it must be recorded whether hard-bottom, soft-bottom or glass sponge aggregations are observed (cold-water sponge aggregations). The dominant and secondary species should be repeated for each data point, or as a minimum for each transect line.

- Hard-bottom sponges are attached to stones or other hard substrate. It is common to find sponges on hard substrate. When the sponge density is high, these areas will also be ecologically important.
- Soft-bottom sponges are often voluminous sponges that grow directly on the seabed. These species are typical of the OSPAR habitat 'Deepsea Sponge Aggregations' (OSPAR 2010a).
- Glass sponges. Dense aggregations of glass sponges may occur, particularly in deeper waters.

Hard-bottom sponges	Soft-bottom sponges	Glass sponge aggregations
•*Phakellia* •*Axinella* •*Antho dichotoma*	•*Geodia baretti,* •*Geodia atlantica,* •*Geodia spp* •*Aplysilla sulfurea* •*Stryphnus ponderosus* •*Steletta sp* •*Chondrocladia grandis* •*Asconema setubalense* •*Cladorhiza spp.* •*Asbestopluma sp* •*Cladorhiza spp.* •*Asbestopluma sp*	•*Caulophacus arcticus*

Classification

Sponges are classified according to the following individual density in percentages, per 25 m^2:

- < 1 %
- 1–5%
- 6–10%
- >10%

Habitats – sea pen aggregations

Presence

It must be reported whether sea pen aggregations have been observed in the area surveyed or not. The dominant and secondary species should ideally be reported for each data point, but as a minimum for each transect line.

The following species/genuses occur in the data structure

Sea pen communities
•*Funiculina quadrangularis* •*Virgularia mirabilis* •*Virgularia glacialis** •*Virgularia spp.* •*Pennatula phosphorea* •*Kophobelemnon stelliferum* •*Protoptilum thomsoni** •*Ptilella grandis** •*Halipteris spp.* •*Pennatula aculeata* •*Umbellula encrinus*

*The species *Virgularia glacialis, Protoptilum thomsoni, Ptilella grandis* must be reported as individual specimens under **red-listed species** if their density is 1–5 specimens per m^2.

Classification

Sea pens are classified according to the following density of individuals per 25 m^2:

- 1–5
- 6–10
- 11–15
- >15

Habitats – other habitat-forming fauna

This category is used if there are other habitat-forming fauna that should be reported, but which are not present in the data structure. If this category is selected, the comment field must be used.

Red-listed species

Presence

Red-listed species must be reported. These include the categories RE (Regionally extinct), CR (Critically endangered), EN (Endangered), VU (Vulnerable), NT (Near threatened) and DD (Data deficient), according to the Norwegian list of endangered species – the species red list – prepared by the Norwegian Biodiversity Information Centre (Artsdatabanken).
The species should be reported as individual observations (points) and reported in addition to observed vulnerable habitats, where relevant. For example, bubblegum coral (*Paragorgia arborea*) is reported together with the habitat coral reef.

The following coral species are included and must be reported as present or absent.

Red-listed corals
•*Desmophyllum pertusum* •*Desmophyllum dianthus* •*Madrepora oculata* •*Fungiacyathus fragilis* •*Stenocyathus vermiformis* •*Paragorgia arborea* •*Swiftia pallida* •*Radicipes gracilis* •*Anthomastus grandiflorus* •*Anthelia fallax* •*Clavularia arctica*

Red-listed sea pens
•*Virgularia glacialis* •*Protoptilum thomsoni* •*Ptilella grandis*

Red-listed sponges are not included in the database. This is because many species are in category DD (data deficient), and several species may be difficult to tell apart on video. If

individual occurrences of species that can easily be identified are observed, they may be reported as individual occurrences in the category 'Other'. See point 2.2.3 for other reporting of sponge occurrences.

Other species

The category 'Other species' is used for:

- red-listed species that are not entered in the database
- species that are known to be vulnerable/protected.

The naming of the observations must be in accordance with Norwegian Standard NS-EN 16260. The comment field should be used for providing more detailed information about the observation and any reference to literature if the identification is disputed.

Fish

Red-listed fish species are not to be reported in the database. Any findings must be clearly mentioned in the report. If the species cannot be identified, but the genus or a higher level is known, the fact that endangered status cannot be ruled out must be mentioned. One such example is the rockfish family (Sebastidae), where the golden redfish (*Sebastes norvegicus)* is listed as endangered, but it can easily be confused with other species of the rockfish family and is thus difficult to identify on video.

7.9.2 Photos and videos

All photos and videos from the survey should be uploaded in the database. As a minimum, photos and videos that are used as a basis for classification must be uploaded. It is recommended that the photos be classified based on image quality as:

- Very good
- Good
- Medium
- Poor

Revisions' log

YEAR	CHAPTER	MAIN CHANGES
2023	1.2 Reference to the Regulations on alien species 4. Grab surveys New ch. 5 Decommisioning surveys	Background for requirement to map marine growth. Deadline to deliver preliminary programs changed to 1. mars cf. The Activity Regulations. Utvidete krav til undersøkelser ved avslutning.
2021	5. Visual surveys 3 Water column monitoring and 4 Grab surveys	Clarify requirements for visual surveys and new requirements for data reporting from visual surveys in standardised form. Requirements for monitoring of radioactivity, both in the water column and on the seafloor are included in the guidelines.

Norwegian Environment Agency
Telephone: +47 73 58 05 00 | Fax: +47 73 58 05 01
E-mail: post@miljodir.no
Web: www.environmentagency.no
Postal address: Postboks 5672 Sluppen, N-7485 Trondheim
Visiting address Trondheim: Brattørkaia 15, 7010 Trondheim
Visiting address Oslo: Grensesvingen 7, 0661 Oslo

The Norwegian Environment Agency's primary tasks are to reduce greenhouse gas emissions, manage Norwegian nature, and prevent pollution.

We are under the Ministry of Climate and Environment and have over 700 employees at our two offices in Trondheim and Oslo and at the Norwegian Nature Inspectorate's more than sixty local offices.

Our principal functions include monitoring the state of the environment, conveying environment-related information, exercising authority, overseeing and guiding regional and municipal authorities, cooperating with relevant industry authorities, acting as an expert advisor, and assisting in international environmental efforts.