MARCH 2023
WINTERSHALL NOORDZEE B.V.

ENVIRONMENTAL IMPACT ASSESSMENT,

PLUG AND ABANDONMENT

RAVN A1 AND A2

ENVIRONMENTAL IMPACT ASSESSMENT

COWI

ADDRESS COWI A/S
Havneparken 1
7100 Vejle
Denmark

TEL +45 56 40 00 00
FAX +45 56 40 99 99
WWW cowi.com

MARCH 2023
WINTERSHALL NOORDZEE B.V.

ENVIRONMENTAL IMPACT ASSESSMENT,

PLUG AND ABANDONMENT RAVN A1 AND A2

ENVIRONMENTAL IMPACT ASSESSMENT

PROJECT NO.	DOCUMENT NO.
A240927	006

VERSION	DATE OF ISSUE	DESCRIPTION	PREPARED	CHECKED	APPROVED
1.0	24.03.2023	EIA	EMBC, PLPE, MEND, LBHN, AJCL, JORL, KILR	AJCL/LBHN	LBHN

CONTENTS

1 Abbreviations

ALARP	As Low As Reasonably Possible
BAT	Best Available Technique
BEP	Best Environmental Practice
BOP	Blow-Out Preventer
BSF	Below Seafloor
CaBr2 brine	Calcium Bromide brine
CH4	Methane
CHARM	Chemical Hazard Assessment and Risk Management
CO2	Carbon Dioxides
DEA	Danish Energy Agency
DEPA	Danish Environmental Protection Agency
EIA	Environmental Impact Assessment
GES	Good Environmental Status
GWP	Global Warming Potential
HSE	Health, Safety and Environment
IMO	International Maritime Organization
MBD	Minimum Barrier Depth
MD	Measured Depth
MDRT	Measured Depth Rotary Table
MSFD	Marine Strategy Framework Directive
N2O	Nitrous Oxide
NORM	Naturally Occurring Radioactive Material
NOx	Nitrogen Oxides
OIM	Offshore Installation Manager
OPF	Organic-Phase Drilling Fluids
OSPAR	OSlo PARis convention
P&A	Plug & Abandonment
PLONOR	Pose Little Or NO Risk
PTS	Permanent Threshold Shift (permanent hearing damage)
PWC	Perforate, Wash, Cement
SAC	Special Areas of Conservation
SPA	Special Protection Areas
SO2	Sulphur Dioxide
TTS	Temporal Threshold Shift (temporal hearing damage)
TD	Total Depth
TVD	True Vertical Depth
VOC	Volatile Organic Compounds
WBCO	Wellbore Cleanout

2 Non-technical summary

Wintershall Noordzee B.V. plans to plug and abandon (P&A) the Ravn A1 and Ravn A2 wells in the Ravn field located in the 5/06 block in the Danish sector.

This report includes an Environmental Impact Assessment (EIA) of the P&A of Ravn A1 and Ravn A2.

A separate EIA has been conducted for the decommissioning of the Ravn platform and connected pipelines, these activities are assessed in the Ravn Decommissioning EIA and are not covered in the current EIA. The impacts from the P&A of the Ravn 3 MLS are assessed in an EIA screening and these activities are therefore also not assessed in the current EIA.

2.1 The project

The Ravn field is developed as an unmanned oil production offshore platform, tied-back to the German A6-A platform. Production export is through subsea infrastructure to the German platform and no processing takes place at Ravn.

The Ravn-A1 and Ravn-A2 wells are located in the Greater Ravn field in connection with the Ravn platform and can be seen from Figure 2-1. The Ravn A1 and Ravn A2 wells are to be plug and abandoned in relation to the decommissioning of the Ravn field.

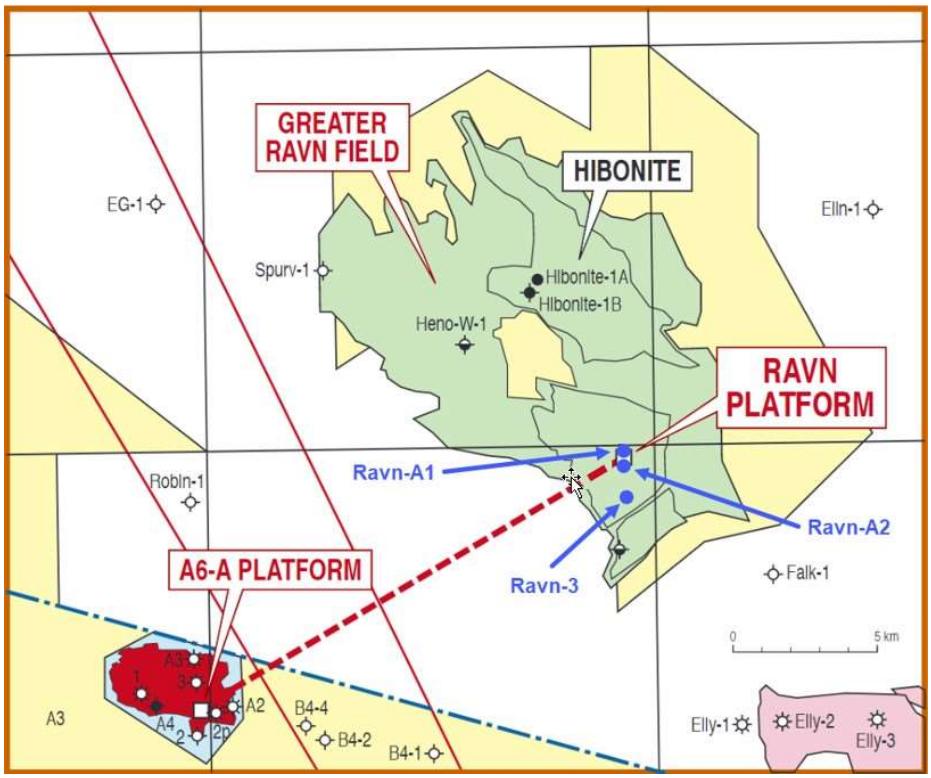

Figure 2-1 Location of the Ravn A1 and Ravn A2 wells. The dotted line represents to the north the Danish Exclusive Zone (EEZ) and to the south the German.

2.2 Alternatives

The 0-alternative is a situation in which the present project is not carried out. However, leaving the wells, can cause severe environmental impacts in time, and thus is not a feasible scenario. Furthermore, according to the Drilling guideline from DEA (DEA, 2009), a well shall be plugged before abandonment. Therefore, the 0-alternative is not an option, and therefore not further assessed.

The wells shall be plugged in accordance with the Drilling guidelines (DEA, 2009).

2.3 Existing environment

The Ravn field is located centrally in the North Sea at the northeast border of the Dogger Bank, in a water depth of around 48 m. This is an area with a relatively low biological production. However, the shallow Dogger Bank has been identified as an area which exhibits high primary production throughout the year.

The water is dominated by Atlantic water with a relatively stable salinity of 35-38 ppm and an average temperature of 10-11 °C. Based on an integrated assessment of the chemical status, most of the Danish part of the North Sea is classified as "problem areas" due to a combination of input of contaminants from sources on both land and sea and input from atmospheric deposition.

The sediment around Ravn consists of mud to muddy sand. The benthic fauna includes infauna that lives within the sediments of the seabed and epifauna that lives on the surface of the seabed. The abundance of infauna at the Ravn field is relatively high, whereas the abundance of epifauna species is relatively low compared to other areas in the North Sea.

Herring, sprat, and mackerel are the dominating pelagic fish species at the Ravn field. The dominating demersal fish species include whiting, haddock, dab, long rough dab, plaice, grey gurnard. Cod, lemon sole and mackerel spawn in the project area.

The waters around Ravn are not important for sea birds. During winter, some seabirds may however be encountered in the area, not because the area is of importance for these species, but because they are distributed over the entire North Sea during winter.

Harbour porpoise is the most common species of cetacean in the North Sea and is regularly encountered in the waters around the Ravn field, although the area is not a core area for the species. Harbour seals and Grey seals are also regularly sighted around oil and gas fields in the North Sea although they tend to be coastal species.

15 km south of the Ravn field is the Dogger Bank, a designated Natura 2000 area in Germany (SAC DE 1003-301 Doggerbank), Netherlands (SAC NL 2008-001 Doggerbank) and the UK (SAC UK003,352). Dogger Bank is designated to protect the habitat type Sandbanks (1110) and the species Harbour porpoise (1356), Harbour seal (1365) and Grey seal (1364).

Valuable and vulnerable areas (SVO-areas) have been designated as marine protected areas in Norway. The closest SVO to Ravn is the Sandeel field South bordering the Danish Exclusive Zone (EEZ).

2.4 Assessment of impacts and environmental risks

2.4.1 Scope of the EIA

Below is an overview of the potential impacts related to the P&A of the Ravn wells and conditions that potentially may affect organisms and other environmental features that have been assessed in the EIA.

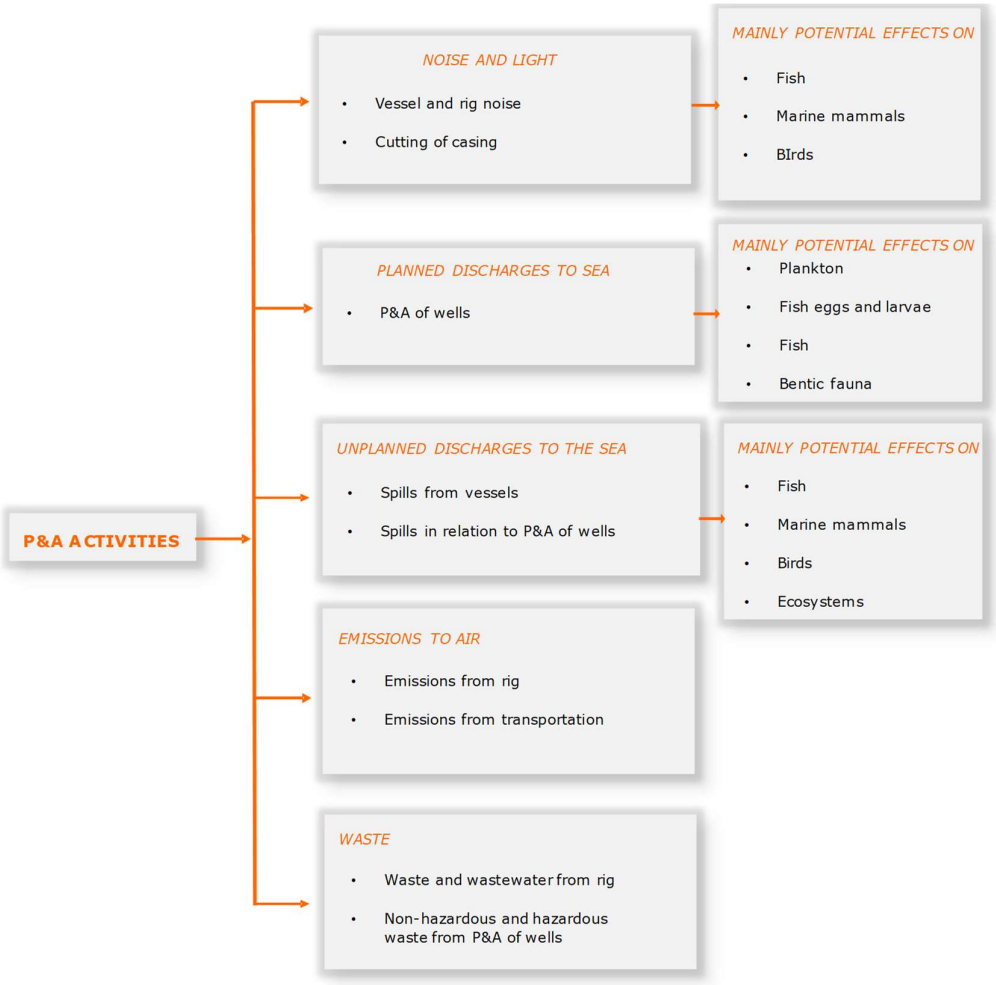

Table 2-1 Overview of potential environmental impacts from P&A activities and effects on environmental components.

2.4.2 Severity and risk of impacts

Environmental severity and risks of different project activities and incidences have been assessed. Environmental risk is defined as the combination of the severity and impact of an activity/incidence and the probability that the impact will occur.

The severity of an impact has been defined by combining criteria for:

- The nature of the impact (Positive or negative)
- Extension of the impact (Local, regional, national or international)

- Duration of the impact (Short-term, medium-term, or long-term)
- Magnitude of the impact (Small, medium, or large)
- Frequency of the impact (Low, medium or high)
- Reversibility of the impact (Reversible or irreversible)

By combining these criteria in a predefined manner, the following severity categories have been used: Positive impact, no impact, minor impact, moderate impact, or major impact.

The probability that an impact will occur has been defined as very low, low, probable, highly probable, or definite.

2.4.3 Impacts during well plugging and abandonment (P&A)

During well P&A there will be discharge of chemicals to sea. The discharges will be short-term and only include chemicals considered not to be of environmental concern or substances exhibiting a smaller degree of environmental hazard.

The discharges will have an effect distance < 250 m. Since the duration of the impact is short term (within hours) and the magnitude of the impact is marginal, it is assessed that the impact of discharge on pelagic organisms is negligible.

Furthermore, particles and gaseous emissions such as NO_X, SO_X and CO_2 will be emitted from the vessels and rig during the P&A activities. These emissions will be limited in amount and short-term. The impacts related to air quality are assessed to be negligible and low for the impacts related to global warming potential.

Underwater noise will be generated from the cutting and pulling the casing and from the vessel and rig activities. Marine mammals will most likely flee from the area as the large offshore vessels/ helicopters arrive. Furthermore, the noise will be short-term.

2.4.4 Summary of environmental impacts

Below a summary of the environmental risk assessment can be seen related to the P&A of the Ravn A1 and A2 wells.

Table 2-2 Environmental risk for P&A activities for Ravn A1 and Ravn A2.

Impact related to plug and abandonment activities	Severity of impact	Probability of impact	Environmental risk
Impacts of underwater noise on marine mammals	Minor	Probable	**Negligible**
Impacts of underwater noise on fish	Minor	Probable	**Negligible**
Impacts of discharge of chemicals to sea	Minor	Probable	**Negligible**

Impacts of air emissions (NO_X, SO_X)	Minor	Probable	**Negligible**
Impacts of air emissions (CO_2-eq.)	Minor	Highly probable	**Low**
Impacts of waste production	Insignificant	Probable	**Negligible**
Impacts of use of natural resources	Minor	Probable	**Negligible**
Blow-out during P&A activities	Minor	Very low	**Negligible**
Oil spill from vessels	Minor	Very low	**Negligible**

2.5 Socio-economic impacts

Based on the description of the environmental effects, the socio-economic effects of the P&A activities are expected to be negligible and therefore the socio-economic impacts of the activities are likewise expected to be very limited. The effects after the activities are mainly expected to be positive, due to increased fishing opportunities.

2.6 Cumulative effects

Potential significant cumulative impacts have been assessed both as cumulation between project related impacts and impacts with other projects within 20 km of the P&A operation. Potentially the Ravn 3 MLS and the pipeline cleaning could result in cumulative effects. However, as these projects will have no impacts on the surroundings, no cumulative effects in relation to the P&A have been identified.

2.7 Cross border impacts

The only potential cross boarder impact identified from the P&A is the release of CO_2. All other potential impacts are local. Compared to national CO_2 emissions, the release is however insignificant (the total CO_2 emissions for the P&A are comparable to the yearly emissions from ca. 133 Danish households corresponding to 0,005% of the Danish Emissions).

2.8 Natura 2000

Underwater noise and accidental spills may potentially affect designated species and habitats of Natura 2000 areas. There will however be no impacts in the Danish Natura 2000-areas due to the distance between these and the Ravn field.

Impacts of a blow-out and accidental spills has been assessed to be negligible given the small risk. The risk from a large oil spill (>1 m^3) from a vessel is comparable to other offshore vessels operating and is thus very small and the extent will be limited.

The nearest Natura 2000-site is the German DE 1003-301 Dogger Bank area located approximately 15 km from the Ravn field. In general, the potential impacts from underwater noise and accidental spills are expected to be local and for a relatively short period of time. P&A activities for Ravn A1 and Ravn A2 wells are therefore not expected to negatively impact the conservation status of habitats and species in this Natura 2000-area.

2.9 Marine Strategy Framework Directive (MSFD)

The EU has a marine strategy that aims to maintain or establish a 'Good Environmental Status' (GES) in all European marine areas by 2020. The strategy is implemented in Denmark by the Danish Marine Strategy II. The Marine Strategy II defines what is regarded as 'Good Environmental Status' of the marine environment using 11 different descriptors. For each descriptor a set of qualitative environmental targets and preliminary indicators are set. The impact of the project on relevant descriptors is assessed in Table 15-1, Table 15-2, Table 15-3 and Table 15-4.

2.10 Monitoring program

After plugging and abandoning the wells the original state of the well site shall be re-established in accordance with the drilling guidelines (DEA, 2009). Thus, a site survey will be carried out.

A post decommissioning monitoring program will be set up for the Ravn field, which will also cover the area around the abandoned wells A1 and A2.

2.11 Mitigating measures (Project mitigation)

In order to limit the emissions to air, the supply and support operations should be optimized to minimize the operation time and all engines should be maintained according to standards from the suppliers.

An inventory will be prepared, where the amount of chemicals, brine, waste and fuels will be included.

An emergency response plan will be in place during the P&A in order to limit impacts from unplanned events.

3 Introduction

Wintershall Noordzee B.V. plans to plug and abandon (P&A) the Ravn A1 and Ravn A2 wells in the Ravn field located in the 5/06 block in the Danish sector. The Ravn field concession is held by a consortium consisting of Wintershall Noordzee B.V. and the Danish North Sea Fund (Nordsøfonden). Wintershall is operator on behalf of the consortium.

Wintershall has commissioned COWI to carry out an environmental impact assessment (EIA) for the P&A of the Ravn A1 and Ravn A2.

The present EIA report documents the process, findings and conclusions. The EIA has been carried out in compliance with the Danish EIA regulations (Consolidated Act No. 1976 of 27/10/2021) and (Executive Order No. 1050 of 27/06/2022).

3.1 Dimensions and location of the project

The Ravn area is located approximately 245 km from the Danish west coast and 11.3 km from the German border, see Figure 3-1.

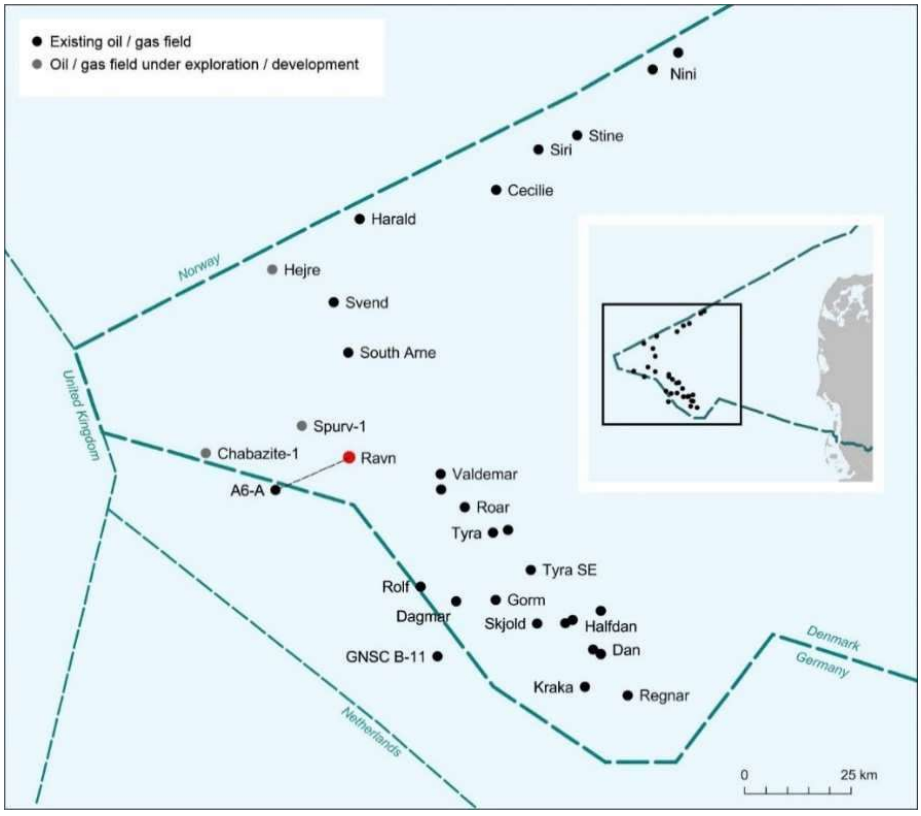

Figure 3-1 Location of the Ravn field in the North Sea.

The Ravn A1 and Ravn A2 wells are located within the Ravn field and produce back to the Ravn platform, which is tied-in to the A6-A in the German sector and can be seen from Figure 3-2. Both wells were drilled in 2015 as horizontally drilled wells. Both wells have previously produced oil. Ravn-A1 is suspended and Ravn-A2 is permanently plugged with the casing, conductor and wellhead left on the well.

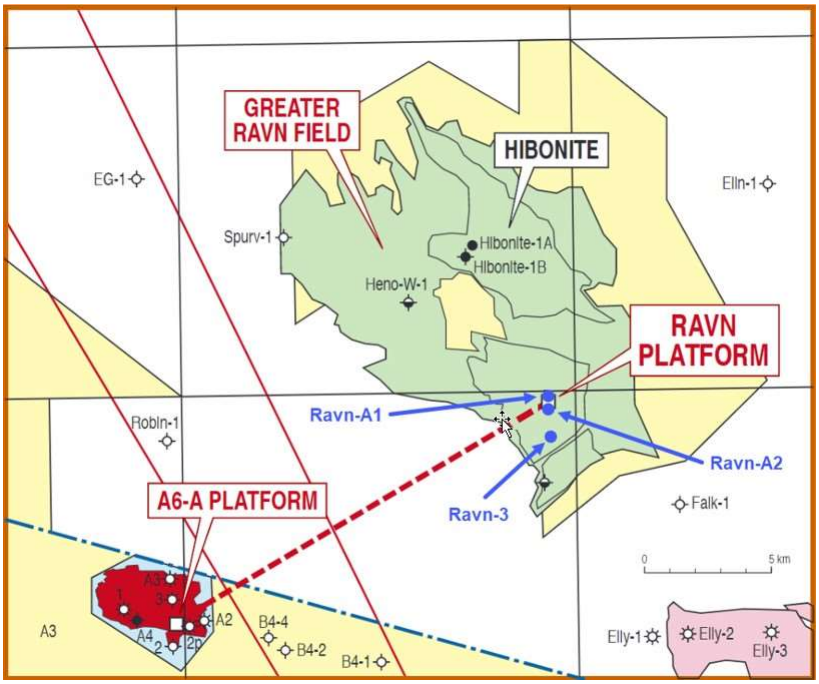

Figure 3-2 Location of the Ravn-A1 and Ravn-A2 wells.

3.2 Scope of EIA

According to the Act No. 4 of 03/01/2023 on environmental assessment of plans, programs, and specific projects (EIA) a project covered by the Annex 1 must undergo an EIA assessment in compliance with the requirements in § 20 and Annex 7. The P&A activities are considered covered by the Annex 1, point 29) *Any change or extension of projects listed in this Annex, provided that such change or extension itself meets the threshold values, if any, set out in this Annex*.

For scoping of the EIA, a screening has been made of the relevant activities from the P&A project along with an assessment of the criteria in Annex 6, see table 3-1.The criteria of Annex 6 are listed below in Table 3-1, together with the corresponding activities/impacts for the P&A. Furthermore, a description of the relevance, and if included the section for the further assessment in the EIA report.

Table 3-1 Criteria mentioned in Annex 6 of the legislation for impact assessment.

Criteria ref. Annex 6, Act No. 4 of 03/01/2023 on environmental assessment of plans, programs, and specific projects (EIA)	Potential impact from project	Description of relevance of impact and reference to section for assessment
Dimensions and construction of the project		The activities in relation to the P&A of the Ravn A1 and Ravn A2 wells are described in **Chapter 7.**
The cumulation of effects with other existing and/or approved projects		The cumulation effects associated with this project or other adjacent project are assessed in **Chapter 12.**

Criteria ref. Annex 6, Act No. 4 of 03/01/2023 on environmental assessment of plans, programs, and specific projects (EIA)	Potential impact from project	Description of relevance of impact and reference to section for assessment
The use of natural resources, in particular land, soil, water and biodiversity		The use of natural resources is assessed in **Section 9.5**
Waste production	Waste and wastewater from rig Non-hazardous and hazardous waste from P&A of wells	Impacts of discharge of chemicals in **Section 0 and** impacts of waste production **9.4**
Pollution and nuisance	Vessel and rig noise Cutting of casing	Impacts from discharges of cuttings, mud and chemicals are assessed in **Chapter 9**
	Spills from vessels Spills in relation to P&A of wells	Impacts of spills are assessed in **Chapter 10.**
	Emissions from rig Emissions from transportation	Impacts of air emissions are assessed in **Section 9.3**
	Disturbance and underwater noise	Impacts of underwater noise are assessed in **Section 9.1**
Risks of major accidents and/or disasters which are relevant to the project concerned	Oil spill	Assessed in **Chapter 10.**
	Vessel activity	Assessed in **Chapter 10.**
Risks to human health	Emissions to air	All emissions take place in an open setting with a high degree of wind replacement far away from populated areas and no impacts on human health are expected. Air quality in relation to human health is therefore not further assessed in the EIA.
	Noise (above and below water)	Since noisy activities offshore are covered by OHS regulations and no noise is expected to reach any populated areas no impacts on human health are expected. Noise in relation to human health is therefore not further assessed in the EIA.
	Handling of waste	Since handling of all waste offshore and onshore is covered by OHS regulations as well as relevant permits no impacts on human health are expected. Handling of waste in relation to human health is therefore not further assessed in the EIA.
The existing and approved land use	N/A	There are no new land uses or new areas being including because of the decommissioning (P&A).

Criteria ref. Annex 6, Act No. 4 of 03/01/2023 on environmental assessment of plans, programs, and specific projects (EIA)	Potential impact from project	Description of relevance of impact and reference to section for assessment
The relative abundance, availability, quality and regenerative capacity of natural resources (including soil, land, water and biodiversity) in the area/ underground	Impact at sea	Assessment shown in **Section 15.**
Wetlands, riparian areas, river mouths	N/A	Not relevant due to location, distance to shore and the type of activities.
Coastal zones and the marine environment	Emissions to air, discharges and noise	There is no impact on abundance, availability, quality, and regenerative capacity of natural resources in the coastal zones as a result of the P&A of well A1 and A2. Impact on the marine environment are described in Chapter 9.1-9.5 and 10.
Mountain and forest areas	N/A	Not relevant due to location and the type of activity offshore.
Nature reserves and parks	N/A	Impacts related to protected areas and species are covered by the present assessment and described in **Chapter 14.**
Areas classified or protected under national legislation; Natura 2000 areas designated by Member States pursuant to Directive 92/43/EEC (Habitats Directive) and Directive 2009/147/EC (Birds Directive);	Underwater noise Airborne noise from vessel/helicopters	Underwater noise is assessed in relation Natura 2000 in **Section 9.1** Airborne noise from vessel and helicopters will not be distinguishable from ship movement in the area and no impact from airborne noises are foreseen.
	Discharges of mud and chemicals	Assessed in relation Natura 2000 in **Section 0.**
Areas in which there has already been a failure to meet the environmental quality standards, laid down in Union legislation and relevant to the project, or in which it is considered that there is such a failure;	Marine Strategy Framework Directive	Assessed in **Chapter 15**.
Densely populated areas	N/A	There are no impacts from the decommissioning that could impact densely populated areas and the criteria is not included in the EIA assessment
Landscapes and sites of historical, cultural, or archaeological significance	Under water cultural heritage	The P&A activities are concentrated in a small area at the well site and the only historical, cultural or archaeological element of importance would be a historical wreck at the well site. The seabed around the platform and the three wells has been surveyed by Fugro Survey BV in 2015 and only small fragments of debris were found. No shipwrecks were present around the platform or at the well site.

In addition, the EIA includes a non-technical summary (Section 2), description of alternatives (Section 6), description of the existing environment (Section 8), methodology

(Section 5), assessment of socio-economic impacts (Section 11), cross-border impacts (Section 13), monitoring programme (Section 16), project mitigations (Section 17), data quality and limitations (Section 18) and references (Section 20).

Below is an overview of the potential impacts related to P&A of the Ravn A1 and Ravn A2 wells and conditions that potentially may affect organisms and other features that have been assessed in the EIA, see Figure 3-3.

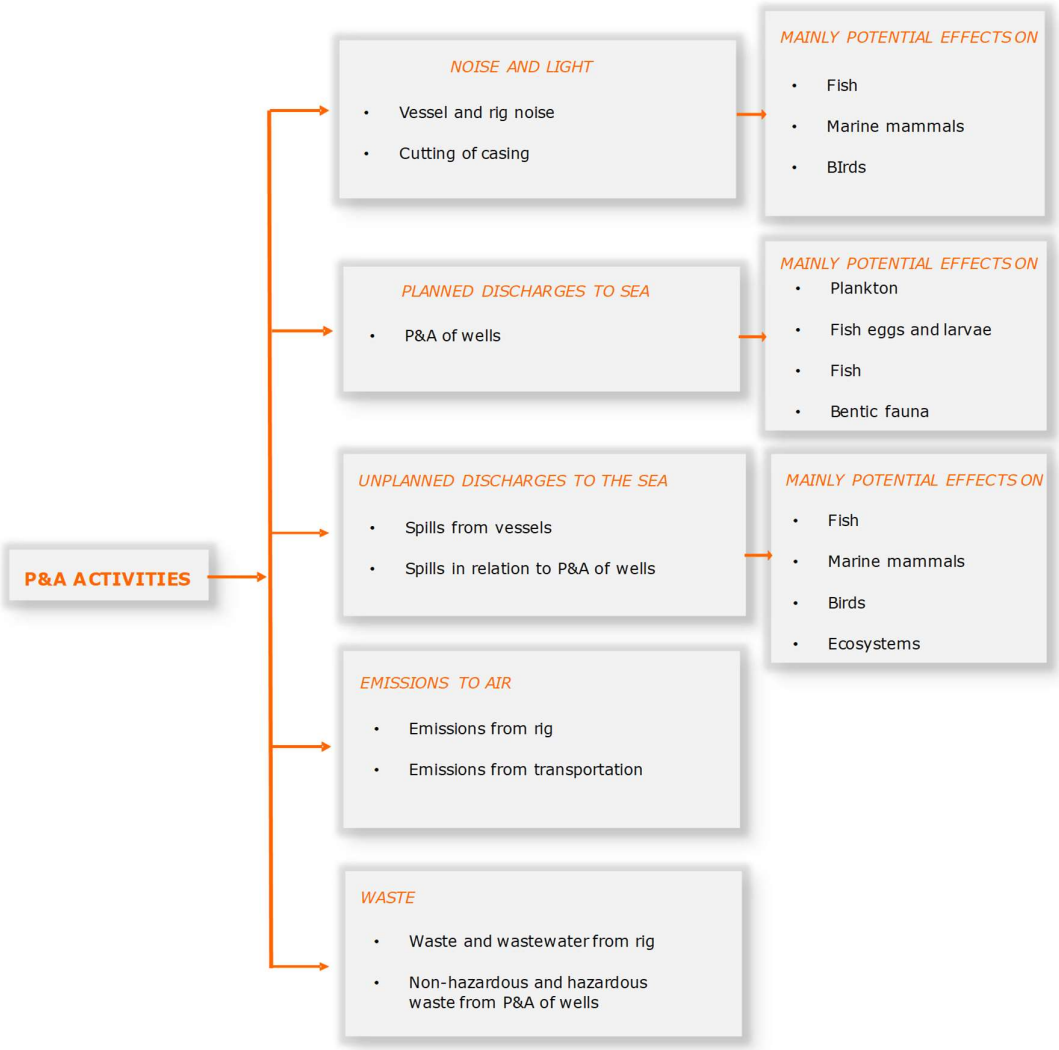

Figure 3-3 Overview of potential environmental impacts from P&A activities and effects on environmental components.

The current EIA only covers the P&A of the Ravn A1 and A2 wells and activities related to the rig, e.g. chemicals used on the rig. Other decommissioning activities are covered in the Ravn decommissioning EIA. These activities include removal of topside and jacket,

decommissioning of pipelines and post decommissioning site surveys. The P&A of Ravn 3 MLS has been included in a separate EIA screening and is not assessed in the current EIA.

The wells will most likely be P&A during August and September 2023. However, there is an unlikely opportunity that it can be plugged later in 2023 or 2024, see the time schedule below in Figure 3-4.

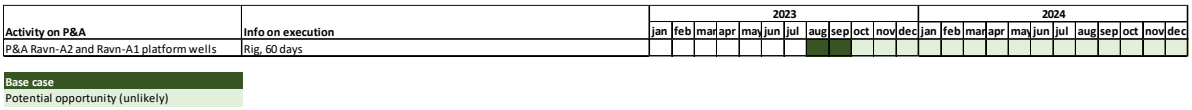

Figure 3-4 Time schedule for base case and potential opportunities for P&A of Ravn A1 and A2.

4 Legal requirements

4.1 Environmental impact assessment

An EIA is required to obtain an approval for changes to activities concerning offshore exploration and production of oil and gas and certain industrial plants. This requirement is set forth in Directive 2011/92/EU of the European Parliament and of the Council of 13 December 2011 on the assessment of the effects of certain public and private projects on the environment. The directive is implemented in Danish legislation through the:

- Subsoil act (Consolidation act no. 803 of 07/06/2022)
- The EIA act (Consolidation act no. 4 of 03/01/2023)
- Offshore impact assessment order (Executive Order no. 1050 of 27/06 2022)

The present EIA is compliant with the above-mentioned legislation.

The public hearing process for offshore projects is as follows:

The project owners' application, the environmental impact assessment report will be available on the website of the Danish Energy Agency (DEA), and the public will have the opportunity to comment on the EIA through an eight-week public hearing phase. After the hearing period the DEA will decide if a permit for the project will be granted.

Decisions regarding the project and the EIA will be published on the DEA website, and any party with relevant and individual interests in the decision may file a written complaint on environmental issues to the Energy Board of Appeal within four weeks of the publication.

4.2 Offshore safety

To prevent and mitigate pollution from major accidents, the Offshore Safety Act (Consolidation act no. 125 of 06/02/2018) requires response contingency plans for offshore platforms carrying out exploration, production and transport of petroleum hydrocarbons. The required content of such plans is specified in the associated regulation on contingency plans in case of pollution of the marine environment from oil and gas pipelines and other platforms (Marine Environment Act (Consolidation act no. 1165 of 25/11/2019 § 34a).

4.3 Natura 2000-areas and Annex IV-species

Natura 2000 is a network of nature protection areas established under the EU Habitats Directive and the Birds Directive. The network consists of Special Areas of Conservation (SACs) designated by the member states under the Habitats Directive (92/43/EEC) and Special Protection Areas (SPAs) designated under the Birds Directive (2009/147/EC).

Prior to any decision on projects with potential impact on a Natura 2000 area, documentation must be presented that the activity will not lead to negative effects on the favourable conservation status of species or habitats that are part of the selection basis or affect the integrity of the area negatively (executive Order no. 1050 of 27/06/2022 on impact assessment regarding international nature conservation areas and the protection of certain species in connection with offshore exploration and production of hydrocarbons, storage in the subsoil, pipelines, etc.).

The EU Habitats Directive (Council Directive 92/43/EEC of 21 May 1992) specifies wild fauna and flora for which the member states must ensure protection. The species to be protected are specified in the Annexes of the directive: Annex IV lists species of animal and plants in need of particularly strict protection. Of the marine mammals encountered in the North Sea, all species of cetaceans are listed in Annex IV.

4.4 Marine strategy directive

The EU has a marine strategy that aims to maintain or establish a 'Good Environmental Status' (GES) in all European marine areas by 2020. This strategy is set forth in Directive of the European Parliament and by the Council of 17 June 2008 on establishing a framework for community action in the field of marine environmental policy (Marine Strategy Framework Directive - MSFD). The directive is implemented in Danish legislation through Marine Strategy Act (Consolidation act no. 1161 of 25/11/2019).

The marine strategy act sets up the content of a marine strategy to include:

1. Basis analysis
2. Description of good environmental status
3. Stipulate environmental targets and indicators
4. Monitoring programme
5. Programme of measures

4.4.1 Danish Marine Strategy II

The Danish Ministry of Environment defines what is regarded as 'Good Environmental Status' of the marine environment using 11 different descriptors. For each descriptor a set of qualitative environmental targets and preliminary indicators are set in the Danish Marine Strategy II – part 1. The 11 descriptors are listed below:

- D1: Biodiversity
- D2: Non-indigenous species

- D3: Commercially exploited fish stocks
- D4: Marine food webs
- D5: Eutrophication
- D6: Sea floor integrity
- D7: Alteration of hydrographical condition
- D8: Contaminants
- D9: Contaminants in fish and other seafood for human consumption.
- D10: Marine litter
- D11: Underwater noise

OSPAR is currently working on a common framework of indicators and assessment values to be used in the Northeast Atlantic. In this EIA, the targets and indicators from the Danish Marine Strategy II has been used to assess the impact of the project on the objectives of the Marine Strategy. The Danish strategy has been prepared based on the 2017 EU criteria for good environmental status (GES).

It should be noted that threshold levels are not defined for all descriptors. The remaining threshold levels are defined as trends that describe a positive development or descriptive threshold level.

4.4.2 Marine Strategy – Monitoring programme

The Danish Ministry of Environment has prepared a monitoring programme as part of the Danish Marine Strategy II covering the period 2021-2026. The monitoring programme includes activities related to all the 11 descriptors and covers both existing monitoring programmes and new initiatives. The monitoring programme serves as input to the Programme of measures planned to be finalized in 2023.

4.5 Maritime spatial plan (MSP)

Maritime spatial planning is regulated through the Danish legislation in the Act on Maritime spatial planning (Consolidation act no. 400 of 06/04/2020).

The Danish Maritime Authority is responsible for establishing Denmark’s first maritime spatial plan. The maritime spatial plan is to form the basis of the coordination of the many uses of Denmark's sea area in a manner that can support the conditions for sustainable growth in Blue Denmark.

The maritime spatial plan is to establish which sea areas in Danish waters can be used for inter alia, offshore energy extraction, shipping, fishing, aquaculture, seabed mining and environmental protection towards 2030. The maritime spatial plan 2.0 is currently through

the process of public hearing and awaits final adoption. The areas of spatial planning at sea of relevance are primarily the zones for offshore energy exploration, see Figure 4-1

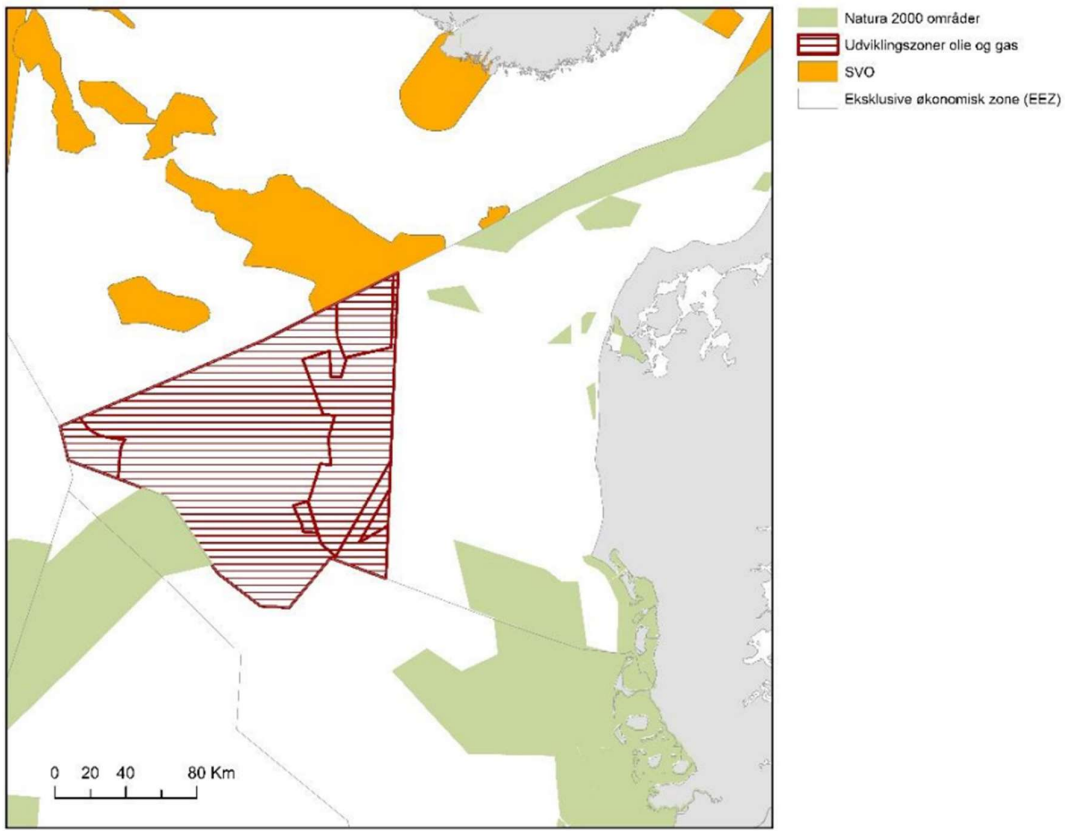

Figure 4-1 Development zone for oil and gas exploration in relation to Norway SVO-areas (especially valuable areas) and Natura 2000 areas in German and Danish sector (COWI, 2021).

4.6 Protection of the marine environment

The Marine Environment Act (Consolidation act no. 1165 of 25/11/2019) regulates discharges from drilling activities.

4.6.1 Discharges to sea

The associated regulation on discharges to the sea of compounds and materials from certain marine facilities (Executive order no. 394 of 17/07/1984) defines the information needed to obtain a permission for discharges.

Danish Environmental Protection Agency (DEPA) is the permitting authority for use and discharge of chemicals and oil to sea.

The discharge permit regulates discharge of oil and chemicals to the sea and, among others, define requirements on:

- Classification of offshore chemicals.

- Use and discharge of offshore chemicals depending on classification (explained below).
- Regularly reporting on discharge of oil and chemicals.

Classification of offshore chemicals

Chemicals are classified according to the DEPA colour coding system, which follows the OSPAR classification (substitution, ranking and PLONOR) and relates to the environmental hazard of offshore chemicals. The codes are:

Black chemicals are the most critical and not acceptable to be used offshore.

Red chemicals are environmentally hazardous to such an extent that they should generally be avoided and be substituted where possible. Substances that are inorganic and highly toxic and/or have a low biodegradation are classified as red.

Green chemicals are considered not to be of environmental concern (so-called PLONOR-substances that ''Pose Little Or NO Risk'' to the environment).

Yellow chemicals are those that do not fall into any of the above categories, i.e. substances exhibiting some degree of environmental hazard, which in case of significant discharges can give rise to concern. Substances that meet one of three criteria of low biodegradation, high bioaccumulation or toxicity are classified as yellow.

Mud and Cuttings

The OSPAR Decision 2000/03 on the Use of Organic-Phase Fluids (OPF) and the Discharge of OPF-Contaminated Cuttings regulates the management of mud and cuttings.

4.6.2 Regulation of non-indigenous species

Regulation to prevent introduction of non-indigenous species through ballast water regulated through consolidating order no. 733 of 19/05/2022 about handling of ballast water and sediments from ship ballast tanks. In addition, introduction of non-indigenous through ballast water is regulated through the following international conventions and declarations:

- IMO's Convention on the Prevention of Marine Pollution by Dumping of Wastes and other Matter (known as the London Convention 1972) including the 1996 Protocol which became effective in 2006.
- IMO has adopted the International Convention for the Prevention of Pollution from Ships (MARPOL) and management of wastewater, waste etc. are regulated via MARPOL.

4.7 Emissions

Air emissions from ships are regulated by The Marine Environment Act (Consolidation act no. 1165 of 25/11/2019).

4.8 Waste and Naturally Occurring Radioactive Material (NORM)

Waste from the plug and abandonment activities will be handled in compliance with the Danish Environmental Protection Act (Consolidation Act no. 879 of 26 June 2010) and the relevant Statutory Order on waste no. 2512 of 10/12/2021.

Offshore oil production in the North Sea is associated with contamination of certain parts of the processing equipment by low-level radioactivity substances, known as NORM (Naturally Occurring Radioactive Material).

NORM naturally occurs in the reservoirs in the North Sea; hence NORM may occur in drill cores and cuttings in drilling mud. The radioactive elements occur in chemical compounds in the produced water (formation water) either dissolved in the water or as small particles in the multiphase flow from the wells. NORM also occurs in systems where formation water and sea water are mixed. The radioactive particles or NORM can be accumulated and concentrated in separators (sludge) or deposited as scale in pipes and process equipment due to changes in pressure and temperature. NORM can also occur in the production liner of the wells.

The use (handling, storage, discharge, and disposal etc.) of radioactive substances such as NORM is regulated through The Radiation Protection Act (Act no. 23 from 23 of January 2018 on Ionizing Radiation and Radiation Protection No. 23 of 15/01/2018) and its underlying orders:

- Executive Order No. 669 of 1 July 2019 on ionizing Radiation and Radiation Protection.
- Executive Order No. 670 of 1 July 2019 on Use of Radioactive Substances.

The above legislation also regulates the use of sealed radioactive sources.

4.9 Decommissioning

Decommissioning is regulated through Danish legislation in the Subsoil Act (Consolidation act no. 1533 of 16/12/2019) and the Marine Environment Act (Consolidation act no. 1165 of 25/11/2019).

According to the Subsoil Act decommissioning plans for offshore oil and gas installations shall be prepared, submitted and approved by the DEA before the installations can be removed. DEA has prepared a guideline for these decommissioning plans called "Guideline on decommissioning plans for offshore oil and gas facilities or installations" dated August 2018. The guideline explains the legal framework and the required contents of the plans.

In addition, decommissioning is regulated through the following international conventions and declarations:

- IMO's Convention on the Prevention of Marine Pollution by Dumping of Wastes and other Matter (known as the London Convention 1972) including the 1996 Protocol which became effective in 2006.

- The London Convention is a global convention that aims at protecting the marine environment from human activities by promoting control of sources of marine pollution and by taking steps to prevent pollution of the ocean. Under the convention all dumping of waste is prohibited except certain types of waste listed on the convention's 'reverse list'.

- Ministerial Declaration of the Ninth Trilateral Governmental Conference on the Protection of the Wadden Sea (known as the Esbjerg Declaration 2001).

- OSPAR Commission's OSPAR Convention (1992 and 1998), Annex III on Prevention and elimination of pollution from offshore sources, Decision 98/3 on Disposal of disused offshore installations, and recommendation 77/1 on Disposal of pipes, metal shavings and other material resulting from offshore petroleum hydrocarbon exploration and exploration operations.

- Regarding decommissioning, the Esbjerg Declaration states that more environmentally acceptable and controllable land-based solutions are preferred, and that decommissioned offshore installations therefore shall either be reused or be disposed on land.

The OSPAR Commission establishes the framework for decommissioning including guidelines and procedures. Recommendation 77/1 states that dumping of bulky waste such as pipes and containers is prohibited without special permission excluding inter-field pipelines. All dumping or leaving wholly or partly in place of offshore installations in the North Sea is prohibited according to Decision 98/3. However, derogation from this regulation is possible when there are significant reasons why an alternative disposal is preferred. Decision 98/3 does not include decommissioning of pipelines.

DEA Drilling guidelines (DEA, 2009) states how wells should be plugged before abandonment according to approved procedures. The P&A procedures secure that well sites will be re-established in accordance with the original state and that the area shall be verified before abandonment.

5 Methodology for evaluation of environmental severity and risk

The P&A activities will take place in an area, where the existing environment is relatively well known due to earlier monitoring of the seabed in neighbouring areas. The description of the existing environment is based on seabed surveys carried out by DHI on behalf of the operators in the period 1998-2021. The EIA for the Ravn field has also been consulted.

Environmental impacts as discharge to sea, emissions to air and underwater noise have been calculated or evaluated based on inputs from Wintershall Noordzee B.V. and experience from similar activities described in EIA's from existing installations in the area.

Environmental risk is the combination of the significance (severity) of an impact and the probability that an impact may arise. This implies for instance that an incidence that may cause severe impacts but is not very likely to occur has a low environmental risk.

For each operation or incidence, the assessment of environmental risk includes three steps:

- Assessment of environmental significance (severity) of an impact.
- Assessment of the probability that an impact will occur.
- Assessment of risk by combining severity and probability.

The environmental significance (severity) and risk of impacts of the project on environmental and socioeconomic receptors has been evaluated using the methodology described below.

5.1 Environmental impact assessment of planned operations

The environmental impact of P&A activities will be assessed by the significance of the impact (severity) as outlined below (Table 5-1). Severity is assessed by the criteria described in Table 5-2. The assessment of impacts is before any mitigating actions are considered.

Table 5-1 Criteria for assessment of severity of potential impacts of the project.

Severity rating	Relation with the criteria on nature, extent, duration and magnitude that describe the impact
Positive impact	The assessed ecological or socioeconomic feature or issue is improved compared to existing conditions
No impact	The assessed ecological or socioeconomic feature or issue is not affected
Insignificant impact	Small magnitude, with local extent and short-term duration, low frequency and reversible
Minor impact	1) Small magnitude, with any combination of other criteria (except for local extent and short-term duration, and long-term duration and national or international extent) 2) Medium magnitude, with local extent and short-term duration 3) Reversible impact
Moderate impact	1) Small magnitude, with national or international extent and long-term duration; or 2) Medium magnitude, with any combination of other criteria (except for local extent and short-term duration; and national extent and long-term duration) 3) Large magnitude, with local extent and short-term duration 4) Some irreversible but at a local scale
Major impact	1) Medium magnitude, with national or international extent and long-term duration; 2) Large magnitude, with any combination of other criteria (except for local extent and short-term duration) 3) No reversibility of impact (irreversible)

Table 5-2 Criteria for assessment of nature, extent, duration, and magnitude of impacts.

Criterion	Description
Nature	***Nature of the environmental change***
Positive	Beneficial environmental change
Negative	Adverse environmental change
Extent	***The geographical area that may be affected by the impact***
Local	Only the place where the activities directly related to construction may occur
Regional	Effects may occur in the Central North Sea
National	Effects may occur in Danish waters
International	Effects may occur in the entire North Sea
Duration	***Period along which the impact is expected to occur***
Short-term	Less than 8 (eight) months
Medium-term	Between 8 (eight) months and 5 (five) years
Long-term	More than 5 (five) years
Magnitude	***The magnitude of impacts on environmental and social processes***
Small Medium Large	If possible, the magnitude of an effect is assessed from results of environmental modelling. Otherwise, the magnitude of an effect is based on an expert assessment based on previous experience from other projects. The following factors are taken into consideration: › The extent to which potentially affected habitats and organisms are unaffected by human activity › The numbers/areas of an environmental feature that will be potentially affected › The uniqueness/rarity of potentially affected organism and habitats › The conservation status of habitats or organism (Natura 2000 areas, Annex IV species etc.) › The sensitivity of the habitat/organism › The robustness of the organism/habitats against impacts, i.e. and evaluation of the ability to adapt to the impact without affecting the conservation status, uniqueness or rarity › The potential for replacement i.e. an assessment of to what extent the loss of habitats or populations of organisms can be replaced by others.
Frequency	***How often the impact will occur***
Low	The impact occurs rarely or as a single event
Medium	The impact occurs regularly
High	The impact occurs often or continuously
Reversibility	***Whether or not an impact is permanent***
Reversible	The impact is not permanent
Irreversible	The impact is permanent

5.2 Environmental risk assessment

The environmental risk of different operations and incidences will be assessed combining significance (severity) and probability of an impact according to a risk matrix as outlined below in Table *5-4*. The probability that an incident will occur will be assessed using the criteria outlined in Table 5-3.

Table 5-3 Criteria for assessment of the probability of that an unplanned incident will occur.

Probability criterion	Degree of possibility of impact occurrence
Very low	The possibility of occurrence is very low, either due to the project design or due to the project nature, or due to the characteristics of the project area
Low	The possibility of occurrence is low, either due to the project design or due to the project nature, or due to the characteristics of the project area
Probable	There is possibility of the unplanned incident to occur
Highly Probable	Possibility of occurrence of the unplanned incident is almost certain
Definite	There is certainty that the unplanned incident will occur

Table 5-4 Qualitative risk assessment matrix for an unplanned incident

	Significance /severity of impact			
Probability	**Insignificant Impact**	**Minor impact**	**Moderate impact**	**Major impact**
Definite	Negligible risk	Low risk	Significant risk	High risk
Highly probable	Negligible risk	Low risk	Significant risk	High risk
Probable	Negligible risk	Negligible risk	Low risk	Significant risk
Low	Negligible risk	Negligible risk	Low risk	Low risk
Very low	Negligible risk	Negligible risk	Negligible risk	Low risk

6 Alternative concepts

6.1 0-Alternative

The 0-alternative is a situation in which the present project is not carried out. However, leaving the wells, can cause severe environmental impacts in time, and thus is not a feasible scenario. Furthermore, according to the Drilling guideline from DEA (DEA, 2009), a well shall be plugged before abandonment. Therefore, the 0-alternative is not an option, and therefore not further assessed.

The wells are to be plugged in accordance with the Drilling guidelines (DEA, 2009).

7 Dimensions and technical description of the project

7.1 Location of the project

The Ravn field is developed as an unmanned oil production offshore platform, tied-back to the German A6-A platform. Production export is through subsea infrastructure to the German platform and no processing takes place at Ravn. The platform is located in Block 5504, approximately 245 km from the Danish west coast and 11.3 km northeast of the border between Germany and Denmark, see Figure 7-1.

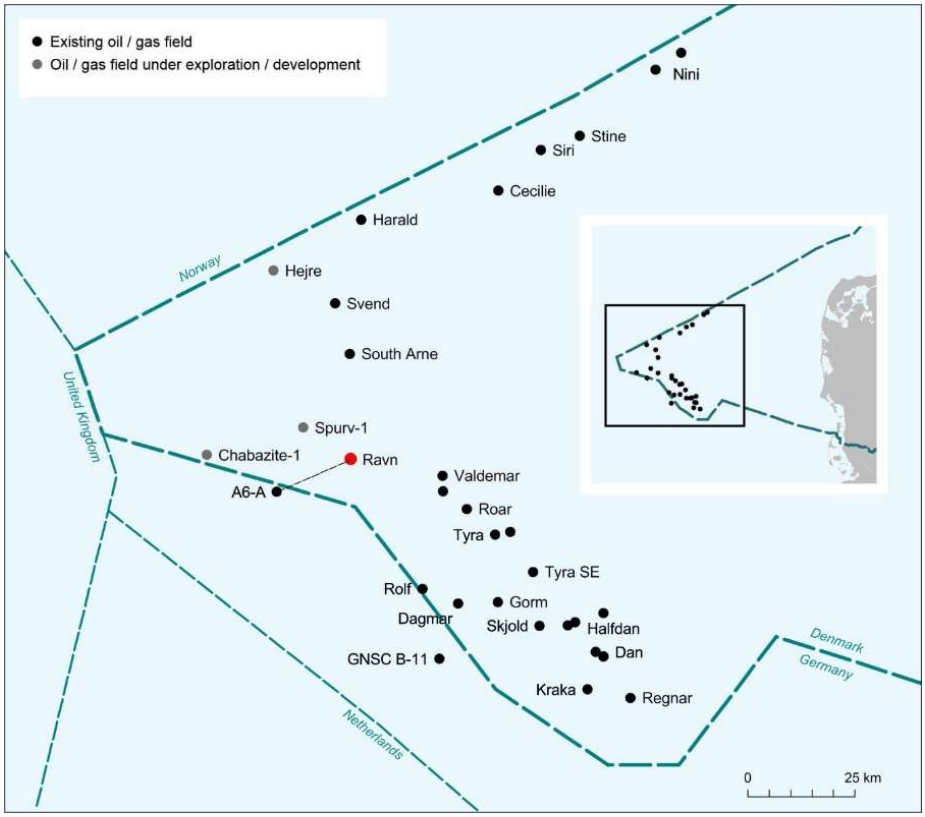

Figure 7-1 Location of the Ravn field in the North Sea.

The distance to the nearest manned platforms to Ravn are South Arne (21 km) and Valdemar (22 km). The A6-A platform is placed approximately 18 km from Ravn. The Humber – Denmark shipping lane is the nearest shipping lane situated 29 km to the southeast of the Ravn platform.

The Ravn-A1 and Ravn-A2 wells are located in the Greater Ravn field and can be seen from Figure 7-2 and Table 7-1. Both wells were previously oil producing but are now suspended (Ravn-A1) and permanently plugged (Ravn-A2) with the casing, conductors and wellhead left on the wells.

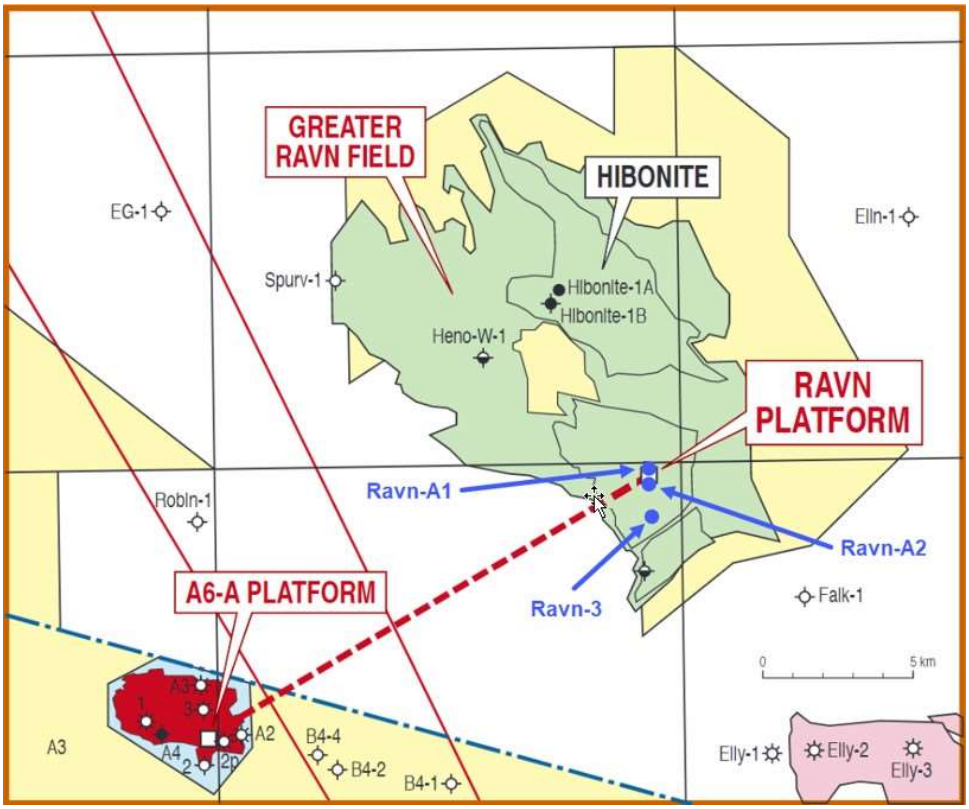

Figure 7-2 Location of the Ravn-A1 and Ravn-A2 wells.

Table 7-1 Location of wells and well status.

Platform wells	Designation	Depth (m) (TVD/MD)	Production tubing (inch)	Coordinates	Status
Ravn A1	Oil	4192 / 5985	4.5”	55°52'50.1" N 4°14'4.6" E	Suspended.
Ravn A2	Oil	4179/5788	4.5”	55°52'50.1" N 4°14'4.7" E	Plugged as per P&A RAVN A2 Program and abandoned per august 2018. (conductor still in place)

The Ravn-A1 and Ravn-A2 wells are placed offshore 245 km west of the Danish west coast. The distance to the nearest manned platform is at least 15 km. There are no Danish (marine) natural reserves in the area.

7.2 The reservoir/well status

The Ravn A1 well has been in production intermittently since 2017.

From January 2017 until June 2020 the Wintershall Noordzee B.V. well service team have had continuously activities on the Ravn installation in order to improve the production from Ravn A1. Activities consisted of inhibiting with KCl brine, slickline operations and treatment with diesel as solvent in relation to wax/asphaltene debris in the well. Flowing of the well was also supported by gas lift.

In March 2020 the well was shut-in for regular maintenance and due to indication of gas leak between the A-annulus to the B-annulus, it was decided to keep the well shut-in. A leak test was performed in April 2020 and in May 2020 the well was classified as shut in for well integrity reasons even though no more leaking occurred due to the preventive measures taken in March (stop of production and depressurization of the annuli). In June 2020 it was decided that the well should be suspended with two barriers.

The suspension activities took place in July/August 2020 when 2 plugs were placed in the well as shown on Figure 7-3. Inflow test and pressure test has been prepared as a part of the monitoring after safeguarding the well. The pressure in the void between the installed deep-set plugs is monitored remotely and by that the well can be checked that the barriers are intact and if there is an increase in pressure build-up. below the top barrier when re-entering the well for P&A. A risk assessment has been conducted in relation to the method for suspension of the well.

The current situation with a sustained casing pressure does not have an effect on the risk of oil spill or blow-out as the pressure is contained in the well barrier envelope, which consists of different barriers to prevent flows.

The bottom-hole reservoir pressure has also declined significantly which reduces the risk of oil spill or blow-out as the pressure is contained in the well barrier envelope. Permanent plugs will be set below the minimum barrier depth (MBD) during the P&A and will thereby permanently isolate the reservoir and the risk of oil spill and blow-out.

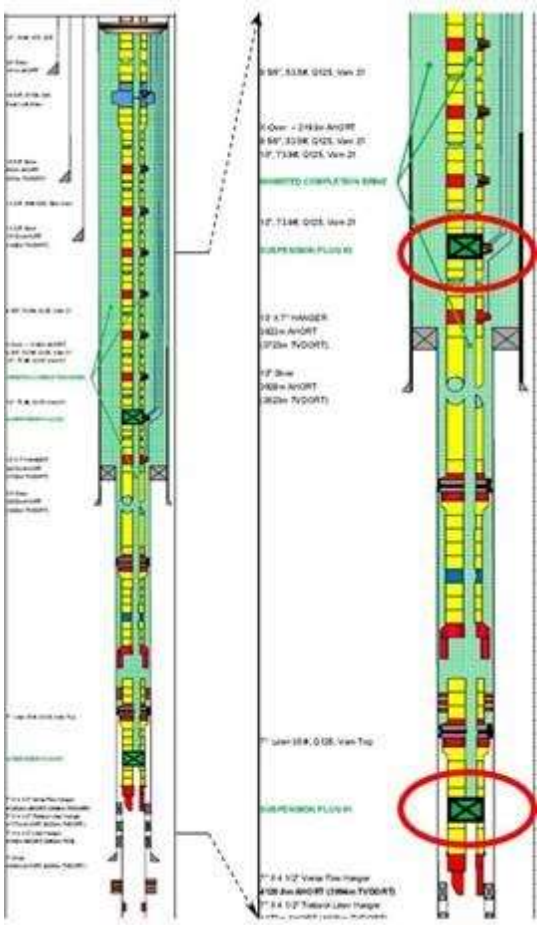

Figure 7-3 2 plugs in the well.

Information about the Ravn A1 well can be seen in Table 7-2.

Table 7-2 Well information of the Ravn A1 (Wintershall Noordzee B.V.).

Well Name	**Ravn A1 Platform Production Well**
License Area:	5/06
Well Status:	Suspended with deep set plugs
Operator:	Wintershall Noordzee B.V
Partners:	The Danish North Sea Fund
Surface Location:	55° 50' 50.02"N 04° 14' 04.55"E
Downhole location:	55° 51' 29.12"N 04° 13' 55.08"E
Well Depth (TD):	4191mTVD (5982m MDRT)

The Ravn A2 well has been in production intermittently since 2017. In July/August 2018 Wintershall plugged the Ravn A2 well successfully as per the P&A program for Ravn A2. However, the conductor is still in place and thus removal of the remaining casing string and conductor pipe still needs to be performed.

The current situation with sustained casing pressure does not have an effect on the risk of oil spill or blow-out as the pressure is contained in the well barrier envelope. Further remedial work is planned to plug the sustained casing pressure.

Information about the Ravn A2 well can be seen in Table 7-3.

Table 7-3 Well information of the Ravn A2 (Wintershall Noordzee B.V.).

Well Name	**Ravn A2 Platform Production Well**
License Area:	5/06
Well Status:	Plugged with mechanical and cement plugs
Operator:	Wintershall Noordzee B.V
Partners:	The Danish North Sea Fund
Surface Location:	55° 50' 50.02”N 04° 14' 04.67"E
Downhole location:	55° 52' 44.458”N 04° 12' 17.801"E
Depth (TD):	4179mTVD (5788m MDRT)

7.3 Plug and Abandonment operation

The plug and abandonment of the Ravn A1 and Ravn A2 wells is planned to commence in August 2023 earliest to ensure the wells are P&A before the scheduled arrival of the heavy lift vessels to remove the platform. The availability of the rig from November 2023 onwards is not given and depends on availability from the rig provider.

Below the P&A process is described.

7.3.1 Mobilisation of the rig

A jack-up rig is a mobile installation with a hull that contains drilling equipment, utilities, helideck and accommodation. The rig has three legs in a lattice structure, which can be lowered to the seabed by means of a cogwheel system. When the legs are lifted, the hull is floating, and the rig can be towed to the position by tugs. When it is in operation, the legs will be lowered into the seabed and spud cans are mounted on the end of the legs to stabilize and distribute the weight of the rig on the seabed. The hull is then lifted above the water level.

The P&A of the Ravn A1 and Ravn A2 wells will be conducted by a rig and thus a rig will be mobilised and present at the site during the P&A operation.

7.3.2 Plug and abandonment activities

Well decommissioning is the permanent isolation of any underground formation with hydrocarbons or/and flow potential, isolation of hazardous substances and the restoration of the seabed to its previous state.

Ravn A1:

The P&A operations summary for the Ravn A1 well involves P&A activities from the deep-set plug at 4006mMD and to isolate sustained casing pressure in the B and C annulus below the minimum barrier depth (MBD) and to cut and remove the casing and the 30" conductor from 30mBSF and 5mBSF, respectively, which is detailed as follows.

- Re-enter the well and pull 3.75" plug/prong at 3,191mMD. The existing plug set previously will be removed, by pulling it.
- Attempt to bullhead the tubing with 1,25SG CaBr2 brine down to 4,105mMD. CaBr2 brine will be pumped into the tubing in order to balance the well and create well control. All CaBr2 brine will be reused or transported to shore.
- Re-install a 3.56" plug/prong at 4,030mMD. Pressure and inflow test plug.
- Nipple down production tree and nipple up blow-out preventer (BOP). The valves with gauges and chokes, which provides flow control while producing will be dismantled and removed and a BOP will be installed as a barrier to seal, control and monitor the well.
- Punch completion tubing at 4,000mMD. The tubing will be perforated in order to be able to circulate the well.
- Circulate the well to 1.25SG CaBr2 brine. CaBr2 brine will be pumped down the well and circulate to clean up the well, so no excessive material will contaminate the plugs in the well. The CaBr2 brine will be reused or transported to shore.
- Pump wash spacer ahead to ensure oil free. A fluid (spacer) will be pumped down hole before the cement in order to clean the well for oil. All chemicals will be transported to shore and thus there will be no discharge.
- Cut and pull completion tubing to surface. The tubing will be cut and pulled to the surface and transported to shore.
- Run Wellbore cleanout (WBCO) string and clean up well with 1,25SG CaBr2 brine. A WBCO, which is a string including both mechanical and chemical clean up tools, will be run in the hole to clean up the well and remove e.g., dirt etc. for the setting of mechanical and cement barriers and ensure that only an overbalance 1,25SG CaBr2 brine is left in the well. All chemicals will be transported to shore and thus there will be no discharge.

- Set deep cement plugs 1a and 1b (4,000mMD to 3,823mMD and 3,823mMD to 3,725mMD). Cement plugs will be set at the above-mentioned depths ensuring isolation of the reservoir. All chemicals will be transported to shore and thus there will be no discharge.

- Set intermediate cement plugs 2 and 3a (2,800mMD to 3,000mMD and 1,565mMD to 1,350mMD). Cement plugs will be set at the above-mentioned depths ensuring isolation of any potential shallow flow zones. All chemicals will be transported to shore and thus there will be no discharge.

- Set Perforate, Wash, Cement (PWC) cement plug 3b (1,350mMD to 1,250mMD). When setting the plug at 1,350mMD to 1,250mMD the PWC technic will be used, where the cement plug is set by forcing the cement through perforation and into the annulus to isolate any potential shallow flow zones.

- Circulate well to seawater.

- Cut and pull 9⅝" casing to surface. The casing will be cut and pulled to the surface and transported to shore.

- Cut and pull the 13 3/8" casing to surface. The casing will be cut and pulled to the surface and transported to shore.

- Cut and pull the 18 5/8" casing to surface. The casing will be cut and pulled to the surface and transported to shore.

- Place a 20m surface cement plug from 30m to 10mMD below the seafloor (BSF).

- Cut the 30" conductor from 5mBSF. The conductor pulled to the surface and transported to shore by the rig.

The well to be abandoned will be plugged downhole and cut below the seabed in accordance with DWEA draft Guideline 6.5.2.1 Health and safety aspects regarding offshore well operations.

No installations on the platform will be removed.

Ravn A2:

The P&A Operations Summary for the Ravn A2 well involves P&A activities from the 13-3/8" casing shoe to isolate sustained casing pressure in the B and C annulus below the minimum barrier depth (MBD) and to remove the casing and the 30"conductor from 30mBSF and 5mBSF, respectively, which is detailed as follows.

- Circulate well to 1,08SG Water-based mud (WBM). WBM will be pumped down hole to prepare the well for the drill bit.

- Drill out cement plug 4b to 1540mMD. The cement plug will be drilled out. All chemicals and WBM used will be transported to shore and thus there will be no discharge.

- Pull the 9 5/8" casing from 1540mMD. In unsuccessful, cut and pull the 9 5/8" casing at 600mMD. The casing will be cut and pulled to the surface and transported to shore.
- Circulate out water-based mud (WBM) from behind 9 5/8" casing (B annulus). The WBM will be transported to shore and thus there will be no discharge.
- Pull the 9 5/8" casing from 600mMD to 1540mMD. The casing will be cut and pulled to the surface and transported to shore.
- Cut & mill the 13 3/8" casing from 1535mMD. The casing will be cut and milled away (mill). The mud will make sure that the materials are transported to the surface and taken to shore. Set a cement plug across 13 3/8" x 17 ½" annulus from 1535mMD. A cement plug will be set at 1535mMD to isolate the C annulus below the minimum barrier depth (MBD). All chemicals will be transported to shore and thus there will be no discharge.
- WT cement plug in 13 3/8" casing with drill pipe to 10 kips (1,000 lbf).
- Pull the 13 3/8" and 18 5/8" casing from the mudline suspension (MLS) or 5 m below seafloor (BSF) as the 13 3/8" is cemented above the MLS. The casing will be cut and pulled to the surface and transported to shore.
- Place a 20m surface cement plug from 30m to 10mBSF.
- Cut and pull 30" conductor from 5mBSF. The conductor will be cut and pulled to the surface and transported to shore.

The well to be abandoned will be plugged downhole and cut below the seabed in accordance with DWEA draft Guideline 6.5.2.1 Health and safety aspects regarding offshore well operations.

No installations on the platform will be removed.

7.4 Muds, chemicals and waste

During the P&A of the Ravn A1 well brines will be recovered from the wells. During the P&A of the Ravn A2 well the Water-based mud (WBM) will be recovered from the well. The wells do not contain any Oil Based Mud (OBM).

In Table 7-4, the amounts of brines recovered from the wells in relation to the P&A activities are shown and quantified with regard to expected volumes of brines. In Table 7-5, the amounts of mud recovered from the wells in relation to the P&A activities are shown and quantified with regard to expected volumes of muds.

The contaminated KCL brine will be transported onshore. The CaBr2 brine will be partly transported onshore (approx. 5 tonnes) and the remaining will be reused in the well (approx. 28 tonnes). The contaminated WBM will also be transported onshore.

Table 7-4 Amounts of brines expected to be reused and their fate during the P&A of Ravn A1.

Types of brines and waste	Amount* [tonnes]	Fate
Brine from well (3% KCL)	30	Transported onshore
Brine from well (CaBr2)	33	Transported onshore/reused

Table 7-5 Amounts of muds expected to be used and their fate during the P&A of Ravn A2.

Types of mud and waste	Amount* [tonnes]	Fate
Contaminated WBM	311	Transported onshore

Based on the above information, there will be no discharge of mud or brine and thus **no impacts**. This will not be further assessed.

7.5 Chemicals

The specific chemical products to be used during the P&A process are not decided upon yet. However, the functions and the pre-screening category is known.

The vast majority of the chemicals will either be "green" (PLONOR) or "yellow". "Black" chemicals will not be used at all and use of "red" chemicals will be avoided to the extent possible and only for highly specific purposes. In line with the OSPAR recommendations and Danish regulatory practice, red chemicals will not be discharged to the sea.

During P&A of the Ravn A1 and A2 wells P&A chemicals, cementing chemicals and rig chemicals related to the jack-up rig used for the P&A will be used, see Table 7-6, Table 7-7 and Table 7-8.

Table 7-6 Use and discharge of P&A chemicals during P&A of Ravn A1 and A2.

Activity	Function	Expected use [Tons]	Expected discharge [Tons]	Left in well [Tons]	Pre-screening category
P&A	Weighting Agent	400	0	400	Green
	pH control	10	0	10	Green
	pH control	4	0	4	Yellow
	Detergent	20	0	20	Green
	Defoamer	2	0	2	Green
	Viscosifier	8	0	8	Green

	Cement retarder	4	0	4	Green
	H_2S Scavenger	2	0	2	Yellow
	Base fluid	700	0	700	Yellow
Total		**1.150**	**0**	**1.150**	
Total Red		0	0		
Total Yellow		736	0		
Total Green		414	0		

Table 7-7 Use and discharge of cementing chemicals during P&A of Ravn A1 and A2.

Activity	Function	Expected use [Tons]	Expected discharge [Tons]	Left in well [Tons]	Pre-screening category
Cementing	Cement additive	4	0	4	Green
	Cement additive	2	0	2	Green
	Cement additive	2	0	2	Green
	Cement	200	0	200	Green
	Cement	200	0	200	Green
	Cement additive	6	0	6	Green
	Cement additive	4	0	4	Yellow
	Cement additive	4	0	4	Yellow
	Cement additive	40	0	40	Green
	Cement additive	4	0	4	Green
	Fluid loss control	4	0	4	Green
	Cement additive	2	0	2	Green
	Cement additive	4	0	4	Green
	Cement additive	2	0	2	Green
	Cement additive	2	0	2	Green
	Cement additive	20	0	20	Green
	Cement additive	2	0	2	Red
	Cement additive	2	0	2	Red
	Cement additive	2	0	2	Red
	Dye	2	0	2	Green
	Cement additive	4	0	4	Red
	Antifoam	0,03	0	0,03	Green
	Cement additive	5,5	0	5,5	Green
Total		**518**	**0**	**518**	
Total Red		10	0	10	
Total Yellow		8	0	8	
Total Green		500	0	500	

Table 7-8 Use and discharge of rig chemicals related to rig operations during P&A of Ravn A1 and A2.

Activity	Function	Expected use [Tons]	Expected discharge [Tons]	Other [Tons]	Pre-screening category
Rig chemicals	Jacking grease	0,45	0,125	0,25 remain in rig system	Yellow
	Rig wash	0,5	0,5	0	Green
	Pipe dope	0,5	0	N/A (will be contained in WBM and brine shipped to shore)	Yellow
Total		**1**	**0,75**	**0,25**	
Total Red		0	0	0	
Total Yellow		0,5	0,25	0,25	
Total Green		0,5	0,5	0	

As can be seen from the above, no chemicals or fluids will be discharged to sea during the plug and abandonment process, except for some of the jacking grease being washed from the rig legs and the rig wash chemicals. The rig wash chemicals are significantly diluted before being discharged to the sea and pre-screened as a green substance, and therefore the impact is insignificant. All P&A chemicals and cementing chemicals will be contained in the well and there will be no discharge to the sea. Any P&A chemicals and cementing chemicals not used will be taken to shore for disposal.

There will be no formation cuttings from the plug and abandonment process.

Thus, only the impact from the discharge of the yellow jacking grease rig chemical will be further assessed. No impacts related to other chemical discharges will occur, and this will not be further assessed.

WBM and brine returned from the well will be shipped to shore for disposal and there will be no discharges.

7.6 Emissions to air

Emissions to air in relation to plug and abandonment activities are related to:

- Rig activities (mainly generator)
- Crew transport activities by helicopter
- Standby vessel
- Transport of goods by supply vessels

A jack-up rig will be used and the emission from the rig is mainly from energy production for equipment used during plug and abandonment activities. Energy will be produced by diesel generators.

In Table 7-9 the expected transport related to plug and abandonment activities can be seen.

Table 7-9 Type of transport related to plug and abandonment activities (Wintershall Noordzee B.V.).

	Numbers	Days	Fuel consumption [m³/day]
Rig operation during P&A of wells			
Rig	1	60	8.3
Supply vessel	1	60	11.77*
Standby vessel	1	60	2
Helicopter	1	60	1.2**

* The fuel consumption is given per round trip. There will be 3 round trip/week = 8 round trips in total. **The fuel consumption is given per day. There is 3 hours helicopter flight three days a week for 9 weeks corresponding to 3 full days.

The assumptions are:

- All estimated days include contingency for weather delays and unforeseen events.
- The rig is operating 60 days in total.
- The supply vessel is doing one round trip/week, equivalent to 8 round trips in total for the 60 days.
- The helicopter crew change from Den Helder is three flights per week with a standby on the rig for less than 30 min or shutdown on the rig for one hour.
- The standby boat is available 24 hours/day while the rig is operating.

7.7 Waste production and management

Decommissioning of the wells include removal of the casing. After plugging of the well, the upper casing sections and the conductor will be cut from 30 and 5m below the seabed, respectively and removed with the rig. Alternatively, the conductor can be cut by the rig and removed with the HLV when removing the platform at a later stage, depending on the decommissioning strategy.

It is the intention to leave the deeper laying sub-surface parts of the injection-/production piping. The strategy to be selected eventually will determine the final P&A method and the parts and amounts to be removed to shore for recycling. It is expected that up to approx. 412 tons of steel will be recovered from the wells and the remaining parts of steel will remain left in the wells because it is either not possible to remove and/or not required to be removed.

Table 7-10 Amounts of steel expected to be recovered from the two wells (Wintershall Noordzee B.V.).

Casing size [in]	Length [m]	Total weight [Tonnes]
30	232	118
18 3/4	250	36
13 3/8	250	28
9 5/8	1674	147
4 ½	4000	83
Total		**412**

Domestic-type wastewater (grey and black) and waste will be generated at the rig (staff accommodation and kitchen facilities). The waste and wastewater management are regulated by IMO and will be in accordance with MARPOL annex IV.

All waste products will be shipped to shore to be handled by certified waste management facilities according to European regulation. A specific contractor has not yet been selected for the P&A of the wells. The procurement process dictates that WINZ is only contracting companies which are fully compliant with internal company standards and latest local/European regulatory requirements. The currently most likely scenario is transport of waste to the Netherlands. WINZ has a lot of experience with Reym/Renewi/Hoondert for waste handling in the Netherlands. WINZ is ISO14001 certified documenting that WINZ is fully compliant to any environmental requirement amongst which a proper waste disposal process.

8 Description of the existing environment

This chapter describes the physical, biological and ecological conditions and characteristics in the North Sea, which are relevant for the assessment of impacts during the plug and abandonment of the two wells Ravn A1 and Ravn A2 at the Ravn Field.

The chapter includes general descriptions for the North Sea and specific project site descriptions. The specific project site descriptions are based on the full descriptions on the existing environment included within the approved EIA for the Ravn Field (Wintershall Noordzee B.V., 2014) in addition to updated information, hereunder the description in the "Stilllegung der Pipelines zwischen A6-A und Ravn - Umweltfachlicher Vergleich zwischen dem In Situ-Belassen der Pipelines und dem Rückbau" (ARSU, 2022).

8.1 Physical environment

The Ravn field is located centrally in the North Sea around 245 km from the west coast of Jutland. The North Sea is a shelf sea placed between the Northwestern continental Europe and Great Britain. The water is relatively shallow with a maximum depth of 800 m in the north down to 20 m at the Dutch and German coasts (average depth 80 m).

The water depth at the well site is approximately 48-50 m and the prevailing surface currents at the site are east going. The currents are mainly driven by the topography and determined by the water inflow from the North Atlantic through the English Channel, river outflow and the out-going currents from the Baltic Sea. The general circulation of the tidal currents in the North Sea are characterised by a strong north going current along the continental coast and an east going current in the central North Sea (Otto et al. 1990) (Figure 8-1).

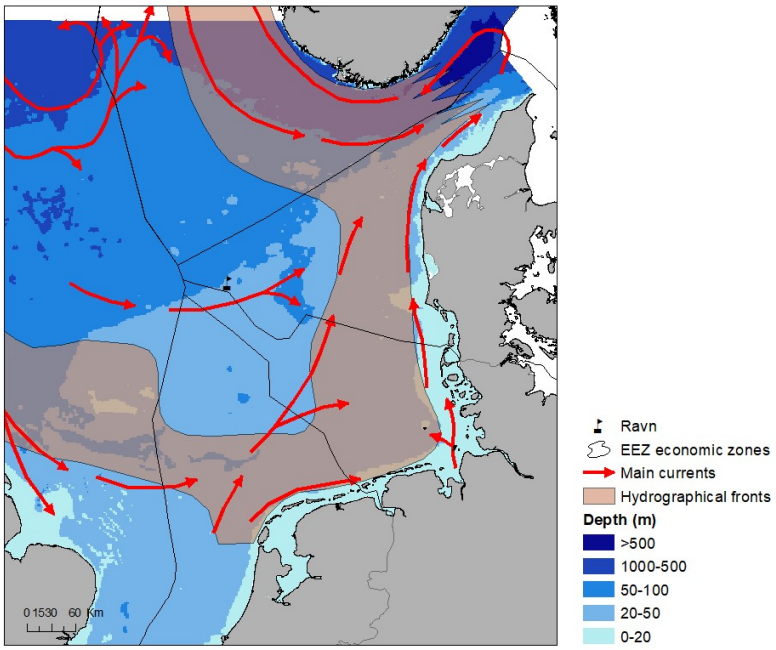

Figure 8-1 General circulation of surface currents in the North Sea and the location of areas in the North Sea where hydrographical fronts may develop (OSPAR, 2000).

The location of the wells is more than 100 km from the existing high productive hydrographical fronts that are located along the more coastal parts of the North Sea (Figure 8-1) and that are important nursery areas for fish larva as well as important feeding areas for seabirds.

The water masses in the North Sea are fully mixed during the winter months. In the summer period a thermocline separating the upper and lower water masses develops in the area of the Ravn field due to heating of the upper layer. This thermocline breaks down during the autumn as a result of storms and cooling.

8.2 Water quality

The water at the Ravn field is dominated by Atlantic water with a relatively stable salinity of 35-38 ppm. The temperature of the surface water varies from 10-11 °C (Ministry of Environment and Food , 2019). The concentration of nutrients in the North Sea is highest in the coastal waters near river runoffs.

The implementation of EUs Marine Strategy Framework Directive requires an assessment of the environmental status in the North Sea (among others). An integrated assessment of the chemical status in Europe's seas has been published (EEA, 2018) and it is concluded that most assessment units in the Danish part are classified as "problem areas" and thereby not fulfilling the objective of a good environmental status according to the EUs Marine Strategy Framework Directive. This impaired state is caused by a combination of input of contaminants from sources on both land and sea, in addition to input from atmospheric deposition.

For contaminants the objective of achieving a good environmental status is currently not achieved due to an exceedance of the threshold levels in fish for PBDE and mercury (Ministry of Environment and Food , 2019).

8.3 Plankton

Plankton constitutes the base of the trophic food web and includes phytoplankton (pelagic microscopic algae) and zooplankton (pelagic microscopic animals) drifting passively with currents. Zooplankton includes both organisms that stay planktonic during the entire life cycle (holoplankton) and organisms that are only planktonic in the earliest life stages (meroplankton) such as larvae of fish, sea urchins, starfish, mussels, bristle worms, shrimps, crabs and lobsters.

Phytoplankton blooms occur during spring in the entire North Sea as the light returns and the water masses become stratified. Diatoms and autotrophic dinoflagellates dominate the phytoplankton in the North Sea. During summer, the biomass of plankton decreases due to stratification of water columns and the depletion of nutrients in the surface waters. A minor bloom is often observed during the autumn, when the waters are mixed again, and nutrients are again available in the surface waters.

Copepods dominate the zooplankton in the North Sea. Copepods are food for fish and other organisms, including larvae, juveniles and mature individuals of many commercially

important fish species such as herring and sprat. The composition of the copepod populations in the North Sea is dominated by *Calanus finmarchicus* and *C. helgolandicus*.

The composition of the copepod populations in the North Sea has changed markedly. The biomass of the previously dominant "cold-water" copepod *Calanus finmarchicus* has declined by 70% since the 1960s and is now primarily encountered in colder waters north and north-west of the North Sea. On the other hand, species with warmer water affinities e.g., *C. helgolandicus* has moved northwards into the North Sea from the south to replace *C. finmarchicus*. The displacement of cold- and warm water species to the north has been related to global warming and the observed increase in the water temperature in the North Sea (ICES, 2016; Planque and Fromentin, 1996).

8.4 Sediment composition and quality

The Danish sector of the North Sea is characterized by a sandy or sandy to muddy sediment. A few areas have silt or coarse sediment. The substrate type at the Ravn field is categorised as "mud to muddy sand" (Figure 7 3). This is confirmed by an investigation at the A6-6 platform within the German Exclusive Economic Zone (EEZ), which found that silty sands had been found around the Ravn platform and that the organic content decreased towards the sandy Dogger Banke (ARSU, 2022).

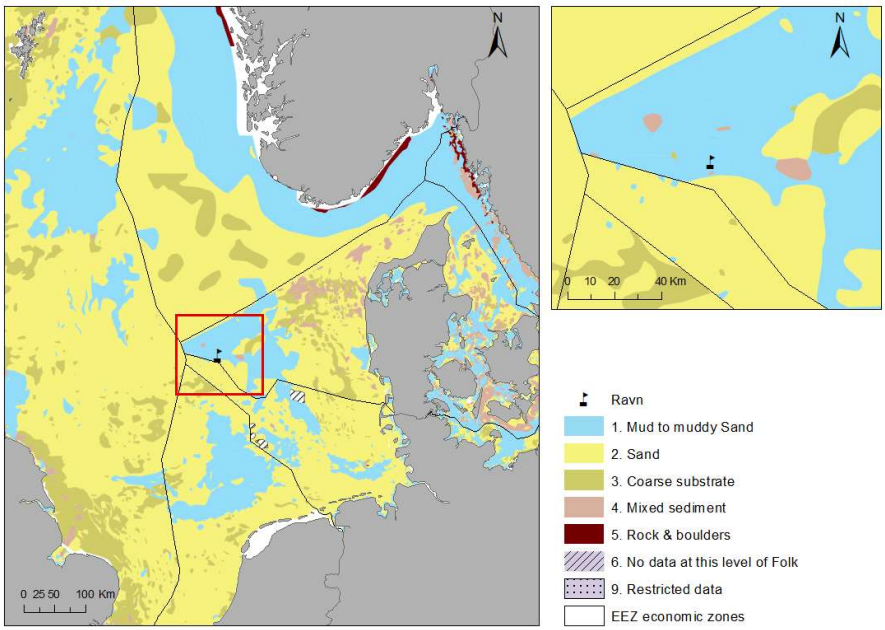

Figure 8-2 Substrates in the North Sea with indication of the project area. EMODnet reclassification substrate (GEUS, 2019). Note that classification of substrate may vary between national borders.

The composition and quality of the sediments around the Ravn field have not been monitored.

8.5 Benthic fauna

Benthic fauna includes a wide variety of invertebrate species such as species of bristle worms, mussels, snails and crustaceans. The benthic fauna can be grouped in infauna and epifauna. Infauna includes benthic fauna that live within the sediments of the seabed while epifauna live on the surface of the bottom substratum. The abundance of infauna at the Ravn field is relatively high whereas the abundance of epifauna species is relatively low compared to other areas in the North Sea (Reiss et al., 2010). The composition of the benthic fauna in an area is dependent on a complex interaction between environmental factors (the type of sediment, oxygen levels, currents, stratification or mixing of water column, salinity, pollutants etc.). This is because the species differ in terms of tolerance and preference of specific environmental factors. Biological interactions (predation, competition symbiosis, parasitism etc.) and random variation also play a role.

The benthic fauna can be grouped in fauna communities consisting of species that are adapted to (or can tolerate) specific environmental conditions. Reiss et al. (2010) carried out multivariate statistical analysis of a large number of fauna data from all over the North Sea. The analysis showed that:

- The infauna community in the Ravn field area is characterised by the occurrence of the bristle worms *Spiophanes bombyx* and *Magelona filiformis*, the brittle star *Amphiura filiformis* and the bivalve *Mysella bidentata*.

- The epifauna community is characterised by the occurrence of Common starfish *Asterias rubens*, Sand star *Astropecten irregularis* and the crustaceans *Pagurus bernhardus*, and *Corystes cassivelaunus*.

The analysis also showed that the most influential environmental variables that determine the composition of the benthic fauna communities in the North Sea appear to be hydrographical variables such as bottom water temperature, bottom water salinity and tidal stress. Previous investigations indicate that the sediment conditions (section 8.4) are homogeneous, and it is therefore also assumed that the area as a whole can be classified as homogeneous based on the species composition (ARSU, 2022).

In general, it has been found that the benthic fauna is not affected beyond 1500 meters from the platforms and that the local reference stations have good environmental status according to the MSFD (Oil & Gas Denmark, 2017)

There is a relatively high abundance of benthic fauna living in the seabed sediments (infauna) at the site whereas the abundance of species living on the seabed (epifauna) is low compared to other areas in the North Sea.

8.6 Fish

Approximately 230 fish species are found in the North Sea. Compared to other areas in the North Sea, the diversity is low, but increases westwards towards the coast. The fish species in the North Sea can be grouped in pelagic species (species living in the free water masses) and demersal (bottom dwelling) species.

Pelagic species commonly found in the Danish sector of the North Sea include Herring (*Clupea harengus*), sprat (*Sprattus sprattus*) and mackerel (*Scomber scombrus*).

The abundance of demersal (bottom dwelling) fish species in the project area is relatively low compared to other areas in the North Sea (ICES International Bottom Survey database, Reiss et al. 2010). The typical demersal fish species found at 50-100 m depth in the central North Sea include whiting (*Merlangius merlangus*), haddock (*Melanogrammus aeglefinus*), dab (*Limanda limanda*), long rough dab (*Hippoglossus platessoides*), plaice (*Pleuronectes platessa*) and grey gurnard (*Eutrigla gurnardus*). It should, however, be noted that the abundance of haddock is larger in the northern North Sea, compared to the central North Sea. Cod (*Gadus morhua*), lemon sole (*Microstomus kitt*) and sandeel (*Ammodytes*/*Hyperoplus* sp.) are also relatively common.

There are two main ways fish spawn: demersal and pelagic spawning. Demersal spawners lay their eggs on the seabed, pelagic spawners lay their eggs in the free water masses where they remain free flowing for fertilization.

Cod, plaice, dab, long rough dab, lemon sole, mackerel and whiting are pelagic spawners. All are encountered at the Ravn field (Sundby et al., 2017; Warnar et al., 2012). Sandeel is demersal spawner (lay egg on the seabed) and is dependent on sandbanks. However, sandeel banks are not identified at the Ravn field area (Figure 8-7).

The locations of spawning areas in the North Sea for lemon sole, mackerel, cod and plaice are shown in Figure 8-3, Figure 8-4, Figure 8-5 and Figure 8-6. It can be seen that the Ravn field is located inside the spawning area for all these four species. The Ravn field may not be located in spawning areas for sprat, long rough dab and whiting, however as spawning areas for fish are not static and fixed delimited areas, these species may spawn at the Ravn Field.

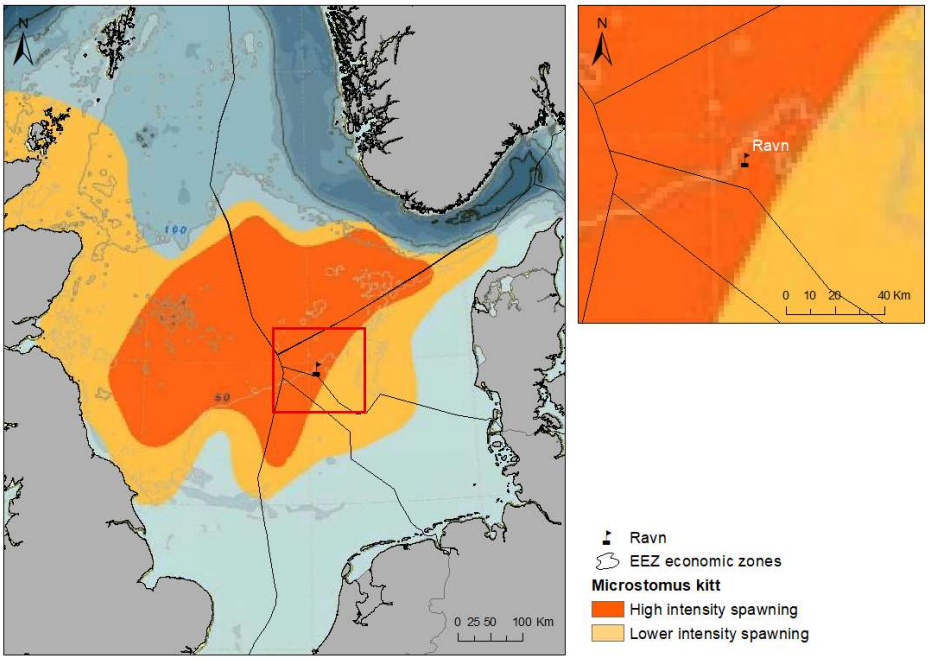

Figure 8-3 Spawning areas for lemon sole (Solea solea) in the North Sea. The blue areas indicate the bathymetry. (Based on Sundby et al., 2017).

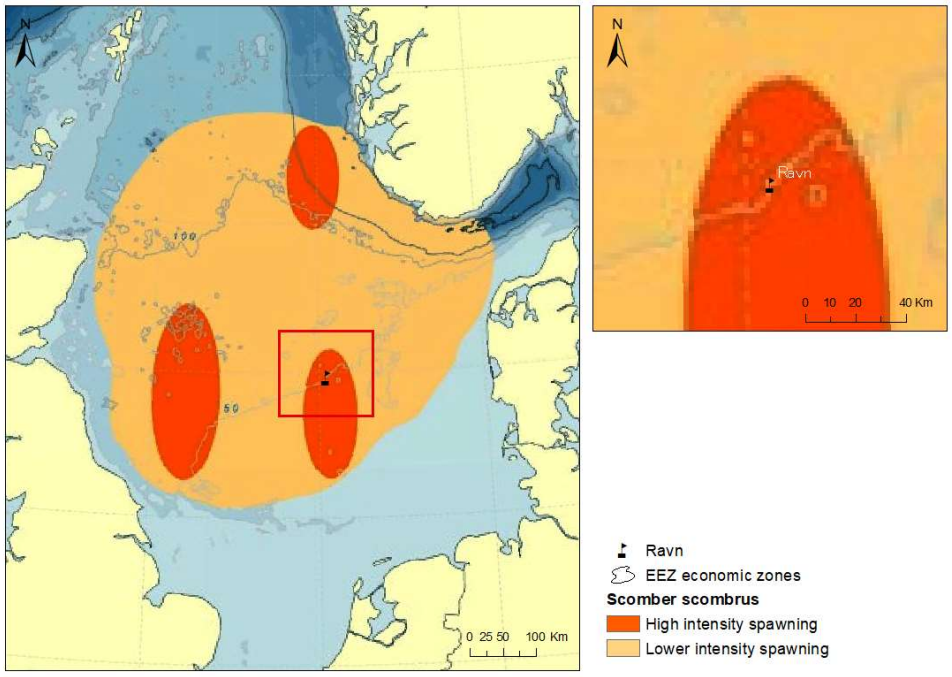

Figure 8-4 *Spawning areas for mackerel (Scomber scombrus) in the North Sea (Based on Sundby et al., 2017). The blue areas indicate the bathymetry.*

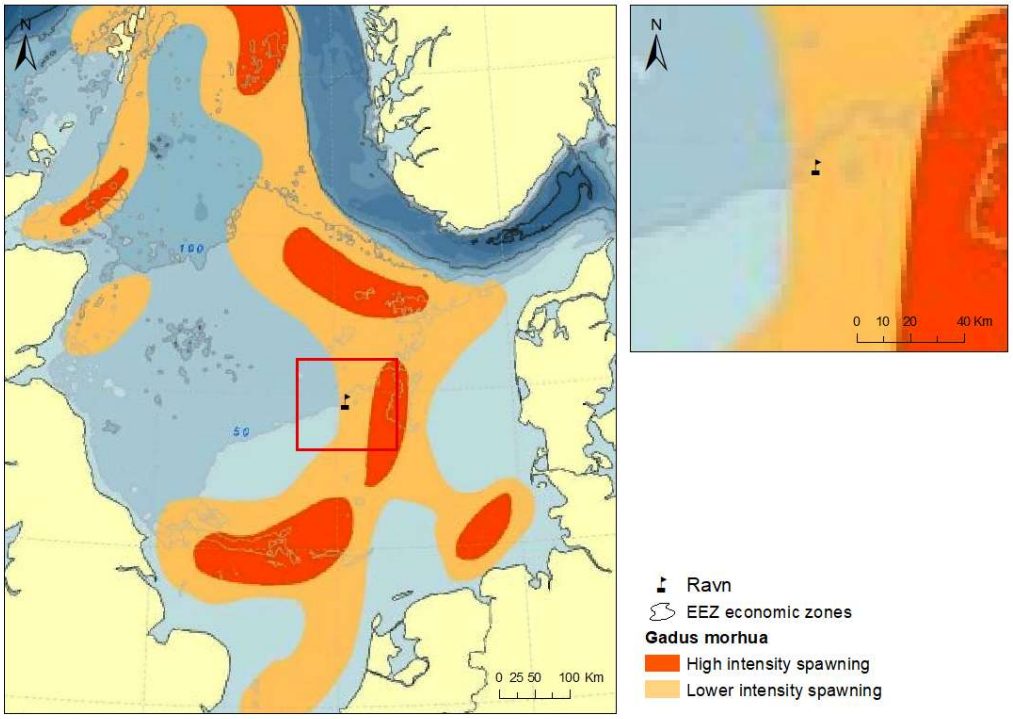

Figure 8-5 *Spawning areas for cod in the North Sea. The blue areas indicate the bathymetry (Based on Sundby et al., 2017).*

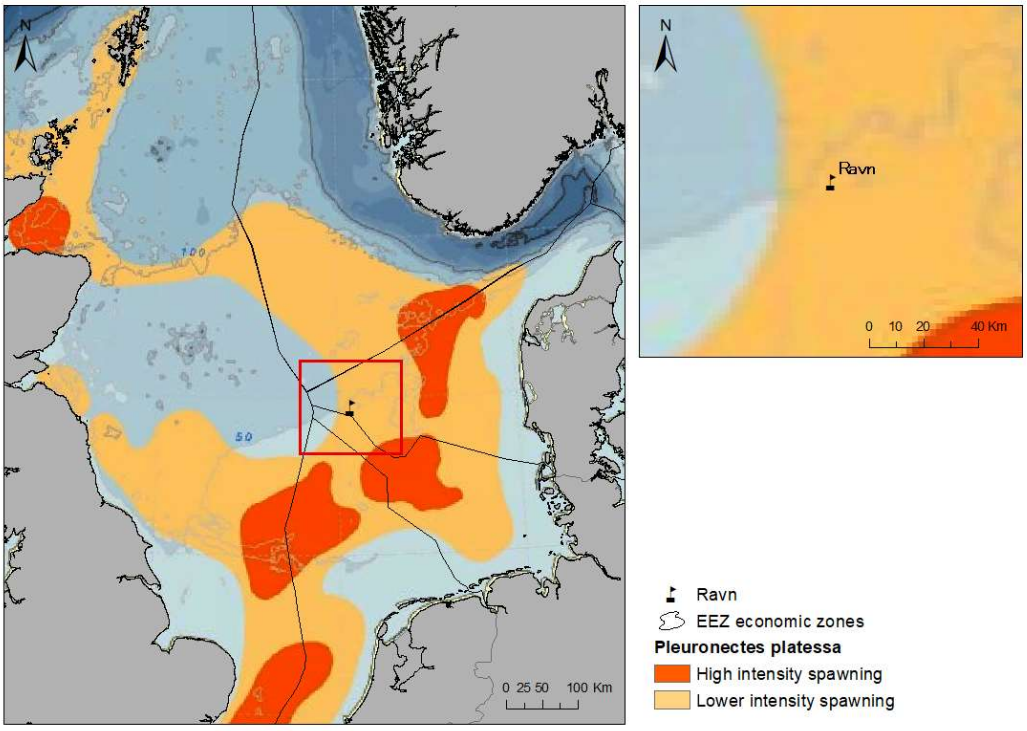

Figure 8-6 Spawning areas for plaice (Pleuronectes platessa) in the North Sea. The blue areas indicate the bathymetry (Based on Sundby et al., 2017)

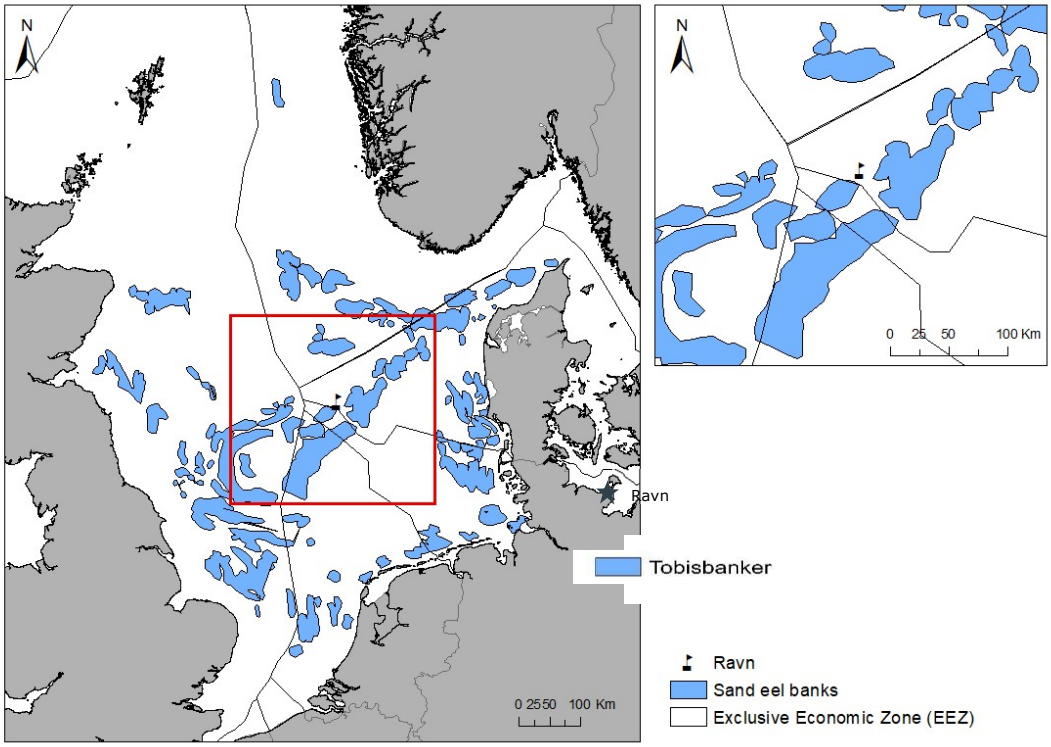

Figure 8-7 *Spawning areas (banks) for sand eel (Ammodytes spp.) in the North Sea. (van Deurs, 2019).*

The spawning seasons for the species that are likely to spawn are shown in Table 8-1. It is seen that most spawning takes place during winter, spring and early summer.

Table 8-1 Spawning seasons for fish that may spawn at Ravn (Sundby et al., 2017). Light grey: Total spawning period. Dark grey: Peak spawning.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Cod												
Whiting												
Plaice												
Dab												
Long rough dab												
Lemon sole												
Mackerel												
Sandeel												

Eggs and larvae are carried with the prevailing east, north-east and north going currents to the front areas close to the coasts of the eastern North Sea and Skagerrak, where they can benefit from the high plankton production at the hydrographical fronts. Several field surveys have demonstrated that high concentrations of larvae of cod, whiting and sandeel are encountered in the front areas of Skagerrak and north-eastern North Sea south of Norway. Other surveys have shown that the front area along the Danish west coast and in the German Bight houses large concentrations of larvae of sandeel, plaice, cod and whiting (Knutsen et al., 2004; Munk et al., 2002; Munk et al., 1999; Munk et al., 1995).

8.7 Birds

The North Sea is an important area for seabirds. This is primarily caused by the high productive hydrographical front areas which are important feeding areas for birds. It is estimated that more than 10 million birds make use of the North Sea for breeding, feeding, or migratory stopovers every year. Furthermore, important breeding colonies fringe the coastlines (Skov et al., 1995). The Ravn field is located far from important bird areas (Figure 8-8).

The important bird areas in the North Sea coincide with the highly productive areas where hydrographic fronts can be formed, producing an abundance of food for seabirds (Figure 8-8).

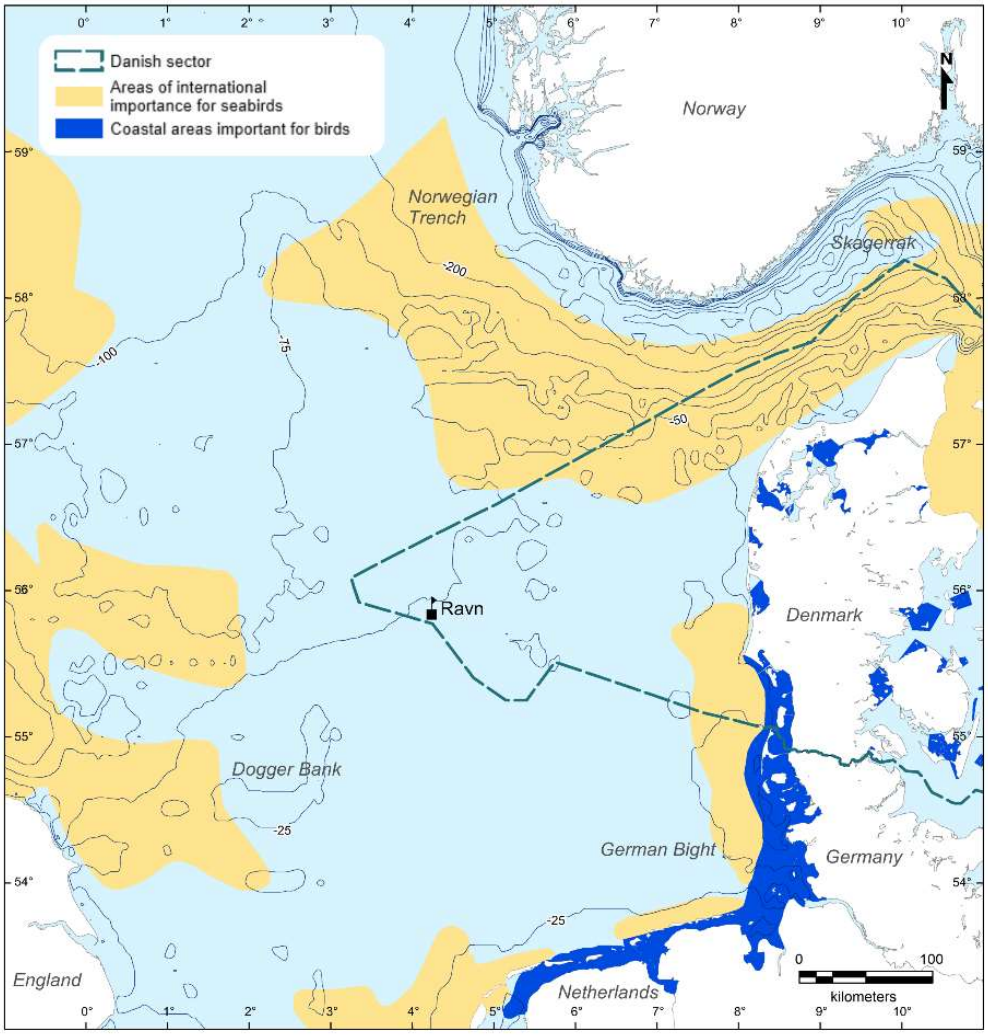

Figure 8-8 *Areas of international importance for seabirds (light brown shading) and coastal areas important for birds (blue shading). (Data: Skov et al., 1995; Falk & Brøgger Jensen, 1995).*

During winter some seabirds may be encountered at the Ravn field since these species are distributed over the entire North Sea during winter. The predominant species are fulmar (*Fulmarus glacialis*) and kittiwake (*Rissa tridactyla*). Additionally, Gannet (*Sula bassanus*), razorbill (*Alca torda*) and common guillemot (*Uria aalge*) occur in low densities. These species are mainly associated with cliffs and offshore islands and only occur in the open sea outside the breeding season. They occur in larger densities in other areas of the North Sea with more favourable feeding opportunities that the central parts (COWI 2006, Skov et al., 1995).

Large numbers of land birds migrate across the North Sea between the UK and Western Europe including waders and species of thrushes, chats, warblers and finches (Baptist, 2000; Lack, 1959, 1960, 1963). Several of these species may sporadically be encountered at the Ravn field.

8.8 Marine Mammals

Sightings around oil and gas installations in the Danish sector of the North Sea has confirmed the presence of 7 marine mammal species, of these five cetaceans: harbour porpoise (*Phocoena phocoena*), minke whale (*Balaenoptera acutorostrata*), white-beaked dolphin (*Lagenorhynchus albirostris*), killer whale (*Orcinus orca*), pilot whales (*Globicephala spp.*) (Delefosse et al. 2018). Only harbour porpoise, white-beaked dolphin and minke whale are encountered regularly in the western part of the Danish sector of the North Sea (Sveegaard et al., 2018; SCANS II; Kinze, 2007; Reid et al., 2003).

Harbour porpoise is the most abundant whale species in the North Sea. The highest abundance of harbour porpoise in Danish waters are encountered in the inner Danish waters, the Skagerrak and the waters of Blåvandshuk. They also occur in the central North Sea but less frequent compared to the Danish inshore core areas. High density areas for harbour porpoise are however found in the German sector at the Dogger Bank south – southwest of the Ravn platform. The white-beaked dolphin and minke whale are encountered fairly regularly in the western part of the Danish sector at Ravn.

All whale species in the North Sea are listed in Annex IV of the EU habitats directive (Council Directive 92/43/EEC of 21 May 1992). Annex IV lists animal and plant species in need of particularly strict protection.

The harbour seal (*Phoca vitulina*) is the only species of seal observed regularly in the Danish sector of the central part of the North Sea. Harbour seals are primarily coastal, depending on isolated and undisturbed land areas for resting, breeding and moulting. The harbour seal does not generally venture more than 20 km offshore. They may however undertake foraging missions far out into the North Sea from their core areas along the coast and harbour seals have been observed near the Ravn platform.

In the North Sea, the grey seal (*Halechoerus grypus*) breeds in several colonies on islands on the east coasts of Great Britain. Notably large colonies are at Donna Nook (Lincolnshire), the Farne Islands off the Northumberland Coast Orkney and North Rona off the north coast of Scotland. In the German Bight, colonies exist off the islands Sylt and Amrum and on Helgoland. Tagging experiments have indicated that grey seals breeding in Great Britain migrate long distances into the North Sea from their breeding colonies, but they have not actually been observed in the offshore parts of the Danish sector of the North Sea

Harbour seal and grey seal are listed Annex II of the EU habitats directive. Harbour seal is included in the designation of 22 Danish Natura 2000 sites and 12 sites includes the grey seal in these sites the favourable conservation status of the species must be restored or maintained in their natural range.

8.9 Protected areas

The EU Habitats Directive (Council Directive 92/43/EEC of 21 May 1992) specifies natural habitats and wild fauna and flora for which the member states must ensure protection. The species and nature habitats to be protected are specified in the Annexes of the directive:

- Annexes I and II to the Directive contain the types of habitats (Annex I) and species (Annex II) whose conservation requires the designation of Special Areas of Conservation (SACs). For birds, Special Protected Areas (SPAs) are designated. Together SACs and SPAs make up Natura 2000 areas.

- Annex IV lists species of animal and plants in need of particularly strict protection. Of the marine mammals encountered in the North Sea, all species of cetaceans are listed in Annex IV.

The Ravn Field is situated far from Danish designated Natura 2000 areas (Figure 8-9). However, immediately south-west of Ravn is a German designated Natura 2000 area: DE 1003-301 Dogger Bank. The distance to this area from the Ravn field is 11.3 km. In this area harbour porpoise and harbour seal are included in the basis for the designation. As an extension of this area is the Dutch NL 2008-001 Dogger Bank of which harbour porpoise, harbour seal and grey seal are included in the basis for designation (Table 8-2).

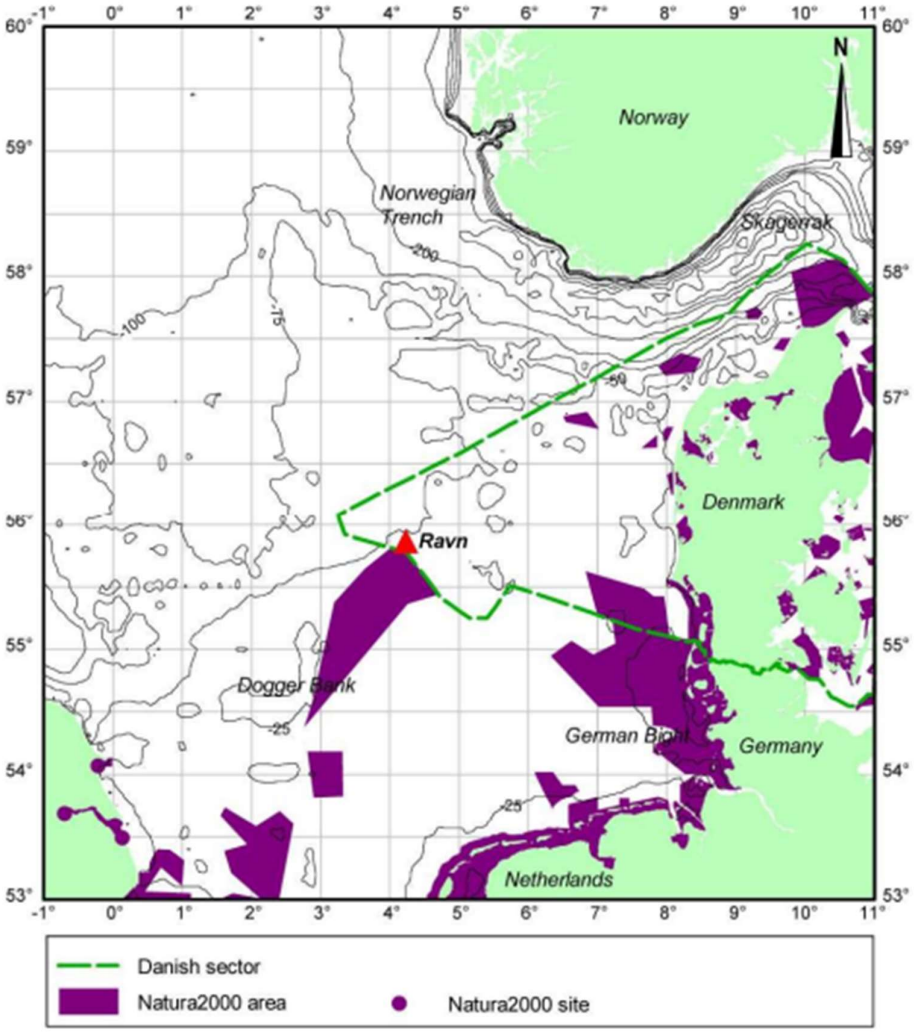

Figure 8-9 *Nature 2000 sites in the North Sea. Note that former UK Natura 2000 sites are included although these are now designated as UK marine protected areas.*

Table 8-2 Basis for the designation of the closest Natura 2000 areas.

Natura 2000 areas (SACs)	Basis for the designation
DE 1003-301 Dogger Bank	Annex I habitat type 1110 Sandbanks which are slightly covered by sea water all the time and Annex II species 1351 Harbour porpoise and 1365 Harbour seal.
NL 2008-001 Dogger Bank	Annex I habitat type 1110 Sandbanks which are slightly covered by sea water all the time and The Annex II species 1351 Harbour porpoise, 1365 Harbour seal and 1364 Grey seal
UK0030352 Dogger Bank	Annex I habitat type 1110 Sandbanks which are slightly covered by sea water all the time and The Annex II species 1351 Harbour porpoise, 1365 Harbour seal and 1364 Grey seal

In addition, a Marine Strategy Framework Directive protected area (named Area H) is located in the far western part of the Danish EEZ (Figure 8-10). Ravn is located outside this area to the east. As the Marine Strategy Framework Directive protected areas only regulate activities within the actual area and not activities outside the area (Miljøministeriet 2021), this Area H will not be discussed further.

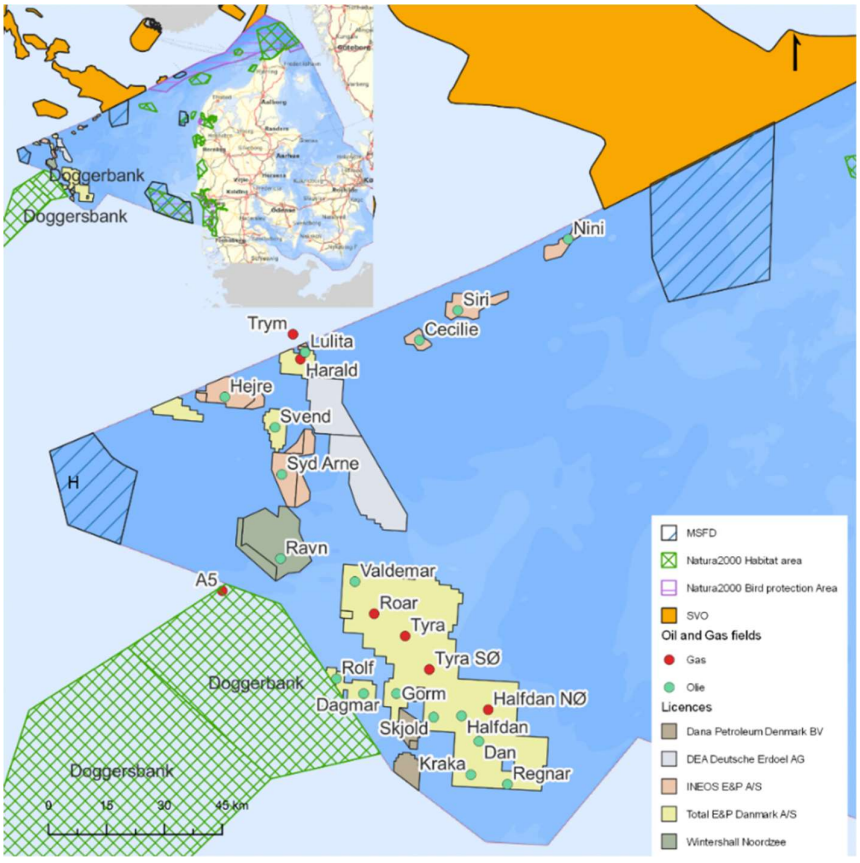

Figure 8-10 Marine Strategy Framework Directive protected areas in the Danish part of the North Sea. Areas marked with red is protected areas, light green are new bird protected areas and dark green are existing protected areas (Miljøministeriet, 2021).

8.10 Non-indigenous species

The term non-indigenous species means that the species is introduced outside its natural, past or present range (Ministry of Environment and Food, 2019).

Distribution of non-indigenous (NIS) related to oil and gas installations in the Danish North Sea is described in Oil and Gas Denmark's report from February 2017 "Descriptor-based review of 25 years of seabed monitoring data collected around Danish offshore oil and gas platforms". The inventory of the benthic species was compared with catalogues of NIS (AquaNIS; Olenin et al., 2014). The trend in abundance, the temporal occurrence and spatial distribution were evaluated. Four of the more than hundreds of NIS reported in the North Sea were identified in the benthic samples collected at platforms and reference stations from 1989-2015. NIS were typically found in low numbers with an average of 1.2 +/- 0.3 individuals per 0.1 m^2. The rare occurrence and low abundance reported is not indicative of a well-established population considering that the four benthic NIS observed have been present in the North Sea coastal areas for several decades.

9 Pollution and impacts of planned activities

Generally, environmental impacts from P&A activities are expected to be of the same nature, extent, and order of magnitude as the impacts related to the drilling of the wells. Long-term environmental impacts from the P&A activities are expected to be negligible. In addition, incremental cumulative impacts and transboundary effects associated with the planned P&A activities are expected to be negligible.

Based on the project description, the potential impact mechanisms from P&A activities include the following:

- Underwater noise
- Planned discharge of chemicals
- Emissions to air
- Solid waste production

In this chapter the potential environmental impacts of the plug and abandonment activities are described and assessed to the extent possible at this early stage.

9.1 Impacts of underwater noise

During the plug and abandonment operation, the following sources may generate underwater noise:

- Cutting of the conductor 5 meter below seafloor from inside the conductor (app. 10 hours per well)
- The mechanical plant, pumping systems and miscellaneous hammering of gear on the rig (app. 60 days)
- Machinery, propellers and thrusters of support vessels (on/off for 60 days)

9.1.1 Impact on marine mammals

Underwater noise may affect marine organisms in different ways. As cetaceans (whales, porpoises, and dolphins) depend on underwater acoustics for navigation, finding preys and communication, they are sensitive to underwater noise. However, seals and fish may also be affected by underwater noise.

Possible effects of underwater noise on marine mammals include:

- **Hearing damage**. Intense underwater noise may damage hearing of cetaceans and seals. There are two levels of damage. Temporary threshold shift (TTS), which is a reversible hearing loss, from which the animal subsequently will recover. Permanent threshold shift (PTS) which is an irreversible hearing loss. Generally, PTS will occur only after repeated TTS episodes or exposure to higher levels of sound that cause TTS (Southall et al., 2019).

- **Behavioural reactions**. Underwater noise may cause avoidance reactions and other behavioural effects of cetaceans and seals, such as changes in surfacing, breathing and diving behaviour, cessation of feeding, aggression, aversion and panic (e.g. Dähne *et al.*, 2013; Southall *et al.*, 2008; Thompson *et al.*, 2010). Behavioural impacts to acoustic exposure are generally more variable, context-dependent, and less predictable than the effects of noise exposure on hearing.

- **Masking.** Because cetaceans depend on the underwater acoustic environment for orientation (echo location) and communication an emitted cetacean sound can be obscured or interfered with (masked) by manmade underwater noise (Tougaard, 2014). There are examples of whales changing their vocalisation because of underwater noise (Weilgart, 2007).

The most commonly used predictor for TTS and PTS is the sound exposure level (SEL), cumulated over a period of at least two hours. Guiding threshold values of sound exposure levels that may cause TTS or PTS or behavioural/avoidance reactions for harbour porpoise, white-beaked dolphin, minke whale and seals are presented in Table 9-1. In general, the harbour porpoise seems to be the most sensitive species and the seals the least sensitive species to underwater noise.

Table 9-1 *Sound exposure levels, that are harmful to cetaceans and seals. I-type sounds are impulsive sounds characterised by a very fast onset, often, but not always, followed by a slower decay, short in duration as a fraction of a second and with a large bandwidth. Other sounds are defined as sounds not defined as I-type sounds. Based on "Guideline for underwater noise" (DEA, 2022).*

Impact	I-type sounds $SEL_{(cum)}$ $L_{E,p,xx,24h}$ $(dB\ re\ 1\mu Pa^2s)^3$	Other sounds $SEL_{(cum)}$ $L_{E,p,xx,24h}$ $(dB\ re\ 1\mu Pa^2s)^3$
Harbour porpoise (very high frequency cetacean)		
Sound exposure level causing permanent threshold shift (PTS)	155	173
Sound exposure level causing temporary threshold shift (TTS)	140	153
Behavioural reactions	103[1]	103[1]
White beaked dolphin (high frequency cetacean)		
Sound exposure level causing permanent threshold shift (PTS)	185	198
Sound exposure level causing temporary threshold shift (TTS)	170	178
Minke whale (low frequency cetacean)		

Impact	I-type sounds SEL (cum) $L_{E,p,xx,24h}$ (dB re 1µPa²s)[3]	Other sounds SEL (cum) $L_{E,p,xx,24h}$ (dB re 1µPa²s)[3]
Sound exposure level causing permanent threshold shift (PTS)	183	199
Sound exposure level causing temporary threshold shift (TTS)	168	179
Seals (phocid carnivores in water)		
Sound exposure level causing permanent threshold shift (PTS)	185	201
Sound exposure level causing temporary threshold shift (TTS)	170	181

1) SPL $L_{p,rms,125ms}$

The total P&A operation is described in section 7.3 and is expected to have a duration of 60 days.

It is expected that the general underwater noise generated by the P&A activities will be "other sounds" and only very limited if any "I-type sounds". It is not expected that noisy activities during the P&A operation will exceed the threshold for triggering temporary or permanent hearing damage (TTS and PTS) of harbour porpoises, minke whale or white beaked dolphin (Tougaard et al. 2016). These species have been assessed to be relevant for projects located in the North Sea (DCE 2021).

The cutting of the conductor is expected to take place 5 meter below seafloor for less than 10 hours, so for both the Ravn A1 and A2 wells, the cutting will take place less than twenty hours during the total period of 60 days. The plugging activities deep in the wells are not expected to generate significant underwater noise.

The cutting is performed using an abrasive water jet, which is a technology that does not involve metal-to-metal contact during the process. No underwater noise measurements for water jet cutting could be found in the literature, and the following is based on general expectations.

The primary source of noise from water jet is the turbulence caused by the steep velocity changes between the high-speed jet and the surrounding medium. For industrial cutters in workshops, it is known that submerging the cutting in water dramatically reduces this noise, and one supplier reports (airborne) noise levels in the order of 75 dB(A). The jet noise is continuous, with a broadband character and with expected maximum in the lower kHz frequency range. For the present P&A scenario, the jet noise propagates from the localised cutting point through the pipe wall and subsequently passes through the seabed before reaching the water column. Due to the attenuation by the conductor wall and seabed

material, it seems likely that the resulting noise contribution from the jet itself is insignificant.

A secondary noise source from the cutting concerns acoustic radiation of the conductor pipe due to induced vibration. The vibration is introduced in radial direction at the cutting point 5 m down the embedded part of the pipe. On that background significant attenuation is expected before the vibration reaches the water-loaded part. When radiated into the water, this noise is expected to attenuate at 15·Log distance dependence, which is a reduction of approximately 5 dB per doubling of distance. Hence, it seems likely that the noise contribution from the conductor is insignificant.

In general, the underwater noise is expected to mainly consist of underwater noise generated by manoeuvring the jack-up rig, support vessels, machinery, etc.

Cetaceans and seals are expected to flee from the site during rig-docking/rig departure manoeuvres (Todd et al. 2007, Todd et al. 2009) however, the probability of the impact is not certain. Bach et al (2010) monitored "click" activity around two platforms in the North Sea using T-PODs. They concluded that drilling activities in general do not affect porpoise and other small cetaceans and that behavioural effects are only expected during the ramming of conductors (hammering of conductors produces the highest levels of underwater noise and is not part of the P&A activities).

The operation will have a local impact due to the described activities. The impact is expected to result in avoidance by marine mammals of the area in the immediate vicinity of the wells during the P&A operation. As the site is not assessed to be an important area for marine mammals and as the impact is temporary and local the impact is assessed to be insignificant.

The P&A activities are expected to take place during August 2023 to October 2023. The project area is not expected to be important for either harbour porpoises, white-beaked dolphins or minke whales. Similarly no breeding areas are identified in the area. Based on this and on the general negligible impacts, this impact assessment is valid no matter when the P&A activities takes place during the year.

9.1.2 Impact on fish

Noise levels from ramming activities and the potential effects on fish has been assessed and the noise levels that may cause effects are shown in Table 9-2. Note however, that these levels should serve as a guideline only, as they are based on ramming activities, which are not part of this project.

Table 9-2 Levels of underwater noise that have been reported to harm fish, fish eggs and fish larvae (Andersson et al. 2017). These levels are based on ramming activities.

Effect	$SPL_{(peak)}$ (dB re 1µPa)[1]	$SEL_{(ss)}$ (dB re 1µPa^{2}s)[2]	$SEL_{(cum)}$ (dB re 1µPa^{2}s)[3]
Risk of serious injuries of inner organs or risk of death	≥ 207	≥ 174	≥ 204
Damage of fish eggs and fish larvae	≥ 217	≥ 187	≥ 207

1) $SPL_{(peak)}$ = Sound Pressure Level= Maximum overpressure generated by ramming.
2) $SEL_{(ss)}$ = Sound Exposure Level (Single Strike) = Sound energy level emitted during a single ramming strike.
3) $SEL_{(cum)}$ = Sound Exposure Level (Cumulative) = Cumulative sound energy level emitted during several ramming strikes over a certain period.

Fish has also been observed to flee from underwater noise (avoidance reaction) or to alter behaviour such as changing of swimming speed and/or swimming direction or to show "freeze" reaction (i.e., a reaction in which the fish suddenly stops swimming) (Mueller-Blenke et al. 2010).

Field studies have shown that several species of fish may be disturbed by noise from passing vessels and they may flee from the vessel while other species are not affected (Freon et al. 1993). However, potential impacts are only expected in the immediate vicinity of the wells during the p6A operation. As the noisy activities are insignificant, local, and temporary and will not affect fish populations, the impact is assessed to be insignificant.

The P&A activities are expected to start during the Q3-Q4 2023. According to Table 8-1 there is expected limited spawning during this period. However, even if the P&A activities were to take place during a different time of year with more spawning activities, no impacts are expected due to the overall negligible impact caused by the expected local impact during a short period of time.

9.1.3 Impact assessment underwater noise

Based on the above and using the criteria described in chapter 5, it is assessed that the environmental risks related to planned activities of plug and abandonment of wells on marine mammals and fish is **Negligible** (Table 9-3).

Table 9-3 Environmental risk of underwater noise generated during the plug and abandonment operation.

Impact	Extension of impact	Duration of impact	Magnitude of impact	Severity of impact	Probability of impact	Frequency	Reversibility	Environmental risk
Impacts of underwater noise on marine mammals	Local	Short term	Small	Minor impact	Probable	Low	Reversible	**Negligible**
Impacts of underwater noise on fish	Local	Short term	Small	Minor impact	Probable	Low	Reversible	**Negligible**

9.2 Impacts of discharge of chemicals

During P&A of A1 and A2, only one chemical will reach the water. The jacking grease will dissolve into the water from the rig legs. The discharge can potentially impact the surrounding aquatic environment by affecting eggs, larvae, and fish. The assessment is based on following info:

- Estimated use and discharge amounts of chemicals for the P&A, cementing and rig related activities
- Discharge patterns for the P&A, cementing and rig related activities
- Environmental hazard assessment of the chemical substances based on HOCNF information

The toxicity data for the substances is used to determine the PNEC-value (Predicted No Effect Concentration). The PNEC-value sets the level for which neither short-term nor long-term effects in the aquatic environment will occur. The PNEC-value is related to the PEC-value (Predicted Environmental Concentration) for the substances in different distances from the platform after discharge.

If the PEC/PNEC-ration is below 1, no impacts are expected since the environmental concentration of the substance is lower than the concentration where negative biological effects will occur.

To assess the impact of the discharge of chemicals related to the rig operations to P&A the wells, discharge calculations have been conducted.

The discharge calculations estimate the distance measured from the platform, where the discharged chemicals are expected to have no biological impacts. The calculations are conducted in a dispersal model developed by COWI and based on the CHARM-model. The dispersion model is a modified version of the CHARM-model, whereas the PEC/PNEC-ration is based on the OSPAR guidelines, and thus assesses the potential impact for each substance individually.

The discharge calculations have not been conducted for PLONOR substances, as these are considered to Pose Little Or No Risk.

The one yellow discharge has been modelled with the point of discharge located near the water surface, as the chemicals will be discharged from the rig.

In accordance with OSPAR, the PNEC-value is determined so the environment is protected against negative effects also by long-term impacts. However, during P&A the discharges will be short-term and the impacts will occur once or very rarely during a short period of time. Thus, it is the acute effects that are used as basis for the assessment (PEC/PNEC-ration for acute effects).

Since the discharge will only occur over a short time, an assessment of the distance of impact based on acute criteria should be taken into consideration. Thus, as for the P&A chemicals the distance of impact is modelled based on PNEC-values derived based on acute L(E)C50 data with an assessment factor of 1000.

Discharge from the P&A activities will only be related to rig jacking grease and significantly diluted rig wash chemicals, as all other chemicals are either shipped to shore for treatment or left in the well. The modelling has only been conducted for the chemicals which are pre-screened as yellow or red, as these are the chemicals which can cause negative effects.

It is assumed 50% of the jacking grease will be discharged to sea, over a period of 12 hours. The jacking grease is assumed to be discharged undiluted. The result of the modelling can be seen in Table 9-4.

Table 9-4: Results for the PEC/PNEC discharge calculations for chemicals used and discharged during P&A activities. The discharge calculations have not included PLONOR substances as these are considered to Pose Little Or No Risk to the environment.

Activity	Type of chemical	Max. distance (m) from discharge point at which PEC/PNEC = 1 (assessment factor = 1000)	Duration of discharge
Rig chemicals	Jacking grease	<250	12 hours

It can be seen that the jacking grease chemical will exceed the PEC/PNEC ratio on shorter distances of below 250 m. Discharge of chemicals will potentially affect pelagic species consisting of fish, fish larvae, zooplankton and phytoplankton in the affected area. Since the duration of the impact is short term (within hours) and the magnitude of the impact is marginal, it is assessed that the impact of discharge on pelagic organisms is negligible.

Based on the above conclusion, the potential impact is assessed to be **negligible**, as can be seen below.

Table 9-5: Environmental severity and risk of impacts discharge of chemicals of activities related to P&A of A1 and A2.

Impact	Extension of impact	Duration of impact	Magnitude of impact	Severity of impact	Probability of impact	Frequency	Reversibility	Environmental risk
Impacts of discharge of chemicals to sea during P&A	Local	Short term	Small	Minor impact	Probable	Low	Reversible	**Negligible**

9.3 Impacts of air emissions

During plug and abandonment of the wells, the main activities causing emissions to air will be:

- Energy consumption from jack-up rig
- Fuel consumption from supply vessel and standby boat
- Helicopter consumption from crew change

During the plug and abandonment activities, the rig will use energy for the equipment, accommodation etc. In addition, a standby boat will be present nearby during the plug and

abandonment operations in order to ensure safety. A supply vessel will be transporting equipment, waste etc. between Esbjerg.

Total estimated emissions to air during the plug and abandonment of Ravn A1 and Ravn A2 can be seen in Table 9-6.

Table 9-6 Total estimated emissions to air in relation to the plug and abandonment of Ravn A1 and Ravn A2. The estimates include weather delays and other unforeseen events.

	CO_2-eq[3)] [Tons]	NO_X [Tons]	SO_2 [Tons]	nmVOC [Tons]
Jack-up rig[1)]	1,344	22	0.4	2
Standby boat[1)]	324	5	0.1	0.5
Supply vessel[2)]	254	4	0.1	0.4
Helicopter	10	0.04	0.01	0.0026
Total	**1,932**	**32**	**0.6**	**3**

[1)] The jack-up rig and the standby boat is operating 60 days.
[2)] The supply vessel is assumed to make one round trip per week and 8 in total.
[3)] The CO_2-equivalents include CO_2, CH4 and N2O. For converting CH4 and N2O a Global Warming Potential (GWP) value is added using 28 and 265 respectively from the Fifth Assessment Report (AR5) (IPCC, 2014).
The days include weather delays and other unforeseen events.

9.3.1 Impact assessment air emissions

The emissions to air will be short-term and be of regional extent, except for CO_2-eq., which is a greenhouse gas and thus will be of international extent. However, the amounts emitted are relatively small compared to the yearly emission from production of oil and gas. Based on the above it is assessed that the environmental impact of air emissions generated during plug and abandonment is **Negligible** for the NO_X and SO_X emissions and **Low** for the greenhouse gas (CO_2-eq.) emissions. (Table 9-7).

Table 9-7 Environmental risk of air emissions generated during plug and abandonment operation.

Impact	Extension of impact	Duration of impact	Magnitude of impact	Severity of impact	Probability of impact	Frequency	Reversibility	Environmental risk
Impacts of air emissions (NO_X, SO_X)	Regional	Short term	Small	Minor impact	Probable	High	Reversible	**Negligible**
Impacts of air emissions (CO_2-eq.)	International	Short term	Small	Minor impact	Highly probable	High	Irreversible	**Low**

9.4 Impacts of waste production

It is expected that up to approx. 412 tons of steel will be recovered from the wells and the remaining parts of steel will remain left in-situ in the wells. The amount is considered to be insignificant in comparison to decommissioning of other offshore structures such as platforms etc.

The amounts of fluids, cement and chemicals to be discharged, left *in-situ* and taken to shore is estimated in section 7.4.

9.4.1 Impact assessment of waste production

Based on the above and using the criteria described in chapter 5, it is assessed that the environmental risks related to planned activities of plug and abandonment of wells on waste production is **Negligible** (Table 9-8).

Table 9-8 Environmental risk of waste production during plug and abandonment operation.

Impact	Extension of impact	Duration of impact	Magnitude of impact	Severity of impact	Probability of impact	Frequency	Reversibility	Environmental risk
Impacts of waste production	Local	Short term	Small	Insignificant impact	Probable	Low	Reversible	**Negligible**

9.5 Consumption of natural resources

The project does not entail consumption of natural resources of any significance. A limited amount of fossil fuel (diesel) will be used by the project, primarily for power generation and water supply from shore will be needed for drinking water and food preparation. The amounts of fluids and chemicals to be discharged, left *in-situ* and taken to shore is estimated in section 7.4.

9.5.1 Impact assessment of consumption of natural resources

Based on the above it is assessed that the environmental impact related to consumption of natural resources is **Negligible** (Table 9-9).

Table 9-9 Environmental risk of use of natural resources during the plug and abandonment operation.

Impact	Extension of impact	Duration of impact	Magnitude of impact	Severity of impact	Probability of impact	Frequency	Reversibility	Environmental risk
Impacts of use of natural resources	Regional	Short term	Small	Minor impact	Probable	Low	Irreversible	**Negligible**

10 Impacts of blow-out and accidental oil spills

Oil spill can occur through leakage from the wells.

As previously described the P&A activities is in accordance with guidelines. The risk of spill from P&A is thus minimal/non-existent.

The likelihood of an oil spill or a blow-out to occur during the P&A activities is significantly reduced from the original oil spill modelling described in the Ravn EIA. The likelihood is assessed to be very low as several barriers are in place in order to reduce the risk of a blow-out or an oil spill to occur e.g., the blow-out preventer (BOP) is installed during the P&A activities, the already installed plugs function as barriers and the use of brine during the P&A activities that keeps the well in control at all times. The final brine weight will keep the well in a balance state at the time the well is abandoned, and the barrier plugs are set below the minimum barrier depth for any potential flow zones assuming original formation pressure.

Furthermore, the reservoir pressure is reduced from the original reservoir pressure by approx. 50% and the flow will be limited by having to pass through the narrow 4 ½" tubing at 4000mMD, which will reduce the potential flow from the well significantly. Thus, in the unlikely event of a blow-out, the flow from the well would be significantly lower and the environmental impact will be similarly reduced. In the original Ravn EIA the severity of an impact is assessed to be moderate, and the environmental risk is assessed to be negligible. Based on the reduced pressure in the reservoir and the narrow flow path and the measures in place during the P&A activities the severity of the impact is assessed as minor and the environmental risk as negligible.

After the P&A activities there will be no flow potential as the reservoir is permanently isolated and several plugs are installed to isolate any potential shallower flow zones. There is thus no longer a risk of a blow-out from the well. All plugs will be weight and/or pressure tested.

In addition to the risks mentioned above, oil can be spilled from the standby or supply vessels. The risk from a large oil spill (>1 m3) from a vessel is comparable to other offshore vessels operating and is thus very small and the extend will be limited.

Based on the above the environmental risk of a blow-out and the risk of an accidental oil spill is assessed to be **Negligible**.

Table 10-1 Environmental risk of blow-out during the P&A of Ravn A1.

Impact	Extension of impact	Duration of impact	Magnitude of impact	Severity of impact	Probability of impact	Frequency	Reversibility	Environmental risk
Blow-out during P&A activities	Regional	Short term	Small	Minor impact	Very low	Low	Reversible	**Negligible**
Oil spill from vessels	Regional	Short term	Small	Minor impact	Very low	Low	Reversible	**Negligible**

11 Socio-economic assessment

This chapter consists of an assessment of the potential derived socio-economic consequences for the population in the area, which could arise from the environmental impact of the P&A activities in relation to the decommissioning of the Ravn field. The surrounding area is defined as the entire west coast of Jutland.

11.1 Method

The assessment is a general assessment of the derived socio-economic consequences without detailed impact assessment and economic analysis. The assessment of the derived socio-economic consequences is primarily based on the description of the environmental effects in chapter 9.

The assessment of the consequences is based on the fact, that in the future the areas around the wells will not be covered by safety zones, which limit the possibilities for fishing.

11.2 Scope of the assessment

The proposed project is expected potentially to bring predominantly positive changes experienced by local businesses and societal groups or society as a whole. As described in chapter 9, the analysis shows that the environmental impacts related to the P&A activities are expected to be negligible and therefore the socio-economic impacts of the activities are likewise expected to be limited.

The socio-economic analysis therefore focuses on the effects after the decommissioning phase.

The socio-economic impacts considered in this chapter are:

- Potential changes in fish catch due to lifting or keeping restrictions in the safety zones;
- Potential changes for the shipping industry due to lifting or keeping restrictions in the safety zones.

The socio-economic assessment expects primarily positive effects, due to increased fishing opportunities.

12 The cumulation of effects with other existing and/or approved projects

Cumulative effects can be generated in combination with other ongoing projects or activities if they take place at the same time and within the same geographical area. Cumulative effects include discharges of chemicals from the activities, production of waste, noise generation from vessels and emissions of CO_2.

The DEA home page and the BSH (Bundesamt für Seeschiffahrt und Hydrographie) Offshore Aktuell as well as Wintershall's knowledge on planned and ongoing projects have been consulted. Table 12-1 shows projects or activities that have been identified by the project or by the authorities close to the P&A project area and occurring within the same timeframe. The area searched for relevant projects has an approximate radius of 20 km around the Ravn platform.

Table 12-1 Planned and approved projects/activities with potential cumulative impacts with the P&A of A1 and A2. Projects in italics have yet to be approved.

Location	Activity	Duration	Approximate Distance to Project (km)
Ravn field	*P&A of Ravn A-1 and A-2 platform wells*	*Q3-Q4 2023*	*0 km*
Ravn field	*P&A of Ravn-3 MLS well*	*Q3 2023*	*~3 km*
Ravn field	*Cleaning pipelines Ravn-A6A with rig on Ravn*	*Sep - Oct 2023*	*0 km*

Activities with potential cumulative effects are described below.

12.1 P&A of Ravn-3 MLS

The P&A of the Ravn-3 MLS is planned to occur in the same time period as the P&A of Ravn-A1 and Ravn-A2. From the EIA screening of Ravn-3 MLS there is no discharge of chemicals to sea, production of waste, underwater noise from vessels and emissions to air is considered insignificant. It is assessed that the P&A of Ravn-3 MLS will have no cumulative impacts with the P&A of Ravn-A1 and Ravn-A2.

12.2 Cleaning of Ravn-A6A pipeline

Wintershall North Sea operates an 18 km long 8-inch multi-phase pipeline, an 18 km long 3-inch gas lift pipeline and an umbilical between the A6-A and the Ravn platform. Cleaning of the pipeline between the Ravn platform and the A6-A platform will occur in the same time period as the P&A of A1 and A2. As agreed with DEA, this activity as a regular activity.

During the installation the 3-inch line was piggybacked to the 8-inch (connected by piggyback blocks and steel straps). The pipeline bundle has been trenched over its entire length. The umbilical has been installed and trenched separately.

In 2020 Wintershall decided to cease the Ravn oil and gas production. The multi-phase content was removed out of the 8-inch pipeline. The 3-inch gas lift pipeline was de-gassed. Both lines were flushed and conservated with 3 bar nitrogen pressure for potential future reuse. Since a reuse option for these pipelines has not been identified, the pipelines can be cleaned before the system will be decommissioned. To ensure safe removal of the A6-A and Ravn platform in the future the pipeline bundle and umbilical needs to be disconnected subsea from the A6-A and the Ravn platform.

Because the Ravn platform is a satellite platform, Ravn does not have sufficient space to accommodate a cleaning spread to receive the pipeline content during the cleaning operation. This means the cleaning operation needs to be executed from Ravn to A6-A. Only the cleaning of the pipelines is a part of the scope of this EIA since this occurs in the same time period as the P&A.

Wintershall will clean the 8-inch multi-phase pipeline to remove possible wax/paraffin/oil deposits out of the pipeline. To achieve this, the pipeline needs to be depressurized to ambient by venting the 3 bar nitrogen pressure via the Ravn or A6-A vent system. Subsequently a batched pig train will be transferred from Ravn to A6-A. The batched pig train consists of cleaning pigs and cleaning agent batched in between the pigs. The batched pig trains will be transferred to A6-A with sea water.

Onboard A6-A the cleaning pigs will be received in the permanent A6-A pig receiver. As soon as the first pig is detected in the upper part of the riser (Magnetic pig signaller), the flow onboard A6-A will be transferred to temporary storage tanks to collect the cleaning chemicals. After the last pig has been received, the pigging operation will be stopped and the pigs retrieved from the receiver for inspection. After the pigs have been collected the pipeline will be flushed with sea water.

The sea water flow flushing the pipeline will be directed to the temporary skimmer to separate possible oil/paraffin deposits from the water phase. The oil will be removed from the skimmer and transferred to empty tank containers. The flush water quality entering and leaving the skimmer will be measured for oil content. If applicable the flush water flow leaving the skimmer will be directed to a twin filter unit to filter the last oil particles out of the flush water and after measurement guided overboard if oil in water content is < 30 ppm. If the oil in water content remains <30 ppm the flushing operation will come to a stop.

Final sampling of pipeline flush water will be executed by a cleaning operator to determine the oil-water content. The samples will be taken from the pipeline receiver. Oil in water content shall be < 30 mg/l (30 ppm). First sample to be taken after the last slug of cleaning agent has passed the A6-A receiver to determine the emulsion concentration. The OSPAR sample shall be sent to an independent Certified Laboratory for analyses and to confirm the results. The tank containers having collected the chemicals and the oil content of the temporary skimmer will be demobilised to shore.

The 3-inch gas lift pipeline was used to transport dry gas from A6-A to Ravn. This means the pipeline does not contain liquid hydrocarbons. To enable a pigging and cleaning operation, the pipeline needs to be depressurized to ambient by venting the 3 bar nitrogen pressure via the Ravn or A6-A vent system. After depressurizing 3-inch foam pigs will be transferred from Ravn to A6-A with sea water. The sea water will be measured for hydrocarbons onboard A6-A and if required routed to a twin filter unit to filter the last hydrocarbon particles out of the water flow. If the hydrocarbon content is less than 30 ppm the water flow will be directed overboard.

Onboard A6-A the cleaning foam pigs will be received in a temporary A6-A pig receiver. At arrival of the first foam pig the sea water flow onboard A6-A will be transferred to the skimmer. After the last pig has been received, the pigging operation will be stopped and the pigs removed out of the receiver. After the pigs have been collected the pipeline will be flushed with sea water. The sea water flow flushing the pipeline will be directed to either the skimmer, the twin filter unit or directly overboard depending on the measured oil in water content (< 30 ppm). If the oil in water content remains <30 ppm the flushing operation will come to a stop.

Final sampling of pipeline flush water will be executed by a cleaning operator to determine the oil-water content. The samples will be taken from the pipeline receiver. Oil in water content shall be < 30 mg/l (30 ppm). First sample to be taken after the last foam pig has been received onboard A6-A. The OSPAR sample shall be sent to an independent Certified Laboratory for analyses and to confirm the results.

The umbilical has been used to transport methanol, corrosion inhibitor and asphaltene inhibitor from A6-A to Ravn. As part of the decommissioning process each chemical in the umbilical will be removed and collected in separate waste tank containers. The chemicals shall not be mixed. The tank containers including the chemicals will be demobilised to shore. The umbilical content is as specified below:

2 ea ½-inch tubing each containing 2.3 m^3 of multitreat 13803
2 ea ½-inch tubing each containing 2.3 m^3 of multitreat 9336
1 ea ½-inch tubing containing 2.3 m^3 of multitreat 14953
1 ea ½-inch tubing containing 2.3 m^3 of Glycoshell (25% MEG and 75% water)
1 ea ½-inch tubing containing nitrogen
1 ea ¾-inch tubing containing 5,2 m^3 methanol

The tubing of the methanol line in the umbilical will be connected to a HP nitrogen hose to displace the Methanol through the tubing. The HP hose will be connected to a nitrogen quad. High pressure nitrogen is required because of the friction caused by the small diameter of the line in combination with the length. The multitreat inhibitors in the ½-inch lines will be displaced by injecting sea water. The tubes will be connected to a HP pump and a flow meter onboard Ravn.

Onboard A6-A the umbilical lines will be connected to temporary hoses routed and connected to separate temporary storage tank containers to collect the umbilical fluids. The tank containers having collected the chemicals will be demobilised to shore.

As can be seen in the above, no discharges which could cause cumulative effects in combination with the P&A of A1 and A2 occur during the cleaning of the pipeline.

13 Cross-border impacts

The distance to the Danish - German border is 11,3 km and environmental impacts related to the P&A operations must therefore have a geographical extension of at least 11,3 km to pose a cross-border impact.

There will as described in section 7.5 be no discharges to sea in connection with the actual P&A operation of the wells A1 and A2 as all chemicals will be left in well or transported to shore where they will be disposed of.

There will be a discharge to the sea of one chemical from the jack-up rig used for the P&A process (jacking grease) as described in section 7.5. The impact of this discharge has been calculated and assessed in section 0. The impact is local (< 250 m from the rig).

There is therefore no risk of transboundary effects from discharge of chemicals to the sea.

There will be no cuttings from the plug and abandonment process.

The duration of the P&A operation is expected to be 60 days. The P&A activities will result in a temporary and local disturbance from these activities including noise from the operations and vessel traffic (see section 9.1). It is expected that marine mammals and fish will avoid the area surrounding the well during the operation period. The impact is assessed to be local and insignificant and does not result in transboundary effects.

There will be an unavoidable minor emission of CO_2-eq related to the P&A operation. The total calculated CO_2-eq emissions from the P&A operation is 1.932 tons CO_2-eq (see section 9.3). Any CO_2 emission has a global effect on the climate. The emissions are small and unavoidable in order to decommission the two Ravn wells. The impact is considered short term and minor with a low environmental risk.

The risk of a blow-out or oil spill was assessed in the original Ravn EIA (Wintershall Nordzee B.V (2014)) to have a very low probability of taking place and a constitute a negligible risk. The risk of a blow-out or an oil spill during the P&A activities are assessed in chapter 10 to be significantly lower than the risk modelled in the original Ravn EIA and is therefore assessed to be negligible and limited in extend and thus does not result in transboundary effects.

14 Natura 2000-areas & Annex IV-species

14.1 Natura 2000-areas

The Ravn field platform is situated far from Danish Natura 2000 areas. However, approximately 15 km southwest of the Ravn field is the German Natura 2000 area DE 1003-301 *Doggerbank*. As an extension of this area is the Dutch NL 2008-001 *Doggerbank* and the UK0030352 *Dogger Bank* in the UK sector (Figure 14-1).

The designation basis of Danish Natura 2000 areas in the North Sea and the Natura 2000 areas at Dogger Bank are listed in Table 14-1.

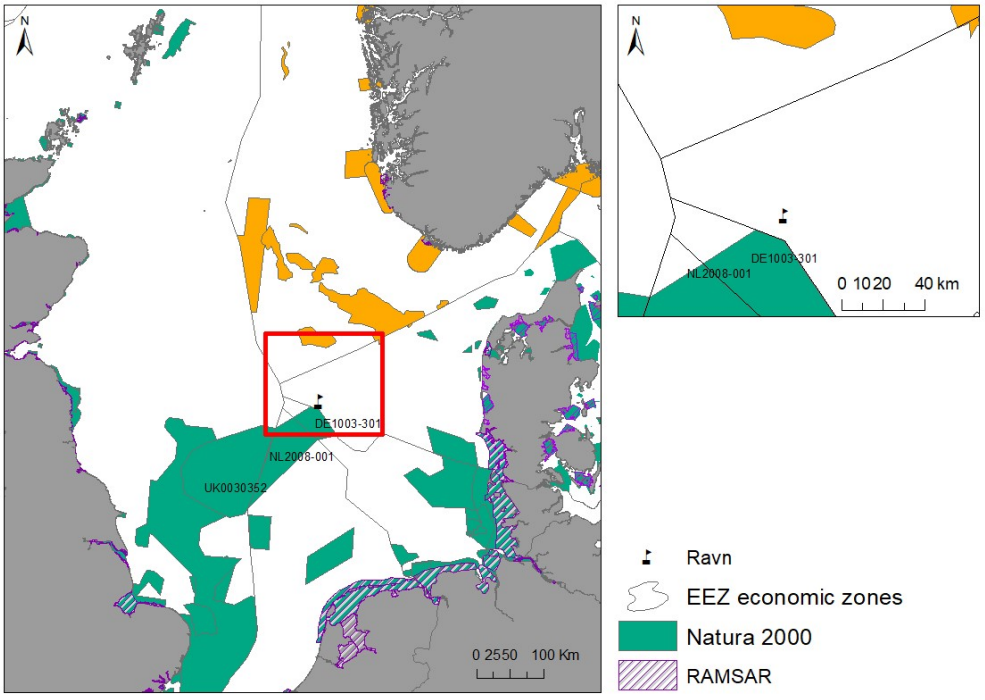

Figure 14-1 Location of Natura 2000-areas (SAC) in the North Sea.

Table 14-1 Habitats and species that are basis for the designation of Natura 2000 areas at the Dogger Bank and Danish Natura 2000 areas in the Danish sector of the North Sea.

Natura 2000 area	Basis for designation
UK0030352 Doggerbank	1110 Sandbanks 1351 Harbour porpoise 1365 Harbour seal 1364 Grey seal
NL 2008 -001 Doggerbank	1110 Sandbanks 1351 Harbour porpoise 1365 Harbour seal 1364 Grey seal
DE 1003-301 Doggerbank	1110 Sandbanks 1351 Harbour porpoise 1365 Harbour seal 1364 Grey seal
DK00VA348 *Thyborøn stenvolde*	1170 Reef 1351 Harbour Porpoise
DK00VA257 Jyske Rev, *Lillefiskebanke*	1170 Reef 1351 Harbour Porpoise
DK00VA340 *Sandbanker ud for Thyborøn*	1110 Sandbanks which are slightly covered by sea water all the time 1351 Harbour Porpoise
DK00VA259 *Gule rev*	1170 Reef 1351 Harbour Porpoise
DK00VA301 *Lønstrup rødgrund*	1170 Reef 1351 Harbour Porpoise
DK00VA258 *Store rev*	1170 Reef 1351 Harbour Porpoise
DK00FX112 *Skagens Gren og Skagerrak*	1110 Sandbanks which are slightly covered by sea water all the time 1180 Submarine structures made by leaking gases 1351 Harbour Porpoise 1365 Harbour seal
DK00EX023 *Agger Tange*	19 different species of sea birds including species of terns, ducks, and wading birds.
DK00VA347 *Sydlige Nordsø*	1110 Sandbanks, which are slightly covered by sea water all the time 1351 Harbour Porpoise 1365 Harbour Seal 1364 Grey Seal Red-throated diver, Black-throated diver, and Little gull

Due the distance between the Ravn field and any Danish Natura 2000-areas, it is unlikely that the P&A activities will impact the habitat types within these areas. It cannot be ruled out that species like the Harbour porpoises, Grey seals and Harbour seals, which constitute the basis for designation for some of the Danish Natura 2000-areas, may be found in the area around the Ravn field, including some of the bird species. However, the potential risk from the P&A activities impacting any Natura 2000-areas must first and foremost be the German DE 1003-301 Doggerbank area.

The following potential impacts on Natura 2000 sites and Annex IV species have been assessed:

- Impacts of underwater noise during the P&A activities
- Impacts of a blow-out and accidental oil spills

Impacts of underwater noise on marine mammals have been discussed above (Section 9.1.1) and has been assessed to be local and short term and thus insignificant. Based on this assessment and the distance from the P&A activities to the nearest Natura 2000 site (approximately 11.3 km) underwater noise from the P&A activities will have insignificant impact on the conservation objectives of the habitat types and species in the Natura 2000 sites.

Impacts of a blow-out and accidental spills have been discussed above (Section 10) and has been assessed to be negligible. The risk from a large oil spill (>1 m3) from a vessel is comparable to other offshore vessels operating and is thus very small and the extent will be limited.

It is noted that the designation basis for the German DE 1003-301 Doggerbank area, included the habitat sandbanks and the three species Harbour porpoise, Grey seal and Harbour seal. In the unlikely event of a small accidental oil spill, these three species is expected to flee the area. In addition, for an oil spill limited in extent will not impact the sand banks significantly. It is therefore not expected that the integrity of this area will be impacted.

14.2 Annex IV-species

All whale species in the North Sea are listed in Annex IV of the EU habitats directive (Council Directive 92/43/EEC of 21 May 1992). Annex IV lists animal and plant species in need of particularly strict protection. According to the Habitats Directive (92/43/EEC), Article 12 for the Annex IV-species the following is prohibited:

- All forms of deliberate capture or killing of specimens of these species in the wild
- Deliberate disturbance of these species, particularly during the period of breeding, rearing, hibernation and migration
- Deliberate destruction or taking of eggs from the wild
- Deterioration or destruction of breeding sites or resting places

Sightings around oil and gas installations in the Danish sector of the North Sea has confirmed the presence of 7 marine mammal species, of these five cetaceans: harbour porpoise (*Phocoena phocoena*), minke whale (*Balaenoptera acutorostrata*), white-beaked dolphin (*Lagenorhynchus albirostris*), killer whale (*Orcinus orca*), pilot whales (*Globicephala*

spp.) (Delefosse et al. 2018). Only harbour porpoise, white-beaked dolphin and minke whale are encountered regularly in the western part of the Danish sector of the North Sea (Sveegaard et al., 2018; SCANS II; Kinze, 2007; Reid et al., 2003).

The white-beaked dolphin lives in the temperate part of the North Sea, and in Danish waters it is common in the northern part of the North Sea and in Skagerrak, mostly during the summer (DCE 2008). The abundance of the white-beaked dolphin has been mapped during SCANS survey sin 1994, 2005 and 2016 and there seems to be a stable population in the North Sea of approximately 20.000 individuals (Hammond et al. 2017). However, the knowledge of distribution, reproduction, behaviour, etc. is generally lacking (Kyhn et al. 2012, Miljøstyrelsen 2022).

The minke whale in Danish waters is typically observed in the Northern part of the North Sea and in Skagerrak (Kinze 2022). Most observations in Danish waters take place during May–July, and no observations have been made during February-April. Breeding takes place during the winter along the North American coastline. It is assessed that the area for the P&A activities is not a core area for the minke whale (Figure 14-2).

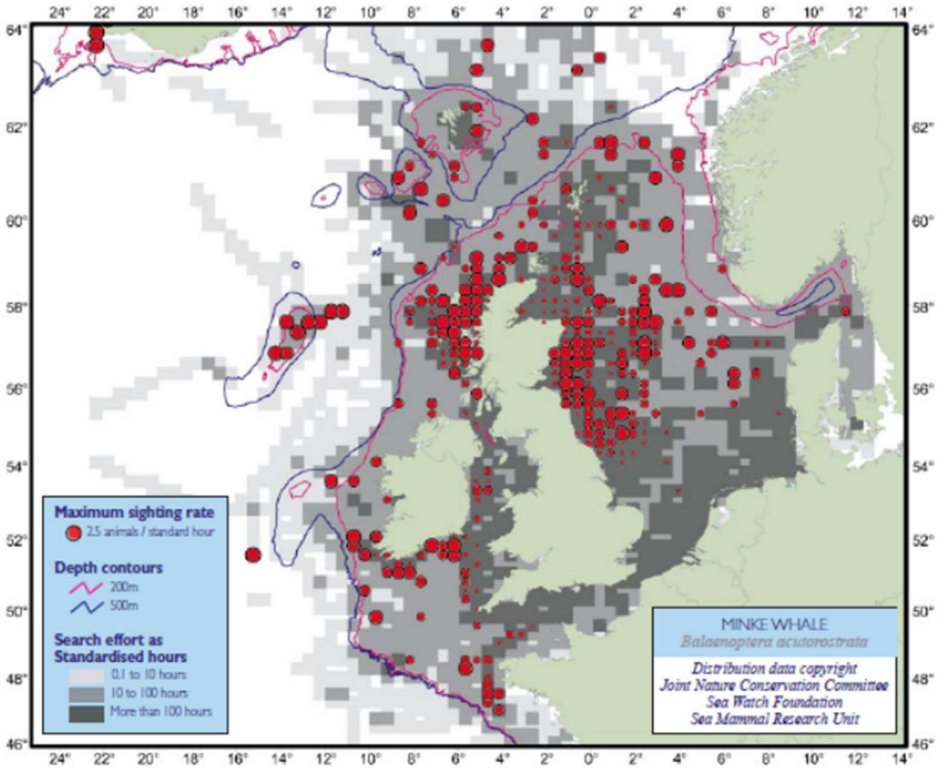

Figure 14-2 Observations of minke whale in the North Sea and surrounding waters from (Reid et al 2003 in Kyhn et al 2021).

The P&A activities and operation will not engage in any capture or killing of Annex IV-species. It is not expected that the area is a breeding or rearing site for neither the harbour porpoise, the white-beaked dolphin or the minke whale.

The different threshold levels for temporary threshold shifts and permanent threshold shifts for the three cetacean species (Table 9-1), are not expected to be exceeded (section 9.1).

This is due to the expected limited underwater noise from the P&A activities, and this is expected although the three species hear underwater sounds differently, as the harbour porpoise is a very high frequency cetacean, the white-beaked dolphin is a high frequency cetacean and the minke whale is a low frequency cetacean.

No threshold levels have been identified for behavioural reactions for the white-beaked dolphin or the minke whale. However, for all three cetaceans, potential impacts on the behaviour are only expected for a relative short distance from the P&A activities, and only a very limited number of animals may potentially be impacted for a relative short period of time. It is therefore assessed that the ecological functionality of the distribution areas and in particular the breeding and rearing sites is maintained.

It is concluded that the P&A activities will not negatively affect the conservation status of habitats and species, for which potentially affected Natura 2000-sites have been designated as well as species listed on Annex IV of the EU Habitats directive (Directive 98/43EEC of 21 May 1992).

The P&A activities are expected to take place during August 2023. The project area is not expected to be important for either harbour porpoises, white-beaked dolphins or minke whales. Similarly, no breeding areas are identified in the area. Based on this and on the general negligible impacts, this impact assessment is valid no matter when the P&A activities takes place during the year.

15 Marine Strategy Framework Directive (MSFD)

The EU Marine Strategy Framework Directive (MSFD) is put in place to protect the marine ecosystem and biodiversity upon which the health and marine-related economic and social activities depend.

To help EU countries achieve a good environmental status (GES), the directive sets out 11 illustrative qualitative descriptors (Section 4.4). The descriptors D1, D4 and D6 are related to the existing conditions of the marine environment while descriptor D2, D3, D5-D11 are related to the impact on the marine environment from human activities.

According to the Danish Marine Strategy II (Miljø- og fødevareministeriet 2019), which implement the MSFD, the most important impacts in the North Sea/Skagerrak are caused by these aspects: nutrients, non-indigenous species, fisheries, noise, contaminants, marine litter (micro plastic in sediment), shipping and physical modifications (Danish Marine Strategy II figure 19.6). Not all of these aspects are relevant for the oil and gas production activities.

The most relevant and important descriptors for oil and gas production activities in general are D8 Contaminants, specifically for acute pollution events, and D11 Underwater noise (Miljø- og fødevareministeriet 2019).

The EU Commission has defined criteria and methodological standards on good environmental status of marine waters (GES Commission Decision (EU) 2017/848 of 17 May 2017). The Ministry of Environment and Food has defined environmental targets for each descriptor, based on the criteria defined in the GES Decision. According to the Marine Strategy Act (Consolidation act no. 1161 of 25/11/2019, (§18), the Danish authorities may not issue approvals etc. which are in conflict with these environmental targets in addition to the programme of measures.

Based on the above considerations, in addition to the potential environmental impacts from the P&A operation as described in Chapter 9, the assessment according to the Marine Strategy Framework Directive will be conducted in a two-step process:

1 The descriptors that are not specifically relevant for the decommissioning of Ravn A1 will be identified and the justification why these descriptors are not specifically relevant will be presented. The identified descriptors include (Table 15-1):

    - D1: Biodiversity
    - D2: Non-indigenous species
    - D3: Commercially exploited fish stocks
    - D4: Marine food webs
    - D5: Eutrophication
    - D6: Sea floor integrity
    - D7: Alteration of hydrographical condition
    - D9: Contaminants in fish and other seafood for human consumption.

2 The descriptors specifically relevant for the decommissioning of Ravn A1 will be presented. The associated environmental targets will each be evaluated according to the expected impacts. The identified descriptors include:

- D8: Contaminants
- D10: Marine litter
- D11: Underwater noise

The main potential impacts from the P&A operation are assessed to arise from acute pollution discharges e.g. in the form of a blow-out (D8), production of marine litter (D10) and from underwater noise (D11). For these aspects the following is concluded (Table 15-2, Table 15-3 and Table 15-4):

- D8: Contaminants: There will be no planned discharges to the sea from the P&A operation. Acute pollution events are extremely rare events. The risk of a blow-out is prevented through a number of mitigating measures.

- D10: Marine litter: All waste generated during the P&A operation will be handled according to MARPOL Annex IV. Limited amounts of steel will remain in-situ in the wells, however the potential impacts from this are assessed to be insignificant.

- D11: Underwater noise: The majority of noise generated is not expected to be impulse noise. The noise levels will not exceed the threshold for triggering temporary or permanent heating damage (TTS and PTS) for the species of marine mammals in the area. The P&A operation is expected to cause local impacts which will result in avoidance by marine mammals and fish in the immediate vicinity of the activities. This impact is local and temporary and thus assessed to be insignificant.

Table 15-1 Impact of the P&A operation on the 8 descriptors of the Marine Strategy Framework Directive that are found not to be specifically relevant

No.	Descriptor	Description of impact
1	Biological diversity is maintained. The quality and occurrence of habitats and the distribution and abundance of species are in line with prevailing physiographic, geographic and climatic conditions. Environmental targets – birds: 1.1 Incidental by-catch of birds is at a level that does not threaten the species in the long term. 1.2 Populations and habitats for birds are conserved and protected in accordance with objectives under the Birds Directive. 1.3 The Ministry of Environment and Food contributes to regional work regarding establishment of threshold values and determination of good environmental status, and works to ensure that the status for biological diversity is in accordance hereto. 1.4 More knowledge about by-catch of seabirds is collected pursuant to the relevant monitoring programmes. 1.5 Need for protection initiatives for HELCOM and OSPAR Red List species is assessed. If there are any Red List species that are endangered or not sufficiently protected, the Ministry of Environment and Food will assess specifically the need for further initiatives in collaboration with relevant ministries. Environmental targets – marine mammals: 1.6 Incidental by-catch of harbor porpoise is reduced as much as possible, and as a minimum to a level below 1.7% of the total population.	There is no impact on biological diversity from the planned activities. The P&A operation will remove the existing well structure to appx. 5 m under the seabed. Discharges to the marine environment has been assessed in section 0 to insignificant. Birds: Birds may potentially be impacted by light and noise disturbances although impacts are assessed to be negligible. The project area is not considered important for seabirds Marine mammals: The marine mammals may potentially be impacted by underwater noise and disturbance. The noise levels are not expected to cause any hearing damage, but the mammals may exhibit avoidance behavior. The project area is not assessed to be a core area for marine mammals. The impacts will be temporary and not expected to affect the marine mammal populations. Fish: Some fish species may be disturbed by noise from passing vessels and they may flee from the vessel, while other fish species are not affected. The potential impacts will be temporary and not expected to affect fish populations. Pelagic habitats: The project will not impact the abundance of plankton.

	1.7 Incidental by-catch of seals is at an adequately low level that does not threaten populations in the long term. 1.8 Harbor porpoise, harbor seal and grey seal achieve favorable conservation status in accordance with the timeline laid down in the Habitats Directive. 1.9 The Ministry of Environment and Food contributes to setting population-specific threshold values for by-catches of harbor porpoise in a regional context with a view to subsequently setting environmental targets for vulnerable populations of harbor porpoise. 1.10 More knowledge about by-catches of marine mammals is collected pursuant to the relevant monitoring programs. 1.5 Need for protection initiatives for HELCOM and OSPAR Red List species is assessed. If there are any Red List species that are endangered or not sufficiently protected, the Ministry of Environment and Food will assess specifically the need for further initiatives in collaboration with relevant ministries. Environmental targets – fish: 1.11 The Ministry of Environment and Food carries out an analysis of by-catches of shark and ray in Danish marine areas, and the possibility of a DNA-based approach to determining species is investigated. 1.12 The Ministry of Environment and Food establishes a national indicator to evaluate the status of Danish fish that are not exploited commercially, and the opportunities to further develop regional indicators are investigated. 1.3 The Ministry of Environment and Food contributes to regional work regarding establishment of threshold values and determination of good environmental status, and works to ensure that the status for biological diversity is in accordance hereto. Environmental targets – pelagic habitats: 1.13 The abundance of plankton follows the long-term average. 1.14 The Ministry of Environment and Food is tracking developments and improving the knowledge base about plankton through monitoring.	There is no impact on biological diversity from the planned activities. In general, potential impacts are assessed to be insignificant, local, and temporary. It is expected that there will be no impacts on the environmental targets.
2	Non-indigenous species introduced by human activities are at levels that do not adversely alter the ecosystems. Environmental targets: 2.1 The number of new non-indigenous species introduced through ballast water, ship fouling and other relevant human activities is decreasing. 2.2 The distribution of certain invasive species is, as far as possible, at a level so that significant adverse effects are stable or decreasing. 2.3 The Ministry of Environment and Food contributes to regional work regarding establishment of threshold values and determination of good environmental status, and works to ensure that the number of new non-indigenous species and impacts from invasive species are in accordance hereto.	There is no risk of introducing non-indigenous species as all vessels used are vessels that operate within the North Sea. If relevant, the vessels will adhere to the requirements stated in the Ballast Water Management Convention. The vessels will also be guided by the IMO Guidelines for the control and management of ships' biofouling to minimize the transfer of invasive aquatic species from 2011. These guidelines are currently under review in IMO. It is expected that there will be no impacts on the environmental targets.
3	Populations of all commercially exploited fish and shellfish are within safe biological limits, exhibiting a population age and size distribution that is indicative of a healthy stock. Environmental targets:	There is no impact on commercial fish populations other than a possible local and temporary disturbance in the area of the P&A operation.

	3.1 The number of commercially exploited fished stocks regulated pursuant to the MSY principles in the Common Fisheries Policy is increasing. 3.2 Within the framework of the Common Fisheries Policy, fish mortality (F) is at levels that can ensure a maximum sustainable yield (Fmsy). 3.3 Within the framework of the Common Fisheries Policy, spawning biomass (B) exceeds the level that can ensure a maximum sustainable yield (MSY Btrigger).	It is expected that there will be no impacts on the environmental targets.
4	All elements of the marine food webs, to the extent that they are known, occur at normal abundance and diversity and levels capable of ensuring the long-term abundance of the species and the retention of their full reproductive capacity. Environmental targets: 4.1 The Ministry of Environment and Food contributes to regional work regarding establishment of threshold values and determination of good environmental status and works to ensure that the anthropogenic impacts on the food web are in accordance hereto 4.2 The Ministry of Environment and Food contributes to regional knowledge and methodology development on marine food webs. 4.3 The Ministry of Environment and Food is tracking the development in the food web through monitoring the individual sub-elements of the web.	There is no impact on the descriptor from the P&A operation. Once the P&A operation has been carried out, the seabed will return to the state it had before the well was established. It is expected that there will be no impacts on the environmental targets.
5	Human-induced eutrophication is minimised, especially adverse effects thereof, such as losses in biodiversity, ecosystem degradation, harmful algae blooms and oxygen deficiency in bottom waters. Environmental targets: 5.1 The Ministry of Environment and Food contributes to regional work regarding establishment of threshold values and determination of good environmental status for the North Sea, including the Skagerrak, and works to ensure that anthropogenic eutrophication and its effects are in accordance hereto. 5.2 Danish inputs of nitrogen and phosphorus (TN, TP) comply with the maximum acceptable inputs stipulated under HELCOM. 5.3 Coastal waters: Target loads and needs for measures for fjords, estuaries and coastal waters determined in accordance with the Water Framework Directive are complied with. Targets and needs are described in the Danish river basin management plans.	There are no expected discharges of nutrients and therefore no impact on the descriptor. The project will not cause any significant release of nutrients associated with the sediment plumes, as these potential sediment plumes will be minimal in extent for a short duration of time. It is expected that there will be no impacts on the environmental targets.
6	Sea-floor integrity is at a level that ensures that the structure and functions of the ecosystems are safeguarded and benthic ecosystems, in particular, are not adversely affected. Environmental targets – losses and physical impacts: 6.1 Ministry of Environment and Food contributes to work regionally and in the EU regarding establishment of threshold values and determination of good environmental status, and works to ensure that losses, physical disturbance, and adverse effects on the sea floor are in accordance hereto. 6.2 The knowledge base about the Danish sea floor, as well as the abundance and the location of the benthic habitats and their status, is	The well will be removed to below seabed level and the seabed will return to the state it had before the well was established. Epi- and infauna is expected to recolonize the abandoned area. The location of a rig in addition to the spudcans on the seabed is temporary and will have no permanent impact on the seafloor integrity. The physical disturbance of the seabed is thus limited in extent and duration. This also applies for the potential sediment plumes. It is expected that there will be no impacts on the environmental targets.

	improved pursuant to the monitoring programme (NOVANA) 6.3 Through regional work and the work in the EU, better understanding of the impacts on the seafloor in relation to losses, disturbances and adverse effects is achieved. 6.4 In connection with licensing offshore activities requiring an environmental impact assessment (EIA), the approval authority encourages assessment and reporting to the Danish Environmental Protection Agency (monitoring programme) of the extent of physical losses and physical disturbances of benthic broad habitat types. Environmental targets – habitat types and sea floor: 6.5 The marine habitat types under the Habitats Directive achieve favourable conservation status in accordance with the timeline laid down in the Habitats Directive. 6.6 The northern Sound is designated as a marine protected area pursuant to the Marine Strategy Framework Directive, and new licences to extract mineral resources are stopped. This will not result in any changes in relation to the existing fisheries regulation. 6.7 The most important habitats contain the typical species and communities for Danish marine areas. 6.8 When threshold values for losses, disturbances and adverse effects are established through cooperation at regional and Union level, the Ministry of Environment and Food will initiate a project to form the basis for establishing environment targets in accordance with the thresholds and good environmental status. 6.9 Need for protection initiatives for HELCOM and OSPAR Red List habitats is assessed. If there are any natural habitats on the Red Lists that are endangered or not sufficiently protected, the Ministry of Environment and Food will assess specifically the need for further initiatives in collaboration with relevant ministries. 6.10 The need for additional marine protected areas or other initiatives in the Baltic Sea and the North Sea is assessed, and a similar assessment is subsequently carried out for the Danish Straits.	
7	Permanent alteration of hydrographical conditions does not adversely affect marine ecosystems. Environmental targets: 7.1 Anthropogenic activities that are particularly associated with physical loss of the sea floor, and which cause permanent hydrographical changes only have local impacts on the sea floor and in the water column, and are designed to take account of the environment and what is technically possible and financially reasonable to prevent harmful effects on the seabed and in the water column. 7.2 In connection with licensing offshore activities requiring an environmental impact assessment (EIA), the approval authority is encouraging reporting to the Danish Environmental Protection Agency (monitoring programme) of hydrographical changes and the adverse effects of these.	The well will be removed to below seabed level and the seabed will return to the state it had before the well was established. There is no impact on the descriptor. The location of the legs of the rig in the water column is temporary and will have no permanent impact on the hydrographical conditions. It is expected that there will be no impacts on the environmental targets.
9	Contaminants in fish and other seafood for human consumption do not exceed levels	Discharges of chemicals are assessed in section 0. Impacts are assessed to be insignificant.

	established by Community legislation or other relevant standards. Environmental targets: 9.1 Emissions of contaminants generally do not lead to exceeding of the maximum residue levels applicable in the food legislation for seafood. 9.2 Emissions of contaminants generally do not lead to exceeding of the maximum residue levels applicable in the food legislation for seafood. 9.3 The Danish Environmental Protection Agency is monitoring developments in relation to emissions of POPs (including dioxins) from wood-burning stoves to assess the need for further initiatives. 9.4 The Danish Environmental Protection Agency is gradually improving emission estimations of POPs into the air. 9.5 Danish Veterinary and Food Administration is inspecting concentrations of contaminants, particularly dioxins and PCBs to monitor developments in organisms at risk of containing high concentrations.	It is expected that there will be no impacts on the environmental targets.

Table 15-2 Environmental targets for Descriptor 8 according to the Danish Marine Strategy II and potential impacts on these environmental targets from the P&A operation.

Targets	Impact from the P&A operation	Comments
8.1 Discharges of contaminants in the water, sediment and living organisms do not lead to exceeding of the environmental quality standards applied in current legislation	According to the Danish Marine Strategy Directive II threshold values are decided for PFOS, PBDE, Benz(A)pyrene and mercury. Only Benz(A)pyrene and mercury are present around the installations in very small concentrations. The values can although not directly be compared as the thresholds are defined by concentrations in fish or mussels.	Discharges of chemicals are assessed in section 0. Impacts are assessed to be insignificant.
8.2 Emissions, discharges, and losses of PBDE and mercury are ceased or phased out	See 8.1	
8.3 The Ministry of Environment and Food contributes to work regionally and in the EU regarding establishment of threshold values and determination of good environmental status and works to ensure that the quantities of contaminants are in accordance here to.	See 8.1	
8.4 There is a gradual decrease in the levels of imposex/intersex in marine gastropods.	N/A	
8.5 By 2021, a process has been carried out to trace the source of the most	See 8.1	

Targets	Impact from the P&A operation	Comments
polluting substances which prevent meeting the environmental targets laid down for surface water bodies in the Water Framework Directive. If necessary, the relevant licences and permits will be revised as far as possible		
8.6 The Ministry of Environment and Food is working to ensure that more indicators for contaminants are established	N/A	
8.7 The Ministry of Environment and Food ensures increased coordination between policy areas/directives when new national environmental quality requirements are set for selected substances in matrices, where there is monitoring data.	N/A	
8.8 The Ministry of Environment and Food is working to develop additional regional joint tests for biological impacts.	N/A	
8.9 The spatial extent and duration of acute pollution events is gradually reduced as much as possible through prevention, monitoring and risk-based scaling of contingency and response facilities.	Acute pollution events are extremely rare events. The risk of a blow-out is furthermore prevented through a number of mitigating measures, including the use of the blow-out preventer, the already installed plugs and the use of brine that keep the well balanced at all times.	Acute pollution events may include oil spills through leakage from the well or a blow-out. Due to a reduced pressure in the reservoir and the narrow flow path in the tube and measures in place, the severity of the potential impact is assessed as minor and the risk to the environment as negligible (Section 10).
8.10 Adverse effects on marine mammals and birds from acute pollution events are prevented and minimised as much as possible. For example, this may be secured by means of floating booms as well as through contingency plans for marine mammals and birds injured in oil spills	See 8.9	
8.11 Up to the next monitoring programme (2020), the Danish Environmental Protection Agency will examine how the adverse effects of the most significant pollution events can be monitored and registered in the specific cases	N/A	

Table 15-3 Environmental targets for Descriptor 10 according to the Danish Marine Strategy II and potential impacts on these environmental targets from the P&A operation.

Targets	Impact from the P&A operation	Comments
10.1 The amount of marine litter is reduced significantly to achieve the UN goal that marine litter is prevented and significantly reduced by 2025.	All waste generated during the P&A operation will be handled according to MARPOL Annex IV. Limited amounts of steel will remain in-situ in the wells, however the potential impacts from this are assessed to be insignificant.	Potential impacts are assessed in Section 9.4.
10.2 The Ministry of Environment and Food contributes to work regionally and in the EU regarding establishment of threshold values and determination of good environmental status, and works to ensure that the quantities of marine litter are in accordance hereto	N/A	
10.3 Losses of fishing gear in Danish waters are prevented to achieve the UN goal that marine litter is prevented and significantly reduced by 2025	N/A	
10.4 The Ministry of Environment and Food implements the National Plastics Action Plan and the associated Political Agreement on collaboration of 30 January 2019, with a view to improving recycling of plastic and reducing plastic litter and pollution from plastic litter	N/A	
10.5 The Ministry of Environment and Food is working to develop indicators and measurement methods for microplastics in seabed sediments and the water column.	N/A	
10.6 The Danish Fisheries Agency draws up an estimate of the amount of lost fishing gear in Danish marine areas up to 2020.	N/A	
10.7 The Ministry of Environment and Food prepares a catalogue of potential and targeted measures to prevent marine litter	N/A	

Table 15-4 Environmental targets for Descriptor 11 according to the Danish Marine Strategy II and potential impacts on these environmental targets from the P&A operation.

Targets	Impact from the P&A operation	Comments
11.1 As far as possible, marine animals under the Habitats Directive are not exposed to impulse sound which leads to permanent hearing loss (PTS). The limit value for PTS is currently assessed as 200 and 190 dB re.1 uPa2s SEL for seals and harbour porpoise, respectively. The best knowledge currently available is on these species. However, it is likely that these limits will be revised as new knowledge on the area becomes available. The values are the sound-exposure level accumulated over two hours.	Activities which potentially may cause environmental impacts from underwater noise include cutting of the conductor 5 meter below the seafloor, noise from the mechanical plant, pumping systems and miscellaneous hammering of gear on the rig, and in general the machinery, propellers and thrusters of support vessels. The majority of noise generated is thus not expected to be impulse noise.	The noise levels will not exceed the threshold for triggering temporary or permanent heating damage (TTS and PTS) for the species of cetaceans in the area. The P&A operation is expected to cause local impacts which may result in avoidance by marine mammals and fish in the immediate vicinity of the activities. This impact is local and temporary and thus assessed to be insignificant.
11.2 Anthropogenic activities causing impulse sound are planned such that direct adverse effects on vulnerable populations of marine animals from the spatial distribution, temporal extent, and levels of anthropogenic impulsive sound are avoided as far as possible and such that these effects are assessed not to have long-term adverse effects on population levels.	See 11.1	
11.3 Activities by the authorities under the Ministry of Defence that cause impulse noise in the marine environment are, as far as possible, being assessed and adapted to reduce possible adverse effects on marine animals under the Habitats Directive, provided this does not conflict with national security or defence objectives. Defence Command Denmark applies current NATO standards when carrying out environmental assessments.	N/A	
11.4 When conducting preliminary seismic studies, adequate remedial action is taken in accordance with the Danish Energy Agency's guidelines on	N/A	

Targets	Impact from the P&A operation	Comments
standard terms and conditions for preliminary studies at sea.		
11.5 The Ministry of Environment and Food contributes to work regionally and in the EU regarding establishment of threshold values and determination of good environmental status and is working to ensure that the level of underwater noise is in accordance hereto.	N/A	
11.6 In connection with licensing offshore activities requiring an environmental impact assessment (EIA), the approval authority is encouraging reporting to the Danish Environmental Protection Agency (monitoring programme) of registrations of impulse noise.	N/A	
11.7 Through increased monitoring, the Ministry of Environment and Food is improving knowledge about the extent and levels of low-frequency noise in the Baltic Sea and the North Sea.	N/A	

The Danish Environmental Protection Agency (DEPA) has issued a monitoring programme specifically for the marine strategy framework directive (Miljø- og fødevareministeriet 2020). Monitoring activities have been defined for each of the 11 descriptors. The P&A operation is assessed not to impact any of the monitoring activities described in the monitoring programme (Figure 15-1).

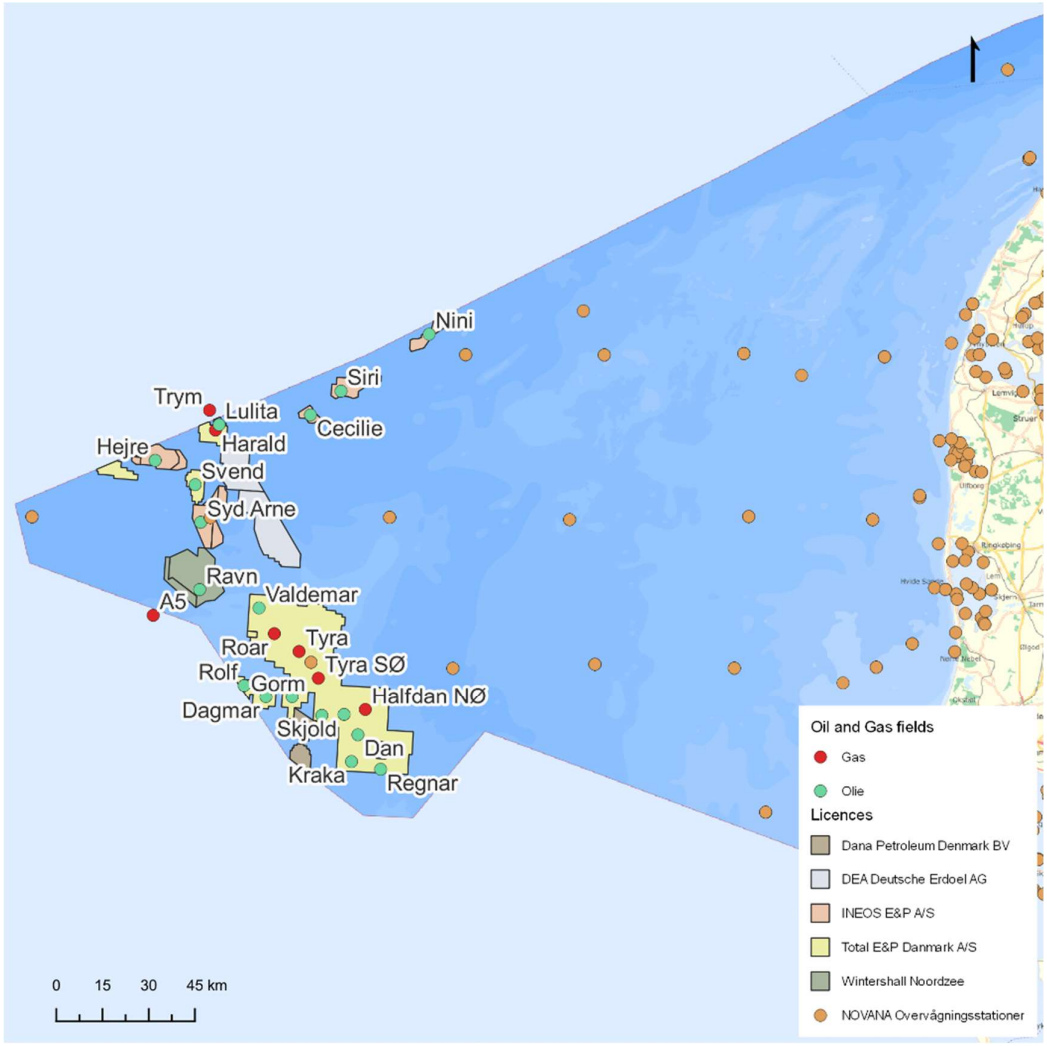

Figure 15-1 Location of NOVANA monitoring stations designated under the marine strategy framework directive.

Denmark's current programme of measures is from 2017 (Miljø- og fødevareministeriet 2017), although a new programme of measures is expected to be released in 2023. Measures have been introduced for each of the 11 descriptors and include measures and efforts to be implemented to achieve or maintain a good environmental status. The P&A operation is assessed not to impact any of the measures described in the programme of measures.

Overall, the P&A operation is not expected to impact the overall goal of the Marine Strategy Framework Directive to achieve or maintain a good environmental status. In addition, the P&A operation is not expected to impact the monitoring activities, or the activities included in the programme of measures.

16 Monitoring program

After plugging and abandoning the wells the original state of the well site shall be re-established in accordance with the drilling guidelines (DEA, 2009). A monitoring programme will be prepared as a part of the decommissioning of the Ravn platform and it is expected that a site survey will be carried out. This will also cover the area around well A1 and A2 so that a final, collective monitoring report can be made.

17 Project mitigation

17.1 General

Wintershall Noordzee B.V. operates with a HSE policy and Management system. People and organisations working for Wintershall Noordzee B.V. have to do their daily work at any time with responsible care for health, safety and environmental aspects.

17.2 Air emissions

With the purpose of minimizing air emissions in relation to use of drilling rig and vessels following actions are required:

- Supply and support operations should be optimized to minimize the operation time
- All engines are to be maintained according to standards from suppliers to achieve efficient performance

17.3 Environmental monitoring

A monitoring program for the well after abandonment will be set up in agreement with the authorities.

An inventory will be prepared for the plug and abandonment operation. The inventory will among others include:

- Amounts of used and discharges of chemicals
- Amount of used and discharged brine
- Amounts of brine transported to shore
- Amount of solid waste transported to shore
- Use of fuel on the rig

17.4 Unplanned oil spill

17.4.1 Plug design and pressure test

The plugs include mechanical and cement plugs that are designed to a certain weight and pressure. All plugs will be weight and/or pressure tested after installation with a pressure higher than the anticipated formation pressure at depth. A minimum cement plug length of 100m is placed below the MBD to isolate potential flow zones and to restore the cap rock strength.

The cement plugs are;

- designed for the highest differential pressure and highest downhole temperature expected, and
- positioned across a depth interval where formation integrity is higher than potential pressure from below, and
- designed for isolating sources of inflow containing hydrocarbons to prevent gas migration, including CO_2 and H_2S, if present.

17.4.2 Emergency response plan

The actions to take after a spill of oil or chemicals to the sea, during the P&A of the Ravn wells, are described in the Oil & Chemicals Spill Contingency Plan (HSE-09-P037). This plan follows a tiered approach and describes the actions to be taken depending on the volume of the spill (tier 1 to 3). The plan describes actions for both the drilling contractor offshore as well as the Wintershall organization onshore and includes the external support from specialized organizations (Oil Spill Response Ltd., Wild Well Control).

The Wintershall Company Representative on board the drilling rig will contact the Wintershall Operation Chief, who in turn will contact the Safety Officer and, in case of Tier 2 or Tier 3, the Incident Commander. The Incident Commander will mobilize the Emergency Response Team, in line with the Wintershall Emergency Response Procedure (HSE-09-P001).

The Emergency Procedure describes who is involved in the follow-up of an accident/ incident and what tasks are to be performed. In case of a spill of oil or chemicals the assistance of Oil Spill Response Ltd. will be called in.

The Offshore Installation Manager (OIM) will take over the role of On Scene Commander and will be the ultimate responsible person for the oil combating actions on site. The OIM will be supported by the Emergency Response Team onshore. The effects of the spill to environment are combatted by the Wintershall onshore organization according to the Oil & Chemicals Spill Contingency Plan and the Emergency Response Procedure.

18 Data quality and limitations

18.1 Environmental assessments of emissions to air

The assessment of emissions to air is attached with some uncertainties regarding the fuel consumption, emission factors, days of operation of vessels etc.

The emission factors that are used calculating emissions from vessels are generic emission factors. This also means, that the actual emission from vessels could be different if measuring the emissions.

The standard emission factors for vessels are from Norwegian Oil & Gas and are assumed to be diesel oil burned in motors (OLF, 2019). These are almost similar to emission factors for marine diesel oil/marine gas oil used for ships in the EMEP/EEAs Inventory Guidebook, 2019. The standard emission factors for helicopters are from E&P Forum (E&P Forum, 1994).

Likewise, the fuel consumption are generic data, as the actual vessel fleet is not decided upon yet, and thus it could be other types of vessels used when actually carrying out the work. However, it is sought to use data for vessels that could be expected to be used.

The estimated days of operation are estimated and include weather delays and other unforeseen events. Thus, these can be expected to be conservative.

18.2 Environmental assessments of chemical discharges

The amount and type of chemicals to be used have been assessed based on best available estimates from Wintershall Noordzee B.V.

The assessment of the impacts from the discharge of chemicals is based on ecotoxicological data provided in the HOCNF documents for the chemicals or pre-screening documents and thus a conservative estimate for the toxicity is used, as the toxicity for the original chemicals are used as a worst-case scenario though some of the product will degrade into reaction products with a lower toxicity. These data have been used in the modelling of impacts.

The dispersal modelling has been carried out using a model developed by COWI, based on the CHARM-model1 developed by the industry, chemical suppliers, and members of OSPAR. The dilution part of the model is a slightly modified version of the CHARM model, and estimations of risk indicators of negative environmental effects (PNEC and PEC/PNEC ratios) are calculated according to OSPAR guidelines. The dispersion model calculates PEC/PNEC ratios in up to 5 km from the discharge point.

Using the dilution model, the distance at which the chemical will impact the pelagic environment may be calculated. Rapid dilution of the discharges and biodegradation in the water column is ignored.

[1] CHARM = Chemical Hazard Assessment and Risk Management (Thatcher et al., 2017).

The distance at which the chemical will impact the benthic environment is calculated under the assumption that the sedimenting particles settle evenly around the platform under the influence of a standard refreshment rate of the seawater. Biodegradation in the sediment is assumed to occur only approx. 10 % of the time due to bioturbation of anaerobic marine sediments and resulting oxygen depletion.

The potential for bioaccumulation of discharged chemicals is assessed based on information on bioconcentration factors (BCF) or octanol-water partition coefficients (logPow). The potential for bioaccumulation is not quantified.

The model considers the conditions in the North Sea with a current velocity of 0,05 m/s. As the point of discharge for the chemicals used in the Ravn field, it is set at surface level.

The input and the model are attached with a range of uncertainties including:

- Uncertainties related to the actual products to be used
- Uncertainties related to estimated amounts of chemicals to be used and discharged
- Uncertainties related to the chemical testing including ecotoxicity of the chemicals
- Uncertainties related to the model.

The products modelled are what is expected to be used at the time of writing. However, the exact products are not yet decided upon, and thus the exact ecotoxicity profile can vary. However, it can be expected that the products used will be within the predicted pre-screening categories.

The exact amounts and discharges are estimated at the time of writing, and thus can be expected to be a conservative estimate and may vary with up to a factor 2.

The results are based on a range of assumptions of the processes taking place and are based on testing results. E.g., the partitioning coefficient are based on $logP_{ow}$ values and the ecotox data is also based on tests conducted for different trophic levels. These data are also attached with uncertainties and thus an assessment factor is applied in the magnitude of a factor 1000.

The model is likewise attached with uncertainties e.g., the concentration in the sea is attached with uncertainties due to fluctuations in the discharge and variations in the sea current. Thus, the model includes conservative calculations of the conditions.

As described above the results are attached with a whole range of uncertainties which added together could impact the results. However, conservative estimates are incorporated and thus the results are highly conservative.

18.3 Environmental assessment of waste amounts

The assessment of the waste amounts is based on the technical documentation received from Wintershall Noordzee B.V. No on-site visible inspection has been made. This has limited the possibility to take measurement of components and structures and to inspect the state of component inside.

The uncertainty on the estimate presented is -15% / +15%

19 Conclusion

The summary of the environmental risk assessment of the impacts from the planned activities are shown in Table 19-1 and the environmental risk assessment of an unplanned event (blow-out and spills).

The conclusion from the environmental risk assessment of the impacts during P&A activities can be expected to be **Negligible** or **Low**.

Table 19-1 Summary of the assessed environmental impacts of P&A of Ravn A1 and Ravn A2.

Impact	Environmental risk
Impacts of underwater noise on marine mammals	Negligible
Impacts of underwater noise on fish	Negligible
Impacts of discharges of chemicals to sea during P&A	Negligible
Impacts of air emissions (NO_X, SO_X)	Negligible
Impacts of air emissions (CO_2-eq)	Low
Impacts of waste production	Negligible
Impacts of use of natural resources	Negligible

Table 19-2 Environmental risk of blow-out and oil spill during the P&A of Ravn A1 and Ravn A2.

	Severity of impact	Likelihood of impact	Environmental risk
Blow-out	Minor	Very low	Negligible
Oil spill from vessels	Minor	Very low	Negligible

The P&A of Ravn A1 and Ravn A2 well will not negatively affect Natura 2000-sites or Annex IV species.

The environmental impacts will not influence the descriptors as defined in the Marine Strategy Framework Directive, or the impact will be **negligible**.

Based on the description of the environmental effects, the socio-economic effects of the P&A activities are expected to be negligible and therefore the socio-economic impacts of the activities are likewise expected to be limited. The effects after the activities are mainly expected to be positive, due to increased fishing opportunities.

20 References

Andersson M.,H., Andersson, S., Ahlsèn J., Andersson B.D., Hammar J., Persson L.KG, Pihl J. Sigray P., Wikström A. (2017). A framework for regulating underwater noise during pile driving. Vindval.Report 6775 August 2017.

ARSU (2022): Stilllegung der Pipelines zwischen A6-A und Ravn - Umweltfachlicher Vergleich zwischen dem In Situ-Belassen der Pipelines und dem Rückbau. 15 August 2022. Erstellt im Auftrag von: Wintershall Noordzee B.V.

Bach S.S., H. Skov and W. Piper (2010). Acoustic Monitoring of Marine Mammals around Offshore Platforms in the North Sea and Impact Assessment of Noise from Drilling Activities. SPE International Conference on Health, Safety and Environmental Oil and Gas Exploration and Production. 12-14 April. Rio de Janeiro Brazil. Society of Petroleum Engineers.

DEA (2009). Guidelines for Drilling – Exploration. 1988 (2009). Danish Energy Agency.

DEA (2022). Guideline for underwater noise. Installation of impact or vibratory driven piles. May 2022. Danish Energy Agency.

DCE (2021). Marine mammal species of relevance for assessment of impulsive noise sources in Danish waters. Background note to revision of guidelines from the Danish Energy Agency. Scientific note from DCE – Danish Centre for Environment and Energy. Aarhus University.

Delefosse, M., Rahbek, LM.L., Roesen, L., Clausen, K.T. (2018) Marine mammals sightings around oil and gas installations in the central North Sea. J Mar Biol Ass. 98(5): 993-1001

Däne M. et al (2013). Effects of pile driving on harbour porpoises (Phocoena phocoena) at the first offshore windfarm in Germany-Environmental Research letters 8: 025002.

E&P Forum (1994). Methods for estimating atmospheric emissions from E&P Operations, Report No. 2.59/197, The Oil Industry International Exploration & Production Forum.

EEA (2018) Contaminants in Europe's seas -Moving towards a clean, non-toxic marine environment. EEA report nr. 25/10/2018

Freon P., F. Gerlotto and O.A. Misund (1993). Consequences of fish behaviour for stock assessment. ICES mar. Sci. Symp, 196: 190-195. 1993.

GEUS 2019. Marine raw materials database. https://data.geus.dk/geusmap/

Kinze C. C. (2007). Hvaler s. 262 - 311. In: Dansk Pattedyr Atlas. Baagøe, H.J. & T. S. Jensen (red.) (2007) Gyldendal, København, 392 pp.

Knutsen H., C. Andrè, P.E. Jorde, M.D. Skogen, E. Thuròczy and N.C. Stenseth (2004). Transport of North Sea cod 'Larvae into the Skagerrak coastal populations. Proc. R. Soc. Lond. B 2004 pp 1338-1344.

Lack D (1960), Migration across the North Sea studied by radar Part 2. The spring departure 1956–59. Ibis, 102: 26–57.

Lack, D. (1959), Migration across the North Sea studied by radar Part 1. Survey throughout the year. Ibis, 101: 209–234.

Lack, D. (1963), Migration across the southern North Sea studied by radar Part 4 Autumn Ibis, 105: 1–54

Miljø og Fødevareministeriet (2017). Danmarks havstrategi, Indsatsprogram. 10. maj 2017. Miljøstyrelsen.

Miljø- og Fødevareministeriet (2019). Danmarks havstrategi II, Første del, God Miljøtilstand, Basisanalyse, Miljømål.

Miljø- og Fødevareministeriet (2020). Danmarks havstrategi II, Anden del, Overvågningsprogram, Juli 2020. Miljøstyrelsen.

Miljøministeriet (2021) Nye beskyttede havstrategiområder i Nordsøen og Østersøen omkring Bornholm.

Ministry of Environment and Food (2019) Danmarks havstrategi II, Første del. God miljøtilstand, basisanalyse, miljømål. Miljø- og Fødevareministeriet. ISBN: 978-87-93593-73-2

Mueller –Blenke, C., Gill, A.B., McGregor, P.K., Metcalfe, J., Bendall, V., Wood, D., Andersson, M.H., Sigray, P., Thomsen, F. (2010). Behavioural reactions of cod and sole to playback of pile driving sound. J. Acoust. Soc. Am. 128, 2332.

Munk P., P.J. Wright & N.J., Pihl (2002). Distribution of the early larval stages of cod, plaice and lesser sandeel across haline fronts in the North Sea. Estuarine and Coastal Marine Science 55: 139-149.

Munk P., P.O. Larsson, D. Danielsen & E. Moksness (1995). Larval and small juvenile cod *Gadus morhua* concentrated in the highly productive areas of a shelf-break front. Marine Ecology Progress Series 125: 21-30.

Munk P., P.O. Larsson, D. Danielsen & E. Moksness (1999). Variability of frontal zone formation and distribution of gadoid fish larvae at the shelf break in the north-eastern North Sea. Marine Ecology Progress Series 177: 221-233.

Oil & Gas Denmark (2017) Descriptor-based review of 25 years of seabed monitoring data collected around Danish offshore oil and gas platforms.

Olenin, S., Narščius, A., Minchin, D., David, M., Galil, B., Gollasch, S., et al. (2014). Making non-indigenous species information systems practical for management and useful for research: an aquatic perspective. Biol. Conserv. 173, 98–107.

Otto L., Zimmerman J.T.E., Furnes G.K., Mork R., Saetre R., Becker G. (1990). Review of the physical oceanography of the North Sea. Netherlands Journal of Sea Research. 26 ()2-4: 161-238

Reid J.B. P.G.H. Evans and S.P Northridge (2003). Atlas of Cetacean distribution in North-West European waters. Joint Nature Conservation Committee.

Reiss, H., Degraer, S., Duineveld, G., Kröncke, I., Craeymeersch, J., Aldridge, Robertson, M., VandenBerghe,E., VanHoey,G., Rees, H.L. (2010) Spatial patterns of infauna, epifauna and demersal fish communities in the North Sea. ICES Journal of Marine Science 67(2): 278-293

Sundby S., T. Kristiansen, R. Nash and T. Johannesen (2017). Dynamic Mapping of North Sea spawning. Report of the KINO Project. Fisken og Havet nr. 2-2017.

Skov H., J. Dürinck, M.F. Leopolds & M.L.Tasker (1995). Important Bird Areas in the North Sea--BirdLife International Cambridge.

Southall, B.L., et al.(2007). Marine mammal noise exposure criteria: initial scientific recommendations. Aquatic Mammals 33, 411–521.

Sveegaard, S. Nabe-Nielsen J. and Teilmann J. (2018). Marsvins udbredelse og status for de marine habitatområder i danske farvande. Aahus Universitet, DCE -Nationals Center for Miljø og Energi, 36 s. -Videnskabelig rapport nr. 284

Thompson et al. (2010). Assessing the responses of coastal cetaceans to the construction of offshore wind turbines. Marine Pollution Bulletin 60: 1200-1208.

Tougaard, J. (2014). Vurdering af effekter af undervandsstøj på marine organismer. Del 2 – Påvirkninger. Aarhus Universitet, DCE – Nationalt Center for Miljø og Energi, 51 s. - Teknisk rapport fra DCE - Nationalt Center for Miljø og Energi nr. 45.

Tougaard, J., Wright, A., & Madsen, P. (2016). Noise Exposure Criteria for Harbor Porpoises. In P. A., & H. A., The Effects of Noise on Aquatic Life II. New York, NY: Advances in Experimental Medicine and Biology, vol 875. Springer.

Todd et al (2009). Echolocation activity of harbour porpoises (Phocoena phocoena) around an offshore gas-production platform drilling rig complex. In: Fifth International Conference on Bioacoustics 2009, 31st March-2nd April 2009,

Todd V.L.G., P.A. Lepper & I.B. Todd (2007) Do harbour porpoises target offshore installations as feeding stations? 2007 IADC Environmental Conference & Exhibition 3rd April 2007, Amsterdam, Netherlands.

van Deurs, M. DTU Aqua-rapport nr. 348-2019. Understøttelse af den løbende udvikling af forvaltningsplaner for fiskebestande. Institut for Akvatiske Ressourcer, Danmarks Tekniske Universitet. 16 pp. + bilag

Weilgart, L.S. A (2007). Brief Review of Known Effects of Noise on Marine Mammals. International Journal of Comparative Psychology, 20(2), 159-168.

Wintershall Noordzee B.V. (2014). Environmental Impact Assessment. Ravn Field. Final report. COWI, May 2014.