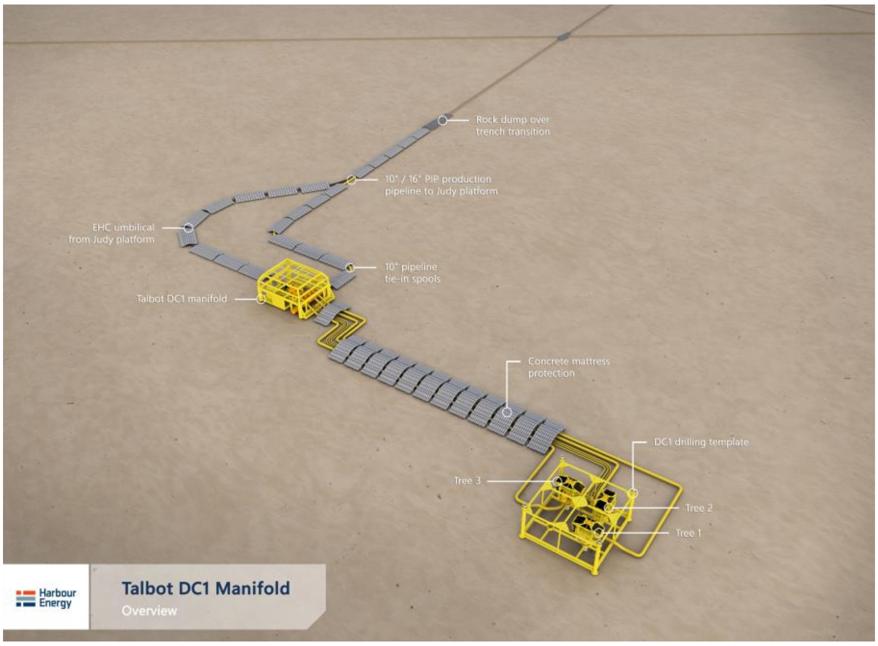
Harbour Energy

Talbot Field Development

Chrysaor Petroleum Company U.K. Limited

Environmental Statement



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0 Non-Technical Summary

This Environmental Statement (ES) presents the findings of the Environmental Impact Assessment (EIA) conducted by Harbour Energy PLC (Harbour) on behalf of itself and its co-venturer, ENI UK Limited to develop the Talbot Field. The Talbot Field is located in the central North Sea (CNS), on the United Kingdom Continental Shelf (UKCS) approximately 278 kilometres (km) southeast of Peterhead on Scotland's east coast, approximately 7 km west of the UK/ Norway median line and 16 km southeast of the existing Judy Platform (Figure 0:1). Water depth across the Talbot is between 71.2 and 75.4 metres (m) Lowest Astronomical Tide.

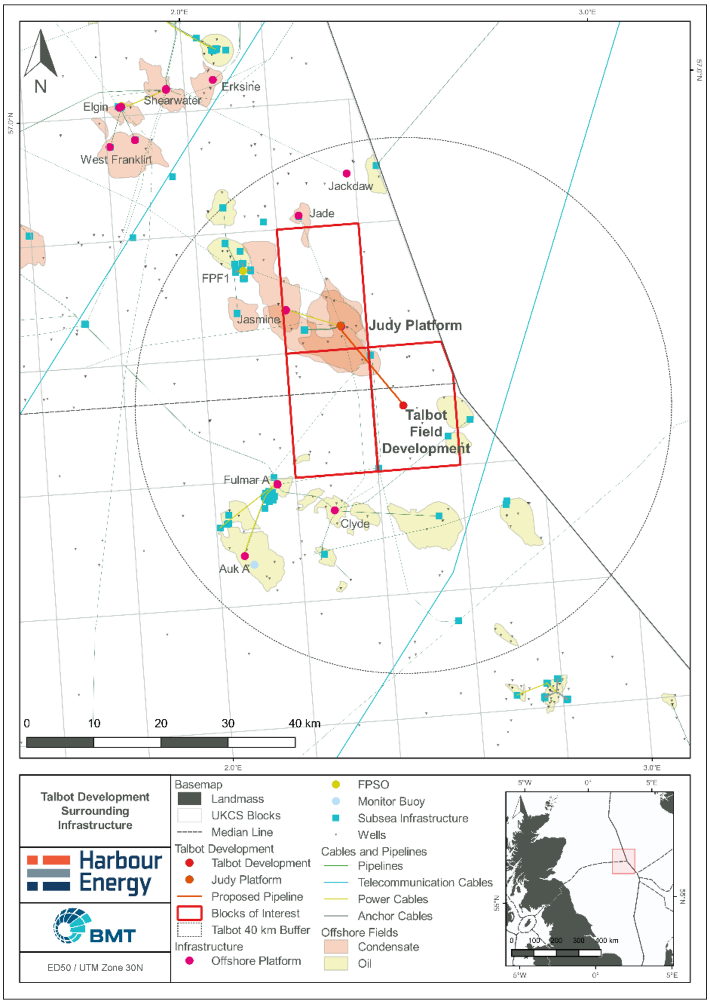

Figure 0:1 – Location of the Talbot Development project

The Talbot Field is proposed to be developed as a three production well subsea tie-back to the existing Judy Platform infrastructure for onward processing and export (Figure 0:2). Impact assessment has been undertaken for a 4th well should a redrill be required but production data is based only on a 3 well development in line with the Field Development Plan. This document assesses the potential impacts that may arise from the proposed, up to four well, development project with associated infrastructure at one drill centre, along with identification of mitigation measures to minimise any potential environmental or societal impacts.

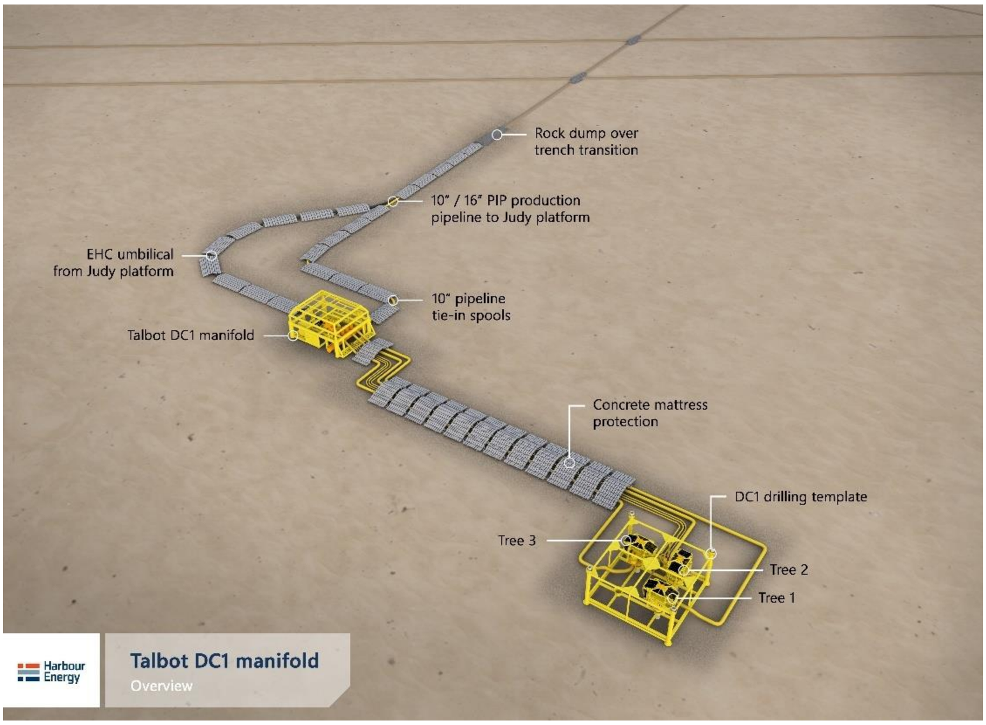

Figure 0:2 – Visualisation of Talbot 500m Zone

0.1 Project Description

Concept development and selection involved early engagement with key contractors, across the facilities and wells areas, integrated with Harbour team members. A concept matrix was developed to identify and then critically evaluate, as an integrated team, the decisions required to enable an economically efficient and environmentally responsible development. The key decision criteria for concept development in addition to minimising environmental and socioeconomic impact were:

1. Enable flexibility to capture the potential upside in recoverable volumes within the reservoir.
2. Maximise environmental performance through selection of efficient and effective processes and methodologies.
3. Development of the project so as to allow Harbour to meet their 2035 Net Zero target.
4. Minimise cost and schedule to achieve a lower minimum economic field size given the range of recoverable resources in the Talbot Field.

After drilling and evaluating the Talbot field appraisal well the proposed Talbot Field Development scope and scale was established as three development wells within a four-slot drilling template and three subsea production systems installed within a subsea manifold. The manifold, nearby to the drilling template structure, will be installed using spools to connect to the three subsea production systems.

Connections between the Talbot subsea manifold and existing Judy infrastructure will come from a 10”/16” (or 12”/18”) subsea pipe-in-pipe (PiP) production flowline and umbilical carrying power, communications, hydraulic supply, methanol and chemicals, with an approximate length of 16 km. These will connect with the existing PL1000 “South” Joanne 12” production pipeline within the 500 m safety zone of the Judy Platform.

The development wells and associated subsea infrastructure will be controlled by a hydraulic-electrical control system and chemical injection system on the Judy Platform. First production is estimated to begin in Q3 2024.

0.2 Environmental Baseline

Information about the Talbot Field Development marine environment and the surrounding area has been collated to allow an assessment of those features that might be affected by the proposed installation, operation and decommissioning activities associated with development of the Talbot Field.

Dedicated site specific surveys, geophysical, environmental baseline survey and habitat assessment have been conducted in the Talbot Field Development area specifically for this project. Additionally, Jasmine to Judy export pipeline survey was used as a source of information for the project baseline. The Talbot Field Development traverses the English and Scottish offshore waters boundary.

The Talbot reservoir lies within Block 30/13e, in the CNS. The pipeline connection from the Talbot Field to the Judy Platform infrastructure, located in Block 30/7a, will cross Blocks 30/13, 30/12 and 30/7. The proposed Talbot Field Development lies within a relatively homogenous seabed with no notable bathymetric features, deepening very gently towards the northwest. The surficial seabed sediments are medium density silty fine sand with frequent shell fragments. The sediment chemistry was considered representative of background for the central North Sea.

Tidal currents in the central North Sea area are generally weak and are readily influenced by other factors such as winds and density driven circulation. This results in a relatively atypical pattern to the tidal currents. Tidal currents in the Talbot field development area are between 0.25 and 0.50 metres per second (m/s) for maximum spring tides and between 0.11 and 0.25 m/s for maximum neap tides. The annual mean wave height at the Talbot field development area varies between 2.01 and 2.25 m.

The Fulmar Marine Conservation Zone (MCZ) is located within Blocks 30/12 and 30/13 and overlaps with the proposed Talbot Field Development. The MCZ is designated for protection of broad-scale habitats of subtidal mud, subtidal sand and subtidal mixed sediment, as well as protection of hard-shell clam ocean quahog (*Arctica islandica*). It also protects important habitats for marine animals, providing food, spawning areas and shelter. Offshore subtidal sands and gravels and ocean quahog are listed as a Priority Marine Features. Potential Annex I habitats exist within 40 km of the block of interest, however no Special Areas of Conservation (SACs) designated for the protection of Annex I habitats are located near the Talbot Development. Of the possible Annex II species recorded in the North Sea, only harbour porpoise has been sighted in significant numbers around the Talbot site.

Plankton is typical for this area of the central North Sea. The benthic fauna can be described as typical for offshore circalittoral sand sediments of the central North Sea, characterised by a diverse range of macrofaunal species, namely polychaetes (dominated by bristle worms), arthropods (including crabs and shrimps), molluscs (including bivalves and snails) and echinoderms (including star fish and brittle stars). Ocean quahog, species of conservation importance, were recorded during the environmental baseline surveys.

Spawning areas for cod, lemon sole, mackerel, Norway pout, plaice and sandeel have been identified in the Talbot area. Anglerfish, blue whiting, cod, European hake, haddock, herring, ling, Norway pout, plaice, sandeel, spotted ray, sprat, spurdog and whiting have potential nursery areas within the area.

The most common species of seabird found in the Talbot area include the Northern Fulmar (*Fulmarus glacialis*), Northern Gannet (*Morus bassanus*), Great Skua (*Stercorarius skua*), Arctic Skua (*Stercorarius* *parasiticus*), Black-legged Kittiwake (*Risa tridacla*), Great Black-backed Gull (*Larus marinus*), Common Gull (*Larus canus*), Herring Gull (*Larus argentatus*), Common Guillemot (*Uria aalge*), Razorbill (*Alca torda*), Little Auk (*Alle alle*), and Atlantic Puffin (*Fratercula arctica*) (Kober et al., 2010). Seabird sensitivity peaks at extremely high in May and June in the surrounding blocks, followed by very high at Block 30/13 in May and June. In the remaining months seabird sensitivity is low in Blocks 30/13, 30/12, 30/7 and surrounding blocks, with the exception of Block 30/12 in February which has a medium seabird sensitivity. There was no data available in October and November for all blocks within Talbot area, and data for April and December were only available for some blocks.

Cetacean species known to occur in the area include minke whale (*Balaenoptera acutorostrata*), bottlenose dolphin (*Tursiops truncatus*), common dolphin (*Delphinus delphis)*, white-beaked dolphin (*Lagenorhynchus albirostris)*, white sided dolphin (*Lagenorhynchus acutus)* and harbour porpoise (*Phocoena phocoena)*. Very high abundance of white-beaked dolphin has been sighted in the area during May, while very high abundance of white-sided dolphin has been sighted in July. Grey and harbour seals may be found in very low abundance.

The Talbot Field Development is located within an area defined by the International Council for the Exploration of the Sea (ICES) as rectangle 42F2 and for 2020 had a relative value to the UK commercial fishing industry of £18,196, with a total landing of 8 tonnes. Only active demersal fishing gear was used in the area, with fishing effort mainly occurring between April and August. Twenty-five demersal species, 5 shellfish species and 1 pelagic species were targeted.

Shipping density in Block 30/7 is low, while shipping density in Blocks 30/13 and 30/12 is considered very low. There are no renewable energy developments, aggregate extraction licences or military exercise areas in the vicinity of the proposed Talbot Field Development. There are three potential carbon capture and storage sites (May, Balder and Forties) within the Talbot Field Development area.

Nine oil and gas platforms are located within 40 km of the Talbot infrastructure. In addition, there are 13 wells within Block 13/30, and 61 pipelines within a 40 km radius.

Two telecommunication cables are located in the near vicinity of the Talbot Development. The TAMPNET Clyde telecommunication cable is located in Blocks 30/12 to Block 30/13, and the TAMPNET Valhall telecommunication cable is located approximately 9 km southeast of the Talbot field development.

There are three unknown wrecks within the proposed Talbot Field Development. Two of the wrecks are located in Block 30/7 and one is located in Block 30/13. All the wrecks are classified as non-dangerous, and none is a designated wreck of historical significance.

0.3 Environmental Impact Assessment Approach

Harbour undertook the following tasks to identify key environmental sensitivities, and discuss sources of potential impact and identify those sources which required further assessment:

- An Environmental (Risk) Identification (ENVID) Workshop for the project team and independent environmental consultants.
- Informal consultation following submission of a scoping report. Responses were received from the Department for Business, Energy & Industrial Strategy, Ministry of Defence, Marine Coastguard Agency, Marine Scotland, Scottish Fishermen's Federation, National Federation of Fishermen's Organisations and the Joint Nature Conservation Committee (JNCC).

This approach identified the following key issues for impact assessment:

- Physical seabed disturbance;

- Drilling and production discharges;
- Atmospheric emissions;
- Noise generation;
- Accidental events; and
- Societal impacts.

To help inform these assessments, the following supporting studies were also conducted:

- Accidental hydrocarbon releases numerical modelling;
- Atmospheric emissions and greenhouse gas (GHG) assessment;
- Underwater noise modelling; and
- Vessel traffic survey.

Each of the key issues are fully assessed in the individual impact sections of the ES, including residual, cumulative, transboundary and decommissioning environmental impacts. Mitigation measures to be put in place to manage and reduce impacts to an acceptable level were also described. The impact assessments are summarised below in Sections 0.4 to 0.9.

0.4 Seabed Impacts

The Talbot Field Development infrastructure which has the potential to result in seabed impacts includes the physical presence of the mobile offshore Heavy Duty Jack Up (HDJU) drilling unit/ rig, anchoring of the HDJU rig, one subsea manifold structure, one drilling template, subsea pipeline (pipe in pipe) to the Judy Platform and placement of protective materials.

Where infrastructure or anchors are placed on the seabed, there will be disturbance to and displacement of the species present. The seabed may not fully recover until cessation of the production at the field and removal of associated infrastructure.

Seabed impacts will be both short- and long-term. Short-term seabed impacts associated with temporary activities may result in sediment disturbance and benthic disturbance. Long-term seabed impacts associated with permanent placement of materials such as pipelines, mattresses and rock, will result in benthic disturbance and habitat change.

The seabed disturbance from the Talbot Field Development will be localised to an area of 0.18 km^2 of seabed, of which 0.046 km^2 will be within the Fulmar MCZ. The seabed is expected recovery over time, through the natural processes of re-sedimentation and re-colonisation of benthos from the surrounding areas. Whilst the seabed sediments and habitats within the development area are relatively homogenous, it does have the potential to support a species of specific conservation concern, the ocean quahog. The total area of the Fulmar MCZ impacted by planned Talbot activities is relatively small, estimated at 0.002% of the total protected area.

The cumulative long-term impact of the Talbot Field Development is considered to be negligible given that the majority of the subsea infrastructure will be removed within the blocks of interest. Decommissioning surveys have shown seabed recovery following infrastructure removal in the area. As such, it is considered that whilst this development may contribute towards long-term cumulative impacts, this may be naturally remediated following removal of the development infrastructure.

Overall, the potential seabed impact from the Talbot Field Development is considered to be of medium significance.

0.5 Drilling and Production Discharges

During the Talbot project, discharges to sea primarily result from the drilling phase. These constitute drill cuttings, cement and associated chemicals. Discharged cuttings will consist of, seabed constituents, seawater, sweeps and water based muds and as such will have little or no toxic effects upon the marine environment. The potential effects are anticipated to be smothering and/ or habitat loss. Existing evidence suggests that seabed recovery will commence shortly following completion of drilling operations. The presence of drill cuttings piles is expected to remain and influence seabed over the long-term. The cuttings resulting from the use of low toxicity oil based mud will be either be treated offshore by an offshore cuttings processing unit or placed in skips and shipped to shore for treatment and disposal. Both options have been retained and are under further assessment.

The Talbot cuttings piles are expected to contribute an additional 0.2% of the total central North Sea cuttings pile volume. Consequently, the cumulative effects of discharged cuttings for the Talbot Field Development are considered negligible.

Mud, cementing and completion chemicals which are planned for use within the Talbot project are subject to control under the Offshore Chemicals Notification Scheme (OCNS) and the Offshore Chemicals Regulations, 2002 (as amended). Harbour intends to predominantly use chemicals which Pose Little or No Risk, OCNS category E or low risk quotient, and have been selected to minimise impacts upon the marine environment. These discharges are not expected to have any toxic effect upon the marine environment.

Based on the consideration and calculation of planned discharges to sea during the drilling, installation, commissioning and operational stages, it is anticipated that some short-term and localised impacts will be observed in the surrounding marine environment. The environmental risks are therefore considered acceptable when managed within the additional controls and mitigation measures described in the ES with no anticipated impact to the Fulmar MCZ site conservation objectives. Discharges that do occur will be dilute before entering the marine environment and of low toxicity. Smothering events may impact individuals near the wellsite but will have a negligible impact away from the immediate area. All impacts will be localised and limited.

0.6 Atmospheric Emissions

Atmospheric emissions will be produced during drilling and production operations, as a result of power and heating requirements onboard the HDJU rig, construction vessels, the Judy Platform and helicopters activities as well as associated support vessels. These emissions will contribute to local and global environmental effects. At a local level, impacts are mitigated by health and safety measures in place to control emissions and by the dispersive nature of the offshore environment. Localised impacts from combustion emissions during Talbot operations are considered to be negligible

Atmospheric emissions considered in this ES will be produced during fabrication of new materials (embodied carbon), drilling and production operations, as a result of power and heating requirements onboard the HDJU rig, construction vessels, the Judy Platform, and helicopters activities as well as other associated support vessels. The worst-case annual CO_2 equivalent (CO_2e) Global Warming Potential (GWP) contributions, expressed in tonnes of CO_2e, from the proposed Talbot Field Development is relatively small (45,742 tonnes) which is 0.03% of the annual total 2018 GWP emissions at a UK wide level (14,804,699 tonnes). Relative to the total UKCS atmospheric emissions, those generated during Talbot operations are not considered to be significant. It is not possible to assess the cumulative impact of atmospheric emissions from the proposed operations to potential global environmental impacts, such as global climate change, but Talbot will inevitably contribute to an increase in global emissions.

No measurable cumulative impact is expected between Talbot development project and Judy Platform due to the distance of Talbot from Judy. Locally at Talbot there may be a slight reduction in air quality and a localised cumulative effect during some points in the development with multiple vessels on location simultaneously but this will be temporary in nature and the offshore environment will typically rapidly disperse emissions. There will be no impact on protected sites or on species from protected sites, the local cumulative consequence of atmospheric emissions is ranked as negligible.

Harbour is committed to the dual challenge that the world energy markets face, whereby an increase in energy supply is required to meet local and global demand growth, but with lower GHG emissions. Key to this is appreciating the context of the business and understanding what Harbour can influence, either directly or indirectly, by taking action to minimise the use of energy and emission of gases with a global warming potential.

Central to this is the Scottish and UK Governments' long-term goal of being a net carbon zero economy by 2045 for Scotland and 2050 for the rest of the UK. Harbour has aligned to the North Sea Transition Deal (NSTD), UK Net Zero Strategy, Energy White paper, and the UK Carbon Budgets by setting a net zero target by 2035 and continues to develop the short-term and medium-term targets to ensure the business is on the correct trajectory to net zero.

The NSTD introduces targets to reduce GHG emissions from upstream oil and gas activities through Supply Decarbonisation, against a 2018 baseline, by 10% in 2025, 25% in 2027 and 50% in 2030, while reducing carbon emissions to zero by 2050. Following the initial GHG emissions from the installation and commissioning of Talbot, the subsequent years will show only a marginal increase in base case emissions and a positive impact on the Judy Platform's carbon intensity profile. The emissions from the Talbot Field Development, as a proportion of the allotted emissions from the UKCS, do not hinder progress towards the targets or adversely affect the ability of the offshore oil and gas industry to meet them.

The UK Committee on Climate Change (CCC) 6th Carbon Budget (UKCCC, 2020) sets a challenging carbon budget for 2033-2037 following the adoption in law of achieving net zero emissions by 2050 (and 2045 in Scotland). A key element of the Balanced Net Zero Pathway used for the CCC 6th Carbon Budget builds on a study into electrification of the UKCS by the OGA which affirms that oil and gas platform electrification is essential to cutting sector production emissions

Key industry members, including Harbour, are collaborating in a multi hub CNS Electrification project which aims to significantly reduce production emissions from key CNS infrastructure through electrification, and if executed (please note Harbour has not committed to at this stage) would make a material contribution to the NSTD target of reducing production emissions by 50% by 2030. The Talbot Field Development ties in to the longevity of the Judy platform, and as such supports the CNS Electrification Project. Should the CNS Electrification Project proceed with J-Area participation, it is expected to offset the incremental emissions from Talbot.

0.7 Noise Generation

The principal sources of noise generation originate from vessels, helicopters and piling activities. The pile driving operations associated with the installation of the drilling template and manifold will generate impulsive noise and the impact from these will likely dominate any of the continuous noise sources such as those from vessels, while all other installation activities will be dominated by continuous vessel noise.

The main environmental receptors of the noise impact are marine mammals. Records indicate previous sightings of up to six cetacean and two pinniped species within the Talbot Field Development area throughout the year. These species are all subject to regulatory protection from injury and disturbance.

The predicted cumulative source sound level during the piling operations is 218.5 dB re 1 µPa m during pile driving into the seabed, which does not exceed the threshold for injury to cetaceans. During piling, cetaceans may be temporarily displaced from the centre of operations. There is a potential for marine mammals to suffer injury within about 15 m of the piling. Non-piling operations, like vessel activity in the Talbot area, are unlikely to cause injury to any marine mammals. Temporary displacement from cumulative vessel noise may occur during piling operations.

Harbour will consult with JNCC closer to the start of the piling activities and an agreement will be made to put in place appropriate mitigation measures.

0.8 Accidental Events

Two major types of accidental events were considered: hydrocarbon and chemical spills.

0.8.1 Hydrocarbon Spill

The risk of an accidental hydrocarbon spillage to the sea is an environmental concern associated with offshore oil industry activities. Spilt oil at sea can have a number of environmental and economic impacts, the most conspicuous of which are on seabirds and coastal areas. The impacts will depend on a multitude of factors, including the volume and type of hydrocarbon released, the metocean and meteorological conditions during the spill event, and response to the oil spill.

A well blowout involving the uncontrolled release of fluids from a wellhead has been identified within this EIA as having the potential to cause the worst-case hydrocarbon spill in terms of surface oiling, water column contamination and coastal oiling. The behaviour and consequences of an accidental hydrocarbon release has been numerically assessed for the well blowout scenario.

The numerical modelling based on this scenario has indicated that the:

- The well blowout scenario resulted in a potential environmental impact in terms of surface, water column and shoreline oiling;
- The coasts of western Norway and Sweden are predicted to be impacted with the overall shortest arrival time of 24 days for Norway;
- The probability of shoreline oiling is the highest on the western coast of Norway with a probability of 35%; and
- The maximum amount of oil that came ashore in any one simulation is, approximately, 108 m^3 (or 89.7 tonnes), for a simulation starting during spring months.

The vulnerability of seabirds to oil pollution in Talbot area varies from low to high throughout the year, with increased vulnerability corresponding to the periods when coastal bird colonies feed offshore and during periods of moulting.

There is the potential for MCZs, Nature Conservation Marine Protected Areas (NCMPAs) and Special Areas of Conservation (SACs) to be impacted by a well blowout. The Fulmar MCZ, Swallow Sand MCZ, East of Gannet and Montrose Fields NCMPA, Norwegian Boundary Sediment Plain NCMPA and the Dogger Bank SAC may all be affected by surface oiling.

Historical data indicates that the likelihood of a release is remote. The planning, design and support of all activities for the Talbot Field Development aims to eliminate or minimise potential environmental risks from well drilling and during operations. Further, Harbour will have a range of detailed and fully tested contingency response plans to respond to such an event. As such the likelihood of an accidental hydrocarbon release is considered to be reduced to as low as reasonably practicable.

Inherently, there exists the potential for cumulative impacts should an accidental hydrocarbon release occur at the proposed Talbot Field Development. The probability of a release is remote thus limiting the cumulative impact from the Talbot Field Development and existing installations.

Following cessation of production, the main source of an accidental hydrocarbon release will be removed from the Talbot Field Development area. Thus, the likelihood of a major hydrocarbon release is low following decommissioning.

0.8.2 Chemical Spill

The environmental implication of a chemical spill is largely dependent on the type of chemical involved, the spill's size and location, and the prevailing weather conditions. The hazard presented by a spill will also depend on the exposure concentration, which is determined by the quantity and rate of spillage, and the dilution and dispersion rates. Most chemicals will be diluted by the seawater very quickly after which they will gradually disperse and degrade.

Control and mitigation of accidental chemical releases includes use of appropriate storage containers with sealed drainage and bunding, risk assessments for specific activities and the application of suitable operational procedures. All chemicals used offshore have been approved for use in the UKCS by the Centre for Environment, Fisheries and Aquaculture Science and the Offshore Petroleum Regulator for Environment and Decommissioning.

The low risk associated with an accidental chemical release would not likely result in a cumulative impact. Should any spills occur, they would be mostly small (less than one tonne), rarely exceeding 10 tonnes, of a limited duration and be localised around the discharge point. The potential for cumulative effects from a chemical release is considered to be negligible.

All chemicals used will have been approved for use under the relevant chemical permit and so would be unlikely to present a significant environmental risk. Preference will be given to the selection and use of low dosage, low risk chemicals. As a result, the environmental risks from chemical spills are considered minor.

0.9 Societal Impacts

Following completion of construction activities, societal impacts to commercial fishing activity and commercial shipping will be largely due to the introduction of 500 m exclusion zones. These zones will reduce the area available for fishing during the duration of oil and gas operations at Talbot, as well as limit vessel traffic access in the vicinity. However, these impacts will be minimised by reducing vessel traffic in the area and by notifying relevant users via notices to mariners. The loss of access will be limited to the lifespan of the Talbot Field Development, as the area will likely become available to other users of the sea following decommissioning of the development. Although the development is close to the UK/ Norway median line, no transboundary societal impacts have been identified.

Onshore societal impacts are possible from the transport of waste to shore which will use recycling facilities and/ or landfill resources. The impact will be minimised by segregation and recycling of waste and the use of licensed waste handling facilities. The introduction of additional offshore waste to a facility is likely to result in additional traffic and waste treatment, which may result in deterioration of air quality locally and temporarily this however, will only be during the project phase and once operational waste generation accountable to Talbot will be minimal.

Talbot will contribute positively to the economy with many local companies being contracted to undertake and support this project and ultimately mobilise UK controlled hydrocarbons; generating revenues and helping with security of supply.

0.10 Mitigation and Controls

Mitigation measures have been developed and will be implemented for the Talbot Field Development to reduce potential impacts to as low as reasonably practicable. A commitments register is included within the ES which summarises the mitigation measures for incorporation into the Harbour Environmental Management Plan. The commitments will be reviewed regularly to ensure that they are being met.

0.11 Environmental Management System

Harbour has a Health, Safety, Environment, Quality (HSEQ) and Asset Integrity (AI) system, which will be implemented for the Talbot Field Development. This management system identifies, evaluates, manages and controls potential HSEQ, AI and marine hazards facing UK operations. A company commitment has been made by Harbour to successfully implement and operate all aspects of the management system throughout all activities.

Reflecting industry best practice, this HSEQ and AI management system recognises the principles of ISO international standards including ISO 14001 (environment) and ISO 9001 (quality). There are a number of associated benefits with the business EMS having ISO 14001:2015 accreditation including, but not limited to, promoting continual improvement, maintaining a high internal environmental management standard and aligning to Harbour's values and business principles.

Application of the management system will ensure the identification and mitigation of risk. For this ES potentially significant environmental risks are identified and addressed in an Environmental Management Plan (EMP). This plan will be implemented and maintained during the field life to reflect changes in legislation, guidance and industry standards.

0.12 Conclusions

The Talbot Field Development has considered the objectives and marine planning policies of the Scottish National Marine Plan and the Northeast Offshore Marine Plan. Harbour considers that the Talbot field development is in broad alignment with these objectives and policies. This ES has been developed in line with the requirements set out in the 2020 Offshore EIA Regulations and Guidance (July 2021).

The Talbot Field Development project will be developed incorporating current best practices. Detailed design, strong operating practices and using appropriately trained personnel will ensure the proposed project does not result in significant long-term environmental, societal, cumulative or transboundary effects. Additional procedures will be in place during the operating phase to ensure effective and rapid response to potential emergency scenarios. Mitigation measures have been developed to reduce the environmental and societal impacts. These will be incorporated into the project's EMP.

Talbot Field Development project is expected to have a positive impact on the Judy Carbon Intensity performance and will still allow Harbour to meet their 2035 Net Zero target.

The ES assesses the worst-case scenario and as such represents a conservative indication of the potential impacts. The most substantial potential impact identified during the EIA is that of a well blowout. However, the probability of such an event occurring is very low and Harbour will have in place control measures that meet or exceed stringent industry standards for well control to further reduce/mitigate the risks and potential impacts.

Overall, seabed impact resulting from the placement of the development infrastructure is considered to have a low to medium significance. Following decommissioning of the subsea infrastructure, the seabed and benthic communities are expected to recover over time through re-sedimentation and recolonisation by marine species from the surrounding areas.

Underwater noise resulting from piling is unlikely to contribute any significant impact on marine species. Harbour will consult with JNCC closer to the start of the piling activities and an agreement will be made to put in place appropriate mitigation measures.

All other issues assessed during this EIA were concluded to have a negligible impact upon the environment. Therefore, it is the conclusion of the ES that the current proposal to develop the Talbot Field can be completed without causing significant impact to the environment or society.

0.13 Mitigation and Control

Several mitigation measures have been developed and will be implemented to ensure that the potential impact from Talbot is not significant. The commitments register (Table 0:1) summarises the mitigation measures and will be incorporated into the Harbour EMP. Each commitment will be reviewed regularly to ensure that it is being met.

Table 0:1 – Mitigation measures and commitments register

Aspect	Commitment
Physical Seabed Disturbance (ES Section 6)	Post-decommissioning survey and remediation when needed.
	Seabed visual inspection prior to placement of drilling template and manifold.
	ROV monitoring of rock placement and mattress deployment.
	Rock berm profile overtrawlable and rock size graded.
	The quantity of rock placement and mattresses will be minimised.
	Rock to be placed by fall-pipe for accurate deployment.
	Established 500 m safety zone around HDJU drilling rig, with seabed infrastructure around the drill centre placed within a 500m zone.
	Designated lifting zones on rig and platform (dropped object control).
	Pre- and post-installation debris surveys.
Discharges to Sea (ES Section 7)	The use and discharge of the drilling, cementing and completion chemicals will be approved under a drilling application with a well specific chemical permit.
	Only permitted discharge of WBM cuttings.
	WBM formulations use mainly PLONOR chemicals.
	Cement returns monitored by ROV, and mixing will stop as soon as returns at surface are observed.
	Excess dry cement will be shipped to shore.
	Cement volumes will be carefully calculated, and volumes of excess cement will be minimised by following good operating procedures.

	Only visibly clean fluid will be discharged, that meets permit discharge criteria.
	Discharge samples and analysis as per permit required during wellbore clean-up.
	Produced fluids from Talbot will be routed to the Judy platform where produced water will be treated and discharged overboard as per updated existing platform oil discharge permit.
Atmospheric Emissions (ES Section 8)	Adherence to strict maintenance regimes for all equipment and vessels.
	Equipment kept at optimum efficiencies to minimise fuel consumption.
	Flaring will be minimised and is planned to occur for start-up and shutdown only. Development well clean ups are planned to utilize the separator on Judy rather than flare offshore on the rig.
	Vessel and fuel use optimised where possible by minimising the number of vessels required and their length of time on site.
	Some of the gas produced from Talbot will be utilised for power generation on Judy platform, reducing the quantity of produced gas to be flared and the need for additional diesel fuel.
	Sea and air supply traffic managed to minimise number of trips.
Underwater Noise (ES Section 9)	Pre-piling searches by qualified marine mammal observers (MMO) for marine mammals 30 minutes prior to activity.
	At least 500-m radius search/ mitigation zone around the piling operations.
	Piling delayed if positive sighting/ detection within mitigation zone.
	Minimum 20-minute minimum soft-start of pile driver with incremental increase.
	Searches and soft start repeated for all breaks in piling activity.
	Acoustic Deterrent Devices considered if determined appropriate.
	Report piling activity and any marine mammal detections via the MMO report submitted upon completion.
	Machinery and equipment in good working order and well-maintained.
	The number of vessels utilising DP will be optimised.
Accidental Release (ES Section 10)	Operations undertaken utilising an approved OPEP and CIP.
	Relief well plan in place for well blowout scenario.
	Well control contingency planning.
	Management policy to be adhered to.
	Install BOP.
	Mariner notices/ shipping alerts for leaks, ruptures, vessel collisions.
	Provide accidental release data/ information for Kingfisher charts.
	Use of standby vessels to reduce chances of loss of inventory from vessel collision.
	Use industry standard notifications, navigation aids and communications.
	Ensure consent to locate and OPEP is put in place prior to any offshore activities.
	Prior to rig transfer check of hose maintenance procedures and compliance with interface documents.
	Break away couplings and observers with radios for fuel transfers to minimise spillage.
	High level alarms for spill alerts.
	Constant and clear communication regarding rig moves.
	Mud and chemicals are correctly stored in bunded areas.

	Chemical handling risk assessment. With plentiful oil and chemical spill kits around the rig.
	Rig procedures for chemical handling and movements.
	Designated lifting zones on rig and platform (dropped object control).
	Pre- and post-installation debris surveys.
	Lift planning will be undertaken to manage lifting activities, to include consideration of prevailing environmental conditions.
Societal Impacts, ES Section 11	Mariner notices/ shipping alerts will be issued for all vessel movements.
	500 m mitigation zone around drilling rig, eliminating potential conflict with fisheries and commercial vessels.
	Industry standard notifications, navigation aids and communications including e-mail, will be used for all rig moves.
	Consent to locate will be in place assessing vessel interaction risks
	Information supplied for Kingfisher charts.
	Controlled/ monitored deployment of jack-up rig.
	Post-installation of jack-up rig seabed survey.
	Geophysical survey and EBS will determine the extent of potential rock placement and also identify and facilitate rig placement to avoid any sensitive habitats.
	Operational controls during trenching and burial, including accurate positioning and in situ monitoring by ROV, with pre- and post-lay surveys.
	Optimise use of rock and mattresses wherever possible to reduce size of footprint.
	Seabed infrastructure to be fishing-friendly by design.
	Use of fall-pipe and ROVs to monitor rock dump placement and mattress placement to ensure accurate deployment and optimised quantity of rock used
	Rock berm profile overtrawlable with rock sizes graded.
	Best practice when conducting onshore disposal of solid waste (rig and vessels) at licensed wastes facilities, as defined in waste management procedures
	Ensure majority of recyclable waste is recycled
	Pipeline route survey, EBS, engineering studies and planning to optimise the pipeline configurations, designs, routes and installation methods.
	LTOBM recirculated within a closed system and recovered to the rig, contained and shipped to shore for treatment (e.g., thermal desorption) and disposal.
	Ensure subsea structures are fishing friendly.

Abbreviations, Acronyms and Units

Term	Definition
%	Percentage
”	inch
°C	degrees Celsius
µPa	MicroPascal
AET	Apparent Effects Thresholds
AHV	Anchor Handling Vessels
AI	Asset Integrity
AICD	Autonomous Inflow Control Device
ALARP	As Low as Reasonably Practical
API	American Petroleum Institute
As	Arsenic
ASSI	Area of Special Scientific Interest
AVO	Bright Far Offset Seismic Amplitudes
Ba	Barium
BAT	Best Available Techniques
bbls	Barrels
BEIS	Department for Business, Energy and Industrial Strategy
BEP	Best Environmental Practice
BOP	Blow Out Preventer
BOPD	Barrels of Oil Per Day
BTEX	Benzene, Toluene, Ethylbenzene and Xylene
c.	Circa (approximately)
CA	Comparative Assessment
CaCO3	Calcium Carbonate
CAPEX	Capital Expenditure
CATS	Central Area Transmission System
CCS	Carbon Capture and Storage
Cd	Cadmium
CEFAS	Centre for Environment, Fisheries and Aquaculture.
CH_4	Methane
CNS	Central North Sea
CO	Carbon monoxide
CO_2	Carbon Dioxide
CoP	Cessation of Production
CSV	Construction Support Vessel
CtL	Consent to Locate
Cu	Copper
dB	Decibel
dBht (species)	Sound level in decibels above the hearing threshold of a species
DC	Drill Centre
DECC	Department of Energy and Climate Change
DEFRA	Department of Environment, Food and Rural Affairs
DP	Dynamic Positioning
DPM	Diesel particulate matter
DROPS	Dropped Objects Prevention Scheme
DSV	Dive Support Vessel
DTI	Department of Trade and Industry
EC	European Commission
EEMS	Environmental and Emissions Monitoring System
EEZ	Exclusive Economic Area
EIA	Environmental Impact Assessment
EIF	Environmental Impact Factor
EMODNet	European Marine Observation and Data Network
EMP	Environmental Management Plan
EMS	Environmental Management System
ENVID	Environmental (risk) Identification (workshop)
EOR	Enhanced Oil Recovery
EPS	European Protected Species
ERRV	Emergency Response and Rescue Vessel
ES	Environmental Statement
ESAS	European Seabirds at Sea
ETS	Emissions Trading Scheme

Term	Definition
EU	European Union
EUNIS	European Nature Information System
EWT	Extended Well Tests
FDP	Field Development Plan
FeAST	Features, Activities, Sensitivities Tool
FEED	Front-End Engineering and Design
FID	Financial Investment Decision
FPSO	Floating production storage and offloading (vessel)
ft	foot
GHG	Greenhouse gases
GWP	Global warming potential
h	hours
HDJU	Heavy Duty Jack Up
HIPPS	High Integrity Pressure Protection System
HP	High Pressure
HP/ LP	High-pressure to low-pressure
HPHT	High-Pressure and High-Temperature
HSEQ	Health, Safety, Environment and Quality
HYCOM	Hybrid Coordinate Ocean Model
Hz	Hertz
ICD	Inflow Control Device
ICES	International Council for the Exploration of the Sea
ICV	Inflow Control Valves
IoP	Institute of Petroleum
IPIECA	International Petroleum Industry Environmental Conservation Association
ITOPF	International Tanker Owners Pollution Federation Limited
JRP	Jasmine Riser Platform
JNCC	Joint Nature Conservation Committee
JWHP	Jasmine Wellhead Platform
kHz	kilo hertz
km	kilometre

Term	Definition
km^2	kilometre(s) squared
LAT	Lowest Astronomical Tide
LOD	limits of detection
LP	Low Pressure
LTOBM	Low toxicity oil-based mud
LWIV	Light Well Intervention
m	metre(s) (All water depths are given to Lowest Astronomical Tide)
m/s	metres per second
m^3	metre(s) cubed
MARPOL	The International Convention for the Prevention of Pollution from Ships
mbwpd	Million barrels of water per day
MCA	Marine Coastguard Agency
MCZ	Marine Conservation Zone
MEG	Mono-Ethylene Glycol
MER	Maximise Economic Recovery
mg	milligrams
mg/l	milligrams per litre
mm	millimetres
MMBOE	million barrels of oil equivalent
MMO	Marine Management Organisation
MMOA	Marine Mammal Observer Association
MMOs	Marine Mammal Observers
MMscf	Million standard cubic feet
mmscfd	Million standard cubic feet per day
MOD	Ministry of Defence
MPA	Marine Protected Area
MS	Marine Scotland
MSFD	Marine Strategy Framework Directive
MW	Megawatts
N_2O	nitrous oxide
NCMPA	Nature Conservation Marine Protected Area
NFFO	National Federation of Fishermen's Organisation
Ni	Nickel

Term	Definition
nm	nautical mile
NMHC	non-methane hydrocarbons
NMP	National Marine Plan
NMPI	National Marine Plan interactive
NOAA	National Oceanic and Atmospheric Administration
NorBrit	Norway-United Kingdom Joint Contingency Plan
NOx	oxides of nitrogen
NRC	National Research Council
NSTA	North Sea Transition Authority
NUI	Normally Unmanned Installation
O&G	Oil and gas
O_3	Ozone
OCNS	Offshore Chemicals Notification Scheme
OD	Outer Diameter
ODU	Offshore Decommissioning Unit
OESEA	Offshore Energy Strategic Environmental Assessment
OGA	Oil and Gas Authority
OPEP	Oil Pollution Emergency Plan
OPEX	Operational Expenditure
OPOL	Offshore Pollution Liability Association
OPPC	Oil Pollution Prevention and Control
OPRED	Offshore Petroleum Regulator for Environment and Decommissioning
OSCAR	Oil Spill Contingency and Response
OSPAR	Oslo and Paris Conventions
OSPRAG	UK Oil Spill Prevention and Response Advisory Group
OSRL	Oil Spill Response Limited
PAH	polycyclic aromatic hydrocarbons
PAM	Passive Acoustic Monitoring
PCE	Pressure Control Equipment
PCU	Production Control Umbilical
PETS	Portal Environmental Tracking System
PGS	Latest Available Seismic Data

Term	Definition
PIP	Pipe-in-Pipe
PLONOR	Pose Little or No Risk to the environment
PLV	Pipelay Vessel
PMF	Priority Marine Features
PNEC	Predicted No Effect Concentrations
POOH	Pull Out of Hole
ppg	pounds-per-gallon
ppm	parts per million
ppt	parts per thousand
psa	Pressure swing adsorption
PTS	permanent threshold shift
PW	Produced Water
PWA	Pipeline Works Authorisation
PWV	Production Wing Valve
RBA	Risk based Approach
RDV	Rock Dump Vessel
RIH	Run in Hole
rms	root mean squared
ROV	Remotely Operated Vehicle
RQ	Risk Quotient
SAC	Special Area of Conservation
SCANS	Small Cetaceans in the European Atlantic and North Sea
scf	Standard cubic feet
SCSSV	Surface Controlled Subsurface Safety Valve
SEI	Significant Environmental Impact
SEL	Sound Exposure Level in dB re 1 µPa2 s
SFF	Scottish Fishermen's Federation
SL	Source levels
sm3	standard cubic meter
SMRU	Sea Mammal Research Unit
SNH	Scottish Natural Heritage
SOSI	Seabird Oil Sensitivity Index
SOx	oxides of sulphur

Term	Definition
SPA	Special Protected Area
SPL	sound pressure level
SPS	Subsea Production System
SSIV	Subsea Isolation Valve
SSS	Side Scan Sonar
SSSI	Site of Special Scientific Interest
stb	Stock Tank Barrel
SUV	Survey Vessel
Te	Tonnes
THC	Total Hydrocarbon Concentration
TOOPEP	Temporary Operations OPEP
TSV	Trenching Support Vessel
TTS	Temporary Threshold Shift
TUTU	Topsides Umbilical Termination Unit
TVDSS	True Vertical Depth Subsea

Term	Definition
UCM	Unresolved Complex Mixture
UHB	Upheaval Buckling
UK	United Kingdom
UKCS	United Kingdom Continental Shelf
UKDMAP	UK Digital Marine Atlas
UKHO	UK Hydrographic Office
UKOOA	United Kingdom Offshore Operators Association
µm	micrometres
UTM	Universal Transverse Mercator
VMS	Vessel Monitoring System
VOC	Volatile Organic Compounds
WBM	Water based mud
WMP	Waste Management Plan
XT	Christmas Tree

Definitions

EIA Regulations	means the Offshore Oil and Gas Exploration, Production, Unloading and Storage (Environmental Impact Assessment) Regulations 2020 (the 2020 EIA Regulations)
Harbour Energy	means Chrysaor Petroleum Company U.K. Limited (Company number 00792712) and Chrysaor Limited (Company number 06418649) are wholly owned indirect subsidiaries of Harbour Energy plc, a public limited company incorporated in Scotland (Company number SC234781) whose registered office is at 4th Floor, Saltire Court, 20 Castle Terrace, Edinburgh, EH1 2EN. The term **Harbour Energy** is used interchangeably in this ES to describe, as the context requires either or both: (i) Chrysaor Petroleum Company U.K. Limited in its capacity as the Talbot Operator; and (ii) each of Chrysaor Petroleum Company U.K. Limited and Chrysaor Limited in their respective capacities as Talbot Owners.
Host or Judy Platform	means the existing offshore production platform (which includes the Judy riser platform and connecting bridge) located in block 30/7a of the UKCS.
Licence	means the United Kingdom Petroleum Production Licence No. P2456 dated 8 October 2018 and with a Start Date (as defined in the Licence) of 1 October 2018 issued by the Minister (as defined therein) as amended, supplemented or extended from time to time and shall include any other licence issued to the Talbot Owners in substitution or partial substitution for it.
may	indicates on acceptable course of action.
Project	means the project to evaluate, design, engineer, construct, install and commission the infrastructure and facilities associated with the proposed Talbot Field Development.
shall	indicates a mandatory requirement.
should	indicates a preferred course of action.
Talbot or Talbot Field	means the hydrocarbon accumulation underlying UKCS block 30/13e (under Licence No. P.2456)' which is commonly referred to as the 'Talbot' field and is under consideration for field development consent by the NSTA.
Talbot Field Development	the proposed development of the Talbot Field and tie-back to the Host Platform by the Talbot Owners
Talbot Operator	means the person appointed from time to time by the Talbot Owners to operate the Talbot Field, when acting in that capacity and not as a Talbot Owner, which at the date hereof is Chrysaor Petroleum Company U.K. Limited (Company number 00792712) and its respective successors and assigns.
Talbot Owners	means those persons having a legal and/or beneficial interest in the Talbot Field from time to time acting in that capacity, who at the date hereof are Chrysaor Limited (Company number 06418649), Chrysaor Petroleum Company U.K. Limited (Company number 00792712) and Eni UK Limited (Company number 00862823) (as further detailed in Table 1:1) and their respective successors and assigns and **Talbot Owner** shall be construed accordingly.

Information Sheet

Project Name	Talbot Field Development
Development Location	Blocks 30/13e, 30/12a and 30/7a These blocks, each as indicated in Figure 1:2 below, comprise blocks(s) that: (i) form part of the Talbot to Host pipeline route: 30/13e, 30/12a and 30/7a; (ii) form part of the Talbot Field – 30/13e; and (iii) include the location of the Judy Platform and SSIV – 30/7a).
Licence No.	P.2456 (in relation to Block 30/13e)
ICES Rectangle	42F2
OPRED Reference No.	D/4273/2021
Type of Project	New Subsea Tie-back Development
Operator	Chrysaor Petroleum Company U.K. Limited
Licensees/Owners	<table><tr><th>Owner Group</th><th>Talbot Owner</th><th>% Holding</th></tr><tr><td rowspan="2">Harbour Energy plc</td><td>Chrysaor Petroleum Company U.K. Limited</td><td>36.5</td></tr><tr><td>Chrysaor Limited</td><td>30.5</td></tr><tr><td>Eni UK Limited</td><td>Eni UK Limited</td><td>33.0</td></tr></table>
Short Description	The Talbot Field is proposed to consist of three development wells within a four-slot drilling template tied-back to the existing Judy Platform for onward processing and export. The proposed development concept can be summarised as follows: • Drilling and completing three development wells; • Installation of three subsea production systems within the drilling template structure; • Installation of a four-slot subsea manifold, proximate to the drilling template structure with connecting spools to the three subsea production systems; • Installation of a SSIV within the Judy Platform 500 m safety zone with associated electro-hydraulic controls umbilical; • Installation and commissioning of a subsea pipe-in-pipe production flowline and umbilical carrying power, communications, hydraulic supply, methanol and chemicals (lengths approximately 16 km) between the Talbot drill centre subsea manifold and existing Judy Platform infrastructure; • Connection to the existing PL1000 “South” Joanne 12” production pipeline and riser, for purposes of tie-in to the existing Judy-Joanne high pressure separator; • Installation of suitable hydraulic-electrical control system and chemical injection system on the Judy production platform, inclusive with installation of 16 km umbilical and manifold-to-

<table>
<tr><td></td><td colspan="2">template tie-in jumpers to control the 3-development wells and associated subsea infrastructure; and
First production Q3 2024.
An appraisal well (30/13e-12Z) was drilled in September 2021 to support FID. As anticipated, the appraisal well results did not materially change the development concept. FEED revalidation of the project was kicked off in December 2021 to incorporate results from the appraisal well

This ES assesses the largest impact of the project as a four well development; however, the project base case is, and FDP is for, 3 wells.</td></tr>
<tr><td>Proposed Key Dates (Indicative of Minimum Development Concept)</td><td colspan="2"><table>
<tr><th>Activities</th><th>Date</th></tr>
<tr><td>Installation Drilling Template</td><td>Q3 2022</td></tr>
<tr><td>Drilling of wells</td><td>Q3 2022 – Q2 2023</td></tr>
<tr><td>Subsea installation</td><td>Q2 and Q3 2023</td></tr>
<tr><td>Well tie-ins and commissioning</td><td>Q1 2024</td></tr>
<tr><td>First production</td><td>Q3 2024</td></tr>
</table></td></tr>
<tr><td>Anticipated Field Life</td><td colspan="2">Minimum 10 years, aligned to Host cessation of production (CoP)</td></tr>
<tr><td>Significant Environmental Effects Identified</td><td colspan="2">It is the conclusion of this ES that the current proposal for the Talbot Field Development can be completed without causing significant long term environmental impacts or cumulative and transboundary effects.</td></tr>
<tr><td>Statement Prepared by</td><td colspan="2">Chrysaor Petroleum Company U.K. Limited (as Talbot Operator acting on behalf of the Talbot Owners) and BMT UK Limited (as consultant to the Talbot Operator)</td></tr>
<tr><td>Company</td><td>Job Title</td><td>Relevant Qualifications/Experience</td></tr>
<tr><td rowspan="3">Chrysaor Petroleum Company U.K. Limited</td><td>Environmental Advisor</td><td>18 years of oil and gas environmental experience in drilling, operations and projects.</td></tr>
<tr><td>Senior Subsea Project Engineer</td><td>11 years of oil and gas experience in operations, projects involving subsea, wells and topsides. Chartered Mechanical Engineer.</td></tr>
<tr><td>Senior Project Engineer</td><td>15 years of oil and gas experience in project and operations involving topsides, subsea and marine sectors. Chartered Naval Architect.</td></tr>
<tr><td rowspan="3">BMT UK Limited</td><td>Principle Consultant/Project Manager</td><td>15 years of experience in marine science and industry</td></tr>
<tr><td>Consultants</td><td>3 years of experience in environmental consulting</td></tr>
<tr><td>Principal Consultant/Associate</td><td>>30 years' experience in marine science and industry</td></tr>
</table>

1 Introduction

The Talbot Operator acting for and on behalf of the Talbot Owners wish to develop the Talbot Field. The Talbot Field is located on the UKCS approximately 278 kilometres (km) southeast of Peterhead on Scotland's east coast, approximately 7 km west of the UK/ Norway median line and 16 km southeast of the existing Judy Platform to which the Talbot Field Development is proposed to tie-back to. Water depth across the Talbot Field Development is between 71.2 and 75.4 m.

The Talbot reservoir lies within Block 30/13e under Licence P.2456, in the central North Sea (CNS) (Figure 1:1). A pipeline connection is planned to connect the Talbot Field to the Judy Platform located in Block 30/7a. The proposed Talbot-Judy pipeline route is intended to pass through Blocks 30/13e, 30/12a and 30/7a (as shown in Figure 1:2).

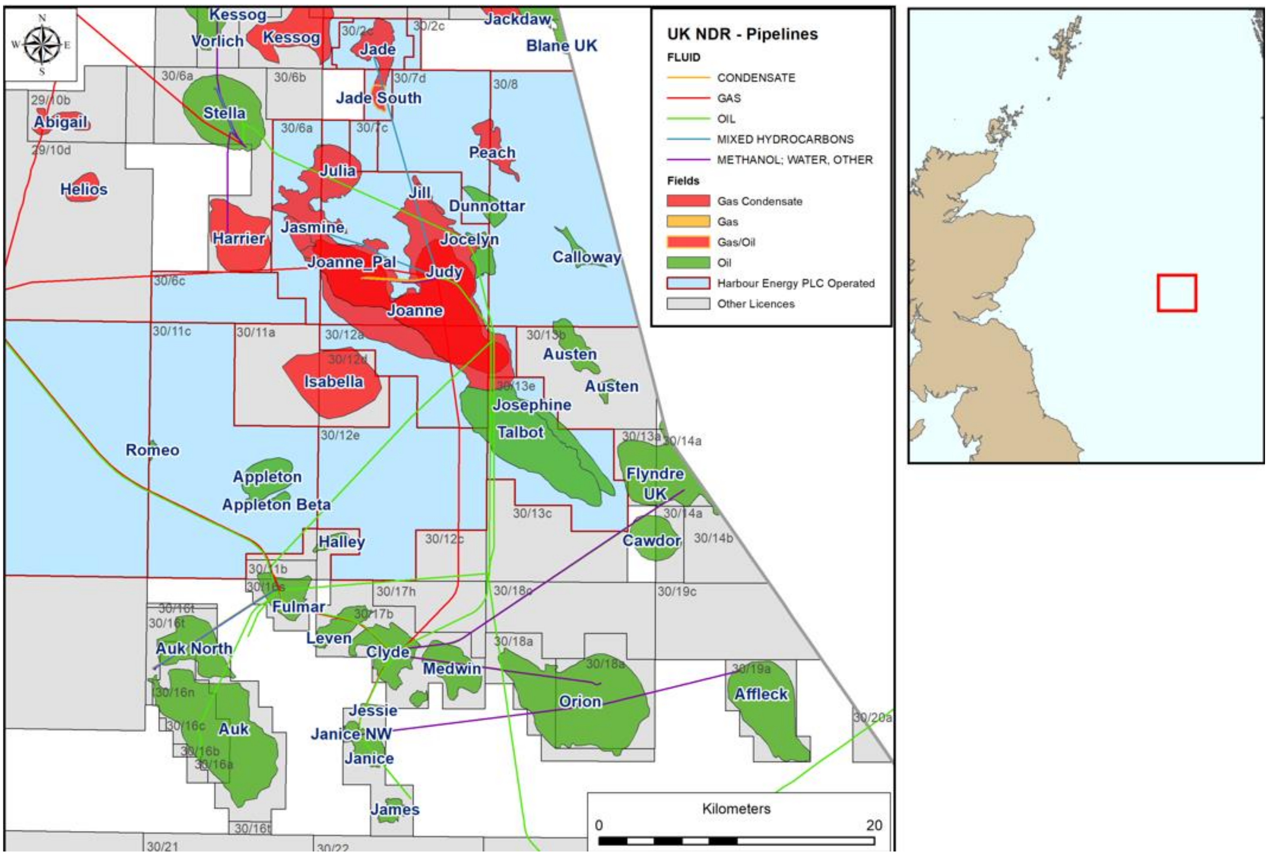

Figure 1:1 – Location of Talbot Field Extents

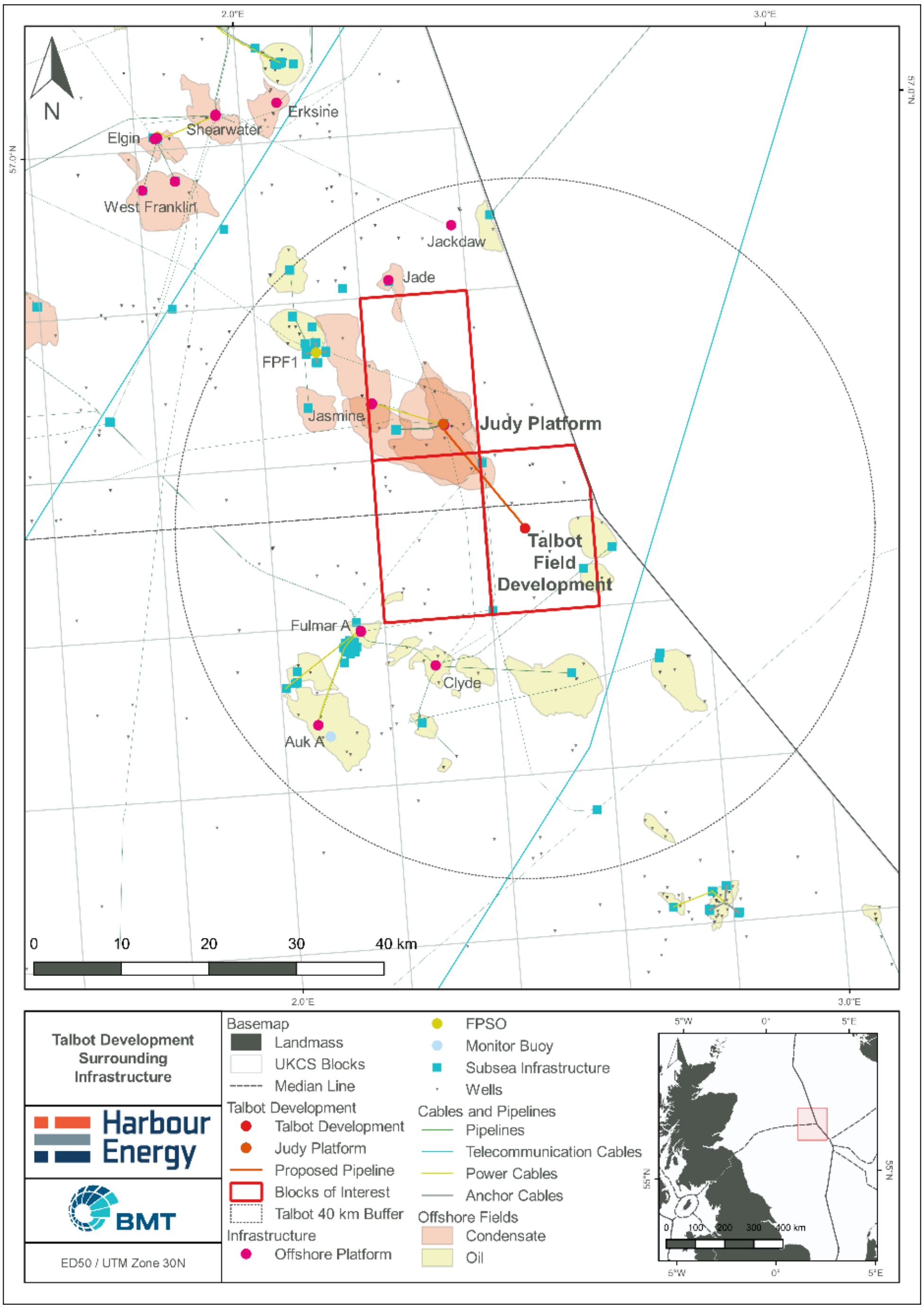

Figure 1:2 – Proposed Location of Talbot Field Development, Judy Platform, and Scottish and English Waters Boundary

In October 2018, following a successful application as part of the UKCS 30th Licensing Round, ConocoPhillips Petroleum Company U.K. Limited became operator of the Talbot licence (P.2456) holding a 36.5% interest together with Chrysaor Limited (30.5%) and Eni UK Limited (33%) as joint venture partners.

On 30th September 2019, ConocoPhillips' UK upstream business was acquired by the Chrysaor group resulting in ConocoPhillips Petroleum Company U.K. Limited changing name to Chrysaor Petroleum Company U.K. Limited on 1 October 2019. As a result, Chrysaor UK group's net interest in Talbot increased from 30.5% to 67% (with ownership split between Chrysaor Petroleum Company U.K. Limited (36.5%) (as operator) and Chrysaor Limited (30.5%)) as further detailed in Table 1:1. On 31 March 2021 Premier Oil Plc completed the acquisition of the entire issued share capital of the ultimate parent company of the Chrysaor group - Chrysaor Holdings Limited and Premier Oil plc was renamed Harbour Energy plc. Both Chrysaor Petroleum Company U.K. Limited and Chrysaor Limited are wholly owned indirect subsidiaries of Harbour Energy plc and form part of the Harbour Energy group.

Table 1:1 – Ownership Interests in the Talbot Field, J-Block Fields and Jade Field

Part A - Talbot		
Owner Group	**Talbot Owner**	**% Holding**
Harbour Energy plc	**Chrysaor Petroleum Company U.K. Limited (operator)**	**36.5%**
	Chrysaor Limited	30.5%
Eni UK Limited	Eni UK Limited	33.0%
Part B – J-Block		
Owner Group	**J-Block Owner (Jasmine, Joanne and Judy fields (including the Judy Platform)**	**% Holding**
Harbour Energy plc	**Chrysaor Petroleum Company U.K. Limited (operator)**	**36.5%**
	Chrysaor Limited	30.5%
Eni UK Limited	Eni UK Limited	33.0%
Part C – Jade		
Owner Group	**Jade Owner**	**% Holding**
Harbour Energy plc	Chrysaor Limited	35.00%
	Chrysaor Petroleum Company U.K. Limited (operator)	**32.50%**
Ithaca Energy	Ithaca Gamma Limited	19.93%
Eni UK Limited	Eni UK Limited	7.00%
Siccar Point Energy	Siccar Point Energy E&P Limited	5.57%

Detailed subsurface potential and economic evaluations were undertaken for the 30th licence round, and identified the Talbot Discovered Resource Opportunity as having potential for an economic development via tieback to the existing J-Area facilities. This is supportive of North Sea Transition Authority (NSTA) initiatives to maximise economic recovery as Talbot was previously considered too marginal to be sanctioned, whilst still allowing the company's Net Zero goals. Please note the NSTA, previously called the Oil and Gas Authority, recently changed its name and therefore reference to OGA is still used extensively throughout legislative and regulatory text used and issued by the NSTA.

The proposed Talbot Field Development will consist of three development wells within a four-slot drilling template with three subsea production systems installed within the drilling template structure. Connection between the subsea manifold and existing Judy infrastructure will come from a 10"/16" (option of 12"/18") subsea pipe-in-pipe (PiP) production flowline and umbilical carrying power, communications, hydraulic supply, methanol and chemicals, with an approximate length of 16 km. These will connect with the existing PL1000 Joanne South 12" production pipeline at the Judy Platform.

Talbot produced fluids will comingle with Joanne field fluids on the Judy Platform topsides, prior to entering the Judy-Joanne high-pressure production separator for onward processing on the Judy Platform. At the Judy Platform, Talbot produced fluids will be separated into gas and liquids streams and commingled with other J-Block area fields' (Jade, Jasmine, Joanne and Judy) production. Talbot gas will be transported as part of a commingled stream from the Judy Platform, via a 20" gas export line (reference PL977), to the CATS pipeline system and thereon to Teesside, UK for processing. Talbot liquids will be sent, via the 24" oil export line (reference PL978), to the Norpipe liquids pipeline which in turn transports the liquids to the Norsea terminal at Teesside, UK for processing.

Under the Offshore Oil and Gas Exploration, Production, Unloading and Storage (Environmental Impact Assessment) Regulations 2020 (the 2020 EIA Regulations), hereafter referred to as the EIA Regulations, an Environmental Impact Assessment (EIA) and Environmental Statement (ES) are required to be submitted to the Department for Business, Energy and Industrial Strategy (BEIS) for approval. This requirement is due to the anticipated volumes of hydrocarbons to be produced from the Talbot Field, as consent is sought for *'Extraction of oil and natural gas for commercial purposes where the amount extracted exceeds 500 tonnes per day in the case of oil and 500,000 cubic metres per day in the case of natural gas'.*

1.1 The J-Area Hub

The J-Block Operating Area production hub is comprised of four fields: Jasmine, Joanne and Judy fields, and the Jade field. The J-Block and Jade fields are operated by Chrysaor Petroleum Company U.K. Limited and owned by the owners as detailed in Parts B and C of Table 1:1.

The Judy Platform serves as a production hub for petroleum operations from the J-Block and Jade fields, including production wells situated on the Judy Platform, fluids from the Jasmine Wellhead Platform (JWHP), fluids from the Jade normally unmanned wellhead platform and fluids from the Joanne subsea manifold. The commingled gas stream is transported from the Judy Platform, via a 20" gas export line (reference PL977), to the CATS pipeline system and thereon to Teesside, UK for processing. Commingled liquids are transported, via the 24" oil export line (reference PL978), to the Norpipe liquids pipeline which in turn transports the liquids to the Norsea terminal at Teesside, UK for processing.

A representative diagram of the J-Area assets is shown in Figure 3:14, with a photograph of the Judy Platform complete with the bridge-linked Judy Riser Platform (JRP) shown in Figure 3:15.

1.2 Overview of the Talbot Field Development Project

The proposed minimum development, hereby referred to as "base case" concept can be summarised as follows:

- Installation of a four-slot drilling template;
- Drilling and completing three development wells;
- Installation of three subsea production systems within the drilling template structure;
- Installation of a four-slot subsea manifold, proximate to the drilling template structure with connecting spools to the three subsea production systems;
- Installation of a SSIV and associated electro-hydraulic controls umbilical within the Judy Platform 500 m zone;
- Installation, trenching, backfilling and commissioning of a 10"/16" (option of 12"/18") subsea PiP production flowline and umbilical carrying power, communications, hydraulic supply, methanol and chemicals (lengths approximately 16 km) between the Talbot subsea manifold and existing Judy infrastructure;
- Connection to the existing PL1000 "South" Joanne 12" production pipeline and riser, for purposes of tie-in to the existing Judy-Joanne high pressure separator;
- Installation of a hydraulic-electrical control system and chemical injection system on the Judy production platform, inclusive with installation of 16 km umbilical and manifold-to-template tie-in jumpers to control the three development wells and associated subsea infrastructure; and
- First production Q3 2024.

The Talbot project completed Harbour's internal assurance process for 'Approval for Execute' on an 'appraise while develop' basis; however, this was not sanctioned at the approval stage in March 2020 and an 'appraise prior to develop' phase began. The Talbot appraisal well was approved by Harbour and joint venture partner Eni in January 2021. The appraisal well was drilled in September 2021 to support FID and the appraisal- E side-track encountered hydrocarbon bearing sands. The development drilling long leads were also approved by the Talbot Owners with orders placed to ensure delivery ahead of the earliest possible development drilling in Q4 2022. As anticipated, the appraisal well results did not materially change the development concept. FEED revalidation of the project was kicked off in December 2021 to incorporate results from the appraisal well.

The ES assesses the largest potential impact of the project. The ES therefore looks to exceed the Field Development Plan to ensure a precautionary approach is taken and that all actual events that occur on the project and potential impacts are the worst case assessed in the ES. With this approach the ES has assessed this development to drill four wells, but base case is a 3 well development with fourth well assessed for drilling impacts rather than 4 production wells.

The Talbot Field Development project has elements in both Scottish and English waters with the template and manifold itself being in English waters and the majority of the pipeline being in Scottish waters as is Judy the hub platform that Talbot would be tied back to. Scoping and consultation have been undertaken with representatives from both English and Scottish consultees.

1.3 Purpose of the Environmental Statement

The Offshore Oil and Gas Exploration, Production, Unloading and Storage (Environmental Impact Assessment) Regulations 2020 (the 2020 EIA Regulations) requires the undertaking of an EIA and the production of an ES for certain types of offshore oil and gas projects likely to have a significant effect on the environment.

The purpose of this ES is to report on the EIA process undertaken to meet both statutory and Harbour internal project requirements. The ES provides a public consultation document which informs the public and consultees and allows them to raise concerns and questions of the project and potential impacts. It is therefore required to be a comprehensive report. The ES provides an opportunity to demonstrate to the Regulator and consultees that Harbour is informed and understands:

- The likely consequences of the activities, emissions, discharges and physical presence of the project;
- The local environment; and
- The nature of the environmental and commercial issues arising from other users of the sea.

The ES has been prepared in accordance with the 2020 EIA Regulations and guidance from BEIS (BEIS, 2021a).

1.4 Scope of the Environmental Statement

This ES reports the findings of the EIA and presents the potential environmental impacts of the planned Talbot Field Development only. Talbot will be developed with the potential to tie-in stranded reserves, aiding MER, but any development outside the scope of this Talbot Field Development will be assessed separately and be required to evaluate any incremental impacts in its own right. The EIA sets out to investigate and evaluate the impacts of any emissions to air, discharges to sea, seabed disturbance, noise, waste production and resource use resulting from the proposed development on a range of receptors including flora, fauna, water, air, climate and material assets. In addition, the potential interactions with other sea users are considered. These aspects are considered for planned activities and unplanned, i.e., accidental, events.

The ES has been developed in line with the Talbot Field Development Plan (FDP). However, the ES has always taken the worst case (highest) impact option and assessed that to ensure the assessment within the ES at least meets and preferably exceeds the actual impact so taking a precautionary approach. For example; produced water data has taken a high case and then applied a contingency factor on top to ensure a high case is assessed and actual rates will expect to be below this. So direct numerical comparison between FDP and ES may not equate exactly but that is simply due to the ES taking the highest environmental risk and ensuring that those impacts can be managed so to not result in significant impact to the receiving environment.

Talbot is located within the Fulmar Marine Conservation Zone (MCZ) (details of designating features are provided in Section 4.4). The impacts of the proposed project on the MCZ are considered in detail.

1.5 Legislation and Policy

This section provides a brief overview of the current legislative framework applicable to this project. The Petroleum Act 1998 and the Energy Act 2008 (each as amended) establish the regulatory regime applying to oil and gas exploration and production in the UK. The latest amendments to the EIA Regulations now incorporate modifications made by Article 2 of the Energy Act 2008 (Consequential Modifications) (Offshore Environmental Protection) Order 2010. Relevant marine legislation for Scotland and England is included as well, since the proposed development will be located in both Scottish and English sectors of the UKCS.

1.5.1 Environmental Impact Assessment

The assessment complies with the Offshore Oil and Gas Exploration, Production, Unloading and Storage (Environmental Impact Assessment) Regulations 2020 (the 2020 EIA Regulations) and the associated BEIS guidance on the interpretation of the regulations (BEIS, 2021a). These regulations ensure that BEIS takes environmental information into consideration before deciding whether to agree to the grant of consent certain offshore activities (including the development of new fields) which is the consented only by the NSTA.

1.5.2 Protected Sites and Species

The EIA must consider impacts of the proposed activity on the surrounding environment, including on any protected species and areas. Protected species and areas were designated around the UK EU as a result of EU Directives, in particular the Habitats Directive (92/43/EEC) and the Birds Directive (2009/147/EC). Since January 2021 these are now maintained and designated under the Habitats Regulations for England and Wales, Scotland and Northern Ireland. Amendments to the Habitats Regulations mean that the requirements of the EU Nature Directives continue to apply to how European sites (Special Areas of Conservation (SACs) and Special Protection Areas (SPAs)) are designated and protected. The Habitats Regulations also provide a legal framework for species requiring strict protection, e.g., European Protected Species (EPS). The UK Marine and Coastal Access Act 2009 (MCAA) enables the designation of marine conservation zones (MCZs) in English and Welsh waters, while the Marine (Scotland) Act 2010 provides for the designation of NCMPAs in Scottish waters beyond 12 nautical miles.

1.5.3 Discharges to Water

Under the Offshore Petroleum Activities (Oil Pollution Prevention and Control) Regulations 2005 (as amended) all offshore installations are required to have an oil discharge permit. This includes a maximum 30 mg/l monthly average concentration of oil discharged in produced water. A similar permit is also required for discharges during the drilling of wells, discharges from pipelines or discharges occurring during decommissioning. These permits must include Best Available Techniques (BAT) assessments in order to justify the treatment and discharge options that have been selected.

Under the Offshore Chemical Regulations 2002 (as amended) a chemical permit is required for the use and discharge of chemicals used offshore (with some exemptions). All offshore activities, including production, drilling, discharges through pipelines and decommissioning are covered by the aforesaid 2002 Regulations. A risk assessment of chemical discharges is required as part of the permit application.

The Oslo-Paris (OSPAR) Recommendation 2012/5 for a Risk-based Approach (RBA) to the Management of Produced Water Discharges from Offshore Installations aims to produce a method for prioritising mitigation for discharges and substances that pose the greatest environmental risk. It is intended that all offshore installations in the OSPAR area with produced water discharges will have been assessed to determine the risk level, allowing appropriate measures to be taken to reduce the risk posed by the most hazardous substances.

Installations selected for inclusion in the RBA programme commencing in 2023 will be based on the results from the RBA implementation phase. Only those installations with implementation phase results that would not allow the installation to be screened out at Tier 3 or below are included in the programme commencing in 2023. BEIS has issued guidance on the RBA for UK installations (BEIS, 2020).

1.5.4 Atmospheric Emissions

The Offshore Combustion Installations (Pollution Prevention and Control) Regulations 2013 (as amended) (PPC) transpose the relevant provisions of The Industrial Emissions Directive 2010/75/EU in respect to specific atmospheric pollutants from combustion installations with a thermal capacity rating ≥50 MW on offshore platforms undertaking activities involving oil and gas production. These regulations mirror those of the Offshore Petroleum Activities (Oil Pollution Prevention and Control) Regulations 2005 (as amended) (OPPC). Permitting under these regulations include emission allowances for carbon monoxide (CO), oxides of nitrogen (NOx), oxides of sulphur (SOx), methane (CH_4) and volatile organic compounds (VOCs) including, as with the OPPC Regulations, demonstration of BAT.

Combustion installations on oil and gas platforms with a rated thermal input of ≥20 MW require permitting under the UK Emissions Trading Scheme (UK ETS), which replaced the EU Emissions Trading Scheme (EU ETS) on 1st January 2021. The UK ETS is established through The Greenhouse Gas Emissions Trading Scheme Order 2020. This includes emission allowances for carbon dioxide (CO2).

The revised OGA (now NSTA) Strategy (which came into force on 11 February 2021) retains a binding obligation on 'relevant persons' (which includes holders of petroleum licences, operators under petroleum licences, owners of upstream petroleum infrastructure, persons planning and carrying out the commissioning of upstream infrastructure and owners of relevant offshore installations) in the exercise of their 'relevant activities' (which include the development, construction, deployment and use of the infrastructure or installation) to take the steps necessary to:

"a. secure that the maximum value of economically recoverable petroleum is recovered from the strata beneath relevant UK waters; and in doings so,

b. take appropriate steps to assist the Secretary of State in meeting the net zero target, including by reducing as far as reasonable in the circumstances greenhouse gas emissions from sources such as flaring and venting and power generation, and supporting carbon capture and storage projects.".

The revised Strategy is supported by Stewardship Expectations (SE). The OGA 'Stewardship Expectation 11 – Net Zero' (March 2021) (SE 11) sets out the NSTAs expectations of the steps that should be taken across the exploration and production lifecycle, to reduce emissions and promote CCS and hydrogen.

1.5.5 Accidental Events

The Merchant Shipping (Oil Pollution Preparedness, Response and Co-operation Convention) Regulations 1998 (as amended by the Merchant Shipping (Oil Pollution Preparedness, Response and Co-operation Convention) Regulations 2015) make provision for certain facilities in the UK's internal waters, territorial sea and continental shelf to have an Oil Pollution Emergency Plan (OPEP). The 2015 amendments extend the requirement for an OPEP to non-production installations in the territorial sea and the continental shelf and apply further requirements to installations and their connected infrastructure which are carrying out offshore oil and gas operations, including decommissioning operations. The regulations require the arrangements for responding to incidents which cause, or may cause, marine pollution by oil to be in place and the consequences of potential incidents to be assessed.

1.5.6 Marine and Coastal Access Act 2009

The MCAA controls marine activities in English and Welsh waters through introducing a marine planning system, which makes provision for a statement of the Government's general policies, including for each of the devolved administrations, for the marine environment. The MCAA allows the government to take a strategic and co-ordinated overview of the range of human activities and use of space and resources in the marine environment, while ensuring there is adequate space for marine wildlife. The MCAA makes provision for a streamlined marine licensing system, improved marine nature conservation measures, improved enforcement measures, and for marine plans which will set out in detail what is to happen in the different parts of the areas to which they relate. As well as this, it also provides the designation of MCZs. Most activities authorised solely under the BEIS environmental regime, including chemical and hydrocarbon discharges, use of explosives and decommissioning are exempt from the MCAA.

1.5.7 Marine (Scotland) Act 2010

The Marine (Scotland) Act controls marine activities in Scottish territorial waters and provides a legal mechanism to ensure clean, healthy, safe, productive and biologically diverse seas. It comprises a strategic marine planning system, a streamlined marine licensing system, improved marine nature conservation measures, improved measures for the protection of seals and improved enforcement measures. The Act enables the designation of NCMPAs which are equivalent to MCZs in English and Welsh waters.

1.5.8 North East Offshore Marine Plan

The North East Offshore Marine Plan (DEFRA, 2021), published in June 2021, introduces a strategic approach to planning within the offshore waters between the Scottish border and Flamborough Head, in Yorkshire. This marine plan was prepared for the purposes of Section 51 of the Marine and Coastal Access Act 2009. The plan includes the area from 12 nautical miles extending out to the seaward limit of the Exclusive Economic Zone (EEZ), a total of approximately 50,000 km2 of sea, bordering Norway, Denmark, Germany, Netherlands, Scotland and the East Offshore Marine Plan area. It provides a clear, evidence-based approach to inform decision-making by marine users and regulators on where activities might take place within the marine plan area, with objectives aiming to achieve a sustainable marine economy, ensure a strong, healthy and just society and to live within environmental limits. Objectives with particular relevance to the Talbot Field Development include:

- The marine environment and its resources are used to maximise sustainable activity, prosperity and opportunities for all, now and in the future.
- Marine businesses are taking long-term strategic decisions and managing risks effectively. They are competitive and operating efficiently.
- The coast, seas, oceans and their resources are safe to use.
- Biodiversity is protected, conserved and, where appropriate, recovered, and loss has been halted.
- Healthy marine and coastal habitats occur across their natural range and are able to support strong, biodiverse biological communities and the functioning of healthy, resilient and adaptable marine ecosystems.
- Our oceans support viable populations of representative, rare, vulnerable, and valued species.

Policies contained in the North East Marine Plan support delivery of the plan objectives to achieve the vision and address issues (challenges and opportunities) identified in the north east marine plan areas. Sector specific policies outlined in the North East Offshore Marine Plan for the oil and gas sector will be of relevance to Talbot. These policies are:

- Proposals in areas where a licence for oil and gas has been granted or formally applied for should not be authorised unless it is demonstrated that the other development or activity is compatible with the oil and gas activity.
- Proposals within areas of geological oil and gas extraction potential demonstrating compatibility with future extraction activity will be supported.

1.5.9 Scotland's National Marine Plan

The National Marine Plan (NMP) (Scottish Government, 2015) provides an overview framework for marine activity in Scottish waters out to 200 nautical miles, with the aim of enabling sustainable development and the use of the marine area in a way that protects and enhances the marine environment, while promoting existing and emerging industries. A core set of general policies underpin this objective. Consideration should be given to key environmental risks including the impacts of noise, oil and chemical contamination and habitat change. Policies with particular relevance to the Talbot Field Development include:

- General planning principle – There is a presumption in favour of sustainable development and continued use of the marine environment, when it is consistent with the policies and objectives of the Plan;
- Economic benefit – Development which provides economic benefit to Scottish communities is encouraged when consistent with the policies and objectives of the plan;
- Natural heritage – Development and use of the marine environment must comply with legal requirements for protected areas and species, not result in a significant impact on the national status of Priority Marine Features (PMFs) and protect (and if possible, enhance) the health of the marine area;
- Noise – Development and use in the marine environment should avoid significant adverse effects of anthropogenic noise and vibration;
- Air quality – Development and use in the marine environment should not result in deterioration of air quality, nor should it breach statutory air quality limits;
- Engagement – Early and effective engagement should be undertaken with the general public and stakeholders to facilitate planning and consenting; and
- Cumulative impacts – Any cumulative impacts affecting the ecosystem within the NMP area should be addressed in decision-making and implementation.

Sector specific policies are outlined in the Plan, where a particular industry brings issues distinct from those set out in the general policies, and those policies relating to the oil and gas sector will be of relevance to Talbot. The NMP sets out specific key issues for the oil and gas sector in supporting the objectives of the plan:

- Maximise extraction;
- Reuse infrastructure;
- Transfer skills to renewables and carbon capture storage (CCS);
- Cooperation with the fishing industry;
- Noise impacts to sensitive species;
- Chemical and oil contamination of water, sediments and fauna; and
- Habitat change.

The NMP also sets out general policies and objectives as part of the UK's shared framework for sustainable development. The proposed operations as described in this ES have been assessed against all NMP objectives and policies but specifically General Policies 1, 4, 5, 9, 12, 14, 20, and 21.

1.5.10 Other Relevant Legislation

The following are each relevant to Talbot:

- Energy Act 2008, Part 4A Consent to Locate
- The Petroleum Licensing (Production) (Seaward Areas) Regulations 2008;
- Fluorinated Greenhouse Gases Regulations 2015;
- Ozone-Depleting Substances Regulations 2015;
- The Energy Act (Consent to Locate) 2008;
- The Offshore Installations (Emergency Pollution Control) Regulations 2002;
- Merchant Shipping (Prevention of Pollution by Sewage and Garbage from Ships) Regulations 2020;
- International Convention for the Control and Management of Ships' Ballast Water and Sediments 2004; and
- Offshore Installations (Offshore Safety Directive) (Safety Case etc.) Regulations 2015.

1.6 Environmental Impact Assessment Process

The EIA methodology systematically, and in detail, identifies the potential environmental impacts and their likely significance regarding the proposed project and proposes mitigation measures to avoid, prevent, reduce, or offset likely significant adverse effects on the environment. Assessing the significance of a potential impact includes consideration of mitigation and residual impacts, focusing on those impacts which cannot be reduced, removed or otherwise mitigated.

Offshore drilling, development, and production activities can involve several environmental interactions and impacts. For example, operational emissions and discharges, and general disturbance. The objective of the EIA process is to incorporate environmental considerations into project planning and design activities, to ensure that best environmental practice is followed, and a high standard of environmental performance is achieved. The process allows for stakeholder considerations to be identified and addressed, as far as reasonably possible, at an early phase. It ensures that the planned activities are compliant with legal requirements, and with Harbour Energy's Environmental Management System (EMS) as per Section 1.7. The main elements of the EIA process are outlined below.

1.6.1 Scoping and consultation

Consultation on the scope of this ES was undertaken between June 2019 and February 2020 with both informal and statutory consultation with the following bodies:

- Department for Business, Energy and Industrial Strategy (BEIS), Offshore Petroleum Regulator for Environment and Decommissioning (OPRED);
- Marine Scotland (MS);
- Joint Nature Conservation Committee (JNCC);
- Maritime and Coastguard Agency (MCA);
- The Scottish Fishermen's Federation (SFF);
- The National Federation of Fishermen's Organisation (NFFO); and
- Ministry of Defence (MOD).

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During the process to assess the environmental impact of the proposed project, Harbour consulted:

- BEIS - engagement and framing on 18/06/19;
- OPRED, BEIS - emissions, chemicals and produced water review on 28/11/19; and

- BEIS – project status update on 22/01/20.

A summary of the issues raised at informal consultation with stakeholders is provided in Table 1:2. In addition, in April 2022, Harbour issued a revised Scoping Report to a number of stakeholders. Issues, recommendations, and requests raised in the responses received are also detailed in Table 1:2. Harbour will endeavour to address all relevant points throughout the ES process. Formal consultation on this ES, with statutory bodies and the public, will take place following formal submission of the document to BEIS.

As required by the EIA Regulations (BEIS, 2021a), a summary of the project, a copy of the ES and the public notice has been made publicly available on the Harbour's website at the time of submission: May 2022.

Table 1:2 – Summary of Stakeholder Responses Following Informal Consultations

Consultee Comments	Harbour Energy Response
JNCC	
Activity will occur within the Fulmar MCZ; therefore, the consideration of impacts is extremely important to ensure conservation objectives are met.	Addressed in Section 6, Seabed Impacts.
Use of the Seabird Oil Sensitivity Index (SOSI) is appropriate; this index should be documented separately to a bird baseline.	Addressed in Section 4, Environmental Baseline.
The SOSI identifies periods of concern and is a tool used to ensure the potential implications of drilling operations and/or an accidental release of oil on seabirds are considered during months of extremely or very high seabird sensitivity in a particular area. JNCC advise that the ES includes adequate justifications to ensure these implications are fully considered and mitigation measures are identified to minimise potential adverse effect.	Addressed in Section 10, Accidental Events.
Presence of species or habitats of nature conservation interests, with particular attention to the ocean quahog (*Arctica islandica*) should be highlighted based on conducted surveys.	Addressed in Section 4, Environmental Baseline.
Request the smallest possible footprint of operations in order to reduce potential seabed disturbance.	Addressed in Section 6, Seabed Impacts.
Introduction of hard substrate for stabilisation operations should provide an understanding of their actual nature conservation impacts.	Addressed in Section 6, Seabed Impacts.
Potential to disturb contaminated sediment should be considered.	Addressed in Section 6, Seabed Impacts.
Marine Scotland	
General technical information to be included.	Addressed in Section 3, Project Description.
The basis of Concept Selection should be included.	Addressed in Section 2, Concept Selection.
Best environmental practice and BAT demonstrated considering lifecycle of the project and future decommissioning.	Addressed in Sections 2, Concept Selection and Section 3, Project Description.
Overview of how adjacent pipelines were installed (Shell UK Gannet) and whether this was considered for pipeline installation method.	Addressed in Section 2, Concept Selection.
Produced water management and worst-case discharge profiles should be provided.	Addressed in Section 2, Project Description and Section 7, Drilling and Production Discharges.
Risk assessments for worst-case scenarios detailed.	Addressed in Section 5, Identification of Potential Impacts, with further detail for different items in Sections 6 to 11.

Consultee Comments	Harbour Energy Response
Alignment of the project with the SFF Offshore Oil and Gas Decommissioning Policy and Key Principles documents would benefit from being discussed.	Addressed in Section 11, Societal Impacts.
Alignment of the project with the SFF Offshore Oil and Gas Decommissioning Policy and Key Principles documents would benefit from being discussed.	Addressed in Section 11, Societal Impacts.
Clear and concise detailed maps on the physical characteristics, biotopes, priority marine features, and surrounding marine infrastructure should be included.	Addressed in Section 4, Environmental Baseline.
Basic assessment of spawning habits and preferred habitats of the main species identified.	Addressed in Section 4, Environmental Baseline.
Highlight the use of NMPI for Vessel Monitoring System (VMS) data. Provide context when comparing landing and effort figures as this may highlight additional mitigation measures.	Addressed in Section 4, Environmental Baseline.
Discuss how proposed development complies with Scottish and English National Marine Plan.	Addressed in Section 4, Environmental Baseline.
An overview of the method used to allow impacts to be ranked and an indication of the criteria used to determine whether an impact is 'likely' and 'significant'.	Harbour Energy carried out ENVID workshop to systematically assess potential impacts of planned activities. The results of the assessment are presented in Section 5, Identification of Potential Impacts.
Potential impacts on fish spawning and nursery areas are to be specifically considered.	Addressed in Section 4, Environmental Baseline, with further detail for different items in Sections 6 to 11.
Reasonable worst case should be assessed in subsea footprint/ habitat loss and disturbance to avoid incremental change to deposits.	Addressed in Section 6, Seabed Impacts.
Details of whether any proposed infrastructure will be fitted with fish friendly/ over trawlable structures should be included.	Addressed in Section 11, Societal Impacts.
Atmospheric emissions are discussed and put into context with wider UK emissions.	Addressed in Section 8, Atmospheric Emissions.
In-combination, cumulative and transboundary impacts should be discussed.	Addressed in Sections 6 to 11.
Firm commitment to implementing mitigation measures stated in ES.	Addressed in Section 5, Identification of Potential Impacts, with further detail for different items in Sections 6 to 11.

Consultee Comments	Harbour Energy Response
A summary table of any feedback received from stakeholders to be included in the ES.	Addressed in Section 5, Identification of Potential Impacts.
ES should contain a comprehensive conclusion summarising main environmental sensitivities and significant impacts.	Addressed in Section 12, Conclusions.
OPRED (BEIS)	
General technical information on the project and Concept Selection to be included.	Addressed in Section 2, Concept Selection and Section 3, Project Description.
Include alternative means of developing the well (from Field Development Plan (FDP)). Alternatives include environmental consideration. Consider full project lifecycle.	Addressed in Section 2, Concept Selection.
Environmental baseline trend information to determine if sensitivities have changed over time.	Addressed in Section 4, Environmental Baseline.
Site Specific surveys must be used, with maps showing location of infrastructure. Survey results from sample stations in the Fulmar MCZ need highlighting.	Addressed in Section 4, Environmental Baseline.
Include existing metocean conditions that determine habitat recovery.	Addressed in Section 4, Environmental Baseline.
Consideration of the potential to disturb contaminated sediment and anticipated degree of disturbance.	Addressed in Section 6, Seabed Impacts.
Overview of the worst-case impacts associated with WBM, cuttings, cement discharges and chemicals discharges, including on the Fulmar MCZ.	Addressed in Section 6, Seabed Impacts and Section 7, Drilling and Production Discharges.
Impacts assessed in terms of installation, production and decommissioning.	Addressed in Section 5, Identification of Potential Impacts with further detail for different items in Sections 6 to 11.
Impacts from atmospheric emissions must be incorporated, ability to meet thresholds and impact on receptors such as climate	Addressed in Section 8, Atmospheric Emissions
Noise impacts must be modelled.	Addressed in Section 9, Underwater Noise.
Review on impact of development on produced water, chemical and reservoir hydrocarbon discharges.	Addressed in Section 7, Drilling and Production Discharges.
Review of potential interaction with other sea users during installation/ operation should be considered.	Addressed in Section 11, Societal Impacts.
Includes the cumulative impact of the development as whole on receptors. Also includes assessing significant cumulative effect on Fulmar MCZ along with other developments located in that site.	Addressed in Sections 6 to 11.

Consultee Comments	Harbour Energy Response
Transboundary effects must be included in Environmental Statements.	Addressed in Sections 6 to 11.
OPRED want Harbour Energy to consider OPPC management in the early stages of design and concept selection. Instead of being reactive and resulting in exceedance of OPPC non-conformities.	Harbour Energy will engineer up to "mid-case" produced water option throughout FEED/ Execute and evaluate requirements post Talbot start-up.
OPRED want to ensure Harbour Energy have understood the fundamental issues/ concerns with a new development. Apply suitable and reasonable measures to assess and ensure capacity, capability and operability of produced water handling to minimise discharges.	Harbour Energy will ensure produced water plan assesses year-on-year optimisation of produced water discharges based in new technology or upgrades on exiting equipment.
MCA	
Develop a collision risk management plan for the drilling operations and pipeline trenching operations.	Addressed in Section 11, Societal Impacts.
An OPEP and Emergency Response Procedures to be in place.	Addressed in Section 10, Accidental Events.
Any consented cable/ pipeline protection works must ensure existing and future safe navigation is not compromised.	Addressed in Section 11, Societal Impacts.
MOD	
The MOD had no objection regarding activities in the location specified.	No further action required.
NFFO	
As the project is predominantly in Scottish waters NFFO has deferred to the Scottish Fisherman's Federation to take the lead role and advise on any possible fishing concerns throughout the development of the Talbot Field.	Addressed in Section 11, Societal Impacts.
SFF	
Email acknowledgement but no feedback as such.	The societal impacts addressed in Section 11.

1.6.2 Information gathering

Information was gathered on the natural and the socioeconomic environments in the vicinity of the proposed field development and associated subsea infrastructure. This helped to identify potential sensitivities. Information was also gathered on the proposed operations (including alternative options considered), the relevant environmental legislation and Harbour Energy policies and standards.

1.6.3 Commissioning Specialist Studies

The Talbot Owners commissioned site-specific surveys to provide an environmental baseline to inform the Talbot EIA. These surveys, completed August 2019, include:

- Environmental Baseline Survey (Gardline, 2019a);
- Environmental Habitat Assessment Survey (Gardline, 2019b).

The survey information characterises the general seabed topography, features and obstructions, provides information on habitats present and identifies any sensitive habitats, features or species of conservation interest. Full details on the findings of these surveys can be found in Section 4 – Environmental Baseline.

Harbour commissioned key modelling studies to inform on the potential impact of the proposed development on the marine environment. The results from these studies are incorporated into the ES in Section 8 – Atmospheric Emissions, Section 9 – Underwater Noise and Section 10 – Accidental Events.

1.6.4 Identification and assessment of environmental effects

A core element of the EIA process is identification of potential environmental effects associated with proposed project activities. An environmental effect may be defined as any change to the environment or its use. Effects can be positive or negative and can result directly or indirectly from project activities or events. A systematic approach was used to ensure that all aspects of the project were considered.

The initial step was to determine all project phases to ensure that all activities are fully considered. The complete life cycle of the proposed drilling and production operations was reviewed for potential environmental impacts with the intention of eliminating or reducing their cause (that is, avoiding the impact). Those aspects of the project that have the potential to interact with the environment in a significant way were identified. Central to this process was an Environmental Issues Identification (ENVID) workshop held on 27th October 2021, which was attended by key project representatives from Harbour Energy and its advisor BMT.

A series of matrices were prepared for the ENVID workshop that identified the interactions associated with Talbot. These interactions were then assessed for significance in order to determine the key environmental issues associated with each phase of the project. Details of this procedure, the key interactions, and potential impacts identified are presented in Section 5 – Identification of Potential Impacts. Following the ENVID workshop, the environmental assessment process then involved detailed evaluation of each of the interactions that could have a potential environmental impact. This included the interactions identified by the ENVID process and issues identified through stakeholder consultations. Each potential interaction is thoroughly considered through the:

- Description of the potential environmental impact;
- Description and quantification of the effects from the proposed project;
- Identification of information or data gaps and understanding and explaining how these are managed; and
- Measures that can and will be taken to mitigate the impact.

1.6.5 Development of mitigation measures

Identifying and assessing impacts and mitigating their significance is an iterative process conducted throughout the project. Mitigation measures were explored throughout the assessment process in order to eliminate or reduce the significance of the identified impacts. Mitigation measures are described in Sections 6 to 11 and summarised and concluded in Section 12.

1.6.6 Reporting of the outcome of the EIA process in the ES

The ES reports the findings of the EIA process and explains how the conclusions have been reached. The intention has been to present the information in such a way to allow readers to form their own opinions on the acceptability of the residual levels of impact associated with the project. The document presents the following:

- The rationale for the development, the nature and role of the EIA and EMS (Section 1 – Introduction);
- A description of the option selection process and final proposed development and operations (Section 2 – Concept Selection and Section 3 – Project Description);
- A description of the environment in the vicinity of the proposed operations (Section 4 – Environmental and Socioeconomic Baseline);
- The methods used to identify the environmental interactions associated with the programme (Section 5 – Identification of Potential Impacts);
- A detailed assessment of each interaction, including potential cumulative and transboundary impacts and mitigation measures (Section 6 – Seabed Impacts to Section 11 – Societal Impact); and
- Conclusions (Section 12 – Conclusions).

In addition, an overview is provided in the Non-Technical Summary at the front of this report.

1.7 Environmental Management System

Harbour Energy has a Health, Safety, Environment, Quality and Asset Integrity system, which identifies, evaluates, manages and controls potential Health, Safety, Environment and Quality (HSEQ), Asset Integrity (AI) and Marine Hazards facing UK Operations. All systems follow a Plan, Do, Check, Act model and meet the requirements of HS(G)65, ISO 9001:2015 and are certified to ISO 14001:2015. See Figure 1:3 to Figure 1:7 for Harbour Energy Policies.

The framework ensures:

- Clear assignment of responsibilities;
- Excellence in environmental, health and safety performance;
- Sound risk management, planning and decision making;
- Efficient and cost-effective planning and conduct of operations;
- Legislative compliance throughout all operations;
- A systematic approach to critical business activities; and
- Continuous improvement.

The EMS provides a tool for managing the impacts of Harbour's activities, products and services on the environment. It provides a structured approach for continuous planning, implementing, reviewing and improving on environmental protection measures as well as working towards increasing environmental sustainability.

There are a number of associated benefits with the business EMS having ISO 14001:2015 accreditation including, but not limited to, promoting continual improvement, maintaining a high internal environmental management standard and aligning to Harbour's values and business principles.

Waste management is a core component of the EMS and is important to ensure compliance with regulations governing waste disposal and transfer. Harbour is committed to minimising waste associated with their operations and the recycling of such waste wherever practicable. All opportunities for waste minimisation, recycling, reuse and recovery will be identified.

Talbot will follow Harbour's waste management procedure, which has been written to ensure compliance with relevant laws and regulations and to manage all projects and processes through their life cycles in a way that protects health and safety and prevents pollution and manages wastes. Harbour acknowledges that waste management within the UK is regulated through different regulations, under the authority of the Environmental Protection Act 1990, with regulations differing between, Scotland, England and Wales, and Northern Ireland. Therefore, regional and project specific regulations will be applied. The Talbot Waste Management Plan will address all current UK waste management legislation and also international legislation applicable to offshore regulations, namely the Basel Convention 1992 and MARPOL Convention (Annex IV/V) 1973/78.

Harbour acknowledges that its business activities have an associated environmental impact. Whilst environmental aspects can have a positive or negative impact, the vast majority of Harbour's business activities have a negative environmental impact. As such, these require careful and responsible management to mitigate, where possible, their negative impact.

Harbour Energy

Health, Safety, Environment and Security

Policy

Harbour Energy is committed to operating responsibly and securely, never compromising our Health, Safety, Environmental or Security (HSES) standards. Harbour Energy will do all that is reasonably practicable to reduce HSES risks, ensure the safety and security of everyone affected by our operations, protect the environment by minimising our environmental impacts, and protect our assets and business data.

To achieve this Harbour Energy will:

- Provide strong, visible leadership and commitment at all levels of the business
- Effectively identify hazards, threats and vulnerabilities to assess and manage risks
- Meet or surpass our legal and other requirements (e.g., compliance obligations)
- Set objectives and targets to drive improvement
- Support and train our people and assure their competence
- Provide appropriate resources
- Encourage open and honest communication
- Effectively manage the HSES risks associated with contracted work
- Maintain safe, clean, healthy and secure workplaces to protect our people, environment, assets and data
- Maintain protected high quality documented systems and processes
- Plan and prepare for potential emergencies
- Report, investigate and learn from any incidents and near misses
- Routinely inspect the workplace and audit systems and processes
- Seek opportunities to continually improve our performance

It is the responsibility of everyone in Harbour Energy to conform to our Policies and Standards and to assist the business in their implementation.

Linda Z Cook
CEO Harbour Energy Plc
01 April 2021

HAE-GLO-HSE-POL-0001, Revision 1

Figure 1:3 – Harbour Energy Health, Safety, Environment and Security Policy

Harbour Energy

Climate Change

Policy

Harbour Energy is an independent, global oil and gas exploration and production company with a role to play in meeting the world's energy needs through the safe, efficient and sustainable production of hydrocarbons whilst delivering competitive returns for shareholders.

As global energy demand grows, Harbour Energy wants to support the twin objectives of providing affordable energy to a growing global population whilst mitigating effects of our emissions. This forms part of our overall commitment to carrying out all that Harbour Energy does efficiently and with care for the environment.

Harbour Energy is committed to attaining a goal of Net Zero no later than 2035. This commitment includes our share of Scope 1 (direct) and Scope 2 (related to purchased electricity) emissions from operated and non-operated assets.

To achieve this, Harbour Energy will:

- Establish time-bound targets that support the ambitions of the Paris Agreement.
- Identify and pursue opportunities to minimise our carbon footprint and greenhouse gas emissions within our operations
- Participate with industry partners in the development of viable CO_2 capture and sequestration projects
- Invest, to the extent that we cannot reduce all of our Scope 1 and 2 emissions, in Carbon-offsets, so as to achieve our net zero ambitions
- Communicate with internal and external stakeholders in a transparent manner our climate change related performance and our associated governance, risk management and target-setting
- Integrate carbon pricing and scenario analysis into decision-making across our asset portfolio, to test the robustness of our investments and strategy
- Collaborate with industry and other associations on climate change adaptation and mitigation
- Identify, manage and mitigate the physical and transitional climate change risks associated with our activities
- Include emissions related targets in the incentive compensation programme

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Figure 1:4 – Harbour Energy Climate Change Policy

Harbour Energy

Responsibility for climate change matters ultimately rests with Harbour Energy Plc's Board of Directors, and the Chief Executive Officer (CEO) has executive responsibility. To oversee our climate change response, Harbour Energy have established a dedicated Climate Change Committee of cross-disciplinary experts that reports to the CEO.

This Policy will be continually reviewed and updated alongside our business strategy as our understanding of climate-related risks, new technologies, and associated regulations evolves.

Linda Z Cook
CEO Harbour Energy Plc
01 April 2021

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Figure 1:5 – Harbour Energy Climate Change Policy

Sustainability

Policy

Harbour Energy delivers shareholder value by investing in high quality oil and gas production, development and exploration opportunities. Harbour Energy recognises that our licence to operate as a global oil and gas business is earned through responsible behaviour, a key determinant of our business success.

This Policy reflects a commitment to demonstrate increased beneficial, sustainable and measurable socio-economic impact from Harbour Energy's business activity.

Harbour Energy commits to and is accountable for:

- Identifying, managing and mitigating the physical and transitional climate change risks associated with our activities
- Acting with respect for people, communities, and the environment
- Acting honestly and openly with all stakeholders, respecting the law and human rights
- Contributing to development goals and value creation of host countries
- Promoting a culture of inclusion and to ensure the values of diversity and equality are reflected in the way Harbour Energy operates
- Integrating Environment, Social, Governance (ESG) principles into our business strategy, planning, decision-making, implementation processes and operating management systems
- Providing clear public reporting on our management systems and performance relating to ethics, human rights, employees, health and safety, environment and communities

This Policy is underpinned by more detailed Policies and Statements on Climate Change, Business Ethics, Global Code of Conduct, Human Rights, Modern Slavery and Community Investment.

It is the responsibility of everyone in Harbour Energy to conform with our Policies and to assist the business in their implementation.

Linda Z Cook
CEO Harbour Energy Plc
01 April 2021

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Figure 1:6 – Harbour Energy Sustainability Policy

Risk Management

Policy

Harbour Energy is committed to continuously improving our approach to risk management.

Effective risk management in Harbour Energy provides the Harbour Energy Plc Board with an appropriate level of assurance of:

- The likelihood of achieving our business objectives
- The safeguarding and protection of our people, assets, reputation and the environment
- The quality of our decision making and planning
- Our learning from and resilience to changing events, incidents and crises
- Our effective identification, evaluation and analysis of uncertainty
- Compliance

To achieve these Harbour Energy will:

- Seek to identify, evaluate and communicate risks associated with all aspects of our business including those risks to which we might be exposed by others with whom we work or do business
- Define a risk appetite approved by the Harbour Energy Plc Board which for the avoidance of doubt will never compromise our Health, Safety, Environment & Security Policy and Standards
- Adopt a risk management framework based on ISO31000 principles and guidelines
- Develop, resource and implement appropriate identification, responses, accountabilities and action to control and mitigate risks
- Ensure that the necessary risk controls and mitigating measures are effective

It is the responsibility of everyone in Harbour Energy to conform with our Policies and to assist the business in their implementation.

Linda Z Cook
CEO Harbour Energy Plc
01 April 2021

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Figure 1:7 – Harbour Energy Risk Management Policy

1.8 Areas of Uncertainty

This ES was prepared during the Define Phase of the project. Where assumptions have been made, the environmental worst case option has been assessed. Assumptions and uncertainties are outlined below.

1.8.1 Talbot Hydrocarbon Production Profiles

Production profiles based on models have a certain degree of uncertainty associated with them. The production profiles presented in this ES are based on a high case and are an annualised average of the projected production for Talbot.

1.8.2 Talbot Produced Water Profiles

Produced water profiles based on models have a certain degree of uncertainty associated with them. The profiles presented in this ES are based on a high case and are an annualised average of the projected production for Talbot. It should be noted that the profiles shown are all the high cases this does not mean they are representative of an actual real time of what would come out of the reservoir. High produced water is usually associated with a reducing hydrocarbon profile, but we have taken highest of all to ensure adequate assessment.

1.8.3 Rock Cover, Mattresses and Grout Bags

Maximum anticipated quantities of rock cover, mattresses and grout bags are presented in the ES to assess the worst-case scenario in terms of impacts on the seabed. The requirements for mattresses and grout bags will be further assesses and confirmed in the subsequent Pipeline Works Authorisation (PWA) applications.

1.8.4 Well Design

Well design information contained within the ES is based on anticipated depths in line with current engineering status. The casing and well construction architecture will remain the same for each development well. During detailed engineering depths and trajectories will be altered to account for individual reservoir target locations. The assessed quantities within the ES are seen to be representative and suitably bounded for the maximum associated impact.

2 Concept Selection

This section of the ES discusses the process leading to the selection of the proposed development concept, the decision-making steps undertaken through the concept selection process, and the key options considered for the development of Talbot.

2.1 Selection Process and Criteria

Key to the integrated approach has been the parallel working deployed throughout the Pre-FEED (Front-End Engineering and Design) period between the subsurface team characterising the reservoir uncertainties and the facilities, and wells earlier maturity for the essential building blocks to develop the field. This has enabled a progressive and earlier definition of the development plan to be completed with greater certainty over cost and schedule elements. This work has been supported by the Contracting Strategy and Project Execution Plan.

The key decision criteria for concept development were, whilst environmental and socioeconomic impact was minimised:

1. Maximise environmental performance through selection of efficient and effective processes and methodologies;
2. Minimise cost and schedule to achieve a lower minimum economic field size given the range of recoverable resources in the Talbot Field; and
3. Enable flexibility to capture the potential upside in recoverable volumes within the reservoir.

Emphasis has been placed on the standardisation of equipment and operations within the Talbot Field Development area and upon the management of interfaces from the hydrocarbons reaching seabed surface to export via Judy Platform, to identify project and environmental risk reductions and commensurate cost, and schedule savings. The key results of the concept matrix-based selection process with environmental impact are summarised in subsequent subsections.

The talbot Operator received no-objection from the NSTA to the selected concept on 5th November 2019.

2.2 Key Decisions

The following subsections summarise the key aspects of Talbot Field Development project decision making.

2.2.1 Field Development Type

A subsea tieback was selected concept for the Talbot Field Development. A summary of the development options is shown in Table 2:1, Selection 1, a subsea tieback, is in line with the goals of the North Sea transition deal to reduces greenhouse gas emissions and assist in meeting the UK net zero target. Harbour ensured that Talbot does not affect emission reduction targets within the NSTD & White Paper, does not preclude future emission reduction projects, whilst ensuring the UK security of energy supply. This development aligns with the Harbour Energy Net Zero target by 2035 and to the ambitions of the recently published British Energy Security Strategy (H.M Government, April 2022) with a large gas component of the development and tying into a facility like Judy with genuine emission reductions capability over life of field.

Table 2:1 – Talbot Field Development Type Considerations

Option	Summary	Considerations
1 (Selected)	Subsea tieback	• Smaller overall environmental footprint and opportunity to reduce power requirements by utilising capacity in existing Judy facilities. • Lower incremental Capital Expenditure (CAPEX) than Options 2 and 3. • Lower ongoing Operational Expenditure (OPEX) than Options 2 and 3. • Lower Greenhouse Gas (GHG) emissions and resource use when compared to Options 2 and 3 • Greater chemical efficiencies savings when tied back to existing platform compared to Options 2 and 3. • Lower embodied carbon across Lifecyle of project • Lower seabed disturbance in a protected habitat • No significant increase in flaring or overboard discharge • Favourable delivery schedule for 1st oil date. • Supports security of local supply to UK. • Best option in line with goals of the North Sea transition deal
2	Fixed jacket, Unmanned Wellhead Platform (UWP)	• Greater overall environmental footprint and ongoing energy requirements. • Easier to enter wells for future intervention • High incremental Capital Expenditure (CAPEX). • High ongoing Operational Expenditure (OPEX). • Delivery schedule not favourable for 1st oil date. • Higher GHG emissions and resource use when compared to Option 1 • Lower chemical efficiencies when compared to Options 2 and 3. • Higher embodied carbon across Lifecyle of project • Higher seabed disturbance in a protected habitat • Larger decommissioning footprint. • Supports security of local supply to UK. • Increase in flaring and overboard discharge
3	Floating Production System (FPS)	• Greater overall environmental footprint and ongoing energy requirements. • Easier to enter wells for future intervention • High incremental Capital Expenditure (CAPEX). • High ongoing Operational Expenditure (OPEX). • Delivery schedule not favourable for 1st oil date. • Higher GHG emissions and resource use when compared to Option 1 • Lower chemical efficiencies when compared to Options 2 and 3. • Higher embodied carbon across Lifecyle of project • Larger decommissioning footprint. • Supports security of local supply to UK. • Increase in flaring and overboard discharge

2.2.2 Host Selection

A number of potential host production facilities were identified for screening: Judy, Stella, Flyndre-over-Clyde and Clyde. Tieback to Harbour Energy operated Judy Platform was the selected Host. A summary of the development options is shown in Table 2:2.

Table 2:2 – Talbot Host Selection Considerations

Option	Summary	Considerations
1 (Selected)	Tieback to Judy Platform (Harbour Energy operated)	• Judy is closest viable host, 16 km northwest of Talbot • Judy has available and sufficient capacity for processing oil and gas and exporting it to market. • Minimises both processing energy requirements and resultant generated emissions as Talbot hydrocarbons and water will be processed by existing facilities with minimal additional energy requirements. Using Judy rather than new infrastructure being built it prevents the requirement for further surface oil and gas infrastructure being built in the North Sea and inefficient duplication of processes and the physical presence. • Forecasted Cessation of Production (CoP) date in line with Talbot premised field life. • Judy has potential for improved efficiency and potential decarbonisation • Minimal topsides modifications required as Talbot fluids are analogous to other Judy fluids. • Pre-existing tie-in facilities available • Utilisation of many UK companies and supporting UK supply chain. • Within reasonable distance to minimise tie-back CAPEX cost.
2	Tieback to other nearby 3rd party operated platform or FPS	
2a	Stella	• Increased distance from Talbot (bypassing Judy) would increase overall environmental impact. • Would form a 3rd party tie-in to non-Harbour Operated asset whereas Judy is Harbour Operated. • Higher OPEX and CAPEX cost as a result.
2b	Flyndre-over-Clyde	• Capacity constraints for processing and export. • Considerations of potential CoP dates. • Higher OPEX and CAPEX cost incurred with reduced whole-life economics.
2c	Clyde	• Clyde is the second closest viable host, 19 km southwest of Talbot, however this will result in pipelines being laid entirely within the Fulmar Marine Conservation Zone (MCZ) • Considerations of potential CoP dates • Would form a 3rd party tie-in to non-Harbour Operated asset whereas Judy is Harbour Operated. • Higher OPEX and CAPEX cost incurred with reduced whole-life economics.

2.2.3 Field Development Options

Reservoir engineering, in conjunction with Wells and Facility engineering groups evaluated development options for the Talbot Field. The evaluation considered the subsurface uncertainty whilst maximising the flexibility of the development to cater for the full bounding ranges (high and low) of potential recoverable volumes and associated flowrates.

In order to reduce project risk a development concept was selected that minimised up-front CAPEX whilst allowing for the reservoir appraisal. An up-front appraisal concept was selected as the development option. A summary of the development options is shown in Table 2:3.

Table 2:3 – Talbot Field Development Considerations

Option	Summary	Considerations
1	Appraise-while-develop.	• Retains the option to include future wells in a continuous or phased drilling programme, with associated second drill centre (DC).
2	No development, exit license.	• Prior appraisal wells and current subsurface characterisation show an available economic development. • Reduction in UK energy resource resulting in further import reliance and potentially higher emissions cost due to transport and from less regulated country.
3	No appraisal, low well count.	• In all cases some form of appraisal to test wider reservoir upside is premised.
4 (Selected)	Up-front appraisal.	• Additional mobilisation and demobilisation of the Heavy Duty Jack Up (HDJU) rig and widened 1st oil date.
5	No appraisal, maximum well count.	• Potential for high cost exposure given uncertainty on wider reservoir upside. • Additional time during project phase with increased emissions and impact potentially for no net gain in production.

2.2.4 Pipeline Selection

A carbon steel PiP pipeline, trenched and backfilled, was the selected concept for pipeline. Table 2:4 outlines the selection summary.

Table 2:4 – Talbot Pipeline Selection

Option	Summary	Considerations
Pipeline Type		
1 (Selected)	Insulated PiP	• Insulation performance meets flow assurance requirements based on Talbot fluid properties and flow profiles. No requirement to heat line. Reduces requirement for additional power generation and more complex line to carry heat.
2	Wet insulated pipeline	• Insulation performance does not meet flow assurance requirements based on Talbot fluid properties and flow profiles.
3	Bundle pipeline	• Available fabrication length does not meet requirement for tieback length. High fabrication and resource cost (more carbon intensive). • Difficult to decommission
Lay Method		
1 (Selected)	Reel laid	• Pipeline length suitable for contractor service provision and premised pipelay vessel. • Other operators within area have conducted similar operations with success (Ithaca Stella Oil Export, Shell Gannet Export). • Most energy efficient (reduced vessel days, number of vessels) therefore lower emissions generated and on location for a shorter time so shorter period of disturbance.

Option	Summary	Considerations
		• Allows export line and umbilical to be laid together reducing disturbance impact and improving efficiency.
2	Float and lay	• Available installation length does not meet requirement for tieback length, would require multiple sections with in-line tees.
3	Lay barge	• Prohibitive from a CAPEX perspective for installation timeframe. • Dependent on type can require large amount of anchor works with damage to MCZ.
Protection and Stabilisation Method		
1 (Selected)	Trenched (mechanical) and backfilled	• Provides adequate protection and minimises snag risk for other sea users. • Minimises potential rock usage for stabilisation, and consequently habitat loss. • Meets performance requirements for water depth and hydrodynamic conditions. • Reduction in rock use means reduction in embodied carbon of the project and reduced time for rock dumping vessel on location again reducing emissions of the project. • Proposed depth of burial and cover favourable for decommissioning, in line with current decommissioning guidance
2	Trenched (jet) and backfilled	• Provides adequate protection and minimises snag risk for other sea users. • Minimises potential rock usage for stabilisation, and consequently habitat loss. • Geophysical seabed conditions and efficiency in achieving target depth
3	Weight-coat (concrete) and surface laid	• Not possible with chosen lay method. • Presents higher snag risk for other sea users. • Concrete coat involves higher embodied carbon content

Table 2:5 – Talbot Rig Selection

Option	Summary	Considerations
1	Semi-submersible rig	• Relatively shallow water for semi-sub to operate in. • Open water location so feasible to use. • Higher fuel use and resultant in greater emissions. • Number of impacts from multiple large anchor array in MCZ. • Higher noise generation in the water. • Higher cost for minimal technical gains.
2 (selected)	HDJU rig	• Optimal water depth for HDJU rig • Lower total emissions for time on location. • Proven performance in this location and on Talbot reservoir. • Semi-submersibles have advantages for multiple well campaigns (that Talbot is) when the rig needs to physically move to reach its next target. However, for Talbot, with the rig working over a single drilling template, the rig only needs the single move onto location and then can Cantilever to each well without the rig requiring movement. • Less subsea noise generation. • Smaller area of impact to seabed. • HDJU rig is more suited to running the completions for Talbot wells.

3 Project Description

The Talbot Project helps Harbour and the NSTA meet their Central Obligation under MER "Relevant persons must, in the exercise of their relevant functions, take the steps necessary to secure that the maximum value of economically recoverable petroleum is recovered from the strata beneath relevant UK waters" (Central obligation Section 7, The MER Strategy for the UK as presented to Parliament in accordance with section 9A (2) of the Petroleum Act 1998). OGA (now NSTA) amended the MER UK Strategy to include meeting Net Zero as one its key elements. Harbour has a target of meeting Net Zero by 2035 and the Talbot Field Development has been assessed as being able to be undertaken without compromising this target date.

3.1 Introduction

Harbour propose to develop the Talbot Field as a three production well subsea tie-back to the existing Judy Platform infrastructure, using the processing and export facilities of the Judy Platform further downstream. The template being laid will have 4 slots in it and therefore this Environmental Statement has assessed the development for 4 wells though it should be noted the Field Development Plan will only specify 3 wells (Figure 3:1). Assessing 4 wells was considered a precautionary approach but a 4th well is not part of any current development plan and in the ES is only assessed in terms of drilling and related impacts rather than 4 development wells. Hence only 3 subsea production systems are discussed in the following chapter.

3.1.1 Base Case Development and Assessment within the ES

Talbot reservoir has been appraised with wells 30/13-2 (Phillips in 1972), 30/13a-9 (Talisman in 2011), 30/13a-11 and 30/13a-11Z (both GDF Suez in 2013). In Q2/Q3 2021 Harbour successfully drilled the 30/13e-12Z appraisal well to further assess the Talbot reservoir and confirm commercial potential of the reservoir; inform FID.

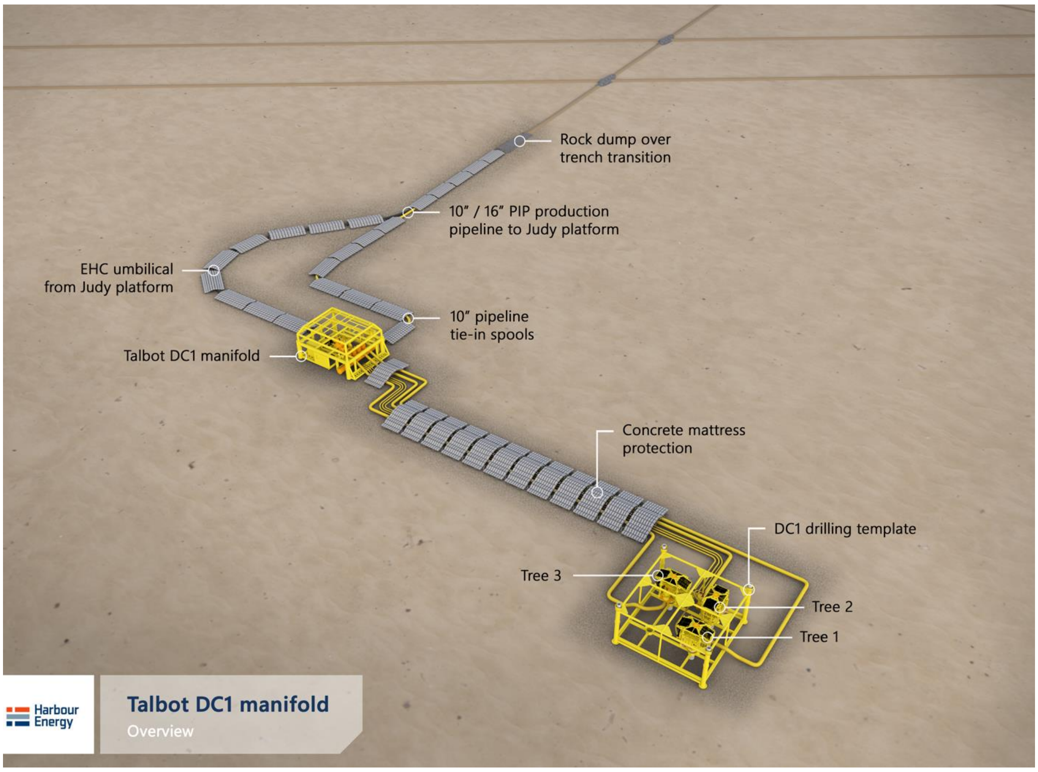


Figure 3:1 – Talbot Concept Visualisation

Table 3:1 summarises the base case development concept as outlined within the proposed FDP submission to NSTA in relation to the maximum upside case assessed within the ES (4 wells rather than 3 and option for 12”/18” pipeline).

Table 3:1 – Field Development and ES Assessment Summary

Item	Assessment Case Within ES
Number of Production Wells	4 (FDP =3)
Number of Pipelines	1
Number of Umbilicals	1
Number of Subsea Production Systems and Associated Hook-up Spools and Control Bundles	3
Total	9

3.2 Field Layout

The overall Talbot Field layout is shown in Figure 3:2, with further details on the Talbot subsea manifold and drilling template in Figure 3:3, proposed Talbot 500 m zone drill centre in Figure 3:4, and the proposed layout at Judy Platform 500 m zone in Figure 3:5.

The overall field infrastructure is proposed to consist of the items listed in Table 3:2, with references to numbered items within Figure 3:3, Figure 3:4, and Figure 3:5.

Table 3:2 – Talbot Infrastructure Summary

Item	Description	Location	Number Assessed	Detailed Description
1	A c. 16 km x 10”/16” outer diameter (OD) multiphase PiP pipeline. (option for 12”/18”)	Talbot 500 m zone to Judy 500 m zone	1	Section 3.8
2	c. 254 mm OD x c. 88.1 m hook-up spools from pipeline (*Item 1*) to SSIV (*Item 3*)	Judy 500m Zone	1	
2a	c. 254 mm OD x c. 71.8 m hook-up spools from pipeline (Item 1) to PL1000.	Judy 500m Zone	1	
3	A Subsea Isolation Valve (SSIV) c. 12.06m (L) x 5.81m (W) x 4.18m (H), hammer piled with four corner piles.	Judy 500m Zone		
4	c. 254 mm OD x c. 48 m hook-up spools from pipeline to Talbot subsea manifold.	Drill Centre	1	
5	A c. 16 km x 164 mm OD Production Control Umbilical (PCU) carrying power, communications, hydraulic fluid and chemical supply.	Talbot 500 m zone to Judy 500 m zone	1	Section 3.9
5a	A c. 650m x 181mm OD Production Control Umbilical carrying power, communications, hydraulic fluid and chemical supply.	Judy 500m Zone	1	Section 3.9
5b	A c. 258m x 115mm OD Production Control Umbilical carrying power, communications, hydraulic fluid and chemical supply.			Section 3.9

Item	Description	Location	Number Assessed	Detailed Description
6	A four-slot drilling template c. 14.85 m (L) x 14.85 m (W) x 8.97 m (H), hammer piled with four corner piles.	Drill Centre	1	Section 3.9
7	A four-slot subsea manifold c. 12.00 m (L) x 7.25 m (W) x 4.71 m (H), hammer piled with four corner piles.		1	
8	Subsea Production System (SPS) inclusive of Christmas Tree (XT), control system components and multiphase flowmeter.		3	Section 3.7.1
9	c. 130 m x 130mm OD hook-up spools between XT and subsea manifold.		3	
10	c. 140 m x 120 mm OD control bundles carrying power, communications, hydraulic fluid and chemical supply from subsea manifold to XTs.		3	

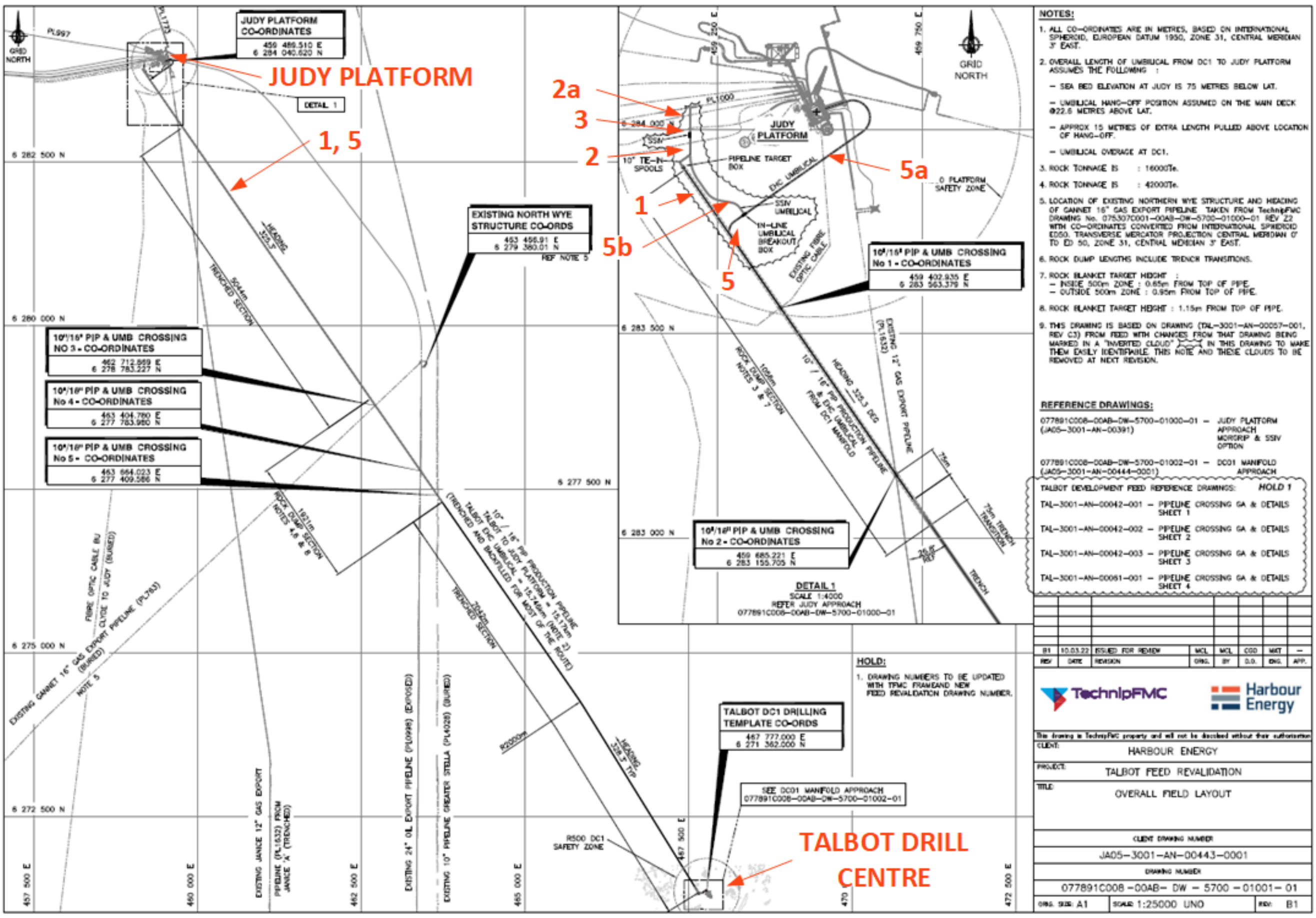


Figure 3:2 – Proposed Talbot Field Layout and Tie-in to Judy Platform

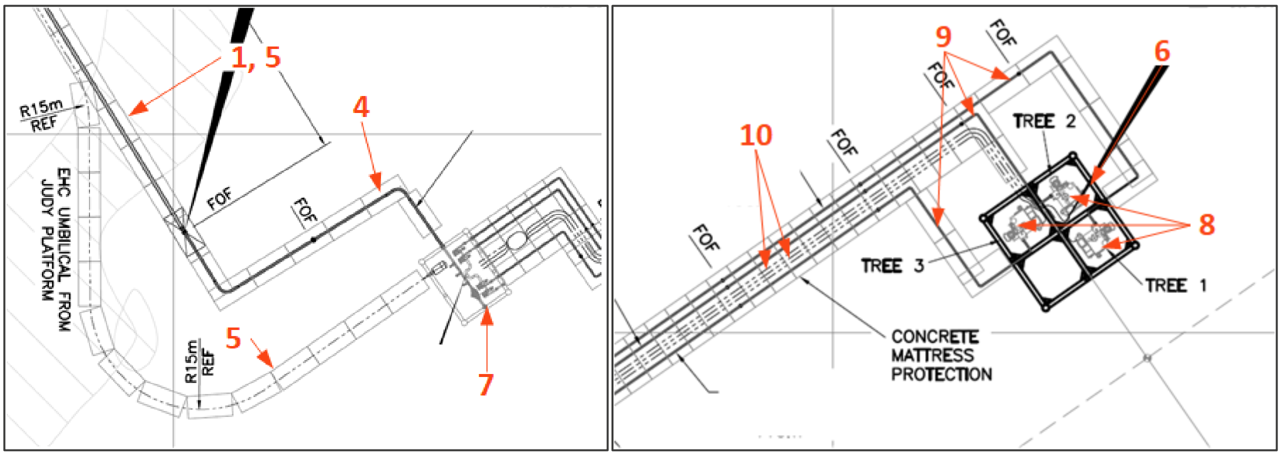


Figure 3:3 – Talbot Subsea Manifold (Left), Drilling Template (Right)

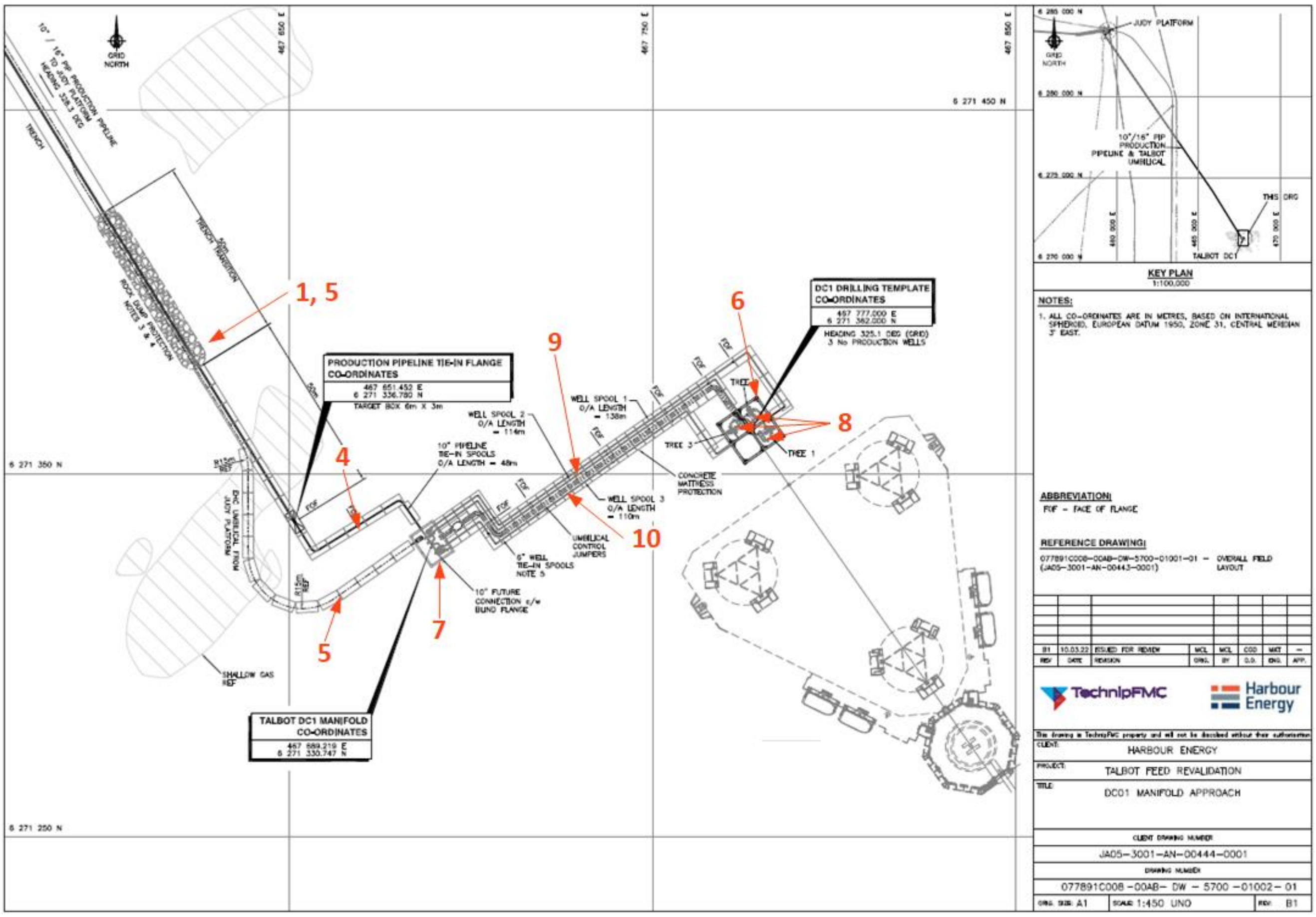


Figure 3:4 – Talbot Drill Centre Arrangement (Base Case)

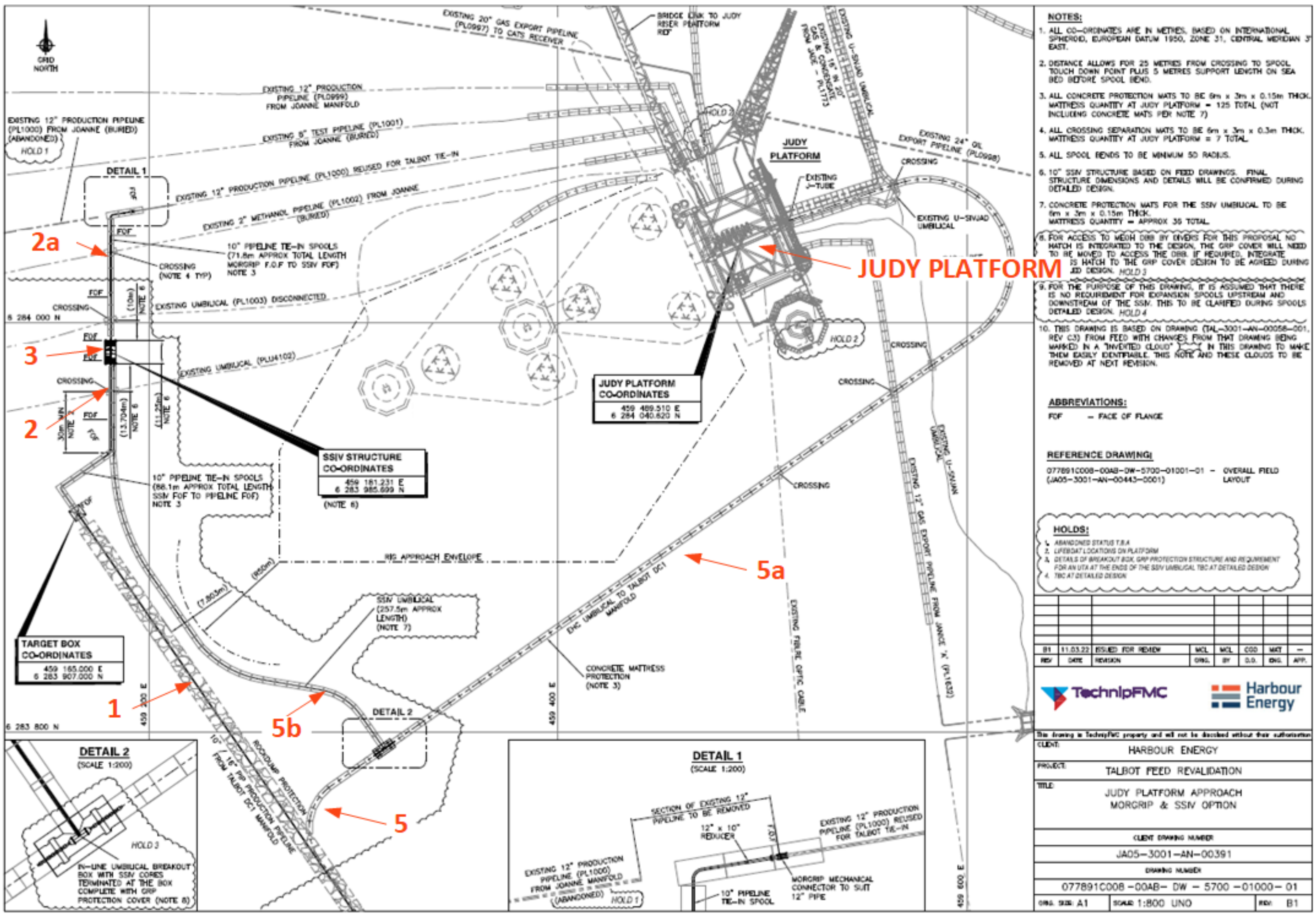


Figure 3:5 – Proposed Arrangement at Judy Platform 500m Zone

3.3 Reservoir Details

Talbot is a hydrocarbon discovery with light volatile oil (40˚ API) and associated gas resources. The characteristics for the Talbot reservoir are summarised in Table 3:3.

Table 3:3 – Talbot Reservoir Properties

Property	Value
Reservoir Type	Light oil with associated gas components
Reservoir Depth	c. 9,500 ft TVDSS*
Recoverable Reserves (P50)	c. 18.1 MMBOE**
Stock Tank Oil Density	40˚ API
Gas/Oil Ratio (GOR)	2037 scf/stb***
Oil gravity	40˚ API****
Gas gravity	0.794
Wax Content	c. 6.6%
*ft TVDSS – feet True Vertical Depth subsea **MMBOE – Million Barrels of Oil Equivalent ***scf/stb – Standard Cubic Feet per Stock Tank Barrel ****API – American Petroleum Institute	

The reservoir in the Talbot Field is the Lower Balmoral (L2) sandstones of the Lista formation and the field is adjacent to developments in the L2 sandstone, with the Joanne Field to the north, operated by Harbour Energy, and the Flyndre Field, a Total operated development to the east as shown in Figure 3:6.

The L2 is a thin reservoir (15-30 ft thick) below seismic resolution but within seismic detectability. As indicated before five wells have been drilled on the Talbot structure. Two Drill Stem Tests (DST's) have been performed in the L2 sandstone interval on Talbot, in 30/13-2 (1972) and 30/13a-11 (2013). The DST in 30/13-2 produced both oil and water. The DST in 30/13a-11 produced dry oil with no evidence of water during the test. Therefore, Harbour undertook the 30/13e-12Z appraisal well in 2021 to improve data for the Talbot subsurface and ensure the economic feasibility of the project.

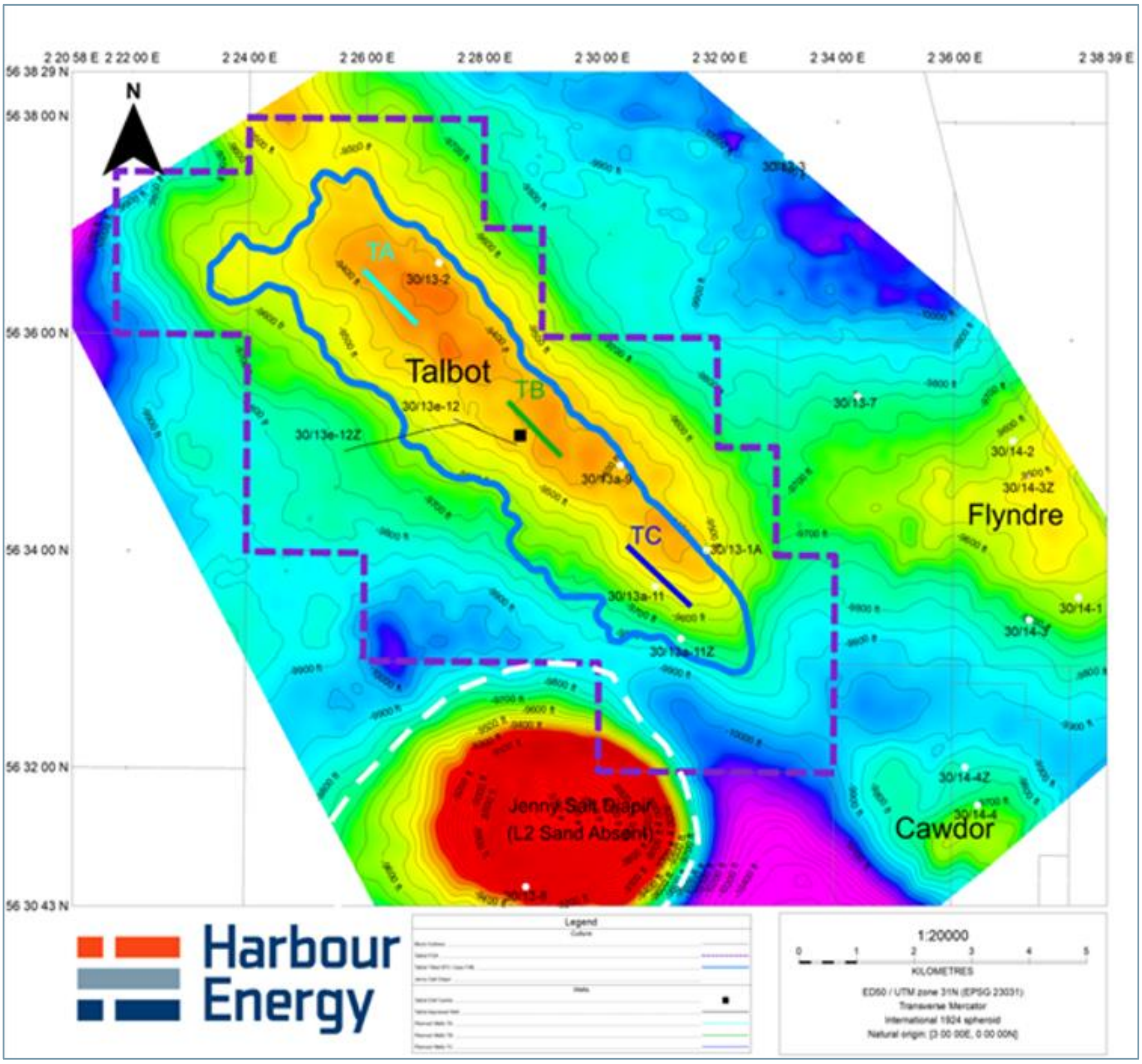


Figure 3:6 – High Case Talbot Field Subsurface Overview

3.4 Schedule of Activities

The anticipated schedule of activities associated with drilling, brownfield topsides modifications, subsea infrastructure installation, hook-up and commissioning, and first oil is summarised in Figure 3:7. Key dates are:

- Commencement of FEED revalidation works December 2021;
- Drilling Template Installation Q3-2022;
- Development well spud Q4-2022; and
- Talbot first oil Q3-2024.

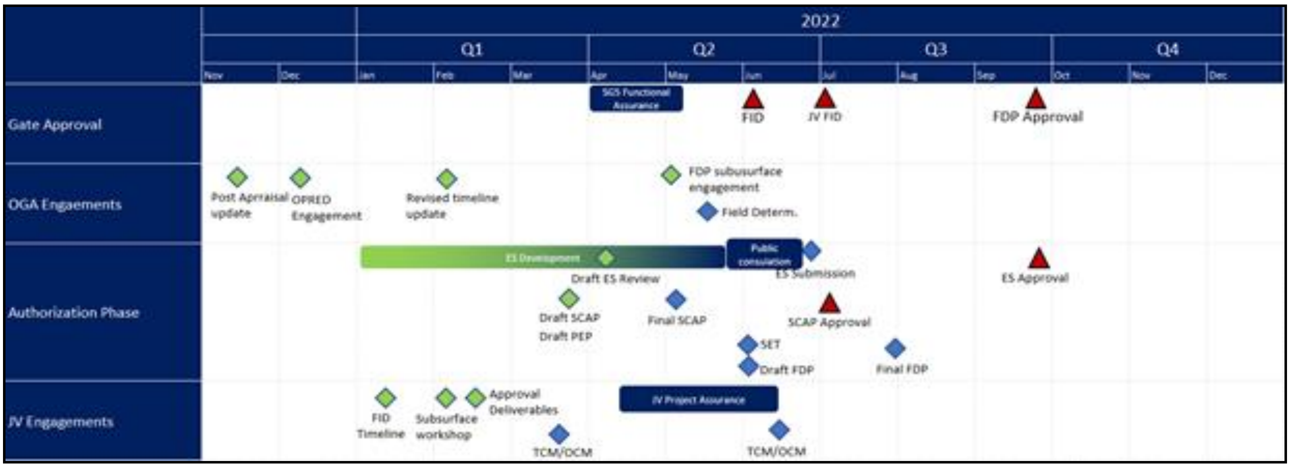


Figure 3:7 – Talbot Field Development Schedule

3.5 Drilling Operations

The development drilling operations are proposed to be conducted from a heavy-duty jack up (HDJU) drilling unit which is suited to the water depths and expected metocean conditions that will be found at the Talbot location. It is proposed drill the wells using a HDJU rig, certified for year-round working in the UKCS. As such all assessment within the ES has been carried out utilising the typical particulars of this class of rig.

3.5.1 Drilling Location

The proposed Talbot DC location is 56˚ 35’ 03.12” N and 2˚ 28’ 31.518” E, Universal Transverse Mercator (UTM), Central Meridian 3˚ East, International Spheroid 1924 European Datum 1950 (ED50) Zone 31. A maximum of one rig move has been assessed as part of the ES in addition to the mobilisation and demobilisation of the HDJU rig. There is however no intention and should be no need to move the rig once on location. The rig can reach all wells by used of its cantilever which moves the drilling assembly to target multiple wells.

3.5.2 Positioning and Anchoring of the HDJU Rig

Anchor Handling Vessels (AHV’s) will be required to locate the HDJU rig on location. Four moorings will be deployed once the HDJU rig is at a stand-off location in order to position the HDJU rig onto final location and achieve positional accuracy. Anticipated details for mooring configuration are detailed in Table 3:4.

Table 3:4 – HDJU Rig Mooring Line Details (per Line)

Mooring Item	Estimated Weight	Dimensions
Anchor	6.5 Te	Shank c. 3.2 m
Flute Width c. 2.0 m	6.5 Te	2.0m
Chain	N/A	c. 200 m length x 76 mm OD

Once the HDJU rig is in position the legs would be pinned, the rig jacked up to minimal airgap and pre-loading completed to confirm seabed stability. On conclusion of satisfactory preloading the HDJU rig would be jacked up to the required air gap. The moorings would subsequently be recovered.

Details of the placement of the anchors will be provided in the Consent to Locate (CtL) permit application which will be submitted under the drilling operations' permit application.

3.5.3 Well Design

The development well design is common and based on recent Harbour drilling performance in Paleocene wells, summarised in Table 3:5. The casing and well construction architecture will remain the same for each development well (Figure 3:8). Detailed engineering depths and trajectories will be altered to account for individual reservoir target locations.

Detailed specifics relating to well design will be reflected in future drilling operations' permit applications.

Table 3:5 – Well Casing Design Summary

Hole Section	Associated Casing OD	Total Vertical Depth Below Seabed	Section Length (ft)	Containment Status
42" x 36"	36" x 30"	300 ft (92 m)	300	Open-hole
26"	20"	1,400 ft (430 m)	1100	
16"	13 3/8"	c. 4,600 ft (1,402 m)	3200	Contained within High Pressure (HP) drilling riser
12 ¼"	10 ¾" x 9 7/8"	c. 9,500 ft (2,896 m)	9500	
8 ½"	5 ½" (Sandscreens)	c. 9,500 ft – 9,800 ft (2,896 m – 2,987 m)	4000	

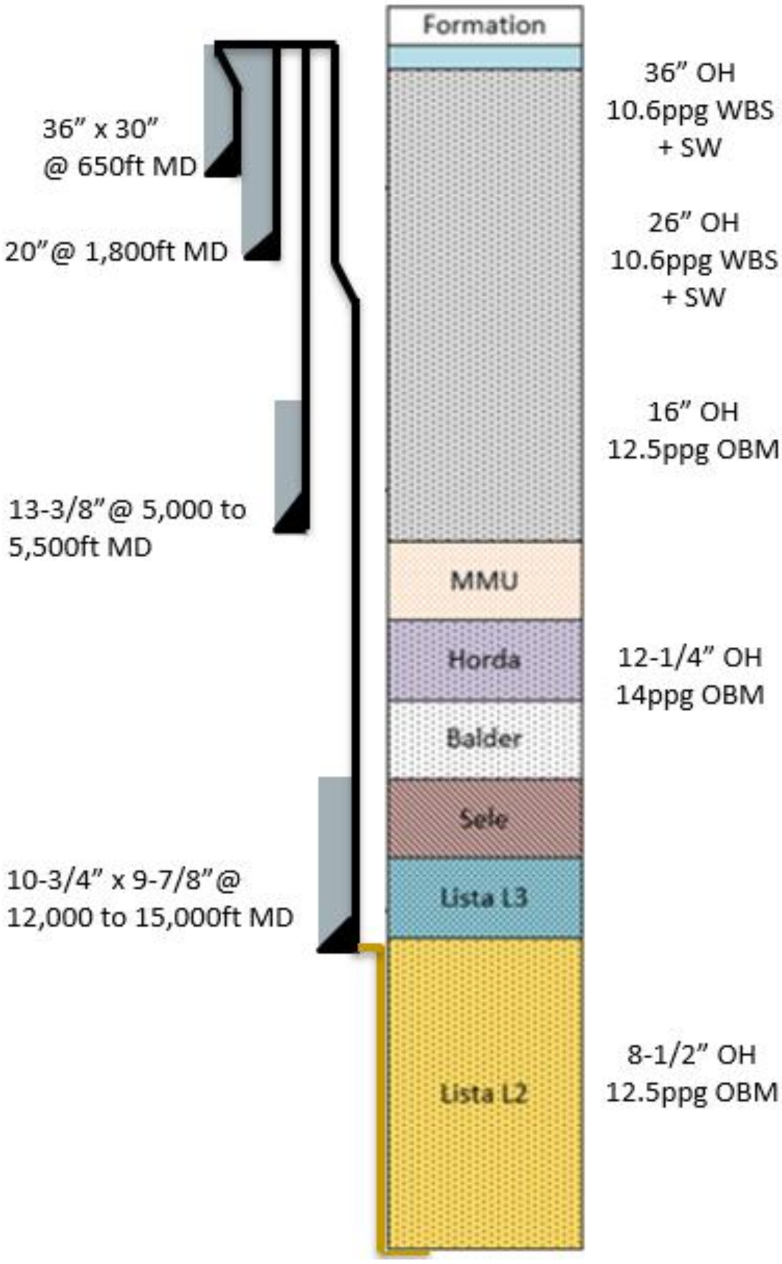


Figure 3:8 – Schematic of Proposed Well Design

The well design is based on a 36" conductor to transfer the loads from the drilling operations and the well to the seabed, with a 20" casing to enable the high pressure wellhead to be set within the conductor housing assembly, and two casing points to the top of reservoir (Figure 3:8). The reservoir will be completed in 5 ½" sand screens, with 4 ½" production tubing to surface.

The steel casings installed in the wells provide structural strength to support the wellheads and XTs, isolate unstable formations and separate formations which have different pressures and fluids.

For the development wells, data acquisition will include routine measurement while drilling logs for the overburden sections 16" and 12-1/4". Deep reading resistivity tool or pilot holes may be used for landing the 12-1/4" and deep reading resistivity for geo-steering the 8-1/2" reservoir section along with biostratigraphy.

As such, within the ES the maximum assessment for possible pilot holes have been assessed.

3.5.4 Drilling Sequence

The proposed drilling sequence assessed as part of the ES, is as follows:

1. Batch-setting of open-hole sections:
    i. Drill 36" hole section, run and cement 30" conductor casing for three wells; and
    ii. Drill 26" hole section, run and cement 20" surface casing for three wells.
2. Install HP drilling riser on first well within template. Drill and complete first well within template;
3. Move HP drilling riser from first well to second well within template. Drill and complete second well within template;
4. Move HP drilling riser from second well to third well within template. Drill and complete third well within template; and
5. Recover HP riser and prepare for rig move operations.

The open-hole sections are a required stage to install the primary structural steel conductor and the second steel casing complete with wellhead housing. After which, the HP drilling riser is installed onto the wellhead, which shall form the pressure containing envelope between the well and the Pressure Control Equipment (PCE) utilised on the HDJU rig, the main item of PCE being the Blow-out Preventer (BOP) which shall be located on the HDJU rig.

The trajectories of development wells will be similar to those previously drilled in the J-Area Paleocene, with a vertical top hole, followed by a steady build to the required tangent angle and building inclination to land the well either inside or just above the reservoir. The reservoir section will then be drilled as horizontal, using geosteering techniques to stay within the layer of reservoir sand.

3.5.5 Drilling Mud and Cuttings

Throughout the drilling phase of all hole sections within the wells drilling mud is required to:

- Maintain well control throughout drilling operations and providing sufficient hydrostatic pressure;
- Maintain hole stability to ensure efficient installation of steel casing sections and well completion equipment;
- Transport of cuttings out of the wellbore; and
- Keep the drill bit sufficiently cool and lubricated.

Throughout the open-hole designated sections (36" and 26") a water-based mud (WBM), mixture of seawater and stabilising gel, is proposed to be utilised. During the open-hole drilling sections, cuttings generated are planned to be deposited at seabed level by means of a subsea cuttings transportation system within the Drilling Template, utilising a pump system deployed by a Remotely Operated Vehicle (ROV). The subsea cuttings transportation system is required to prevent excess build-up of cuttings within the Drilling Template structure which may hinder installation operations. Estimated volumes of cuttings per well proposed to be deposited to the seabed are summarised in Table 3:6 with assessment of impact within Sections 6 and 7.

Detailed specifics relating to seabed cuttings deposition will be reflected in future drilling operations' permit applications.

Following installation of the HP drilling riser onto the particular well, the remaining sections of the well will be drilled using a Low Toxicity Oil-Based Mud (LTOBM). The LTOBM will be pumped through the drill-string, exiting the drill bit and circulated back up the inside of the HP riser for processing on the HDJU rig. The returned mixture of cuttings and LTOBM will be separated over shale-shakers, with LTOBM reused wherever possible. Contaminated cuttings, those generated using LTOBM will be processed in one of two methods. Firstly, processing offshore where oil on cuttings is reduced to <1% by a dedicated unit on the drilling rig and then the cuttings discharged at location, with recovered oil re-used or sent back to shore. Second option would be the cuttings will be transported onshore to a dedicated and approved vendor for further processing before being disposed of in an environmentally prudent manner, otherwise known as "skipped and shipped". At this stage both options are being kept open and if the offshore processing was selected a "skip and ship" option would be retained should there be any issues with the offshore processor.

Estimated weight of cuttings per well are shown within Table 3:6. Prudent contingency has been applied to assess the maximum extent of cuttings return based on possible scenarios. Contingency cuttings estimates are assessed as a worst-case and are not activities planned within the base drilling schedule, these would be typically generated through mechanical side-tracks where one section has run into technical problems and has to be re-drilled and will therefore generate more cuttings to achieve this and get back to its original target.

Full details of the mud volumes to be used will be provided in the subsequent Subsidiary Application (SAT) applications to BEIS.

Table 3:6 – Well Section Cuttings Estimate (per Well)

Hole Size	Section Length (m)	Mud System	Weight of cuttings (tonnes)*	Disposal route of cuttings
36"	85	Seawater / Gel sweeps	130	Discharge to seabed
26"	370	Seawater/ Gel sweeps	295	Discharge to seabed
16"	1,300	LTOBM	392	Processed offshore or contained and shipped to shore for treatment and disposal
12.25"	2,900	LTOBM	513	Processed offshore or contained and shipped to shore for treatment and disposal
12.25" Appraisal	2,900	LTOBM	513	Processed offshore or contained and shipped to shore for treatment and disposal
12.25" Pilot	2,900	LTOBM	513	Processed offshore or contained and shipped to shore for treatment and disposal
8.5"	1,300	LTOBM	111	Processed offshore or contained and shipped to shore for treatment and disposal
Contingency				
16" Sidetrack	1,300	LTOBM	392	Contained and shipped to shore for treatment and disposal
12.25" Sidetrack	2,900	LTOBM	513	Contained and shipped to shore for treatment and disposal
8.5" Sidetrack	1,300	LTOBM	111	Contained and shipped to shore for treatment and disposal

*Cuttings density/specific gravity assessed as 2.327

3.5.6 Cementing

Each steel casing will be cemented into place to provide a structural bond and an effective seal between the casing and formation rock. During cementing, excess cement may be generated. However, mixes will be optimised to ensure excess cements, and the requirement to discharge to sea, will be minimised. All chemicals to be used within the cement will be selected based on their technical specifications and environmental performance. Chemicals with Centre for Environment, Fisheries and Aquaculture Science (CEFAS) substitution (SUB) warnings will be avoided where technically possible.

The cement slurries will be designed with special additives to have low heat of hydration while setting of cement as well as low thermal conductivities to minimise disassociation of naturally occurring shallow hydrates while drilling and in production. The slurries will also have adequate compressive strength to support the casing string and blow out preventer (BOP) stack and will be suitable for temperatures which are expected at the Talbot.

The cementing strategy will be to use a Tuned Light XL E in the first two hole sections and a G+ 35% silica cement type thereafter, suitable for use in wells in this location. Anticipated cement volumes are summarised in Table 3:7 however these will vary based on specific well design and cemented section lengths.

Table 3:7 – Well Casing Cement Volume Estimate (per Well)

Casing			Cement				
Hole size	Casing OD	Setting depth (ftMD)	Top of cement (ftMD)	Tail length (ft)	Cement Weight (ppg)	Cement type	Anticipated Volumes (bbls)
36”	30”	650	Mud line	N/A	16.0	Tuned Light XL E +35% SSA-	215
26”	20”	1,800	Mud line	N/A	16.0	Tuned Light XL E +35% SSA-	250
16”	13 3/8”	5,000 to 5,500	+/- 2,500	750	13.2 / 16	G+ 35% silica	105
12.25”	9-7/8”	12,000 to 16,000	+/- 1,000 above Balder Formation	N/A	16.0	G+ 35% silica	150

Similar to the drilling and completions chemicals, the chemicals associated with the cementing operations will be detailed in the subsequent drilling operations’ permit applications.

3.5.7 Completion Design

The development wells are premised with 5 ½” stand-alone sand screen lower completion within the horizontal reservoir section to provide solids control. The upper completion is premised to be 4 ½” production tubing to surface and include downhole scale inhibitor injection below the Subsurface Safety Valve (SCSSV) and a downhole pressure gauge for reservoir monitoring.

Once completed, each well is planned to be left in a suspended state, with minimum of two barriers isolating the wellbore. Further to departure of the drilling rig, the subsea production systems (XTs) are planned to be installed by a Construction Support Vessel (CSV).

3.5.8 Well Testing and Clean-up

Well flowback is premised to be through the Judy Platform processing system. Although not the primary option, provision exists to clean-up the wells via the HDJU rig and flare the associated hydrocarbon production. Clean-up test flaring has been assessed within the ES as contingency not exceeding 96 hours or 2,000 tonnes of oil, therefore cannot be classed as extended well tests (EWT). NSTA have been consulted on clean up options for this well.

3.6 Subsea Infrastructure

This section summarises the proposed infrastructure at key locations, the Talbot drilling centre location and within the Judy Platform 500 m zone.

3.6.1 Subsea Drill Centre Summary

The drill centre is proposed to comprise of (Figure 3:3, Figure 3:4 and Figure 3:5):

- One drilling template, as detailed in Section 3.7.1;
- One subsea manifold (including mud-mats and anodes) which will support up to four production wells, as detailed in Section 3.7.2; and
- Subsea production systems and associated infrastructure, as detailed in Section 3.7.4.

3.6.2 Subsea Layout at the Judy Platform

The proposed layout within the Judy Platform 500 m zone is shown in Figure 3:6, with key infrastructure as follows:

1. 10”/16” (with 12”/18” option) PiP production flowline and hook-up spools as detailed in Section 3.8; and
2. Production Control Umbilical (PCU) carrying hydraulic, power, communication and chemical services as detailed in Section 3.9.

3.7 Subsea Infrastructure

3.7.1 Drilling Template

The subsea drilling template, shown in Figure 3:9, has three key functions:

1. Ensures adequate spacing between wells to achieve the maximum skidding envelope for the HDJU rig without requiring a rig move;
2. Provides dropped object protection for the subsea wellheads during drilling operations on adjacent well drilling and completion operations; and
3. Provides dropped object and fishing interaction protection for the Subsea Production Systems (detailed in Section 3.7.4) throughout field life.

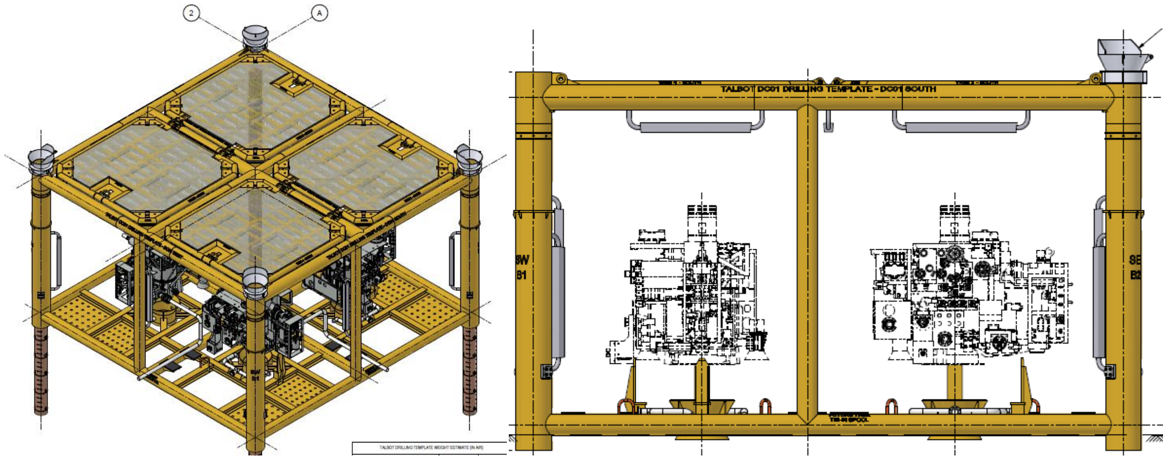


Figure 3:9 – Drilling Template Isometric (Left) and Side View (Right) Showing Four Subsea Production Systems Installed

The drilling template will be capable of accommodating up to four well slots and associated SPSs and be of dimensions 14.85 m (L) x 14.85 m (W) x 8.97 m (H) with a weight of approximately 123 tonnes in air. To ensure provide fixture to the seabed for stability and protection, the drilling template will be piled to the seabed in four corners using four steel piles c. 30 m in length each and weighing approximately 43 tonnes each in air.

The design will be of an overtrawlable "fishing friendly" snag-free design to limit potential for fishing gear snagging. To account for any unplanned fishing gear impact and interaction the structure will be designed to impact load/energies specified in ISO-13628.

3.7.2 Subsea Manifold

The purpose of the subsea manifold (Figure 3:10) is:

- To co-mingle process flow from all connected Talbot wells into a single flowline and route into the main PiP production pipeline; achieved by 6" production slots connecting to a 10" production header with electrically actuated double acting split gate valves installed on each 6" production slot;
- Serve as the final laydown point for the PCU;
- House the requisite infrastructure to distribute hydraulic, power, communication and chemical services to the connected Talbot Subsea Production Systems;
- To provide injection facilities for corrosion inhibitor for the purposes of protecting the carbon steel 10"/16" (12"/18" option) PiP pipeline;
- To provide injection facilities for methanol on the 10" header for the purposes of hydrate management;
- Provide dropped object and fishing interaction protection for all contained systems; and
- Provide capability for future third party expansion of the infrastructure as detailed in Section 3.16.

The subsea manifold will be capable of accommodating up to four production slots and be of dimensions c. 12 m (L) x 7.5 m (W) x 5.3 m (H) with a weight of c. 95 tonnes in air. To ensure fixture to the seabed for stability and protection, the subsea manifold will be piled to the seabed in four corners using four 24" in diameter steel piles c. 30 m in length each and weighing c. 40 tonnes each in air. A proposed design of the subsea manifold is shown in Figure 3:10.

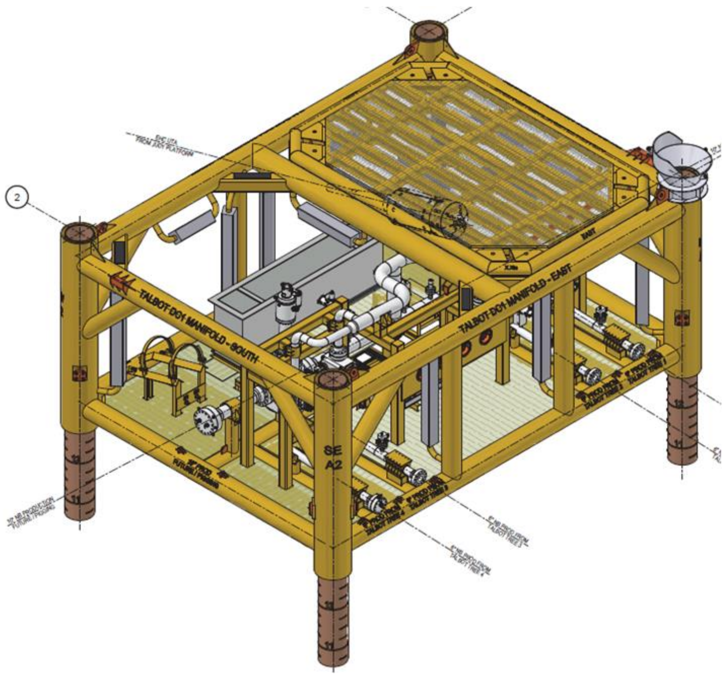


Figure 3:10 – Proposed Subsea Manifold Isometric

The design will be of an overtrawlable "fishing friendly" snag-free design to limit potential for fishing gear snagging. To account for any unplanned fishing gear impact and interaction the structure will be designed to impact load/energies specified in ISO-13628.

3.7.3 Subsea Isolation Valve (SSIV)

The purpose of the SSIV and associated structure (Figure 3:10) is:

- To act as additional closeable barrier from hydrocarbon production fluids to add additional safeguard to the Judy Platform from Talbot flow in the event of a serious topsides or subsea emergency event within the 500m zone
- House the requisite infrastructure to distribute hydraulic, power, communication and chemical services to the operate the SSIV, monitor process conditions;
- To provide injection facilities for methanol on the 10" header for the purposes of hydrate management;
- Provide dropped object and fishing interaction protection for all contained systems; and
- Provide capability for future third party expansion of the infrastructure as detailed in Section 3.16.

The SSIV structure is anticipated to be of dimensions c. 12.06 m (L) x 5.81 m (W) x 4.18 m (H) with a weight of c. 62 tonnes in air. To ensure fixture to the seabed for stability and protection, the subsea manifold will be piled to the seabed in four corners using four 24" in diameter steel piles c. 30 m in length each and weighing c. 40 tonnes each in air. A proposed design of the SSIV structure is shown in Figure 3:10.

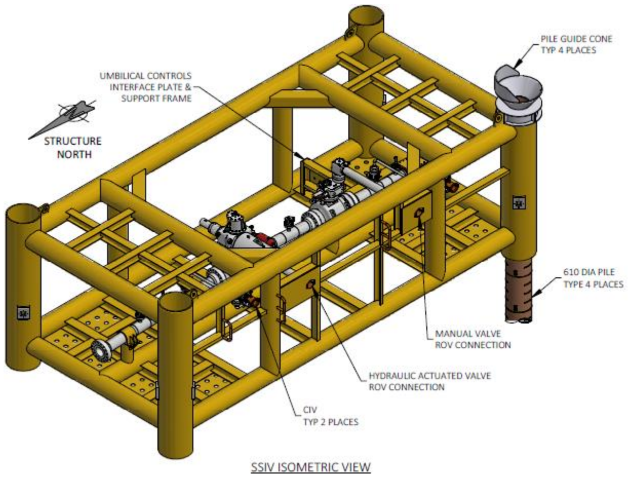


Figure 3:11 – Proposed Subsea Isolation Valve (SSIV) Structure

3.7.4 Subsea Production Systems

The Subsea Production Systems, inclusive of XTs (detailed in Figure 3:12) and all associated infrastructure are common to the development wells and will include:

- Suitable valves, pressure and temperature sensors to enable well-control and integrity inclusive of a tree-mounted electrically actuated choke valve;
- Tree-mounted subsea control architecture (inclusive of discrete hydraulic and power/signal modules) for the purposes of electro-hydraulic control and signal monitoring;
- A tree-mounted multiphase flow meter for the purposes of production allocation;
- Injection of methanol upstream and downstream of the production wing valve, for the purposes of hydrate management;
- Injection of scale inhibitor for the purposes of prevention of downhole scale formation, and backup injection upstream of the choke; and
- Injection of wax inhibitor for the purposes of preventing wax deposition in the carbon steel 10”/16” (12”/18” option) PiP pipeline during shut-down, low-flow, and transient conditions.

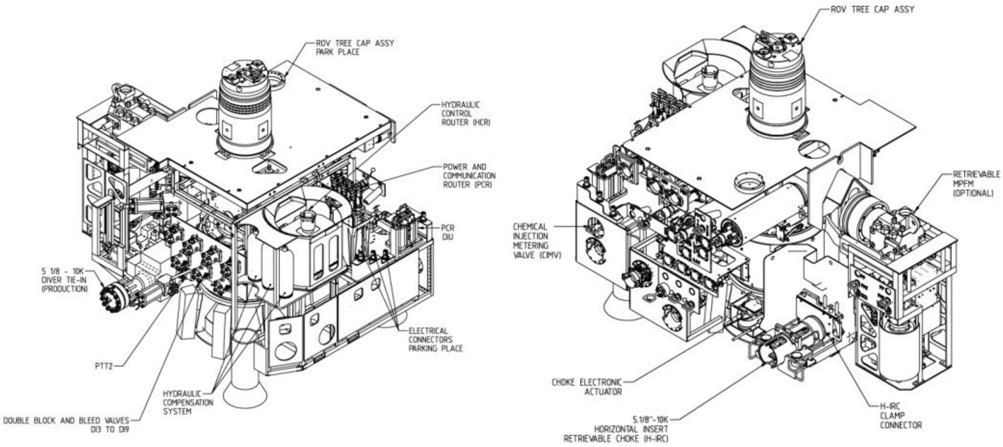


Figure 3:12 – Proposed Subsea Production Tree Isometric Drawing

The production trees will be connected to the Talbot subsea manifold by way of 6” corrosion resistant alloy spools, and suitable electrical, hydraulic and chemical jumpers.

The hydraulically and electrically actuated valves on the XTs and subsea manifold will be operated by a subsea control system, controlled from the Judy Platform. Hydraulically actuated valves are proposed to utilise a water-based control fluid in an open-loop configuration; as such during routine valve operations the water-based control fluid will be discharged to sea in a controlled manner. The proposed control fluid shall be non CHARMable, minimum of OCNS Group D with no substitution warning.

Application for intermittent discharge of water-based hydraulic control fluid during routine valve operations will be included as a chemical permit SAT under the J-Block production MAT.

3.7.5 Field Monitoring

The subsea production system and downhole pressure gauge provides for pressure, temperature and multi-phase flow monitoring on a per-well basis. Pressure and temperature monitoring on the subsea manifold and at the Judy arrival facilities enables pipeline comingled monitoring.

Each development well can be controlled via the per-well choke valves, and the overall pipeline flow condition can be controlled via a topside mounted choke valve on the arrival facilities.

3.8 Pipeline

3.8.1 Information and Installation

The selected option (as summarised in Section 2.2.4) and proposed pipeline for the Talbot Field Development is a continuous 10”/16” PiP pipeline (option being assessed to increase this to a larger 12”/18”). This incorporates a 10” pressure containing inner pipe contained within a 16” non-pressure retaining outer carrier pipe, separated by aerogel type insulation (the larger 12”/18” option is exactly the same design but scaled up). The purpose of the carrier pipe is to contain the insulation which is in turn required to achieve the required thermal performance of the pipeline in order to manage flowing conditions and mitigate risk of blockage mechanisms such as wax or hydrates.

The pipeline is proposed to be constructed of carbon steel with a 3-layer polypropylene (3LPP) anti-corrosion coating, designed to pressures and temperatures both to meet the expected Talbot properties and match existing infrastructure within the Judy 500 m zone. The anti-corrosion coating will be supplemented by sacrificial bracelet anodes to meet a 20 year design life. The estimated length is c. 16 km and shall be designed in accordance with DNGVL-ST-F101 for mechanical design and DNVGL-RP-F112 for on-bottom stability.

The proposed installation method is reel laid, based on suitable size and length for reeling and similar pipelines have been successfully laid in this area utilising similar methods. Due to potential fishing activity within the area, geophysical seabed conditions, water depth and hydrodynamic conditions, trenching and subsequent backfilling was the selected option to ensure pipeline stability and minimise potential snagging risks.

Along the main lay route between the Talbot drill centre location and the Judy 500 m zone there are five proposed crossings with both the 10"/16" PiP flowline and PCU. These are summarised in Table 3:8.

Table 3:8 – Proposed Pipeline Crossings on Main Pipelay Route

No.	PL Number	Size, Field and Service	Operator	Status
1	PL4028	10" Stella Oil Export	Ithaca	In use
2	PL0998	24" Judy Oil Export	Harbour Energy	In use
3	PL0763	16" Gannet Oil Export	Shell	In use
4	PL1632	12" Janice Gas Export	Total	Suspended
5	Norsea Com 1 Seg 1 PL1773	Fibre Optic Cable	Tampnet	In use

As part of the proposed subsea pipeline tie-in, and installation of PCU, there are seven proposed crossings within the Judy 500m zone, summarised in Table 3:9.

Table 3:9 – Proposed Crossings within the Judy 500m Zone

No.	PL Number	Size, Field and Service	Operator	Status
1	PLU4102	Joanne Control Umbilical	Harbour Energy	In use
2	PL1003	Joanne Control Umbilical	Harbour Energy	Suspended
3	PL1002	2" Joanne Methanol Supply	Harbour Energy	In use
4	Norsea Com 1 Seg 1 PL1773	Fibre Optic Cable	Tampnet	In use
5	PL1632	12" Janice Gas Export	Total	Suspended
6	U-SIVJAN	Janice Import SSIV Umbilical	Total	Suspended
7	U-SIVJAD	Jade Import SSIV Umbilical	Harbour Energy	In Use

Once laid, a mechanical plough is proposed to be utilised to trench the pipeline to a target trench depth of approximately 1.8 m. Up to two passes of the trenching plough may be required to reach the target depth. The premised target depth will maximise the amount of sediment backfilled on top of the pipe, and so reduce the likelihood of upheaval bucking. The use of a mechanical plough has been selected based on the geophysical seabed conditions, efficiency in achieving target depth and reduced seabed impact compared to jet trenching. Visual and measured confirmation of burial status will be obtained during pipelay and trenching, and where any potential snagging risks are identified (e.g., clay berms) these would be remediated as appropriate to leave a safe seabed.

The PCU, summarised in Section 3.9, is proposed to be laid in the same trench as the pipeline once the PiP pipeline has been trenched. This option has been selected in order to mitigate a second trench and reduce overall seabed disturbance and impact.

A mechanical backfill plough will be used to cover both the pipeline and the umbilical. Where the new pipeline and umbilical cross existing infrastructure (pipelines, umbilicals and cables) they will be laid on the surface of the seabed at trench transitions and protected by concrete mattresses and rock designed to be over-trawlable.

3.8.2 Hook-up within Judy 500 m Zone

The Talbot pipeline is proposed to be connected to the Judy Platform by way of repurposing an existing 12" production pipeline (PL1000) and riser, currently in use by the Joanne Field. The Joanne subsea manifold has two associated 12" production pipelines (PL0999 – North, PL1000 – South).

During Q3/ Q4 2023 it is proposed that the 12" Joanne PL1000 pipeline is suitably flushed, cleaned, disconnected and suspended, with the South manifold inlet blinded and leak tested. The timing of this operation is in conjunction with replacement of Joanne Riser Emergency Shut-Down Valves (RESDV) on the Judy Platform. Joanne production is proposed to be continued via the North pipeline PL0999. This option was selected based on re-utilisation of existing infrastructure, production capacity and design conditions that meets the Talbot Field Development requirements.

The suspended section of PL1000 between the Joanne manifold and Judy Platform, 5 km in length, will be filled with chemically treated seawater and sealed at both ends to prevent internal corrosion in the time period between suspension and proposed hook-up of the Talbot pipeline.

The environmental permits required for the flushing, disconnection and suspension of PL1000 will be submitted to BEIS via additional permit applications under an appropriate PLA MAT, pipeline permit.

As part of the Talbot pipeline tie-in to PL1000, it is proposed that a mechanical connector be utilised in combination with rigid spools as shown in Figure 3:13. This option has been chosen to minimise vessel activities in proximity to the Judy Platform, to access a suitable tie-in location and reduce the overall length of seabed impact within the 500 m zone due to additional spool lengths to the riser base. The proposed operation involves de-burial of the existing PL1000 pipeline with an estimate trench size of 80 m (L) x 3 m (W) x 1.1 m (H), giving a contingent estimate of 730 m3 seabed required to be excavated. Following de-burial of the line a 20 m section of PL1000 is proposed to be removed and recovered by means of abrasive cutting, following which the mechanical connector will be installed and tied back to the pipeline by way of 10" hook-up spools inclusive of a 10"/12" reducer spool.

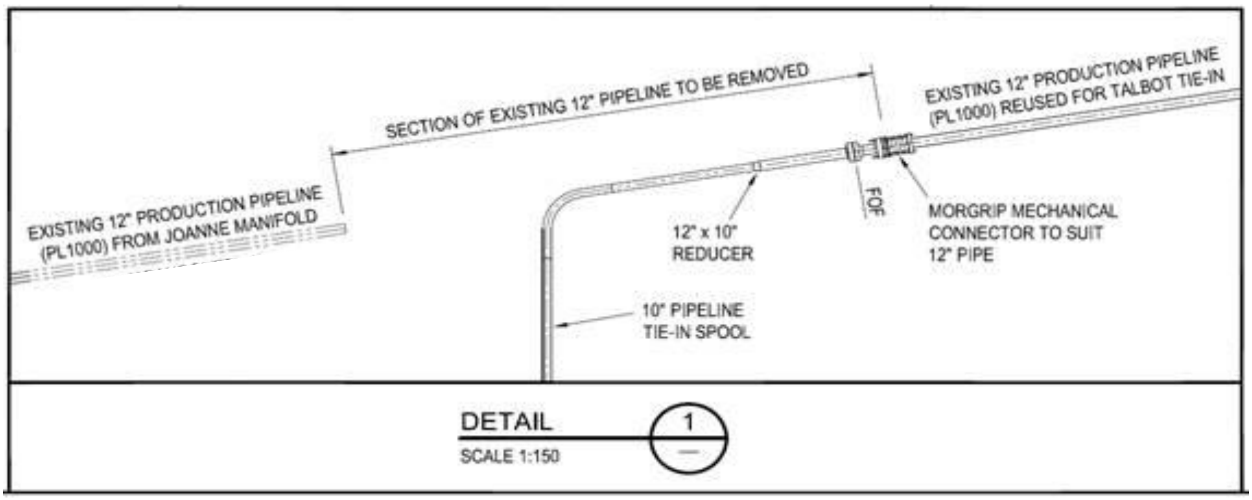


Figure 3:13 – Proposed Connection Method for Talbot Pipeline to PL1000

3.8.3 Pre-Commissioning and Commissioning

Following installation of the PiP pipeline and prior to use, a series of pre-commissioning activities will be undertaken. These are proposed to include:

- Flooding with inhibited seawater, cleaning and gauging of the pipeline;

- Hydrostatic strength testing of the pipeline;
- Tie-in of pipeline to the subsea manifold and existing PL1000 pipeline; and
- Hydrostatic leak testing of the completed pipeline system.

Following hydrostatic leak testing the pipeline will be left filled with inhibited seawater. The treatment chemicals remaining in the pipeline are anticipated to be corrosion inhibitor, oxygen scavenger, biocide and leak testing dye. The proposed dewatering method of the pipeline is to sea, utilising nitrogen from the Judy Platform to push a de-watering pig through the pipeline, to be recovered at the Talbot subsea manifold. An estimated cumulative volume of 640 m3 of seawater would be discharged with an associated chemical discharge of 500 L of treatment chemicals contained with the pipeline volume.

Assessment of the chemical usages will be supplied within the chemical permit to be submitted to BEIS.

3.9 Production Control Umbilical (PCU)

3.9.1 Information and Installation

The PCU serves the following purposes:

1. To provide electrical power and communication to the Talbot subsea control system;
2. To supply hydraulic fluid for actuation of valves; and
3. To supply chemicals to aid in production operations and pipeline protection as per Section 3.14.

The umbilical will be laid from the Judy Platform (pulled up an existing spare J-Tube). As described within Section 3.8.1, the PCU is proposed to be laid within the same trench as the PiP pipeline to minimise seabed impact from an additional trench.

3.9.2 Pre-Commissioning and Commissioning

Pre-commissioning and hook-up of the umbilical involves hydrostatic leak testing and fluid displacement which will result in minimal discharge to sea of water based hydraulic fluid and Mono-Ethylene Glycol (MEG). Chemicals will remain in the umbilical cores until operation commences, at which point they will be used to treat the produced fluids and enter the Judy process system for discharge over field life. Chemicals will be applied for under the appropriate permit and will include environmental assessment of their impact on the receiving environment.

3.10 Pipeline and Umbilical Protection Materials

In addition to trenching, the pipeline and umbilical will be protected by a combination of rock, concrete mattresses and grout bags.

Rock and grout bags are required not only to provide a stable base for crossings and a smooth trench transition, but throughout the lay route to mitigate against upheaval buckling (UHB). The estimated volume of rock throughout the main lay route is approximately 37,706 tonnes at 18 spot locations, with a further 655 tonnes of rock at each pipeline end transition. A further 78,993 tonnes of rock has been estimated as required due to the proximity of several pipeline crossings along the route as summarised in

Table 3:10. Crossings may also require the use of concrete plinths in order to achieve initial separation before laying of the pipeline. Indicative crossing drawings are shown in Section 6, Figure 6:1 to Figure 6:6.

Mattresses are laid to give additional protection. The mattresses are typically of the following dimensions 6m length x 3m width x 0.15m thickness. They may also be covered partially or fully by rock.

Prior to laying any rock cover, mattresses or grout bags Harbour will submit a Deposit Consent application to the NSTA and a supporting Screening Direction to BEIS. Stabilisation and protection materials used (other than rock) are all made of non-biodegradable materials, but all are intended to be removed during decommissioning.

Table 3:10 – Estimated Protection Material Required

Location	Sub Location	Rock (tonnes)	Concrete mattresses*	Grout bags	Support Plinth**
Talbot 500 m zone	Pipeline and Umbilical Transition and Protection	655	37	280	0
	DC Infrastructure Protection	0	54	320	0
Pipeline Lay Route	Main Lay Route***	37,706	0	0	0
	Crossings	78,993	32	0	4
Judy 500 m zone	Pipeline and Umbilical Crossing and Protection	655	232*	440	0
Totals		**118,009**	**355**	**1,040**	**4**

*Mattresses within the Judy 500 m may be replaced with rock placement to minimise number of mattresses.
**Support plinth dimensions estimated c. 8 m (L) x 1.5 m (W) x 1.05 m (H).
***Estimated total of 18 spot rock dump locations to mitigate upheaval buckling (UHB).

3.11 Judy Platform

3.11.1 Platform Description

Judy Platform is located in Block 30/07a of the CNS, approximately 260 km south east of Aberdeen. The platform provides full processing and conditioning of gas and condensate from Judy, Joanne, Jade and Jasmine Fields as summarised in Figure 3:14.

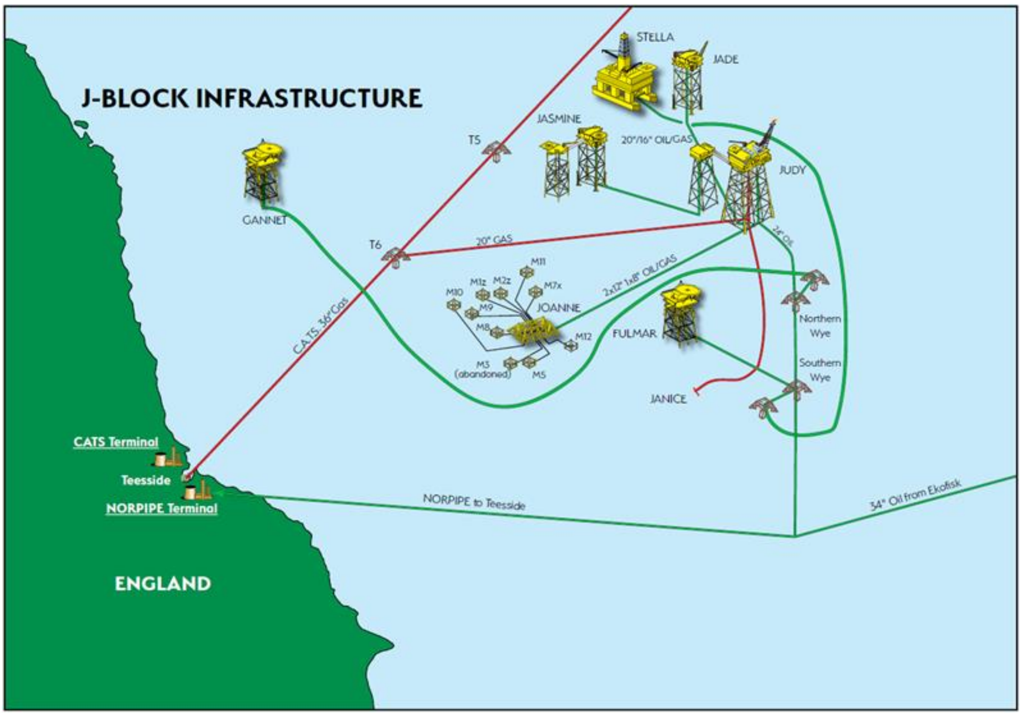


Figure 3:14 – Overview of J-Area Assets

The Judy and Joanne fields commenced production in 1995. The Jade field commenced production in 2002 and the Jasmine Field commenced production in 2013. Following processing on the Judy Platform, gas is transported through the CATS pipeline system to Teesside and liquids are exported to Teesside through the Norpipe export pipeline. Figure 3:4 provides a photograph of the Judy Platform and JRP.

The rated processing capacity of Judy Platform is detailed in Table 3:11.

Table 3:11 – Rated Capacity of the Judy Processing Platform

Processing Stream	Rated Total Capacity
Oil	**60,000 bbls/d** (7,727 Te/d)
Gas	**300mmscf/d** (8,495,100 sm^3/d)
Water	**13,800 bbls/d** (2,260 Te/d)

No capacity constraints for oil and gas processing are foreseen for the assessed Talbot production profiles shown in Section 3.12. On arrival to the Judy Platform the combined Talbot fluids will be processed and separated into the three export streams; oil, gas and water along with the native J-Block area produced streams. The flow assurance work today accounts for existing Judy production and Talbot influences assessed to ensure risks to process upsets are known, addressed and can be adequately managed throughout field life and we do therefore not expect Talbot fluids to interfere with Judy process or cause excessive disruption resulting in additional flaring or venting.

Talbot produced fluids will co-mingle with Joanne and Judy production fluids upstream of the Joanne/Judy HP separator and be separated in the first stage. The resultant fluids will be combined with Jade and Jasmine fluids and separated in the Judy Low Pressure (LP) separator before final treatment and export. The oil phase will be separated and treated in accordance to existing export specification requirements and exported to Teesside via the 24” oil export pipeline PL0998.

Figure 3:15 – Judy Platform (Foreground) and JRP (Background)

The produced gas will be separated, dried, treated to export specifications and compressed for export via the 20” gas export pipeline PL0997 into the CATS pipeline. A proportion of Talbot gas will be utilised as fuel gas on Judy platform as part of a combined inlet stream into the fuel gas system with the existing J-Block gas streams. Based on the processing capacity on the Judy Platform and current throughput it has been assessed that no additional diesel or gas-powered turbines will be required for processing and export of the Talbot hydrocarbons. Judy will be likely to operate on 2 train compression operations (largely on single train operation recently) during some of 2024 and into 2025 as result of Talbot coming online and other field hydrocarbon volumes through Judy. After this period, it is expected that Judy would return to predominantly single train operations with Talbot then accounting for very little additional fuel gas. For ES purposes we have assumed all increased fuel gas use and assessed all additional train operations to Talbot. Additional flaring due to Talbot Field cold start-up and shut-down has been assessed at maximum five times per year.

The produced water is passed to the Judy produced water treatment system following separation in the LP separator. Produced water will be separated using existing facilities on Judy and discharged at hydrocarbon concentrations of <30 mg/l. Further details of discharge impact potential on the receiving environment are summarised in Section 7.

No planned well interventions are foreseen over the producing life of the Talbot wells, however corrective intervention may occur in the event of uncontrolled scale formation across well completion equipment. Formation water analysis has shown a potential for scale formation, as such downhole scale inhibitor injection per well is premised once water production commences to mitigate scale formation.

3.11.2 Proposed Topsides Modifications

Topsides modifications to Judy Platform necessary to enable inclusion of the Talbot oil and gas include installation of a hydraulic power unit, topsides umbilical termination unit (TUTU), chemical pumps and associated connecting piping.

Replacement of five existing valves is premised on the existing Joanne production flowlines as part of the Talbot scope of work, with pressure and velocity control provided by provision of a topsides 16” choke. Talbot shall have access to the Judy test separator by means of an existing production divertor valve on the topside manifold, for non-routine operation and testing where required.

Due to space constraints, the control system cabinets will be integrated with the Joanne Field system cabinets. This will enable a mid-life upgrade of the Joanne Field control system while providing Talbot with an effective control system integration to the Judy control and safety system.

3.12 Production

Forecasted production profiles are included this section and are representative of the upper of Talbot oil, gas and water production throughout the anticipated field life. Representative high case profile ranges are based on probabilistic reservoir models hence are potentially higher than likely values. For the purposes of assessment within this ES of the potential impacts in relation to discharges to sea and atmospheric emissions the annual average of the highest likely rates have been utilised. Table 3:12 illustrates the bounding ranges of forecasted production.

Oil production is premised to commence in year 2024 with an approximate rate of 3,817 Te/day as shown in Table 3:12, continuing until end of field life. Following this peak, oil production is expected to decline with field life (Figure 3:16).

Gas production is premised to commence in year 2024 with an approximate rate of 1,742,560 m^3/day as shown in Table 3:12, continuing until end of field life. Following this peak, gas production is expected to decline with field life (Figure 3:16).

The data shown here will be considerably higher than that used in the Talbot Field Development Plan. This is deliberately done by taking the highest probable case and then applying some further contingency to this. By doing this we ensure that the production values used and assessed here should not be exceeded and any impacts and mitigations developed more than cope with actual levels achieved. The same philosophy will be applicable to the Standard Economic Template which again will align closely with the Talbot FDP but the ES will have a high (worst case environmentally) assessment to ensure all foreseeable reservoir performance scenarios are captured. Produced water is explained in more detail below but again this is a high case with a contingency factor applied to it. Typically produced water rates increase as the reservoir performance drops and hydrocarbon production is substituted increasingly by produced water.

Table 3:12 – Talbot Average Annual Peak Daily Production Rates Used for ES

Year	Oil (Te/d)	Produced Water (Te/d)	Produced Gas (sm^3/d)
2024	3,817	339	1,742,560
2025	1,885	406	848,065
2026	966	503	429,322
2027	691	549	279,512
2028	547	685	225,322
2029	443	712	164,825
2030	378	878	165,531
2031	317	753	121,388
2032	290	772	104,340
2033	250	716	84,471
2034	236	769	88,145
2035	224	925	87,137
2036	187	629	78,484

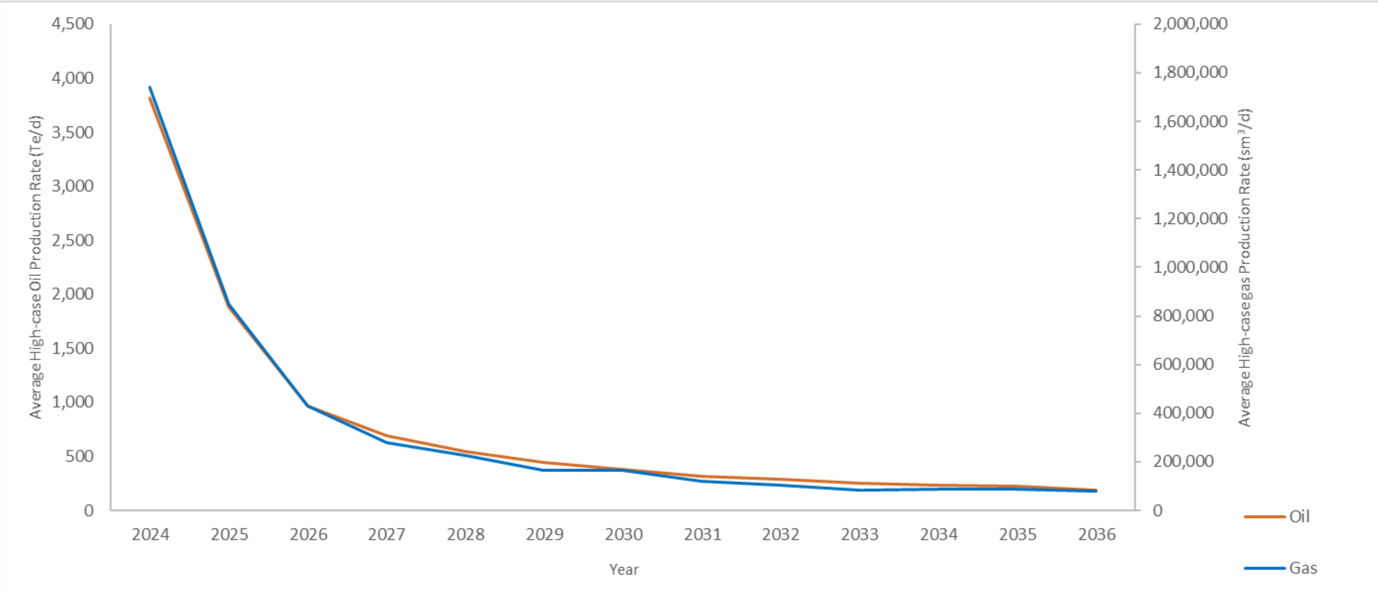


Figure 3:16 – Predicted average annual high-case oil and gas production at Talbot

Oil density used was atmospheric conditions = 825.9kg m^{-3}

3.13 Produced Water

Produced water has been modelled with an initial approximate rate of 339 Te/day as shown in Table 3:12, rising to peaks of 878 Te/day and 925 Te/day in 2030 and 2035, continuing until end of field life. The produced water rates vary with different cases due reservoir performance uncertainty and potential for cyclic production from wells throughout field life. As such the maximum expected produced rates have been assessed. There is a modification project underway to increase Judy produced water capacity in 2024 from between 17,200 to 20,000 bwpd. This project is not required specifically for Talbot but is a result of ageing wells producing more produced water across the J-Area in the coming years.

Judy platform currently produces on average 570 m^3/d (based on first 5 months of 2022 data and in 2021 averaged 608 m^3/d).

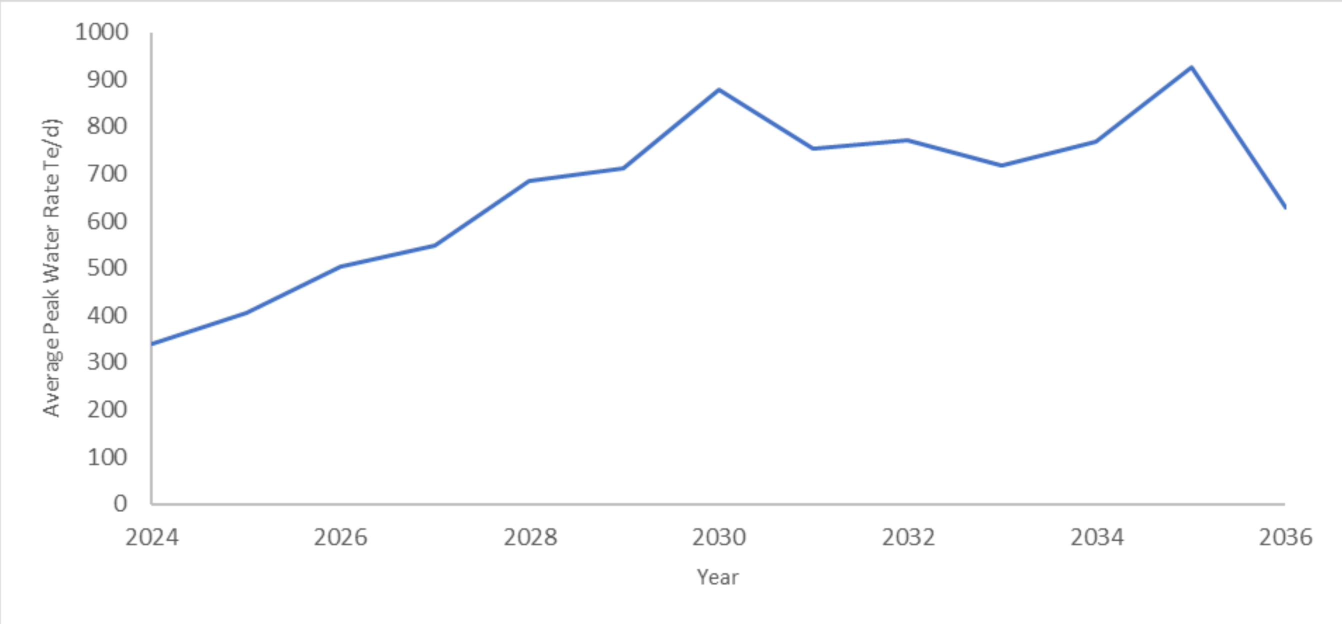


Figure 3:17 – Predicted average annual high-case produced water at Talbot

3.14 Production Chemicals

The following chemical groups are premised to be required during production operations. Chemical usage and discharges will be included in an update to the Judy production permit prior to production commencing.

- Methanol – injected at the XT upstream and downstream of the Production Wing Valve (PWV), to aid hydrate mitigation at start-up and shut-down;
- Corrosion inhibitor – injected at the subsea manifold to inhibit corrosion at the carbon steel section of pipe;
- Scale inhibitor – injected downhole into the well below the Surface Controlled Subsurface Safety Valve (SCSSV) or upstream of the production choke and topsides prior to Talbot fluids co-mingling with Joanne fluids, to mitigate scale deposition;
- Wax inhibitor – injected at the XT to mitigate against wax deposition in the pipeline; and
- Hydraulic control fluid – water based control fluid as summarised in Section 3.7.4.

Chemical selection will be in line with existing J-Block chemicals and proposed future chemicals in all instances aside from inclusion of water based hydraulic control fluid. Information on specific chemical use, risk and associated environmental impact will be assessed in the relevant drilling and production permit applications prior to the commencement of activities.

3.15 Other Vessels and Helicopters

In addition to the HDJU drilling rig, the Talbot Field Development will require support vessels (supply vessels, emergency response and rescue vessel (ERRV) and a standby vessel), and helicopter crew change of personnel from the drilling rig.

It is anticipated that marine logistics will be based in Aberdeen. For energy usage estimation, a worst-case scenario is assumed with all helicopter flights from Aberdeen. All transport of drilling and production equipment, supplies, water, fuel and food will be undertaken by supply vessels, which will also return waste and surplus equipment to shore. The estimated fuel consumption of all vessels and aircraft involved with the proposed field development operations are presented in Section 8 - Atmospheric Emissions.

3.16 Future Expansion

The Talbot Field Development plan enables potential future normal-pressure and normal-temperature third party access to support the Maximising Economic Recovery stewardship requirements, subject-to suitable technical and commercial study, through the provision of the following facilities:

- Sizing the control system for up-to 12 wells, which is greater than the maximum foreseen Talbot well count. This sizing is inclusive of the topsides control equipment, with umbilical core sizing analysis completed for eight wells at a tie-back distance of 18 km and a further four wells at a further incremental step-out at a distance of 20 km from Talbot (38 km from Judy). This is subject to the future third-party utilising the same chemical, hydraulic and power and signal philosophy as Talbot.
- Sizing of the pipeline for 10”/16” (with option to increase to 12”/18”) carbon steel PiP, inclusive of a topsides choke to manage back-pressure to enable early and late life flow assurance. Subject to evaluation of future operational and reservoir back-out, corrosion inhibitor selection and chemical injection to manage integrity, fluid properties for corrosivity and wax potential.
- Provision of a full-bore (10”) tie-in point and umbilical termination assembly on the upstream subsea manifold to enable future tie-in of a third party.

3.17 Decommissioning

The arrangements for decommissioning of the Talbot facilities will be developed in accordance with the UK government legislation and international agreements in force at the time. During the late field life and decommissioning planning stages, decommissioning options will be fully reviewed and discussed with BEIS, Offshore Decommissioning Unit (ODU) and the NSTA decommissioning team.

On cessation of production, the wells will be decommissioned in accordance with the requirements of the prevailing UK and international law of the time. All wells are premised to be abandoned using a jack-up drilling rig and light well intervention vessel (LWIV) in separate campaigns and will be abandoned to OGUK Well Decommissioning Guidelines. The subsea XTs, wellheads and subsea manifold at the drill centre will be recovered. The Judy Platform will be decommissioned as per the existing Judy Platform FDP and decommissioning plans. Harbour has extensive experience in both abandonment and decommissioning operations. An overview of and key elements of what Harbour would look to be achieved during decommissioning is provided below. The decommissioning operation would be undertaken only after development and approval of a decommissioning ES with all aspects and impacts of the operation considered prior to start.

The abandonment plan is based on the following assumptions:

- Plug and abandon all wells;
- Remove the conductor below the mudline;
- Remove the subsea XTs;
- Remove the subsea manifold, template and connecting flowlines;
- Main export pipeline left in-situ in a safe condition; and
- Third party survey conducted to confirm seabed clearance.

More specific details on the subsea decommissioning activities are as follows:

- Pipelines will be flushed and cleaned to a worst-case 30 mg/l hydrocarbon content. Pipeline sections exposed on the seabed within 500 m zones will be recovered, and additional exposed sections will either be removed or covered with rock;

- Umbilical cores will be flushed and cleaned. Sections exposed on the seabed within 500 m zones will be recovered, and additional exposed sections will either be removed or covered with rock;
- All structures or infrastructure placed on the seabed to be recovered. Structure piles to be cut below seabed level. All grout supports/ concrete mattresses/ turning bollards/ hold-down structures, and similar, to be recovered.
- An inspection program will be required post-decommissioning to monitor the condition of infrastructure left in situ and the condition of the seabed (e.g., trenches, rock berms) to prevent deterioration and snagging hazards to fisheries in the future.

4 Environmental and Socioeconomic Baseline

This section describes the baseline environmental setting of the proposed area within which the Talbot Field Development activities will occur. In addition, it identifies those components of the physical, chemical, biological and socioeconomic environments that might be sensitive to the potential impacts arising as a result of the proposed activities. An understanding of the environmental sensitivities at both the local and regional level informs the assessment of environmental impacts and risks associated with the project's oil and gas activities.

A summary of the environmental and socioeconomic baseline within the vicinity of the Talbot Field Development is provided in Table 4:1.

Table 4:1 – Summary of environmental and socioeconomic sensitivities in the vicinity of the Talbot Field Development

Aspect	Detail
Site overview	
The Talbot Field Development will be located within Block 30/13, with the pipeline to be laid in Blocks 30/13, 30/12 and 30/7 and in Block 30/7a tied-in to Judy platform. The proposed development is also located within the International Council for the Exploration of the Sea (ICES) rectangle 42F2 and UK North Sea Quadrant 30. The proposed Talbot Field Development area is located approximately 278 km southeast of the Scottish coastline and 7 km west of the UK/ Norway median line. Average water depth across the proposed Talbot Field Development is between 71.2 and 75.4 m Lowest Astronomical Tide (LAT).	
Conservation Interests within 100 km of proposed Talbot Field Development	
Offshore Marine Protected Areas and Annex I habitats	
Fulmar MCZ	The Fulmar MCZ is located within Blocks 30/12 and 30/13 and overlaps with the proposed Talbot Field Development area, with Judy platform located 9.3 km north (Figure 4:11). The Fulmar MCZ is designated for protection of broad-scale habitats of subtidal mud, subtidal sand and subtidal mixed sediment, as well as protection of ocean quahog (*Arctica islandica).* The Fulmar MCZ protects important habitats for marine animals, providing food, spawning areas and shelter. Ocean quahog and offshore subtidal sands and gravels are listed as a PMF.
East Gannet and Montrose Fields NCMPA	The East Gannet and Montrose Fields NCMPA is located approximately 67 km northwest of the proposed Talbot Field Development (Figure 4:11). The NCMPA is designated for protection of ocean quahog, including the supporting habitat, sand and gravel. The NCMPA also includes a band of offshore deep-sea mud which provides important habitat for many species of worms and molluscs which in turn, provide an important food source for fish. Ocean quahog and offshore deep-sea mud are listed PMFs.
Swallow Sand MCZ	The Swallow Sand MCZ is approximately 96 km southwest (Figure 4:11) of the proposed Talbot Field Development area and is designated for protection of broad-scale habitats of subtidal sand and subtidal coarse sediment, as well as the geomorphological feature, the North Sea glacial tunnel valley, known as the Swallow Hole.
Offshore Annex II species	

Aspect	Detail
Harbour porpoise (*Phocoena phocoena*)	A high abundance of harbour porpoise is recorded in Quadrat 30 and adjacent quadrants for June, August and November, a moderate abundance for September and a low abundance for May, June and October (UKDMAP, 1998; Reid et al., 2003; Hammond et al., 2017)
Bottlenose dolphin (*Tursiops truncatus)*	Recorded only by Reid et al. (2003) but no other sources (UKDMAP, 1998; Hammond et al., 2017).
Grey seals (*Halichoerus grypus*)	Grey seal densities range from 0 to 5 individuals per 25 km2 in the area. There are no haul-out or breeding sites within the vicinity of the Talbot Field Development.
Harbour seals (*Phoca vitulina*)	Harbour seal densities range from 0 to 1 seal per 25 km2 in the area. There are no haul-out or breeding sites within the vicinity of the Talbot Field Development.
Plankton	
The phytoplankton community of the North Sea is dominated by the dinoflagellate genus *Tripos* (*T. fusus, T. furca, T. lineatum*), with diatoms such as *Thalassiosira spp*. and *Chaeoceros spp*. also, abundant. The zooplankton community is dominated by copepods, and euphausiids, and decapod larvae are also important components of the zooplankton assemblage. (OESEA, 2016).	
Benthic environment	
Seabed sediments	Offshore subtidal sands and gravels are the PMFs identified as present at the proposed Talbot Field Development area. The EUNIS classification system identifies the area as having deep circalittoral sand (A5.27) and deep circalittoral mixed sediments (A5.45) (Gardline, 2009; Gardline, 2019a; NMPI, 2022).
Benthic fauna	The benthic fauna can be described as typical for offshore circalittoral sand sediments of the central North Sea, characterised by a diverse range of macrofaunal species, namely polychaetes (dominated by polychaete annelids (bristle worms)), arthropods (including crabs and shrimps), molluscs (including bivalves and snails) and echinoderms (including star fish and brittle stars) (Gardline, 2009; Gardline, 2019a; NMPI 2019). No species of conservation importance were recorded during recent survey (Gardline, 2019a).
Fish and shellfish – spawning and nursery areas	
Spawning areas	Blocks 30/13, 30/7 and 30/12 overlap with spawning areas for mackerel (*Scomber scombrus*), Norway pout (*Trisopterus esmarkii*), cod (*Gadus morhua*), plaice (*Pleuronectes platessa*), sandeels (*Ammodytidae sp*.) and lemon sole (*Microstomus kitt*) (Coull et al., 1998; Ellis et al., 2010). ICES rectangle 42F2 is considered a high intensity spawning area for North Sea mackerel and Norway pout.
Nursery areas	There are potential nursery areas in the ICES rectangle 42F2 (and Blocks 30/13, 30/12 and 30/7) for anglerfish (*Lophius piscatorius*), blue whiting (*Micromesistius poutassou*), cod, European hake (*Merluccinus merluccinus*), haddock (*Melanogrammus aeglefinus*), herring (*Clupea harengus*), ling (*Molva molva*), mackerel, Norway pout, plaice, sandeel, spotted ray (*Raja montagui*), spurdog (*Squalus acanthias*), whiting (*Merlangius merlangus*) and sprat (*Sprattus sprattus*) (Coull et al., 1998; Ellis et al., 2010; Aries et al., 2014). There is high intensity nursery ground identified for cod within ICES rectangle 42F2 and within all blocks of interest (Ellis et al., 2010).

Aspect	Detail
Anglerfish, blue whiting, cod, herring, mackerel and whiting are mobile species on the PMF list, indicated to receive appropriate protection and conservation measures (SNH, 2014). Except for Atlantic cod, which is listed as vulnerable, all other species are indicated as of least concern on the IUCN red list of threatened species (IUCN, 2019).	
Marine Mammals	
Cetaceans	Minke whale (*Balaenoptera acutorostrata*), common dolphin (*Delphinus delphis*), white-beaked dolphin (*Lagenorhynchus albirostris*), white-sided dolphin (*Lagenorhynchus acutus*) and harbour porpoise have been sighted in the Talbot Field Development area (Quadrant 30 and surrounding quadrants) (UKDMAP, 1998; Reid et al., 2003; Hammond et al., 2017). Reid et al. (2003) also indicates the presence of bottlenose dolphin within Quadrant 30. Minke whale, bottlenose dolphin, common dolphin, white-beaked dolphin, white-sided dolphin, and harbour porpoise are on the PMF list, indicated to receive appropriate protection and conservation measures (SNH, 2014). Harbour porpoise is listed as vulnerable on the IUCN red list of threatened species (IUCN, 2019).
Seals	Harbour seals can potentially be found in Blocks 30/13, 30/7 and 30/12 in very low abundance (0-1 seals) (NMPI, 2022). Grey seals can potentially be found in Blocks 30/13 and 30/7 in very low abundance (0-1 seals) and low abundance (1-5 seals) in Block 30/12 (NMPI, 2022).

Cetaceans in Quadrant 30 and surrounding quadrants

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Harbour porpoise					L	H	L	H	M	L	H	
Minke whale					L	L	M	L			L	
Common dolphin						L	L					
White-beaked dolphin	L			L	VH	L	H	L	H	H	H	
White-sided dolphin					H		VH	L	H			

VH Very high; H High; M Moderate; L Low; (blank) No data

Aspect	Detail
Seabirds	
The following species have been recorded within the proposed Talbot Field Development area: Northern Fulmar (*Fulmarus glacialis*), Northern Gannet (*Morus bassanus*), Great Skua (*Stercorarius skua*), Arctic Skua (*Stercorarius parasiticus*), Black-legged Kittiwake (*Risa tridacla*), Great Black-backed Gull (*Larus marinus*), Common Gull (*Larus canus*), Herring Gull (*Larus argentatus*), Common Guillemot (*Uria aalge*), Razorbill (*Alca torda*), Little Auk (*Alle alle*), and Atlantic Puffin (*Fratercula arctica*) (Kober et al., 2010). No hotspots have been identified in the vicinity of the blocks of interest.	
Seabird sensitivity	Seabird sensitivity in the region of the proposed Talbot Field Development area (Blocks 30/13, 30/12, 30/7 and surrounding blocks) varies from low to extremely high throughout the year. Seabird sensitivity peaks at extremely high in May and June in the surrounding blocks, followed by very high at Block 30/13 in May and June. In the remaining months there is low seabird sensitivity in Blocks 30/13, 30/12, 30/7 and surrounding blocks, with the exception of Block 30/12 in February which has a medium seabird sensitivity. There was no data available in October and November for all blocks within the proposed Talbot Field

Aspect	Detail
	Development area, and data for April and December were available for some blocks (Webb et al., 2016).

Block	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
30/1	5	5	5	ND	5	5	5	5	5	ND	ND	ND
30/2	5	5	5	ND	5	5	5	5	5	ND	ND	5
30/3	5	5	5	ND	4	4	5	5	5	ND	ND	5
30/6	5	5	5	ND	5	5	5	5	5	ND	ND	ND
30/7	5	5	5	ND	5	5	5	5	5	ND	ND	5
30/8	5	5	5	ND	1	1	5	5	5	ND	ND	5
30/11	5	5	5	ND	5	5	5	5	5	ND	ND	ND
30/12	5	4	5	5	5	5	5	5	5	ND	ND	5
30/13	5	5	5	5	2	2	5	5	5	ND	ND	5
30/14	5	5	5	ND	2	2	5	5	5	ND	ND	5
30/16	5	5	5	5	5	5	5	5	5	ND	ND	ND
30/17	5	5	5	5	5	5	5	5	5	ND	ND	ND
30/18	5	5	5	5	5	5	5	5	5	ND	ND	5
30/19	5	5	5	5	4	4	5	5	5	ND	ND	5

Key – seabirds sensitivity (ND – no data); red – interpolated data

1	Extremely high	2	Very high	3	High	4	Medium	5	Low

Socioeconomic Aspects	
Fisheries	The fishing effort, value and quantity of live weight has decreased greatly from 2016 to 2020, from 49 tonnes landed in 2016 at value of £82,923 to 8 tonnes landed in 2020 at value of £18,196 (MMO, 2021). Trawls were the most utilised gear type used in ICES rectangle 42F2 in each year from 2014 to 2020 (MMO, 2021). No shellfish water protected areas or active aquaculture sites occur in the vicinity of the proposed Talbot Field Development. The closest active aquaculture sites are on the Aberdeen coast >250 km to the west of the proposed Talbot Field Development (NMPI, 2022).
Shipping	Shipping density in Block 30/7 is low while shipping density in Block 30/13 and Block 30/12 is considered very low (OGA, 2016).
Oil and gas industries	There are six platforms within 40 km of the Talbot Field Development Field infrastructure: Clyde (18.9 km southwest); Judy (20 km northwest); Fulmar AD (23.0 km southwest); Jasmine JLQ (24.0 km northwest); Jade (33.8 km north); and Auk A (37.2 km southwest, as well as one FPSO; Stella FPF1 (31.2 km northwest) (NMPI, 2022).
Offshore renewables	There are no current or proposed windfarms located within, or near Block 30/13, Block 30/12 or Block 30/7 (NMPI, 2022).
Aggregate activities	There are no designated aggregate extraction areas near Block 30/13, Block 30/12 or Block 30/7 (Crown Estate, 2018).

Aspect	Detail
Carbon Capture and Storage (CCS)	There are three CCS sites (May, Balder and Forties) of potential within the Talbot Field Development area (Crown Estate, 2018).
Military activities	There is no military activity expected within 100 km of the Talbot Field Development (NMPI, 2022).
Wrecks	There are three non-dangerous, unnamed wrecks within blocks of interest; two in Block 30/7 and one in Block 30/13 (NMPI, 2022).
Telecommunications	Two telecommunication cables occur in the near vicinity of the proposed Talbot Field Development. The TAMPNET Clyde telecommunication cable is located within the proposed Talbot Field Development area and the TAMPNET Valhall telecommunication cable is located approximately 9 km southeast of the proposed Talbot Field Development area (KIS-ORCA, 2019).
Licence conditions	There is a period of concern for seismic surveys between May and August in all three blocks of interest imposed by Marine Scotland (OGA, 2019). There are no licence conditions applied to Blocks 30/7, 30/12 or 30/13 on behalf of the Ministry of Defence (MOD) or Joint Nature Conservation Committee (JNCC).

4.1 Site Specific Surveys

Dedicated, site specific surveys, geophysical, environmental baseline survey and habitat assessment, have been conducted in UKCS Blocks 30/13, 30/12 and 30/7 in the central North Sea (Table 4:2). The Talbot Field Development traverses the England and Scotland offshore waters boundary. Additionally, Jasmine to Judy export pipeline survey was used as a source of information for the project baseline (Table 4:2).

Table 4:2 – Relevant survey data for the Talbot Field Development Project

Survey	Report Reference
Talbot Site and Route Survey UKCS Blocks 30/7, 30/12 and 30/13 - Environmental Baseline Survey	Gardline, 2019a
Talbot Site and Route Survey UKCS Blocks 30/7, 30/12 and 30/13 - Habitat Assessment Report	Gardline, 2019b
Jasmine to Judy Export Pipeline Corridor Route Survey (Phase II operations) UKCS Blocks 30/6 to 30/7	Gardline, 2009

The geophysical and geotechnical survey operations were conducted between 10th July and 28th August 2019, with all environmental survey work undertaken between 4th and 21st August 2019. The environmental baseline survey findings are summarised in Gardline (2019a).

The habitat assessment survey (Gardline 2019b) was conducted in conjunction with the environmental baseline survey. The objective of the habitat assessment was to identify and delineate any sensitive habitats or species observed within the survey area. in total 28 stations were investigated across the Talbot Field Development area, with 19 stations located along the proposed pipeline route. Initially six camera transects, each running a length of 200 m, were conducted over those stations with sediments samples taken along the transects using 0.1 m2 modified day grab. Further nine stations selected across the survey area were higher or mottled reflectivity was detected during preliminary side scan sonar transects. Those stations were investigated using a drop down digital still camera and video system only (Gardline, 2019a; Gardline, 2019b).

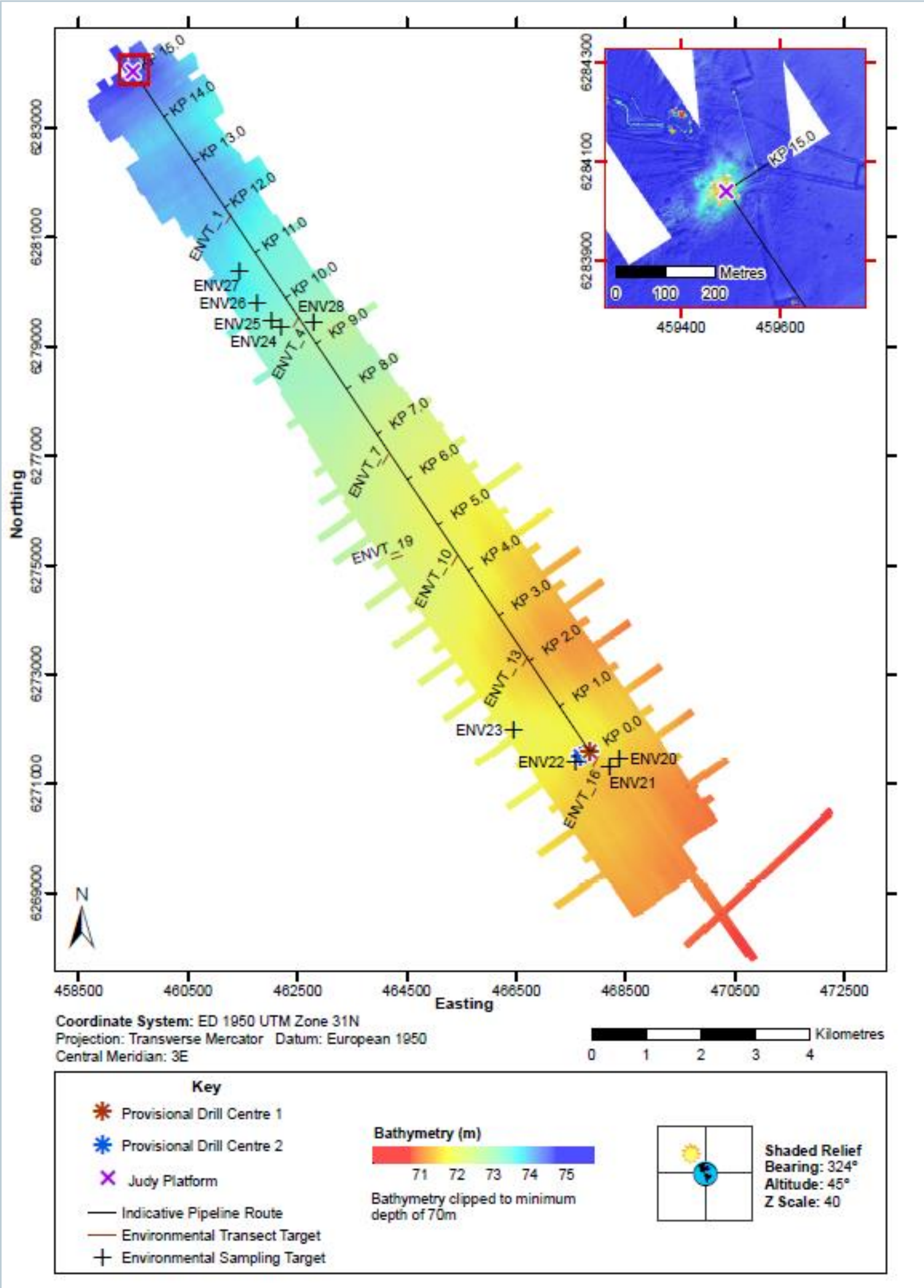
For geophysical data, to determine the general seabed topography, features and obstructions, single and multibeam echo sounder, side scan sonar, magnetometer and sub-bottom profiler were used (Gardline, 2019b).

Where necessary, a dedicated Talbot surveys were supplemented by the information coming from the geophysical, geotechnical and environmental surveys that were conducted between 19th March and 4th April 2009 between Jasmine platform location and Judy spool connection (Gardline, 2009). A total of seventeen stations were investigated where core samples and cone penetrometer tests helped to determine site characteristics.

4.2 Physical Environment

4.2.1 Bathymetry

Water depths in the survey area ranged from 71.2 m LAT in the southeast to 75.4 m LAT in the northeast (Figure 4:1, Gardline 2019b). Multibeam data showed the seabed was generally featureless and deepened very gently towards the northwest with an average seabed gradient of <1°, with slight shoaling in the central region of the Block 30/13 site (Gardline, 2019b).

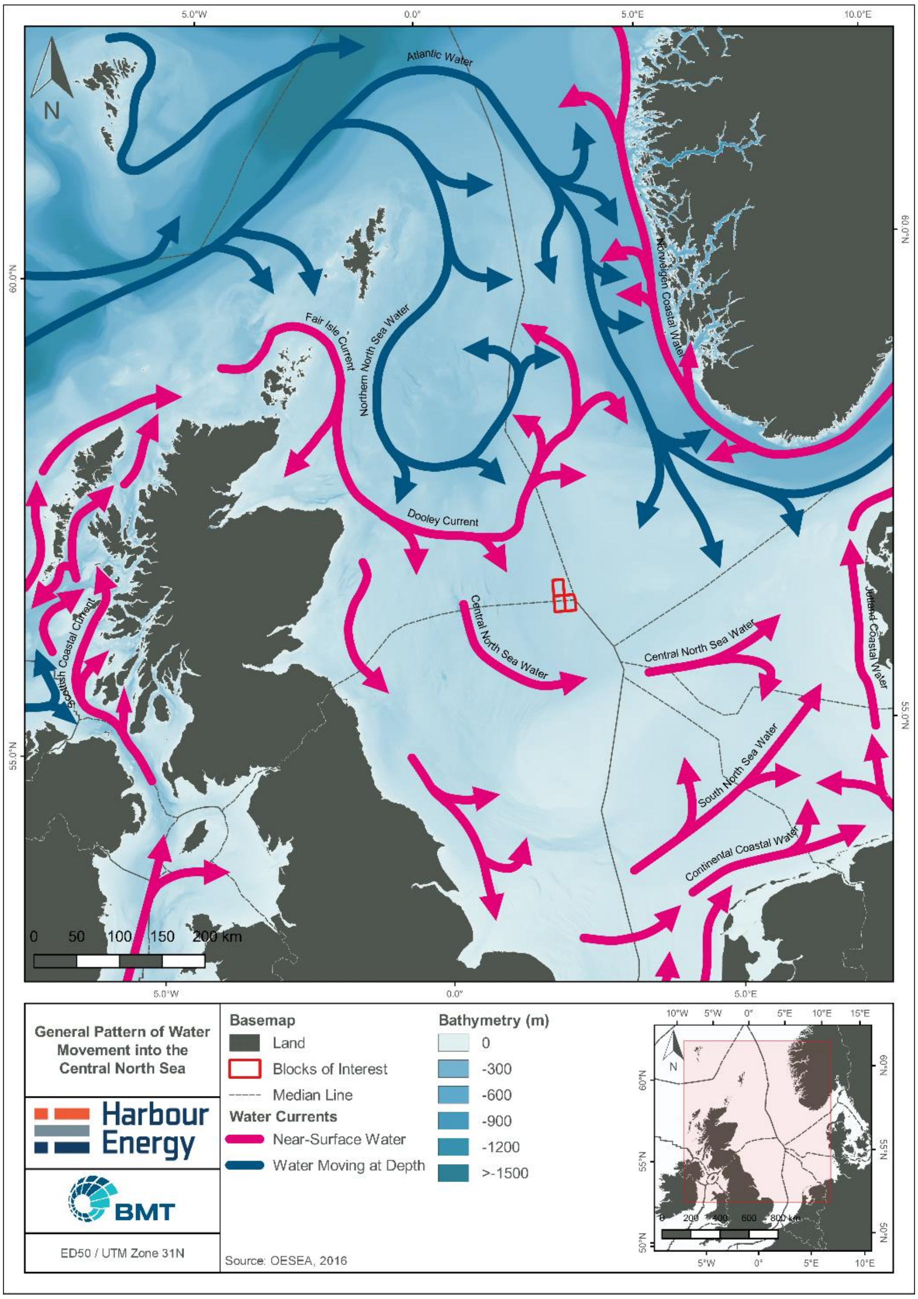


Source: Gardline (2019b)

Figure 4:1 – Bathymetry overview of Talbot Field Development area [Note: Survey undertaken when two drill centres were planned]

4.2.2 Metocean

The metocean (current, tide and wave) regime has a direct influence on the suspension, dispersion, transport and ultimate fate of any discharges during offshore activities. Tidal currents in the central North Sea area are generally weak and are readily influenced by other factors such as winds and density driven circulation (Figure 4:2). This results in a relatively atypical pattern to the tidal currents. Tidal currents in the Talbot Field Development area are between 0.25 and 0.50 m/s for maximum spring tides and between 0.11 and 0.25 m/s for maximum neap tides (ABPmer, 2016).



Source: OESEA (2016)

Figure 4:2 – Schematic diagram of the major water masses and residual circulation in the central and northern North Sea

The annual mean wave height at the Talbot Field Development area varies between 2.01 and 2.25 m (ABPmer, 2016). The seasonal variation is provided in Table 4:3.

Table 4:3 – Seasonal variation in wave heights

Block	Spring wave height	Summer wave height	Autumn wave height	Winter wave height
30/13	1.76-2.00 m	1.26-1.50 m	2.26-2.50 m	2.76-3.00
30/12	1.76-2.00 m	1.26-1.50 m	2.26-2.50 m	2.76-3.00
30/7	2.01-2.25 m	1.26-1.50 m	2.26-2.50 m	2.76-3.00

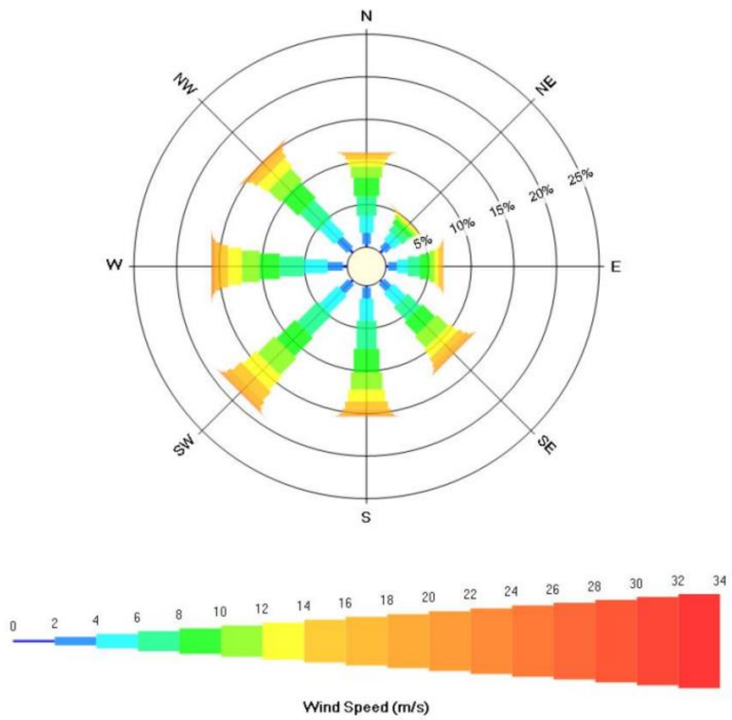
Source: ABPmer (2016)

4.2.3 Wind

Wind direction in the central North Sea can occur from any direction, however winds from the southwest to the northwest tend to dominate (Figure 4:3). The annual wind speed range at the Talbot Field Development area is 9.5 to 10.5 m/s. The seasonal variation is provided in Table 4:4.

Table 4:4 – Seasonal variation in wind speeds

Block	Spring wind speed	Summer wind speed	Autumn wind speed	Winter wind speed
30/13	9.0-9.5 m/s	7.5-8.0 m/s	10.5-11.0 m/s	12.0-12.5 m/s
30/12	9.0-9.5 m/s	7.5-8.0 m/s	10.5-11.0 m/s	12.0-12.5 m/s
30/7	9.0-9.5 m/s	7.5-8.0 m/s	10.5-11.0 m/s	12.0-12.5 m/s



Source: Shell U.K. Limited (2019)

Figure 4:3 – Annual mean wind rose at 10 m above sea level for the Jackdaw Field area, located 36 km to the northeast of the Talbot Field Development

4.2.4 Air Quality

An understanding of the existing air quality in the area of a development is useful when assessing the potential future impact upon air quality from the proposed operations. However, data on air quality offshore is limited. Emissions of carbon dioxide, nitrous oxides and sulphur oxides will result from power generation from vessels during operations. Further information on air quality and energy and emissions is provided in Section 8.

4.2.5 Sea Temperature and Salinity

The water column in the central North Sea is generally stratified in summer when the water becomes layered according to different temperature and subsequent density characteristics of the different water bodies. Typically, a warmer, thinner layer of water overlies a deeper, cooler layer. This stratification begins to break down in September due to the increased severity of wind mixing and gales and seasonal cooling of surface waters (OESEA, 2016).

Surface sea temperatures within the Talbot Field Development area range from 5.7 to 15.0°C. Seabed temperatures range from 5.5 to 7.0°C. Salinity between the surface and seabed ranged between 34.85 and 35.05 ppt (Table 4:5).

Table 4:5 – Seasonal variation in wave heights

Block	Mean seabed salinity (ppt)		Mean sea surface salinity (ppt)		Mean Seabed Temperature (°C)		Mean Sea Surface Temperature (°C)	
	Winter	Summer	Winter	Summer	Winter	Summer	Winter	Summer
30/13	35.05	34.95	35.05	34.85	5.5	7.0	5.7	15.0
30/12	35.05	34.95	35.05	34.85	5.5	7.0	5.7	15.0
30/7	35.05	34.95	35.05	34.85	5.5	7.0	5.7	15.0

Source: UKDMAP (1998)

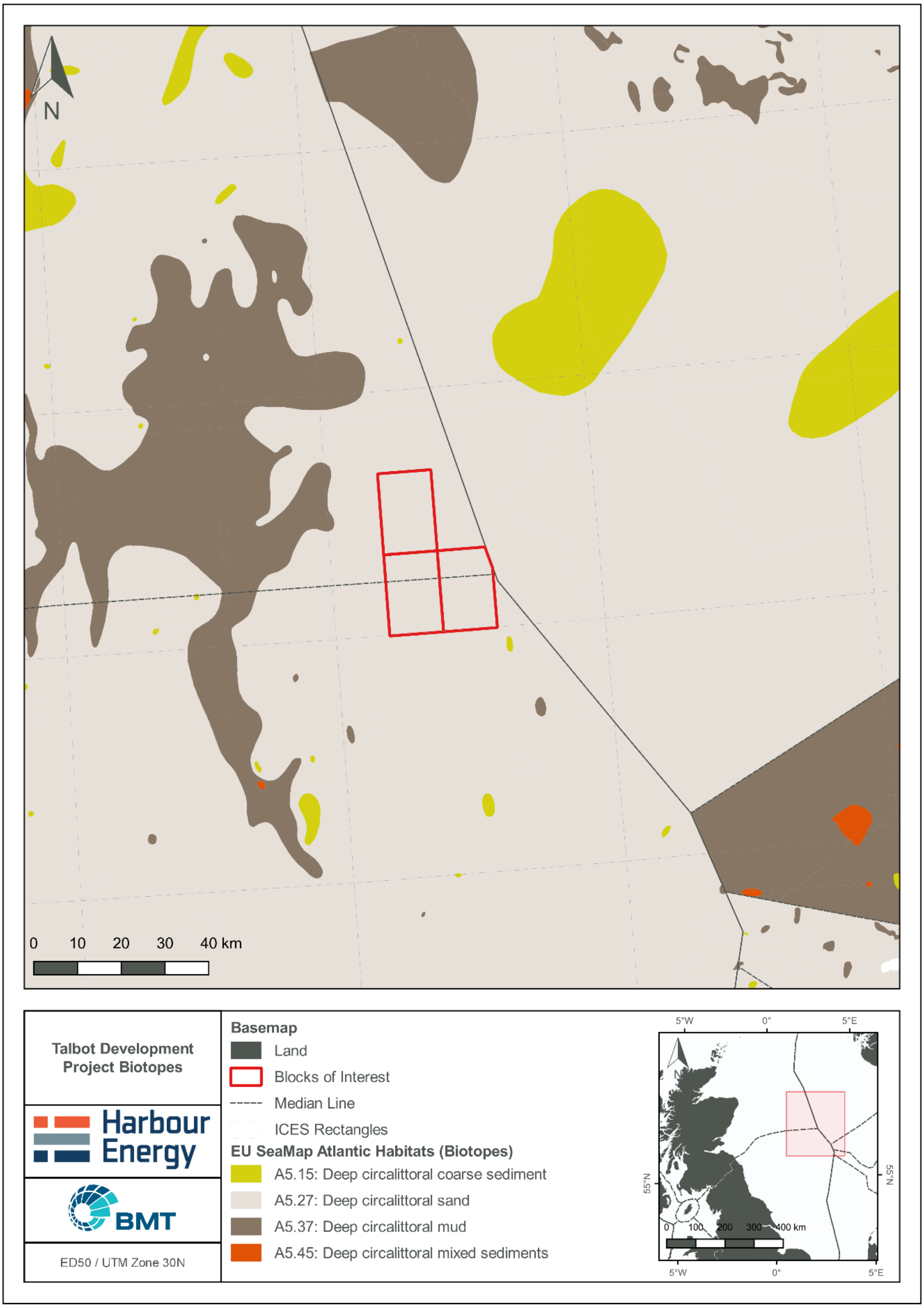
4.2.6 Sediment Characteristics and Features

The side scan sonar (SSS) survey at the centre of Block 30/13 found loose to medium density silty fine sand with frequent shell fragments at a depth of 0 to <0.5 m (Holocene Formation). Sediments underlying this at depths >0.5 m were found to be a medium dense to very dense fine sand overlying medium to high strength sandy clay with occasional gravel, stated as having Forth Formation (Gardline, 2019a).

SSS survey results were backed up by seabed grab samples used for particle size analysis and environmental camera investigations. On average, retained samples were acquired approximately 2.4 m from their target location (Gardline 2019b). Seabed grab samples recorded soft sediment with scattered shell fragments with occasional gravel at all survey sampling locations. Particle size analysis found a homogenous distribution across survey stations, with a dominance of medium sand. Mean particle size ranged from 240.7 to 274.2 µm. All stations were classified as 'medium sand' with the exception of one which was classified as 'fine sand' according to the Wentworth classification system (Wentworth, 1922; Gardline, 2019b). The sand fraction (≥63 µm to <2 mm) dominated the sediment composition at all stations and contributed to between 90.1 to 98.5% of the sediment composition. This resulted in all stations across the survey area being classified as 'sand' under the modified Folk classification (Folk, 1954; Gardline, 2019b). Gravel (≥2 mm) was not identified in any of the sediment samples acquired (Gardline, 2019b).

On a regional scale, this area of the central North Sea is classified as having predominantly EUNIS biotope complex A5.27 (deep circalittoral sand), while localised patches of other EUNIS biotopes are recorded throughout the region (Figure 4:4). Across the survey area, two separate broadscale level 4 EUNIS categories were identified. The first was the EUNIS biotope complex A5.27 (deep circalittoral sand), which represented areas of sandy sediment with little coarse material (Gardline, 2019b). This biotope is listed as being endangered (EN) on the European Red List of Habitats (Gubbay et al., 2016). The second EUNIS biotope was identified as complex A5.45 (deep circalittoral mixed sediments), which represents areas of sand with increased aggregations of gravel, cobbles and boulders (Gardline 2019b). This biotope is listed as being VU on the European Red List of Habitats (Gubbay et al., 2016). Photographic representation of the recovered sediments is shown in Figure 4:5.

Thirty-three boulders up to 0.8 m height were observed from sonar records in the Talbot Field Development area survey (Gardline, 2019a). Two wellheads were reported within the survey area, well 30/13 and well 30/13-9 were observed via sonar and multibeam imagery (Gardline, 2019a). Anchor scars extended approximately 2 km southeast of the Judy platform (Gardline 2019b). Anchor scars were also observed approximately 88 m from a plugged and abandoned wellhead to the far south of the survey area. Across the survey site, three debris areas, two rock dump areas and four mounds were observed (Gardline 2019b). No gas seeps or methane derived authigenic carbonates were observed in either the seabed imagery or from geophysical interpretations (Gardline 2019b). Four pipelines were observed passing through the survey area (Gardline 2019b). The Tampnet Clyde to Judy Telecom Cable was interpreted at the northwestern edge of the survey boundary, but could not be observed by sonar, due to burial. The Judy oil export pipeline and the Stella oil export pipelines ran parallel through the survey area (Gardline 2019b). Seabed features are presented with the photographs of seabed samples in Figure 4:6.



Source: NMPI (2022)

Figure 4:4 – Biotopes at Talbot Field Development

Source: Gardline 2019b

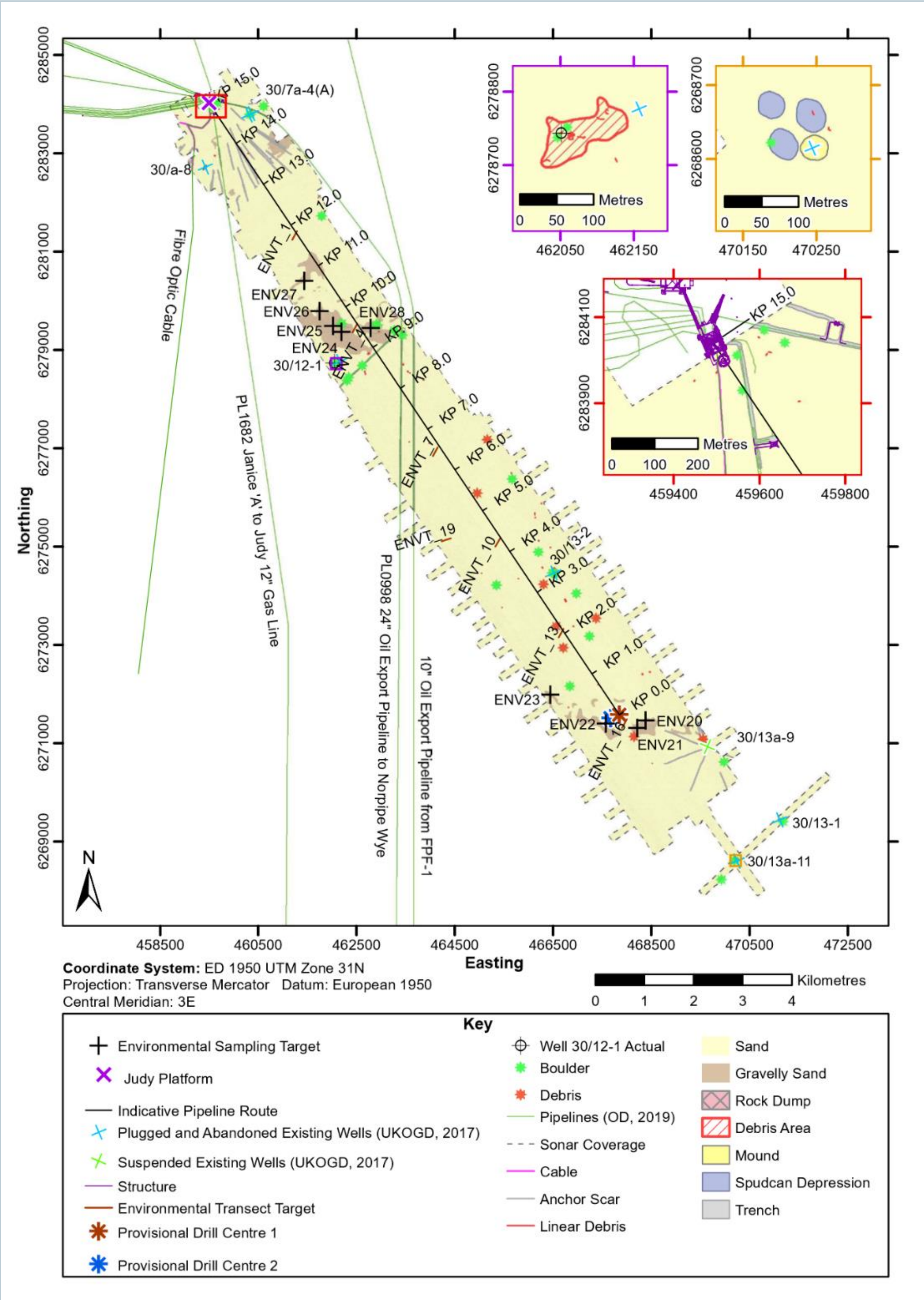
Top left plot: Station ENVT_1 Photography. Sediment: soft sediment with occasional shell fragments. Fauna: Cnidaria (Anthozoa), Echinodermata (Asteroidea), Mollusca (Scapphopoda). EUNIS Classification: A5.27 deep circalittoral sand.

Top right plot: Station ENV1 Sieve. Sediment: Soft sediment with scattered shell fragments. Fauna: Echinodermata (Echinoidea), Mollusca (Scaphopoda). EUNIS Classification: A5.27 deep circalittoral sand.

Bottom left plot: Station ENV1 Grab. Sediment: Soft Sediment with scattered shell fragments. Fauna: No visible fauna. EUNIS Classification: A5.27 deep circalittoral sand.

Bottom Right plot: Station ENV24 Photography. Sediment: soft sediment with shell fragments and scattered cobbles. Fauna: Annelida (*Oxydromus flexuosus*, Pectinariidae, Serpulidae), Arthropoda (Paguroidea), Cnidaria (*Hydractinia echinata*), Echinodermata (Asteroidea). EUNIS Classification: A5.27 deep circalittoral mixed sediments.

Figure 4:5 – Photographs of seabed samples at sampling sites around the Talbot Field Development area



Source: Gardline (2019a)

Figure 4:6 – Seabed Feature Overview of Talbot Site [Note: Survey undertaken when two drill centres were planned]

4.2.7 Sediment Chemistry

Within surveyed Talbot Field Development area, the total hydrocarbon (THC) concentrations (comprising n-alkanes, pristane, phytane, unresolved complex mixture (UCM) and PAHs) ranged from 7.6 to 14.4 µg g-1 with a mean of 11.7 µg g-1 (±1.3 SD) (Gardline, 2019a). These concentrations fall below the UKOOA (2001) 95th percentile of 40.1 µg g-1 and recognised toxicity threshold of 50 µg g-1 (UKOOA, 2002a; Kjeilen-Eilertsen et al., 2004; UKOOA, 2005) that are expected to have a 'significant environmental impact' (SEI). Therefore, the faunal community is not expected to be influenced by THC concentrations. However, all but all one station sampled were above the UKOOA (2001) mean of 9.5 µg g-1. Overall, THC concentrations were considered representative of background for the central North Sea.

Chromatographic profiles presented a consistent pattern of low level, high molecular weight resolved n-alkanes and UCMs (Gardline, 2019a). At all stations, the UCM was found primarily between nC20 and nC38, peaking between nC32 and nC33. Such distributions are considered typical for North Sea sediments displaying background levels of contamination, characteristics of which include a relatively low level of UCM distributed between nC20 and nC33. UCM was found in excess of 65% of THC across all stations, indicating that at each station the majority of hydrocarbons were weathered. However, these hydrocarbons did not indicate the presence of point source contamination.

Total n-alkane concentrations ranged from 0.089 to 0.229 µg g-1 with a mean of 0.170 µg g-1 (± 0.046 SD) (Gardline, 2019a). Concentrations were lower than the UKOOA (2001) mean background concentration of 0.40 µg g-1 for n-alkanes typically recorded in the central North Sea. These results are considered representative of background for the region.

Pristane values ranged from 0.005 to 0.050µg g-1. Phytane concentrations were at or below limits of detection (LOD) at all stations across the survey area with the exceptions of four stations, where concentrations ranged from 0.001 to 0.005 µg g-1. Carbon preference index values ranged from 2.2 to 3.5, suggesting a mixture of biogenic aliphatic hydrocarbons within the high molecular weight (HMW) range such as higher plant waxes (Bouloubassi et al., 2001), with a minor petrogenic signal. The overall predominance of Pr over Ph along with CPI values suggested that biogenic aliphatic hydrocarbons contributed to the THC concentration at all stations.

Concentrations of polycyclic aromatic hydrocarbons (PAH) across the survey area were well below their respective effects range low values and indicated that toxic effects of fauna by PAHs are unlikely. Total PAH concentrations ranged between 0.032 and 0.185 µg g-1, with a mean of 0.069 µg g-1 (±0.039 SD). Furthermore, low molecular weight and high molecular weight PAH concentrations were recorded well below their respective apparent effects thresholds (AET) (1.2 and 7.9 µg g-1) at all stations, further suggesting that overall adverse biological impacts would be unlikely.

Metals concentrations were generally considered background for the region (OSPAR, 2005; UKOOA, 2001). No metals exceeded any background concentration, background assessment criteria or background/ reference concentration values across the survey area. Therefore, metal concentrations within the current survey can be considered typical of the wider area (Gardline, 2019a). However, comparatively higher concentrations of barium (Ba), arsenic (As), copper (Cu) and nickel (Ni) were recorded at four stations located along transects routes when compared to all other sampling locations. Although no point source of origin could be confirmed, this suggested possible evidence of residual contamination associated with diffuse discharges from historical oil and gas exploration related activity in the wider area. All metals were below their AET's (Buchman, 2008) indicating that toxicological impacts to biota are unlikely to occur.

4.3 Biological Environment

An understanding of the main biological characteristics within the area must be ascertained in order to assess the potential environmental impact that may arise from the proposed Talbot Field Development project. This section summarises the characteristics of plankton, benthos, finfish and shellfish spawning and nursery grounds, marine mammals, seabirds and offshore conservation areas relevant to the Talbot Field Development area. As UKCS Blocks 30/13, 30/12 and 30/7 include English and Scottish offshore waters, both English and Scottish National Marine Plans and legislations are considered.

4.3.1 Habitat Characterisation and Benthic Fauna

As previously stated (Section 4.2.6), the benthic habitat in the Talbot Field Development are comprised predominantly of sand with a fines component (Gardline, 2019b). Shell aggregations and shell fragments were observed, as well as boulders. The most frequently observed taxon across the survey area was the mollusc Scaphonopoda, present in 69% of images across the survey site. The second and third most frequently observed taxa were the annelid *Ampharate falcata* and echinoderm Asteroidea, recorded in 46 and 41% of images, respectively (Gardline, 2019b). The horse mussel, *Modiolus modiolus* was identified at all stations, along with bacterial mats (Gardline, 2019b). The biogenic reefs formed by horse mussel are listed under Annex I of the Habitats Directive and is classified as a threatened and/ or declining habitat (OSPAR, 2008). However, the criteria for positive identification of the biogenic reef were not fulfilled for the Talbot Field Development survey area (Gardline, 2019b).

Other visible benthic fauna included: Annelida (*Echiurus sp*., *Oxydromus flexuosos*, Pectinariidae, *Sabella sp*., *Spirobranchus sp*.); Arthropoda (*Corystes cassivelaunus*, Decapoda, *Liocarcinus sp*., Lithodidae, Paguroidea); Bryzoa; Chordata (*Agonus cataphractus*, *Callionymus sp*. Gadidae, Myxinidae, Pleuronectidae, Rajidae); Cnidaria (Actiniaria, *Alocyonium digitatum*, *Epizoanthus sp*., Hydrozoa, *Luidia sarsi*, Ophiuroidea); Echinodermata (Asteroidea including *Asterias rubens*, *Astropecten irregularis*, Echinoidea, *Spatangus purpureus*); Mollusca (*A. islandica* shells, Bivalvia, Buccinidae, Gastropoda, *Modiolus modiolus*, Nudibranchia, Scaphopoda); and Porifera (Gardline, 2019b).

The Talbot Field Development is in an area where the ocean quahog (*A. islandica*) has been recorded. Siphons closely resembling those of *A. islandica* were observed at four stations and three transects, with empty shells were recorded at all stations and almost all transects (Gardline, 2019b). This thick-shelled clam can live for more than 400 years, making it one of the longest-living creatures on Earth and the slowest growing marine bivalves (OSPAR, 2009a). The greatest threat to populations of *A. islandica* is considered to be seabed disturbances and thus habitat loss, particularly that caused by beam trawling (OSPAR, 2009a). With respect to the oil and gas industry, it is considered that seabed disturbance activities will also have the potential to directly affect the species, in addition to indirect effects resulting in reductions in growth rates around exploration facilities (Witbaard, 1997). The OSPAR Commission (OSPAR, 2009a) suggests that it is unlikely that the *A. islandica* will become extinct in the North Sea due to the following:

- The long pelagic larval stage which is unaffected by fishing activity;
- Low catch efficiency of the beam trawl of the bivalve; and
- Wide-spread distribution in the North Sea.

4.3.2 Plankton

Plankton form a fundamental link in the food chain and vary seasonally in community structure according to temperature, water column mixing and nutrient availability. They are defined as small plants (phytoplankton) and animals (zooplankton) which live freely in the water column and move passively with the water currents.

The phytoplankton community of the North Sea is dominated by the dinoflagellate genus *Tripos* (*T. fusus*, *T. furca*, *T. lineatum*), with diatoms such as *Thalassiosira spp*. and *Chaeoceros spp*. also abundant. The zooplankton community is dominated by copepods, and euphausiids, and decapod larvae are also important components of the zooplankton assemblage (OESEA, 2016).

4.3.3 Fish Spawning and Nursery Grounds

The Talbot Field Development is located within ICES rectangle 42F2. This ICES rectangle coincides with the spawning grounds for cod (January to April), lemon sole (April to September), mackerel (March to August), Norway pout (January to April), plaice (December to March) and sandeels (November to February) (Coull et al., 1998; Ellis et al., 2010). Figure 4:7 presents the indicative areas for spawning grounds derived from Coull et al. (1998) and Ellis et al. (1998).

The Talbot Field Development area also lies within the nursery grounds for anglerfish, blue whiting, cod, European hake, haddock, herring, ling, mackerel, Norway pout, plaice, sandeel, spotted ray, sprat, spurdog and whiting (Aires et al., 2014; Ellis et al., 2010; Coull et al., 1998) (Figure 4:8 and Figure 4:9).

Although Ellis et al. (1998) indicates low intensity spawning grounds for cod in the vicinity of the Talbot Field Development, a more recent paper that aims to Gonzalez-Irusta and Wright (2016) indicate that the location may be unfavourable grounds for spawning cod (NMPI, 2022). The same was also found for the sandeel, with the likelihood of there being buried sandeel in the sediment was low (Langton et al, 2021).

In the vicinity of the Talbot Field Development, recent data indicate the probable presence of Age 0 group fish (Aires et al., 2014). Age 0 group fish are defined as fish in the first year of their lives or those that can be classified as juveniles. The predictive model for this group uses previously identified nursery grounds data from Coull et al. (1998), combined with environmental habitat variables. The results provide the probability of the presence of Age 0 group fish within areas that have defined and predictable environmental habitat specifications for the development of juveniles. A low probability of cod, haddock and mackerel has been predicted for all blocks of interest (Aries et al., 2014). A low probability has been predicted for Blocks 30/7 and 30/12 for anglerfish, sprat and whiting, and for Norway pout in Block 30/12. In ICES rectangle 42F2 a low probability has been predicted for European hake and herring (Aries et al., 2014).

Anglerfish, blue whiting, cod, ling, mackerel, Norway pout, herring, sandeel, spurdog and whiting are mobile species listed on the PMF list and as such, receive appropriate protection and conservation measures within Scotland's seas (SNH, 2014). Except for cod, which is listed as vulnerable, all other species are indicated as of least concern on the IUCN red list of threatened species (IUCN, 2019).

4.3.4 Seabirds Sensitivities

Kober et al. (2010) analysed European Seabirds at Sea (ESAS) density data for seabirds within the British Fishery Limit to identify 'hotspots,' with a view to assigning these marine areas Special Protection Area (SPA) status (Section 4.4.4 provides more detail on SPA designation). Several hotspots for seabirds have been identified around UK, however, none of these overlap with the Talbot Field Development area. Table 4:6 presents predicated maximum monthly density of seabirds in the Talbot Field Development area (Kober et al., 2010). Seabird density surface maps were developed using Poisson kriging, a special interpolation technique, to generate continuous density surface maps for 32 species and seabirds' assemblages. The most abundant species found in the area are Black-legged Kittiwake and Northern Fulmar in breeding and winter seasons (Kober et al., 2010).

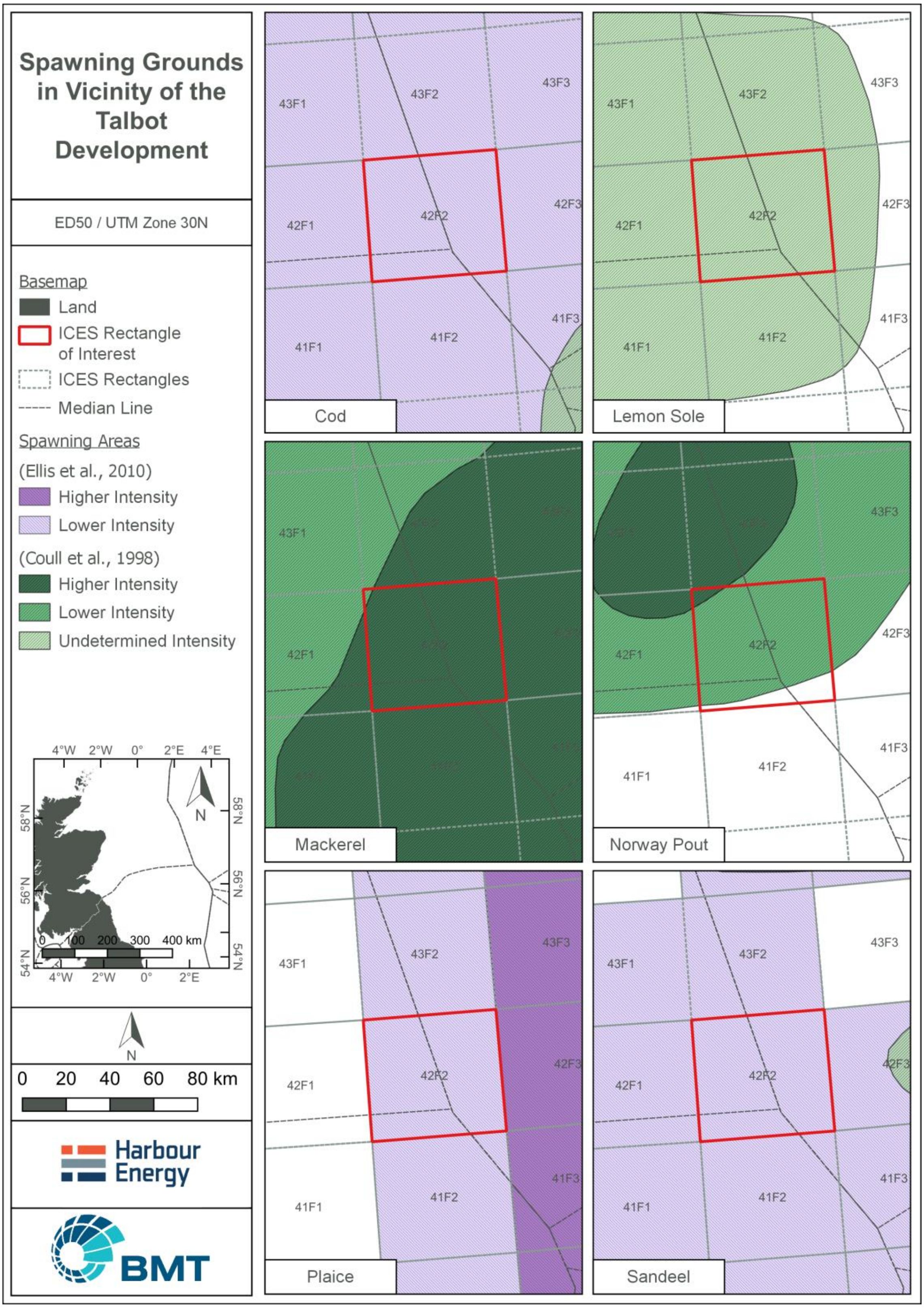


Figure 4:7 – Spawning areas in the vicinity of the Talbot Field Development Project

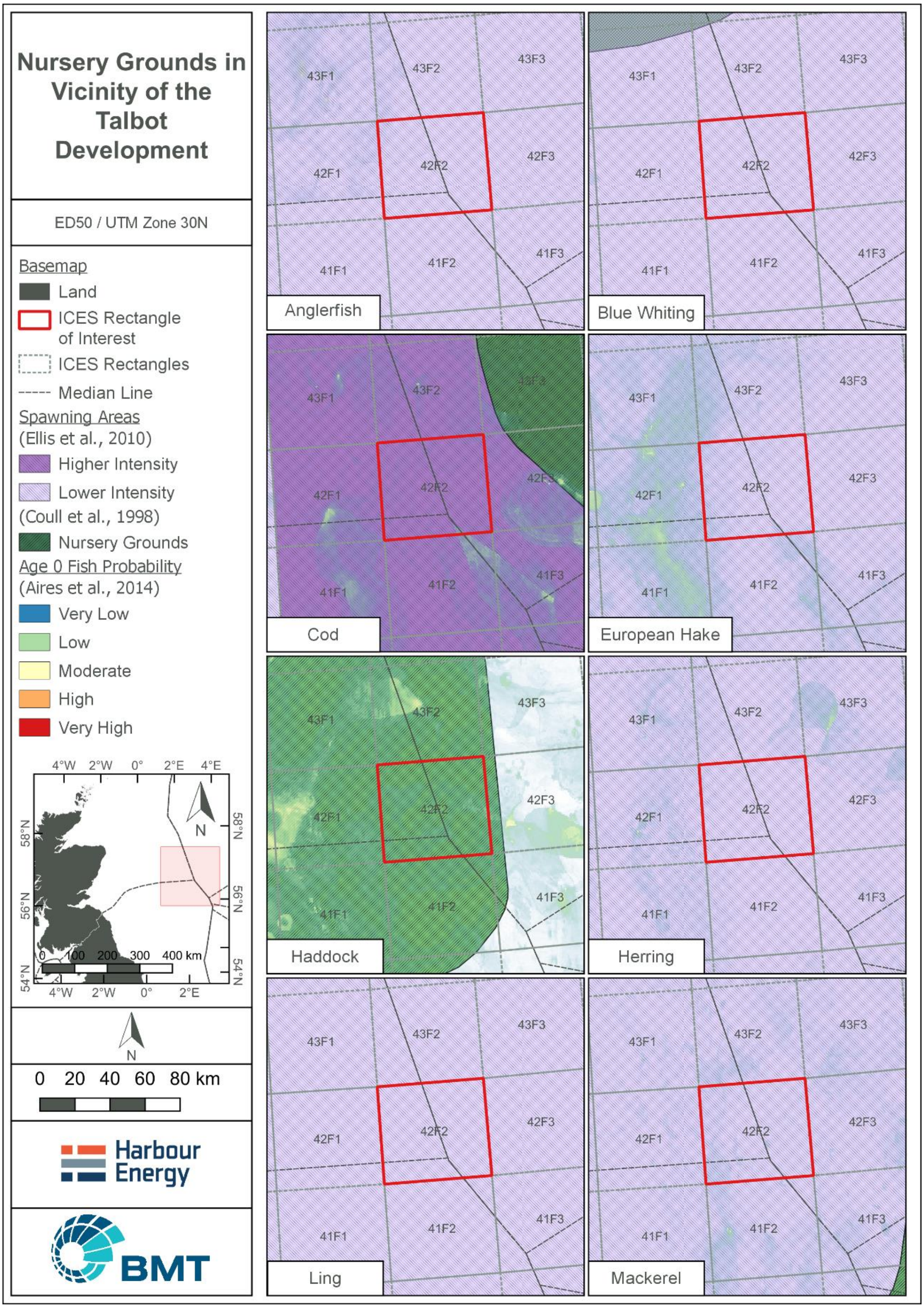


Figure 4:8 – Nursery areas in the vicinity of the Talbot Field Development Project (a)

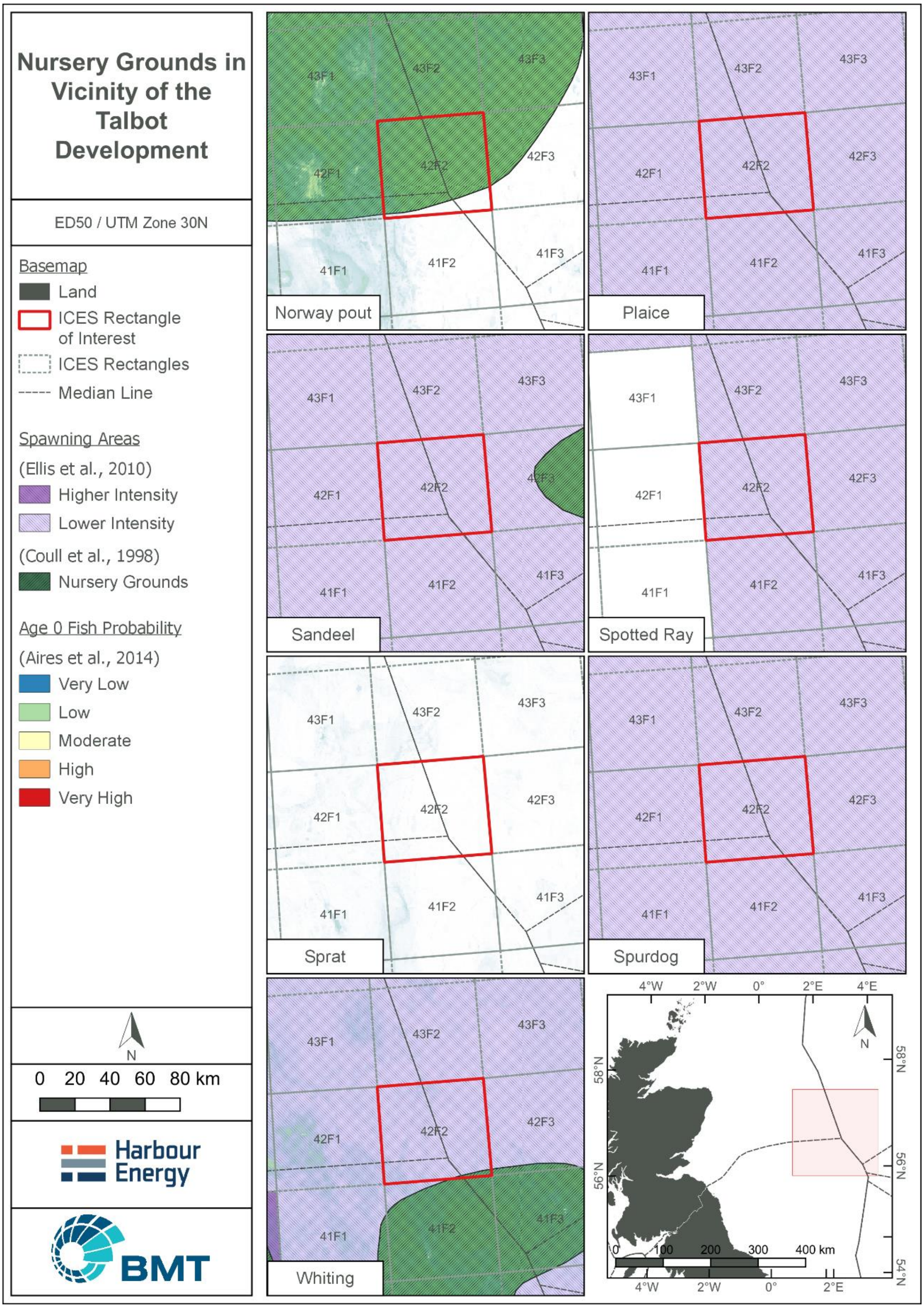


Figure 4:9 – Nursery areas in the vicinity of the Talbot Field Development Project (b)

Table 4:6 – Predicted monthly surface density of seabirds in the Talbot Field Development area

Species	Season	Month											
		J	F	M	A	M	J	J	A	S	O	N	D
Northern Fulmar	Breeding			1.0 – 5.0	1.0 – 5.0	1.0 – 5.0	1.0 – 5.0	1.0 – 5.0					
	Winter	1.0 – 5.0	1.0 – 5.0						1.0 – 5.0	1.0 – 5.0	1.0 – 5.0	1.0 – 5.0	1.0 – 5.0
Northern Gannet	Breeding					<1.0	<1.0	<1.0	<1.0	<1.0			
	Winter	<1.0	<1.0	<1.0	<1.0						<1.0	<1.0	<1.0
Arctic Skua	Breeding					<1.0	<1.0	<1.0	<1.0				
Great Skua	Breeding					<1.0	<1.0	<1.0	<1.0				
	Winter	<1.0	<1.0	<1.0	<1.0					<1.0	<1.0	<1.0	<1.0
Black-legged Kittiwake	Breeding					10.1 – 20.0	10.1 – 20.0	10.1 – 20.0	10.1 – 20.0	10.1 – 20.0			
	Winter	1.0 – 5.0	1.0 – 5.0	1.0 – 5.0	1.0 – 5.0						1.0 – 5.0	1.0 – 5.0	1.0 – 5.0
Great Black-backed Gull	Breeding				<1.0	<1.0	<1.0	<1.0	<1.0				
	Winter	<1.0	<1.0	<1.0						<1.0	<1.0	<1.0	<1.0
Common Gull	Winter	<1.0	<1.0	<1.0	<1.0					<1.0	<1.0	<1.0	<1.0
Herring Gull	Breeding				<1.0	<1.0	<1.0	<1.0	<1.0				
	Winter	<1.0	<1.0	<1.0						<1.0	<1.0	<1.0	<1.0
Razorbill	Additional								1.0 – 5.0	1.0 – 5.0			
Common Guillemot	Breeding					1.0 – 5.0	1.0 – 5.0						
	Additional								<1.0	<1.0			
	Winter	<1.0	<1.0	<1.0	<1.0						<1.0	<1.0	<1.0
Little Auk	Winter	1.0 – 5.0	1.0 – 5.0	1.0 – 5.0								1.0 – 5.0	1.0 – 5.0
Atlantic Puffin	Breeding				1.0 – 5.0	1.0 – 5.0	1.0 – 5.0	1.0 – 5.0					
	Winter	<1.0	<1.0	<1.0					<1.0	<1.0	<1.0	<1.0	<1.0
All species combined	Breeding			>20.0	>20.0	>20.0	>20.0	>20.0	>20.0	>20.0	>20.0		
	Summer							>20.0	>20.0				
	Winter	1.0 – 5.0	1.0 – 5.0	1.0 – 5.0								1.0 – 5.0	1.0 – 5.0
Key													
Seabirds' density (numbers per km2)		Not recorded		<1.0		1.0 – 5.0		5.1 – 10.0		10.1 – 20.0		>20.0	

Source: Kober et al. (2010)

Planned offshore oil and gas operations do not normally affect seabirds (DTI, 2001), however, they are vulnerable to oiling from surface oil pollution. This occurs either by direct toxicity through ingestion or hypothermia as a result of the birds' inability to waterproof their feathers. Certain species become flightless during the moulting season. This is particularly true for auk species such as Common Guillemot, Razorbill and Atlantic Puffin that spend a large amount of time on the water surface, which makes them particularly vulnerable to surface oil pollution (DTI, 2001).

The Seabird Oil Sensitivity Index (SOSI) is a tool which aids planning and emergency decision making with regards to oil pollution (Webb et al., 2016). Identifying areas at sea where seabirds are likely to be most sensitive to oil pollution, it is based on seabird survey data collected from 1995 to 2015, from a wide survey area extending beyond the UKCS using boat-based, visual aerial and digital video aerial survey techniques. The index is independent of where oil pollution is most likely to occur; rather it indicates where the highest seabird sensitivities might lie if there were to be a pollution incident. The SOSI in and around Talbot Field Development area is recorded in Table 4:7. In the primary blocks of interest (30/7, 30/12 and 30/13), sensitivity ranges between low and very high for the months where data are available. In Block 30/13 very high seabird sensitivity was recorded in May and June, while in February moderate seabird sensitivity was recorded in Block 30/12. In other months typically low seabird sensitivity was recorded in all blocks of interest, with the exception of November and December, and April in Block 30/7 only, where there were no data (Table 4:7).

Table 4:7 – Seabird vulnerability (SOSI) within the Talbot Field Development area

Block	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
30/1	5	5	5	ND	5	5	5	5	5	ND	ND	ND
30/2	5	5	5	ND	5	5	5	5	5	ND	ND	5
30/3	5	5	5	ND	4	4	5	5	5	ND	ND	5
30/6	5	5	5	ND	5	5	5	5	5	ND	ND	ND
30/7	**5**	**5**	**5**	**ND**	**5**	**5**	**5**	**5**	**5**	**ND**	**ND**	**5**
30/8	5	5	5	ND	1	1	5	5	5	ND	ND	5
30/11	5	5	5	ND	5	5	5	5	5	ND	ND	ND
30/12	**5**	**4**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**ND**	**ND**	**5**
30/13	**5**	**5**	**5**	**5**	**2**	**2**	**5**	**5**	**5**	**ND**	**ND**	**5**
30/14	5	5	5	ND	2	2	5	5	5	ND	ND	5
30/16	5	5	5	5	5	5	5	5	5	ND	ND	ND
30/17	5	5	5	5	5	5	5	5	5	ND	ND	ND
30/18	5	5	5	5	5	5	5	5	5	ND	ND	5
30/19	5	5	5	5	4	4	5	5	5	ND	ND	5

KEY		
	1	Extremely high seabird vulnerability
	2	Very High seabird vulnerability
	3	High seabird vulnerability
	4	Moderate seabird vulnerability
	5	Low seabird sensitivity
	ND	No data
	X	Interpolated data red text
	Bold text	Primary blocks of interest

Source: Webb et al. (2016)

4.3.5 Marine Mammals

Marine mammals include whales, dolphins and porpoises (cetaceans) and seals (pinnipeds). Marine mammals may be vulnerable to the effects of oil and gas activities and can be impacted by noise, contaminants, oil spills and any effects on prey availability (SMRU, 2001). The abundance and availability of prey, including plankton and fish, can be of prime importance in determining the numbers and distribution of marine mammals and can also influence their reproductive success or failure. Changes in the availability of principal prey species may result in population level changes of marine mammals but it is currently not possible to predict the extent of any such changes (SMRU, 2001).

Cetaceans (whales, dolphins and porpoises)

The main cetacean species occurring in the Talbot Field Development area (primary Quadrant 30 and surrounding quadrants 22, 23, 29, 37, 38, 39 and 31) are minke whale, common dolphin, white-beaked dolphin, white-sided dolphin and harbour porpoise (Reid et al. 2003, UKDMAP 1998; Hammond et al., 2017). Reid et al. (2003) also recorded presence of bottlenose dolphin in the area, which is not confirmed by other sources. The highest numbers of sightings for the cetacean species that have been recorded within Quadrant 30 or one of the surrounding quadrants (UKDMAP, 1998) are presented in Table 4:8. Only white-beaked dolphin and harbour porpoise were recorded in low (July to October) and medium numbers (June), respectively, within Quadrant 30.

Of four Annex II species recorded in the offshore UK waters (JNCC, 2019a), only harbour porpoise has been recorded in the Talbot Field Development area in very high numbers. The harbour porpoise and other marine mammal species listed in Table 4:8 are mobile species on the PMF list, designated to receive appropriate protection and conservation measures (SNH, 2014).

Table 4:8 – Cetacean densities in quadrants in and surrounding the Talbot Field Development Project

Species	J	F	M	A	M	J	J	A	S	O	N	D
Minke whale					L	L	M	L			L	
Common dolphin						L	L					
White-beaked dolphin	L			L	VH	L	H	L	H	H	H	
White-sided dolphin					H		VH	L	H			
Harbour porpoise					L	H	L	H	M	L	H	

KEY		
	VH	Very High Abundance
	H	High Abundance
	M	Moderate Abundance
	L	Low abundance
		No data

Source: Reid et al. (2003) and UKDMAP (1998)

Pinnipeds (seals)

The grey seal and the harbour seal are both resident in UK waters and occur regularly over large parts of the North Sea (SCOS, 2009). Density mapping indicates a 0-1 harbour seal abundance in Blocks 30/7, 30/12 and 30/13 (NMPI, 2022; Figure 4:10). Density mapping indicates a 1-5 grey seal abundance in Block 30/12 and a 0-1 grey seal abundance in Blocks 30/7 and 30/13 (NMPI, 2022; Figure 4:10). This is to be expected given the 278 km distance from nearest land.

The grey and harbour seal are mobile species on the PMF list, designated to receive appropriate protection and conservation measures (SNH, 2014).

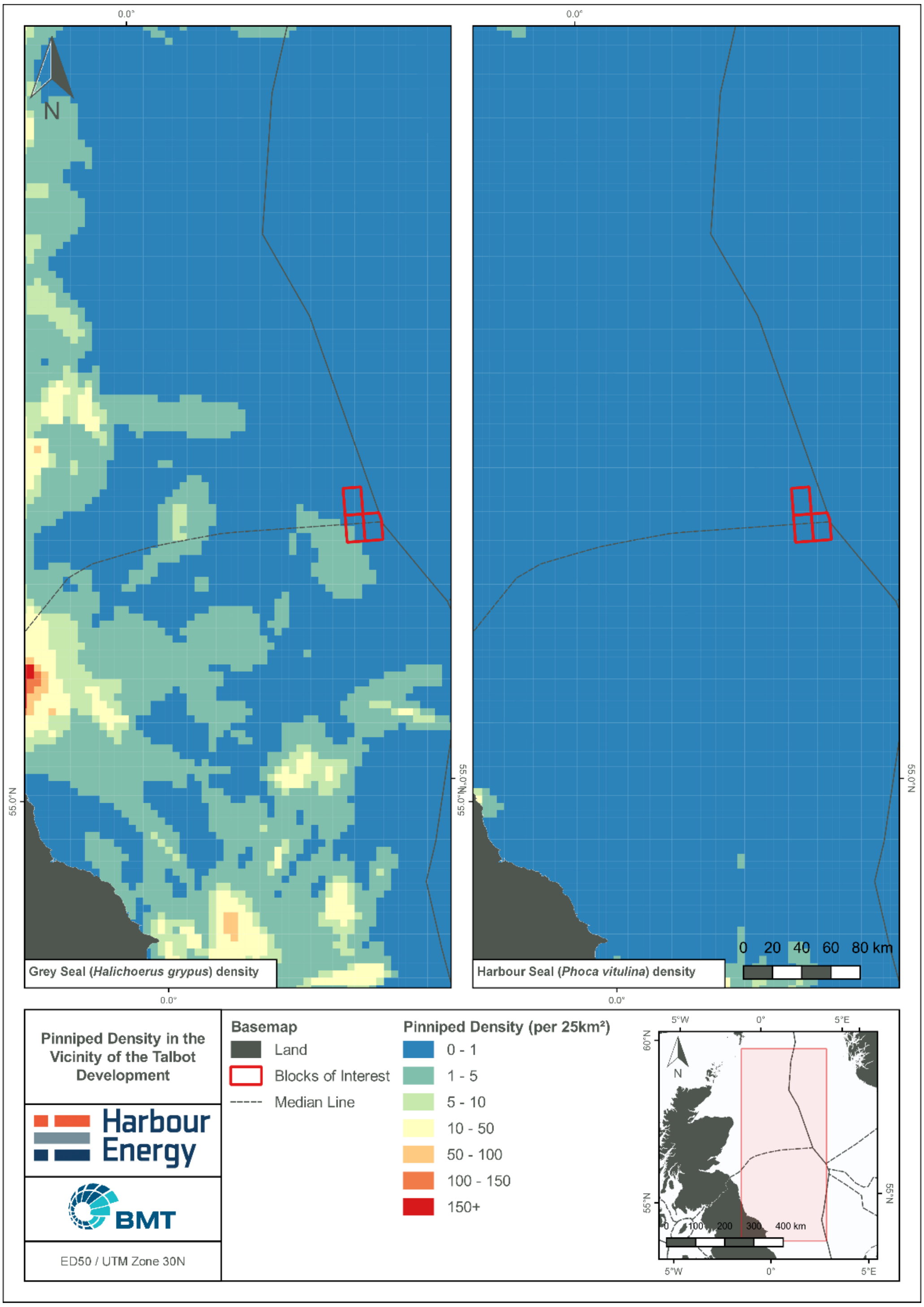


Figure 4:10 – Pinniped density in the Talbot Field Development area

4.4 Offshore Conservation Areas

Designated conservation sites are widespread and abundant around the UK coastline and in the marine environment. Numerous levels of designation exist from statutory international to local voluntary schemes. These afford differing levels of protection for habitats, species, as well as geological, cultural and landscape features. More widespread designations include the Special Areas of Conservation (SACs) and Special Protection Areas (SPAs) and the Sites/ Areas of Special Scientific Interest (SSSIs/ ASSIs) (DECC, 2011).

The Government is in the process of identifying and designating potential marine conservation sites (Marine SACs), as well as the identification of new marine SPAs, the boundaries of some coastal and marine sites are being extended. In addition, the Marine and Coastal Access Act 2009 has introduced measures for the designation of marine protected areas, known as Marine Conservation Zones (MCZs) in England (DECC, 2011). SACs are sites that were originally adopted by the European Commission (EC) and were formally designated by the government of each country in whose territory the site lies. SACs have continued to be designated by the UK government after the UKs departure from the European Union (EU). NCMPAs are areas designated under the Marine (Scotland) Act 2010 and the Marine and Coastal Access Act 2009, for the conservation of important marine biodiversity and geodiversity out to 200 nm (JNCC, 2019b).

Figure 4:11 shows the location of designated conservation areas, Annex I habitats and ocean quahog observations in the vicinity of the Talbot Field Development are also outlined.

4.4.1 Marine Plans

The Marine (Scotland) Act 2010 and the UK Marine and Coastal Access Act 2009 (Marine Act) established a legislative and management framework for the marine environment, allowing the competing demands on the sea to be managed in a sustainable way across all of Scotland's seas (Scottish Government, 2015). Under the Marine (Scotland) Act 2010 Scottish Ministers must prepare and adopt a National Marine Plan covering Scottish inshore waters. In addition, the Marine Act requires Scottish Ministers to seek to ensure that a marine plan is in place in the offshore region when a Marine Policy Statement is in effect (Scottish Government, 2015).

The Scottish and UK Governments published a marine plan for Scotland's inshore waters and a marine plan covering Scottish offshore waters in a single document collectively referred to as the National Marine Plan. The National Marine Plan was prepared in accordance with, and gives consideration to, EU Directive 2014/89/EU which came into force in July 2014 (Scottish Government, 2015). The Directive introduces a framework for maritime spatial planning and aims to promote the sustainable development of marine areas and the sustainable use of marine resources.

The Marine Act, mainly affecting England and Wales, defines the arrangements for a new system of marine management across the UK. The English marine area has been broken up into 11 different Marine Plan areas that comprise inshore and offshore marine regions. The Talbot Field Development area is located within the North East Offshore Marine Plan, which covers an area of around 56,000 square kilometres of inshore and offshore waters stretching from the Scottish border to Flamborough Head, in Yorkshire, taking in a total of approximately 6,000 square kilometres of sea (DEFRA, 2021). The North East Marine Plan is developed in accordance with the requirements set out under the Marine and Coastal Access Act 2009 and introduces a strategic approach to planning. It provides a clear, evidence-based approach to inform decision making by marine users and regulators on where, when or how activities might take place within the northeast inshore and northeast offshore marine plan areas (DEFRA, 2021).

Marine Act powers allow the creation of a new type of Marine Protected Area (MPA), called in English, Welsh and Northern Irish waters a Marine Conservation Zone (MCZ). MCZs will protect a range of nationally important marine wildlife, habitats, geology and geomorphology. They can be designated anywhere in English, Welsh and Northern Irish territorial and UK offshore waters (JNCC, 2019c).

In accordance with Article 5(3) of the Directive, a wide range of sectoral uses and activities have been considered within the National Marine Plan.

The General Policies of the National Marine Plan introduce General Policy 9 (Natural Heritage), which concerns the development and use of the marine environment. The policy states that development and use of the marine environment must not result in significant impact on the national status of PMF. Supporting the National Marine Plan, the Strategy for Marine Nature Conservation in Scotland's seas sets out aims and objectives to achieve sustainable development and use, including the protection and, where appropriate, enhancement of the health of the Scottish marine area. Scottish Natural Heritage (SNH), the Joint Nature Conservation Committee (JNCC) and Marine Scotland have been working together to develop a priority list of marine habitats and species in Scotland's sea known as PMFs. The list contains 81 habitats and species considered to be of conservation importance in Scotland's seas (SNH, 2014), that will help to focus future conservation action and marine planning, direct research and education and promote a consistent approach to marine nature conservation advice (Marine Scotland, 2011). Habitats and species on the PMF list in the vicinity of Talbot Field Development area are acknowledged within this document.

Blocks 30/13, 30/12 and 30/7 are located approximately 278 km southwest of the nearest coastline (NMPI, 2022). The proposed operations are within the area covered by the Scottish National Marine Plan and English North East Offshore Marine Plan; the interactive NMPi map has been used where appropriate to inform this submission (NMPI, 2022). Both Scottish and English marine plans were examined due to the Talbot Field Development area crossing both jurisdictions, with drilling and majority of subsea infrastructure installations planned in English waters, while pipeline commissioning and oil and gas production discharges occurring in Scottish waters.

4.4.2 NCMPAs and MCZs

To date, 30 NCMPAs, of which 13 are offshore, have been formally designated in Scottish waters (JNCC, 2019c). The East Gannet and Montrose Fields NCMPA is the nearest, located approximately 67 km northwest of the proposed Talbot Field Development (Figure 4:11). The NCMPA is designated for protection of ocean quahog, including the supporting habitat, sand and gravel. The NCMPA also includes a band of offshore deep-sea mud which provides important habitat for many species of worms and molluscs which in turn, provide an important food source for fish. Ocean quahog and offshore deep-sea mud are listed as PMFs (SNH, 2014).

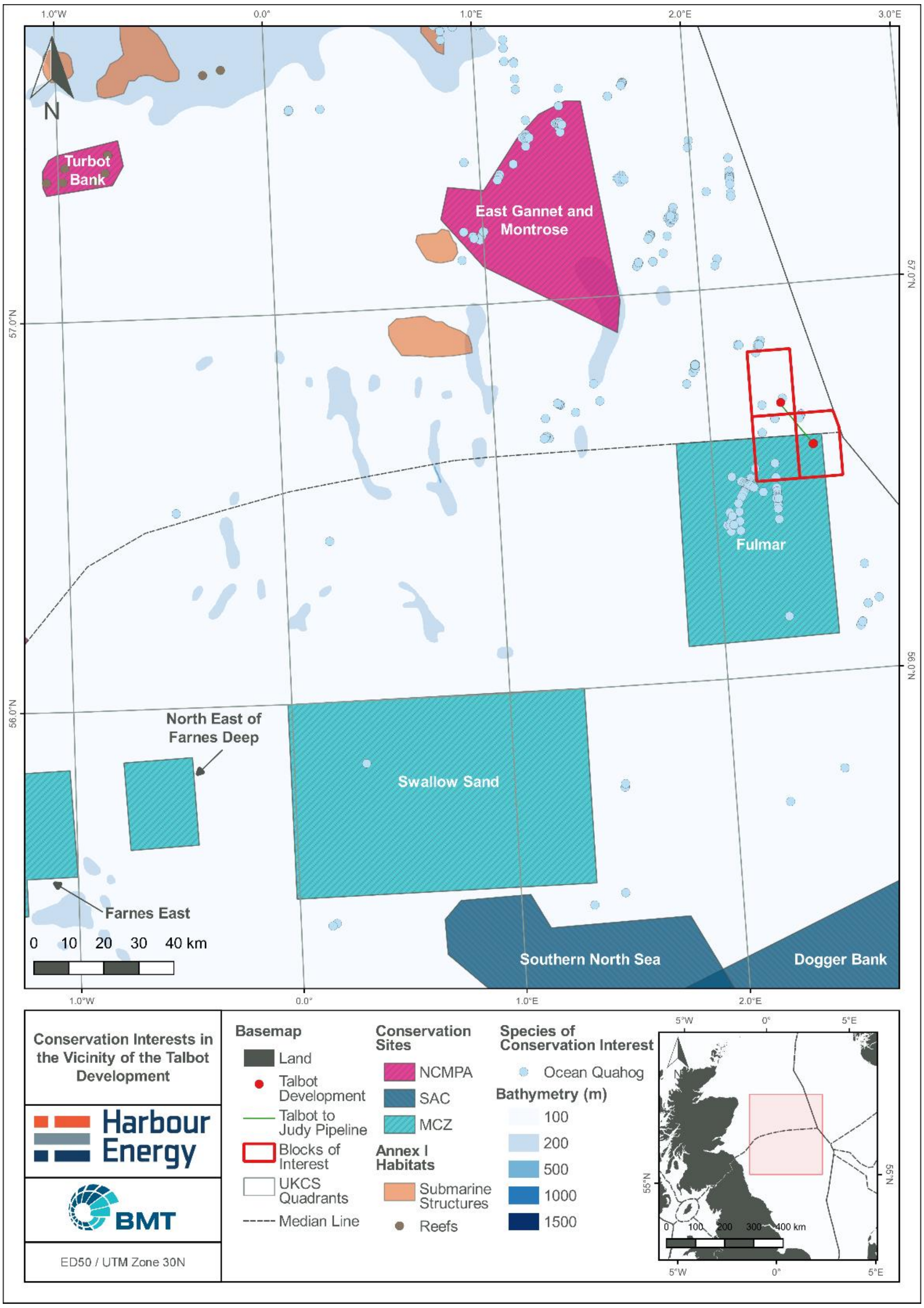


Figure 4:11 – The location of the Talbot Field Development in relation to conservation areas

There are currently 89 MCZs designated in English waters and two in Northern Irish waters, of which 27 are offshore (JNCC, 2019d). The nearest to development, Fulmar MCZ, is located within Blocks 30/12 and 30/13 and overlaps with the proposed Talbot Field Development area (Figure 4:11). It is designated for protection of broad-scale habitats of subtidal mud, subtidal sand and subtidal mixed sediment, as well as protection of ocean quahog. It also protects important habitats for marine animals, providing food, spawning areas and shelter (JNCC, 2019d). Offshore subtidal sands and gravels and ocean quahog are listed as PMFs (SNH, 2014).

The Swallow Sand MCZ is located approximately 96 km southwest of the proposed Talbot Field Development area (Figure 4:11) and is designated for protection of broad-scale habitats of subtidal sand and subtidal coarse sediment, as well as the geomorphological feature, the North Sea glacial tunnel valley, known as the Swallow Hole (JNCC, 2019d). Offshore subtidal sands are listed as a PMF (SNH, 2014).

4.4.3 Special Areas of Conservation

The UK government, with guidance from the JNCC and the Department of Environment, Food and Rural Affairs (DEFRA), had statutory jurisdiction under the EC Habitats Directive to propose offshore areas or species (based on the habitat types and species identified in Annexes I and II) to be designated as SACs. The UKs departure from the EU does not alter the standard of protection for these sites. Within UK offshore waters there are currently 23 designated SACs, one candidate SAC (cSAC) and one Sites of Community Importance (SCIs) (JNCC, 2019e). The cSACs are sites that have been submitted to the EC but not yet formally adopted and SCIs are sites that have been adopted by the EC but not yet formally designated by the government of each country (JNCC, 2019f). In relation to UK offshore waters, three habitats from Annex I and four species from Annex II of the Habitats Directive are currently under consideration for the identification of SACs in UK offshore waters (JNCC, 2019g; Table 4:9).

Table 4:9 – Annex I habitats and Annex II species which are qualifying features for marine SAC designations in the UK waters

Annex I habitats considered for SAC selection in UK offshore waters	Annex II species considered for marine SAC selection in UK waters
• Sandbanks which are slightly covered by seawater all the time. • Reefs (bedrock, biogenic and stony). • Bedrock reefs – made from continuous outcroppings of bedrock which may be of various topographical shapes. • Stony reefs – these consist of aggregations of boulders and cobbles which may have some finer sediment in interstitial spaces. • Biogenic reefs – formed by cold water corals (e.g., Desmophyllum pertusum and Sabellaria spinulosa). • Submarine structures made by leaking gases.	• Harbour porpoise • Harbour seal • Grey seal • Bottlenose dolphin

Source: JNCC (2019f)

Annex I Habitats

Potential Annex I habitats exist within 40 km of the block of interest as detailed Figure 4:11, however no SACs designated for the protection of Annex I habitats are located in the vicinity of Talbot Field Development (JNCC, 2019c).

Annex II Species

There are no SACs designated for the protection of Annex II species in the vicinity of Talbot Field Development (JNCC, 2019c). Of the possible Annex II species recorded in the North Sea, only harbour porpoise have been sighted in significant numbers within and around Quadrant 30, although all four species were recorded (UKDMAP, 1998; Reid et al., 2003; Hammond et al., 2017; NMPI, 2022).

Annex IV Species

All cetacean species are listed in Annex IV of the EC Habitats Directive, which protects them from any deliberate disturbance particularly during the periods of breeding and migration. Those cetaceans which have been classified as being present in and around Quadrant 30 within which the blocks of interest is located are: minke whale, bottlenose dolphin, common dolphin, white-beaked dolphin, white-sided dolphin and harbour porpoise (UKDMAP, 1998; Reid et al., 2003; Hammond et al., 2017; NMPI, 2022).

Of those cetaceans located within Talbot Field Development area, only the harbour porpoise is listed on the IUCN red list of threatened species (vulnerable) (IUCN, 2019).

4.4.4 Special Protection Areas

SPAs are protected areas which have been classified in accordance with Article 4 of the Conservation of Offshore Marine Habitats and Species Regulations 2017 (as amended) in the UK offshore area. They are classified based on the location of rare and vulnerable birds and also for frequently occurring migratory species which are listed on Annex I of the Directive. No SPAs were recorded within the vicinity of the Talbot Field Development area.

4.5 Socioeconomic Environment

This section provides information on the broader social and economic considerations within the Talbot Field Development area. For offshore oil and gas developments consideration is given to the potential impact on other sea users, such as the fishing and shipping industries, the renewable energy sector, and the military operations. The existence of submarine cables, historic wrecks and other oil and gas installations is also considered.

Socioeconomic considerations can also include changes in demographics and to communities, direct and indirect effects on employment, expenditures and incomes, and economic benefits to the wider area resulting from the proposed development. However, no attempt has been made to quantify these potential changes, and social benefits are only discussed in the context of potential economic impacts.

4.5.1 Commercial Fisheries

An assessment of fishing activity in the area has been derived from ICES fisheries statistics, information provided by the Marine Analytical Unit at Marine Scotland (Scottish Government, 2021). Statistical data from ICES rectangle 42F2 on the UK fishing effort, and live weight of demersal, pelagic and shellfish landed by UK vessels, provided by the Scottish Government (2021), are reported below. The overall value of the different species by area (financial yield per ICES rectangle) is an indication of the differential worth of areas and is used as a method of expressing commercial sensitivity (Coull et al., 1998).

The type of fishing gear and techniques employed by fishermen depends on a variety of factors, such as:

- Species fished, e.g., demersal, pelagic or shellfish;
- Water depth and seabed bathymetry; and
- Seabed characteristics.

Species found in the water column (pelagic species) are fished using techniques that do not interact with the seabed, whereas demersal and shellfish species are generally fished on or near the seabed. Finfish, such as cod, whiting, haddock and flatfish, and shellfish species, such as Nephrops, which are found on or near the seabed, are caught by demersal gear. Demersal trawling methods interact with the seabed and may interact with the existing infrastructure on the seabed and historical seabed anomalies created by oil and gas activities, including disturbance from subsea structures decommissioned in situ such as footings, pipelines, rock placement or concrete mattresses left or buried in the sediment. The EBS survey reported that across the survey site, three debris areas, two rock dump areas and four mounds were observed (Gardline 2019b)

Trawls were the most utilised gear type used in ICES rectangle 42F2 in each year from 2014 to 2020 (Scottish Government, 2021).

Fishing effort

Most of the recorded instances of fishing within ICES rectangle 42F2 were from active demersal fishing gear, specifically trawls, with only one recorded instance of passive demersal gear being used within the rectangle in 2019 (Scottish Government, 2021). The total number of days effort in ICES rectangle 42F2 was 87 days for 2014, dropping to 10 days for 2020. Fishing effort for 2018 has not been disclosed, as fewer than five >10 m vessels undertook fishing activity in the rectangle in that year.

Annual fishing effort

A consideration of the fishing effort on a monthly basis has also been undertaken. Of note is that, due to returns of disclosive data, there is only a partial indication of when fishing effort is at its greatest within an annual period. Since 2014, the fishing effort within ICES rectangle 42F2 has primarily occurred between April and September (Scottish Government, 2021). However, much of this data is disclosive, with data only available for May and July in 2014, and May and June in 2015 (Table 4:10).

Table 4:10 – Variation in fishing effort within an annual period, for 2014 to 2020, within ICES rectangle 42F2

Month	2014 effort (days)	2015 effort (days)	2016 effort (days)	2017 effort (days)	2018 effort (days)	2019 effort (days)	2020 effort (days)
Jan				DD			
Feb						DD	
Mar		DD					
Apr	DD		DD				DD
May	29	26	DD	DD	DD	DD	DD
Jun	DD	10	DD	DD	DD	DD	DD
Jul	34	DD	DD		DD	DD	DD
Aug	DD	DD	DD	DD	DD		DD
Sep	DD		DD				
Oct							
Nov						DD	
Dec							
TOTAL	**87**	**42**	**33**	**16**	**DD**	**11**	**10**

Source: Scottish Government (2021)
DD – disclosive data; blank cells – no data
* Totals include disclosive data from Scottish Government.

4.5.1.1 Fishing quantity and value

The relative quantity and values of fish landed from ICES rectangle 42F2 in 2020 was low for shellfish and demersal species, with no pelagic species caught (Figure 4:12; MMO, 2021). Between 2016 and 2020, the annual total live weight of fish landed from ICES rectangle 42F2 ranged from 49 tonnes landed in 2016 to 8 tonnes in 2020, progressively decreasing over the period (Table 4:11; MMO, 2021). Total annual value in ICES rectangle 42F2 was between £88,427 in 2018 and £18,196 in 2020 (MMO, 2021). Of the total commercial catch, there were 25 demersal species, 5 shellfish species and 1 pelagic species (MMO, 2021).

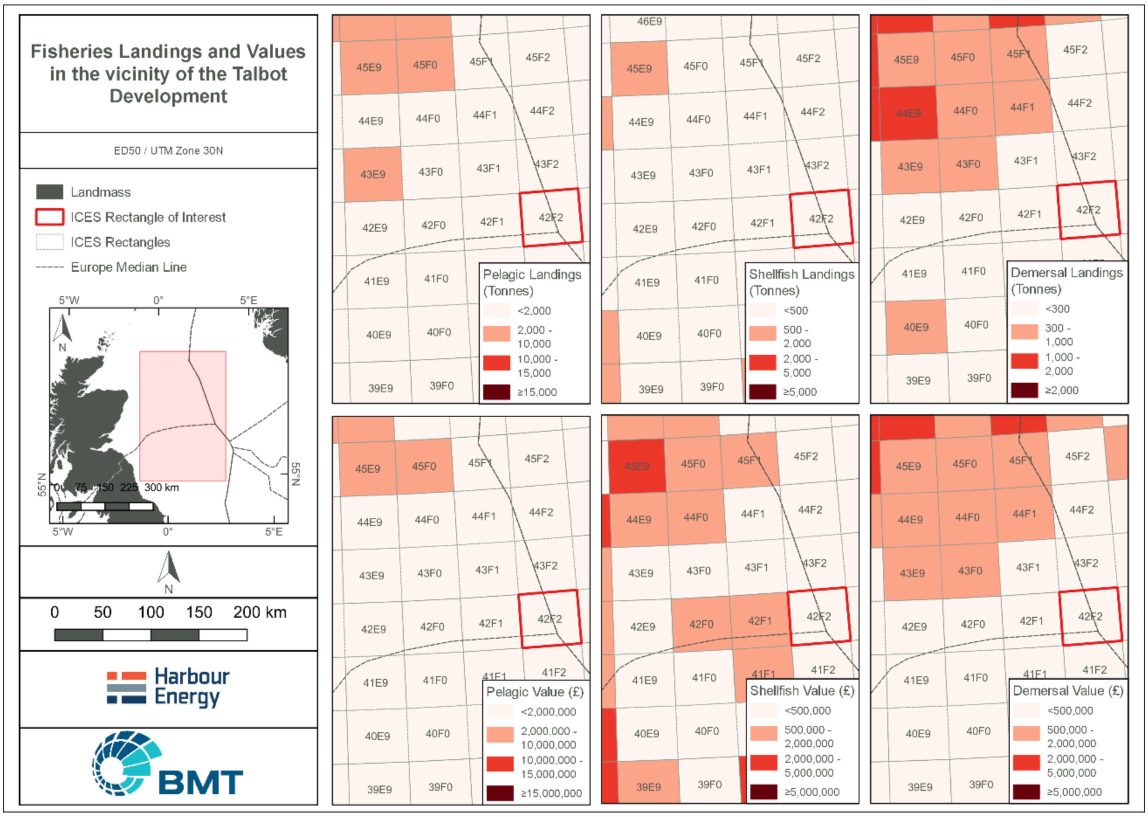


Figure 4:12 – Relative value (£) and landings (tonnes) for demersal, pelagic and shellfish species caught within ICES rectangle 42F2, and surrounding ICES rectangles, for 2020

Table 4:11 – Variation in fishing effort within an annual period, for 2014 to 2020, within ICES rectangle 42F2

Year	Total effort* (days)	Gear type	Total value (£)	Species type	Value (£)	Total quantity (tonnes)	Species type	Quantity (tonnes)	Percent of total quantity (%)
2020	DD	Trawls	18,196	Demersal	5,529	8	Demersal	4.27	56
				Pelagic	-		Pelagic	-	-
				Shellfish	12,667		Shellfish	3.36	44
2019	DD	Trawls & Demersal Seine	33,048	Demersal	32,600	18	Demersal	18.26	99
				Pelagic	-		Pelagic	-	-
				Shellfish	449		Shellfish	0.10	1
2018	DD	Trawls	88,427	Demersal	88,322	37	Demersal	37.25	100
				Pelagic	-		Pelagic	-	-
				Shellfish	105		Shellfish	0.02	0
2017	16	Trawls	22,109	Demersal	18,785	12	Demersal	11.34	94
				Pelagic	75		Pelagic	0.05	0
				Shellfish	3,249		Shellfish	0.67	6
2016	33	Trawls	82,923	Demersal	70,339	49	Demersal	46.93	96
				Pelagic	-		Pelagic	-	-
				Shellfish	12,583		Shellfish	2.20	4

Vessel Monitoring System data

Vessel Monitoring System (VMS) satellite tracking data complement the ICES fisheries data and shows information for the years 2010 to 2022 for all UK registered commercial fishing vessels over 15 m in length (NMPI 2022; Figure 4:13). In order to differentiate between vessels steaming and fishing, only those vessels with speeds between 0 and 6 knots are assumed to be fishing. The data is limited to fishing method used. Low fishing activity was recorded within ICES rectangle 42F2, with only otter trawls targeting demersal fisheries having any discernible activity within the ICES rectangle of interest (Figure 4:13).

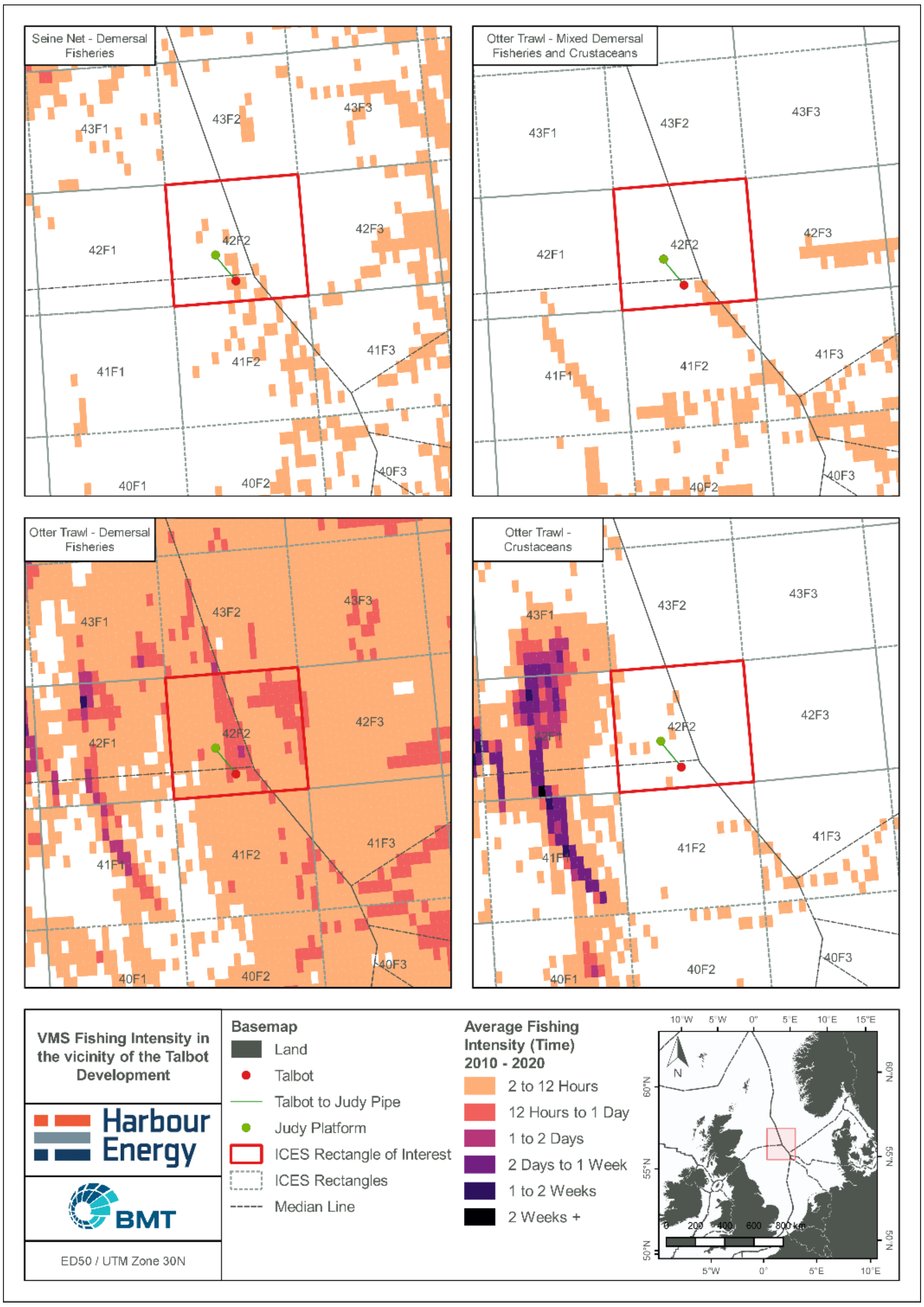
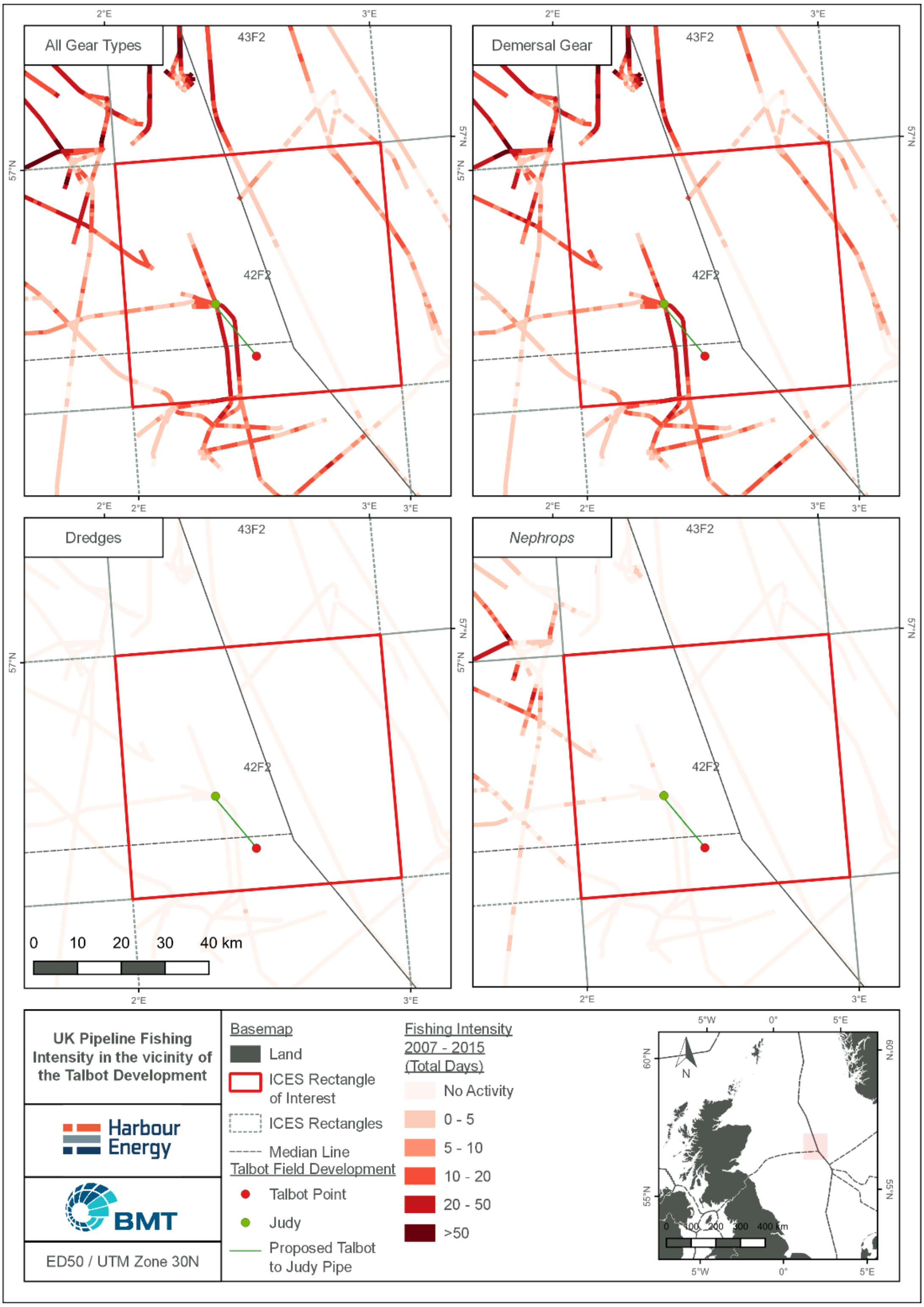


Figure 4:13 – Satellite (VMS) commercial fishing intensity (hours) by gear type (2010 – 2020)

Commercial fishing in combination with other sea users

Spatial representation of commercial fishing activities associated with the location of oil and gas pipelines is shown in Figure 4:14 (NMPI, 2022). The figure shows that no dredging or mobile fishing of Nephrops occurred along pipelines within 42F2. VMS tracks show very low activity along pipelines in the vicinity of the Talbot Field Development area between 2007 and 2015.



Source: NMPI (2022)

Figure 4:14 – Fishing intensity associated with oil and gas pipelines (2007 – 2015)

4.5.2 Oil and Gas Infrastructure

The central North Sea is densely populated by various oil and gas infrastructure. Structures in the 40 km radius of the Talbot Field Development area include (NSTD, 2022):

- Judy platform;
- Jade platform;
- Fulmar A & AD platform;
- Auk A platform;
- Jasmine platforms;
- Clyde platform;
- Stella FPF1 FPSO
- Various oil and gas export flowlines;
- Flyndre-Cawdor production PIP; and
- Joanne electro-hydraulic umbilical.

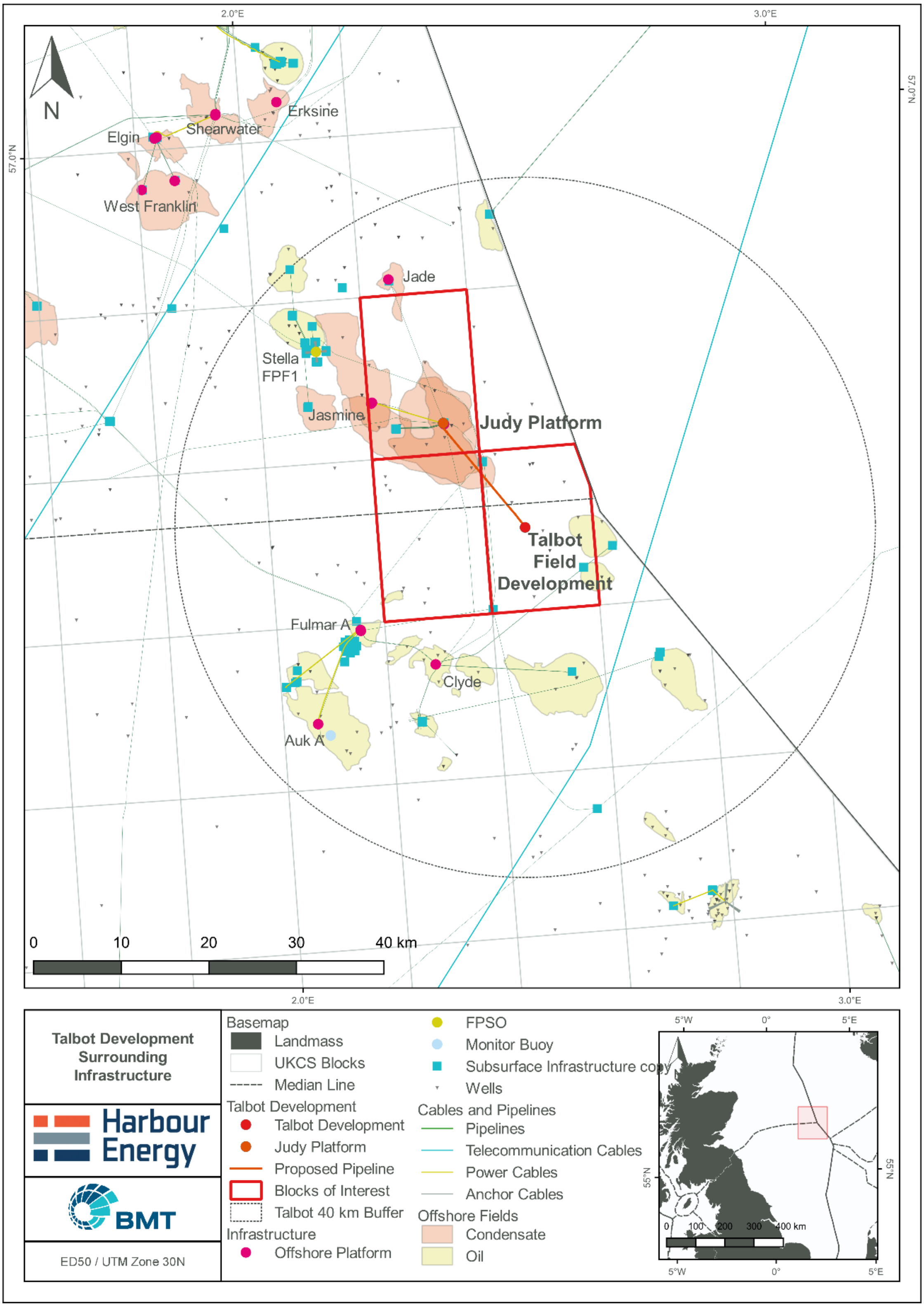
Within Block 30/13, there is the following infrastructure:

- 4 subsea infrastructure features;
- 13 wells; and
- 4 pipelines intersecting.

Further detail is provided in Table 4:12 and the locations of these structures in relation to the Talbot Field Development are shown in Figure 4:15.

Table 4:12 – Platforms and subsea infrastructures located within 40 km of the Talbot Field Development Project

Platform/ subsea structure	Distance (km)	Direction	Block	Operator	Status, as applicable
Platforms					
Judy	15	NW	30/7	Harbour	Active
Auk A	37	SW	30/16	Repsol Sinopec	Active
Clyde	19	SW	30/17	Repsol Sinopec	Active
Stella FPF1 (FPSO)	31	NW	30/6	Ithaca Energy	Active
Fulmar A	23	SW	30/16	Repsol Sinopec	Active
Fulmar AD	23	SW	30/16	Repsol Sinopec	Active
Jade	34	NW	30/2	Harbour	Active
Jasmine JLQ	24	NW	30/7	Harbour	Active
Jasmine Wellhead	24	NW	30/7	Harbour	Active
Judy JRP	15	NW	30/2	Harbour	Active
Wells					
A total of 487 wells	Up to 40 km	-	-	Numerous	-
Pipelines					
A total of 61 pipelines are found within 40 km of the Talbot Field Development Project. Pipelines found within the Talbot Field Development blocks include:					
Joanne Electro-Hydraulic Umbilical	15	NW	30/7	Harbour	Active
Jasmine to Judy Bundle	15	NW	30/7	Harbour	Active
Fulmar to Judy	10	SW	30/12	Repsol Sinopec	Active
Judy Oil Export	5	W	30/7	Harbour	Active
Jade to Judy	15	NW	30/7	Harbour	Active
Judy Export Pipeline	5	W	30/7 & 30/13	Harbour	Active
Janice Oil Export Flowline	10	SW	30/13	Total	Not in Use
Janice Gas Export Flowline	7	W	30/7 & 30/12	Total	Not in Use
Flyndre-Cawdor Production Pipe-In-Pine	8	SE	30/13	Total	Active
Joanne Production Pipeline	16	NW	30/7	Harbour	Active
Stella Oil Export Pipeline	5	W	30/13	Ithaca	Active
Joanne Test Pipeline	15	NW	30/7	Harbour	Active

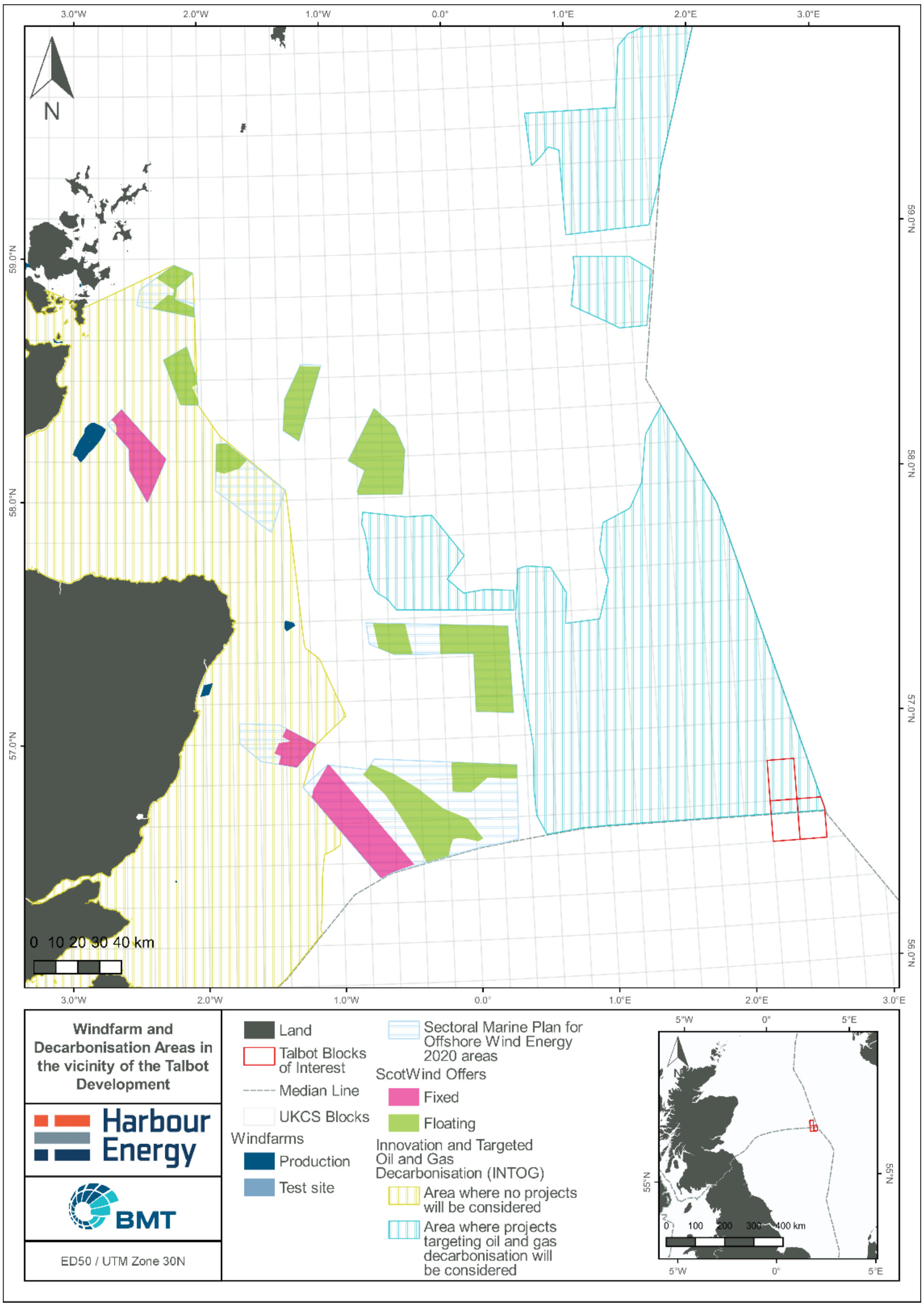


Source: NSTD (2022)

Figure 4:15 – Oil and gas installations 40 km from the Talbot Field Development area and further afield

4.5.3 Other Offshore Commercial Activities

There are no known aggregates or windfarm developments within 100 km of the Talbot Field Development Project (Figure 4:16). The closest offshore wind area in production is the Hywind Scotland Pilot Park, over 250 km west of Talbot Field Development. Future developments have been proposed, including a floating windfarm over 130 km west of the Talbot Field Development (Figure 4:16).



Source: NMPI (2022)

Figure 4:16 – Scottish Windfarms and Decarbonisation Areas in the Vicinity of the Talbot Field Development

Judy is within an area where projects targeting oil and gas decarbonisation will be considered under the Sectoral Marine Plan - Offshore Wind Innovation and Targeted Oil and Gas (INTOG), a leasing process for offshore wind farms to help decarbonise Scotland's oil and gas sector.

There are three saline aquifers (Balder, Forties and May) with potential as carbon dioxide storage sites in the Scottish Offshore Area overlapping the Talbot Field Development (NMPI, 2022).

4.5.4 Commercial Shipping

Commercial shipping density within Block 30/7 is classified as low, while for Blocks 30/13 and 30/12 are classified as having a very low shipping density (OGA, 2016).

Within 10 nm radius around Talbot Field Development commercial shipping can be categorised into two different types (BMT, 2019a; Figure 4:17):

- Main stream traffic - the movements of 'routine traffic' passed through the study area a clear travelled pattern (directional and centreline) and portray as a representative of traffic route; and
- Non-routine traffic - the movements of uncharacteristic traffic where vessel tracks are shown without any regular pattern; i.e., vessel passing back and forth or moving around in small region within the study area. These typically are fishing vessels, naval vessels, tugs, dredgers, yachts and offshore service vessels.

A dedicated vessel traffic survey of Talbot Field Development area (BMT, 2019a; Appendix A) identified an annual total of 262 main stream vessel movements within 10 nm of the proposed jack-up rig location at the Talbot Field Development, which corresponds to less than one passing vessel per day. The majority of this came from cargo vessel traffic (39%) and tanker traffic (33%), with the remaining traffic being comprised of fishing vessels (13%), construction vessels (5%) and other traffic (10%). A large seasonal variability occurs with main stream traffic in the vicinity of the Talbot site, peaking in June with 52 transits over the month in 2019, while the lowest month for traffic was recorded in March, with four vessels traversing the location. The main stream traffic flow occurs to the south and north of the Talbot Field Development, heading in a horizontal direction (Figure 4:17; BMT, 2019a).

For non-routine traffic, a total of 127 vessels were identified in the vicinity of the Talbot Field Development area over a 12-month period (BMT, 2019a; Appendix A). The general movements of fishing vessels are found to the south and southwest of the center point within the study area, while construction vessels occur particularly in the northeast of the Talbot Field Development location. Annual traffic volume along main routes around Talbot Field Development is summarized in Figure 4:18.

The probability of a vessel being on a collision course with the Project considering the installation of jack-up rig, i.e., risk of collision, has been calculated as a combination of three factors:

- Number of vessels within passing traffic streams;
- Geometric distribution of vessels within traffic streams; and
- Causation factor for the case where a vessel fails to take the correct avoidance action.

An annual ship collision frequency for Main Traffic Stream has been calculated at 5.8E-06, and annual ship collision frequency for Non-Routine Traffic has been calculated at 7.0E-07.

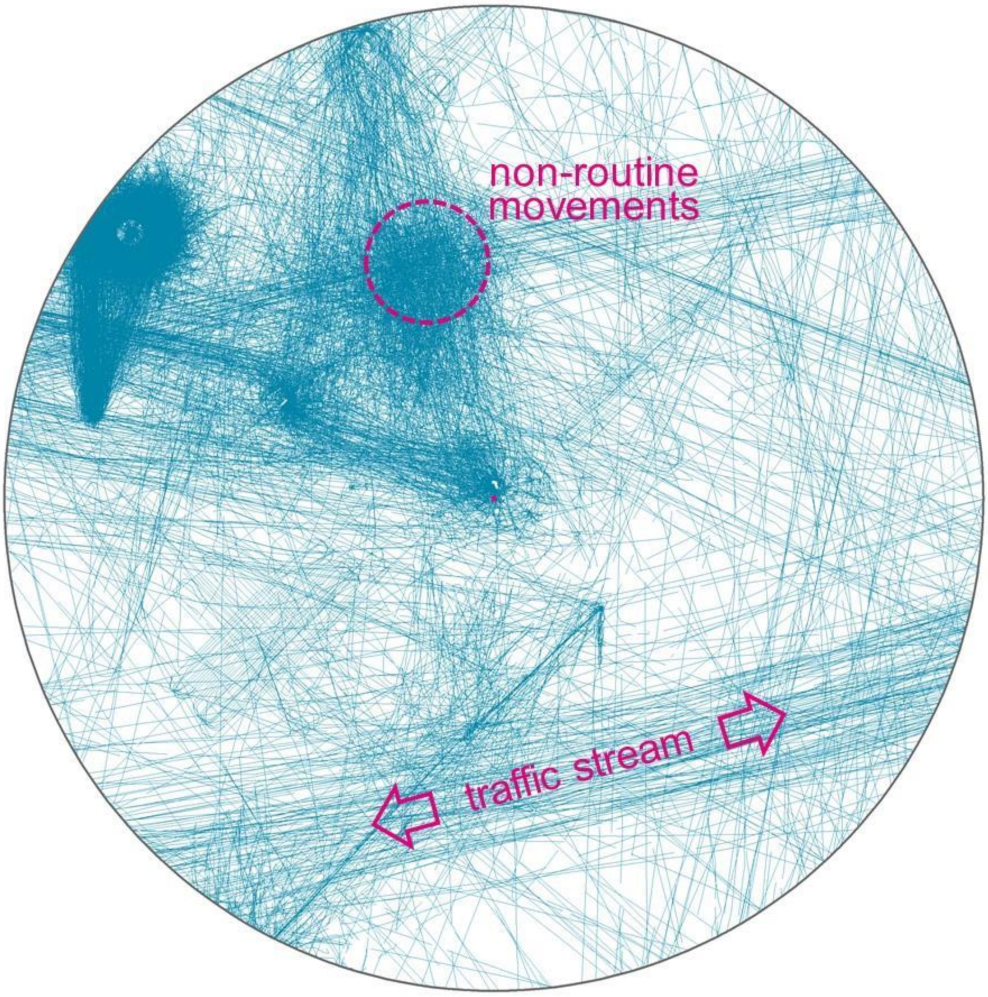


Figure 4:17 – Vessel traffic distribution (12 months of AIS Data) within 10 nm of Talbot Field Development Project

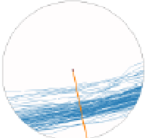
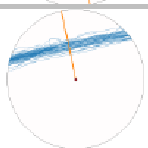
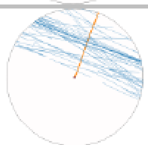
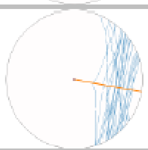
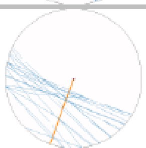
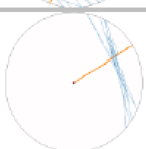
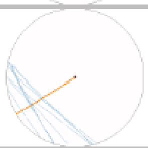
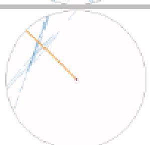
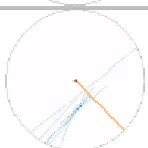
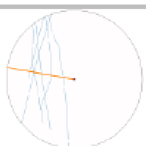
Vessel Tracks	Route No.	CPA (nm)	Ships Per Year	% of Total
	3.2	5.6	98	37%
	3.1	4.9	43	16%
	2.2	5.1	36	14%
	5.1	6.7	27	10%
	2.1	4.6	19	7%
	1.2	6.8	13	5%
	1.1	6.9	9	3%
	4.2	7.1	8	3%
	4.1	2.7	4	2%
	5.2	4.4	5	2%
	TOTAL		**262**	**100%**

Figure 4:18 – Annual traffic volume along traffic routes within 10 nm from Talbot Field Development Project

4.5.5 Military Activities

According to the Ministry of Defence (MoD) there are no licence conditions applied to Blocks 30/7, 30/12 or 30/13 and there are no military training areas within 100 km of the Talbot Field Development (NMPI, 2022).

4.5.6 Cables

Two telecommunication cables occur in the near vicinity of the Talbot Field Development (Figure 4:15). The TAMPNET Clyde telecommunication cable is located in Blocks 30/12 to Block 30/13, and the TAMPNET Valhall telecommunication cable is located approximately 9 km southeast of the Talbot Field Development (KIS-ORCA, 2019).

4.5.7 Wrecks

- There are three unknown wrecks within the proposed Talbot Field Development (NMPI, 2022). Two of the wrecks are located in Block 30/7 and one is located in Block 30/13. All the wrecks are classified as non-dangerous, and none is a designated wreck of historical significance (NMPI, 2022).

5 Identification of Potential Impacts

This section describes the environmental impact assessment approach to the proposed work programme for Talbot Field Development (Block 30/13e) and associated pipeline connection to the Judy platform (Blocks 30/13, 30/12 and 30/7), which has the potential to cause significant environmental impact. The approach described meets the requirements of The Offshore Oil and Gas Exploration, Production, Unloading and Storage (Environmental Impact Assessment) Regulations 2020 – A Guide (BEIS, 2021a).

Several potential environmental and socio-economic impacts from the activities associated with the Talbot Field Development have been identified, including physical disturbance to the seabed, discharges to the sea, impact to marine species and disruption to the activities of marine stakeholders. These impacts could emerge during the following aspects of the work scope:

- Drilling and well development;
- Installation of subsea infrastructure and pipeline connection to Judy Platform;
- Production/ operations activities; and
- Projected decommissioning at end-of-life.

The EIA guidelines (BEIS, 2021a) advises that the significance of all impacts should be assessed relative to appropriate national and international quality standards. Where relevant standards do not exist, the ES should describe the judgments (assumptions and value systems) that underpin the attribution of significance. The guidance then goes on to emphasise that the "assessment of significance should consider the deviation from the established baseline, the sensitivity of the environment and the extent to which the impact will be mitigated or is reversible. The range of factors which are likely to influence the assessment of significance should be clearly identified, and consideration given to how relevant variables will affect the significance of the impacts over the life of the development and any that will remain following mitigation".

An assessment of the significance of the risks posed to environmental and societal receptors as a result of Talbot Field Development are examined in relation to planned/ unplanned operations and accidental events. The risk assessment process also included discussions on site specific, transboundary and cumulative impacts, where appropriate.

The Environmental (Risk) Identification (ENVID) workshop (BMT, 2022a; Appendix B), as discussed in Section 1, had the following objectives:

- To ensure that the project team was aware of the main environmental sensitivities within the sphere of influence of Talbot Field Development;
- Apply a suitable and systematic approach to the identification of environmental, social and community health risks associated with the development;
- Identify the risks/ effects associated with the various project activities and aspects of the field development, which may lead to an environmental, societal or community health impact;
- Based on the environmental sensitivities for the proposed development area, identify the receptors that may be affected by the activity;
- Identify potential mitigation measurements or best available techniques (BAT);
- Consider what project controls are within the project design that mitigates these risks/ effects to acceptable levels;
- Score the potential risk/ effect following mitigation;
- Determine whether additional mitigation is required to reduce those risks/ effects to as low as reasonably practicable (ALARP)/ BAT; Identify any additional data requirements/ actions to be carried out and the responsible party; and

- Carry forward any environmental, social and community health risks for the development programme which have the potential to be significant.

5.1 Risk Assessment Methodology

The ENVID process required identifying and splitting the interactions between environmental receptors and the main activities of the field development plan into individual sub-operations. For planned operations and accidental events, the potential risks to the environmental receptors from all relevant project activities were scored using an environmental risk assessment matrix, which combines likelihood of activities against their potential consequence of environmental impact (severity) based on the criteria defined below (BMT, 2022a; Appendix B). The potential risk to the receptor is assessed during the ENVID after consideration of prevention, control and mitigation measures resulting in what is often referred to as a residual impact.

For each activity, a risk rating was calculated in order to determine whether the project impact was potentially significant. The risk rating was calculated as:

Risk Rating = Consequence x Likelihood

The ENVID risk matrix and definitions of likelihood and consequence/ severity for planned operations and accidental events are presented in Table 5:1, Table 5:2 and Table 5:3.

Table 5:1 – Risk Assessment Matrix

		Consequence/ Severity				
		Negligible (1)*	Minor (2)	Moderate (3)	Significant (4)	Catastrophic (5)
Likelihood	Frequent (5)*	Medium Risk (5)**	Significant Risk (10)	High Risk (15)	High Risk (20)	High Risk (25)
	Probable (4)	Low Risk (4)	Medium Risk (8)	Significant Risk (12)	High Risk (16)	High Risk (20)
	Occasional (3)	Low Risk (3)	Medium Risk (6)	Medium Risk (9)	Significant Risk (12)	High Risk (15)
	Remote (2)	Low Risk (2)	Low Risk (4)	Medium Risk (6)	Medium Risk (8)	Significant Risk (10)
	Improbable (1)	Low Risk (1)	Low Risk (2)	Low Risk (3)	Low Risk (4)	Medium Risk (5)

*Values assigned for each category; **Scores for assigned risk

Table 5:2 – Harbour Guidelines for Impact Likelihood/ Sensitivity for Unplanned and Planned Events

Likelihood	Definition
Frequent (5)	• Impact is virtually certain; 90-100% probability • Occurs multiple times per year within Harbour business unit
Probable (4)	• Impact is likely; 66-90% probability • Occurred within Harbour business unit or more than once per year within Harbour
Occasional (3)	• Impact is possible; ~33-66% probability • Occurred within Harbour or more than once per year within the oil and gas industry
Remote (2)	• Impact is remote; 10-33% probability • Occurred or has been heard of within the oil and gas industry
Improbable (1)	• Impact is improbable or very unlikely (e.g., accidental); ~0-10% probability • Virtually unrealistic, never heard of in the oil and gas industry

Table 5:3 – Harbour Impact Consequence/ Severity or Magnitude Guideline

	Consequence/ Severity				
	1	2	3	4	5
Environmental Impact	• Negligible environmental impact • Small contained release that stays on site	• Minor environmental impact • Onshore release limited to facility and adjacent area • Offshore release mitigated through natural processes	• Moderate environmental impact • Release affects surrounding area and impacts flora/ fauna • Localised surface contamination	• Major environmental impact • Release affects large offsite area including sensitive habitats • Widespread surface/ contamination	• High environmental impact • Catastrophic release impacting sensitive ecosystems, drinking water supplies, fishing and/ or recreational areas
Societal Impact	• No restriction on access and no impact on operations • Negligible impact to/ from key stakeholders • Issue resolved quickly	• Brief restriction on access and minor impact to operations • Minor impact to/ from key stakeholders • Issue resolved in a minimum amount of time	• Temporary restriction on access and moderate impact to operations • Moderate impact to/ from key stakeholders • Issue resolved in a moderate amount of time	• Permanent partial restriction on access and major impact to operations • Major impact to/ from key stakeholders • Issue will take a significant amount of time to resolve	• Extended permanent loss of access and loss of operations • Severe impact to/ from key stakeholders requiring executive level involvement • Damage is permanent
Biodiversity Impact	• Limited extent/ • Negligible impacts an ecological community type that is apparently secure • Does not impact a species of special concern or a high-profile species • Does not impact an area of importance for the provision of ecosystem services • Some minor loss/ migration of habitat or species that are short term and immediately and completely reversible	• Local extent/ Low • Impacts a species of special concern or a high profile species at the local scale (i.e., Asset Team or project) • Within an ecological community type that is vulnerable at the local scale • Impacts areas of local significance for provision of ecosystem services • Brief, but reversible loss/ migration of habitat or species ecosystem. Minor mitigation efforts required for total reversal	• Regional extent/ Medium • Impacts a species of special concern or a high profile species at the regional scale (i.e., Business Unit) • Within regionally unique habitat or habitat that supports seasonal concentrations of species • Impacts regionally important areas that provide ecosystem services • Temporary, but reversible loss/migration of species population, habitat or ecosystem. Moderate mitigation efforts required for total reversal	• National extent/ High • Impacts a Nationally listed endangered or threatened species • Within an ecological community type that is critically imperilled or imperilled at the national scale • Within an IUCN category I-VI National or regional protected area • Within a designated national conservation area • Serious loss or migration of species population, habitat or ecosystem. Partial mitigation only possible through prolonged and resource intensive effort (>50 years)	• International extent/ Very high • Impacts an internationally (e.g., IUCN Red List), or federally listed endangered or threatened species • Within an ecological community type that is critically imperilled or imperilled at the global or national scale • Within an IUCN category I-IV federal protected area • Within a UNESCO World Heritage Site, Ramsar Site, or Important Bird Area • Catastrophic permanent loss/ extinction of species, habitat or ecosystem. Irrevocable loss, no mitigation possible

The outcome from the ENVID for the proposed project's planned and unplanned activities are summarised in Table 5:4. All project impacts determined to be Medium (■), Significant (■) and High (■) are potentially significant, requiring further assessment with the EIA and mitigation, where appropriate. Project impacts determined to be Low (■) indicate a potential risk but associated impacts were deemed to be insignificant, requiring no further impact assessment.

Table 5:4 – Summary of the number of risk categories associated with activities at the Talbot Field Development

Activities	Risk categories							
	Low		Medium		Significant		High	
	Planned operations	Unplanned operations	Planned operations	Unplanned operations	Planned operations	Unplanned operations	Planned operations	Unplanned operations
Drilling and well development	9	0	6	3	0	1	0	0
Installation of subsea infrastructure & connection to Judy platform	6	0	5	3	1	0	0	0
Production/ operations activities	6	1	3	2	0	1	0	0
Decommissioning	7	0	6	2	0	1	0	0

5.2 Summary of Key Interactions

Throughout the ENVID process, several environmental interactions associated with the Talbot project were found to have potentially significant impacts, while several activities were identified as having low impact but require further assessment due to associated regulatory issues and/ or stakeholder concerns. All potential impacts requiring further assessment are summarised in Table 5:5 below, including physical presence, discharges to sea, underwater noise, emissions, hydrocarbon spills and accidental events.

Potential impacts associated with decommissioning were also assessed during the ENVID workshop (BMT, 2022a; Appendix B). The following activities were identified as being significant or requiring further investigation due to regulatory issues and/ or stakeholder concerns:

- Physical presence of vessels and other types of transport;
- Localised disturbance to the seabed arising from the installation and drilling activities;
- Discharge of pipeline contents to the marine environment during pipeline installation and commissioning;
- Atmospheric emissions arising from the installation, drilling and production activities;
- Underwater noise;
- Physical presence of the subsea infrastructure (incl. stabilisation materials) on the seabed;
- Hydrocarbon spill from vessels and rigs;
- Objects dropped into the sea;
- Well blow-out of oil and gas; and
- Localised disturbance to the seabed during future decommissioning activities.

Harbour Energy

Table 5:5 – Summary of environmental and socioeconomic sensitivities in the vicinity of the Talbot Field Development

Risk: High (red); Significant (orange); Medium (yellow); Low (green)

Activity	Physical and chemical: Sediment structure/ chemistry	Physical and chemical: Water quality	Physical and chemical: Emissions	Biological: Sediment biology (benthos)	Biological: Water column (plankton)	Biological: Finfish and shellfish	Biological: Seabirds	Biological: Sea mammals	Biological: Conservation sites	Biological: Biodiversity	Socio-economic: Use of resources	Socio-economic: Use of disposal facilities	Socio-economic: Commercial fishing	Socio-economic: Shipping	Socio-economic: Military operations	Socio-economic: Other users	Socio-economic: Trans-boundary effects	Socio-economic: Stakeholder concerns	Overall significance (Risk)	Section Reference
Drilling and well development																				
Planned events																				
Physical presence of drilling rig and vessels													√	√		√			9	Section 11
Spudding of jack-up rig	√			√		√			√				√						6	Section 6
Gaseous emissions from drilling rig and vessels			√															√	8	Section 8
Aqueous discharges from drilling rig		√			√	√	√	√	√										6	Section 7
Permitted discharge of WBM cuttings	√	√		√	√	√			√	√								√	6	Section 7
Skip and ship of LTOBM cuttings			√								√	√				√		√	2	Sections 8 and 11
On-site cuttings processing and disposal	√	√	√	√	√	√			√	√								√	6	Sections 6 and 7
Cement discharge	√			√		√			√										4	Section 7
Underwater noise from drilling and vessels						√		√										√	2	Section 9
Transport, helicopters			√					√			√					√		√	4	Sections 8 and 9
Accidental/ Unplanned Events																				
Well blow-out of oil and gas		√	√		√	√	√	√	√	√		√	√	√		√	√	√	10	Section 10
Hydrocarbon spill, e.g., from vessel collision		√	√		√	√	√	√	√	√		√	√	√		√	√	√	9	Section 10
Spills of chemicals, muds and emergency cement discharge	√	√		√	√	√	√	√	√	√			√				√	√	8	Section 10
Objects dropped into the sea	√			√		√							√	√		√		√	6	Section 6
Installation of subsea infrastructure & connection to Judy platform																				
Planned events																				
Vessels																				
Physical presence of vessels													√	√		√			9	Section 11
Gaseous emissions from vessels			√															√	8	Section 8
Underwater noise from pipelaying and support vessels						√	√	√										√	4	Section 9
Pipeline, umbilical, flowlines and power cables																				
Pipeline and umbilical lay operations	√	√	√	√		√			√	√	√		√					√	4	Sections 6 and 11
Trenching and backfill	√	√	√	√		√			√	√			√					√	6	Sections 6 and 11
Rock placement along pipelines	√		√	√		√			√	√			√					√	9	Sections 6 and 11
Testing and commissioning of pipelines	√	√		√	√	√	√	√	√									√	3	Section 7

Activity	Environmental and Societal Receptors/ Activities																		Overall significance (Risk)	Section Reference
Risk: High (red); Significant (orange); Medium (yellow); Low (green)	Physical and chemical			Biological							Socio-economic									
	Sediment structure/ chemistry	Water quality	Emissions	Sediment biology (benthos)	Water column (plankton)	Finfish and shellfish	Seabirds	Sea mammals	Conservation sites	Biodiversity	Use of resources	Use of disposal facilities	Commercial fishing	Shipping	Military operations	Other users	Trans-boundary effects	Stakeholder concerns		
Crossings, installation of rock, concrete mattresses and plinths	✓		✓	✓		✓			✓	✓	✓		✓			✓		✓	9	Sections 6 and 11
Installation of protective materials, concrete mattresses and grout bags	✓		✓	✓		✓			✓	✓	✓		✓					✓	4	Sections 6 and 11
Manifold and skids																				
Installation on the seabed	✓		✓	✓		✓			✓	✓			✓			✓		✓	4	Sections 6 and 11
Underwater noise from piling operations			✓			✓	✓	✓			✓							✓	12	Section 9
Accidental/ Unplanned Events																				
Pipeline leak or rupture (third party) during pipelay and trenching operations	✓	✓		✓	✓	✓	✓	✓	✓	✓			✓			✓	✓	✓	8	Section 10
Hydrocarbon spill, e.g., from vessel collision		✓	✓		✓	✓	✓	✓	✓	✓		✓	✓	✓		✓	✓	✓	9	Section 10
Spills of chemicals, muds and emergency cement discharge	✓	✓		✓	✓	✓	✓	✓	✓	✓			✓				✓	✓	8	Section 10
Production/ Operations																				
Planned events																				
Wells and pipelines																				
Physical presence of trees and manifold	✓			✓		✓							✓						4	Sections 6 and 11
Production																				
Power generation			✓														✓	✓	6	Section 8
Gaseous emissions from platform (incl. flaring and venting)			✓														✓	✓	8	Section 8
Produced water management		✓			✓	✓		✓	✓	✓								✓	3	Section 7
Accidental/ Unplanned Events																				
Uncontrolled loss of well integrity		✓	✓		✓	✓	✓	✓	✓	✓		✓	✓	✓		✓	✓	✓	10	Section 10
Pipeline leak/ rupture leading to a hydrocarbon spill	✓	✓		✓	✓	✓	✓	✓	✓	✓			✓			✓	✓	✓	8	Section 10

5.3 Project Aspects Identified for Further Assessment

The most significant project aspects associated with the proposed operations during Talbot Field Development were identified from the results of the ENVID workshop described in Section 5.2 and the issues raised during the informal consultation process outlined in Section 1.6.1.

The key items associated with this project are addressed under the following headings:

- Seabed Impacts (Section 6);
- Drilling and Production Discharges (Section 7);
- Atmospheric Emissions (Section 8);
- Underwater Noise (Section 9);
- Accidental Events (Section 10); and
- Societal Impacts (Section 11).

In line with the requirements of the Offshore Oil and Gas Exploration, Production, Unloading and Storage (Environmental Impact Assessment) Regulations 2020, potential cumulative and transboundary impacts derived from this project have also been assessed and are discussed in the individual impact sections.

Cumulative and in-combination impacts are those from activities or events which may not produce a significant impact individually; however, when combined with impacts arising from different sources that may have overlapping spheres of influence to the activities and events under consideration, they may produce potentially significant impacts. The assessment should also consider the impacts of other existing, consented or planned activities in the development area, and determine whether there are likely to be any significant in-combination or cumulative impacts.

Transboundary impacts comprise any potential environmental impacts on the seabed, water column and/ or atmosphere that extend beyond the boundaries of the United Kingdom continental shelf.

6 Seabed Impacts

This section discusses the potential short- and long-term environmental impacts associated with seabed disturbance as a result of the activities proposed in the Talbot Field Development. The following activities were identified during the ENVID (BMT, 2022a; Appendix B) and risk assessment process (Section 5) as having a medium risk to the environment:

- Anchoring and mooring of jack-up drilling rig;
- Spudding of jack-up rig;
- Pipelay and trenching;
- Rock placement along pipeline and crossings;
- Installing/ removing protective material at pipeline ends and crossings;
- Installation/ removal of manifold and drilling template on the seabed;
- Installation of SSIV;
- Presence of infrastructure on seabed;
- Presence of cuttings piles; and
- Dropped objects.

The seabed also has the potential to be impacted by activities resulting in planned discharges, e.g., discharge of cuttings or cement, and hydrocarbon releases or dropped objects; these are assessed fully in Sections 7 (Drilling and Production Discharges) and 10 (Accidental Events).

6.1 Regulatory Context

Seabed impacts resulting from the proposed Talbot Field Development will be managed in accordance with current legislation and standards as detailed in Section 1.

6.2 Approach

The Talbot Field Development infrastructure with the potential to result in direct seabed impacts includes:

- Anchoring of the jack-up drilling rig;
- Presence of the jack-up drilling rig;
- Subsea manifold structure;
- A drilling template; and
- Subsea pipelines.

Further detail on these items and other aspects of the Talbot Field Development relevant to the ES are presented in Section 3. The short and long-term environmental impacts associated with seabed disturbance during the proposed Talbot Field Development activities are summarised in Table 6:1. Short-term impacts can be defined as those which have transient impacts lasting a few days to a few years. Long-term impacts are those which will continue to have an impact lasting for tens of years or greater. Following Cessation of Production (COP), the decommissioning of the subsea infrastructures will also result in disturbances to the seabed. Such an impact is likely to be temporary in nature and will be assessed in the future decommissioning Environmental Appraisal.

Table 6:1 – Summary of potential sources of seabed disturbance and resultant environmental impacts during the Talbot Field Development activities

Activity outcome	Seabed sediment environmental impact	
	Burial and smothering	Change in habitat
Anchoring and mooring of jack-up drilling rig	Short-term	-
Spudding of the jack-up drilling rig	Short-term	-
Installation of seabed infrastructure	Short-term	-
Presence of seabed infrastructure	Long-term	Long-term
Rock placement over pipelines	Long-term	Long-term
Installation of protection material at pipeline ends and crossings	Long-term	Long-term
Cuttings pile(s)	Long-term	Long-term
Dropped objects	Short-term	Short-term

Note: It is not considered that any of the outcomes will result in a contaminant release on the seabed. Long-term relates to the period for which the item will be in place on the seabed.

In order to encompass a maximum seabed disturbance, a worst-case scenario is considered when there is uncertainty in the method(s) to be used. The assumptions and associated justification and rationale are presented in the sections below. A number of worst-case assumptions have been made to determine the maximum impact, for example it has been assumed that the area of seabed impacted by the infrastructure and stabilisation features to be installed do not overlap. In addition, worst-case volume of rock placement will be assumed.

6.3 Sources of Potential Disturbance

Direct physical disturbance to the seabed as a result of the Talbot Field Development will primarily remain localised to the activities being undertaken and is discussed in the following sections. Indirect impacts to the seabed from sediment re-suspension are also discussed and any such impact is expected to be short-term.

6.3.1 Locating of the Jack-Up Rig

Three AHVs will be used to tow the rig onto location, at which point four mooring anchors will be deployed to the seabed with a radius of approximately 650 m around the rig. The rig will use the anchors to position itself into the final position, pre-load and jack-up, whereupon the anchors will be recovered. Each anchor will weigh 6.5 tonnes and have a shank size of 3.2 m and a fluke width of 2 m. The mooring lines will be a combination of chain and wire segments. The chain segment will be 200 x 0.076 m and the spiral strand wire will be 450 x 0.060 m. Seabed contact along this length is assumed to be one-third of the total length of the line; however, in reality large sections of the overall mooring lines' lengths will be suspended in the water column. The mooring lines and anchors may be subject to lateral movement, potentially 2 m either side of the anchor or anchor chain as a worst-case (Hartley Anderson, 2001).

The HDJU drilling rig will 'jack-up' onto the seabed, with each of its three legs terminating in a spud can with an area of 260 m^2. As a result, the three spud cans will disturb an area of 780 m^2 at the drill centre (0.00078 km^2).

Table 6:2 – Summary of the estimated seabed footprint from anchoring activities at the Talbot Field Development

Activity	Dimensions (km)	Footprint area (km^2)	Footprint within Fulmar MCZ (km^2)
Impact of anchors during rig mooring	4 x 0.0072 x 0.006	0.000173	0.000173
Impact of mooring chains and lines during rig mooring	4 x 0.217 x 0.004	0.003472	0.003472
Impact of spud-cans at the drill centre	1 x 3 x 0.000260	0.000780	0.000780
Total area of seabed disturbance during anchoring/ mooring activities		**0.004425**	**0.004425**

6.3.2 Pipelay, Trenching and Protection Materials

The 16 km 12"/18" production flowline (457 mm outer diameter) is proposed to be reel laid and trenched by mechanical plough. The umbilical (180 mm outer diameter) is proposed to be laid in the same trench as the production flowline and a mechanical backfill plough will be used to cover both lines. The trench is proposed to be between 1.5-1.8 m deep, with a maximum target trench depth of 1.8 m. This is to ensure a coverage depth range of a minimum 0.7 m. It is expected that the maximum width of the trench will be up to four times the combined width of the pipeline and umbilical (3.5 m), with a corridor of impact estimated at 4 m either side of the pipeline, over which trenched material will be placed before backfilling. The total area of seabed impacted by pipelay is therefore expected to be 0.185 km^2 (Table 6:3). Approximately 3.6 km of the pipeline length (22.5%) will be located within the Fulmar MCZ.

Tie-in to the existing south pipeline (PL1000) is currently being considered for the subsea pipeline tie-in within the 500 m exclusion zone at the Judy Platform. The tie-in method would require access to the existing 12" production pipeline (PL1000) from the Joanne manifold, necessitating the excavation of seabed to reach the pipeline (Figure 6:1). It is estimated that 730 m^3 of seabed will be excavated to access the pipeline to install the MORGRIP® Tie-In. Estimations of excavated seabed required two calculations due to the varying depths of the pipelines, down to a maximum depth of 1.30 m and minimum depth of 1.10 m. It is estimated that these operations will impact 0.000638 km^2 of the seabed in the vicinity of the Judy Platform. The excavated area will be either backfilled with loose rock or naturally backfilled.

Rock placement and other protection material comprising concrete mattresses and grout bags will be used for seabed protection at trench transitions and at crossing points. Concrete plinths may also be used at crossing points. A schematic of the rock and mattress placement within the Talbot Field Development is shown from Figure 6:2 to Figure 6:6. In addition to the crossing points and trench transitions shown, rock placement will be required to protect areas where the pipeline becomes exposed, and at risk of buckling. As discussed above, the pipe will be laid and trench at a target depth of 1.8 m to minimise the risk of this occurring. Nevertheless, where minimal depth of burial of 0.7 m is not achieved rock will need to be placed at these points to protect the pipe. Allowance for four areas of potential upheaval buckling has been made. For the purposes of risk assessment, it is assumed that these areas will average 300 m in length and a total of 37,706 tonnes of rock has been set aside to protect these potentially exposed sections. The volumes of rock detailed in Table 6:4 are worst-case estimates. It is Harbour's intention to minimise use of rock as far as possible, to reduce loss of habitat resulting from installation activities.

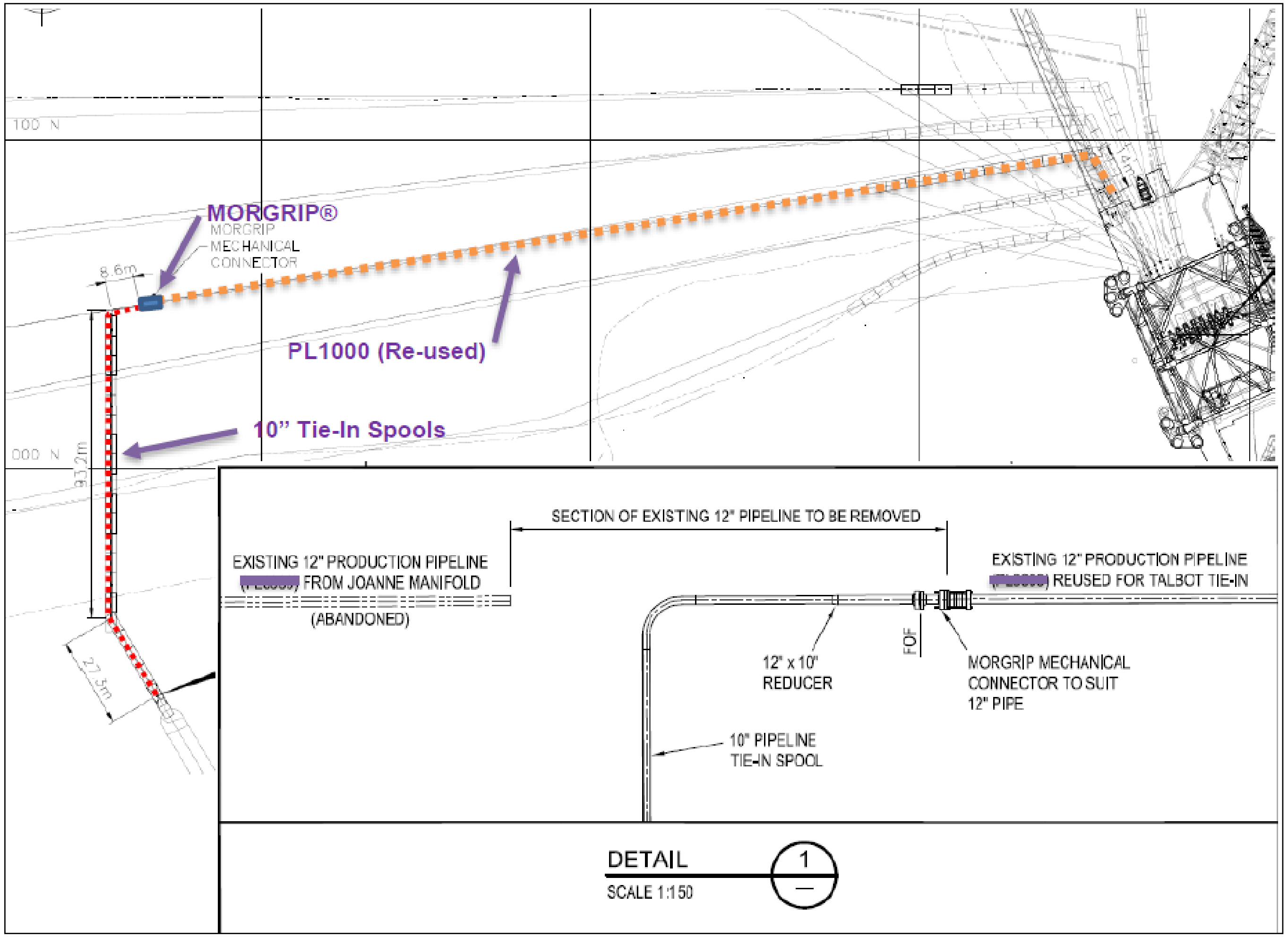


Figure 6:1 – MORGRIP® Tie-In to the south pipeline (PL1000)

Table 6:3 – Summary of the estimated seabed footprint from anchoring activities at the Talbot Field Development

Infrastructure	Dimensions	Seabed Impact (km^2)	Footprint within Fulmar MCZ (km^2)
Pipeline and Umbilical Trench	c. 16 km x 0.0035 km (width of trench)	0.056000*	0.012600
Area impacted on each side of trench	c. 16 km x (2 x 0.004 km)	0.128000	0.028800
Area impacted for tie-in to PL1000	c. 0.058 km x 0.011 km	0.000638	0.000000
Total		**0.184638**	**0.041400**

*Note: Seabed impact of Pipe-in-Pipe (PIP) pipeline and umbilical are included in the width of the trench.

Currently, there is also the intent to use grout bags and a small number of concrete mattresses for protection and stabilisation of the pipeline at crossing locations. The intention is to separate existing buried pipeline and new flexible flowlines/ umbilicals along each corridor or rigid pipeline (depending on location), using concrete mattresses. These would be pre-installed prior to lay of the pipelines, which would be laid over the mattresses. Following installation, rock placement would be installed over the length of the line over the crossing location. This type of arrangement has been previously used for maintaining minimum separation between the lines. Concrete mattresses are proposed be installed at the following locations:

- Crossings over existing pipelines and cables, of which there are five;
- Trench transitions and pipeline ends; and
- Along sections of spools or umbilical which are not buried and require dropped object protection.

The current intent is to install up to 355 concrete mattresses (6 m x 3 m) and 4 plinths (8 m x 1.5 m) within the Talbot Field Development. Up to 1,040 grout bags (0.5 m x 0.3 m) may also be deployed (see Table 3:10). These will be placed at crossing points along the pipeline route and within the Judy 500 m zones. The combined seabed impact will be 6,594 m^2 (0.006594 km^2).

Table 6:4 – Summary of the estimated seabed footprint resulting from rock placement at the Talbot Field Development

Project Reference	Pipeline length (km)	Rock placement corridor width at widest point (km)	Weight of rock placement (Te)	Seabed Impact (km^2)	Footprint within Fulmar MCZ (km^2)
Talbot 500 m Zone transition	0.05	0.005	655	0.000250	0.000250
Judy 500 m Zone Trench Transition	0.05	0.005	655	0.000250	0.000000
Combined Fibre Optic Cable and 12” Janice Crossing	0.217	0.005	11,083	0.001085	0.000000
	0.033	0.013		0.000429	0.000000
Combined 16” Gannet, 24” Judy & 10” Stella Crossing	0.217	0.005	67,910	0.001085	0.000000
	0.12	0.018		0.002160	0.000000
Spot Placement along main route	0.125	0.005	37,706	0.000625	0.000141
Total area of seabed disturbance from rock placement			**118,009**	**0.005884**	**0.000391**

Table 6:5 - Summary of seabed footprint resulting from mattresses and grout bags placed at Talbot Field Development

Protective materials*	Dimensions	Seabed Impact (km^2)	Impact within Fulmar MCZ (km^2)
Mattresses	355 x (0.006 km x 0.003 km)	0.006390	0.002574
Plinths	4 x (0.008 km x 0.0015 km)	0.000048	0.000000
Grout bags	1,040 x (0.0005 km x 0.0003 km)	0.000156	0.000090
Total		**0.006594**	**0.002664**

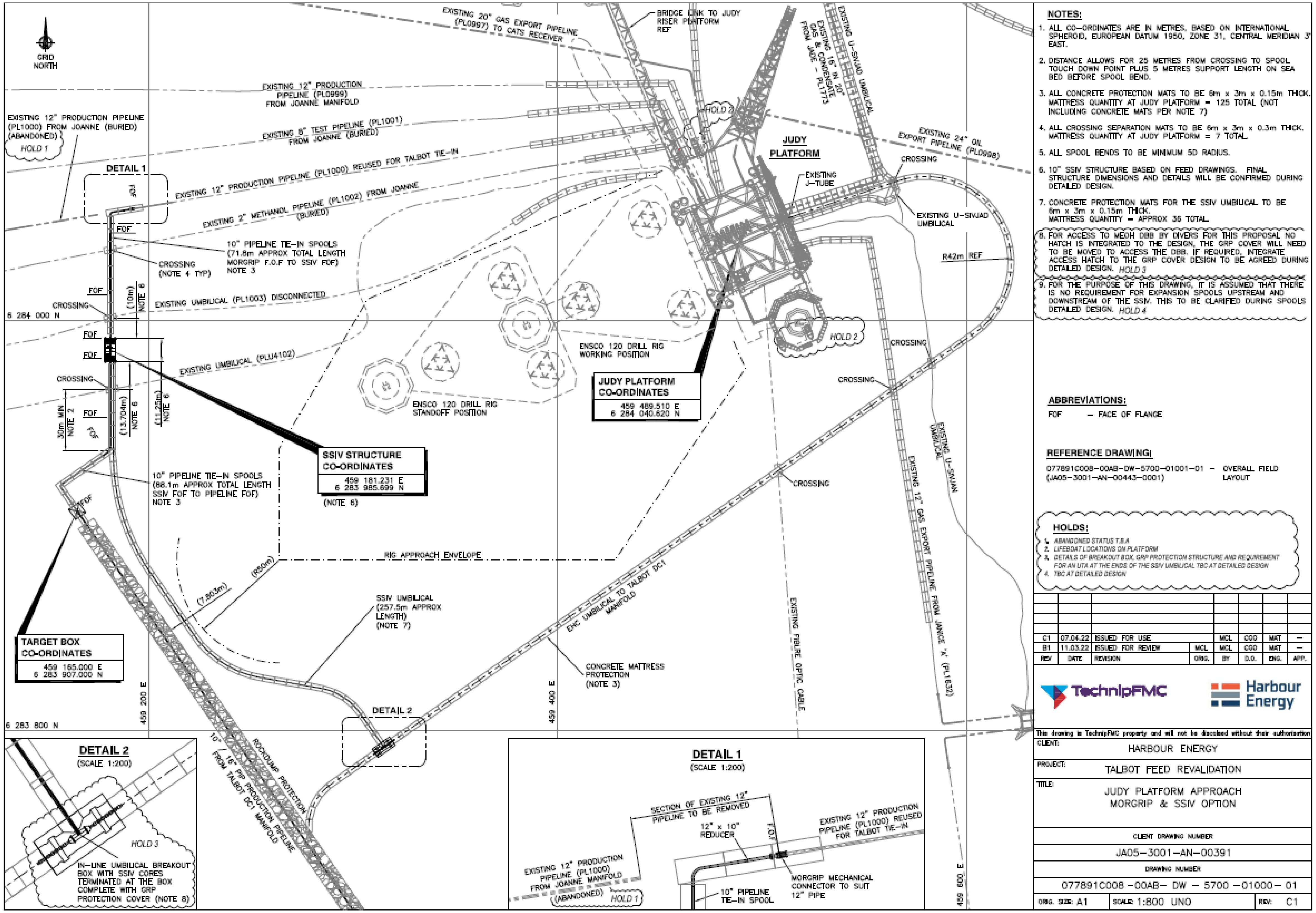


Figure 6:2 – Schematic of Judy approach showing location of rock placement and mattress protection

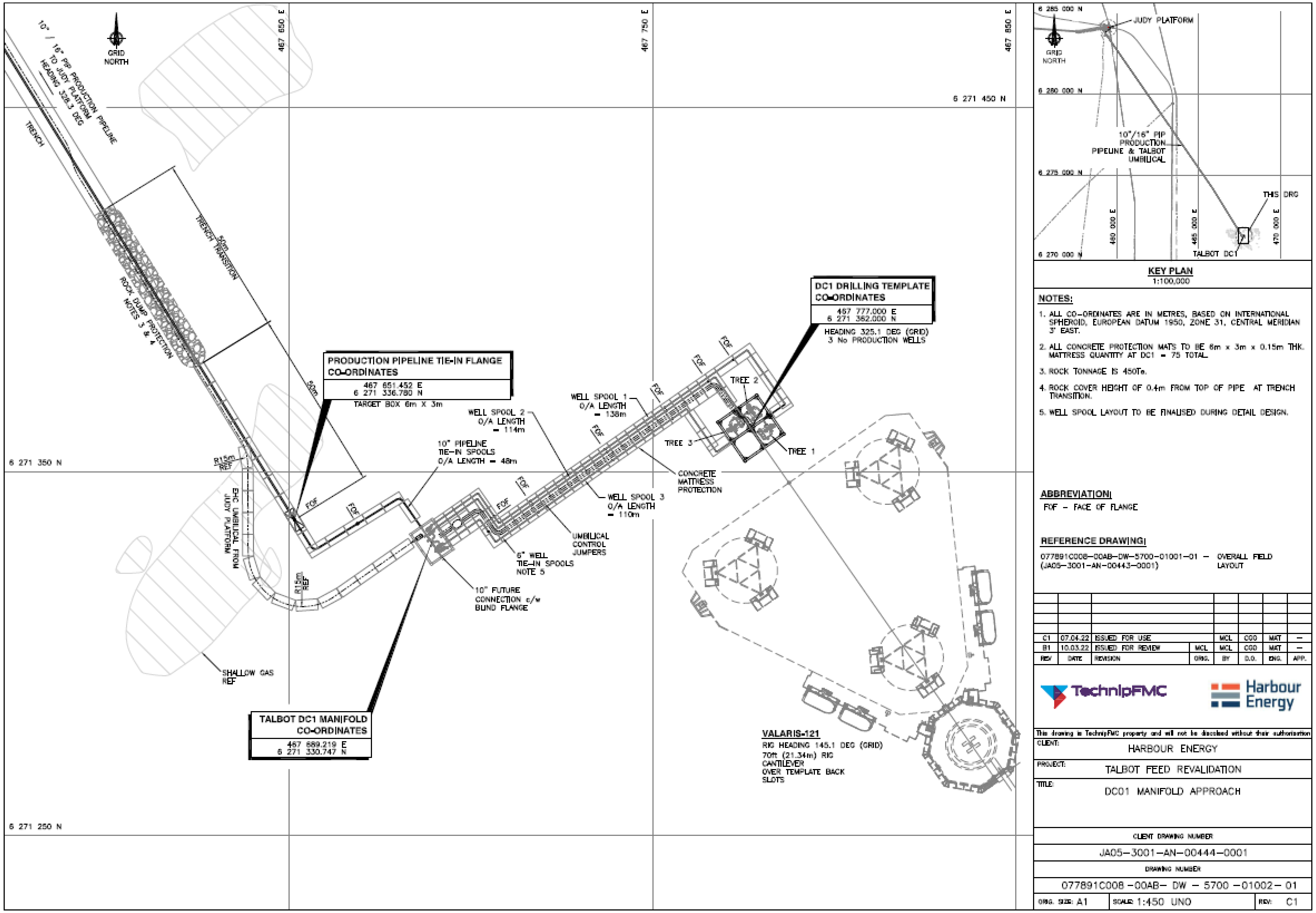


Figure 6:3 – Schematic of the drill centre showing location of rock placement and mattress protection

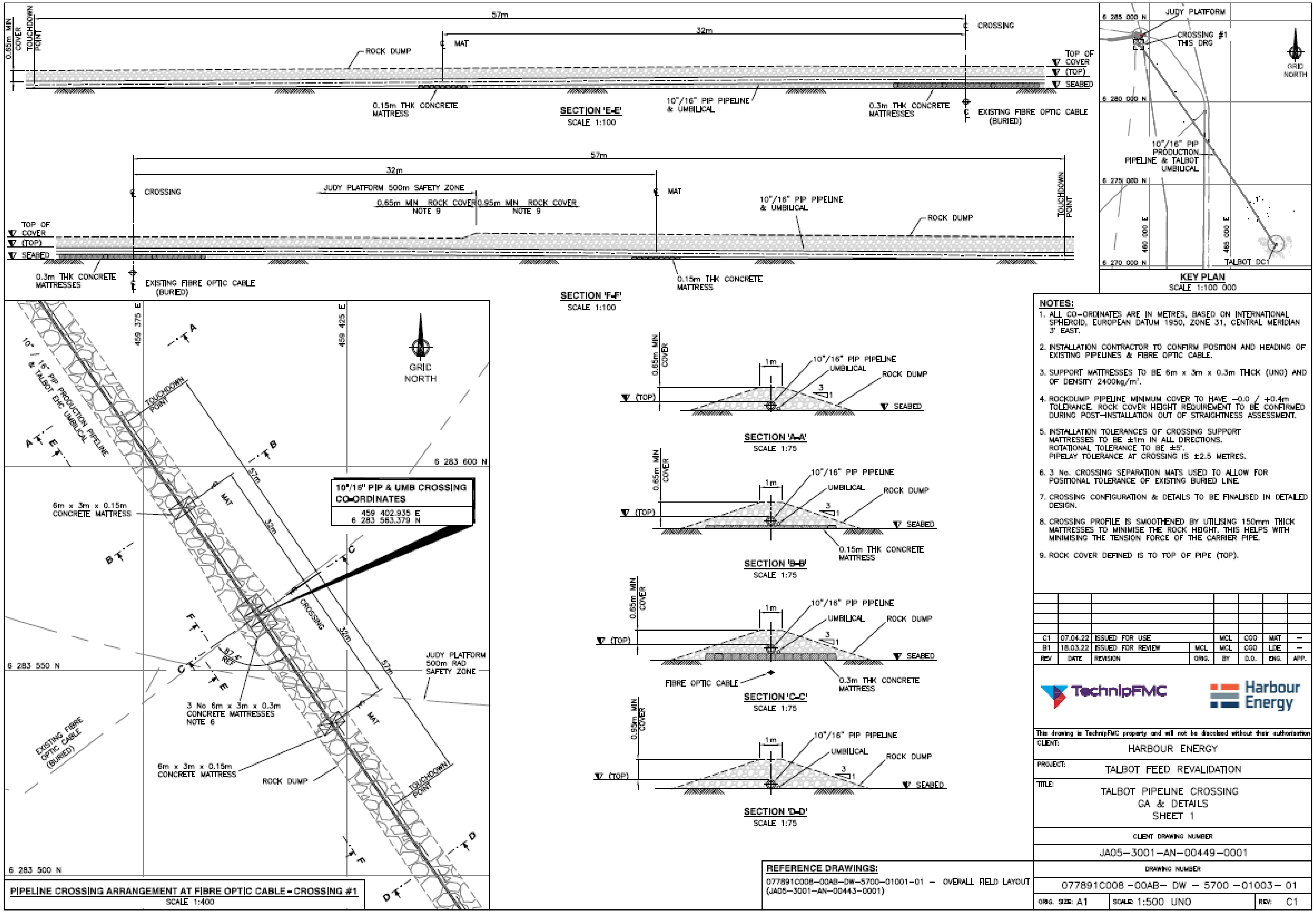


Figure 6:4 – Schematic of Pipeline Crossing Point 1 showing location of rock placement and mattress protection

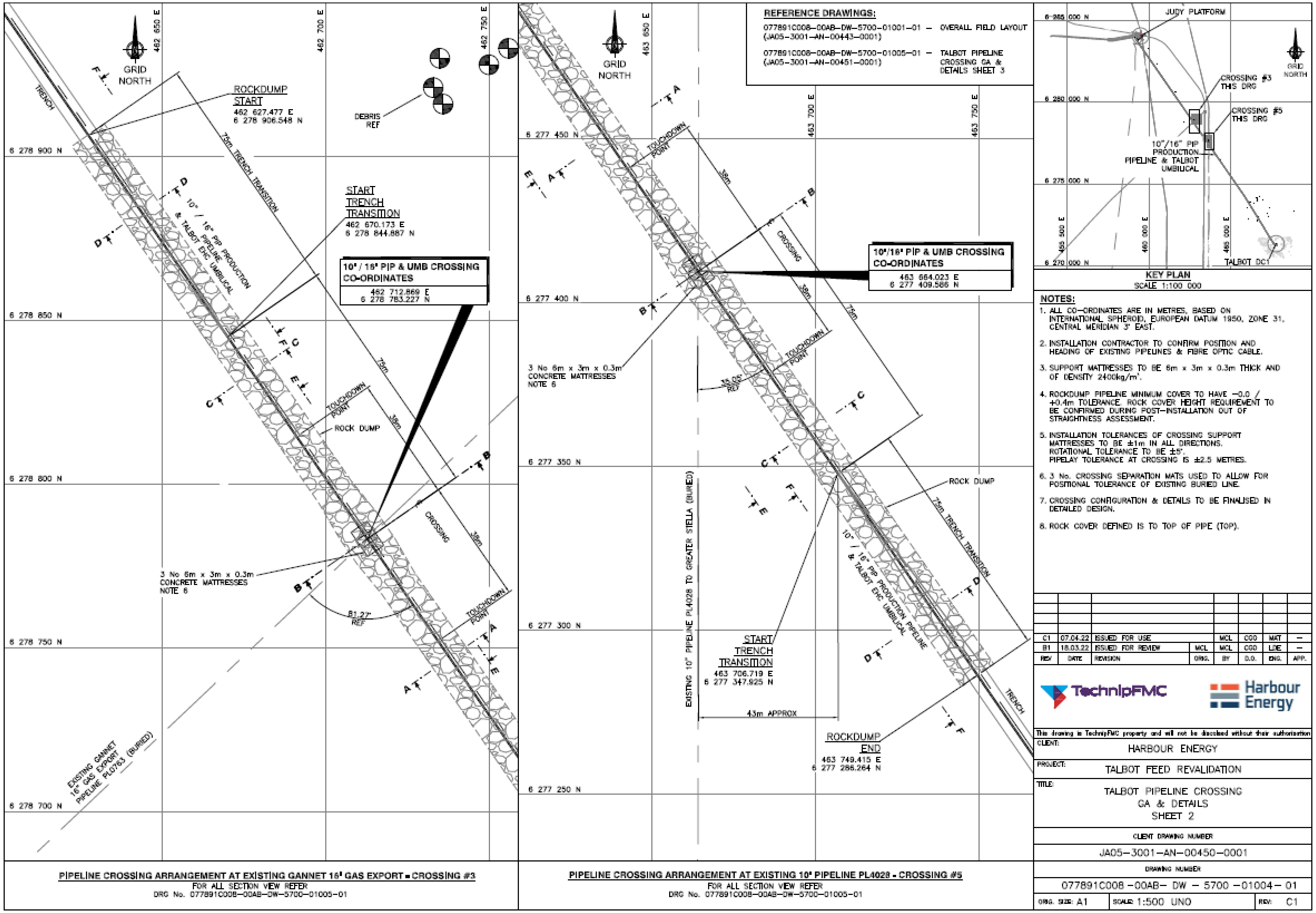


Figure 6:5 – Schematic of Crossing Points 3 and 5 showing location of rock placement and mattress protection

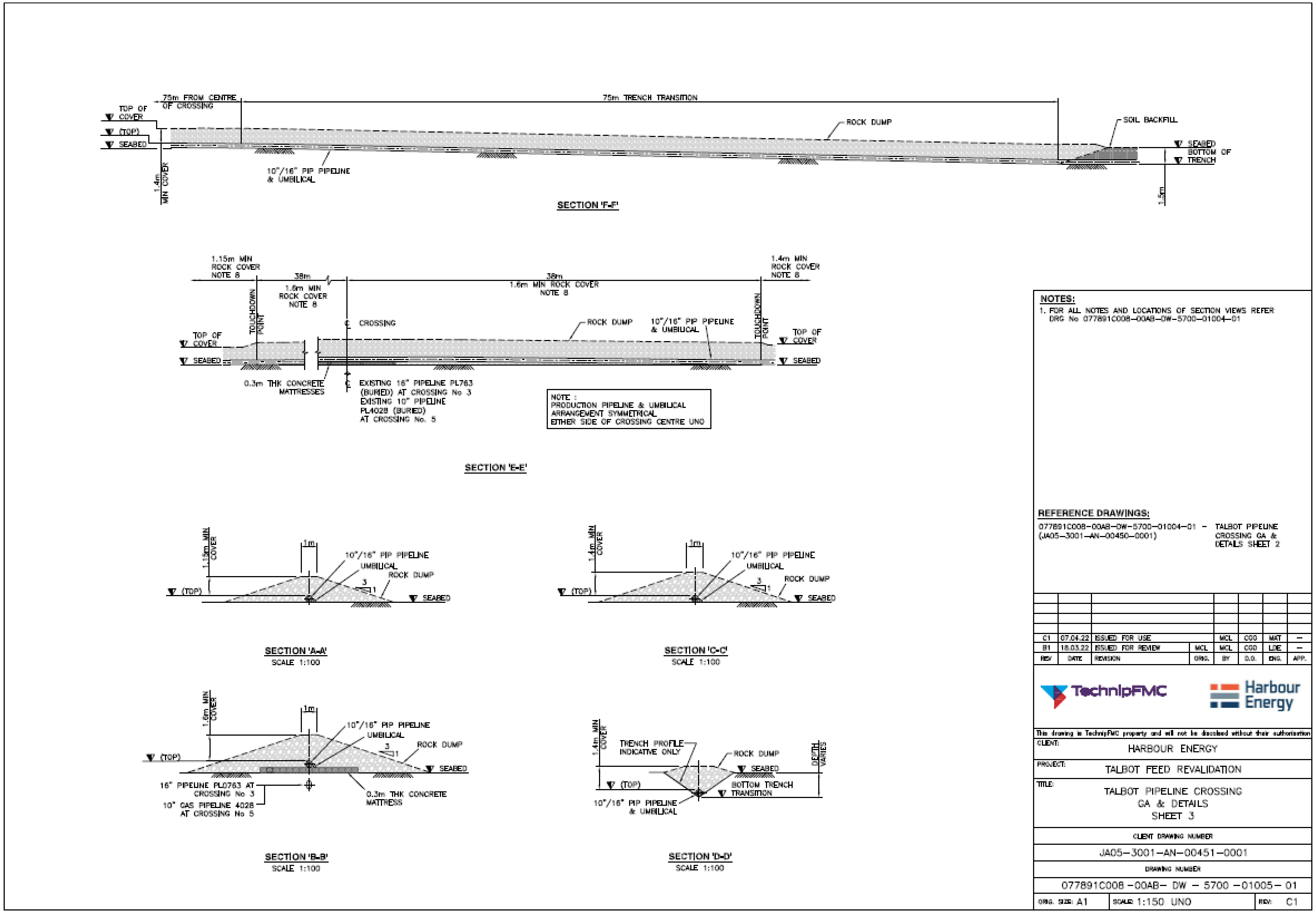


Figure 6:6 – Schematic of Crossing Points 3 and 5 showing location of rock placement and mattress protection

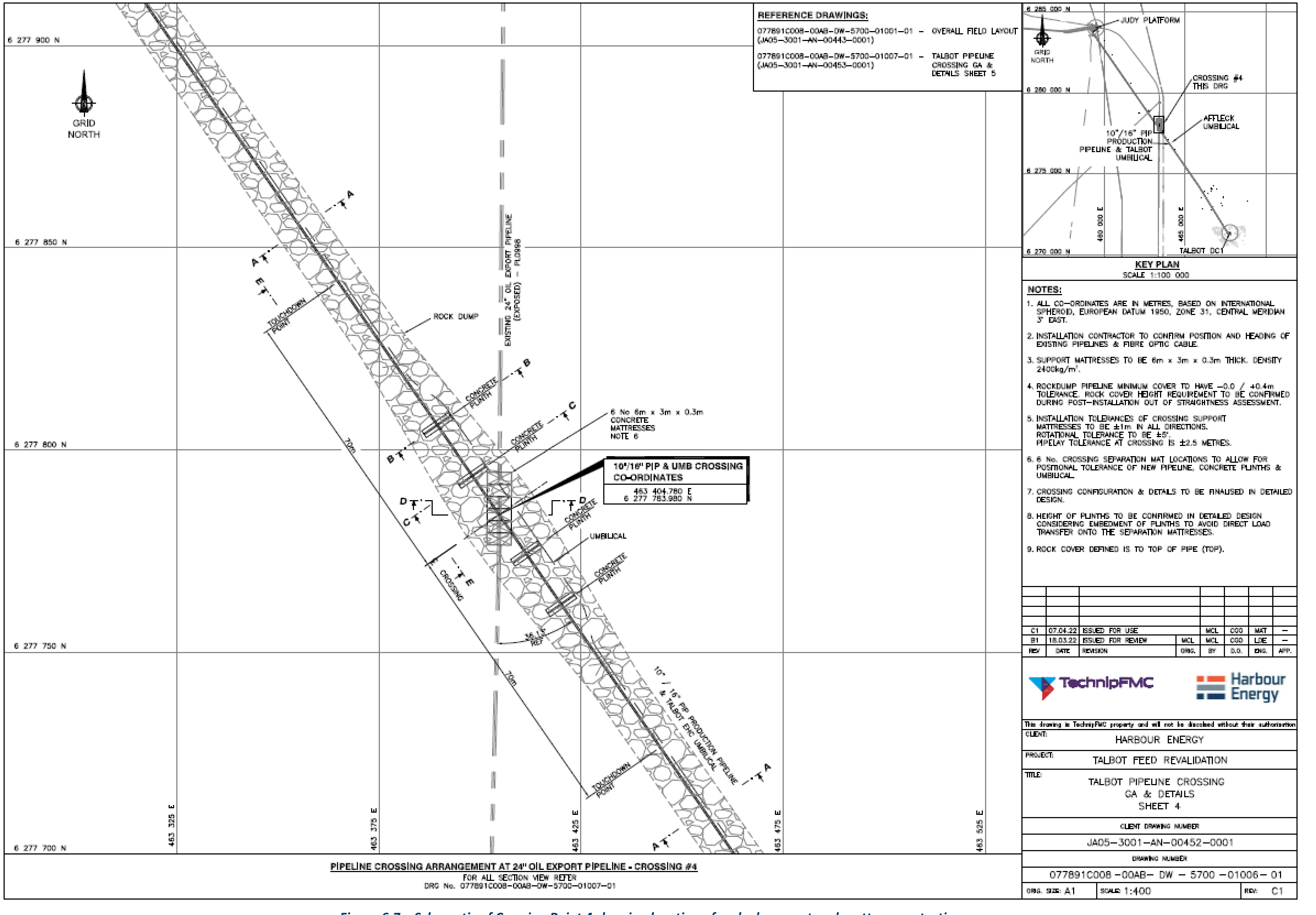


Figure 6:7 – Schematic of Crossing Point 4 showing location of rock placement and mattress protection

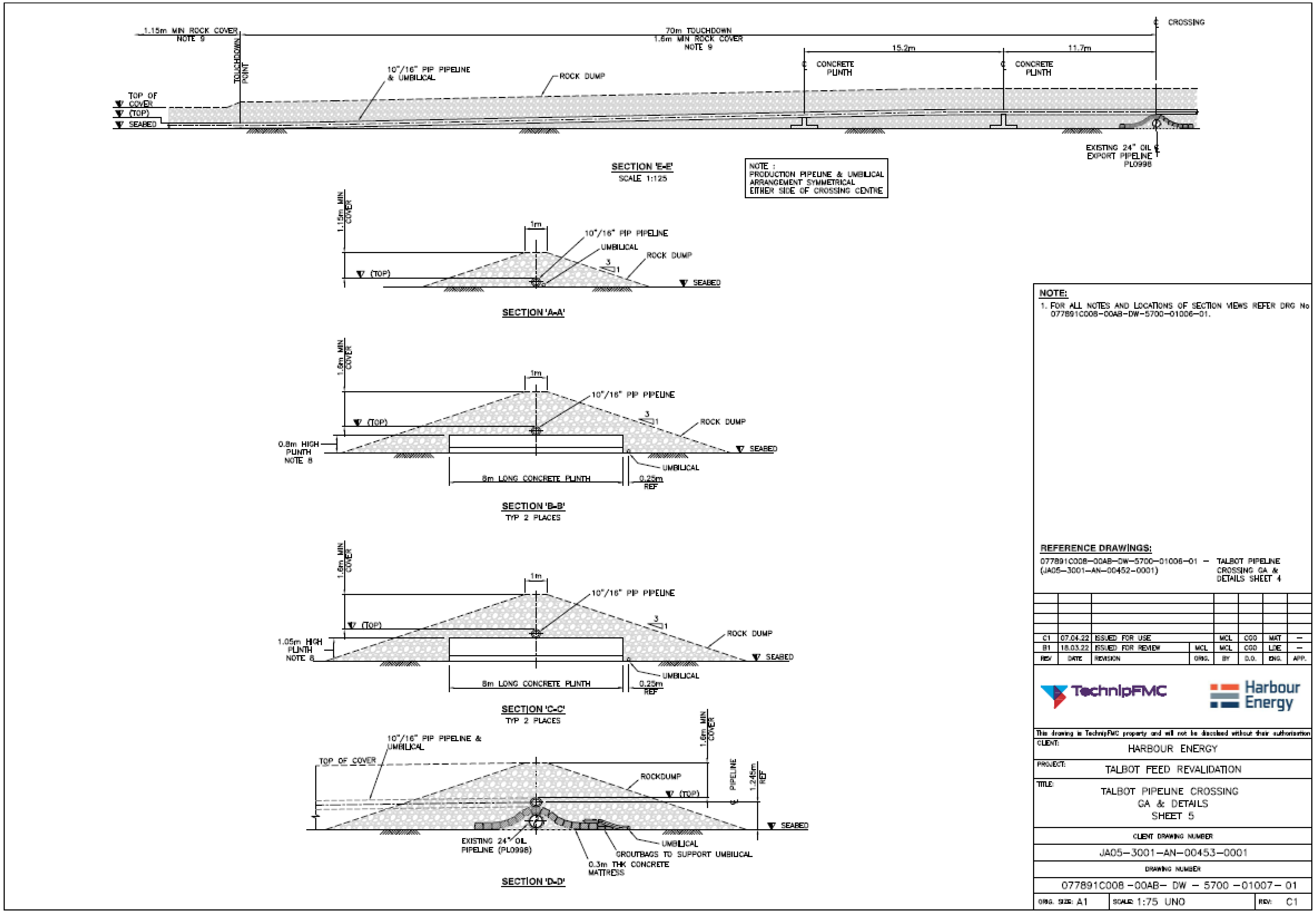


Figure 6:8 – Schematic of Crossing Point 4 showing location of rock placement and mattress protection

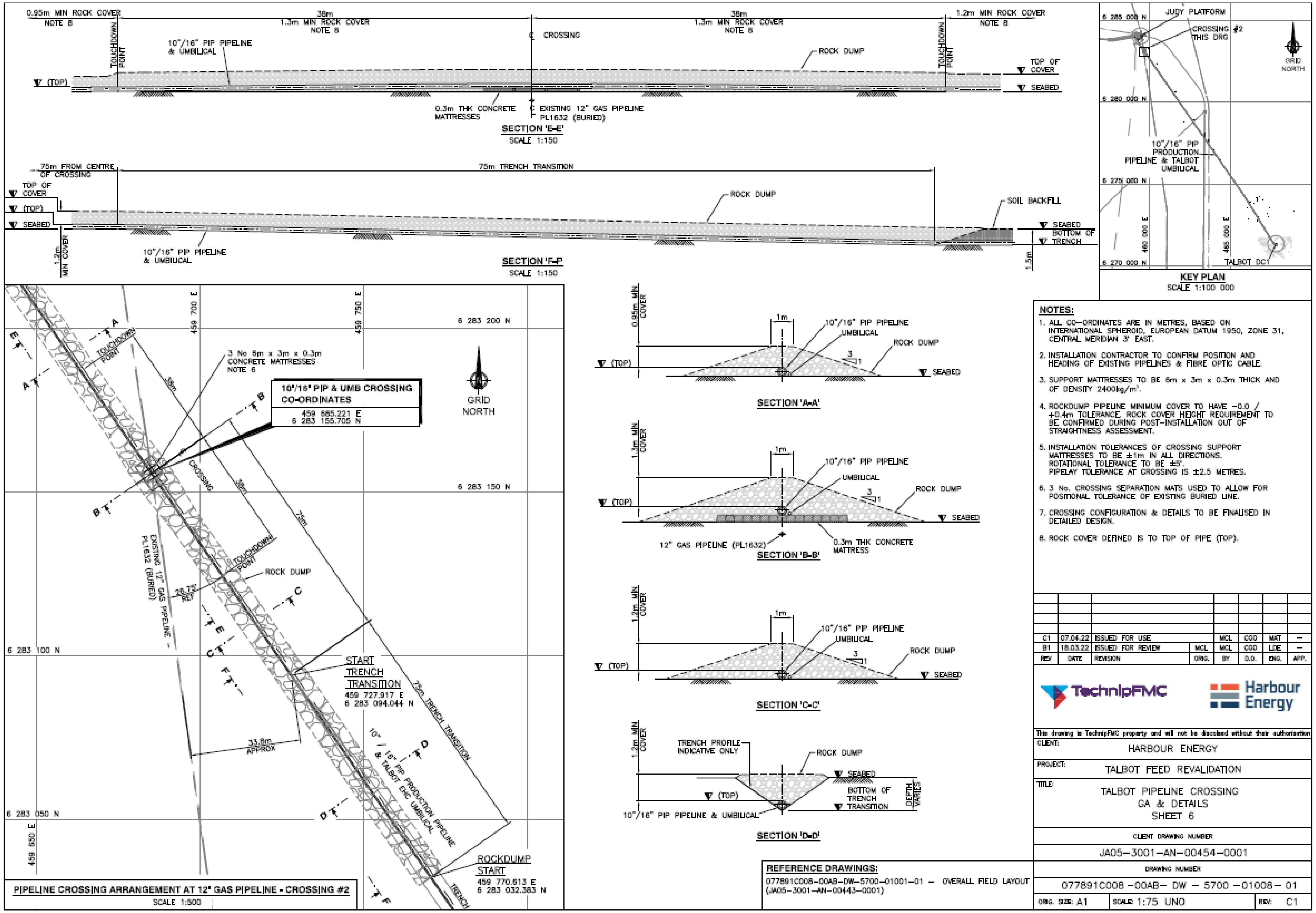


Figure 6:9 – Schematic of Crossing Point 2 showing location of rock placement and mattress protection

6.3.3 Presence of Infrastructure on the Seabed

The Talbot Field Development proposes the placement of the following items as part of a maximum case development:

- One 4-slot manifold;
- One drilling template;
- 6" hook-up spools between the manifold and Xmas Trees; and
- Control umbilicals between the manifold and Xmas Trees.

A summary of the seabed footprint from the presence of these subsea structures is presented in Table 6:6. The footprint of the main 16" PIP pipeline and umbilical is considered in Section 6.3.2.

Table 6:6 – Summary of the seabed footprint resulting from the presence of the subsea structures at the Talbot Field Development

Inventory/ subsea structure	Location	Dimensions (km)	Seabed Footprint (km^2)	Footprint within MCZ (km^2)
1 x manifold: 4-slot	Drill Centre	0.012 x 0.0075	0.00009	0.00009
1 x drilling template	Drill Centre	0.015 x 0.015	0.000225	0.000225
In-field pipelines	Judy 500 m zone	0.000254 x 0.17	0.000043	0
	Drill Centre	0.000254 x 0.05	0.000013	0.000013
	Drill Centre	0.00013 x 0.13	0.000017	0.000017
In-field umbilicals	Drill Centre	0.000180 x 0.14	0.000025	0.000025
Total area of seabed disturbance from subsea inventory			**0.000413**	**0.00037**

6.3.4 Drilling Cuttings

Drilling may result in the deposition of cuttings piles at the seabed. LTOBM will be treated offshore by either a Hellenes Thermal Treatment Unit (HTTU) or a Rotomill, which will separate water and hydrocarbons from solids, significantly reducing the backload, shipping, and onshore disposal of oily waste. As a contingency, cuttings will be skipped and shipped for disposal if these systems are not available. An estimated volume of 772 m^3 of WBM will be left at the drill centre. For the purposes of this assessment, this volume has been compared to the surveyed Fulmar cuttings pile, the largest cuttings pile in the CNS, with a volume of 25,521 m^3 and North West Hutton pile, with a similar volume of 25,225 m^3 (Cordah, 1998; Gerrard et al., 1999). The North West Hutton had a roughly circular footprint of 11,310 m^2 (based on 120 m diameter) when surveyed in 1992, and it is considered likely that this is comparable with the Fulmar pile, given the similar volume. The cuttings pile at Talbot Field Development will contain 3% of the volume of the Fulmar or North West Hutton piles in 1992, therefore it has been assumed each will occupy 3% of the seabed area covered by them. Consequently, a total impact area of 346 m^2 over the cuttings piles at the drill centre has been estimated. A full impact assessment of the effects of cuttings piles on the local environment can be found in Section 7.

6.3.5 Dropped Objects

Dropped objects represent an accidental event (Section 5) for which stringent operational controls will mitigate against. If an object is dropped overboard, its impact upon the seabed, assuming it does not fall onto subsea infrastructure, is likely to primarily result in localised and temporary sediment suspension. The scale of this impact will be dependent upon the weight and shape of the object dropped, the water depth and the seabed sediments (DROPS, 2010). Upon removal, a seabed depression/ scar may remain and will become infilled by the natural process of sedimentation through time.

6.3.6 Total Seabed Impact

The total seabed impact, based on the presence of the Talbot Field Development infrastructure listed in Section 6.3, is summarised in Table 6:7.

Table 6:7 – Summary of the overall seabed footprint resulting from the Talbot Field Development

Activity	Relative contribution (%)	Seabed Footprint (km^2)	Footprint within Fulmar MCZ (km^2)
Locating the rig	2.4	0.004425	0.004425
Pipelay & trenching	91.3	0.167038	0.037440
Rock placement at transitions and crossing points	2.3	0.005884	0.000391
Mattress, plinths & grout bags	3.6	0.006594	0.002664
Subsea inventory	<1	0.000413	0.00037
Cuttings piles	<1	0.000346	0.000346
Total area of seabed disturbance from the Talbot Field Development *		**0.184700**	**0.045636**

Note: For the purpose of the worst-case assessment, it was assumed that areas impacted by activities do not overlap.

6.4 Impact to Receptors

Seabed disturbance has the potential to impact the following receptor groups:

- Benthos;
- Fish and shellfish; and
- Protected habitats and/ or species.

The potential impacts to the benthos and protected habitats/ species are discussed below with impacts to fisheries and other users of the sea detailed in Section 11.

6.4.1 Impacts to the Benthic Environment

Locating the jack-up drilling rig, the installation of subsea infrastructures and the placing of protective structures will cause direct impacts to species living on and in the sediments as a result of physical disturbance to the seabed. The estimated total area of seabed impact is 0.18 km^2.

The disturbance from anchoring and spudding activities will be localised and temporary, occurring at the anchor and spud can locations, as well as along the part of the chain that contacts the seabed. The anchor and spud can penetration depths will be dependent on the load bearing capacity of the seabed soils; a firm seabed will result in less depth of penetration than a soft seabed. Post-disturbance seabed recovery is dependent both upon the strength of the seabed soils and the ability of the metocean regime to re-work disrupted sediments and return the seabed to its original state. As presented in Section 4, the seabed sediments within the Talbot Field Development are predominately medium to fine sands with shell fragments interspersed with patches of sand with higher silt content. Underlying this surficial layer, at approximately 0.5 m depth, is a soft to firm, slightly sandy clay layer (Gardline, 2019a), the base of which exceeds the maximum penetration achieved by the pinger data. It is thus unlikely to undergo deep penetration by spud cans.

The use of the jack-up drilling rig will result in a temporary disturbance to an estimated seabed area of 0.0044 km^2 due to the proposed anchoring and spudding activities (Table 6:7). Once the anchors and spud cans are removed, the natural physical processes of sediment transportation and biological settlement will be expected to restore the seabed to its pre-disturbance condition. Anchor scars were observed during the site and pipeline route survey (Gardline, 2019a; Gardline, 2019b), indicating recovery is likely to be less rapid than in higher energy seabed areas. However, in areas with similar sediments and current conditions, a relatively rapid recovery time of approximately one year might be expected (Hill et al., 2011).

A direct habitat loss and direct mortality of sessile seabed organisms that cannot move away from the contact area would be expected at both the rig spudding locations and subsea infrastructure contact points. The two factors that minimise these impacts are:

- Biological communities are in a continual state of flux and typically either adjust to disturbed conditions or rapidly re-colonise areas that have been disturbed. The movement of much of the seabed environment will aid the recovery of the disturbed areas, although some seabed scars may persist over a long time.

The installation and presence of the pipeline, along with associated rock placement, concrete mattresses and grout bags will have an impact on the seabed's sediment structure resulting in a localised smothering of animals. Surface laid protective materials will also result in a long-term alteration of the local habitat through the introduction of hard substrate (rock placement) into a predominantly soft substrate environment. This impact will be mitigated by trenching and burying the pipeline for most of its length, so allowing soft substrate habitats to recover above the line. Pipelay, including trenching and installation of protective rock and other materials, will lead to an estimated disturbance of 0.178 km^2 of seabed. A secondary effect of the rock placement may be localised scour at the edges of the rock berms. The rock placement may be recolonised by local benthic organisms including tubeworms, barnacles, hydroids, tunicates and bryozoans which are commonly found on hard substrates and offshore structures (Lissner et al., 1991; OSPAR, 2009b). Consequently, the presence of the rock placement is considered to represent a permanent habitat for any colonising organisms.

Indirect impacts may also result from the disturbance or re-suspension of any contaminants on the seabed or buried beneath the surface sediments. This may occur during both installation and removal/ decommissioning activities. Suspended sediments will be transported by the seabed currents before depositing over adjacent seabed areas. There is the potential for a minor impact on the local benthic community of the area due to localised smothering of organisms. The current energy at the seabed of the Talbot Field Development is low and the wave energy ranges from low to moderate (Section 4; NMPI, 2022). Therefore, it is expected that the re-suspended sediments will settle quickly in close proximity to the source of disturbance.

Analysis of sediment samples from the Talbot survey area indicated that hydrocarbon and heavy metal (barium) concentrations, while slightly higher than the background mean of 9.5 $\mu g\ g^{-1}$ for stations more than 5 km from the nearest infrastructure (UKOOA, 2001), were both below the 95th percentile for central North Sea sediments. In addition, both polycyclic aromatic hydrocarbon (PAH) and barium concentrations were below the low effects range (Long et al., 1995) and the apparent effects threshold (Buchman, 2008), indicating that toxic effects on fauna resulting from resuspension of sediments is unlikely. Consequently, no indirect impacts from chemical contaminants are expected to arise as a result of the re-suspension of sediments caused by seabed disturbance as part of the Talbot Field Development activities.

There may be effects on the benthic community arising from cuttings deposition. Please see Section 7 for a full assessment of this impact.

The benthic community in the area is relatively uniform with low diversity, characterised by species normally associated with the area, and comprising predominantly species highly tolerant to sediment re-suspension, burial and indirect effects of contamination such as *P. jeffreysii* (Section 4; Gardline, 2019a).

Once the subsea operations are completed and following the removal of any temporary project infrastructure, both disturbed and resettled sediment will be re-colonised by benthic fauna typical of the area.

This will occur as a result of natural settlement by larvae and plankton and through the migration of animals from adjacent undisturbed benthic communities (Dernie, et al., 2003).

Studies of seabed dredging sites indicate that faunal recovery times are generally proportional to the spatial scale of the impact (where the impact is between 0.1 m^2 and 0.1 km^2 (Foden et al., 2009)). In low energy areas of the North Sea subject to extensive dredging, local fauna took approximately three years to recover to the original level of species abundance and diversity. Studies carried out on the physical and biological impacts to the seabed caused by towed fishing gear (e.g., as reviewed by Løkkeborg, 2005), suggest that few effects last beyond eight months after dredging.

6.4.2 Impacts to Fish and Shellfish

The Talbot Field Development Plan has allowed for 90 days to drill each of the wells. With up to four wells to be drilled, drilling activities will occur throughout the year and as such have the potential to coincide with the spawning periods for mackerel, Norway pout, cod, plaice, sandeels and lemon sole (Section 4.3.3). Mackerel, Norway pout, cod and lemon sole are pelagic spawners, and as such are unlikely to be significantly affected by any seabed disturbance (Table 4:6). From the habitat sampled at the Talbot Field Development site (Gardline, 2019a), two species preferred benthic sandy habitats present at the site to use as their spawning grounds: plaice and sandeels. Plaice are pelagic spawners that release their eggs into the water column and are unlikely to be significantly affected by any seabed disturbance. However, sandeels are demersal spawners, and as such spawning activities may be affected by seabed disturbance. Pipelay and infrastructure installation are scheduled to take place in spring and summer months, outwith the winter spawning periods of these species, and so are unlikely to significantly disrupt spawning. However, sandeels will burrow into areas of suitable sediment, therefore individuals may be impacted from localised trenching and installation activities (Wright et al., 2000).

Although, a localised disturbance to seabed spawning species may arise and demersal spawning species may be temporarily disturbed by the subsea operations, fish are likely to return to the area once the drilling and installation operations, and later, decommissioning activities have ceased. Therefore, the proposed activities are unlikely to have an impact on species populations or their long-term survival.

6.4.3 Impacts to Protected Habitats and Species

The Talbot drilling centre location, along with approximately 3.6 km of the pipeline to Judy, will lie within the Fulmar MCZ. This site has been designated for four protected features: Broad-scale Habitats: subtidal mixed sediments; subtidal sand; subtidal mud; and Species Feature of Conservation Importance: ocean quahog (JNCC, 2018). Conservation objectives for the site with respect to these protected features are that they:

- So far as already in favourable condition, remain in favourable condition; and
- So far as not already in favourable condition, be brought into such condition, and remain in such condition.

With respect to the subtidal mixed sediments, subtidal sand and subtidal mud, this means that the extent of these habitats should be stable or increasing and that the structures and functions, quality, and the composition of characteristic biological communities remain in a healthy condition and do not deteriorate. With respect to ocean quahog, this means that the quality and quantity of the habitat and the composition of the population in terms of number, age and sex ratio are such as to ensure that the population is maintained in numbers which enable it to thrive.

As previously described, following temporary disturbance the seabed features would be expected to recover over time. To minimise long term disturbance, the pipeline is to be trenched and laid to reduce the introduction of hard substrate to the area.

The presence of the ocean quahog, listed on the OSPAR threatened and/ or declining species, has been recorded in the Talbot Field Development area, including during the site survey (Gardline, 2019b). JNCC has contributed to the development of an online application, the Features, Activities, Sensitivities Tool (FeAST, 2020), which assists in determining which activities have the potential to affect the protected feature.

An initial assessment of ocean quahog describes the most relevant pressure with respect to the planned operations as sub-surface abrasion/ penetration resulting in damage to species living within the seabed. Ocean quahog aggregations have a high feature sensitivity and are thought to have no resistance to the pressure and low resilience, and thus a high sensitivity score is assigned (Tillin et al. 2010). Ocean quahog has a thick, solid and heavy shell but despite this, is known to be vulnerable to physical abrasion. The damage to this species is related to their body size, with larger specimens being more affected than smaller ones (Klein and Witbaard, 1993). As a result of dredging in the southeast North Sea, only 10% of empty shells collected were undamaged (Klein and Witbaard, 1993). FeAST revealed similar sensitivities for sandeels (FEAST, 2020).

Further assessment was carried out by searching on the features of conservation interest in the area, namely ocean quahog and sandeel. Ocean quahog aggregations and sandeel populations are also expected to have high sensitivity to the following pressures:

- Physical change to another seabed type;
- Physical removal such as extraction of substratum;
- Changes in siltation, sub-surface abrasion/ penetration; and
- Local temperature changes.

With respect to the proposed operations, subsea infrastructure placement and mattresses and rock placement may result in sub-surface penetration/ abrasion as referenced above (FEAST, 2020; Tillin et al., 2010).

Juvenile ocean quahogs were reported at all but two of the 28 stations sampled in the baseline site and route survey (Gardline, 2019b), with evidence of adults including siphons and empty shells. Ocean quahog are considered to be highly sensitive to a high degree of siltation change but not sensitive to a low degree of siltation change (FEAST, 2020). However, the most disruptive activity, dredging the pipeline trench, will be localised. Compared to the total seabed area of suitable habitat that is available for the bivalve, the area disturbed by the Talbot Field Development (0.18 km^2) is relatively small. Dedicated survey of the Talbot Field Development area undertaken provides information on the locations of ocean quahog in the area (Gardline, 2019b) and will help to refine field design in attempt to avoid protected species.

The proposed activities will be localised, largely along the corridor of the pipeline between the drill centre and Judy. The total area of the activities within the Fulmar MCZ is estimated to be 0.046 km^2, approximately 0.002% of the total area of the Fulmar MCZ (2,439 km^2). Of this, approximately 0.042 km^2 will result from short-term impacts (locating the rig, installing infrastructure and pipelay) and 0.004 km^2 (<0.0002% of the MCZ) will result from longer term disturbance and habitat loss, from rock placement and the presence of protective material and subsea infrastructure. Consequently, it is deemed that any potential deterioration in quality of the protected broad-scale habitat features will affect only a very small proportion of the Fulmar MCZ, and approximately 90% of the estimated worst-case disturbance will be short-term and temporary. In addition, the effects on ocean quahog populations are also expected to be small and temporary, and steps will be taken to minimise direct impact on the species. Consequently, it is considered unlikely that significant disturbance of the Fulmar MCZ and negative impact on the conservation objectives of the site will result from the proposed scope of work at the Talbot Field Development.

6.5 Cumulative and In-Combination Impacts

The sources of cumulative seabed disturbance that result from oil and gas activities include drilling rigs, Xmas tree and wellhead placement and recovery, umbilical and pipeline installation and trenching, in addition to infrastructure decommissioning (DECC, 2009). Of these, activities relating to pipelines account for the largest area of disturbance. Other potential sources of seabed impacts include installation of renewables (OWF), dredging and fishing – particularly demersal trawling. There is no offshore wind development or dredging activity within the Fulmar MCZ.

The Talbot Field Development is predicted to cause a direct seabed disturbance of 0.18 km^2, of which 91% results from the installation of the pipeline, 4% from installation of protective mattresses, plinths and grout bags, and 2% from the placement of rock protection. Whilst the 0.004 km^2 impacted by rock placement represents a long-term impact through the introduction of a new habitat, the affected area is small when compared to the available similar baseline habitat in the development's vicinity. There are a number of established oil and gas activities in proximity to the Talbot Field Development Project (Section 4.5.2; Figure 4:15), with a total of:

- Five platforms with associated subsea infrastructure;
- 461 wells; and
- 61 pipelines intersecting this and neighbouring blocks.

Of key interest is the cumulative impact of the Talbot Field Development on the Fulmar MCZ. Fulmar MCZ extends fully or partially between Blocks 29/15 and 30/13 in the north and 29/30 and 30/28 in the south, with a total area of 2,439 km^2. The maximum impact of all Talbot Field Development activities which will take place within the MCZ (locating the rig, installing the drill centre and associated infield lines and umbilicals, and laying 3.6 km of pipeline with associated protection and cuttings deposition) will be approximately 0.046 km^2, representing just 0.002% of the area of the Fulmar MCZ.

In addition to the seabed disturbance to the conservation site that will be introduced as a result of the Talbot Field Development, there are currently four platforms and approximately 188 km of pipeline located within Fulmar MCZ (NSTD, 2022). Using an estimate of 3,020 m^2 seabed disturbance for locating a rig/ platform, and the same 10.4 m corridor for pipelines as we have used to assess the Talbot to Judy lines, this results in an approximate 1.96 km^2 of seabed impacted by existing oil and gas developments .

Over 2018, 2019, 2020 and 2021, there have been a range of permits applied for and/ or approved within the blocks containing the Fulmar MCZ. Consent to Locate applications, Directions to Deposit Materials and Marine Licences can all be assumed to have a seabed impact. These are summarised (along with the assumptions made in the absence of full data) in Table 6:8.

Table 6:8 – Summary of installation permits applied for in Fulmar MCZ from 2018-2021 and estimate of impact

Operator	MAT/SAT Reference	Block	Estimated seabed Footprint (km^2)
TotalEnergies	DRA/710-CL/1031	30/12	0.003020[1]
	DCA/32-ML/497	30/17	0.003020[1]
	DCA/32-ML/340	30/17	Unknown[5]
	PLA/188-CL/369	30/17	0.003020[1]
	PLA/188-CL/368	30/17	-[2]
	WIA/565-ML/254	30/17	Unknown[5]
	WIA/565-CL/752	30/17	0.003020[1]
	WIA/1292-CL/1234	30/17	Unknown[5]
Shell UK Limited	PLA/614-DEP/1631	30/13	Unknown[5]
	PLA/614-CL/945	30/13	0.003020[1]
Repsol Sinopec North Sea Limited	PLA/602-ML/395	30/16	Unknown[5]
	PLA/602-DEP/1473	30/16	Unknown[5]
Harbour	PLA/629-CL/935	30/13	0.000738[4]
	PLA/629-DEP/1653	30/13	0.000543[3]
Total area of seabed disturbance			**0.016381**

Assumptions:
[1]All rig/ platform installations will have a seabed impact of 3,020 m^2 (based on previous Harbour applications).
[2]Completed Consent to Install Pipeline or Pipeline Systems applications have already been included in the estimated total pipeline figure.
[3]Footprint of concrete mattresses = 18 m^3, footprint of grout bags = 0.15 m^3.
[4]Infield pipeline assumed to have a corridor of impact of 10.4 m, in line with assumptions elsewhere in this submission.
[5]Data not available at this time.

Table 6:9 summarises the total estimated seabed impacts that have been permitted or are planned in the blocks within the Fulmar MCZ.

Table 6:9 – Estimate of total oil and gas impacts within Fulmar MCZ

Activity	Relative contribution (%)	Seabed Footprint (km^2)
Talbot Field Development (within MCZ only)	2	0.045636
Existing Pipeline (~188 km)	96	1.958220
Total existing platform footprint (four platforms)	1	0.012080
Subsea installation permits applied for in 2018-2020 (Table 6:7)	1	0.016381
Total cumulative area of seabed disturbance within Fulmar MCZ		**2.032317**

The total cumulative impact by oil and gas operations within the Fulmar MCZ has been estimated at 2.03 km^2, approximately 0.08% of the area of the protected site.

In addition to the above, decommissioning activity is scheduled to take place at the Auk and Fulmar fields (Repsol Sinopec) over coming years. This work will cause additional short-term seabed disturbance through the locating of rigs and platform removals and is likely to coincide with the development of and production at Talbot Field Development.

As documented in OSPAR (2009b), the use of bottom-fishing gear by fishing vessels results in the greatest level of seabed damage. Development of the seabed through oil and gas activities is considered a low scale threat when compared to bottom trawling fisheries, particularly for benthic slow growing species (OSPAR, 2010). Demersal trawling represents the greatest fishing activity within ICES rectangle 42F2 (Section 4). Nevertheless, fishing activity is very low in the area.

Given that the majority of installation/ removal activities will be completed within the blocks of interest, the cumulative short-term impact of the Talbot Field Development is considered to be negligible. The majority of the impact, including dredging the trench and locating the rig, will be short-term and the habitat would be expected to recover following removal of the pressure. As such, it is considered that whilst this development will contribute towards long-term cumulative impacts, this will only occur for the duration of the period for which the infrastructure is in place.

6.6 Transboundary Impacts

The Talbot Field Development is located approximately 7 km west from the UK/ Norway median line. Seabed impacts will all be localised within the close vicinity of the development and it is considered that there will be no transboundary impacts. No global impacts are anticipated.

6.7 Decommissioning

Subsea infrastructure will be removed during decommissioning of the Talbot Field Development. Protective materials such as mattresses and grout bags will be removed were safe to do so. Any potential impacts that decommissioning operations may have in terms of seabed disturbance will occur in an area that already experienced seabed disturbance during the installation operations. The potential impacts from decommissioning operations are likely to be similar in magnitude to those experienced during installation and thus not significant.

6.8 Mitigation Measures

The planned mitigation measures that Harbour will undertake to minimise the impact of spudding, pipeline and subsea structure installation activities, are detailed in Table 6:10.

Table 6:10 – Planned mitigation measures for potential sources of impact

Potential source of impact	Planned mitigation measures
Jack-up rig spudding activities	Post-decommissioning survey and remediation if needed.
Installation of rock placement and concrete mattresses	ROV monitoring of rock placement and mattress deployment. Rock berm profile overtrawlable and rock size graded. The quantity of rock placement and mattresses will be minimised. Placed by fall-pipe. Accurate deployment.
Presence of infrastructure on the seabed	Placed within 500 m zone where possible. Fishing-friendly by design. Harbour to share site and Pipeline Route Survey reports with JNCC and MS.
Dropped objects	Lifting zones on rig and Judy platform. Pre- and post-installation debris survey. Measures put in place as required.

Note: Harbour note the likely presence of the ocean quahog within the Talbot Field Development and will take every endeavour to minimise damage to this species.

Applying the Risk Assessment methodology described in Section 5 and taking account of the mitigation measures listed above, the seabed disturbance from the proposed activities are considered to be of a medium environmental risk and therefore considered acceptable provided risks are reduced to As Low As Reasonable Possible (ALARP) and managed under the additional controls and mitigation measures as described.

6.9 Conclusion

The seabed that will be affected by the installation and presence of the Talbot Field Development will not fully recover until cessation of the production at the field and the consequential removal of associated infrastructure. Seabed impacts will be both short- and long-term.

- Short-term seabed impacts relate to temporary activities which interfere with the seabed. The likely short-term impacts are sediment disturbance and displacement and smothering of benthic species. Long-term seabed impacts relate to the presence of the pipelines, mattresses and rock placement. The likely long-term impacts arising from these activities are benthic disturbance and habitat change.

Based on the assessment undertaken within this ES, the disturbance will be localised. The Talbot Field Development Project has been shown to have a worst-case seabed impact of 0.18 km^2, of which 0.046 km^2 will be within the Fulmar MCZ. There is expected to be seabed recovery over time, through the natural processes of re-sedimentation and re-colonisation of benthos from the surrounding areas. Whilst the seabed sediments and habitats within the development area are relatively homogenous, it does have the potential to support a species of specific conservation concern, the ocean quahog. The Talbot Field Development will contribute to cumulative seabed disturbance, the total area of the Fulmar MCZ currently impacted is relatively small, estimated at 0.08% of the total protected area. Overall, the potential seabed impact from the Talbot Field Development is considered to be of medium significance.

7 Discharges to Sea

This section discusses the potential short- and long-term environmental impacts associated with planned discharges to sea as a result of the proposed activities associated with the Talbot area. The following activities were identified during the ENVID and risk assessment process (Section 5, Identification of Potential Impacts) as having a medium risk to the environment:

- Permitted discharge of WBM cuttings;
- Cement discharge;
- Well bore clean-up; and
- Presence of cuttings pile.

Additional discharges to sea will include the following permitted discharges:

- Produced water discharges from Judy;
- Discharge of inhibited seawater into the marine environment during installation operations flooding and leak testing of pipelines and risers; and
- Subsea discharges of hydraulic fluid during valve actuation.

The permitted discharge of chemicals to the marine environment is a routine part of subsea installation and operations. The chemicals and quantities to be used and discharged will be determined during the detailed design. Prior to any discharge these will require, under the Offshore Chemicals Regulations 2002, a discharge permit obtained through the UK Energy Portal Environmental Tracking System (PETS). Since the chemical regime will be subject to a separate permit; there is no requirement to replicate in the Environmental Statement the risk and impact assessment that will be carried out for that permit.

All accidental (unplanned) discharges to sea are discussed in Section 10, Accidental Events.

All phases involve the discharge of sewage and food waste from vessels; however, these discharges will be in line with MARPOL requirement and the environmental risks are considered negligible. They are therefore not assessed further in this section.

7.1 Regulatory Context

Discharges to sea resulting from Talbot will be managed in accordance with current legislation and standards as detailed within Section 1.

7.2 Approach

In order to assess the maximum discharges to sea, a worst-case scenario is considered when there is uncertainty in the method(s) to be used.

Planned operations during Talbot will involve a phased drilling programme to target four production wells (Section 3). The current intention is to develop the area consisting of one drill centre containing four slots each.

7.3 Sources of Potential Disturbance

Discharges to sea will occur as part of the planned operations and may also occur in an accidental event. Details are presented in the following sections.

7.3.1 Cuttings from Drilling Operations

During drilling operations, drill cuttings will require disposal. Drill cuttings vary in nature depending on the characteristics of the rock layers present but generally range in size between very fine clay particles (<2 µm) to coarse gravels (>30 mm) (Neff, 2005).

Currently plans are to use seawater and gel sweeps (hereafter referred to as WBM (water-based mud)) for the 36-inch and 26-inch top-hole sections and LTOBM system for the remainder of the drilling operations (16", 12.25", 12.25" pilot, 8.5" and 16", 12.25" and 8.5" sidetrack sections).

The returned WBM will be sucked out of the drilling template and discharged directly to the seabed. Typical WBM consists of a base fluid (76%), either seawater, freshwater or brine, within which clays (6%), barite (14%) and other mineral weighting agents (4%), such as bentonite, are suspended.

The cuttings resulting from the use of LTOBM will be treated offshore by either a Hellenes Thermal Treatment Unit (HTTU) or a Rotomill, which will separate water and hydrocarbons from solids, significantly reducing the backload, shipping, and onshore disposal of oily waste. As a contingency, cuttings will be skipped and shipped for disposal if these systems are not available.

The estimated discharge of cuttings from each of the well sections is presented in Table 7:1. Taking into account the well type and the number of sections that will be drilled, the amount of WBM cuttings generated from all top-hole drilling will be approximately 425 tonnes per well, giving a total of 1,700 tonnes for all four wells. The equivalent total amount of LTOBM generated cuttings will be 3,458 tonnes per well (including three contingency sections) giving a worst-case total of 13,832 tonnes for all four wells. The total cuttings produced from wells to be discharged at the Talbot drill centre are quantified in Table 7:2.

Table 7:1 – Drill cuttings generated for all sections per well

Section	Number of Wells		Section Length (m)	Mud System	Weight of Cuttings Generated (metric tonnes)	Cuttings Disposal Route
	Production	Water				
36-inch	4	0	85	WBM	130	Discharge to seabed
26-inch	4	0	370	WBM	295	Discharge to seabed
16-inch	4	0	1,300	LTOBM	392	HTTU OR Rotomill OR Contained and shipped to shore for treatment and disposal
12.25-inch	4	0	2,900	LTOBM	513	HTTU OR Rotomill OR Contained and shipped to shore for treatment and disposal
12.25-inch Appraisal	4	0	2,900	LTOBM	513	HTTU OR Rotomill OR Contained and shipped to shore for treatment and disposal
12.25-inch Pilot	4	0	2,900	LTOBM	513	HTTU OR Rotomill OR Contained and shipped to shore for treatment and disposal

Section	Number of Wells		Section Length (m)	Mud System	Weight of Cuttings Generated (metric tonnes)	Cuttings Disposal Route
	Production	Water				
8.5-inch	4	0	1,300	LTOBM	111	HTTU OR Rotomill OR Contained and shipped to shore for treatment and disposal
Contingency						
16-inch Sidetrack	4	0	1,300	LTOBM	392	HTTU OR Rotomill OR Contained and shipped to shore for treatment and disposal
12.25-inch Sidetrack	4	0	2,900	LTOBM	513	HTTU OR Rotomill OR Contained and shipped to shore for treatment and disposal
8.5-inch Sidetrack	4	0	2,900	LTOBM	511	HTTU OR Rotomill OR Contained and shipped to shore for treatment and disposal

Table 7:2 – Drill cuttings discharged at the Talbot drill centre

Drill Centre	Number of Wells	Weight of Cuttings Discharged (metric tonnes)
Talbot	4	1,700
Total weight generated		**1,700**

7.3.2 Cement

During the proposed drilling operations steel casings are installed into the well to provide structural strength to the well. In order to provide a robust seal between the casing and the adjacent formation, the casings are cemented in place. This is achieved by pumping the cement down the drill string and pushing it back up through the annulus (the space between the outside of the casing and the borehole). To ensure the initial sets of surface casings are sufficiently secured, it is vital that cement is circulated all the way back up the well until it returns to the seabed.

To allow for variations in wellbore diameter and to ensure a robust cement job, an excess of cement will be pumped down the hole. This may result in some cement being discharged at the surface. In general, once cement returns are observed, the cementing operation is curtailed. An estimated total of 730 tonnes of cement will be used per well, of which 95% is planned to be excess. Of this, only cement from the top-hole sections (380 tonnes per well), has the potential to be discharged to the seabed; for the four wells this is equivalent to 1,520 tonnes. Further detail is provided in

Table 7:3.

For the cementation of the surface casings, the intent is to use a lightweight system specifically designed for deep-water applications. The cement slurries are to be designed with the appropriate additives to ensure a low heat of hydration whilst the cement is setting. The composition will also allow low thermal conductivities to minimise the dis-association of naturally occurring shallow hydrates during both drilling and production. The slurries will also have adequate compressive strength to support the casing string and blow out preventer (BOP) stack

Table 7:3 – Planned cement use for all sections per well

Section (Casing)	Weight of Cement Planned (metric tonnes)	Excess (%)
36-inch (30-inch conductor)	135	300
26-inch (20-inch casing)	245	100
16-inch (13 3/8-inch casing)	103	10
12.25-inch (9 5/8-inch casing)	51	10
12.25-inch (9 5/8-inch casing) Appraisal A	49	10
12.25-inch (9 5/8-inch casing) Pilot	49	10
12.25-inch (9 5/8-inch casing) Appraisal B	49	10
12.25-inch (9 5/8-inch casing) Sidetrack	49	10
Total	730	-

Following cementing operations, residual cement will be discharged overboard following the washing out of the cement unit. Discharges of cements and cement additives are associated with dead volumes in tanks and pits and losses after each cement job, when any remaining cement slurry must be flushed from pumps, tanks and lines. Typical worst-case volumes assumed are 10% of cement mixes and 20% for spacer volumes (the higher % of spacers is simply a function of their relatively smaller volumes used and as such the dead space is a more significant percentage of the total). These are washed through following the completion of that job, so the system is clean and ready for the next mix. It is very important from a well integrity and a safety perspective that cements are not contaminated and perform as expected to provide effective seals.

The discharges associated with the drilling and cementing operations are described briefly here and will be detailed in the Drilling Applications (DRA) permit applications submitted to BEIS prior to commencement of drilling.

7.3.3 Wellbore Clean-up

Wellbore clean-ups refer to the process of changing out an oil-based mud system to a water-based mud system usually to run the completion in. This is done by flushing through the wellbore with a water-based mud system. Typically, a surfactant chemical would be run with it to help remove the oil-based mud components. This chemical would be added and assessed as part of the main Well Chemical Permit application. (This is the removal of oil base mud and base oil should not be confused with “Well Clean-Up”. Well Clean-Ups, follow wellbore clean-up, are either flared off at the rig or sent back to the platform to be cleaned up through a test separator; as will be done for Talbot with reservoir hydrocarbons sent back to the Judy test separator).

The first returns back to surface will typically have a high base oil levels and will usually be contained in tote tanks and sent onshore for treatment and disposal. After the initial flush the fluids may be of sufficiently low in base oil to allow discharge over the side. This can be achieved either through the base oil levels coming back low enough in oil content or putting a clean-up filter spread on the drilling rig which can remove large amounts of the base oil to bring the fluids into permit levels for discharge. Given base oil is a chemical and not a reservoir hydrocarbon it is less toxic to marine environment and being light it breaks down quickly rapidly defusing to very low concentrations. Chemical permits, that hold approve the discharge and place an oil limit typically request oil only be discharged at less than 200 mg/l. It is expected that discharged wellbore fluids will be highly diluted and dispersed in the offshore waters and the oil content will be broken down through bio-physical processes. Any chemicals which are discharged will be in very small amounts and will readily disperse throughout the water column.

Wellbore clean-ups will typically use around 300 m^3 of treated brine or seawater to clean the wells of oil-based mud. This fluid, if intended for discharge, will then be sampled by the on board lab to ensure it meets permit specification before then being approved for discharge and a record of this held and reported at the end of the well program via the EEMS (Environmental Emissions Monitoring System) back to the regulator OPRED.

To provide a worst-case scenario Harbour assumed 500 m^3 of clean up fluid per a well (to allow a repeat treatment) and a maximum oil content of 200 mg/l. This would give a total base oil discharge of approximately 100 kg of base oil. This will be diluted through 500 m^3 (over 3,000 bbls of water). In practice lower volumes would usually be required with oil levels being well below 200 mg/l. The discharge would take place over a number of hours so concentrations in the sea would remain very low and dilute. Temporal gaps between discharges of wellbore clean-ups would also be in the order of weeks and so there is no potential for cumulative impacts as the oil discharged would be rapidly dispersed.

The entire discharge area within 500 m radius of the discharge point would be refreshed with sea water typically within an hour of occurrence. Consequently, along with the other actions working on the base oil content, this discharge would be expected to have a negligible impact on the receiving marine environment with base oil levels undetectable beyond a worst-case 500 m area.

7.3.4 Chemical and Mud Discharges

Mud, cementing and completion chemicals which are planned for use within the Talbot project are subject to control under the Offshore Chemicals Notification Scheme (OCNS) and the Offshore Chemicals Regulations, 2002 (as amended). Talbot intends to predominantly use chemicals which Pose Little or No Risk (PLONOR), OCNS category E or low risk quotient (RQ) and have been selected to minimise impacts upon the marine environment. Should it be necessary to use chemicals with a poorer environmental profile (an RQ greater than one, substitution warnings, Centre for Environment Fisheries and Aquaculture Science (CEFAS) Silver and/ or an OCNS rating of A, B, C), Harbour will seek consent for use within the Chemical Permit Risk Assessment process.

Accidental discharge of these chemicals is covered in Section 10, Accidental Events.

Subsea Discharges

Subsea valve actuation at Talbot will utilise a water based hydraulic fluid, OCEANIC HW443-R, of which a small volume will be discharged to sea. This chemical is an OCNS D rated chemical that carries a low toxicity. Given the small volume of discharge (maximum of 5 litres for a large actuation and typically for a small actuation 2 litres) and the relatively large temporal gaps between discharges (these valves would typically be actuated once a week) it is not expected to have a significant impact on the receiving environment. The small volume released combined with the relatively large time gaps between discharges means that the chemical would not have the opportunity to accumulate making the impact on the receiving environment negligible. This will be covered in the Chemical permit SAT under J-Block area production MAT.

7.3.5 Produced Water Discharges

Talbot will be tied-back to the Judy Platform which is situated to the south of the Fladen ground area of the North Sea. Fluids from Talbot will be processed on the Judy Platform with produced water routed overboard, under an OPPC Permit.

Table 7:4 summarises parameters for the J-Area fields produced water discharge at the Judy platform.

Table 7:4 – Parameters for the J-Area fields produced water discharge

Discharge depth – Judy	5m above sea level
Discharge depth – Judy Riser Platform	41.9 m below sea level
Water depth	75 m
Produced water temperature (excluding Jasmine)	65°C
Produced water temperature (including Jasmine)	90°C
Salinity	44 ppt
Discharge rate (including Jasmine)	1450 m^3/d (2014 average)
Dominant direction of tidal ellipse	NNE (025°)

Produced Water Profile

The predicted produced water profiles are provided in Table 7:5 and Figure 7:1 (Chrysaor, 2022a). There is significant uncertainty in the Free Water Level in the Talbot area as different contacts and oil-down-to were established with each exploration and appraisal well. It is expected that the Talbot wells will produce water with a high range uncertainty on the expected water rates, the date of water breakthrough and the location of water breakthrough along the wellbore. The Judy platform has a current produced water processing capacity in the range of 12 mbwpd to 14 mbwpd. The base case Talbot upgrade would increase the Judy produced water handling capacity to the range of 22 to 24 mbwpd (Chrysaor, 2022b; Section 2).

Produced Water in the Marine Environment

Produced water is diluted by 30 to 100 times after discharge to sea within the first 10 m of the discharge point and by 1,000 to 100,000 times within 500 - 1,000 m. Compounds that are soluble in water dilute rapidly in the sea, particulate material and insoluble products will eventually sink to the sediment (OGP, 2005).

The major constituents of produced water are inorganic salts but it also contains concentrations of trace elements, metals and radioactivity and residual quantities of dispersed and dissolved hydrocarbons, including: fatty acids; volatile aromatics (benzene, toluene, ethylbenzene and xylene (BTEX)); naphthalenes; phenols and polyaromatic hydrocarbons (PAHs). In J-Area produced water, the aromatic fraction can range from 20-66% of the total hydrocarbons (based on samples from 2010-2013).

Table 7:5 – Projected annual peak produced water rates

Year	Average Produced Water (bbl/ day)
2024	3,060
2025	3,166
2026	3,535
2027	3,806
2028	4,427
2029	4,995
2030	5,997
2031	5,480
2032	6,427
2033	5,344
2034	6,972
2035	7,354
2036	6,709

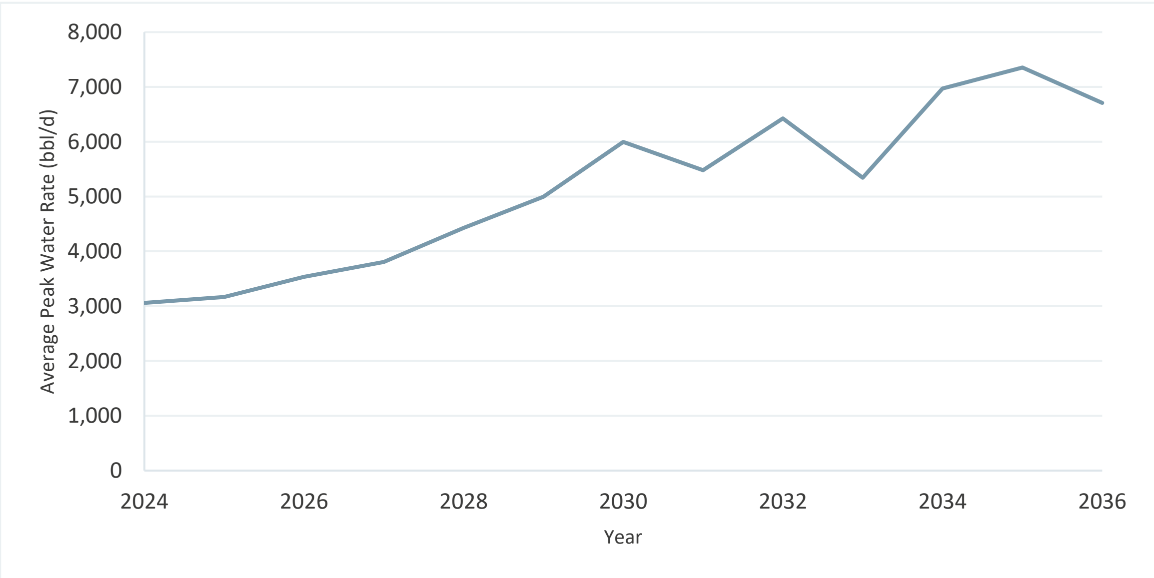


Figure 7:1 – Annual peak produced water rates

The processes of dilution, evaporation, adsorption/ precipitation, biodegradation, and photo-oxidation tend to reduce the concentrations of compounds from the produced water in the receiving environment and this decreases their potential toxicity to marine organisms. The PAH components are of most concern because of their likelihood of being more persistent in the marine environment; the toxic effects of PAHs vary but include non-polar narcosis, phototoxicity, biochemical activation that can cause mutagenic, carcinogenic and teratogenic effects (OGP, 2005).

Studies on the Predicted No Effect Concentrations (PNECs) for the hydrocarbon components most frequently found in produced water have shown that where a 1,000-fold dilution is achieved the PNEC level is reached for these components (OGP, 2002), and furthermore that such dilutions are achieved within minutes of the produced water discharge entering the sea. Therefore, there is limited risk for marine organisms in the water column to be exposed to harmful doses of these constituents.

The Oslo and Paris Commission (OSPAR) Recommendation 2012/5 requires offshore oil and gas facilities to implement a risk-based approach (RBA) for the management of PW discharges from offshore installations. The RBA project report indicates that production chemicals in the produced water discharge account for 9% of Judy's modelled Environmental Impact Factor (EIF) and natural substances (mainly zinc and dibenzo(a-h) anthracene) account for 91% (Table 7:6). Of the production chemicals, clarifier CLAR16036A and corrosion inhibitor CRR11071A are the highest contributors to the toxicity of the discharged produced water.

Table 7:6 – Process Chemical Percentage Contributions to Judy's EIF

Components	Contribution to EIF (%)
EC1071A / CORR11071A (corrosion inhibitor)	3.31
EC6029A / CLAR16029A (deoiler)	2.41
EC6036A / CLAR16036A (deoiler)	3.60
EC6359A / SCAL16359A (scale inhibitor)	0.01

It is expected that the produced water, when it comes through, from the Talbot Field Development will be very similar to the existing J-Block fields' hydrocarbons characteristics and is unlikely to require different or new chemicals to meet the specifications for pipelines and overboard discharges. However, an increase in chemical use overall will inevitably be required in line with increased produced water production although this will be likely to be mitigated as flow rates from existing wells reduce.

Overall, the RBA indicates the potential for an adverse impact on the marine environment in the area of the produced water discharge plume. The production chemicals that contribute to the EIF are integrity and process critical. These are cost effective products for which no suitable alternative has so far been identified.

Given the information presented on the impacts of produced water discharges, along with the dilution and dispersion upon reaching the sea, the environmental risks at Talbot are considered to be within acceptable limits.

7.3.6 Decommissioning and Cuttings Piles

The continued release of cuttings during drilling operations (Section 7.3.1) will ultimately result in the production of a drill cuttings pile at the drill centre. Harbour intends to undertake the decommissioning process according to the prevailing UK and international regulations at the time of decommissioning. This will include consideration for the removal or leaving in situ the drill cutting pile(s).

If all of the drill cuttings released immediately settle at or near the drill centre, the volume of the cuttings piles at Talbot is estimated to be 772 m^3 (Table 7:7). This is equivalent to 3% of the size of the Fulmar drill cuttings pile (25,521 m^3) (Gerrard et al., 1999). In practice the metocean conditions will act to disperse sediments, particularly the finer material, from the discharge point such that the volume of the pile will be less than presented within this assessment. Furthermore, for the purposes of calculating the maximum possible pile volume it has been assumed that all cuttings will be released directly at the seabed.

Table 7:7 – Drill cuttings volume at the Talbot drill centre

Drill Centre	Pile Volume (m^3)
Talbot	772
Total	**772**

Note: Assumes cuttings density of 2.5 kg/l

7.4 Impact to Receptors

Marine discharges have the potential to impact the following receptor groups:

- Benthos;
- Plankton;
- Fish and shellfish; and
- Protected habitats and species.

The potential impacts for these groups are discussed below with the baseline information on fisheries and other sea users detailed in Section 4.

7.4.1 Impacts to the Benthic Environment

Benthic fauna are susceptible to smothering from discharged cuttings and cement from drilling activities. These materials will settle on the seabed and have the potential to smother benthic organisms and release pollutants into the sediments. In the short-term, this would cause localised mortality of benthic organisms and a change in sediment composition. Impacts from drill cuttings are expected to reduce in the longer term, as observed within the North Sea (Breuer et al., 1999) as:

- A reduction through time in the spatial extent of pollution and of any associated biological effects;
- Recovery rates observed at greater than 500 m from drill centre; and
- Biological effects detected up to 250 m from drill centre.

Most of the discharged cuttings and cements are expected to settle on the seabed in close proximity to the discharge point. Some of the finer material may be transported a short distance before settling out of suspension. The discharges of WBM cuttings will remain mainly at the seabed with some migrating to the upper column where currents are faster and benefit from a greater degree of initial dilution. The majority of particularly coarser cuttings are predicted to descend to the seabed. Effects of the discharged materials upon the biological receptors within the water column (plankton) are discussed below (Section 7.4.2). The immediate effect of this discharged material will be to smother the natural seabed sediments and associated benthic communities. The deposited material may be coarser and more cohesive than the ambient sediment types, and as such, erosion by natural metocean processes is likely to occur over longer time scales.

Smothering effects and changes in the sediment grain size and chemistry combine to favour certain species over others. In particular, it is the sessile benthic and epibenthic fauna, such as the ocean quahog, which experience a greater impact. The ocean quahog which are known to be present in this area of the North Sea and were identified in the surveys undertaken for Talbot (Section 4; Gardline, 2019b) could be potentially impacted.

The main environmental impacts likely to arise from the discharge of WBM cuttings are smothering of benthic fauna and fish spawning grounds and the release of chemicals. This may result in mortality to some benthic organisms and temporary alteration to and loss of benthic habitat. However, the constituents of WBM are mainly minerals and clays which are found naturally occurring in the seabed sediments of the UKCS. These, together with water soluble inorganic salts and biodegradable organic polymers, make up the WBM fluid.

The most common chemical effect of WBM discharge is a temporary elevation of barium concentrations of the sediment, which may extend up to 1,000 m from the drilling location along the predominant tidal axis. Barite consists of barium sulphate, an insoluble, chemically inert mineral powder that normally contains measurable concentrations of several trace metals. As such, barium is "biologically unavailable" and will have no measurable effect, in chemical terms, on the benthic fauna (Jenkins et al., 1989; Hartley, 1996). Modelling of WBM cutting discharges indicates that deposition of material is generally thin and quickly reduces away from the well (OESEA, 2016). Studies have shown that impacts from smothering can occur where the depth of cuttings is one millimetre or more (Eastwood et al., 2007). Nevertheless, effects on seabed fauna on the discharge of WBM cuttings are usually subtle, although the presence of cuttings may be detectable chemically (e.g., OSPAR, 2009b; Bakke et al., 2013).

Evidence has shown that, following cessation of drilling activities, re-colonisation may occur within one to two years (Neff, 2010). Furthermore, it has been shown that benthic infauna and epifauna can recover relatively quickly, with recovery occurring in deep water communities within three to ten years (Jones et al., 2012), while Daan & Mulder (1996) reported no detectable effects within 2 months to one year after drilling.

Any exposure to contaminants contained within the cuttings will most likely occur through the colonisation of the drill cuttings pile over time (Breuer et al., 1999). However, this exposure will be limited as all cuttings will either comprise seawater and sweeps or WBMs.

Discharge of cement slurry into the sea also has the potential to cause a localised alteration of the sediment structure and smothering of seabed organisms in the immediate area. Cement that might be released would set to form an inert hard substrate which may be covered by natural sediment re-distribution. Therefore, it is not expected that there would a significant impact on benthos from cement release during drilling.

The potential long-term impacts of drill cuttings discharge are considered likely to be localised. Long-term changes in the benthic habitat and communities at these localised sites are possible, although the discharge of WBM cuttings from the rig means that they will have dispersed and are likely to be at low concentrations on reaching the seabed.

7.4.2 Impacts to Plankton

Any compounds released into the water column will rapidly reduce in concentration and thus decrease their toxicity to marine organisms (Neff, 1987). Following discharge, contaminated fluids will firstly be diluted by the turbulence close to the discharge point, and then widely dispersed by marine currents. The larger particles, which represent approximately 90% of the mass, will form a plume that settles quickly onto the seabed (or until the plume entrains enough sea water to reach neutral buoyancy) (Hinwood et al., 1994; PTTEP, 2018). Of the remaining 10%, another plume will be formed in the upper water column that drifts with prevailing currents away from the platform and will be rapidly diluted in the water column (Neff, 2005; Neff, 2010).

The discharge of WBM drill cuttings will be at the seabed and have only a minimal localised effect on planktonic species. The toxicity of WBM is limited as the additives are either inert or biodegradable. Acute effects are considered unlikely to occur beyond the immediate location of the discharge point (Neff et al., 2011) and so it is only transient organisms that there is the potential to be exposed to discharges. For cuttings from the use of LTOBM either a Hellenes Thermal Treatment Unit or a Rotomill will be used to separate water and hydrocarbons from solids, which will significantly reduce the backload, shipping and onshore disposal of oily waste. Cleaned cuttings will be discharged overboard. As a contingency, LTOBM cuttings will be skipped and shipped for disposal if these systems are not available. Small amounts of base oil may be discharged during wellbore clean-up operations, but discharges will only occur below permitted thresholds and would then be expected to disperse and rapidly dilute further once in the marine environment. Whilst some drilling fluids and completion brine chemicals can be toxic, only organisms located at the discharge point will be exposed to concentrations exceeding toxicity thresholds (Boehm et al., 2002). At these concentrations impacts on plankton will be negligible.

As such, a short-term temporary release of a contaminated fluid will not present a risk to the planktonic community. The long-term impacts of released contaminants are considered negligible due to the dilution factor, the low concentrations released, and the time frame involved.

Discharged cement will fall to the seabed and set as a hard substrate. Therefore, it is not expected that there would be deterioration in water quality or any significant impact on plankton from a release of cement during drilling.

7.4.3 Impacts to Fish and Shellfish

Fish that lay their eggs on the sediment (e.g., herring) or which live in intimate contact with sediments (most shellfish) are susceptible to smothering by discharged solids (such as cuttings) and physical disturbance of the seabed (Section 6).

The highly mobile pelagic finfish are unlikely to experience an impact from the discharges presented within this section. Fish disturbed by drilling operations are likely to return to the area once drilling activities have completed. Through feeding on benthic organisms, fish and shellfish may be exposed to chemical and/ or metal contaminants and these benthic organisms may have been exposed to low levels of contaminants. However, this food web exposure would be of a low concentration and localised and be limited to individual organisms with little or no impact to species' populations in the area. The chemical additives in WBM are generally water soluble and are expected to dissolve, dissociate and disperse during settlement through the water column. Overall, with the low toxicity of WBM and dispersion due to the local current regime in the area, the environmental impact of drilling discharges on the water column is likely to be negligible.

Discharged cement will fall to the seabed and set as a hard substrate. Therefore, it is not expected that there would be a significant impact on fish and shellfish from a release of cement during drilling.

7.4.4 Impacts to Protected Habitats and Species

Although Fulmar MCZ designated for the protection of subtidal sands, subtidal muds, subtidal mixed sediments and ocean quahog overlaps with the Talbot location no significant impact on the Fulmar MCZ conservation objectives is anticipated to occur from the proposed discharges to sea. Surveys indicate that there are no additional Annex I protected habitats or features of conservation importance as protected under Annex I of the EU Habitats Directive within the development area (Gardline, 2019a; Gardline, 2019b; Section 4).

The presence of the ocean quahog, listed on the OSPAR threatened and/or declining species, has been recorded within the central North Sea and recorded in the nine samples taken in the Fulmar MCZ during the EBS of the Talbot Field Development area (Gardline, 2019b; Section 4). It should be noted that single siphons potentially belonging to live ocean quahog were observed at one sampling station and one transect within Fulmar MCZ (one individual at each location); in addition, dead shells were recorded on one transect within Fulmar MCZ (Gardline, 2019b). Although present, the anticipated impact on the species within the MCZ is negligible. The further effects of Talbot upon this species have been discussed in Section 6.4.3.

7.5 Cumulative and In Combination Impacts

No cumulative impacts are expected from discharges associated with other oil and gas activities in the vicinity of proposed project. The other considerations for cumulative impacts include the cuttings plies and cement discharges to seabed. The cuttings piles produced at the drill centre are not expected to overlap spatially.

Further, given the staged nature of the drilling campaigns, temporal overlap is not anticipated such that any plumes produced will remain separate from another.

The potential impact of the cuttings piles has been assessed without a consideration of natural processes, for example sediment dispersal: the drilling of the wells at the drill centre has the potential to produce cutting piles of 722 m^3. Within the central North Sea, cuttings pile volumes are estimated at 700,000 m^3 (UKOOA, 2000), of which the Fulmar pile at 25,521 m^3 is considered one of the largest (Gerrard et al., 1999). The Talbot cuttings piles would therefore contribute an additional 0.11% of the total central North Sea cuttings pile volume. Consequently, the cumulative effects of discharged cuttings for Talbot are considered negligible. The localised settling of discharged cement also means that cumulative effects will be negligible.

Although cuttings piles immediately around the wellsite could be expected to remain for a long period of time, given the very small area of seabed they occupy (Section 6) and hydrodynamic forces that will act to flatten them, these piles will not be expected to have a significant impact on the area.

7.6 Transboundary Impacts

The Talbot Field Development area is located 7 km east from UK/ Norway median line. However, the impacts presented within this section will be localised within UK waters, resulting in no detectable transboundary impacts being identified. No global impacts are anticipated.

7.7 Mitigation Measures

The planned mitigation measures that Harbour will undertake to minimise the impact of discharges to sea, are detailed in Table 7:8.

Table 7:8 – Potential sources of impact and planned mitigation measures

Potential source of impact	Planned mitigation
Permitted discharge of WBM cuttings	The use and discharge of the drilling chemicals will be approved under a drilling application with a chemical permit. Permitted discharge is the conventional disposal method for WBM cuttings. WBM formulations to use mainly PLONOR chemicals.
LTOBM	Either a Hellenes Thermal Treatment Unit or a Rotomill will be used to separate water and hydrocarbons from solids Oily wastes will be shipped to shore for treatment LTOBM cuttings will be skipped and shipped to shore for treatment and disposal if these systems are not available
Cement discharge	Use and discharge of cementing chemicals are subject to risk assessment and consent under a drilling application with a chemical permit. Cement returns monitored by ROV and mixing will stop as soon as returns are observed. Excess dry cement will be shipped to shore. Cement volumes will be carefully calculated and volumes of excess cement will be minimised by following good operating procedures.
Wellbore clean-up	Well clean-up fluids routed to dedicated clean-up on the platform.

Potential source of impact	Planned mitigation
	Chemicals assessed and well clean-up subject to drilling application submitted to BEIS. Discharges will be sampled and analysed prior to discharge to ensure permit conditions are achieved prior to discharging fluids.
Produced Water	Produced fluids from Talbot will be routed to the Judy platform where produced water will be treated and discharged overboard as per existing platform permit. The discharges of produced water and associated chemicals are regulated by the OPPC and OCR regulations and reported through the Environmental Emissions Monitoring Scheme (EEMS). As such, during abnormal operations, Harbour will ensure that sampling, analysis and reporting are undertaken in line with the regulations and permit conditions.

7.8 Conclusions

During the Talbot Field Development, discharges to sea primarily result from the drilling phase. These constitute cuttings, cement and associated chemicals. Discharged cuttings will consist of, seabed constituents, seawater, sweeps and WBMs and as such will have no toxic effects upon the marine environment. The potential effects are anticipated to be smothering and/ or habitat loss. Existing evidence suggests that seabed recovery will commence shortly following completion of drilling operations. The presence of drill cuttings piles is expected to remain over the long-term.

Given the regulatory requirements for the selection and use of discharges, in combination with the opportunity for dispersal, the marine environment is expected to recover quickly from such activities. Despite discharges associated with Talbot occurring within the Fulmar MCZ long term impacts to the area are not considered to be significant following cessation of production and decommissioning operations conditions should be near to pre-operational status.

Based on the consideration and calculation of planned discharges to sea during the drilling, installation, commissioning and operational stages, it is anticipated that some short-term and localised impacts will be observed in the surrounding marine environment.

Applying the risk assessment methodology described in Section 5 and taking account the mitigation measures listed above, the environmental risk associated with the discharges to sea is considered low. The environmental risks are therefore considered acceptable when managed within the additional controls and mitigation measures described with no impact to the Fulmar MCZ site conservation objectives. Discharges that do occur will be diluted before entering the marine environment and of low toxicity with smothering events may impact individuals near the wellsite but will have a negligible impact away from the immediate area. All impacts will be localised and limited.

8 Atmospheric Emissions

The environmental impact assessment, ENVID and subsequent informal consultations with stakeholders (Section 5) identified potentially significant impacts that could arise from atmospheric emissions resulting from:

- Fuel combustion onboard the drilling rig, and associated support/installation vessels and helicopters while developing the Talbot Field;
- Flaring during drilling activities;
- Production operations on the Judy Platform; and
- Decommissioning of subsea infrastructure

Atmospheric emissions generated by offshore operations are primarily associated with combustion for power generation, flaring of hydrocarbons and incidental releases from firefighting and refrigeration equipment.

The main exhaust gases that will be emitted are carbon dioxide (CO_2), together with small quantities of carbon monoxide (CO), oxides of nitrogen (NO_X) and sulphur (SO_X) and trace quantities of volatile organic compounds (VOCs), nitrous oxide (N_2O) and methane (CH_4). The emissions involved are implicated in atmospheric pollution on both local and global scales.

This section quantifies the worst-case atmospheric emissions that will arise from identified sources at the development of Talbot and provides an estimate of emissions during drilling, installation, and production activities. The measures that will be put in place to both minimise emissions, optimise energy use and align the North Sea Transition Deal (NSTD), UK Net Zero Strategy and Energy White paper are also described.

8.1 Regulatory Context

Gaseous emissions generated as a result of the Talbot project will be managed in accordance with current legislation and standards, as detailed within Section 1.

8.2 Approach

The worst-case emissions that could potentially arise from Talbot activities are compared against the 2018 UKCS emissions which are used as the benchmark comparator, forming the basis of the NSTD target reduction of 50% of 2018 UKCS emissions by 2030 (BEIS, 2021). For drilling of the wells and installation of the subsea infrastructure, the methodology estimates atmospheric emissions from vessel operations based on the numbers and types of vessels, the duration and type of operations, the average daily consumption of fuel based on vessel type and published conversion factors for the unit amounts of various gases emitted when fuel is burnt (OGUK, 2019; Institute of Petroleum (IoP), 2000). In addition, worst-case emissions (P90) from Talbot have been compared with the “base-case” emissions from Judy, in the event that Talbot was not developed.

Emissions from flaring of production fluids are estimated based on the total masses of gas and oil burnt and published emission factors for the combustion of those fluids. Estimates of atmospheric emissions resulting from power generation are based on the quantity of fuel (gas or diesel) that will be consumed and published emission factors for fuel combustion. Emission factors, which provide an estimate of the typical amount of each gas produced per unit of a fuel, were taken from UKOOA (2002b), IoP (2000) and EEMS (2008).

The gases produced from the planned operations are known to have the potential to contribute to several environmental processes and impacts including global warming (greenhouse gases), acidification (acid rain), the formation of low-level ozone and local air pollution.

The most commonly used indicator of atmospheric emissions is the Global Warming Potential (GWP), expressed in tonnes of carbon dioxide equivalents (CO_2e). GWP is a measure of the radiative effect of a given gas relative to that of CO_2, integrated over a chosen time horizon (typically a 100-year time period). Simply stated, the GWP of a specific gas is a measure of its climate change impact relative to CO_2 (AEA, 2007). All gaseous substances that contribute towards global warming (for example, CO_2, CH_4, N_2O, CO, and NO_X) have a GWP factor that allows the conversion of individual emissions into CO_2e. As such, GWP can be used to estimate the potential future impacts of gaseous emissions upon the climate system. The GWP factor of each of the most common combustion gases is given in Table 8:1.

Greenhouse gases (GHGs) can be divided into direct and indirect GHGs. Direct GHGs have an effect on the balance of energy entering and exiting the atmosphere (radiative forcing) and include combustion gases such as CO_2, CH_4 and N_2O, as well as naturally occurring gases such as tropospheric ozone (O_3). Reactive gases such as carbon monoxide (CO), VOCs, nitrogen oxides (NO and NO_2) and SO_2 are termed indirect GHGs. These pollutants are not significant as direct greenhouse gases but, through atmospheric chemistry, they impact upon the abundance of the direct greenhouse gases thereby increasing the overall greenhouse effect.

The environmental effects of the most common combustion gases are summarised in Table 8:1.

Table 8:1 – Environmental effect of atmospheric emissions

Gaseous emission	Environmental effect	100-year GWP factor*
Direct greenhouse gases		
Carbon dioxide (CO_2)	CO_2 is a GHG, meaning that it inhibits the radiation of heat into space, increasing temperatures at the Earth's surface.	1
Methane (CH_4)	Contributes to climate change.	29.7
Nitrous oxide (N_2O)	Contributes to climate change.	273
Indirect greenhouse gases		
Carbon monoxide (CO)	Direct effects upon human health (asphyxiate). May contribute indirectly to climate change.	1.6
Oxides of nitrogen (NO_x)	NO_x has direct effects upon human health and vegetation - causes respiratory illness and irritation of the mucous membranes. NO_x acts as a precursor to low-level ozone formation. It also contributes to acid deposition (wet and dry) which can impact freshwater and terrestrial ecosystems.	5**
Volatile organic compounds (VOCs)	VOCs, which include non-methane hydrocarbons (NMHC) and oxygenated NMHC (alcohols, aldehydes, and organic acids), have short atmospheric lifetimes (fractions of a day to months) and small direct impact on radiative forcing. VOCs influence climate through their production of organic aerosols and their involvement in photochemistry — production of ozone (O_3) in the presence of NO_x and light. Generally, fossil VOC sources have already been accounted for as release of fossil C in the CO_2 budgets and therefore are not counted as a source of CO_2e.	5.6
Sulphur dioxide (SO_2)	SO_2 has direct health effects - causes respiratory illness. It also contributes to acid deposition (wet and dry), which can impact freshwater and terrestrial ecosystems.	n/a
Other		

Gaseous emission	Environmental effect	100-year GWP factor*
Particulate matter (PM)	The environmental effect of particulate matter is mainly determined by the size (and shape) of the particles. Particles emitted from modern diesel engines (commonly referred to as Diesel Particulate Matter) are typically in the size range of 100 nanometres (0.1 micrometre) and can penetrate the deepest part of the lungs. In addition, these soot particles also carry carcinogenic components. In high concentrations particulate matter can also affect plant growth.	n/a

Notes: *GWPs are from IPCC Sixth Assessment Report (2021) and refer to the 100-year horizon values.
**The GWP factor of 5 is for surface emissions. Higher altitude emissions (from aircraft) have greater impacts both because of longer NO_X residence times and more efficient tropospheric Ozone (O_3) production, as well as enhanced radiative forcing sensitivity. NO_X emissions from aircraft can therefore have GWPs in the order of 450 for considering a 100-year time horizon. It must be noted however that these numerical values are subject to large quantitative uncertainties.

8.3 Sources of Potential Impact

Several activities associated with the installation of subsea infrastructure and operation of the HDJU rig will release gases to the atmosphere which have the potential to affect air quality at a local level and contribute to global greenhouse gas emissions. The following activities were assessed as part of the environmental impact assessment (Section 5) as sources of atmospheric emissions:

New Infrastructure materials and fabrication

- The production of materials from mining, refining, forming and transport

Drilling and installation activities -

- Consumption of diesel fuel by installation and construction vessels;
- Power generation on the HDJU rig; and
- Vessels and transportation (construction, rock placement, trenching, pipelay, survey, guard, standby and supply vessels, and helicopters).

Production activities –

- Additional power generation on the Judy Platform from Talbot and flaring.

Additional projects for emissions reduction under consideration include optimising the main oil line export pumps, optimising the cooling medium and seawater lift systems, operate on minimum generation (when reliability allows), and optimise the export gas compression system. Given the early stages of each study, these projects are not expected to be decided upon until the end of 2022 at the earliest. Each of these opportunities have their own challenges, given that brownfield modifications may encounter space, weight, resourcing, bedding, system interface and also outage alignment issues. These potential emission reduction measures are not discussed further within this ES.

8.3.1 New Infrastructure materials and fabrication

The production of materials, (mining raw materials, refining, forming, transportation) results in the emission of CO_2e, termed embodied carbon. The embodied carbon in the context of the Talbot Field Development is in relation to the new infrastructure, i.e. the pipe-in-pipe (PiP) flowline, umbilical, spools, well casing and concrete mattresses. The existing Judy infrastructure is not considered as no new emissions will be required to produce materials or for fabrication and no new equipment is planned to be installed on Judy discrete to Talbot requirements.

The quantities material in each item of Talbot infrastructure were calculated based on the available data with expert engineering knowledge. Carbon conversion factors (IPCC, 2021) were applied to obtain the values for the embodied carbon in the materials.

The total embodied carbon for the Talbot Field Development (flowline tied back to Judy) was determined to be 28,129 tonnes CO_2e with a 16" / 10" PiP flow line. This increases to 32,170 tonnes CO_2e with the alternative 18" / 12" PiP flowline option (Table 8:2; XODUS, 2022).

As Talbot is a small subsea development tie-back the embodied carbon in the design is relatively low and many of the elements included could be decommissioned and recycled at the end of field-life, in addition steel line pipe which is the main constituent of much of the subsea infrastructure contains a varying proportion of recycled steel and is rarely made from virgin steel alone. As such the embodied carbon in the design represents a minimal carbon impact if all recycling options are realized at decommissioning.

Table 8:2 – Embodied carbon associated with the new infrastructure for the Talbot Field Development

Infrastructure	Base-Case CO_2e Tonnes - (%)	Base-Case CO_2e Tonnes - (%)
Pipe-in-pipe	16" / 10"	18" / 12"
	15,667 – (57.4)	20,009 (62.8)
Rigid tie-in spools*	183	183
Electro-hydraulic control umbilical	2364 – (8.4)	2364 – (8.4)
Subsea structures	1,202 – (4.3)	1,202 – (4.3)
Wells	8,412 – (29.9)	8,412 – (29.9)
Total	**28,129**	**32,170**

Note: *Percentage included with PiP calculations

8.3.2 Installation and Drilling Operations

During the drilling stages of four wells at the drill centre a HDJU rig, three anchor handling vessels (AHVs), one standby vessel and one supply vessels will be present at the Talbot location for varying amounts of time and will burn diesel fuel, which will result in gaseous emissions. The emissions caused by the power generation on board of the drilling rig have been included as a total of vessel emissions (Table 8:3).

Table 8:3 presents the estimated gaseous emissions for the offshore vessels and Table 8:4 presents the estimated gaseous emissions for helicopter activities for the drilling and construction operations.

Table 8:3 – Estimated gaseous emissions for the drilling and support vessels

Emissions	Days	Fuel consumption		Emissions per tonne						
		t/day	tonnes	CO_2	CO	NO_x	N_2O	SO_2	CH_4	VOC
Marine diesel factors				3.2	0.008	0.059	0.00022	0.004	0.00027	0.0024
HDJU Rig										
Mob/ Demob	14	13	182	582.400	1.456	10.738	0.040	0.728	0.049	0.437
Working	307	13	3991	12,771.200	31.928	235.469	0.878	15.964	1.078	9.578
AHV 1										
Mob/ Demob	4	17	68	217.600	0.544	4.012	0.015	0.272	0.018	0.163
Working	10	50	500	1,600.000	4.000	29.500	0.110	2.000	0.135	1.200
AHV 2										
Mob/ Demob	4	17	68	217.600	0.544	4.012	0.015	0.272	0.018	0.163
Working	10	50	500	1,600.000	4.000	29.500	0.110	2.000	0.135	1.200
AHV 3										
Mob/ Demob	4	17	68	217.600	0.544	4.012	0.015	0.272	0.018	0.163
Working	10	50	500	1,600.000	4.000	29.500	0.110	2.000	0.135	1.200
Standby vessel										
Mob/ Demob	14	5	70	224.000	0.560	4.130	0.015	0.280	0.019	0.168
Working	307	5	1535	4,912.000	12.280	90.565	0.338	6.140	0.414	3.684
Supply vessel										
Mob/ Demob	14	8	112	358.400	0.896	6.608	0.025	0.448	0.030	0.269
Working	307	8	2456	7,859.200	19.648	144.904	0.540	9.824	0.663	5.894
Total vessel atmospheric emissions from drilling operations				32,160.000	80.400	592.950	2.211	40.200	2.714	24.120

Sources: EEMS (2008), UKOOA (2002b), IoP (2000).

Table 8:4 – Estimated gaseous emissions for helicopter activities during drilling and construction operations

Emissions	hours	Fuel consumption		Emissions per tonne						
		t/hour	tonnes	CO_2	CO	NO_x	N_2O	SO_2	CH_4	VOC
Aviation fuel factors	*	**		3.2	0.0052	0.0125	0.00022	0.004	0.000087	0.0008
Helicopters										
Helicopters	831	0.523	434.613	1,390.762	2.260	5.433	0.096	1.738	0.038	0.348
Total atmospheric emissions from helicopter operations				**1,390.762**	**2.260**	**5.433**	**0.096**	**1.738**	**0.038**	**0.348**

Notes: * Based on 5 helicopter flights (3 hr return trip) per week during drilling, 2 helicopter flights per week during subsea construction.
** Based on a helicopter fuel consumption rate of 615 litres/ hour (0.523 tonnes/ hour) .

8.3.3 Subsea Infrastructure Installation

During the subsea infrastructure installation stage, one subsea construction vessel, one pipelay vessel, one trenching umbilical vessel, one subsea umbilical vessel, one survey vessel, one rock dump vessel and one guard vessel will be present at Talbot for varying amounts of time and will burn diesel fuel, which will result in gaseous emissions. Subsea installation includes the pipeline, drilling template, umbilical and manifold.

Table 8:5 presents the total estimated gaseous emissions for the period for installation of subsea infrastructure.

Table 8:5 – Estimated gaseous emissions for the construction and subsea installation vessels

Emissions	Days	Fuel consumption		Emissions per tonne						
		t/day	tonnes	CO_2	CO	NO_x	N_2O	SO_2	CH_4	VOC
Marine diesel factors				3.2	0.008	0.059	0.00022	0.004	0.00027	0.0024
Dive Support Vessel										
Mob/ Demob	21.46	8.5	182.41	583.712	1.459	10.762	0.040	0.730	0.049	0.438
Transit	8.72	38	331.36	1,060.352	2.651	19.550	0.073	1.325	0.089	0.795
Working	67.24	18	1210.32	3,873.024	9.683	71.409	0.266	4.841	0.327	2.905
Pipelay vessel										
Mob/ Demob	4.35	18	78.3	250.560	0.626	4.620	0.017	0.313	0.021	0.188
Transit	1.46	84	122.64	392.448	0.981	7.236	0.027	0.491	0.033	0.294
Working	4.08	26	106.08	339.456	0.849	6.259	0.023	0.424	0.029	0.255
Trenching Support Vessel										
Mob/ Demob	4.51	10	45.1	144.320	0.361	2.661	0.010	0.180	0.012	0.108
Transit	2.92	36	105.12	336.384	0.841	6.202	0.023	0.420	0.028	0.252
Working	5.21	17	88.57	283.424	0.709	5.226	0.019	0.354	0.024	0.213
Construction Support Vessel										
Mob/ Demob	20.57	7.5	154.275	493.680	1.234	9.102	0.034	0.617	0.042	0.370
Transit	9.36	32	299.52	958.464	2.396	17.672	0.066	1.198	0.081	0.719
Working	24.17	14	338.38	1,082.816	2.707	19.964	0.074	1.354	0.091	0.812
Survey vessel										
Mob/ Demob	2.5	7	17.5	56.000	0.140	1.033	0.004	0.070	0.005	0.042
Transit	1.25	24	30	96.000	0.240	1.770	0.007	0.120	0.008	0.072
Working	23.25	11	256.08	819.456	2.049	15.109	0.056	1.024	0.069	0.615
Rock Dump Vessel										
Mob/ Demob	2	23	46	147.200	0.368	2.714	0.010	0.184	0.012	0.110
Working	27	23	621	1,987.200	4.968	36.639	0.137	2.484	0.168	1.490
Transit	0.5	23	11.5	36.800	0.092	0.679	0.003	0.046	0.003	0.028
Guard Vessel										
Working	167	4	668	2,137.600	5.344	39.412	0.147	2.672	0.180	1.603
Total vessel atmospheric emissions from subsea operations*				**15,078.896**	**37.697**	**278.017**	**1.037**	**18.849**	**1.272**	**11.309**

Note: *Subsea operations - i.e., pipelines and manifold installation.
Sources: UKOOA (2002b), IoP (2000).

8.3.4 Production Operations

Routine operations have the potential to produce air emissions throughout the 10-year field life of Talbot. These operations are associated with the power generation on the Judy Platform, shuttle, and support vessels, clean-up/ start up, and flaring. The sources of the atmospheric emissions resulting from Talbot production activities are detailed below, with further detail provided in Section 3.

8.3.4.1 Judy Platform Power Generation

Power generation requirements on the Judy Platform are likely to increase from current operations. If total throughput, with Talbot, requires operation of a second gas compression turbine this will result in an increase in emissions and if required is likely to be early in the life cycle, 2024 and 2025. If a second turbine is not required or not required for long, then additional energy requirements from Talbot at Judy will be minimal and further improve the efficiency of the plant in terms of production for emissions generated. Cold Start Up has been included as a worst-case for the life of the project. This is captured through the estimated flaring during field life in a following section on ‘Flaring’.

8.3.4.2 Vessel and Helicopter Emissions

Power generation onboard the support and standby vessels over the field life (10 years) will result in the emissions of various combustion gases. In addition, helicopter traffic to and from the Judy Platform will also result in various combustion gases. The estimated total annual gaseous emissions for helicopter flights during the 10-year field life operations are presented in Table 8:6.

Table 8:6 – Estimated total annual gaseous emissions for helicopter flights during field operations

Emissions	hours	Fuel consumption		Emissions per tonne						
		t/hour	tonnes	CO_2	CO	NO_x	N_2O	SO_2	CH_4	VOC
Aviation fuel factors	*	**		3.2	0.0052	0.0125	0.00022	0.004	0.000087	0.0008
Helicopters										
Helicopters	780	0.523	407.94	1,305.408	2.121	5.099	0.090	1.632	0.035	0.326
Total atmospheric emissions from helicopter operations				**1,305.408**	**2.121**	**5.099**	**0.090**	**1.632**	**0.035**	**0.326**

Notes: * One helicopter flight every two weeks during operations.
** Based on a helicopter fuel consumption rate of 615 litres/ hour (0.523 tonnes/ hour).

8.3.5 Flaring

Harbour anticipates that a maximum of 8,138 tonnes of gas will be flared intermittently over the life of the field; equating to 20.8 days of flaring from the 3,650 days of the field life. During the drilling phase (2022 to 2023) approximately 2,904 tonnes of oil will be flared. This equates to three 3 days in total of the 1,095 days estimated for drilling. Table 8:7 presents a summary of the total emissions (tonnes) resulting from the proposed flaring during operations on the Judy Platform across the life of the Talbot Field Development. This table also gives the estimated average quantity of emissions generated from flaring for one year, as a percentage of total UKCS flaring emissions.

In the conditions that prevail offshore, dispersion of the emissions generated during the flaring will ensure that, outside of the immediate vicinity of the flare tip, all released gases will be present in low concentrations only (Table 8:8).

Table 8:7 – Summary of estimated gaseous emissions from the proposed flaring

Emissions	CO_2	CO	NO_x	N_2O	SO_2	CH_4	VOC
Emission Factors (per tonne):							
Oil*	3.20	0.018	0.0037	0.000081	0.000013	0.025	0.025
Gas*	2.80	0.0067	0.0012	0.000081	0.000013	0.045	0.005
Gaseous emissions based on 1 MMscf/day and 0.97 m^3 oil over 3,640 days (tonnes):							
Oil / condensate	9,292.86	52.27	10.74	0.24	0.04	72.60	72.60
Gas	22,785.94	54.52	9.77	0.66	0.10	366.20	40.69
Total emissions from flaring	**32,078.80**	**106.79**	**20.51**	**0.90**	**0.14**	**438.80**	**113.29**

Note: * Emission factors derived from Table 12 (Emission factors for well testing) in the Environmental and Emissions Monitoring System Guidelines 2008. Emission factors in tonne/ tonne. Source: EEMS (2008).

Table 8:8 – Summary of average annual estimated gaseous emissions from flaring

Activity	Emissions (tonnes)						
	CO_2	CO	NO_x	N_2O	SO_2	CH_4	VOC
Total estimated oil and gas emissions from flaring from Talbot Field life	32,078.80	106.79	20.51	0.90	0.14	438.80	113.29
Average estimated oil and gas emissions from flaring for one year	3,207.88	10.68	2.05	0.09	0.01	43.88	11.33
Emissions from UKCS flaring**							
Total emissions from 2018 UKCS flaring*	3,036,000	7,030	11,159	ND	534	10,005	11,523
Average of one year of flaring as a % of 2018 UKCS flaring	0.11	0.15	0.02		0.003	0.44	0.10
Emissions from UKCS Offshore Exploration and Production Activities***							
Total emissions from 2018 UKCS offshore exploration and production operations 2018	13,200,000	30,565	48,516*	ND	2,322*	43,500	50,100
Average of one year of Talbot flaring as a % of total 2018 atmospheric emissions to air from UKCS offshore oil and gas installations	0.02	0.03	0.00	ND	0.0006	0.10	0.02

Notes: ND – No Data available for N_2O for 2018 (OGUK, 2019); *2016 Data used; **Flaring only; ***Total emissions for offshore activities include emissions arising from: diesel, gas and fuel oil consumption, flaring, venting, direct process emissions, oil loading and fugitive emissions. This includes emissions from production and mobile drilling rigs. The data does not include emissions produced by support vessels or helicopters. 2018 used as reference year for the NSTD; Source: OGUK (2019).

8.4 Summary of Atmospheric Emissions

Combustion emissions have the potential to reduce local air quality through the introduction of contaminants such as NO_X, VOCs and particulates which contribute to the formation of local low-level ozone and photochemical smog. However, seafaring vessels, such as ships and mobile drilling units, are built and operate to standards and procedures that minimise the exposure risks to crews. Environmental receptors could potentially be in the vicinity of the operations but tend to be sparsely distributed and/ or mobile in their distribution, for example, marine mammals and seabirds.

Local impacts are further mitigated by the open and dispersive nature of the offshore environment. Any impacts at this level would therefore be difficult to measure and distinguish from background variation. On this basis, localised impacts from combustion emissions during the proposed drilling operations will likely be negligible.

It is acknowledged that on a larger scale, emissions derived from the fossil fuel combustion at the well location may contribute to cumulative worldwide environmental impacts such as global climate change, but the individual impact will be impossible to assess as these emissions will only form a very small part of the overall global air emissions. The estimated atmospheric emissions associated with Talbot are only provided here to allow for general comparison to typical values of emissions for the UK exploration and production industry and overall national emissions.

All exploration and production operations on the UKCS in 2018 (including drilling, production, flaring, and well testing) along with all offshore shipping activities generated a total of 14.84 million tonnes (Mt) of CO_2e (Table 8:9). Of this 23% is contributed by flaring alone (OGUK, 2019).

The combined embodied carbon, drilling, construction, and installation operations at Talbot, with a duration of 10 years, are estimated to generate approximately 135,940 tonnes of CO_2e, which will account for 0.92% of the overall offshore emissions for the UKCS for 2018. The total embodied carbon from production of materials used at Talbot is 32,170 tonnes CO_2e, accounting for 0.22% of the overall offshore emissions for the UKCS for 2018, assuming 18" / 12" PiP flowline option (Table 8:9). The vessel and helicopter operations during drilling, construction, and installation are estimated to annually generate approximately 54,498 tonnes CO_2e, equating for 0.36% of the overall offshore emissions for the UKCS for 2018. The vessel production operations are estimated to generate approximately 1,363 tonnes CO_2e over the 10-year Talbot lifespan. Total CO_2e atmospheric emissions from flaring is estimated to be 45,742 tonnes, together accounting for 0.32% of the overall annual offshore emissions for the UKCS in 2018 (Table 8:9). Although the emissions are small in comparison to the overall emissions from exploration and production operations on the UKCS, the potential atmospheric emissions generated during the drilling, construction, installation, and operations phases at Talbot will ultimately contribute GHGs to the atmosphere.

The historical average carbon intensity of large (greater than 10,000 tonne weight) platforms in the Central North Sea (CNS) was 58.9 kg CO_2e/boe (kg CO2e/boe is equivalent to kt CO_2e/mmboe) for platforms older than 25 years and 14.9 kg CO_2e/boe for platforms between 11 and 25 years old (OGA, 2022). Production from Judy commenced in 1997 making it 25-years old in 2022. Judy's carbon intensity in 2021 was 13.45 kg CO_2e/boe which is below the regional 2020 average for similar platforms in the CNS. The carbon intensity for Judy in 2021 was in the 10 % lowest values for CNS platforms when compared to the 2020 platform specific carbon intensity data published by the OGA (OGA, 2022).

The forecast carbon intensity over a 10-year period for Judy and Judy and Talbot forecast that there will be a 26% decrease in the Judy carbon intensity from 15.2 kg CO_2e/boe to 9.2 kg CO_2e/boe. By year-10 the reduction in carbon intensity due to the inclusion of Talbot production is predicted to be around 7% at 51.4kg CO_2e/boe compared to 55.3 kg CO_2e/boe without the Talbot production. This improvement in carbon intensity of the Judy platform is based on the power generation equipment operating with an optimal load when Talbot production flow is included. The additional emissions from Judy once Talbot is tied back are well within the range of annual variation in emissions that have occurred over the phase 3 EU ETS period. The additional production from the Talbot Field Development will be within the variability of the Judy platform emissions without Talbot and do not result in a significant elevation in regional power generation related emissions (Xodus, 2022).

Total project emissions relative to the current Judy base-case are presented in Table 8:10. The embodied carbon in the subsea infrastructure makes the largest contribution to project with emissions from operations at Judy not more than 75 ktCO_2e in any year. The total estimated Talbot associated CO_2e emissions from the project are 255 kt, of which 32.2 ktCO_2e are embodied carbon. Most of the remaining direct emissions (79.8 ktCO_2e) are operational emissions from Judy that occur during commissioning, with subsequent years showing a marginal increase and often a decrease to the forecast Judy base-case emissions in the absence of Talbot. The calculation of incremental emissions at Judy due to Talbot do not take account of any ongoing or planned emissions reduction projects on Judy.

Table 8:9 – Summary of total estimated GWP emissions from the proposed drilling and installation activities and average annual well test operations

Activity	CO_2	CO	NO_x	N_2O	SO_2	CH_4	VOC	Total GWP
Total CO_2e atmospheric emissions from embodied carbon assuming 18" / 12" PiP flowline option (in tonnes)	-	-	-	-	-	-	-	32,170
Total CO2e atmospheric emissions from all vessel and helicopter operations during drilling, construction, and installation (in tonnes)	48,630	193	4,382	913	61	120	200	54,498
Total CO_2e atmospheric emissions from all vessel and helicopter operations during operations (in tonnes)	1,305	3	25	25	2	1	2	1,363
Total CO_2e atmospheric emissions from flaring during operations (in tonnes)	32,079	171	103	244	0.1	13,032	113	45,742
Total 2018 CO_2e atmospheric emissions from UKCS oil and gas installations *	**13,200,000**	**48,904**	**242,582**	**N/A**	**2,322**	**1,291,950**	**50,100**	**14,835,858**
Total embodied CO2e emissions assuming 18" / 12" PiP flowline option as a % of total 2018 UKCS atmospheric emissions	-	-	-	-	-	-	-	0.22
Total vessel and helicopter CO_2e emissions during drilling, construction, and installation as a % of total 2018 UKCS atmospheric emissions	0.37	0.39	1.81	N/A	2.62	0.01	0.07	0.36
Total vessel and helicopter CO_2e emissions during operations as a % of total 2018 UKCS atmospheric emissions*	0.01	0.01	0.01	N/A	0.07	0.00	0.00	0.01
Total flaring CO_2e emissions as a % of total 2018 UKCS atmospheric emissions	0.24	0.35	0.04	N/A	0.01	1.01	0.04	0.30

Notes: Total vessel and helicopter operations covers the drilling, construction, and installation operations; *Environmental and Emissions Monitoring System (OGUK, 2019).

Table 8:10 – Summary of total estimated CO_2e emissions (kilo tonnes) over the expected lifespan of Talbot, relative to current Judy base-case

Activity	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Constructions (Embodied carbon and installation)	87	0	0	0	0	0	0	0	0	0	0	0	0
Operation (deviation from Judy base-case)	0	75	3.2	1.7	-0.2	-0.4	0.1	0.9	-0.1	-0.1	-0.1	-0.1	-0.1
Decommissioning	0	0	0	0	0	0	0	0	0	0	0	0	88

Notes: “Constructions (Embodied carbon and installation)” values based on larger 18”/12” PiP option.

8.5 Environmental Impacts Resulting from Atmospheric Emissions

As discussed, the gases produced from the planned operations are known to have the potential to contribute to a number of environmental processes and impacts including global warming (greenhouse gases), acidification (acid rain), the formation of low-level ozone and local air pollution. Harbour is taking steps within our operations and wider business to reduce emissions and align with the targets set by the Scottish and UK governments to reach net zero.

8.5.1 Localised Impacts

Environmental receptors present in the immediate vicinity of the operations tend to be sparsely distributed and/ or mobile in their distribution, for example, marine mammals and seabirds. Local impacts are further mitigated by the open and dispersive nature of the offshore environment. Impacts at this level are likely to be difficult to measure and distinguish from naturally variable background levels. On this basis, localised impacts from combustion emissions during Talbot operations are considered to be negligible.

8.5.2 Wide Scale Impacts

On a larger scale, emissions derived from the fossil fuel combustion at Talbot will contribute to cumulative worldwide environmental impacts such as global climate change. However, the direct impact will be impossible to assess as these emissions will only form a very small part of the overall global air emissions. The estimated atmospheric emissions associated with the development are, therefore, provided here to allow for general comparison to typical values for emissions for the UK exploration and production industry and overall national emissions to allow an assessment of any likely significant impact of the project. The GWP of the emissions associated with the development are presented in Table 8:9.

All UK operators report atmospheric emissions from production installations to Environmental and Emissions Monitoring System (EEMS) on an annual basis. Although production developments vary in, for example, size, energy requirements and types of emissions generated, these data indicate that the total amount of CO_2e emissions on the UKCS in 2018 for offshore oil and gas production was 14,835,858 tonnes (Oil and Gas UK, 2019). The EEMS dataset does not include emissions from supporting vessels such as standby vessels, which are associated with the proposed development.

Greenhouse gas emissions from all industrial processes, energy production, agriculture, and others, are collated into emissions inventories for each EU member state on behalf of DEFRA, in accordance with the UN Framework Convention on Climate Change (AEA, 2009). The most recent, available version of this inventory covers the period 1990 to 2007. In this inventory, emissions from offshore sources are not allocated to any country and are reported separately within an unallocated inventory category. Statistics for shipping, the other major source of offshore emissions, are reported separately in DEFRA's UK Ships Emissions Inventory (Entec, 2010). In combination, these data sources provide an indication of total UK annual offshore emissions and UK emissions in general, against which Talbot can be compared.

Emissions for Talbot are estimated to generate, approximately 86,668 Te CO_2e during fabrication of new infrastructure materials, drilling, installation, and construction (Table 8:9), and approximately 45,742 Te CO_2e per annum during operations. This is well within the range of emissions for existing installations on the UKCS (Table 8:9). Exploration and production operations on the UKCS in 2018 (including drilling, production, flaring, and well testing) along with all offshore shipping activities generated an annual CO_2e GWP of 14.84 Mt (Table 8:9). Compared to this value, the worst-case CO_2e of the development, combining all drilling, construction, installation and production activities, would account for only 0.90 %, which is a minor proportion of the overall annual CO_2e for the UKCS (Table 8:9).

Relative to the total UKCS atmospheric emissions, those generated during Talbot operations are not considered to be significant.

8.5.3 UK Net Zero Targets

Harbour is committed to the dual challenge that the world energy markets face, whereby an increase in energy supply is required to meet local and global demand growth, but with lower GHG emissions.

Key to this is appreciating the context of the business and understanding what Harbour can influence, either directly or indirectly, by taking action to minimise the use of energy and emission of gases with a global warming potential, all whilst the business continues to grow.

Central to this is the Scottish and UK Governments' long-term goal of being a net carbon zero economy by 2045 for Scotland and 2050 for the rest of the UK. The offshore industry and UK Government have created their pathway for the industry in achieving national and international targets through the NSTD (BEIS, 2021) which encompasses the shared goals of the UK Net Zero Strategy (HM Government, 2021), the Energy White Paper (HM Government, 2020), the UK Carbon Budgets (BEIS, 2022), and the Oil and Gas Authority (OGA) Stewardship Expectation 11 – Net Zero (OGA, 2021).

Harbour has aligned to the NSTD, UK Net Zero Strategy, Energy White paper, and the UK Carbon Budgets by setting a net zero target by 2035 (so supporting the Energy White Paper's commitment to make the UKCS a net zero basin by 2050) and continues to develop the short-term and medium-term targets to ensure the business is on the correct trajectory to net zero.

8.5.3.1 North Sea Transition Deal Targets

The NSTD introduces targets to reduce Greenhouse Gas emissions from upstream oil and gas activities through Supply Decarbonisation, against a 2018 baseline, by 10% in 2025, 25% in 2027 and 50% in 2030, while reducing carbon emissions to zero by 2050. Table 8:10 illustrates that, following the initial Greenhouse Gas emissions from the installation and commissioning of Talbot, the subsequent years will show only a marginal increase, and often a decrease to the forecast Judy base-case emissions.

With respect to the NSTD target for 2025 (10% reduction in UKCS emissions), the annual emissions from Talbot for this year accounts for 0.03% of the total UKCS emissions that would achieve this target. This is just after the peak post-development emissions in 2024. As production stabilises after this point, the Talbot Field Development emissions as a proportion of the 2030 target is 0.06% of total emissions.

It is considered that emissions from the Talbot Field Development, as a proportion of the allotted emissions from the UKCS, do not hinder progress towards the targets or adversely affect the ability of the offshore oil and gas industry to meet them.

8.5.3.2 UK Net Zero Commitments

The UK Committee on Climate Change (CCC) 6^{th} Carbon Budget (UKCCC, 2020) sets a challenging carbon budget for 2033-2037 following the adoption in law of achieving net zero emissions by 2050 (and 2045 in Scotland). The 6th Carbon Budget is based on projections of achievable GHG emissions reductions following implementation of concerted action across all industrial, municipal and public sectors, termed the Balanced Net Zero Pathway. The Pathway includes the full decarbonisation of the power sector and identifies 'opportunities to reduce existing fossil fuel energy supply emissions through measures to improve efficiency, electrify offshore platforms, apply carbon capture and storage and reduce venting, flaring and leakage of methane.' It is estimated that by 2035, the Talbot Field Development would contribute approximately 0.02% of the target 6^{th} Carbon Budget (UKCCC, 2020).

The CCC 6th Carbon Budget recommendations are in line with the OGAs Stewardship Expectation 11 – Net Zero, which set out how the oil and gas industry should reduce its GHG emissions and support delivery of the UK's net zero target. This sets out the requirement for offshore operators to reduce GHG emissions from flaring, venting and power generation. The Net Zero Stewardship Expectation 11 focuses on:

- Creating a culture of GHG emissions reduction within the UKCS;
- Ensuring GHG emissions reduction is considered throughout the Oil and Gas lifecycle; and
- Promoting collaboration between parties to support and progress energy integration to maximise emissions abatement potential, including through electrification, CCS, renewables and hydrogen.

Harbour as a company looks to meet, and ensure if not already in progress, all applicable areas required by the OGA's Stewardship Expectation 11. For Talbot project itself section D is the most pertinent. This ES focusses on the development of and production phase of Talbot and therefore sections D.6 "Development Phase", D.9 "Production Phase" then moving into D.19 "Late-life/pre-cessation of Production Phase" and finally D.25 "decommissioning Phase. Harbour is developing actions around many areas that feed directly into these expectations – Emissions Reduction Actions Plans are being developed for all assets and the Talbot development will feed into the Judy one.

As a company GHG management and performance now form key elements of hub KPI's and company goals driving behaviours to continually focus and improve in emissions reduction and management. Awareness of emissions performance is not limited to specific areas within the company or in end of year reporting only. It is now reported, tracked and discussed in asset daily reports and meetings with any unplanned increases in flaring or venting being highlighted within the asset and addressed. These actions are in line with expectations from sections A: "Measuring, reporting and tracking", B: "Corporate behaviours and decision making" and section C: "General" requiring actions such as development of GHG Emissions Reduction Action Plans and collaboration with industry peers to help meet these commitments. The company also has a Climate Change Policy (Section 1.7) that states Harbour's ambition to reach Net Zero by 2035 and that climate change matters responsibility rests with the company's Board of Directors.

In addition to the CCC 6th Carbon Budget and the OGAs Stewardship Expectation 11 – Net Zero, the UK government launched the Energy White Paper in 2020, which sets out the government's agenda for the energy sector and its role in tackling climate change through transforming the energy sector, supporting green recovery from COVID-19, and creating a fair deal for UK consumers, with the aims of achieving net zero by 2050 (2045 in Scotland).

A key element of the Balanced Net Zero Pathway used for the CCC 6th Carbon Budget builds on a study into electrification of the UKCS by the OGA which affirms that oil and gas platform electrification is essential to cutting sector production emissions (OGA, 2020). The OGA report 'UKCS Energy integration' recognises the challenges associated with offshore electrification, however it also identifies that joint industry projects that share infrastructure and seek to source power directly from offshore windfarms can improve economics OGA, 2020).

Key industry members, including Harbour, are collaborating in a multi hub CNS Electrification project which aims to significantly reduce production emissions from key CNS infrastructure through electrification, and if executed would make a material contribution to the NSTD target of reducing production emissions by 50% by 2030. The participation of multiple hubs with sufficient remaining operating lifetimes, is considered to be critical to the economics of electrification. It provides critical mass of electrical demand and spreads the cost of greenfield (electricity) infrastructure across a larger customer base over a sufficient period of time. The Talbot Field Development ties in to the longevity of the Judy platform, and as such supports the CNS

Electrification Project. Should the CNS Electrification Project proceed with J-Area participation, it is expected to offset the incremental emissions from Talbot.

As well as Harbour's commitments to achieving net zero through electrification, further elements are being looked at and incorporated into Harbour's net zero trajectory, including through emissions optimisation (optimal loading and right-sizing of direct-drive, electric drive, and power generation equipment) and flare optimisation (up to and including flare gas recovery). Harbour have already demonstrated its commitment to achieving net zero through reducing their emissions in the J-Area from baseline by approximately 13% by completing the following:

- Where possible, upgrading the air intake filtration on the power generation gas turbines;
- Operating on the optimum combination of the main oil line pumps and export booster pumps; and
- Operating on the optimal gas compressor gas turbine combination when production allows.

Talbot coming online and dependent with other J-Area fields performance at the time that feed into Judy platform may result in Judy having to utilise two of its gas compressor turbines rather than just one, as it has managed to do recently. Moving to two turbines will increase emissions from Judy though the plant will reduce back to one when able to. If this increase in turbines is required it is expected to be a temporary increase and the emissions are discussed in this section. This will not impact operation or maintenance activities as activity will be managed accordingly. Taking an expected worst-case of running two turbines early in Talbot's life cycle still results in a positive impact of Talbot on Judy's Carbon Intensity and doesn't prevent Harbour's Net Zero target.

8.6 Cumulative and Transboundary Impacts

The assessment of the impacts of atmospheric emissions, as discussed above, is unchanged by the consideration of other emission sources local to the proposed operations. Emissions from the proposed Talbot operations have the potential to combine with those from local shipping, or the existing oil and gas infrastructure in the region.

As described in Section 4, Environmental Baseline, the central North Sea is an area of intensive oil and gas activity, with several developments in the vicinity of Talbot. The nearest actively producing field to the proposed development is the Joanne Field; tied back to the Judy Platform, the same platform proposed for the Talbot Field.

Surface installations present within 40 km from Talbot Field Development area and Judy Platform, on which processing will take place, are summarised in Table 8:10.

Table 8:10 – Surface installations within 40 km from Talbot and the Judy Platform

Surface installation	Block containing structure	Distance from Judy Platform	Distance from Talbot	Operator
Jasmine JLQ Platform	30/7	8.5 km NW	24.0 km NW	Harbour
Jade Platform	30/2	17.7 km N	33.8 km N	Harbour
Fulmar AD Platform	30/16	25.4 km SW	23 km SW	Repsol Sinopec
Auk A Platform	30/16	33.2 km SW	37.2 km SW	Repsol Sinopec
Clyde Platform	30/17	27.7 km S	18.9 km SW	Repsol Sinopec

The contribution of atmospheric emissions from Talbot may increase local impacts due to the relatively small distance between the existing and Talbot and Judy Platform location. Talbot operations may, therefore, have a significant cumulative effect in combination with other local sources of emissions, however the cumulative impact of the emissions is likely to be at least partially mitigated by the highly dispersive nature of the offshore environment. In addition, the development is proposed to repurpose the Joanne South production pipeline, omitting the need for further new infrastructure and unnecessary disruption to the local environment.

As indicated in Section 8.3.4.2, on a wider scale, the additive contribution to the emissions of the overall UK oil and gas industry from the proposed operations can be viewed as of minor significance and therefore their cumulative effect is also expected to be minimal. The sensitivity of the global climate as a receptor is considered high as continued emission of GHG will risk further warming and long-lasting changes in all components of the climate system (IPCC, 2021). However, it is impossible to assess the cumulative impact of atmospheric emissions from the proposed operations to potential global environmental impacts.

Local wind conditions may result in the transboundary transport of atmospheric emissions generated at the proposed Talbot Field Development. However, as the quantities involved are minimal in relation to national scale emissions, the resulting incremental effects of transboundary emissions on other nations' total emissions levels are not expected to be detectable.

8.7 Decommissioning Phase

Decommissioning activities at the end of field life will require a short-term increase in vessel numbers relative to those present during the production phase. Additional, vessels will be involved in recovery activities associated with the wellheads, subsea infrastructure, tie-in jumpers etc. At the time of decommissioning the operator will carry out an energy balance assessment based on the Institute of Petroleum 'Guidelines for the Calculations of Estimates of Energy Use and Gaseous Emissions in the Decommissioning of Offshore Structures' (Institute of Petroleum, 2000) (or applicable guidance at the time). The assessment will include identification of all end points associated with decommissioning each structure, where end points are defined as the final states of the materials at the cessation pf the decommissioning operations, including recycling of materials and the presence of material in landfill sites. For each end point, energy use and resultant atmospheric emissions resulting from vessels, onshore transport to smelting yards, smelting activities etc. will be assessed and their environmental impacts determined. Emissions associated with decommissioning activities are not assessed further at this time.

8.8 Mitigation Measures

Harbour has conducted this work to assess the impact of the Talbot project on climate and the UK Net Zero targets and intend to embed the identification, assessment and minimisation of GHG emissions in the development of the Talbot project.

All equipment on the Judy Platform, HDJU rig and other vessels will be maintained according to a strict maintenance regime. This will help to make sure that all equipment will operate at optimum efficiency, and thus minimise the overall fuel consumption installations. All supply vessels, helicopter, and other traffic to and from the development will be managed appropriately to minimise the number of trips. Well clean up is planned to be via test separator on the Judy Platform during development well drilling which means 3 sets of potential offshore flaring will be eliminated reducing emissions during this phase.

Harbour is committed to playing a leading role in the transition to a lower carbon economy. Their immediate focus is on the following initiatives:

- Investing in a carbon capture and storage project in the UK;
- Improving plant operational efficiency, reducing flaring and methane emissions, and reviewing the feasibility of low carbon electricity to supply our installations;

- Electrification of production operations where feasible;
- Setting an internal carbon price to act as a catalyst for GHG emission reductions across the business; and
- Representing with facts and integrity the part industry needs to play in providing secure and sustainable energy to the UK and how it can contribute to evolving this energy provision.

8.8.1 Operational GHG Emissions

Harbour have produced a J-Area GHG reduction plan which includes the Judy host facility and identifies initiatives that will reduce GHG emissions. Harbour is actively engaged in both their own stand-alone assessment of the full/partial electrification of J-Block and seeking electrification solutions which are aligned with the OGA energy integration strategy.

Harbour has applied a robust and systematic approach to the identification and assessment of GHG emission reduction opportunities covering energy generation, energy demand intensity and flaring. Projects range in scale from easily applied short term opportunities to large scale decarbonization of fuel gas and electrification from shore. At the time of writing, Harbour are conducting a comprehensive energy audit programme for Judy.

Opportunities have been identified and now require scoping/study/quantification before they can be determined in the context of the asset GHG reduction plan and prioritized as appropriate. As part of the emissions reduction opportunities, Harbour are seeking to minimize the methane fugitive emissions through innovation and adoption of best practice. Incremental fugitive emissions are considered not to be significant, due to the minimal brownfield modifications required to the Judy topsides. Harbour are also part of the North Sea methane monitoring group tackling the challenge of methane emissions from North Sea assets by increasing the accuracy of emissions estimates via monitoring of emissions using drones and sensors.

Electrification of Judy is an ongoing project which would involve the installation of electric drive compression and the generation of electricity from low carbon sources. Partial or full electrification aim to reduce emissions on Judy by between 70 ktCO_2e and 170 ktCO_2e including Scope 1 & 2 emissions.

Potential emissions reduction opportunities and energy savings for Judy were identified in the Energy Savings Opportunity Scheme (ESOS) which was a process run from February 2018 to January 2019. A number of opportunities were identified and eliminated for various reasons of poor practicality or uneconomical but three were considered to have potential and carried through for further investigation and implementation if practicable:

- Single train compression in gas export compressors;
- Use of 3 out of 4 power generators; and
- Use of one out of two main oil pumps

All of the above have been implemented when possible though dependent on energy requirements and throughput of total hydrocarbons then it is necessary to adjust sometimes. The previous process though of maintaining spinning reserve as a production assurance has changed and focus now is on improved reliability and less downtime to improve efficiency and allow some systems to be turned off.

Other potential emissions reduction projects that are under investigation for Judy are listed in Table 8:11 and all have an execution date of before 2025 (XODUS, 2022). The only interdependency is between the filter upgrade projects and reducing the spinning reserve from going to 2 out of 4 generation since this results in fewer power generation gas turbines being online and therefore fewer emissions. To date there have been two filter upgrades (500 tCO_2 each) and Main Oil Line (MOL) pumps are now in 1 out of 2 operations (1,000 tCO_2). An engine has also been replaced; however, the CO_2 saving is yet to be determined.

Table 8:11 – Estimated CO_2 reduction impact

Project Description	Estimate CO_2 Reduction Impact (Tonnes per year)
Judy power generator filter upgrades	1,500 (500 for each of the three AGTs)
Optimising Power Generation	9,000
Judy MOL pumps optimisation	1,000
Destage Judy MOL pump	1,800
Cooling medium pump & sea water lift pump optimisation	1,000
Total	14,400

Note: No new measurement instrumentation will be required on Judy as the existing equipment meets the requirements for UK ETS and regulator reporting therefore this has not been identified as an opportunity for improvement for estimations of emissions.

8.8.2 Flare management

Flare minimisation and recommencement of installation production is a key driver, behind safe operations, for any & all asset trips. Flaring will be minimised and is planned to occur for start-up and shutdown. Gas produced from Talbot will be utilised for power generation on Judy Platform while fuel gas will be a combination of Judy, Jade, Joanne, Jasmine and Talbot gas streams.

Monitoring of flare combustion efficiency is an area of focus for Harbour who are screening the market for suitable technologies/services that would give flare combustion efficiency calculations. The tracking of flare unlit periods is now a regulatory requirement under the OGA flare & vent guidance and so is tracked as part of Harbour compliance.

Harbour Energy are signatories to the World Bank Zero Routine Flaring Initiative. The J-Area has a study underway to determine the feasibility of eliminating routine flaring, of which Talbot forms part of that study. Flaring on J-Area is subject to daily scrutiny by offshore and onshore operations, including ensuring that the minimum necessary quantity of gas is flared. Harbour Energy are engaging with technology providers to progress deployment of flare combustion monitoring in real time.

8.8.3 Installation, Commissioning, Maintenance and Decommissioning

The majority emissions during the different phases of the development will result from the use of vessels, which generate power through the combustion of hydrocarbons. Vessels will be owned by a 3rd Party and the activities are therefore subject to supply chain processes of contract selection and management. Minimisation of emissions from vessels will form part of the selection criteria for the installation vessels through the tendering and selection process.

- Each vessel will have a Shipboard Energy Efficiency Management Plan (SEEMP) which contains information of minimising fuel consumptions e.g., economical speeds when operationally appropriate;
- Green DP or economical speeds when operationally appropriate;
- Developing the subsea installation to minimise the number of mobilisations or demobilisations; and
- Streamlining of activities through planning to reduce the time required for vessels and helicopters will be required for these activities and will support the drive to reduce emissions.

8.9 Conclusions

Atmospheric emissions considered in this ES will be produced during fabrication of new materials, drilling and production operations, as a result of power and heating requirements onboard the HDJU rig, construction vessels, the Judy Platform, and helicopters activities as well as other associated support vessels. These emissions will contribute to local and global environmental effects. At a local level, impacts are mitigated by health and safety measures in place to control emissions and by the dispersive nature of the offshore environment. As such, any local air pollution effects are expected to be negligible.

Emissions will also contribute to global environmental issues such as climate change. The worst-case total annual total GWP contribution from Talbot during the proposed operations is relatively small (45,742 tonnes) which is 0.03% of the annual total 2018 GWP emissions at a UK wide level (14.84 MtCO_2e GWP).

9 Underwater Noise

Sources of sound from the proposed offshore Talbot Field Development installation operations have been identified and examined in an underwater noise assessment. The following three general sources of underwater noise were identified for the installation and operations phase of the development:

- Vessels used for transportation and involved in installation operations;
- Helicopters for transportation of personnel; and
- Pile driving operations associated with the installation of the drilling template and a manifold.

Sound can be categorised as continuous noise where there are no sudden rises or falls in pressure, (e.g. from vessels), or impulsive noise (e.g. from activities using piling, seismic air guns or explosives). The sources of sound from the proposed offshore Talbot Field Development construction activities have been identified. Piling operations associated with the installation of the drilling template and manifold will generate impulsive noise and the impact from these will likely dominate any of the continuous noise sources such as those from vessels, while all other installation activities will be dominated by continuous vessel noise.

A maximum of six vessels is likely to be on site at the same time during the piling and installation of the template and manifold, one each of Construction Support Vessel (CSV), Diving Support Vessel (DSV), Trenching Support Vessel (TSV), Survey Vessel (SUV), Pipelay Vessel (PLV) and Guard Vessel (GUV). All vessels aside from the guard vessel will be premised to be using dynamic positioning (DP). The underwater noise impact assessment has been based on the worst-case scenario from these vessels (BMT, 2022b).

Helicopter noise originates from disturbance of the sea surface by the downdraught from the rotor blades and transmission of engine and blade noise directly into the sea, however, sound is largely reflected from the water surface and only a small fraction of helicopter sound is transmitted into the sea.

Piling operations will include four piles (24” x 30 m) to secure one drilling template and a manifold. The installation operations are expected to take 7 hours (h) for the template, and 4 to 7 h for the manifold. The piling operations are expected to take 6 h per pile and piling operations will be sequential. During piling the predicted zero-to-peak (referred to as ‘peak’ hereafter) worst case sound source levels (SL) are 218.5 decibels (dB) re 1 microPascal at 1 metre (µPa m) for the 24” (0.610 m) diameter piles.

The exact dates of the proposed installation operations are not defined yet, but it is envisioned that the work will be undertaken during Q2 2022. This will be confirmed to the BEIS in due course. For the purposes of modelling, the metocean data have been averaged over the summer, April to September inclusive.

9.1 Regulatory Context

The control of underwater noise is driven by Conservation of Habitats and Species Regulations 2017 (‘the Habitat Regulations’), and the Conservation of Offshore Marine Habitats and Species Regulations 2017, which include a specific reference to the disturbance, injury or death of European Protected Species (EPS).

According to these regulations, it is an offence to:

- capture, injure or kill any wild animal of a European Protected Species (EPS); or
- disturb wild animals of any such species.

Disturbance of animals is defined under the Regulations and includes, in particular, any disturbance which is likely to impair their ability to:

- survive, breed, rear or nurture their young; or
- hibernate or migrate (where applicable); or

- significantly affect the local distribution or abundance of the species to which they belong.

In a marine setting, EPS include all the species of cetaceans (whales, dolphins and porpoises) (JNCC, 2010). As underwater noise has potential to cause injury and disturbance to cetaceans, an assessment of underwater noise generated by the subsea installation operations is required in line with guidance provided by the JNCC (JNCC, 2010).

9.2 Approach

The impact of underwater noise on any sensitive receptors is assessed here using a modelling approach, which includes the identification of potential noise sources, an evaluation of the levels and frequencies, an introduction to relevant underwater noise propagation pathways and the appropriate assessment model, followed by an impact assessment. The assessment results are then compared against relevant values from the literature, addressing both behavioural impacts to and injury of the target species. Any identified potential issues are then evaluated with respect to transboundary and cumulative impacts.

For this study, sound propagation from the source was determined using the Marsh- Schulkin model (Schulkin and Mercer, 1985). This model applies to acoustic transmission in shallow water (up to approximately 185 m) and represents sound propagation loss in terms of sea state, substrate type, water depth, frequency and the depth of the mixed layer. A worst-case scenario was used for the underwater noise modelling. A description of the noise quantification, the Marsh-Schulkin model and the parameters used in the model are given in Appendix C.

9.3 Sources of Potential Impact

The sources of sound associated with the proposed subsea installations will vary depending on which activity is underway. However, the main potential sources are vessels, helicopters and piling. The typical level and frequency of sound generated by each source was obtained from published studies ((NMFS, 2018; Southall et al. (2019)) and summed accordingly to generate a cumulative sound level.

9.3.1 Assumptions

In order to model the worst-case scenario, it has been assumed that all sources will operate at all times during each activity. In reality, this will not happen, and the source level is likely to be lower than that predicted within this assessment.

9.3.2 Operations Relevant to Impact Noise Assessment in the Talbot Area

Noise sources resulting from the Talbot Field Development installation operations are detailed in the following sub-sections.

Vessels

Most forms of oil and gas installation activities are typically dominated by vessel noise which is continuous and as such is not captured within the Marine Strategy Framework Directive (MSFD) descriptor for loud, low and mid-frequency impulsive sounds. Broadband source levels for these activities rarely exceed about 190 dB re 1 µPa m and are typically much lower (Hannay and MacGillivray, 2005; DECC, 2011). Whilst continuous noise can mask biologically relevant signals such as echolocation clicks, the sound levels are below the threshold levels for Temporary Threshold Shift (TTS) in cetaceans according to the Southall et al. (2007) criteria (DECC, 2011).

The level and frequency of sound produced by vessels is related to vessel size and speed, with larger vessels typically producing lower frequency sounds (Richardson et al., 1995). Noise levels depend on the operating status of the vessel and can therefore vary considerably with time. In general, vessels produce noise within the range 100 Hz to 10 kHz, with strongest energy within the range of 200 Hz to 2 kHz.

The subsea noise levels generated by surface vessels used during the installation activities are unlikely to result in physiological damage to marine mammals. Depending on ambient noise levels, sensitive marine mammals may be locally disturbed by noise from a vessel in its immediate vicinity, however, the impact is not expected to be significant.

Various combinations of vessels will be on site during the installation operations and for the purposes of modelling it has been assumed that a maximum of six will be operating in the area at any one time. Source levels resulting from a study giving the average of ten merchant ships (lengths 89 to 320 m, average 194 m) during entry or exit to port were used as a basis for this assessment (Hallett, 2004). These data are more conservative than many of the published examples for specific construction and support vessels.

For continuous sound such as shipping noise, it is usual to use a measure of the total root mean squared (rms) sound intensity of a signal. However, the larger zero-to-peak values have been used in the modelling to illustrate the worst-case scenario.

Helicopters and Aircraft

Helicopter noise originates from both the disturbance of the sea surface by the downwash from the rotor blades and the transmission of engine and blade noise directly into the sea. The downwash noise is very similar to wind noise in its frequency characteristics and is greatest in the 2 to 20 kHz region. Additional strong tonals in the 10 to 100 kHz range are associated with rotors and turbine operation respectively (Harland et al., 2005).

When sound travels from air to water, the energy is largely reflected from the water surface and only a small fraction of the sound produced by the helicopter is actually transmitted into the sea. Although helicopter sound is fairly broadband (0 to 20 kHz), the lower frequency sound, up to 200 Hz, is much more pronounced (Berrow et al., 2002), and dominant tones in the noise spectra from helicopters are generally below 500 Hz (Richardson et al., 1995). The angle at which sound from the aircraft intersects the water surface is also important. At angles greater than 13° from the vertical, much of the incident sound is reflected and does not penetrate into the water (Richardson et al., 1995).

Levels and durations of sounds received underwater from a passing aircraft depend on its altitude and aspect, receiver depth, and water depth. In general, the peak received sound level in the water from aircraft directly overhead decreases with increasing aircraft altitude (Richardson et al., 1995).

Piling Operations

Some high intensity sources of underwater sound, such as pile drivers and seismic airguns can be detected over distances of several thousand kilometres (Popper and Hawkins, 2019). Impact piling involves repeated impact of the pile using a hammer to drive the pile to a desired depth in the seabed. Impact piling involves repeated impact of the pile using a hydraulic hammer to drive the pile to a desired depth in the seabed. Piling noise varies with factors such as pile dimensions, impact energy, piling technique and seabed condition (DECC, 2011). Piling generates high levels of underwater sound that is characterised as multiple impulsive sounds with long duration (Nedwell et al., 2005). The frequency spectrum is dominated by low frequency sound within the range of 100 to 400 Hz, with tones at higher frequencies (OSPAR, 2009c; Thomsen et al., 2006). Sound from piling can radiate into the water by at least three transmission paths including (Nedwell et al., 2005):

- Transmission of airborne noise into the water;

- Waterborne noise caused by structural waves created in the pile radiating out into the water surrounding the pile (generally considered the most significant); and
- Waterborne noise caused by seismic waves induced in the seabed by the piling diffracting upwards into the overlying water.

The proposed pin pile diameters are 0.610 m (24”) piles for the drilling template and manifold. Piling will be for a short duration, 6 h per pile. The predicted source sound levels generated during piling are 218.5 dB re 1 µPa m, for the 24” piles (BMT, 2022b). The sound source 1/3 octave band level data used for this study were obtained from data for the 1.5 m diameter piles fabricated during the construction of FINO-1 research platform, Germany (Thomsen et al., 2006). Sound measurements were back calculated to 1 m by the authors (after Thiele, 2002) and further adjusted for the pile diameter of the present study using Equation A1 in Appendix C.

The subsea noise levels generated by surface vessels used during the piling phase would be insignificant when compared to the noise levels generated during marine impact piling (DECC, 2011). Depending on ambient noise levels, sensitive marine mammals may be temporarily displaced by noise from a vessel in their immediate vicinity, however, the impact is not expected to be significant relative to noise from piling.

Ambient Noise

Ambient or background noise in the ocean results from sounds generated by physical factors such as wind and waves; by marine mammal vocalisations; and by other shipping. DEWI (2004) reported on ambient noise measurements from five different locations in the North Sea and this data has been used as a basis for comparison in the current study.

9.3.3 Impact on Sensitive Receptors

Underwater noise can affect the behaviour of, or may cause injury to, several different marine taxa, in particular marine invertebrates, fish and marine mammals such as pinnipeds and cetaceans. Behavioural changes will vary from a minor change in direction to confusion and altered diving behaviours, which may have varied medium and long-term effects on the individual.

Behavioural responses include any change in behaviour from small and short-duration movements to changes in migration routes and leaving a feeding or breeding site. Such responses vary between species and can depend on factors such as an organism’s age or level of motivation, or the time of day or season. Some changes in behaviour, such as startle reactions, may only be transient and have little consequence for the animal or population (Popper and Hawkins, 2019). One of the most critical issues in relation to behavioural effects of sound on marine mammals and fish is whether anthropogenic sound interferes with, or masks, the ability of the animal to detect and respond to biologically relevant sounds (Popper et al., 2014). In effect, masking raises the threshold for detection by an animal and the degree of masking is related both to the level of the masking noise and the frequencies that it contains.

Marine Invertebrates

There have been few studies of the effects of underwater noise on marine invertebrates (Edmonds et al., 2016; Hawkins and Popper, 2017; Hawkins et al., 2014; Morley et al., 2013; Cheesman et al., 2012).

Impulsive noise, which involves sudden high pressure and particle motion changes, may cause behavioural changes, physical damage, mortality, sensory damage and physiological alterations in invertebrates (Fitzgibbon et al., 2017; McCauley et al., 2017). Zooplankton underpin the health and productivity of global marine ecosystems. McCauley et al. (2017) suggested that seismic surveys cause significant mortality to zooplankton populations.

Exposure to sources of sound can result in behavioural responses that alter how species mediate ecosystem processes known to be key determinants of functioning for invertebrate species that do not rely on acoustics for communication (Solan et al., 2016). In the case of *Nephrops norvegicus*, the addition of either continuous or impulsive broadband noise repressed burying and bio-irrigation behaviour and considerably reduced locomotion activity (Solan et al., 2016). For the clam *Ruditapes philippinarum*, the introduction of an anthropogenic sound source elicited a typical stress response where individuals reduce surface relocation activity, move to a position above the sediment-water interface, and close their valves (Solan et al., 2016). These responses reduce the capacity of the organism to mix the upper sediment profile and prevent suspension feeding from taking place. Studies on cephalopods have reported behavioural and physiological responses to waterborne sound stimuli at low frequencies (Mooney et al., 2010; Kaifu et al., 2007).

The potential effects of vibration within the seabed are almost entirely unknown, despite the benthic nature of many marine invertebrates and the direct contact of many anthropogenic sound-producing activities with the seabed (Roberts and Elliott, 2017). Substrate-borne vibrational waves may also propagate through the seabed, particularly when sources directly contact the sediment (Roberts and Elliott, 2017).

Impact pile driving generates water-borne pressure and particle motions, which propagate through the water column and the seabed. Spiga et al. (2016) investigated the influence of impact pile driving on the clearance rate of the blue mussel (*Mytilus edulis*). Mussels had significantly higher clearance rates when feeding upon microalgae during exposure to pile driving compared with individuals tested in ambient conditions. This suggested that mussels under pile driving conditions moved from a physiologically maintenance state to active metabolism to compensate for the stress caused by pile driving. Roberts et al. (2016a; 2016b) found that anthropogenic substrate-borne vibrations resulting from noise pollution have a clear effect on the behaviour of a common marine crustacean the hermit crab (*Pagurus bernhardus*) and the blue mussel. At high enough acoustic energy, oysters (*Crassostrea gigas*) were observed to transiently close their valves in response to frequencies in the range of 10 to < 1000 Hz (Charifi et al., 2017).

Chemical cues and signals enable animals to sense their surroundings over vast distances and find key resources, like food and shelter. However, the use of chemosensory information may be impaired in aquatic habitats by anthropogenic activities, which generate impulsive noise. Roberts and Laidre (2019) reported that fewer marine hermit crabs were attracted to a chemical cue indicative of a newly available shell home after noise exposure in field experiments.

Although marine invertebrates may be affected by the installation activities, there is insufficient knowledge currently available to be able to make an assessment.

Fish

Fish use a variety of sensory systems to learn about their environments and to communicate. Hearing is understood to be present among virtually all fish (National Research Council, 2003) and supplies information in 3D, often from great distances. Fish use sound for communication, orientation and migration, to detect prey and predators, to determine habitat suitability, and during mating behaviour. The sensory systems used by fish to detect sounds are very similar to those of marine (and terrestrial) mammals and hence sounds that damage or in other ways affect marine mammals could have similar consequences for fish (Popper et al., 2014). Thus, the survival and fitness of individuals and populations can be impacted if the ability of a fish to detect and respond to biologically relevant sounds is impaired (Popper and Hawkins, 2019).

In considering the impact of anthropogenic sounds upon fish it is useful to place fish into different functional categories, depending on their structure and degree of hearing specialisation (Popper et al., 2014; Cheesman et al., 2012). Fish may tentatively be separated into:

- Category I - Fish with no swim bladder or other gas volume (particle motion detectors);
- Category II - Fish with a swim bladder or other gas volume, and therefore susceptible to barotrauma, but where the organ is not involved in hearing (particle motion detectors); and
- Category III - Fish with a swim bladder or other gas volume, and therefore susceptible to barotrauma, where the organ is also involved in hearing (sound pressure and particle motion detectors).

Fish species vary in many ways, anatomically, physiologically, ecologically and behaviourally in their response to sound, such that a guideline for a behavioural response can never fit all fish (Popper et al., 2014). Many finfish species display an alarm response of tightening schools, increased speed and moving towards the seabed (McCauley et al., 2003). The abilities of individual fish to coordinate their movements with one another in a group were disrupted when pile-driving sound was played back, compared to when ambient-sound was played back (Herbert-Read et al., 2017).

Most fish respond to the particle motion component of sound waves whereas marine mammals do not. Animals near the seabed may not only detect water-borne sounds, but also sound that propagates through the substrate and re-enters the water column (Popper et al., 2014).

Reviews on the effects of anthropogenic sound on fishes concluded that there are substantial gaps in the knowledge that need to be filled before meaningful noise exposure criteria can be developed (Popper et al., 2014; Popper and Hastings, 2009). However, injury thresholds have been proposed for Category II and III fish (> 207 dB re 1 µPa m) and Category I fish (> 213 dB re 1 µPa m) (Popper et al., 2014).

Pinnipeds

Pinnipeds (seals, sea lions, and walruses) also produce a diversity of sounds, although generally over a low, restricted bandwidth (generally from 100 Hz to several tens of kHz). Their sounds are used primarily in critical social and reproductive interactions (Southall et al., 2007). Available data suggest that most pinniped species have peak sensitivities between 1 and 20 kHz (NRC, 2003). However, the data available on the effects of anthropogenic noise on pinniped behaviour are limited.

Grey seals and harbour or common seals are resident in UK waters and occur regularly over large parts of the North Sea (SMRU, 2001). Both species are found predominantly along the UK coastline but there are few data available on the distribution and abundance of seals when offshore. Tracking of seals suggests they make feeding trips lasting two to three days, normally travelling less than 40 km from their haul-out sites, and with the animal ultimately returning to the same haul-out site from which it departed (SMRU, 2001). Grey seals may spend more time further offshore than common seals.

It is considered unlikely that seals will be encountered near the installation activities given the distance of the Talbot Field from the coast (278 km). Seal numbers recorded by telemetry in the survey area are 0-1 per 25 km2 for both harbour and grey seals (SMRU & Marine Scotland, 2017).

Cetaceans

Cetaceans use sound for navigation, communication and prey detection. Anthropogenic underwater noise has the potential to impact on marine mammals (JNCC, 2010; Southall et al., 2007 and 2021; Richardson et al., 1995).

Several species of cetacean have been recorded in the Talbot Field Development area. In particular, minke whale, bottlenose dolphin, common dolphin, white-beaked dolphin, Atlantic white-sided dolphin and harbour porpoise have been recorded as present in the area (Section 4.3.5; Table 4:8). As the dates for installation operations have not yet been finalised, the modelling period has been extended to run throughout the summer to allow for contingency.

9.3.4 Characterisation of Hearing Sensitivities of Marine Mammals

Currently available data (via direct behavioural and electrophysiological measurements) and predictions (based on inner ear morphology, modelling, behaviour, vocalisations, or taxonomy) indicate that not all marine mammal species have equal hearing capabilities, in terms of absolute hearing sensitivity and the frequency band of hearing (NOAA, 2018). Consequently, vulnerability to impact from underwater noise differs between species. National Oceanographic and Atmospheric Administration (NOAA) recently revised the “hearing types” classifications of different marine mammal species as in Table 9:1.

In addition, audiograms were obtained for harbour porpoise, grey and common seals (Nedwell et al., 2004) and for white-beaked dolphin (Nachtigall et al., 2008). A generalised *Mysticetes* (baleen whale) audiogram was assumed to represent the hearing ability of minke whales (Tech Environmental, 2006). No audiograms are available for common dolphin or Atlantic white-sided dolphin. However, an audiogram is available for another member of the same genus as the Atlantic white-sided dolphin, the Pacific white-sided dolphin (*Lagenorhynchus obliqidens*) (Tremel et al., 1998); and it has been assumed that members of this genus may have similar hearing characteristics.

Table 9:1 – Functional cetacean and pinniped hearing groups

Cetacean functional hearing group	Generalised Hearing Range	Species sighted in the Cotton area
Low-frequency	7 Hz – 25 kHz	Minke whale
Mid-frequency	150 Hz – 160 kHz	White-beaked dolphin Atlantic white-sided dolphin Common dolphin Bottlenose dolphin
High-frequency	200 Hz – 180 kHz	Harbour porpoise
Pinnipeds in water	75 Hz – 100 kHz	Grey seal Common seal

Sources: (National Marine Fisheries Service, 2018; Sea Mammal Research Unit (SMRU) and Marine Scotland, 2017; Southall et al., 2019, 2007; Reid et al., 2003). Note that Southall et al. (2019) reclassified mid- and high-frequency cetaceans as high- and very high-frequency cetaceans, respectively.

9.3.5 Thresholds for Injury and Disturbance to Marine Mammals

The noise level perceived by an animal (the “received noise level”) depends on the level and frequency of the sound when it reaches the animal and the hearing sensitivity of the animal. In the immediate vicinity of a high sound level source, noise can have a severe effect causing a permanent threshold shift (PTS) in hearing, leading to hearing loss and ultimately with increasing exposure, to physical injuries which may be fatal. However, at greater distance from a source the noise decreases and the potential effects are diminished (Nedwell et al., 2005; Nedwell and Edwards, 2004), possibly causing the onset of only a temporary shift in hearing thresholds (Temporary Threshold Shift (TTS)-onset). As noted above hearing sensitivity, in terms of the range of frequencies and sound levels that can be perceived, varies with species; and the minimum level of sound that a species is able to detect (the hearing threshold) varies with frequency.

It has been suggested that TTS itself is not evidence of injury (Richardson et al., 1995), although it may result from injury. During a period of TTS, the survival of the animal may be at risk. Its ability to communicate may be impaired, it may be unable to respond to predators, and its ability to seek out prey may be compromised.

9.3.6 The Southall-NOAA Approach

Southall et al. (2007) undertook a review of the impacts of underwater noise on marine mammals and used this to define criteria for predicting the onset of injury and behavioural response in marine mammals with different hearing characteristics (Table 9:2) when subjected to different types of noise (Table 9:3). The estimated bandwidths have been revised recently by the National Oceanic and Atmospheric Administration (NOAA, 2018). This distinction between noise types is required as single and multiple noise exposures at different levels and durations differ in potential to cause injury to marine mammals.

The 2007 Southall study has been updated and revised noise exposure criteria to predict the onset of auditory effects in marine mammals have been published (Southall et al., 2019). The study which includes estimated audiograms and hearing-weighted functions which are in line with the details documented in the NOAA 2018 Guidelines. The only exception is the re-classification in Southall et al. (2019) of the mid- and high-frequency hearing groups to high- and very-high- frequency groups, respectively. The current study uses the NOAA (2018) terminology.

Table 9:2 – Noise types and activities associated with the Talbot Field Development

Noise type	Definition	Installation activities
Single-pulse	Brief, broadband, atonal, transient, single discrete noise events; characterised by rapid rise to peak pressure	NA
Multiple-pulse	Multiple pulse events within 24 hours	Multiple pile strikes
Non-pulse	Intermittent or continuous, single or multiple discrete acoustic events within 24 hours; tonal or atonal and without rapid rise to peak pressure	Vessel activity

Source for definitions: Southall et al., (2007).

Southall et al. (2007) proposed a severity scaling system, which ranks the behavioural response from a zero for ‘no response’ to a nine for ‘outright panic, flight, stampede, attack of conspecifics or stranding events. A behavioural response with a severity scale of five/ six is considered to represent a disturbance, with animals showing noticeable changes in swimming pattern to minor avoidance reactions.

JNCC (2010), in their guidance on how to assess and manage the risk of causing injury or disturbance to a marine EPS as a result of activities at sea, suggest that disturbance to a marine mammal is likely to occur from sustained or chronic behavioural response with a severity scoring of five or above according to the behavioural response severity scale of Southall et al. (2007 and 2021).

Following this approach, received sound levels from the proposed installation operations that may cause a severe behavioural response have been determined, using noise studies reviewed in Southall et al. (2007), that:

- are relevant to the installation operations because they report on similar sound sources and similar species; and
- report to a behavioural response of severity five or above.

These sound thresholds are compared with the predicted sound levels generated by the installation operations to estimate a distance from the activities within which disturbance may occur.

9.4 Results

Results are presented for the impact of underwater noise generated by the piling and other installation activities (vessels-only) on marine biota. Impact radii for injury and significant behavioural disturbance have been determined for the marine mammals and fish. Estimates of the potential number of marine mammals affected are also recorded.

9.4.1 Subsea Installation Activities Involving Piling

The planned installation operations involving piling will generate a maximum estimated pulse source level (SL) of 218.5 dB re 1 µPa m (expected frequency range 100 Hz to 10 kHz [1], with near peak energy at frequencies of 100 Hz to 1 kHz before attenuation). The planned vessel-only piling operations will generate a maximum estimated source level, SL of 196 dB re 1 µPa m (expected frequency range 10 Hz to 10 kHz). However, the contribution of any vessels to the cumulative noise levels of the piling operations is negligible in comparison to the sound levels generated from the pile-driving.

The Marsh-Schulkin model (Appendix C) was used to predict the distance from the activities, beyond which the sound level would be too low for either injury or avoidance behaviour. This model is valid up to 185 m of water depth and is well within the boundary at the proposed location which has a water depth range of 75 - 80 m. The Southall-NOAA approach was used for marine mammals (Appendix C, Table D.2; Stöber and Thomsen, 2019; Southall et al., 2007; NOAA, 2016; 2018), the Popper et al. (2014) criteria for fish (Appendix C, Table B1).

A description of the noise quantification, the Marsh-Schulkin model and the parameters used in the model and full modelling results are presented in Appendix C.

Impact on Fish

Based on the injury thresholds proposed for fish (Popper et al., 2014), it is anticipated that no fish (Category I fish (no swim bladder) or Categories II and III fish (with swim bladder)) will be injured within a designated 500 m mitigation zone (Appendix C, Table B1).

Impact on Marine Mammals

Noise generated will be detectable by all mammal species present. Injury or behavioural changes varying from a minor change in direction, to confusion and altered diving behaviours may occur. These changes may have medium or long-term effects on individuals.

Southall-NOAA Approach

According to the received sound pressure level (SPL) thresholds for the onset of injury PTS may occur within 15 m of the sound source as a worse case for high-frequency cetaceans (>201 dB re 1 µPa m (peak); NOAA, 2018) (Appendix C, Table B1). Severe behavioural changes (avoidance) or TTS thresholds may be exceeded within 30 m (>195 dB re 1 µPa m (peak); NOAA, 2016) for high-frequency cetaceans (Appendix C, Table B1). Marine mammals from other functional hearing groups (Table 9:2) are unlikely to be adversely affected by any of the installation operations.

9.4.2 Injury and Behavioural Displacement of Marine Mammals

The MSFD (Van der Graaf et al., 2012) and JNCC (JNCC, 2010) suggest that ‘significant displacement’ relates to a change in the natural distribution of a sufficient proportion of individuals, both temporally and spatially,

[1] For reporting purposes for inclusion in the underwater noise register under the Marine Strategy Framework Directive (MSFD) Descriptor 11, Indicator 11.1.1 on low- and mid- frequency impulsive sounds: a SLzp of 208 dB re 1 µPa m will fall within the ‘very low’ category of source levels for generic explicitly impulsive sources, (Dekeling et al., 2014).

such that there is an adverse effect to a local population. Significant behavioural displacement can lead to abandonment of an area or habitat and results in changes in dispersion patterns.

Approximate densities of marine mammals in the Talbot Field Development area, based on the Small Cetaceans in the European Atlantic and North Sea (SCANS) III 2016 survey (Hammond et al., 2017). At sea distribution maps for grey and harbour seal (SMRU & Marine Scotland, 2017) have been used to estimate the number of animals of each species potentially experiencing injury or likely significant behavioural displacement from subsea installation activities (Table 9:3).

Table 9:3 – Estimated number of animals potentially experiencing injury or severe behavioural displacement from subsea installation operations involving piling

Species	Estimated density in area (animals/ km^2)	Estimated number of animals that may experience		
		Behavioural displacement[3]	TTS-onset	PTS-onset (injury)
Minke whale[1]	0.007	2	1	0
Bottlenose dolphin[1]	0	-	-	-
Common dolphin[1]	0	-	-	-
White-beaked dolphin[1]	0	-	-	-
Atlantic white-sided dolphin[1]	0	-	-	-
Harbour porpoise[1]	0.333	116	37	2
Common seal[2]	0.04	5	2	0
Grey seal[2]	0.04	5	2	0

[1] Source: SCANS III Survey, Hammond et al. (2017). Note that bottlenose dolphin, common dolphin, white-beaked and Atlantic white-sided dolphin were not observed in the Talbot Field Development area during the survey.
[2] Source: SMRU & Marine Scotland (2017)
[3] Calculation method based on Southall et al. (2007) as recommended by JNCC (2010), with abundance given to the nearest whole animal

As a general rule, animals do not hear equally well at all frequencies within their hearing range. Whilst noises are less likely to disturb animals if they are at frequencies that the animal cannot hear well; out of band frequencies can still cause physical injury if pressure levels are very high (Matthews et al., 2010). Frequency weighting has been developed as a method of quantitatively compensating for the differential frequency response of sensory systems (Appendix C, Section A.3). It is likely that underwater noise levels from the piling may have attenuated from peak levels before the best auditory frequency range of bottlenose dolphin is reached.

There is little empirical information on the impact of pile driving on cetacean individuals or populations and currently no direct evidence for a causal link between pile driving sound and physical injury exists (JNCC, 2010). However, auditory sensitivity data do suggest that, without mitigation, pile driving is likely to produce sound levels capable of causing injury or displacement to cetaceans (JNCC, 2010; OSPAR, 2009c). Several studies have addressed the impact of pile driving during wind farm construction on harbour porpoises (Brandt et al., 2011; Carstensen et al., 2006; Tougaard and Carstensen, 2006; Tougaard et al., 2009). Tougaard et al. (2009) found that acoustic activity from harbour porpoises decreased at the onset of piling but returned to normal several hours after cessation of piling. The area of impact extended to 21 km from the piling site for 4 m diameter steel monopiles. Tougaard and Carstensen (2006) reported similar impacts, whilst Brandt et al.

(2011) found that the time taken for harbour porpoise acoustic communication to return to baseline decreased with increasing distance from the construction site; at 2.6 km, recovery took one to three days.

Russell et al. (2016) reported that there was no overall significant displacement during construction of a windfarm. During piling, seal abundance was significantly reduced up to 25 km from the piling activity. However, displacement was limited to piling activity; within 2 h of cessation of pile driving, seals were distributed as per the non-piling scenario.

It should be noted that the estimated number of animals either injured or temporarily displaced may be an overestimate. There is no clear relationship between received SPL and likely behavioural response, and so this analysis conservatively uses the lowest reported SPL causing injury or severe behavioural response. Additionally, in practice marine mammals are likely to be sparsely located, whether as individuals or groups of individuals, and move over large areas. There may be no individuals within the estimated zones of injury or displacement at the time of the installation operations.

Scientifically, risk assessment based on noise levels is problematic, since received noise level is a poor predictor of marine mammal behavioural responses (Brandt et al. 2012; Gomez et al. 2016) and fish displacement (Handegard et al., 2013). Merchant et al. (2018) have proposed indicators based on overall exposure to the noise and the distribution of exposure. For example, a small percentage of the population may be exposed for a large percentage of time (chronic exposure), or vice versa (prevalent exposure). Overall exposure was observed to increase by season, over the year, whilst exposure prevalence was markedly lower in spring, yet chronic exposure was higher (Merchant et al., 2018).

9.4.3 Transboundary and Cumulative Impacts

The proposed development is located approximately 7 km from the UK/ Norway median line. At this distance, noise levels from pile-driving, the greatest source of sound associated with the Talbot Field Development activities, would attenuate to a level lower than that likely to cause injury or temporary displacement to any cetacean species. Therefore, there is unlikely to be a transboundary impact from the noise generated by the installation activities.

In terms of cumulative impacts from vessel and impulsive noise, it is unlikely that similar activities will be taking place during the construction period for the Talbot Field Development. Due to the distance from the Scottish coast, it is also unlikely that any piling for wind turbines coast will result in a cumulative impact. The exposure of marine mammals to vessel noise from nearby oil and gas developments and ship traffic is not likely to result in a significant cumulative impact.

9.5 Decommissioning

Decommissioning activities at the end of Talbot field life will affect the same area as the development activities and noise generated during decommissioning is likely to be of smaller impact than currently assessed. Decommissioning noise will be associated mainly with vessels presence and cutting the wellheads below the sea level, which is considered to be masked by vessels (Nedwell and Edwards, 2004). There will be no pilling operations. Considering that the residual impact from development activities was assessed as not significant, the potential impact from decommissioning activities is also likely to be not significant.

At the time of planning decommissioning activities a dedicated noise assessment will be carried.

9.6 Impacts Mitigation and Monitoring

Mitigation measures, in accordance with JNCC guidelines (JNCC, 2010) where available, will be implemented during the proposed subsea installation operations as appropriate (Table 9:4). Two Marine Mammal Observers (MMOs) will be present on the vessel during piling activities.

Table 9:4 – Mitigation measures

Potential source of impact	Planned mitigation measures
Underwater noise from piling	• Using MMO commence pre-piling searches for marine mammals 30 minutes prior to activity. This search will be undertaken within a mitigation zone of at least 500 m radius around the operations, leading to a delay in piling operations if marine mammals are detected. • Delay the commencement of piling activities should any marine mammals be detected during this pre-piling search within a radius of 500 m (the mitigation zone). • Soft-start of pile driver (20 minutes minimum), whereby the piling power is increased slowly over a set time period. This is believed to allow any marine mammals to move away from the noise source, reducing the likelihood of exposing animals to sounds, which may cause injury. In general, shorter piling times and reduced hammer energy will reduce the overall exposure levels and therefore the likelihood of injury. If it is assumed that the animal swims away at the onset of piling, then it is the initial hammer strikes which are the most critical as the SEL dose is greatest at shorter ranges and rapidly reduces with distance. • In consultation with JNCC, consideration will be given to the use of Passive Acoustic Monitoring (PAM) hydrophones1 deployed in the water column to detect vocalising marine mammals after dark and during periods of poor visibility, also leading to a delay in piing if marine mammals are detected within the mitigation zone. • Continue pre-piling search and soft-start to cover any breaks in piling. • Report piling activity and any marine mammal detections via the MMO report submitted upon completion to JNCC.
Underwater noise from construction activities	• Machinery and equipment will be in good working order and well-maintained. • Helicopter maintenance will be undertaken by contractors in line with manufacturers and regulatory requirements. • The number of vessels utilising DP will be minimised.

Notes: 1 PAM equipment can be used with reasonable effectiveness during mitigation for some cetacean species. The harbour porpoise and other small odontocetes (e.g. porpoise species and Cephalorhynchus dolphins) are known to emit regular high-frequency echolocation clicks. If these clicks are detected then animals are generally within a few hundred metres of the PAM system. However, research has shown that aside from these species, the use of PAM equipment for mitigation purposes for other cetaceans should not be considered to represent a reliable sole method but rather supplementary to the use of MMOs (MMOA, 2012).

Drilling, rock-placement, vessel activity and trenching are in general not considered by JNCC (2010) to pose a high risk of injury or non-trivial disturbance. The noise impact assessment undertaken supports this view, showing that there is unlikely to be any significant impact on any marine species. It is therefore considered unlikely that further mitigation measures will be required.

9.7 Conclusions

Sound levels associated with the Talbot Field Development activities attenuate to ambient levels within a few kilometres of the sound source. As such it is unlikely that sound produced by the installation activities or the production operations would have any effect on fish behaviour that would be noticeable at a population level when considering the limited spatial extent of the sound generated and the generally fluid, mobile nature of fish populations.

The proposed Talbot Field Development is over 278 km south east of the nearest UK coastline (Peterhead) so it is unlikely that grey and common seals would be regularly found in the vicinity of the proposed development.

Records indicate previous sightings of up to six cetacean and two pinniped species within the study area during the year. These species are all subject to regulatory protection from injury and disturbance.

The subsea noise levels generated by surface vessels used during the construction phase would be insignificant when compared to the noise levels generated during marine impact piling and are unlikely to result in physiological damage to marine mammals. Depending on ambient noise levels, sensitive marine mammals may be locally displaced by noise from a vessel in its immediate vicinity, or by any other continuous noise source during the offshore construction activities at the Talbot development project, however, the impact would be short term and is not expected to be significant.

The predicted cumulative source sound level during the piling operations is 218.5 dB re 1 µPa m, only when a pile is being driven into the seabed. Comparison with the frequency-weighted SEL thresholds suggest worst case impact radii of 1.1 km for PTS onset, 5.9 km for TTS-onset and 10.5 km for behaviour disturbance, all of which relate to high-frequency cetaceans. This is for a worst-case scenario of 2,400 strikes per pile for the drilling template and completion of its installation (4 piles) within 24 h. This represents < 0.1 % of the reference population of any one of the marine mammal species in the UK being impacted, assuming that the individuals were to remain stationary during the whole piling activity

Using the un-weighted SPL_{pk} thresholds suggests that the onset of injury PTS may occur within 15 m of the sound source (drilling template piling) as a worst-case for high-frequency cetaceans. Severe behavioural changes (avoidance) or TTS thresholds may be exceeded within 30 m for high-frequency cetaceans. Marine mammals from other functional hearing groups are unlikely to be adversely affected by any of the installation operations using the PK metrics.

Note that whilst SEL_{24h} is relatively high, it has been estimated that it should take between ~41 min and ~48 min to drive each pile to the target depth for the manifold and drilling template piles, respectively. This equates to no more than 4 hours of piling noise in a 24 h period.

The contribution of surface vessels to the cumulative noise levels of the piling operations dominates the 1/3-octave level (TOL) spectrum at low frequencies up to about 100 Hz but is negligible at higher frequencies. At low frequencies where the only noise source is from vessels, the cumulative noise level is outwith the hearing range of most species except low-frequency marine mammals such as minke whales. Sound at frequencies between 100-630 Hz will cause the greatest impact as it is both at its loudest and it is within the most susceptible range for low-frequency marine mammals. Depending on ambient noise levels, sensitive marine mammals may be locally displaced by noise from a vessel in its immediate vicinity, or by any other continuous noise source during the offshore construction activities at the Cotton Development, however, the impact is not expected to be significant.

Harbour has an Environmental Management System (EMS) that applies to all oil and gas activities. The proposed activities described in this report will be carried out in accordance with this management system and with Harbour' policy and procedures.

Harbour will re-assess the piling noise levels and the possible impact on protected species closer to the start of the activities and discuss the results with JNCC. Agreements will then be made to put in place appropriate mitigation measures.

10 Accidental Events

This section discusses the potential worst-case accidental events that may result in consequential impacts upon the marine environment as a result of activities undertaken within Talbot. The following accidental events were identified during the ENVID (BMT, 2022b; Appendix B) and risk assessment process (Section 5) as having a medium risk (risk is a function of impact and likelihood of the event occurring and so a medium ranking does not deflect from the potential seriousness of the event were it to occur) to the environment:

- Hydrocarbon release - well blowout of oil and gas/ loss of well integrity;
- Hydrocarbon release – loss of inventory from vessel collision;
- Hydrocarbon release – loss of volume from Talbot to Judy pipeline;
- Accidental spill of chemicals and muds; and
- Dropped object.

10.1 Regulatory Context

Accidental events resulting from the proposed Talbot activities will be managed in accordance with current legislation and standards as detailed within Section 1. Talbot will be included in the J-Area Offshore Oil Pollution Emergency Plan (Ref: CHRY-JAR-HSEQ-PROC-1346; BEIS reference 200066/1) which provides detailed information on response requirements and capabilities and guidance on correct and timely reporting of oil spills. For the drilling operations at Talbot a Communications and Interface Plan (CIP) will be produced to act as a bridging document between the Harbour CNS OPEP and the rig's Non-Production Installation OPEP (NPI-OPEP); which will clearly define specific roles for spill response and reporting.

10.2 Approach

A suite of numerical modelling simulations for a hydrocarbon release, in addition to the use of the evidence base, has been used to determine the potential effects of accidental events upon the marine environment. The numerical modelling allows a determination of the:

- Temporal dispersion and transport of a hydrocarbon release following an event;
- Associated shoreline oiling;
- Exceedance thresholds for oil concentrations; and
- Environmental impacts of an accidental event.

10.2.1 Oil Spill Modelling

Oil spill modelling has been undertaken using the SINTEF Oil Spill Contingency and Response (OSCAR) modelling package v11 software (Appendix D). Stochastic simulations have been used for a release trajectory repeatedly run with a start date that is within the time period covered by the available meteorological and metocean data:

- Representative wind data used in the model was taken from the European Centre for Medium-Range Weather Forecasts (2009 to 2014).
- Representative current data (2009 to 2014) was used in OSCAR, which is taken from predictions from the Hybrid Coordinate Ocean Model (HYCOM).

In accordance with legislative guidance the results were analysed to determine:

- The probability of a visible surface oil with a minimum thickness threshold of 0.3 µm;
- Time of arrival and probability greater than 1% of crossing UKCS median line; and

- Time of arrival and probability greater than 1% of shoreline contamination along UK and EU Member States coastlines.

Oil Spill Modelling Scenarios

One spill scenario was modelled as defined by Harbour in order to investigate the accidental event scenarios identified by the ENVID (BMT, 2019b; Appendix D). The parameters are presented in Table 10:1.

Table 10:1 – Summary of oil spill modelling scenarios

	Total quantity released (bbls)	Release duration	**Model duration**
Well blowout	**1,000,000**	**90 days**	**120 days**

Talbot oil is not characterised within the OSCAR oil database and the modelling results are based on an analogue oil which has been selected by similarity to the oil properties data provided by Harbour.

Many factors influence the fate of the hydrocarbon once it enters the marine environment including but not limited to:

- Type of hydrocarbon released;
- Volume of release;
- Metocean conditions, sea and air temperature; and
- Effectiveness of intervention.

Each incident is unique and so, in the event of an actual incident, computer modelling of the hydrocarbon release will be undertaken using the specific parameters of the incident at the time.

Scenario – Well Blowout

The key inputs and parameters used in the numerical modelling of the worst-case well blowout are presented in Table 10:2.

Table 10:2 – Inputs and parameters used in the stochastic modelling of a worst-case well blowout

Modelled oil release for Well Blowout						
Oil name		Talbot Oil		Assay available	No	
Analogue oil modelled		YME (IKU)		Analogue oil source	OSCAR database	
Oil Matching Comparison						
Name	ITOPF Group	SG/ API	Viscosity (cP)	Pour Point (°C)	Wax Content (%)	Asphaltene Content (%)
Talbot Oil	2	0.82/ 41.0	0.157	9.0	6.6	0.5
YME (IKU)	2	0.833/ 38.4	4.0	6.0	5.9	0.3
Inventory Loss Parameters						
Release source		Well blowout	Unconstrained flow rate		Not given	
Worst case volume		1,000,000 bbl	Justification		Release rate over 90 days	
Anticipated well self-kill (days)			Unlikely to self-kill within relief well drill timings			

Modelled oil release for Well Blowout			
Depth	78 m (see comment after this table)		
Metocean Parameters			
Air temperature (°C)	4–13*	Sea surface temperature (°C)	7–13*
Wind data (years covered)	2009–2014	Wind data reference	European Centre for Medium-Range Weather Forecasts (ECMWF)
Current data (years covered)	2009–2014	Current data reference	Hybrid Coordinate Ocean Model (HYCOM)
Modelled Release Parameters			
Latitude (WGS 84)	56˚ 35' 7.73087"N	Longitude (WGS 84)	2˚ 28' 30.00622"E
UKCS Block	30/13e	Type of release	Well blowout
Release volume	1,000,000 bbl	Release duration assumed to be arrested after 90 days, as indicted by worst case relief well drilling estimated timings.	
Release duration	90 days		
Total simulation time	120 days		
Release period	Multi-year statistic		
Number of simulations for each season	25 per year	Total number of simulations for each season	100
Oil Spill Modelling Software Used	OSCAR (Marine Environmental Modelling Workbench v11)		

* The temperatures presented represent winter conditions. The stochastic analysis uses a North Sea regional dataset of surface and seabed water temperatures that varies according to the simulated release period.

The numerical modelling results are quantified in Table 10:3. The probability (as a percentage) of surface oiling is presented in Figure 10:1, with the potential arrival time of surface oil following a well blowout shown in Figure 10:2 and Table 10:4. The arrival time and probability for shoreline oiling after 90 days for shorelines throughout the North Sea is given in Table 10:5. The probability of water column contamination following a well blowout scenario is shown in Figure 10:3.

Table 10:3 – Stochastic modelling results summary by season for the well blowout scenario

Scenario description	Months	P50 Mass of oil on shore (tonnes)	P50 shoreline arrival time (days)	Probability of shoreline oiling (%)	Maximum mass accumulating on shore in a simulation (tonnes)	Minimum time of arrival (days)
Winter	December–February	0.5	63.5	83	11.7	25.3
Spring	March–May	7.6	74.1	91.0	89.7	31.8
Summer	June–August	16.6	47.9	95.0	63.7	24.0
Autumn	September–November	0.5	51.8	85.0	12.8	24.5

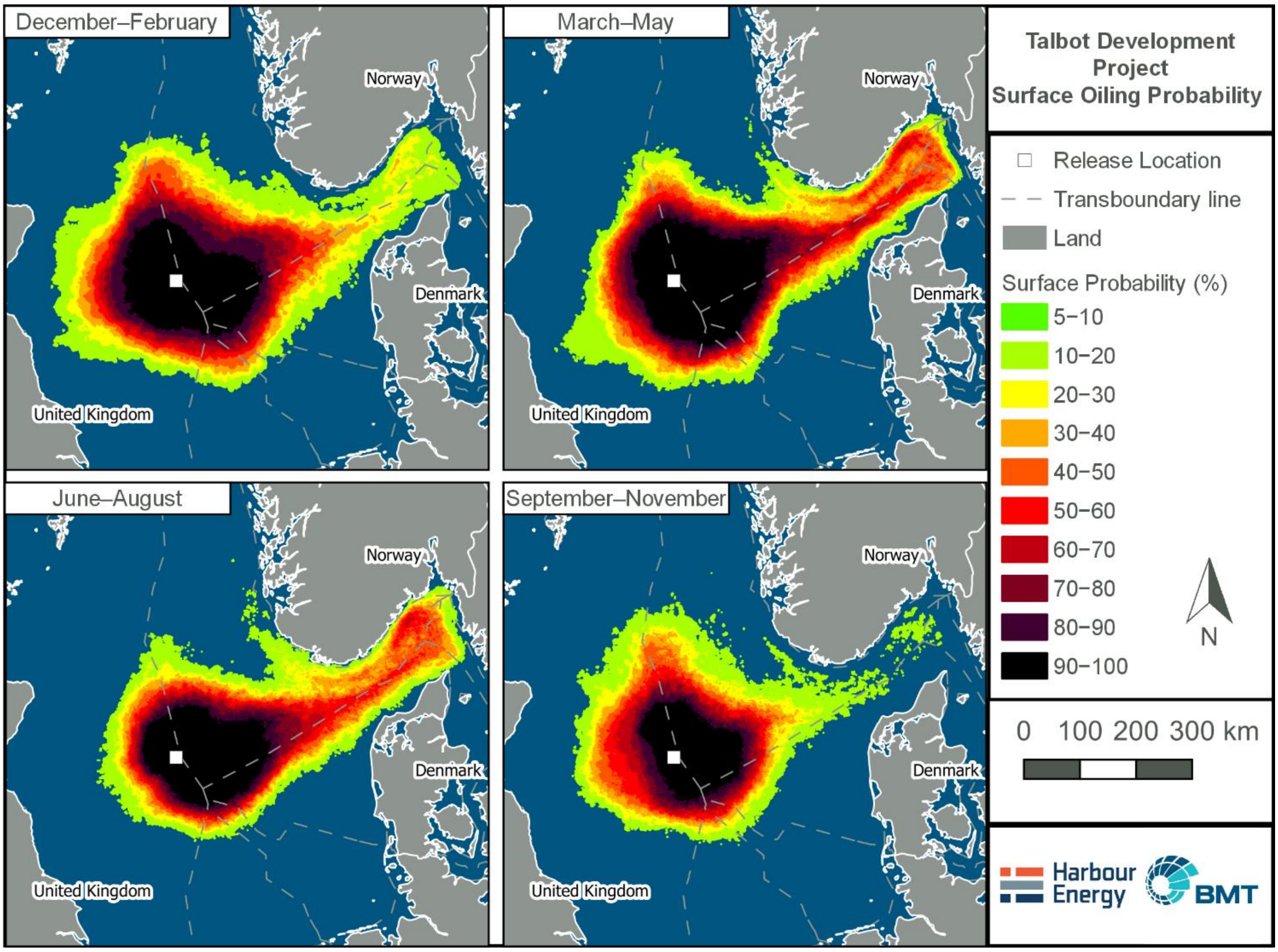
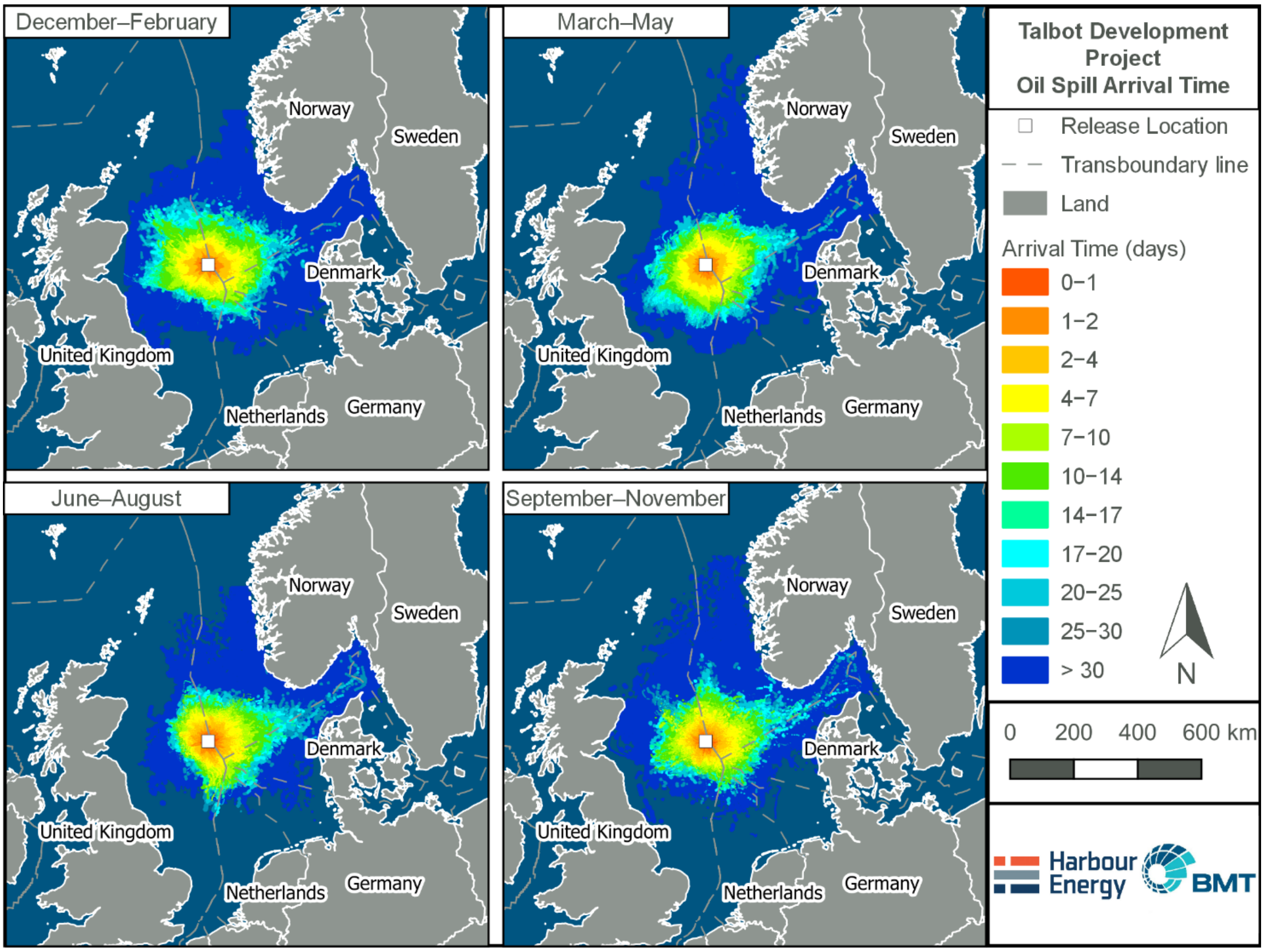


Figure 10:1 – Probability of surface oiling by season for the well blowout scenario



Note: Scale is different to other figures to adequately capture the potential transport of oil at sea.

Figure 10:2 – Shortest time of arrival of oil by season for the well blowout scenario

Table 10:4 – Shortest time for surface oil to reach, and probability of crossing, the median line in the well blowout scenario

Member States	Dec–Feb	Mar–May	Jun–Aug	Sep–Nov
Norwegian Waters	90–100%	90–100%	90–100%	90–100%
	1–2 days	1–2 days	1–2 days	1–2 days
Danish Waters	90–100%	90–100%	90–100%	90–100%
	4–7 days	4–7 days	4–7 days	4–7 days
Swedish Waters	20–30%	50–60%	50–60%	10–20%
	>30 days	20–25 days	20–25 days	25–30 days
German Waters	90–100%	90–100%	90–100%	70–80%
	7–10 days	7–10 days	7–10 days	10–14 days
Dutch Waters	90–100%	90–100%	60–70%	50–60%
	7–10 days	7–10 days	7–10 days	10–14 days
Faroese Waters	<10%	<10%	<10%	<10%
	NA	NA	NA	NA

Note: NA refer to simulations where oil did not reach the shore in that area.

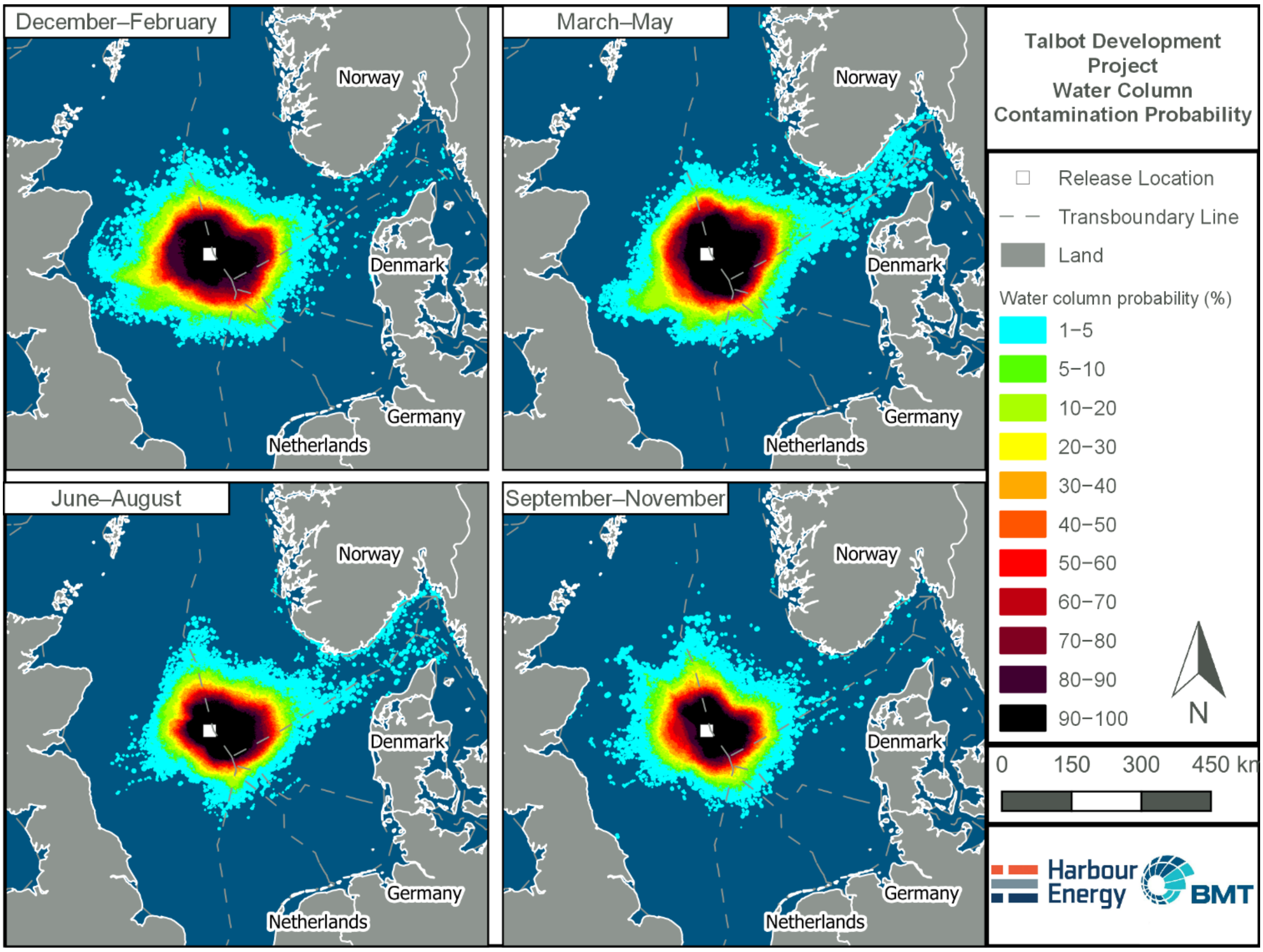


Figure 10:3 – Predicted probability of water column contamination for the well blowout scenario by season

Table 10:5 – Probability and arrival time for shoreline oiling in the well blowout scenario

United Kingdom				
Scotland				
Shetland	<1%	<1%	<1%	<1%
	NA	NA	NA	NA
Orkney	<1%	<1%	<1%	<1%
	NA	NA	NA	NA
Highlands	<1%	<1%	<1%	<1%
	NA	NA	NA	NA
Grampian	<1%	<1%	<1%	2%
	NA	NA	NA	>30 days
Tayside to Lothian	1	1%	<1%	<1%
	NA	>30 days	NA	NA
Borders	<1%	<1%	<1%	<1%

	NA	NA	NA	NA
England				
North East	1%	<1%	<1%	<1%
	>30 days	NA	NA	NA
Yorkshire and The Humber	1%	<1%	<1%	2%
	>30 days	>30 days	NA	>30 days
Member States				
Western Norway	9%	32%	35%	8%
	> 30 days	> 30 days	27.5	24
Western Denmark	8%	13%	17%	6%
	>30 days	>30 days	>30 days	>30 days
Western Sweden	3%	8%	23%	2%
	>30 days	>30 days	>30 days	>30 days
Western Germany	1%	<1%	1%	<1%
	>30 days	NA	>30 days	NA
Northern Netherlands	<1%	<1%	<1%	<1%
	NA	NA	NA	NA
Maximum volume * accumulated onshore in any one simulation (m^3)	**14**	**108**	**76**	**15**

Note: NA refer to within the 90 day simulations where oil did not reach the shore in that area.

Two deterministic simulations were carried out to evaluate the full mass balance using the simulation with the shortest time of arrival across simulations (Figure 10:4) and a simulation with the highest mass ashore (Figure 10:5), both identified over all seasons for this scenario. The results in Figure 10:4 show that 35% of the oil mass evaporated after one day and over time, a significant fraction is dissolved or decayed in the water column. By the end of the simulation (120 days), 7% of the oil mass was decayed and 48% of the oil mass evaporated to the atmosphere. This leaves no significant proportion of the oil on the water surface and 45% settled on the seabed. Maximum volumes ashore have been calculated using the density of the analogue oil (0.833 kg.m-3) in the deterministic simulation after 120 days.

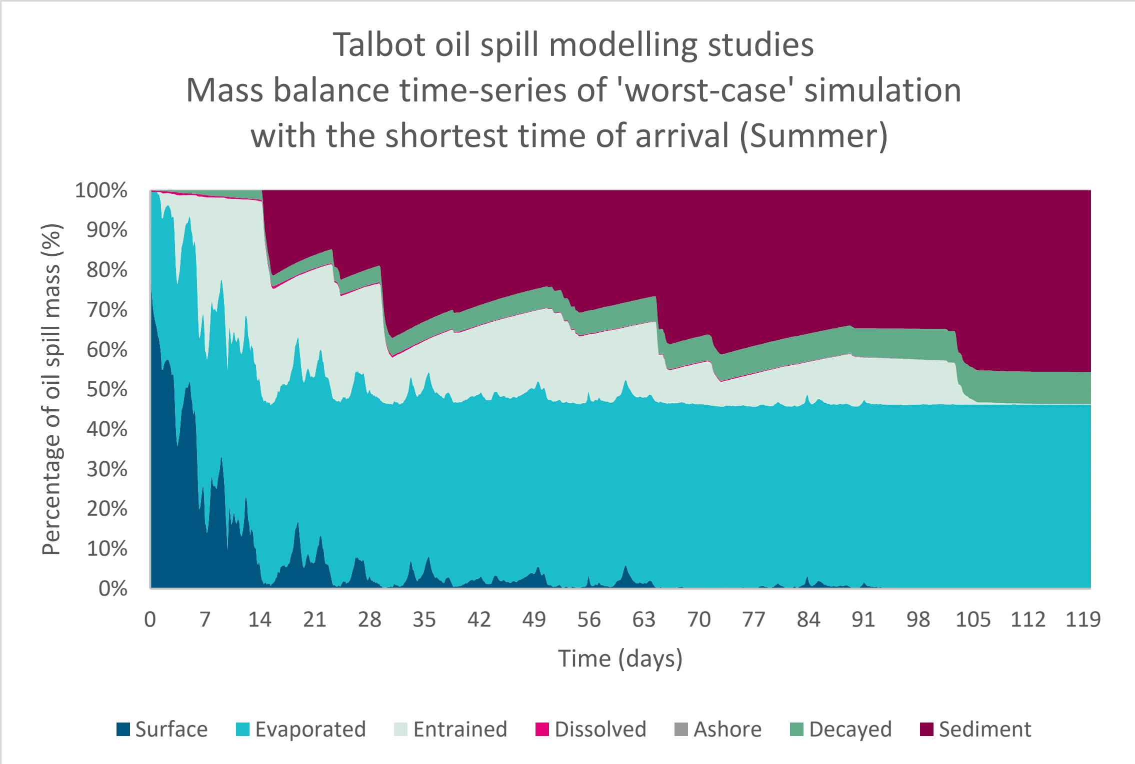


Figure 10:4 – Mass balance of the simulation with the shortest time of arrival for the well blowout scenario. Weathering fates are presented by colour

The results in Figure 10:5 show that 32% of the oil mass evaporated after 1 day and a significant fraction is dissolved or decayed in the water column over time. By the end of the simulation (120 days), 10% of the oil mass was decayed and 50% of the oil mass evaporated to the atmosphere. This leaves no significant proportion of the oil on the water surface, 35% settled on the seabed and 5% entrained. Maximum volumes ashore have been calculated using the density of the analogue oil (0.833 kg.m-3) in the deterministic simulation after 120 days.

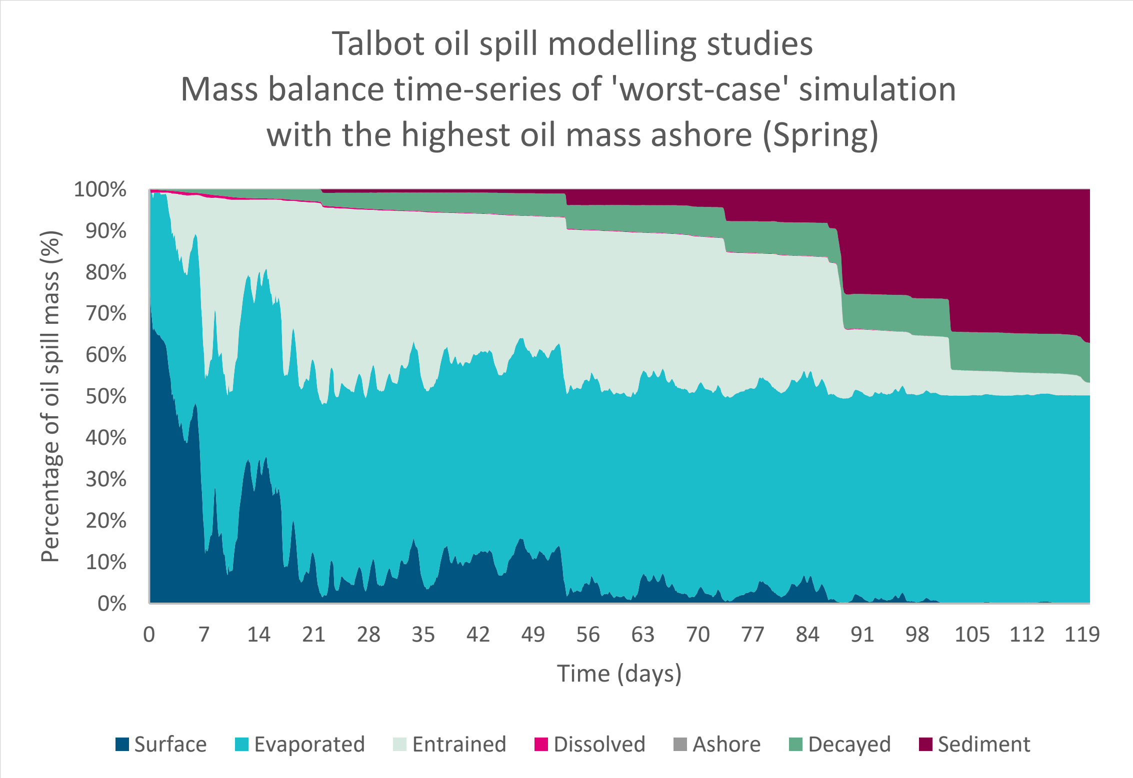


Figure 10:5 – Mass balance of the simulation with the highest mass ashore for the well blowout scenario. Weathering fates are presented by colour

10.3 Behaviour of Hydrocarbons in the Marine Environment

When hydrocarbons are released to the marine environment, they are subjected to environmental conditions different to those when they were contained. This change of environmental conditions begins a process of physiochemical change in the oil called weathering. These changes can include evaporation, dissolution, emulsification, photo-oxidation, biodegradation and hydrocarbon-sediment interactions.

As spilt oil reaches the sea surface, it spreads into slicks and also thin films known as sheens. Wind and surface current speed and direction are the main parameters influencing the movement of oil slicks. During the early days of an oil spill, evaporation and dispersion are the two main weathering mechanisms that displace oil from the sea surface to the atmosphere and water column, respectively. Evaporation can remove up 75% of condensate and ultralight oils, and up to 30% of light oils. Evaporation is facilitated by higher temperatures and is therefore likely to be higher in temperate and warm climates.

After evaporation, the dominant weathering processes are dispersion and dissolution. The rate at which oil disperses is largely dependent upon the nature of the oil and metocean conditions. Lighter and less viscous oils tend to have more water-soluble components, allowing them to dissolve within days. Viscous oils and oils below their pour point tend to form persistent, thick fragments after reaching the shore (ITOPF, 2012).

The immiscible components of an oil spill may either emulsify and disperse as small droplets in the water column or aggregate into tight water-in-oil emulsions, often referred to as “chocolate mousse”. The rate at which this happens, and the type of emulsions formed, depends on variables including oil type, turbulence and temperature. This process is undesirable because it increases the volume of waste to be processed during clean-up operations.

Recent studies from the Deepwater Horizon oil spill suggest that marine oil snow is formed in association with oil spills and was an important factor for the transport of oil to the seabed (Brakstad et.al., 2018). Natural marine snow is defined as the "shower" of particle aggregates formed by processes that occur in the world's oceans, consisting of macroscopic aggregates of detritus, living organisms and inorganic matter. The natural marine snow interacts with oil and dispersants to form what is known as marine oil snow as it sinks from the surface through water column to the seafloor sediments. The danger with marine oil snow is that it transfers oil and its negative impacts from the water column to the sediments on the bottom of the seafloor, delivering a more diverse suite of oxygenated compounds to sediments and deep-sea ecosystems. These oxygenated forms of many oil compounds are more toxic to organisms in the sediments than are the non-oxygenated forms.

10.4 Impact to Receptors

The worst-case oil spill modelling scenario for a well blowout at the well location predicted the hydrocarbons would reach shorelines (Figure 10:1 to Figure 10:5; Table 10:3 to Table 10:5). Designated sites and species and potentially aquaculture sites along the UK (specifically Shetland and Orkney where most of east coast fish farms are located) and other member state North Sea coastlines have the potential to be impacted by a well blowout (Table 10:5). However, in present case, there is no significant impact predicted on these shorelines. The shortest arrival time is 24 days for the well blowout scenario and the predominant transport direction of the spill is centred on itself with a tail towards the east, with the higher probabilities for beaching along the Norwegian coast (Table 10:5). There is a considerable volume of oil predicted to reach the shorelines following a well blowout, and there exists a high potential for multiple conservation and aquaculture sites that would be impacted.

Following a release from a well (Table 10:2), the characteristics of Talbot oil are such that it will eventually reach the sea surface, ultimately undergoing dispersion and emulsification (Cefas, 2001).

The impacts on the marine environment are well documented in literature from around the world, and a summary of these impacts and their effects is given below. Although the effects of oil spills are well understood, it is noted that the effects of each individual spill will be unique, and only broad conclusions can be made when predicting the effects of a crude oil release or diesel spill.

10.4.1 Impacts to the Benthic Environment

Where a surface spill is considered, animals associated with the seabed are less likely to be affected as the floating oil moves above them. However, a fraction of the water-soluble components of a slick may dissolve into the water column, assisted by rough seas or agitation of the sea surface, where they can potentially be harmful to benthic organisms. In deeper offshore areas, these impacts are likely to be very limited due to the water depth. However, if the spilled oil can drift inshore, the benthic communities of shallow coastal areas may be affected.

The seabed in the local area is mainly characterised by sandy sediments (Section 4.2.6). Suspension feeders gather nutrients directly from seawater and would, therefore, take in any oil present within the surrounding water as would be the case in a well blowout. This makes these organisms more vulnerable to the toxic effects of oil dispersed in the water column. Deposit feeders such as tubeworms are supported by the fine organic matter trapped between the fine sediments and, therefore, these animals would only be affected if the oil settles or is entrained into sediments. Of special interest is the ocean quahog, which is found in this area of the North Sea (see Section 4 for discussion).

10.4.2 Impacts to Plankton

Oil, particularly diesel, is toxic to a wide range of plankton. Planktonic organisms living near the sea surface are particularly at risk, as water-soluble components leach from floating oil. Although oil spills may kill individuals, the effects on whole plankton communities appear to be short-term according to some studies; however, more data are required to make a robust assessment of the effects of oil pollution on plankton (Ozhan et al., 2014). Following an oil spill incident such as a well blowout from a Talbot well, plankton biomass may fall dramatically, due either to animal deaths or avoidance of the area.

Studies of the effects of hydrocarbons on plankton communities in the Gulf of Mexico following the Deepwater Horizon spill (Buskey et al., 2016) revealed evidence of toxicity of both crude oil and dispersants within phytoplankton (Ozhan & Bargu, 2014). Zooplankton species have been reported to directly ingest dispersed oil droplets (Lee et al., 2012), while decreases in populations have been reported following oil spills (Guzman de Proo et al., 1986). Reported sublethal effects of exposure to crude oil include reduction in feeding (Cowles & Remillard, 1983), altered swimming behaviour (Cohen et al., 2014) and reproduction (Olsen et al., 2013). Copepods may act as a pathway for crude oil particles from the water column to the benthos, via egestion (Almeda et al. 2015). Nevertheless, despite this, Batten et al., (1998) were able to find few significant impacts on the plankton population following the Sea Empress oil spill in the southern Irish Sea in the 1990s.

10.4.3 Impacts to Fish and Shellfish

Offshore fish populations remain relatively unaffected by oil pollution, as oil concentrations below the surface slick are generally low. There is also evidence that fish can detect and avoid oil-contaminated waters (Claireaux et al., 2018). This avoidance may, however, cause disruption to migration or spawning patterns. Heavily contaminated sediments may have an adverse effect on local populations of demersal fish species and benthic species, due to the impact it has on the food chain.

Fish eggs and larvae are more vulnerable to oil pollution than adult fish. In many fish species, these stages float to the surface where contact with spilt oil is more likely. Certain fish stocks may be more affected than others, particularly if the spill is very large, if it coincides with spawning periods or enters the grounds of species with restricted spawning areas.

If oil reaches the seabed, shellfish species that cannot swim away from oiled sediments are susceptible to its effects. Mortalities may occur if shellfish become smothered by settling oil. Low levels of oil in seawater may cause tainting in shellfish which may be commercially damaging to shellfish fisheries. Tainting problems is more common in filter feeding shellfish, principally bivalves, as they would take up fine oil droplets from the water column. In this offshore area commercially important shellfish are only found in small quantities. Consideration of the impacts upon the ocean quahog are presented in Section 6.3.3, Section 7.4.1 and Section 7.4.4.

10.4.4 Impacts to Marine Mammals

Cetaceans and seals known to occur in Talbot area (Section 4.3.5) and can be exposed to oil in one of two ways:

- Internally (swallowing contaminated water, consuming prey containing oil based chemicals, or inhaling of volatile oil related compounds); and
- Externally (swimming in oil or dispersants, or oil or dispersants on skin and body).

Many cetacean species are highly mobile and range widely, so contact with an oil spill may be relatively brief. However, certain pinniped populations and resident cetacean populations are not as highly mobile and are therefore subject to increased risk from oil spills.

Cetaceans are considered more likely to be able to deal with the effect of an oil spill than seabirds are (Skov et al., 2002) as, unlike seabirds, the body covering of cetaceans is not susceptible to loss of waterproofing or insulation upon oiling (Geraci, 1990). Long-term pollutant accumulation may be of more concern with regards to cetacean vulnerability to hydrocarbons (Kiceniuk et al., 1997). Recent research shows that harbour porpoises may feed around oil and gas platforms at night, possibly due to increased prey abundance in the 500 m fishing exclusion zone (Todd et al., 2009). Smultea and Wursig (1995) found that bottlenose dolphins have difficulty detecting sheen oil at the surface of the water. However, they can detect slick oils, although they have been recorded as still swimming through it. Many other cetacean species have also been recorded as swimming through various types of oil, including at least eleven different species documented swimming through oil and sheen following the deep-water horizon spill, with oil adhered to their skin (Dias et al., 2017). However, oil does not readily penetrate cetacean skin, which is characterized by having a thick epidermis, 10–20 times that of a human (Helm et al., 2015). It is believed that a lack of an olfactory system likely contributes to the difficulty cetaceans have in detecting oil (Evans, 1982). As cetaceans are not generally scavengers, it is not likely they will consume petroleum compounds in food that has died from oil exposure. However, it is possible that cetaceans will capture prey contaminated with oil or ingest oil inadvertently through tainted prey or while digging into sediments in search of prey (Helm et al., 2015). Inhalation of volatile toxic fractions at the air–water interface also poses a risk to cetaceans, which is greatest near the source of a fresh spill due to the volatile toxic vapours dispersing relatively quickly. When concentrated vapours are inhaled, mucous membranes may become inflamed, lungs can become congested, and pneumonia may ensue. Inhaled fumes from oil may accumulate in blood and other tissues, leading to possible liver damage, reproductive impairment and neurological disorders (Helm et al., 2015).

Seals are at risk from marine oiling and from shoreline oiling. High densities of seals come ashore at breeding sites, resulting in high concentrations of animals becoming contaminated if that localised area is affected (Jensen, 1996). New born pups are likely to suffer direct mortality from shoreline oiling because they rely almost entirely on their fur for thermoinsulation. Oiling of fur can also reduce olfactory recognition of pups by mothers (Hansen, 1985). Acute respiratory distress was recorded in grey seals in Shetland following the Braer oil spill (Hall et al., 1996). Behavioural studies have shown that while seals should be able to detect oil through vision and/or smell they apparently do not avoid oil. They are therefore likely to come in contact with oil if it comes into their habitat. Observations have been recorded of individual seals becoming so encased in oil that they were not able to swim and subsequently drowned (Helm et al., 2015).

The nature of the oil and how much it has weathered may also be an important factor in determining impacts on wildlife. Individuals oiled early in a spill may be exposed to the more toxic components of the oil by direct contact and ingestion and suffered greater toxicity than those affected by a more weathered oil.

10.4.5 Impacts to Seabirds

Seabirds are particularly susceptible to oil pollution on the sea surface. During large oil spills, seabird mortality often attracts the greatest levels of public concern. The vulnerability of each bird species to oil pollution is dependent on several factors, such as distribution and behaviour, and varies considerably throughout the year.

The vulnerability of seabirds to oil pollution in Talbot area varies from low to high throughout the year, with increased vulnerability corresponding to the periods when coastal bird colonies feed offshore and during periods of moulting. Physical fouling of feathers and toxic effects of ingesting hydrocarbons can result in seabird fatalities. The effects will depend on species presence, their abundance and time of year. Seabird sensitivity to oil pollution through May and June have very high seabird sensitivity in Block 30/13, while February has moderate seabird sensitivity in Block 30/12, while other months have low seabird sensitivity with the exception of October and November for all three blocks of interest and April for Block 30/7, for which there is no data (Webb et al., 2016; Section 4). Seabirds found within this area of the CNS, including the well location, are most likely migrating to wintering or breeding grounds (season dependent). Consequently, effects from an accidental hydrocarbon release offshore could be prolonged, of high magnitude and spatial extent.

10.4.6 Impacts to Protected Habitats and Species

SPAs are protected areas which have been classified in accordance with Article 4 of the EC Birds Directive. They are classified based on the location of rare and vulnerable birds and also for frequently occurring migratory species which are listed on Annex I of the Directive. No SPAs were recorded within the vicinity of Talbot area. Furthermore, no hotspots for seabirds breading were identified in this area (Kober et al., 2010; Section 4).

To the southwest, Talbot overlaps with the Fulmar MCZ, designated for protection of subtidal sands, muds and mixed sediments that provides important habitats for marine animals, providing food, spawning areas and shelter. Furthermore, Fulmar MCZ is designated for the protection of ocean quahog. Conservation Objectives for the Fulmar MCZ protected features may be affected should Talbot oil reach the seabed within the conservation zone. It is expected that oil will rise to the surface and be dispersed, therefore, it is unlikely that the protected habitats and species, which are all benthic, would be directly impacted. Indirect impacts may occur from marine oil snow that settles on the seabed.

The East of Gannet and Montrose Fields NCMPA located approximately 67 km northwest from Talbot is designated for protection of offshore deep sea muds, and ocean quahog and its supporting habitat.

The Swallow Sand MCZ is located approximately 96 km southwest of the proposed Talbot area and is designated for protection of broad-scale habitats of subtidal sand and subtidal coarse sediment, the geomorphological feature, the North Sea glacial tunnel valley, known as the Swallow Hole, and protection of ocean quahog.

The Norwegian Boundary Plain NCMPA designated for protection of ocean quahog is located 163 km north from Talbot.

The Dogger Bank Special Area of Conservation (SAC) designated for protection of Annex I habitat, sandbanks which are slightly covered by seawater all the time, is located 123 km south from Talbot.

The Fulmar MCZ, Swallow Sand MCZ, East of Gannet and Montrose Fields NCMPA, Norwegian Boundary Sediment Plain NCMPA and the Dogger Bank SAC may all be affected by surface oiling. The location of these sites in relation to Talbot and the potential oil spill coverage is illustrated in Figure 10:6.

The presence of the ocean quahog, listed on the OSPAR threatened and/ or declining species, has been recorded within the CNS and confirmed in almost all samples collected during dedicated survey of Talbot area (Gardline, 2019b). The potential impact of Talbot upon this species has been discussed in Section 6.3.3, Section 7.4.1 and Section 7.4.4.

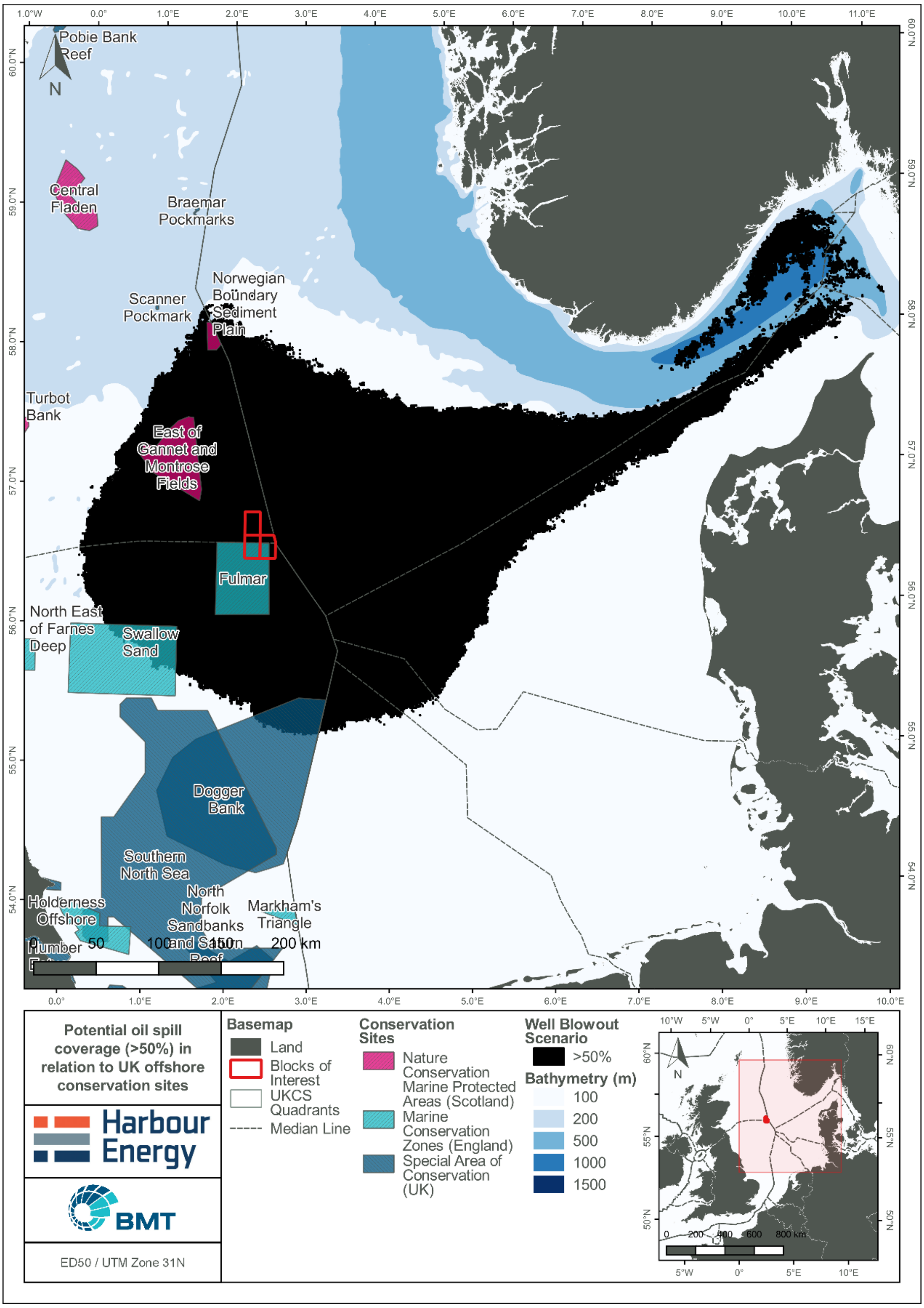


Figure 10:6 – Potential oil spill coverage resulting from Talbot activities in relation to designated sites

10.4.7 Impacts to Shorelines

This section discusses the likely impacts of an accidental oil spill upon the different types of coastal environment.

Rocky Shores

Rocky shores are found along the western coast of Norway, which may be significantly affected by an oil spill such as that modelled in the well blowout scenario. They can be varied in structure, ranging from exposed vertical walls to flat bedrock, or stable boulder fields to aggregations of cobbles. Rocky shores are generally high energy beaches, and while oil may have an impact on the animals and plants which live on them, stranded oil is often quickly removed by wave action and water movement. The vulnerability of rocky shore habitats to oiling is dependent on the type of rocky shore and its exposure. The action of the waves may start to remove the oil from an exposed vertical wall almost immediately, but the oil may remain for longer in more sheltered, kelp dominated areas.

Many of the animals and small seaweeds found on rocky shores would be killed by exposure to hydrocarbons. Beached hydrocarbons may cause damage due to smothering and inhibition of their feeding and respiration mechanisms.

The rate of recovery and the form it takes will depend upon the type of rocky shore and the animals and plants that live on it.

Sedimentary Shores

Sedimentary sandy shores are commonly found throughout eastern Scotland and may be affected by the hydrocarbon release scenarios considered here. The fate of oil stranded on sediment shores depends on the nature of the substratum. Due to the increased sediment movement and relatively large gaps between the particles, beached heavy oil can penetrate further into the more mobile shingle or coarse sand shores. These coarse sediment shores tend to be less productive than sheltered mudflats, as the movement of the loose sediment is very abrasive, meaning few animals can survive in it. Gaps between the shingle or sand grains allow water (and oil) to drain away quickly between the tides and in past cases, where beaching has become inevitable, sandy beaches have been considered sacrificial areas. A spill may be directed towards a sandy beach to protect other, more sensitive shorelines.

Oil does not readily penetrate the sediments in areas of firm waterlogged mud or fine sand and tends to be carried away with the next tide (Clark, 2001). However, there is a concern over oil stranding on sheltered mudflats or associated sensitive areas of saltmarsh and, therefore, these are often priority areas for protection following oil spills. These are generally highly productive areas, with high numbers of invertebrates living within the sediments, which may provide a valuable food source for juvenile fish and birds (Little, 2000). Recovery times tend to be longer in these areas, due to the reduced bacterial hydrocarbon degradation and higher persistence of the oil, particularly if it is entrained into the sediment (IPIECA, 2008).

10.4.8 Commercial Fisheries and Aquaculture

The effects of oil spills on commercial fish and shellfish, and the indirect impacts on their habitats, are described above. Fish and shellfish exposed to oil may become tainted, which could prevent an entire catch from being sold. There is evidence that fish can detect and avoid oil-contaminated waters. Therefore, tainting is generally more a concern for immobile shellfish which cannot swim away and is more common in filter-feeding shellfish, such as scallops, as they could take up fine oil droplets from the water column. Shellfish landings are confined further south and inshore instead, which may be affected if a larger oil slick drifted from the field.

If fishing in the area of an oil spill, gear and catch may become fouled with floating oil. Trawling is a key fishing method in the Talbot area and therefore, fouling of gear and tainting catch by spilled oil are risks. This not only causes damage to the nets themselves but contact with fouled fishing gear may also contaminate subsequent catches. In the event of a major hydrocarbon release it is likely that the affected area will be closed to fishing. Major spills often result in loss of fishing opportunities with boats unable or unwilling to fish due to the risk of fouling and tainting of catch, causing a temporary financial loss to commercial fishermen.

Spilled oil reaching the shorelines of Orkney and the Shetland Islands may affect local aquaculture as fish are in enclosed areas and cannot avoid incoming hydrocarbon pollution. Tainting and mortality of aquaculture fish may damage local economic activity. The hydrocarbon spill scenarios considered here showed less than 1% probability of reaching the Shetland Islands, therefore impacts on aquaculture and shellfish areas in the event of an oil spill from Talbot are not considered to be likely or significant. For Norway probability of oil reaching shorelines is 35% therefore impacts on aquaculture and shellfish along the coastline in these locations are possible.

10.5 Spills of Chemicals and Muds

Chemical spills to the marine environment can result in environmental and economic impacts. Table 10:6 identifies chemicals used during production. Chemicals will also be handled on the jack-up drilling rig and support vessels, and on the Judy platform for production, maintenance, utilities and other purposes. Mud operations will be planned and in the event of a mud spill, the impacts are expected to be localised. A relatively small loss of seabed habitat may be possible, but the impact will be localised.

All chemicals used will have been approved for use under the relevant chemical permit and so would be unlikely to present a significant environmental risk. All chemicals used in offshore operations are required to have a CEFAS template that describes their characteristics and potential impact and toxicity. Some of these that are discharged will be required to have toxicity modelling carried out on them prior to their use. In a spill situation the chemicals may be released in larger volumes and higher dosages than planned and assessed for in the chemical permit but generally chemicals will be selected for low persistence and low biodegradation potential so will not remain active in the marine environment for long periods. Preference will be given to the selection and use of low dosage, low risk chemicals. Chemicals will normally be stored within closed systems but will also be present in low concentrations within systems such as the oil and water phase of the process system. Limited data are available on the frequency of chemical spills offshore however given the situation described it is reasonable to assume that spills of such chemicals, if any, will be mostly small (less than one tonne) and will rarely exceed 10 tonnes, and will only result in localised impact around the discharge point.

Table 10:6 – Summary of production chemicals

Chemical	Intended Use and/ or Location
Enhanced Oil Recovery (EOR) chemicals	Used to increase the crude oil volume that can be extracted from an oil field. This may include polymers.
Demulsifier	Injected downhole to break water-in-oil emulsions.
Antifoam	Injected into the separation train to break the foam, prevent liquid carry-over and maximise gas breakout.
Biocide	A biocide treatment program will be established to prevent sulphate-reducing bacteria introduction to the reservoir and potential souring of the reservoir.
Oxygen scavenger	Injected into the produced water system to manage potential corrosion problems and reservoir souring.

Chemical	Intended Use and/ or Location
Hypochlorite	Required during the production process to prevent biofouling and marine growth.
Methanol	Injected at Christmas tree, upstream and downstream of Production Wing Valve (PWV). Required for hydrate mitigation on both start-up and shutdown.
Scale Inhibitor	Injected downhole into the well, below the Surface Controlled Subsurface Safety Valve (SCSSV), but above the production packer. Required to mitigate scale deposition in all wetted surfaces from well back to Host Platform once water breakthrough has occurred. Scaling studies carried out by ConocoPhillips Bartlesville has shown scaling potential for aquifer water.
Corrosion Inhibitor	Injected at the Christmas tree. Required to inhibit corrosion of carbon steel sections of pipeline.
Wax Inhibitor	Injected at the Christmas tree. Used to mitigate against wax deposition in later field life with lower flowing temperatures.

10.5.1 Decommissioning Phase

During decommissioning activities, the impact of any accidental events is anticipated to be within the impacts discussed above.

10.5.2 Impacts to Receptors

The environmental implication of a chemical spill is largely dependent on the type of chemical, the size and location of the spill and the weather conditions at the time. The actual hazard presented by a spill will also depend on the exposure concentration, which is determined by the quantity and rate of spillage, and the dilution and dispersion rates. These factors will differ according to whether the spill takes place at the sea surface or seabed. The dilution and dispersion of a sea surface spill will depend on the sea state at the time, with larger waves more effective at dispersing a spill than calm sea states. The spill will be diluted as it sinks and will be moved by tidal currents and wave activity. Diluted chemicals would be carried with the body of ambient seawater and gradually disperse and degrade. Although the spill may be detectable within a tidal cycle, it will only be acutely toxic within a very limited area and for a short period of time. The fate of a spill on the benthic environment will depend on the properties of the chemical such as density, solubility as well as on sediment properties. If the chemical is denser than seawater it may spread over the seabed and become mixed within the substratum causing potential harm to the benthic community. A chemical with less density than water will rise through the water column and disperse with the currents. Highly soluble chemicals will disperse rapidly in the water column and if the sediment is sufficiently permeable (such as sandy sediments) then there is potential for entrainment into sediments. Chemicals that are not environmentally persistent will not tend to bio-accumulate and consequently are unlikely to present long-term environmental hazards. Toxic effects from a chemical spill would likely be limited in extent and duration.

10.6 Dropped Objects

Dropped objects represent an accidental event for which stringent operational controls will mitigate against. If an object is dropped overboard, it has the potential to damage subsea infrastructure and may result in the release of hydrocarbons. The scale of this impact will be dependent upon the weight and shape of the object dropped, the water depth and the presence of any protection that has been placed over the infrastructure

(DROPS, 2010). Of note is that Harbour currently plan to trench and bury pipeline and umbilical over the majority of their length with rock and mattress protection over the transition areas and at crossings. Further detail regarding the location and amount of protection materials is provided in Sections 3 and 6 of this ES. Dropped objectives may also present a hazard to fishing vessel as they to their nets in the area. Harbour will undertake a seabed survey following installation of Talbot infrastructure and recover dropped objects that could present a hazard.

10.7 Cumulative and In-Combination Impacts

There are a number of Oil and Gas developments present in the vicinity of Talbot. Inherently, there exists the potential for cumulative impacts should an accidental hydrocarbon release occur. During production, the volume of hydrocarbons which could potentially be released from Judy platform will increase, however due to the mitigation and management measures that Harbour intend to implement, the likelihood of accidental releases occurring does not increase. As indicated by historical data (OGUK, 2019), the likelihood of a release is remote thus limiting the cumulative impact from the Talbot and existing installations. It should be noted that 2018 saw an increase in chemical spills over the previous two years in line with 2013 and 2015 accidents. Oil spills reduced further in 2018 to an eight-year low.

The low risk associated with an accidental chemical release results in a small potential to result in cumulative impacts. Indeed, it has been shown that accidental chemical releases on the UKCS in 2018 represent 0.16% of the total mass of chemicals used (OGUK, 2019). Should a release occur, it will be temporary, of a limited temporal duration and be of a small release volume which will be rapidly dispersed in the receiving environment. The potential for cumulative effects from a chemical release is considered to be negligible.

With respect to in-combination impacts, there is the potential for accidental spills to result from vessel collisions within the Talbot area. There exists a low likelihood of an accidental release from a vessel; over the last 48 years, the number of global spills greater than seven tonnes has reduced considerably (ITOPF, 2018). Further, 50% of the recorded global spills between 1970 and 2017 occurred when the vessel was underway in open water (ITOPF, 2018). Given the mitigation and management systems that all vessels adhere to, the potential for accidental releases due to a collision is considered negligible.

10.8 Transboundary Impacts

Assuming no response measures were implemented, there is a likelihood of a transboundary effect from an accidental event at Talbot. Based upon historical UKCS records; the likelihood of an accidental event of this magnitude is remote. As such, it is currently considered that consultation under the Espoo (EIA) Convention is not required.

In accordance with the Bonn Agreement, in the unlikely event of a major accidental hydrocarbon release during which there exists the potential for oil to enter Norwegian waters, the NorBrit plan, a bilateral contingency plan with the UK, will be implemented. This is particularly relevant given the closeness to the median line of Talbot.

10.9 Natural Disasters

Some natural disasters could increase the risk of a major pollution event occurring at the proposed Talbot field. For example, an earthquake could lead to damage to the subsea infrastructure and potential loss of well control. The likelihood of an earthquake of significant magnitude on the UKCS to impact seabed infrastructure is extremely remote.

Climate change effects, such as extreme weather events and sea level change, are not considered to alter significantly the range of effects considered. Extreme weather may make an accident to the drilling rig more likely, but the rig has procedures in place for making safe and shutting down operations during extreme weather, along with emergency procedures in the case of rig damage, and a full loss of fuel inventory has been considered in the CNS OPEP.

10.10 Evaluation of Major Environmental Incident Potential

The Judy safety case (comprised of two documents: CHRY-HSEQ-ALL-SAC-0001 – Safety and Environmental Management System and the Judy/Joanne Safety Case HBR-JUD-HSE-PRC-0001) presents the Major Accident Hazards (MAHs). Each MAH for which there is a potential for loss of containment has been evaluated and compared to the oil spill scenarios considered in the Harbour J-Area Offshore Oil Pollution Emergency Plan. This comparison allows the identified major accident hazards to be evaluated as potential Major Environmental Incidents (MEI). The worst-case hydrocarbon release scenarios are thus identified and summarised in the safety cases. All other release scenarios identified are considered to have less impact than the worst-case scenarios.

A MEI is an incident which results, or is likely to result, in environmental damage as defined in the Environmental Liability Directive (ELD). 'Environmental damage' is a significant adverse effect to any of the following:

- the conservation status of a protected species or habitat covered by the Habitats Directive;
- the ecological, chemical or quantitative status of water bodies covered by the Water Framework Directive (out to 1 nm);
- the environmental status of marine waters covered by the Marine Strategy Framework Directive (MSFD) ('marine waters' includes the water column, seabed and subsoil). 'Environmental status' is determined by the indicators of Good Environmental Status, as defined in MSFD.

The ELD guidance states that 'short term, transient adverse effects from which the affected water body recovers without the need for remediation measures are not significant enough to cause deterioration of status'.

As discussed above, the fate of spilled oil is dependent upon its physicochemical characteristics and the prevailing meteorological and hydrodynamic conditions. The effect of wind and wave action and the influence of currents will increase the rate of natural dispersion thus increasing the susceptibility of spilled oil to natural weathering and degradation processes that will reduce the volume of oil on the sea surface. Rates of evaporation will be highest during the summer when air and sea temperature are high; rates of mechanical dispersion will increase when wind and sea state are greatest, which is likely to be during winter.

Talbot is located within a Fulmar MCZ established under the Habitats Directive. It is protected for the presence of a number of benthic features. In the event of an MAH event at Talbot, the conservation objectives of this MCZ may be affected if oil reaches the seabed within the MCZ. Talbot is located in offshore waters greater than 1 nm from the UK coast; hence criteria b) for assessing environmental damage is not applicable.

Major accidents to the environment encompass events with the potential to cause severe, widespread, long-term or even permanent damage to ecosystems. All process event MAH scenarios for the Talbot installation that lead to a hydrocarbon release to sea will have an impact of shorter duration than the worst-case scenarios assessed, from which the affected environmental receptors will recover. It is considered that these other release scenarios identified will not result in any significant adverse effect that would affect the environmental status of the North Sea (marine waters covered by the MSFD).

10.11 Mitigation Measures

The planned mitigation measures that Harbour will undertake to minimise the risk and impact of accidental events are detailed in Table 10:7. Harbour is party to a voluntary oil pollution compensation scheme for the North Sea, known as OPOL (Offshore Pollution Liability). In addition, they have access to Oil Spill Response Limited (OSRL) resources and access to the OSPRAG Well Capping Device.

Table 10:7 – Potential sources of impact and planned mitigation measures

Potential source of impact	Mitigation measures
Hydrocarbon release - well blowout of oil and gas/ loss of well integrity	Well plan to be implemented Well control contingency planning Management policy to be adhered to Utilise a Blow Out Preventer (BOP) Develop an Oil Pollution Emergency Plan (OPEP) and Temporary Operations OPEP (TOOPEP) Develop a relief well plan
Hydrocarbon release – loss of inventory from vessel collision	Notice to mariners and shipping alerts Keep Kingfisher charts updated Provide a standby vessel Industry standard notifications, navigation aids and communications Obtain a Consent to Locate OPEP
Spill during drilling rig transfer	Prior to transfer check of hose maintenance procedures and compliance with interface documents. Break away coupling to minimise spillage. Double carcass hose for offloading. Drip tray under hose reel. High level alarms on tanks. Relatively small volumes
Pipeline leak/ rupture	OPEP Subsea Pipeline Leak Detection Notice to Mariners and Shipping Alerts Kingfisher charts Industry standard notifications, navigation aids and communications Constant and clear communication regarding rig moves Consent to Locate
Spills of chemicals and muds	Mud and chemicals are stored in separate containers in bunded areas Chemical handling risk assessment Rig procedures for chemical handling
Dropped objects	Lifting zones on rig and platform Pre- and post-installation debris survey Measures put in place as required

10.12 Conclusion

During the Talbot project, there are several activities which may result in the accidental release of hydrocarbons, chemicals and drilling muds into the marine environment. Harbour recognise the severe impact that such an event would result in and as such, will put in place stringent control procedures and measures.

The assessment undertaken within this ES has intentionally investigated a subsea well blowout, the worst-case releases scenario, using numerical modelling techniques and information contained within the evidence base. Stochastic time-series scenarios were modelled for each season using timeseries wind and current data for a representative five-year period. In addition, the simulation with the shortest arrival time and the highest mass ashore were modelled as two deterministic worst-case outcomes.

The modelling results concluded that:

- This well blowout scenario resulted in a potential environmental impact in terms of surface, water column and shoreline oiling;
- The coasts of western Norway and Sweden are predicted to be impacted with the overall shortest arrival time of 24 days for Norway;
- The probability of shoreline oiling is the highest on the western coast of Norway with a probability of 35%; and
- The maximum amount of oil that came ashore in any one simulation is, approximately, 108 m^3 (or 89.7 tonnes), for a simulation starting during spring months.

Most of the drilling fluids, cementing and other chemicals will be classified as PLONOR (poses little or no risk to the environment) or be of a low hazard quotient (RQ). The control and mitigation of accidental chemical releases include the appropriate storage with sealed drainage and bunding, risk assessment for specific activities and application of suitable operational procedures. As a result, the environmental risks from chemical spills are considered minor.

Dropped objects during Talbot operations are expected to have limited and localised impacts. Consequently, the potential impacts are considered minor.

Based on the modelling undertaken here, the impacts from a hydrocarbon release such as a well blowout are expected to be significant. In numerical simulations it was found that spilt oil is likely to cross median lines and impact coastlines of several European countries with most impacts expected in Norway, Denmark and Sweden.

11 Societal Impacts

This section discusses the potential societal impacts associated with the proposed Talbot Field Development. The assessment of societal impacts is concerned with the human components of the environment and seeks to identify the societal and economic impacts on people and their activities (Morris and Therivel, 2009). This section does not consider Greenhouse Gas emissions resulting from the Talbot Field Development; a summary of emissions and impact assessment can be found in Section 8.

The following activities were identified during the ENVID and risk assessment process (Section 5) as having a medium societal risk:

- Physical presence of drilling rig and vessels;
- Spudding of jack-up rig;
- Trenching and backfill; and
- Crossings, installation of rock, concrete mattresses and plinths.

The following activities were identified as having a low societal risk during the ENVID and risk assessment process. Due to the regulatory issues and/ or stakeholder concerns associated with these activities they are assessed further in this ES.

- LTOBM cuttings;
- Onshore disposal of solid waste (rig & vessels);
- Pipeline and umbilical lay operations;
- Installation of protective materials, concrete mattresses and grout bags; and
- Installation of drilling template and manifold on the seabed.
-

11.1 Regulatory Context

Societal impacts resulting from the activities associated with the proposed Talbot Field Development Project will be managed in accordance with current legislation and standards as summarised in Section 1.

11.2 Approach

The issues identified and listed above are assessed with due consideration to the baseline societal conditions presented in Section 4. Due consideration has also been afforded to the impact sections presented throughout this ES.

11.3 Sources of Potential Impact

The following sections provide a description of the activities that have the potential to result in societal impacts.

11.3.1 Physical Presence of Drilling Rig and Vessels

There will be a presence of the drilling rig and vessels during the installation, drilling and production phases of work, thus increasing the current vessel activity in the area. This increased activity has been ascertained within the ENVID to have a potential impact on commercial fishing, shipping and other sea users. Vessel activity currently being considered for the Talbot Field Development include the following:

- Drilling activities will be carried out by a jack-up rig, the subsea wells will remain a permanent feature during the project.
- During drilling and completion, three AHVs, an ERRV, and a supply vessel will be required.

- During the subsea infrastructure installation, tie-in and commissioning phase of the development DSV, CSV, TSV, SUV, RDV, PLV, and a guard vessel will be required.

To minimise navigational hazards, all vessels engaged in the project operations will have markings and lighting as per the International Regulations for the Prevention of Collisions at Sea (COLREGS) (MO, 1972).

The vessels are equipped with marine navigational aids and an aviation obstruction lights systems, as per the Standard marking Schedule for Offshore Installation (HSE, 2009), to warn ships and aircraft of their positions. The systems comprise:

- Marine navigational light;
- Fog-lights
- Aviation obstruction lights;
- Helideck beacons (helideck status light system);
- Fog-horns;
- Fog-detector;
- Helideck lighting; and
- Radar beacons

As required by HSE Operations Notice 6 (HSE, 2014), a rig warning communication will be issued at least 48 h before any rig movement. Notice of any drilling rig moves and vessel mobilisation associated with the mobilisation and demobilisation of the drilling rig will be sent to the Northern Lighthouse Board (NLB). The drilling rig routes will be selected in consultation with other users of the sea, with the aim of minimising interference to other vessels and risk collisions. Prior to commencement of offshore activities, Harbour will apply for a 500 m exclusion zone at the drilling location to mitigate any collision risks and an ERRV will patrol the Talbot Field Development area. In addition, a CtL permit application will be submitted to BEIS.

11.3.2 Installation and Presence of Subsea Equipment

The installation and presence of the following have been identified to have a potential impact upon commercial fishing activities:

- Drilling template;
- Wellheads;
- Mattresses;
- Pipeline;
- Rock placement;
- Grout bags; and
- Manifold.

On-site installation activities by construction vessels are currently scheduled to take up to 33 days, with the diving support vessel present for up to 60 days. Installation activities will inherently increase the volume of marine traffic in Talbot Field Development area and along transit routes. This will occur for the duration of the installation activities.

Prior to installing the subsea infrastructure, the project will apply for PWA, including a marine licence for deposit of materials. The development will comply with a notification requirements associated with the PWA approval. This will include the positions of any pipelines and control tie-backs. The project will submit a CtL application to BEIS including the results of an up to date vessel traffic survey and collision risk assessment. The location of all infrastructure to be installed will be submitted for inclusion on the admiralty charts.

The presence of subsea equipment will have the potential to present a snagging hazard to commercial fishing activities over the period during which it is installed. This may result in the loss of catch/ revenue for fisheries. Therefore, a 500 m safety exclusion zone that will not be accessible to commercial shipping and fishing industries will be in place around the drill centre.

11.3.3 Treatment of LTOBM Cuttings

For cuttings contaminated with LTOBM either an offshore processing unit may be used to separate water and hydrocarbons from solids or LTOBM cuttings will be skipped and shipped in covered skips for treatment and disposal; both options are currently being assessed. The onshore treatment of LTOBM cuttings may contribute to a deterioration of local air quality and requires more energy for transport. Following processing inert cuttings will be deposited in licensed landfill disposal facilities whilst recovered oils are typically reused in the processing system.

11.3.4 Onshore Disposal of Solid Waste

Solid waste will be shipped to shore to licensed sites for disposal. All wastes returned to shore will be handled and disposed of in accordance with legislation, Waste Management Plans (WMPs) and the waste management hierarchy. The appointed waste management contractor will supply monthly reports for waste sent to shore, will complete controlled waste transfer notes, as required, and maintain records of monthly disposals. Waste management duty of care audits will also be carried out. There is the potential for localised impacts to the societal aspects of such sites through a deterioration in the local air quality. Efforts will be made to minimise waste to landfill and once online Talbot will be responsible for very little waste generation above that of normal platform volumes.

11.4 Impact to Receptors

Receptors potentially impacted by the proposed activities may include:

- Commercial shipping;
- Commercial fishing;
- Other users; and
- Use of resources and disposal facilities.

11.4.1 Commercial Shipping

Commercial shipping density within Block 30/7 is classified as low, while for Blocks 30/13 and 30/12 are classified as having a very low shipping density (OGA, 2016).

The presence of the vessels associated with installation and drilling operations will occur only over the period that these activities will take place. Further, it is not expected that more than six vessels will be present within the Talbot Field Development area at any one time. All activities will be accompanied by the required permitting and notifications to mariners, therefore mitigating potential impact to a minor level of significance.

A Vessel Tracking Study was used to identify the probability of a vessel being on a collision course with the T Talbot Field Development within Block 30/13e (BMT, 2019a; Appendix A), calculated as a combination of three factors:

- Number of vessels within passing traffic streams;
- Geometric distribution of vessels within traffic streams; and
- Causation factor for the case where a vessel fails to take the correct avoidance action.

Although variation in the traffic volumes from month to month was identified, the number of adjacent traffic activity is low within 10 nm radius from the jack-up rig installation. The collision frequency for Main Traffic Streams was calculated to be 5.8 x 10^{-6}, while the collision frequency for Non-Routine Traffic was calculated to be lower at 7 x 10^{-7}. Movement of infrastructure from the transit port(s) is not considered to pose a significant risk to commercial shipping if industry standards are followed and notifications to mariners of planned transit routes are put in place.

11.4.2 Commercial Fishing

Trawls were the most utilised gear type used in ICES rectangle 42F2 in each year from 2014 to 2020 (Scottish Government, 2021; MMO, 2021), which has seen a decline in fishing effort, value and quantity of live weight from 2014 to 2020 (Section 4.5.1). Of the total commercial catch, there were 25 demersal species, 5 shellfish species and one pelagic species (MMO, 2021). Further detail on the commercial fishing statistics is provided in Section 4.

The introduction of a 500 m no fishing zone around the Talbot Field Development drill centre will reduce the available fishing grounds in the local area for the duration of the Talbot Field Development. Subsea infrastructures used have the potential to introduce a snagging hazard, which will incur a financial loss, or even injury and loss of life, for commercial fishers (Rouse et al., 2018). However, all subsea infrastructure will be fishing friendly by being designed for impact and snag loads as per international Norwegian (NORSOK) guidelines.

The pipeline from the Talbot Field Development to the Judy platform will be trenched and backfilled, with suitably graded rock placement used to minimise the risk of snagging fishing gear. Subsea structures and pipelines will be mapped and the UK Hydrographic Office (UKHO) and Kingfisher informed. Following decommissioning, the 500 m safety zones, along with the subsea infrastructure, will be removed to allow commercial fishing to occur.

11.4.3 Other Users

There are several oil and gas installations within a 40 km radius of the Talbot Field Development (Section 4.5.2). Harbour will put the appropriate measures in place to ensure there are no interferences with other oil and gas operations in the area. Other relevant users/ facilities include:

- No renewable energy developments or Ministry of Defence activities occur within 100 km of the proposed Talbot Field Development (Section 4.5.3 and 4.5.4).
- Two telecommunication cables occur in the near vicinity of the Talbot Field Development, the Tampnet Clyde telecommunication cable located in Blocks 30/12 to Block 30/13, and the Tampnet Valhall telecommunication cable located approximately 9 km southeast of the Talbot Field Development (KIS-ORCA, 2020; Section 4.5.6).
- There are three unknown, non-dangerous wrecks within the proposed Talbot Field Development area (NMPI, 2019). There are no known wrecks of historical importance in the vicinity of the proposed Talbot Field Development (Section 4.5.7).
- No aggregate extraction activities occur in the CNS (NMPI, 2019).

11.4.4 Use of Resources and Disposal Facilities

Waste generated during the installation, drilling and operations of the Talbot Field Development will be disposed onshore, including general waste produced on vessels and on the drilling rig. Impacts will occur from the use of landfill resources and may result in a short-term localised deterioration of air quality. The impact on recycling facilities and landfill sites will be minimised by careful planning and introduction of an active WMP. Harbour has already developed waste management procedure for the J-Block (Harbour, 2016). Licensed contractors at licensed sites will undertake processing and there will be few impacts from the controlled operations. Harbour's Duty of Care extends beyond the quayside to ensure that onshore licensed disposal sites undertake all disposal activities in a responsible manner. Waste materials will be recycled whenever possible. The environmental impacts that may be experienced at any onshore site selected for receiving and dealing with material from the Talbot Field Development would be short-lived, localised and managed.

11.5 Cumulative and In-Combination Impacts

Given the density of oil and gas infrastructure in the area, it is possible that cumulative impacts associated with vessel operations relating to other oil and gas infrastructure will take place, particularly related to air quality. Harbour will aim to minimise atmospheric emissions whenever possible (Section 8).

11.6 Transboundary Impacts

Although the Talbot Field Development is in close proximity to the UK/ Norway median line, at 7 km away, the impacts presented within this section have been deemed to be localised within UK waters with no transboundary impacts. No global impacts are also anticipated other than inevitable contribution to greenhouse gas emissions discussed in section 8.

11.7 Decommissioning Phase

At CoP the Talbot infrastructure will be decommissioned as part of a decommissioning programme incorporating Talbot Field Development along with the J-Block area fields. At the commencement of the decommissioning activities, vessel activity in the area will increase relative to the number of vessels typically present in the area of the development during the production phase. All decommissioning activities will occur within the offshore development area such that they are not expected to significantly impact shipping and fishing activities in the area at the time.

Where feasible the mattresses and grout bags and all protective material deposits will be recovered. It is intended that the surface flowlines and umbilicals will also be recovered at end of field life, however in line with the current BEIS Guidance (BEIS, 2018), a comparative assessment will be carried out to determine the optimal approach.

It is intended that recovered infrastructure will be returned to shore and transferred to a decommissioning facility, which will have all necessary approvals and licences in place and possess the capability to reuse or recycle the majority of recovered material. The minimisation of waste is a factor considered at every stage of the project.

The waste generated as a part of the decommissioning activities will be a combination of both hazardous (special) and non-hazardous wastes. As operator, Harbour will have in place a WMP developed to identify, quantify (where possible) and discuss available disposal options for waste resulting from the decommissioning activities. Where possible, materials will be recycled or sold and reused taking into account a waste hierarchy.

Following decommissioning, overtrawl surveys will be carried out along the pipeline and umbilical routes and within the Talbot Field Development 500 m exclusion zone to ensure a clear seabed. Following decommissioning, and subject to legislation and guidance in force at the time, the Talbot Field Development tie-back will surrender the exclusion zone.

11.8 Mitigation Measures

The planned mitigation measures that Harbour will undertake to minimise the societal impacts of the proposed Talbot Field Development are detailed in Table 11:1.

Table 11:1 – Potential sources of impact and planned mitigation measures

Potential source of impact	Planned mitigation measures
Physical presence of drilling rig and vessels	• **Notice to Mariners and Shipping Alerts will be issued prior to rig mobilisation.** • **Updates to Kingfisher charts.** • **Presence of Standby vessel.** • **Ongoing consultation with the SFF.** • **Industry standard notifications, navigation aids and communications. All vessels will adhere to the COLREGS and will be equipped with navigational aids, including radar, lighting and AIS (Automatic Identification Systems).** • **Notification emails on rig moves to all stakeholders.** • **Consent to locate.** • **Vessel use will be optimised by minimising the number of vessels required and length of time vessels are on site.** • **All infrastructure will be laid within an existing chartered Offshore Area Development.** • **500 m safety zone around drill centre.**
Trenching and backfill	• **Operational controls during trenching and burial, including accurate positioning and in situ monitoring by ROV.** • **Pre- and post-lay surveys.**
Crossings, installation of rock, concrete mattresses and plinths	• **Minimise use or rock and footprint wherever possible.** • **ROV monitoring of rock dump placement.** • **Rock berm profile overtrawlable and rock size graded.** • **The quantity of rock dump will be minimised.** • **Placed by fall-pipe and deployed accurately.**
Onshore disposal of solid waste (rig & vessels)	• **Best practice.** • **Defined waste management procedures.** • **Licensed wastes facilities.** • **Majority recycled.**
Pipeline and umbilical lay operations	• **Pipeline route survey, EBS, engineering studies and planning to optimise the pipeline configurations, designs, routes and installation methods.** • **Operational controls during lay and trenching, including accurate positioning and in situ monitoring by ROV.** • **Guard vessel in place.**
Installation of protective materials, concrete mattresses and grout bags	• **ROV monitoring of mattresses placement.** • **The quantity of mattresses and rock will be minimised.** • **Materials will be deployed accurately.** • **The use of all pipeline stabilisation features (e.g. mattresses, rock cover and grout bags) will be minimised through project**

Potential source of impact	Planned mitigation measures
	design and will be used in accordance with industry and SFF best practice. • **As left survey**
Installation of drilling template and manifold on the seabed	• **Fishing friendly structures.** • **Consent to locate.** • **Standard notification to stakeholder bodies.**

11.9 Conclusion

Societal impacts to commercial fishing activity and commercial shipping will be largely due to the introduction of 500 m exclusion zones. These zones will reduce the area available for fishing during the duration of oil and gas operations at the Talbot Field Development, as well as limit vessel traffic access in the vicinity. However, these impacts will be minimised by reducing vessel traffic in the area and by notifying relevant users via Notices to Mariners. The loss of access will be limited to the lifespan of the Talbot Field Development, as the area will likely become available to other users of the sea following decommissioning of the development. Although the development is close to the UK/ Norway median line, no transboundary societal impacts have been established. Onshore societal impacts are possible due to waste being taken to shore, which will use recycling facilities and/ or landfill resources and may result in deterioration of local air quality. Cumulative impacts may occur concerning air quality due to the dense oil and gas activity in the area, but Harbour will ensure that atmospheric emissions are minimised and are of relatively short duration in a high energy environment. The Talbot Field Development is considered likely to bring beneficial societal impacts, bringing support to the local economy and increasing future self-reliance.

12 Conclusions

A detailed assessment of the potential environmental impacts associated with the proposed Talbot Field Development has been carried out. The identification of the potential impacts is based on the nature of the proposed activities and was informed by available literature and guidance documents, site surveys, industry specific experience, and consultation with BEIS and their advisors and stakeholders. The commitments made in this ES will be incorporated into environmental management plans for the drilling, installation, operations and decommissioning phases of the development.

12.1 Environmental Effects

The development area is located in the CNS in a mature oil and gas area.

The potential impacts to the environment from all phases of the project have been identified. The environmental aspects of each of the key activities, for each phase of the development, were identified and quantified in terms of their duration (likelihood with regards to accidental events) and the magnitude of effect. In the case of planned activities, the results were assessed on the basis of the significance of the impact posed to the environment and were summarised as being either low, medium or high. Potential unplanned (or accidental events) were assessed in terms of the environmental risk and were also summarised in terms of being low, medium or high.

The assessment showed that, after implementation of mitigation measures, the significance of impact for all of the planned activities, is either low or medium. Table 12:1 identifies those activities found to be of significance. In each case, the magnitude of effect for planned activities ranked between negligible and moderate, with no effects considered to be major, or severe, following the application of mitigation and control measures.

For three unplanned events identified the risk was considered to be of medium significance and one, a well blowout, was considered to be of a high significance. From Table 12:1, it can be seen that those accidental events of medium risk, had magnitude of effects associated with them that ranged from slight to significant, with none of the anticipated effects considered to be of a major, or severe, significance. Only the well blow out is considered to have a severe magnitude of effect.

The Talbot project has considered the objectives of both Marine Plans (Scottish waters National Marine Plan and the English waters North East Offshore Marine Plan) (Table 12:2).

Table 12:1 – Activities identified to have a low, medium, significant, or high impact/ risk

Aspect	Activity	Consequence	Frequency/ Likelihood	Residual Risk	Significance
Physical Presence	Physical presence of all subsea infrastructure (includes well, flowlines, umbilical, tie-in spools, rock dump, mattresses, grout bags, manifold, pipeline etc.	Moderate	Frequent	Medium	Medium
Seabed Disturbance	Disturbance associated with the installation of subsea infrastructure	Moderate	Occasional	Medium	Medium
	Impacts of spud cans/anchors/ anchor chains on the seabed during positioning of the rig.	Minor	Occasional	Medium	Medium
Discharges to Sea	Planned discharge to sea of WBM and WBM contaminated cuttings, brine, cement and completion chemicals required in the drilling process.	Minor	Occasional	Medium	Low
Emissions to air	Emissions associated with the HDJU drilling rig	Minor	Probable	Medium	Low
	Emissions from construction and support vessels	Minor	Probable	Medium	Low
Underwater noise	General vessel use	Minor	Remote	Low	Low
	Drilling operations	Minor	Remote	Low	Low
	Piling activities	Moderate	Probable	Significant	Medium
Unplanned/ Accidental events	Minor chemicals/ hydrocarbons release from vessels e.g. from drains on vessels of the HDJU drilling rig	Minor	Probable	Medium	Low
	Major oil/ chemical (e.g. fuel oil and diesel) release (potentially due to vessel collision or loss of fuel inventory from drilling rig).	Moderate	Probable	Medium	Medium
	Dropped objects from vessels or drilling rig resulting in damage to subsea infrastructure and seabed.	Minor	Occasional	Medium	Medium
	Loss of containment of OBM (potentially through a burst hose) resulting in a release to sea.	Minor	Probable	Medium	Medium

Aspect	Activity	Consequence	Frequency/ Likelihood	Residual Risk	Significance
	Well Blowout (uncontrolled hydrocarbon release in the event of loss of well control)	Catastrophic	Remote	Significant	High

Table 12:2 – Proposed Talbot Field Development assessed against the Oil and Gas Marine Planning Policies

Scotland's National Marine Plan Principle	Applicable (Yes/ No)	Assessment Against Principle
Oil & Gas 1: The Scottish Government will work with BEIS, the OGA and the industry to maximise and prolong oil and gas exploration and production whilst ensuring that the level of environmental risks associated with these activities are regulated. Activity should be carried out using the principles of BAT and Best Environmental Practice. Consideration will be given to key environmental risks including the impacts of noise, oil and chemical contamination and habitat change	Yes	The environmental risk is addressed in the EIA. BAT and BAP have been applied throughout the FEED and planning stages of the project. Potential environmental. The potentially significant environmental impacts from noise, accidental release and habitat change have been considered within the Talbot Field Development EIA with robust mitigation measures developed where applicable. This development allows access to reserves and potentially could facilitate realising production of future stranded reserves.
Oil & Gas 2: Where re-use of oil and gas infrastructure is not practicable, either as part of oil and gas activity or by other sectors such as carbon capture and storage, decommissioning must take place in line with standard practice, and as allowed by international obligations. Re-use or removal of decommissioned assets from the seabed will be fully supported where practicable and adhering to relevant regulatory process.	Yes	Harbour will review decommissioning best practice closer to the point at which Talbot will be decommissioned. Full consideration will be given to the available decommissioning options, including reuse and removal. Harbour is experienced in decommissioning operations and will draw on this on knowledge to ensure that re-use and recycling are considered and prioritised.
Oil & Gas 3: Supporting marine and coastal infrastructure for oil and gas developments, including for storage, should utilise the minimum space needed for activity and should take into account environmental and socio-economic constraints.	Yes	The Talbot subsea tie-back will make use of existing infrastructure, including the Judy Platform and repurposing pipeline from the Joanne, reducing the requirement for further offshore infrastructure. This option eliminates the need for a larger, more impactful development, minimising environmental footprint of the project and reducing processing energy requirements.
Oil & Gas 4: All oil and gas platforms will be subject to 9 nm consultation zones in line with Civil Aviation Authority guidance.	No	Talbot is located at least 278 km from land and is not expected to conflict with any aviation flight paths. The Judy Platform and HDJU rig are equipped with an aviation obstruction lights system, as per the Standard Marking Schedule for Offshore Installations.
Oil & Gas 5:	Yes	Harbour's CNS OPEP is in place and will be updated to account for changes

Scotland's National Marine Plan Principle	Applicable (Yes/ No)	Assessment Against Principle
Consenting and licensing authorities should have regard to the potential risks, both now and under future climates, to oil and gas operations in Scottish waters, and be satisfied that installations are appropriately sited and designed to take account of current and future conditions.		resulting from the Talbot Field Development. SOPEPs will be in place for project vessels. This development will be subsea and so the infrastructure once in place will have very little impact to it from adverse weather and effects of climate change.
Oil & Gas 6: Consenting and licensing authorities should be satisfied that adequate risk reduction measures are in place, and that operators should have sufficient emergency response and contingency strategies in place that are compatible with the National Contingency Plan (NCP) and the Offshore Safety Directive.	Yes	Harbour is party to a voluntary oil pollution compensation scheme for the North Sea, known as OPOL holds OPOL (Offshore Pollution Liability). In addition, they have access to Oil Spill Response Limited (OSRL) resources and access to the OSPRAG Well Capping Device. The Harbour response strategy and mitigation measures to a largescale accidental hydrocarbon release has been developed to address a worst case scenario with due reference to the NCP.
North East Offshore Marine Plan Policy	**Applicable (Yes/ No)**	**Assessment Against Policy**
NE-OG-1: Proposals in areas where a license for oil and gas has been granted or formally applied for should not be authorized unless it is demonstrated that the other development or activity is compatible with the oil and gas activity.	Yes	The Talbot Field Development Project is within a densely populated area for oil and gas infrastructure that is compatible with these activities.
NE-OG-2: Proposals within areas of geological oil and gas extraction potential demonstrating compatibility with future extraction activity will be supported.	Yes	The Talbot development project is in an area where oil and gas reservoirs have been identified and are already being extracted. There is also potential for further wells in the area to be tied back to the Talbot Field Development, to be further tied back to the Judy Platform.

Source: Scotland's National Marine Plan 2015; Northeast Inshore and Offshore Marine Plan 2021

12.2 Minimising Environmental Impact

The execution of the proposed Talbot Field Development project, when incorporating the control measures identified in this ES, is not expected to have a significant impact on the environment. Following implementation of identified control measures, all residual risks to the environment are considered to be ALARP.

Installation of subsea infrastructure and pipeline will result in seabed disturbance and introduction of new substrate and materials. The disturbance and use of stabilising materials will be localised and minimised wherever possible. Discharges of cuttings drilling muds will be to a small area and any chemical use will be permitted. Routine atmospheric emissions and discharges to sea, would be expected to disperse within a limited distance from the development. It is therefore unlikely that planned emission and discharges will have a transboundary impact (the nearest median line is UK/ Norway is approximately 7 km from the proposed Talbot Field Development). No significant transboundary or cumulative impacts were identified as a result of planned activities. There is a risk of transboundary impacts associated with an accidental spill/ release of oil as discusses in Section 10. However, measures will be in place to minimise the likelihood of such an event occurring. Should an uncontrolled release occur, there will also be measures in place to ensure a co-ordinated and co-operative well control and pollution response campaign (See Section 10).

12.3 Protected Species and Sites

The majority of species protected under Annex I of the Birds Directive that are present within the North Sea will generally be found much closer to shore and may only encounter the project with any regularity during the limited period of the drilling, installation and decommissioning activities.

There will be no significant impact on any Annex I habitat (of the Habitats Directive).

The presence within the Talbot development area of species protected under Annex II Habitats Directive is limited to marine mammals. Harbour has assessed through a noise assessment whether the noise emitting operations (from vessel use, limited hammer piling and drilling) associated with the Talbot Field Development have the potential to result in injury or disturbance to any species. The assessment concluded that there is a very low likelihood of injury (such as temporary or permanent hearing loss), or disturbance as a result of the activities associated with the project when using the proposed mitigation measures and that any potentially significant environmental impacts would be unlikely to result in population impacts.

There are a number of offshore and coastal conservation area on the UK mainland that have been designated under the Habitats Directive as SACs, under the EU Birds Directive as SPAs Marine and Coastal Access Act 2009 as MCZs. The potential for significant impacts on any such sites has been considered within each impact assessment. Particular focus was given to the potential for an accidental hydrocarbon release to interact with such given sites and in particular on the Fulmar MCZ (the drilling centre of the Talbot project lies within the MCZ boundary). Only an indirect impact to the seabed and the Fulmar MCZ is likely from a hydrocarbon release. Also, given the distance from any SACs and SPAs it is unlikely that operational, drilling, installation and decommissioning activities associated with Talbot will have a significant effect on the sites.

Given the short term duration of installation activities at Talbot, the tie-back host and pipeline route (Judy Platform is out with the boundary of the MCZ) and the mitigation and management measures in place (including for well blowout), the Talbot Field Development is considered unlikely to affect the conservation objectives or site integrity of the Fulmar MCZ (and any other SAC and SPA). Considering all the above, no significant impacts are expected upon protected species and habitats. By tying back to Judy this also represents the least amount of pipeline works within the MCZ as well as being the closest asset.

12.4 Mitigation and Control

Several mitigation measures have been developed and will be implemented to ensure that the potential impact from Talbot is not significant. The commitments register (Table 12:3) summarises the mitigation measures and will be incorporated into the Harbour EMP. Each commitment will be reviewed regularly to ensure that it is being met.

Table 12:3 – Mitigation measures and commitments register

Aspect	Commitment
Physical Seabed Disturbance (ES Section 6)	Post-decommissioning survey and remediation when needed.
	Seabed visual inspection prior to placement of drilling template and manifold.
	ROV monitoring of rock placement and mattress deployment.
	Rock berm profile overtrawlable and rock size graded.
	The quantity of rock placement and mattresses will be minimised.
	Rock to be placed by fall-pipe for accurate deployment.
	Established 500 m safety zone around HDJU drilling rig, with seabed infrastructure around the drill centre placed within a 500m zone.
	Designated lifting zones on rig and platform (dropped object control).
	Pre- and post-installation debris surveys.
Discharges to Sea (ES Section 7)	The use and discharge of the drilling, cementing and completion chemicals will be approved under a drilling application with a well specific chemical permit.
	Only permitted discharge of WBM cuttings.
	WBM formulations use mainly PLONOR chemicals.
	Cement returns monitored by ROV and mixing will stop as soon as returns at surface are observed.
	Excess dry cement will be shipped to shore.
	Cement volumes will be carefully calculated, and volumes of excess cement will be minimised by following good operating procedures.
	Only visibly clean fluid will be discharged, that meets permit discharge criteria.
	Discharge samples and analysis as per permit required during wellbore clean-up.
	Produced fluids from Talbot will be routed to the Judy platform where produced water will be treated and discharged overboard as per updated existing platform oil discharge permit.
Atmospheric Emissions (ES Section 8)	Adherence to strict maintenance regimes for all equipment and vessels.
	Equipment kept at optimum efficiencies to minimise fuel consumption.
	Flaring will be minimised and is planned to occur for start-up and shutdown only. Development well clean ups are planned to utilize the separator on Judy rather than flare offshore on the rig.
	Vessel and fuel use optimised where possible by minimising the number of vessels required and their length of time on site.
	Some of the gas produced from Talbot will be utilised for power generation on Judy platform, reducing the quantity of produced gas to be flared and the need for additional diesel fuel.
	Sea and air supply traffic managed to minimise number of trips.
Underwater Noise (ES Section 9)	Pre-piling searches by qualified marine mammal observers (MMO) for marine mammals 30 minutes prior to activity.
	At least 500-m radius search/ mitigation zone around the piling operations.
	Piling delayed if positive sighting/ detection within mitigation zone.
	Minimum 20-minute minimum soft-start of pile driver with incremental increase.
	Searches and soft start repeated for all breaks in piling activity.
	Acoustic Deterrent Devices considered if determined appropriate.

Aspect	Commitment
	Report piling activity and any marine mammal detections via the MMO report submitted upon completion.
	Machinery and equipment in good working order and well-maintained.
	The number of vessels utilising DP will be optimised.
Accidental Release (ES Section 10)	Operations undertaken utilising an approved OPEP and CIP.
	Relief well plan in place for well blowout scenario.
	Well control contingency planning.
	Management policy to be adhered to.
	Install BOP.
	Mariner notices/ shipping alerts for leaks, ruptures, vessel collisions.
	Provide accidental release data/ information for Kingfisher charts.
	Use of standby vessels to reduce chances of loss of inventory from vessel collision.
	Use industry standard notifications, navigation aids and communications.
	Ensure consent to locate and OPEP is put in place prior to any offshore activities.
	Prior to rig transfer check of hose maintenance procedures and compliance with interface documents.
	Break away couplings and observers with radios for fuel transfers to minimise spillage.
	High level alarms for spill alerts.
	Constant and clear communication regarding rig moves.
	Mud and chemicals are correctly stored in bunded areas.
	Chemical handling risk assessment. With plentiful oil and chemical spill kits around the rig.
	Rig procedures for chemical handling and movements.
	Designated lifting zones on rig and platform (dropped object control).
	Pre- and post-installation debris surveys.
	Lift planning will be undertaken to manage lifting activities, to include consideration of prevailing environmental conditions.
Societal Impacts (ES Section 11)	Mariner notices/ shipping alerts will be issued for all vessel movements.
	500 m mitigation zone around drilling rig, eliminating potential conflict with fisheries and commercial vessels.
	Industry standard notifications, navigation aids and communications including e-mail, will be used for all rig moves.
	Consent to locate will be in place assessing vessel interaction risks
	Information supplied for Kingfisher charts.
	Controlled/ monitored deployment of jack-up rig.
	Post-installation of jack-up rig seabed survey.
	Geophysical survey and EBS will determine the extent of potential rock placement and also identify and facilitate rig placement to avoid any sensitive habitats.
	Operational controls during trenching and burial, including accurate positioning and in situ monitoring by ROV, with pre- and post-lay surveys.
	Optimise use of rock and mattresses wherever possible to reduce size of footprint.
	Seabed infrastructure to be fishing-friendly by design.

Aspect	Commitment
	Use of fall-pipe and ROVs to monitor rock dump placement and mattress placement to ensure accurate deployment and optimised quantity of rock used
	Rock berm profile over-trawlable with rock sizes graded.
	Best practice when conducting onshore disposal of solid waste (rig and vessels) at licensed wastes facilities, as defined in waste management procedures
	Ensure majority of recyclable waste is recycled
	Pipeline route survey, EBS, engineering studies and planning to optimise the pipeline configurations, designs, routes and installation methods.
	LTOBM recirculated within a closed system and recovered to the rig, contained and shipped to shore for treatment (e.g. thermal desorption) and disposal.
	Ensure subsea structures are fishing friendly.

12.5 Overall Conclusion

Harbour is proposing to develop the Talbot Field located, 278 km southeast of the Scottish coastline within the CNS. The hydrocarbon reservoirs of the proposed Talbot Field Development project are well understood (based on the industry's history of drilling and field development in the area of the North Sea) and will be developed using proven technology incorporating current best practices and latest generation equipment. A robust design, strong operating practices and a highly trained workforce will ensure the proposed development does not result in any significant long-term environmental impacts cumulative or transboundary effects. The EMS will implement all the requirements of Harbour's ISO14001:2015 certified environment management system in relation to this development. Additional measures will also be in place during the operating phase, to effectively respond to potential emergency scenarios.

The Talbot field can be developed without compromising Harbour's target to reach Net Zero by 2035 and will itself improve the Carbon Intensity profile of the Judy platform. A subsea development with tie-back to Judy represents the best environmental option as both the closest asset and minimises impact to the MCZ and with the Judy asset itself having promising potential for emissions reduction going forward.

The most substantial potential impact identified during the EIA is that of a well blowout. However, the probability of such an event occurring is very low and Harbour will have in place control measures that meet or exceed stringent industry standards for well control to further reduce/ mitigate the risks and potential impacts.

The ES assesses the worst-case impact of the project on the environment and is therefore very conservative. Applying the mitigation measures identified, it is the conclusion of this ES that the current proposal for the Talbot Field Development can be completed without causing significant environmental impacts.

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XODUS, 2022. Talbot Carbon Assessment

Appendix A

Talbot Vessel Tracking Study, 2019

Talbot Development Project

Vessel Traffic Study

Reference: R9664/01 Issue 2
Date: September 2019
Confidential

Talbot Development Project

Vessel Tracking Study

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Reference: R9664/01 Issue 2

Date: September 2019

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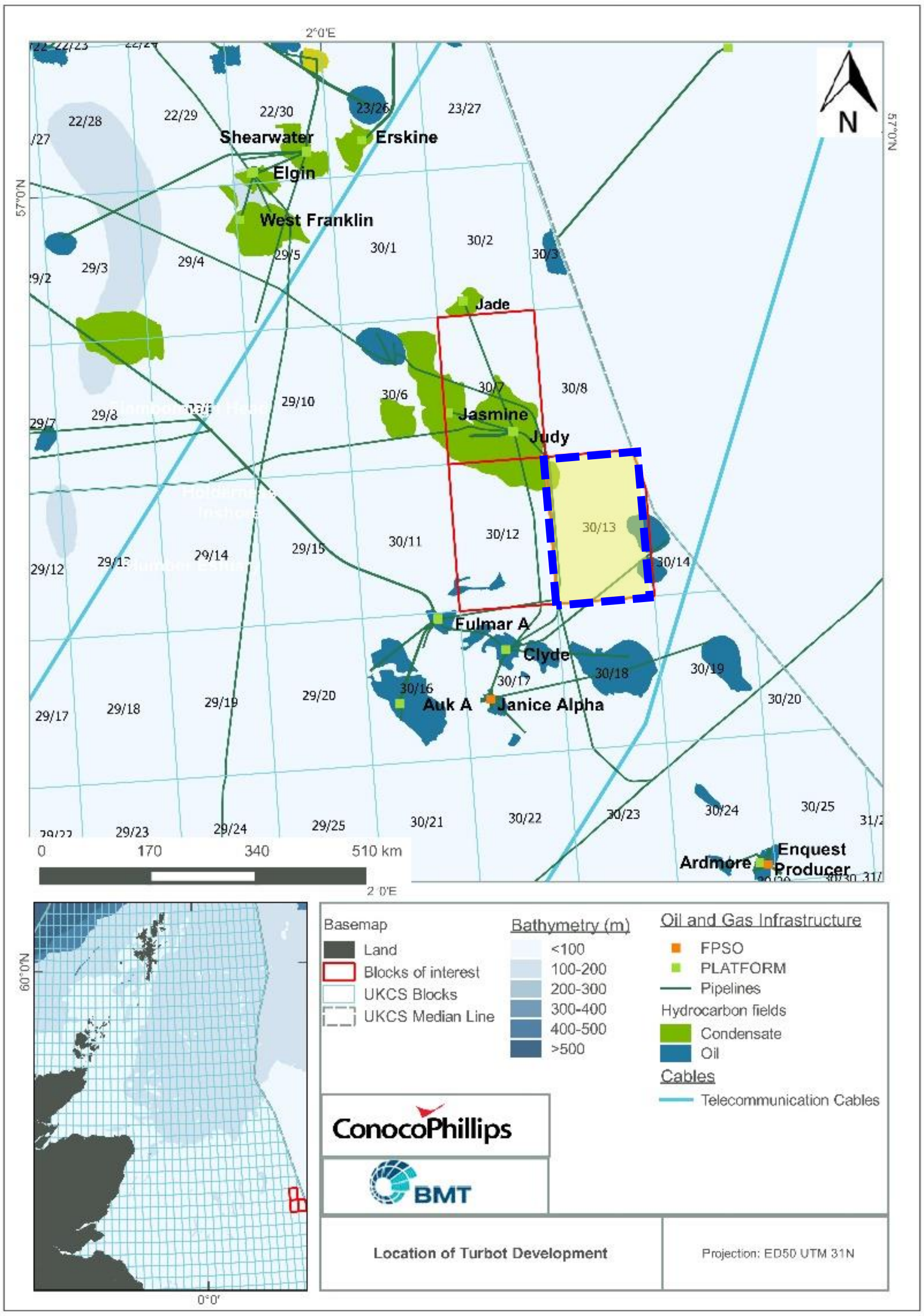
1 Introduction

BMT has been commissioned to conduct a Vessel Tracking Study for the Talbot Development Project in order to understand the current local marine traffic activity around the Project site within Block 30/13e and identify the probability of a vessel being on a collision course with the Project considering the installation of jack-up rig.

Figure 1-1 Project Location



1.1 Objectives

The objectives of this Study are to quantify the likelihood of vessel collision incidents with the Project and assess the risk frequencies associated with marine traffic around the site.

The focus of the Study refers to the assessment of the risk associated with the passing traffic at and around the proposed project site; in particular to identify the types of vessel involved and the frequency at which they may collide with the oil facility.

It should be noted that the risk of collision from Project traffic (tugs and supply vessels that may support operations) has not been included at this stage.Further safeguard measures may consider updates on marine chart and installation of AIS transponder and making the structure visible to others with AIS equipment.Project Background

1.1.1 Location Details

Talbot Development is located approximately 278 km southeast of Peterhead and covers one licence Block 30/13e with two drilling centres.

The geographical coordinates adopted for vessel tracking study are identified in Table 1-1 representing the proposed jack-up rig location in Talbot Field.

Table 1-1 Location Details

Location	Block	Geographical Co-ordinates [UTM (ED50) – Zone 31]	
Name	No.	Latitude	Longitude
Talbot Field Area	30/13e	56º 41' 32.89" N	002º 20' 8.42" W

1.1.2 Size of Rig

With reference to the Valaris JU-121[1] the dimension of the hull is 75m (length overall) x 76m (width). For a conservative assessment, this Study has adopted a dimension for the proposed jack-up rig of 100 m x 100 m footprint for marine traffic risk review.

[1] *https://www.valaris.com/our-fleet/jackups/default.aspx*

2 Study Approach

2.1 Introduction

This Vessel Traffic Study involves the review of the following key issues:

- Baseline Traffic Activity – capture of baseline traffic activity
- Collision Risk Frequency – calculate the annual probability of vessels in different length ranges having collision potential with the Project.

This Section outlines the study approach for risk assessment.

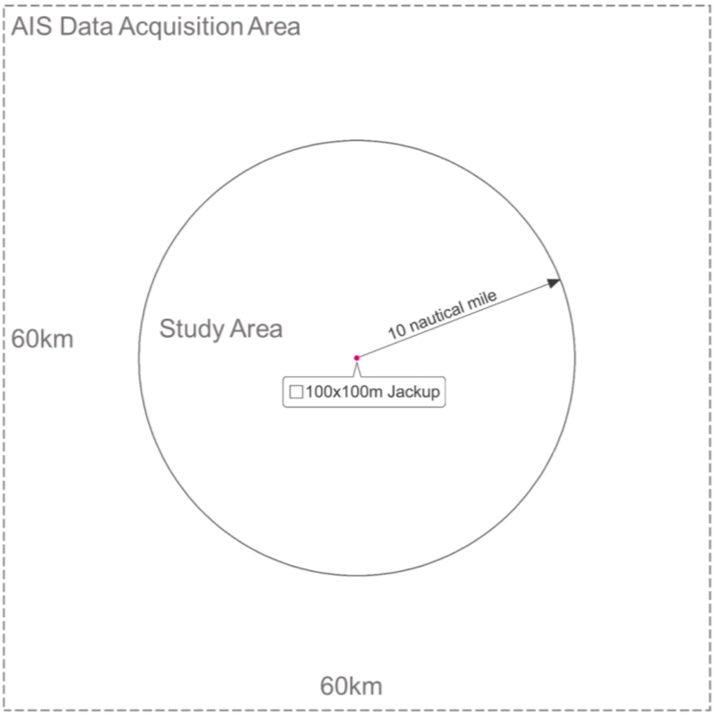
2.2 Methodology

2.2.1 Data Source

This Study uses AIS data from terrestrial and satellite sources that allow tracking and identification of vessels.

The Study Area of 10 nautical mile radius from the proposed jack-up rig location is adopted for assessment. AIS data was acquired within a 60x60km geographical box to capture vessel activity as illustrated in Figure 2-1.

Figure 2-1 Extent of AIS Data Acquisition Area and Study Area



The AIS data for a total of 12 months (from July 2018 to June 2019) was acquired from public domain (www.marinetraffic.com) which would be used to check for seasonal variations in vessel traffic patterns.

AIS and radar data provides 24-hour tracking information (typically contains detailed information on vessels reported at regular intervals including a vessel's name, MMSI (identity) number, type, location, speed, heading, length, width, draft, etc.) that when analysed, provides all necessary information on marine traffic volume and route structure.

2.2.2 AIS Data Processing

The Steps taken to process the AIS data are as follows:

- **Step 1: Data Quality Checking and Correction** – The data is checked for any inaccuracies, inconsistencies and gaps, which are then corrected. For example, the names and MMSI numbers of the vessels in the AIS data were cross-referenced with vessel databases in order to ensure that their characteristics matched. Any that did not were corrected.
- **Step 2: Geo-referencing in Geographic Information System (GIS)** - The latitude and longitude data on ship positions is geo-referenced in a GIS system to plot the location of vessels. Each point represents the position of a vessel at a specific time and is linked to a table containing all the vessel's characteristics.
- **Step 3: Vessel Track Identification** – Vessel tracks are identified from the raw AIS data by joining up the vessel positions by name and MMSI number. BMT's vessel tracking software also does error checking to remove "noise" caused by positional errors in the AIS data (e.g. such as a vessel's position that suddenly shifts by several kilometres within a 30-second interval).

The processed AIS data is then carried forward for analysis to identify vessel traffic patterns, seasonal variations, vessel sizes and vessel types.

2.2.3 Risk Assessment Approach

The risk of collision in this Study is calculated as a combination of the following factors:

- The types of movements and traffic volume within the Area of Interest;
- The geometric distribution of vessels within main traffic streams; and
- Causation probability for a navigation error where a vessel fails to take the correct action to avoid a collision.

As such, the Study approach adopted can be summarised as:

(i) Identify the type of movements & volumes – captured from Automatic Identification System (AIS) data, traffic characteristics, patterns and volume are reviewed, for

(ii) Identify the geometric distribution – also captured from AIS data. The pattern of vessel tracks is analysed to identify main stream traffic and the probability distribution of tracks within them.

(iii) Identify the chance of aberrancy – this will be based on standard factors for errors in navigation from collision risk literature and models.

2.2.4 Annual Collision Probability

The number of vessels within the Study Area for different length ranges is available from an analysis of AIS data. The Annual Collision Risk for the identified traffic is calculated using the following formula:

$$\text{Annual Collision Frequency} = \sum N(i) \times PG(i) \times PC(i)$$

Where:

i:	*traffic stream*
N(i):	*annual number of vessel transits on traffic stream i;*
PG:	*geometric probability of a vessel being present at the Project Site;*
PC:	*causation probability for a navigation error where a vessel on a collision course fails to take the correct action to avoid the collision.*

The values for i and N(i) is established based on AIS data and the detailed methodology for deriving the values for PG and PC is presented in Section 4 of this Report.

3 Baseline Traffic Environment

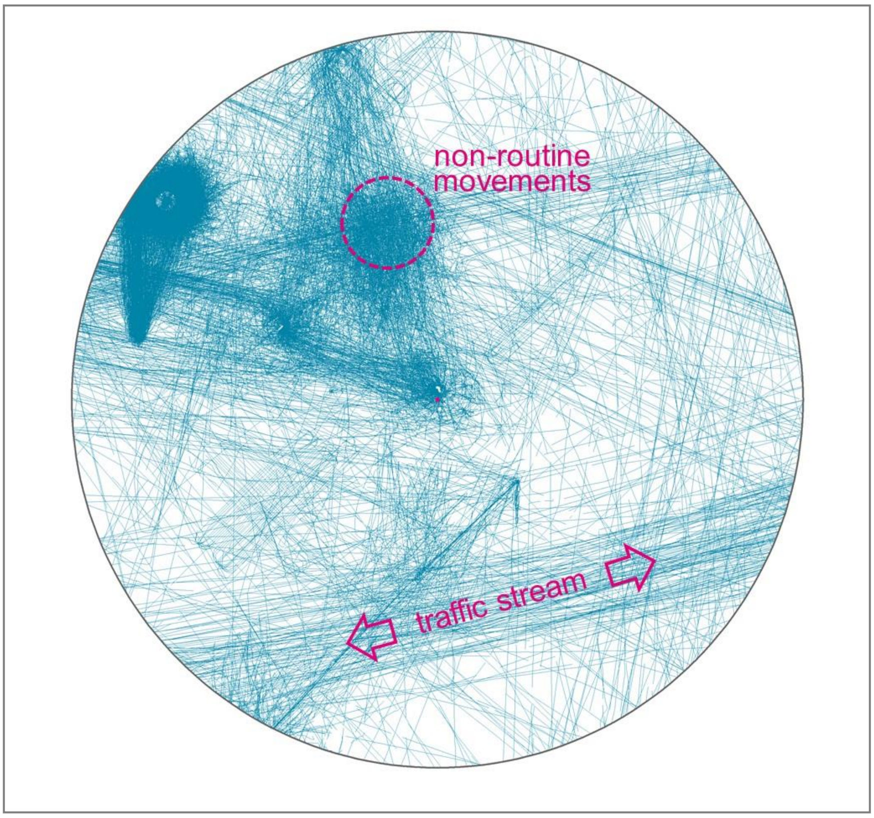
3.1 Introduction

This section summarises the results of twelve months AIS data review of traffic data within a 10nm radius centred at the planned jack-up rig location identifying the vessel types, volumes and routes or travelled pattern within the Study Area.

3.1.1 AIS Data Review

Twelve months of AIS data from July 2018 to June 2019 was reviewed and vessel tracks were identified using BMT's vessel tracking software. Figure 3-1 illustrates the vessel tracks identified of AIS data.

Figure 3-1 Vessel Track Distribution (12 months of AIS Data)



It is identified that there are multiple traffic streams with clear travelled pattern and number of tracks showing uncharacteristic or non-routine travelled pattern passing back and forth or circling within the Study Area.

These tracks were investigated further to better identify vessels' movement passing in proximity to the proposed development.

In view of the baseline traffic environment AIS data is classified into two types:

- **Main Stream Traffic** - The movements of 'routine traffic' passed through the Study Area a clear travelled pattern (directional and centreline) and portray as a representative of traffic route; and
- **Non-routine Traffic** - The movements of uncharacteristic traffic where vessel tracks are shown without any regular pattern; i.e. vessel passing back and forth or moving around in small region within the Study Area. These typically are fishing vessels, naval vessels, tugs, dredgers, yachts and offshore service vessels.

AIS tracks are grouped on the basis of vessel's behaviour and travelled pattern and Figure 3-2 illustrates the vessel tracks for "*Main Stream Traffic*" and Figure 3-3 illustrates the vessel tracks for "*Non-routine Traffic*" within the Study Area.

Figure 3-2 Vessel Tracks for "Main Stream Traffic"

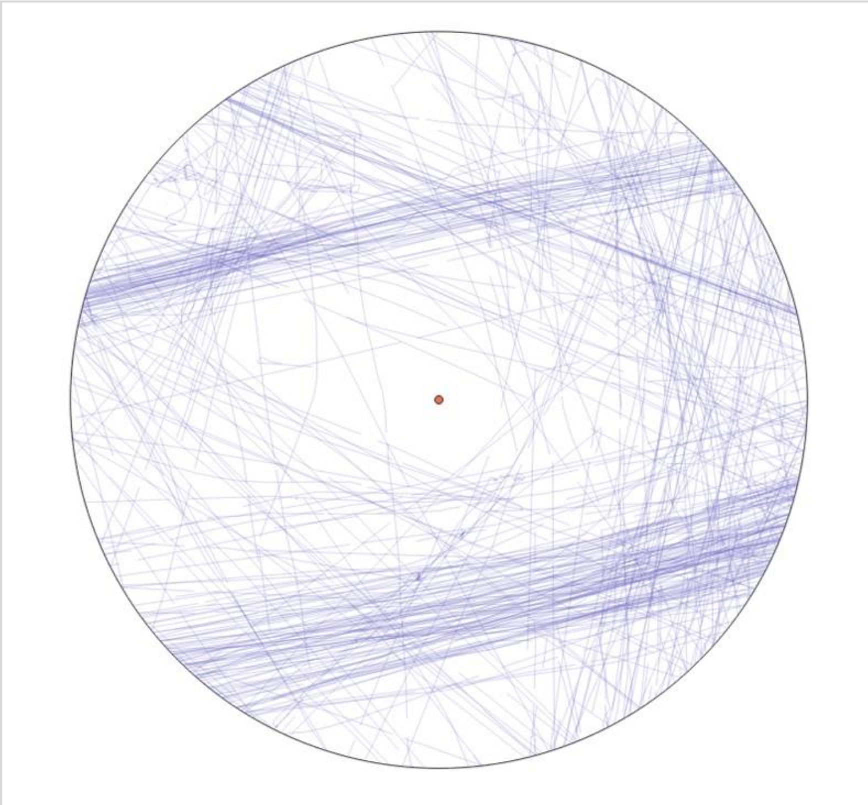
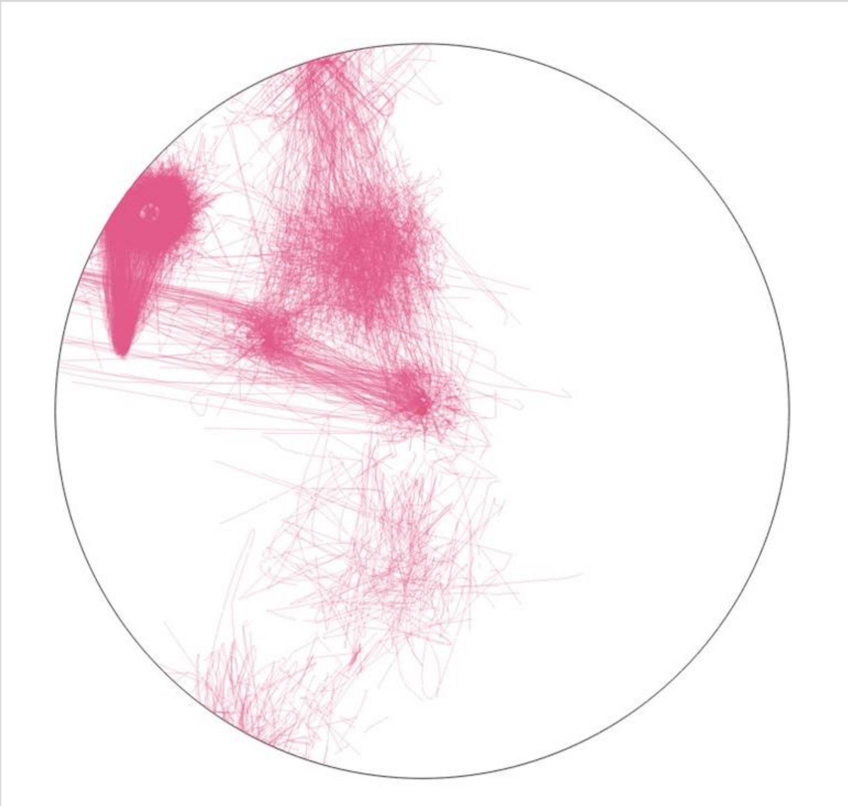


Figure 3-3 Vessel Tracks for "Non-routine Traffic"



The properties of the two identified types of vessel movements are outlined in the following sections.

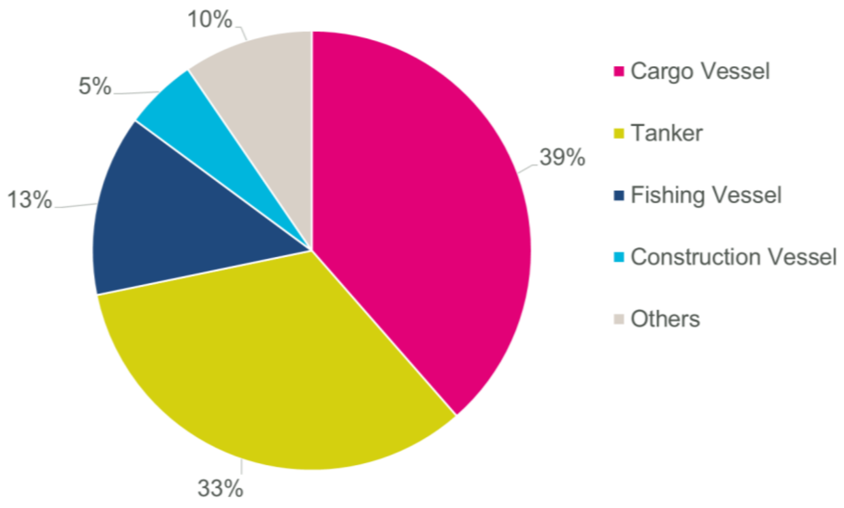
3.2 Main Stream Traffic

3.2.1 Annual Traffic Volume & Vessel Type

Over the twelve months period, an annual total of 262 movement have been identified which corresponding to less than 1 regular movement per day.

The annual traffic volume and vessel type distribution within the Study Area is presented in Figure 3-4. It is identified that majority (69%) of vessels transiting within the Study Area are Cargo Vessel and Tanker.

Figure 3-4 Distribution of Vessel Type



The vessel types being adopted for risk review refer to the attribute of AIS data summarised in Table 3-1.

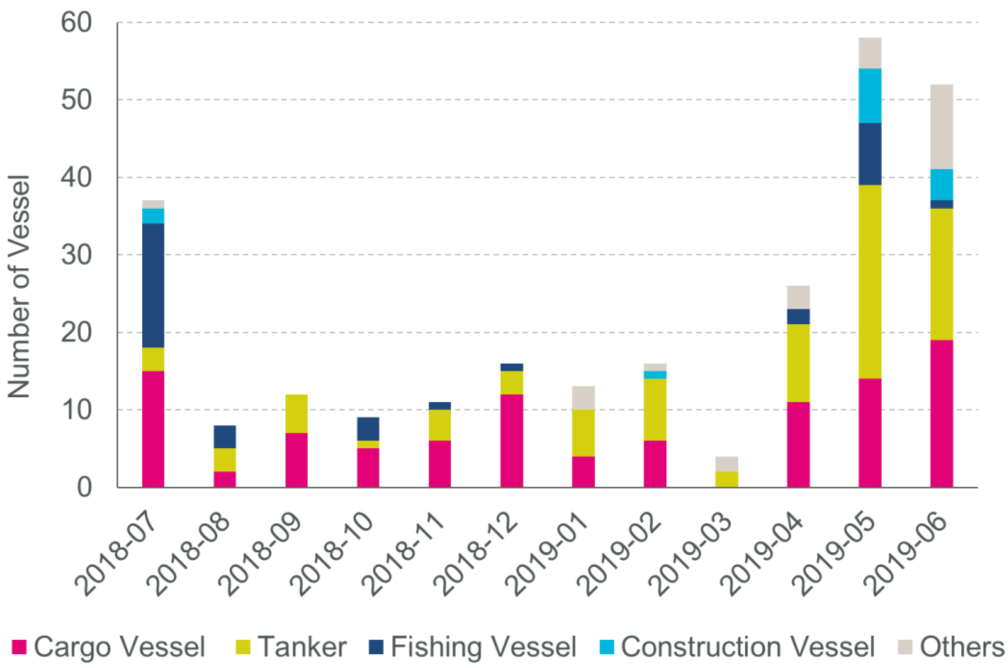
Table 3-1 Vessel Type and Sub-Types

Vessel Type	Sub Vessel Type
Cargo Vessel	Bulk Carrier, Container ship, General Cargo, Heavy Load Carrier, Inland Motor Freighter, Reefer, Ro-Ro Cargo, Container Carrier, Self-Discharging Bulk Carrier, Vehicles Carrier
Tanker	Asphalt/Bitumen Tanker, Oil/ Chemical Tanker, Crude Oil Tanker, LNG/LPG Tanker, Shuttle Tanker
Fishing Vessel	Factory Trawler, Fishery Patrol Vessel, Fishery Research Vessel, Fishing Vessel, Trawler
Construction Vessel	Buoy-Laying Vessel, Diving Support Vessel, Drill Ship, Drilling Jack Up, Multi-Purpose Offshore Vessel, Offshore Construction Vessel, Offshore Supply Vessel, Pipe Layer, Research/Survey Vessel, SAR Aircraft, Special Vessel, Standby Safety Vessel, Tug Vessel
Other	Crew Boat, Passenger Ship, Pleasure Craft, Sailing Vessel, Training Ship, Unspecified

3.2.1 Monthly Variations

Vessel tracks presented in Figure 3-2 for “Main Traffic Stream” have been analysed to identify monthly variations in vessel traffic patterns. Figure 3-5 presents the number of transits within the Study Area per month, categorised by vessel type.

Figure 3-5 Monthly Transits by Vessel Type



The figure shows that there is a high level of seasonal variability in the number of transits. During the peak month of July 2019, there were a total of 52 transits during the month, which is about 2 transits per day. While during the month with the lowest volume, which was March 2018, there were only 4 transits in total during the month.

There is variability in the numbers of vessels of each type from month to month. The most consistent class is Cargo Vessel and Tanker with 5 to 39 transits in any given month, except March. Other classes show much higher variability. For example, Fishing Vessel was very active in the summer time (May and July).

3.2.2 Vessel Length

Figure 3-6 presents the 12 months of AIS data and the histogram summarizes the vessel’s length overall (LOA in meters) corresponding to the different vessel types identified within the Study Area. The largest vessel is Tankers in the >150m category.

3.2.3 Vessel Speed

Figure 3-7 presents the vessel’s speed (knots) corresponding to the different vessel types identified within the Study Area. In general, Cargo Vessel transit at 8 to 12 knots and Tanker at higher speeds of above 12 knots.

Figure 3-6 Distribution by Vessel Type & LOA (m)

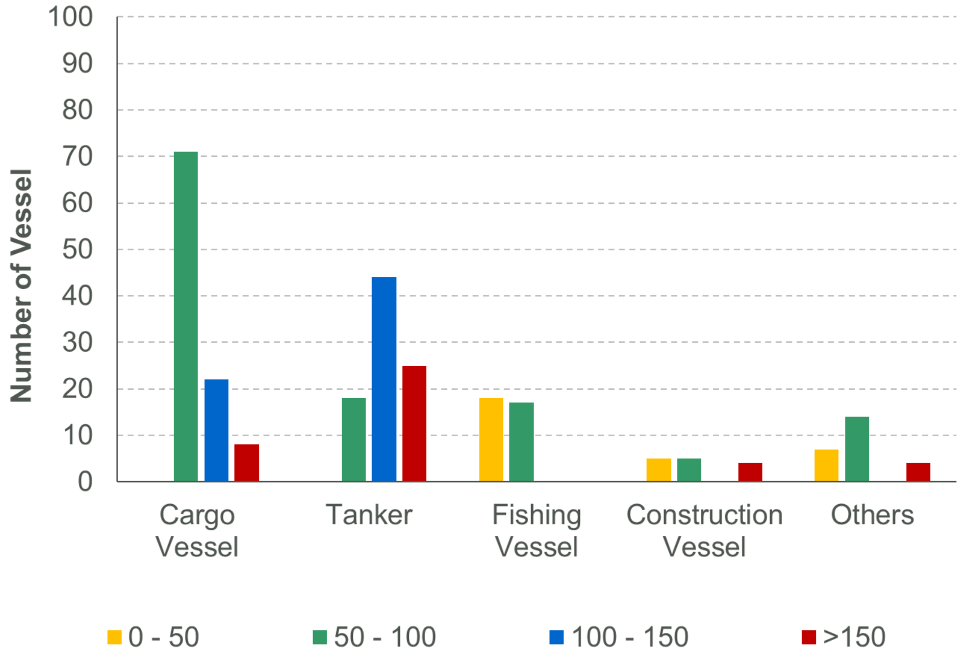
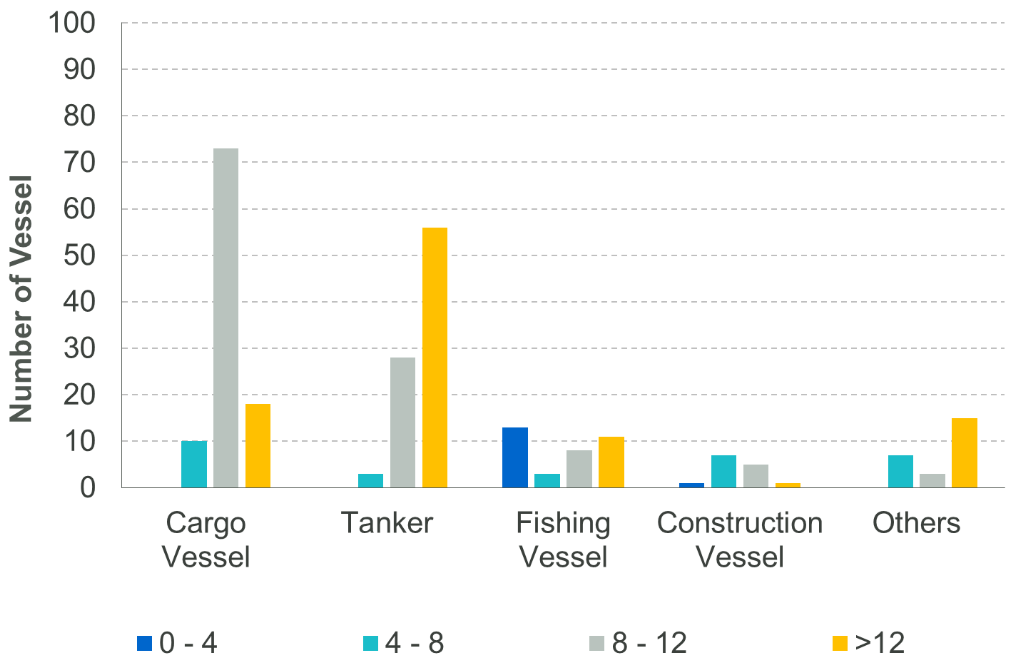


Figure 3-7 Distribution by Vessel Type & Vessel Speed (knots)



For each vessel type, the spatial distributions of tracks categorized by vessel's length and vessel's speed are presented in Figure 3-8 and Figure 3-9 in the following pages and details in Appendix C.

Figure 3-8 Spatial Distribution by Vessel Type & LOA (m)

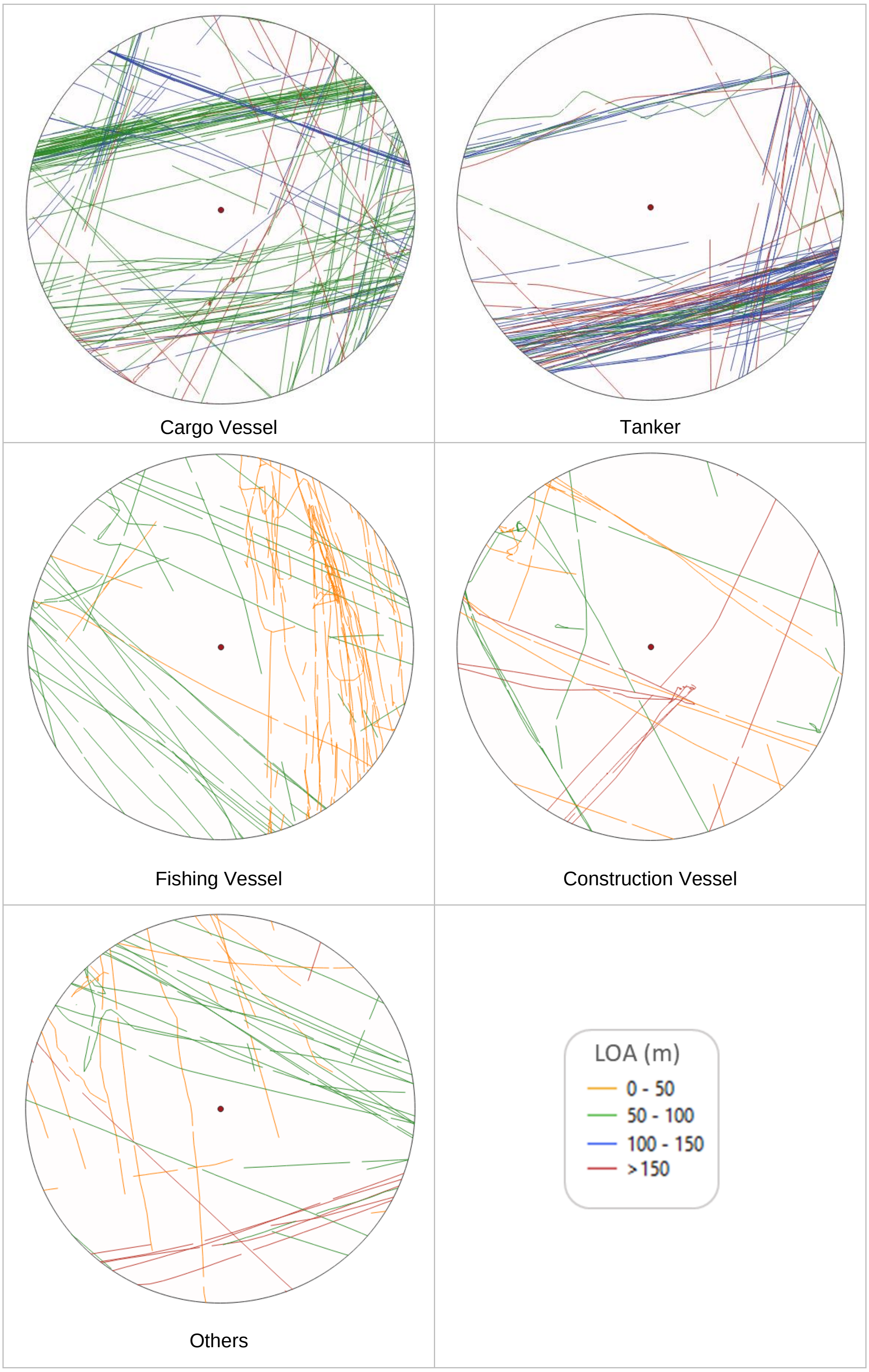
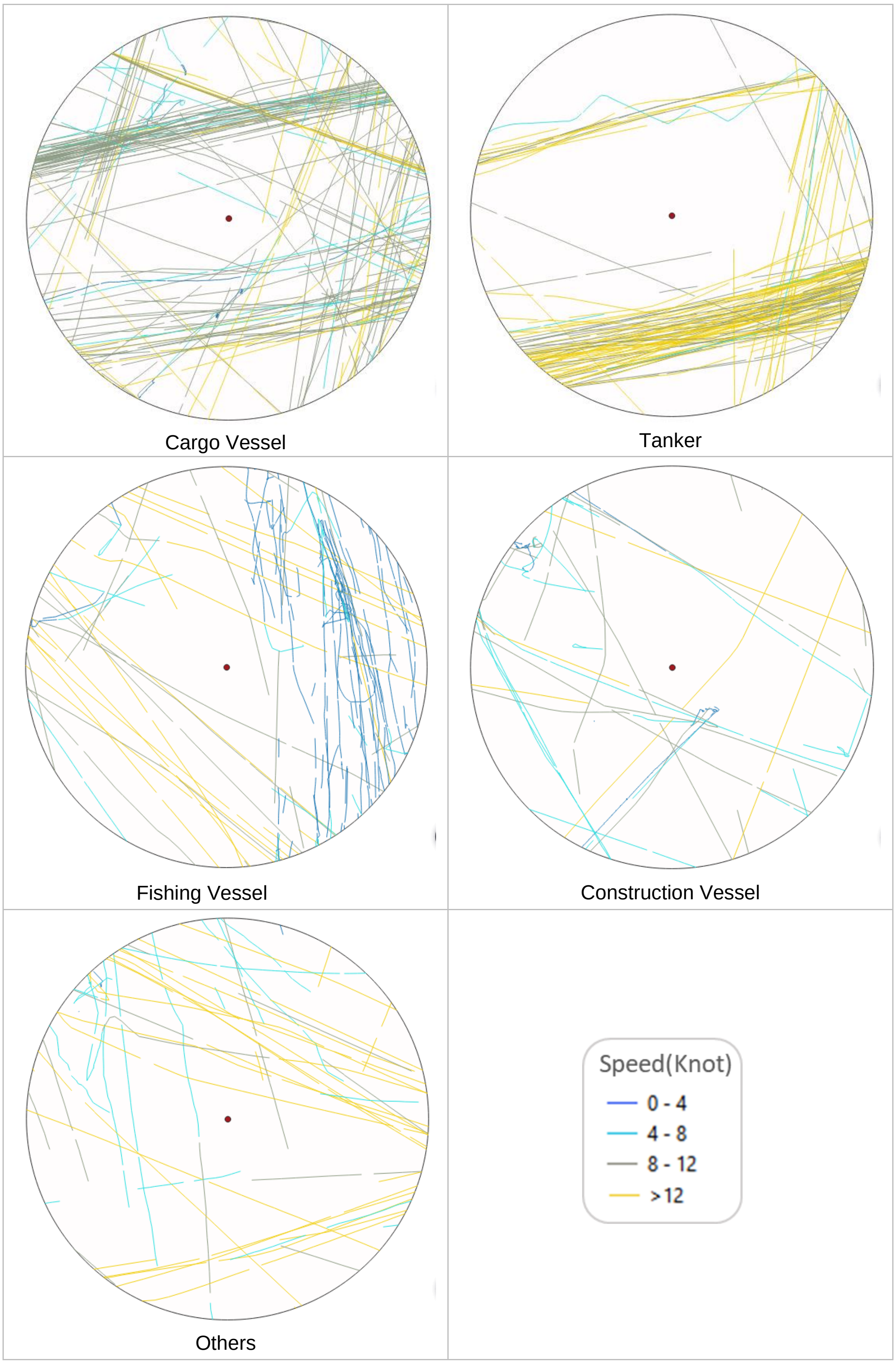


Figure 3-9 Spatial Distribution by Vessel Type & Speed (knots)



3.2.4 Route Pattern

As Figure 3-2 identifies that vessels transiting past the Study Area are generally moving within various traffic streams depending on their origin and destination.

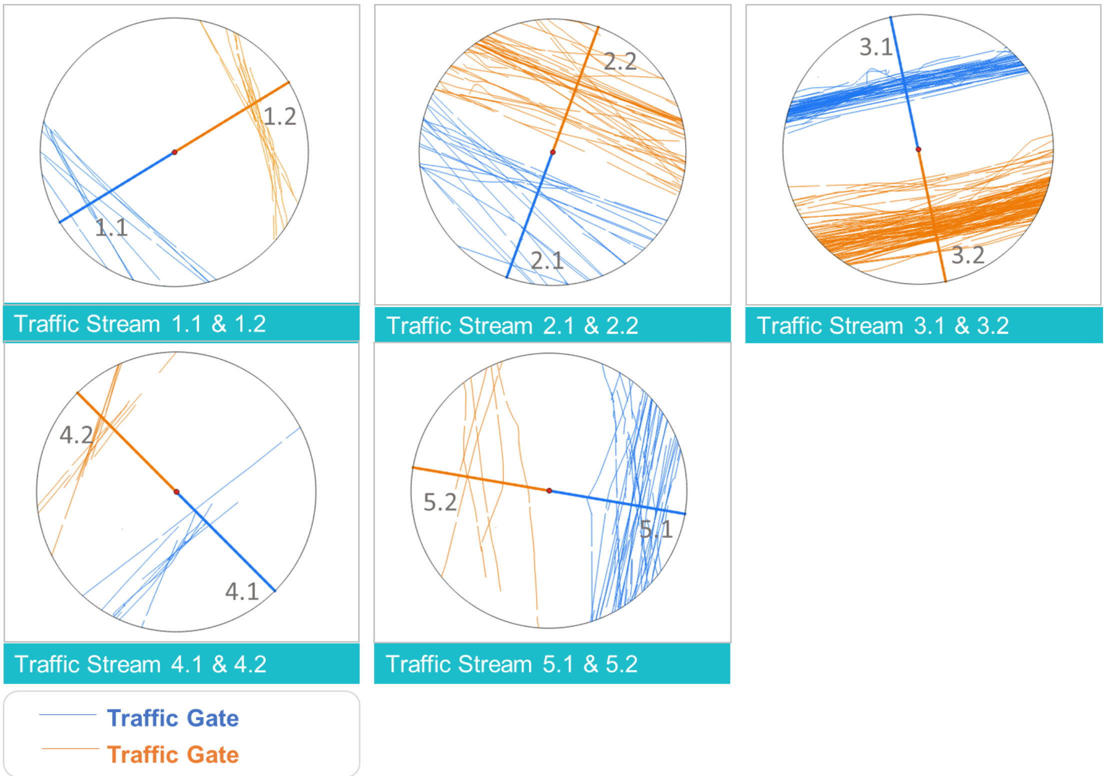
The travelled pattern of each stream categorised based on

(i) Directionality - the direction of travel depending on their origin and destination; and

(ii) Closest Point of Approach (CPA) – the distance between the centre point within the Study Area and the vessel's travelled route

For a more detailed analysis of the vessels transiting past the Study Area, a traffic gate was set as a transect perpendicular to the main traffic streams. Based on the twelve months period of AIS data analysed, 10 vessel streams were defined with similar travelled direction, i.e. the angle crossing the traffic gate. The consolidated routes and traffic gate are illustrated in Figure 3-10.

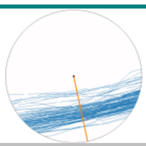
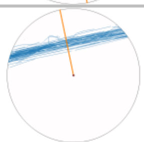
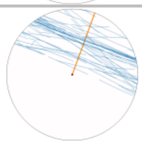
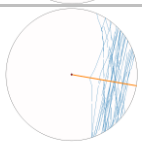
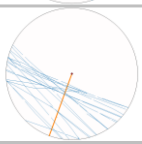
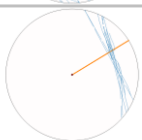
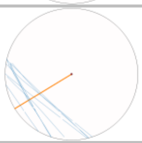
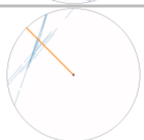
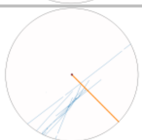
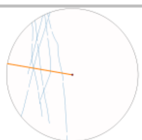
Figure 3-10 Routing and Traffic Gate for Each Traffic Stream



The characteristics of vessel (types, LOA, speed) within each traffic steam has been reviewed from an analysis of AIS data. A summary of traffic level in descending order of level of traffic is summarised in Table 3-2 and detailed findings are presented in Appendix A.

It is identified that over 80% of total traffic are contributed by Traffic Route 3.2, 3.1, 2.2, 5.1 and 2.1.

Table 3-2 Annual Traffic Volume along Traffic Route

Vessel Tracks	Route No.	CPA (nm)	Ships Per Year	% of Total
	3.2	5.6	98	37%
	3.1	4.9	43	16%
	2.2	5.1	36	14%
	5.1	6.7	27	10%
	2.1	4.6	19	7%
	1.2	6.8	13	5%
	1.1	6.9	9	3%
	4.2	7.1	8	3%
	4.1	2.7	4	2%
	5.2	4.4	5	2%
	TOTAL		**262**	**100%**

3.3 Non-Routine Traffic

3.3.1 General Pattern

From the twelve months period of AIS data analysed, an annual total of 127 number of vessels have been identified. The spatial distribution of each vessel types is illustrated in Figure 3-11. The 'non-routine' traffic illustrated in are classified based on vessel types and the types being adopted for risk review refer to the attribute of AIS data collected.

Table 3-3 Annual Traffic Volume for Non-Routine Traffic

Vessel Group	Vessel Types		Ships Per Year
Construction Vessel Group	1.	Offshore Vessel	36
	2.	Supply Vessel	82
Fishing Vessel Group	3.	Fishing Vessel	9

Note: Fishing Vessel includes Factory Trawler, Fishery Patrol Vessel, Fishery Research Vessel, and Fishing Vessel.

Figure 3-11 Distribution of Non-Routine Traffic by Vessel Type

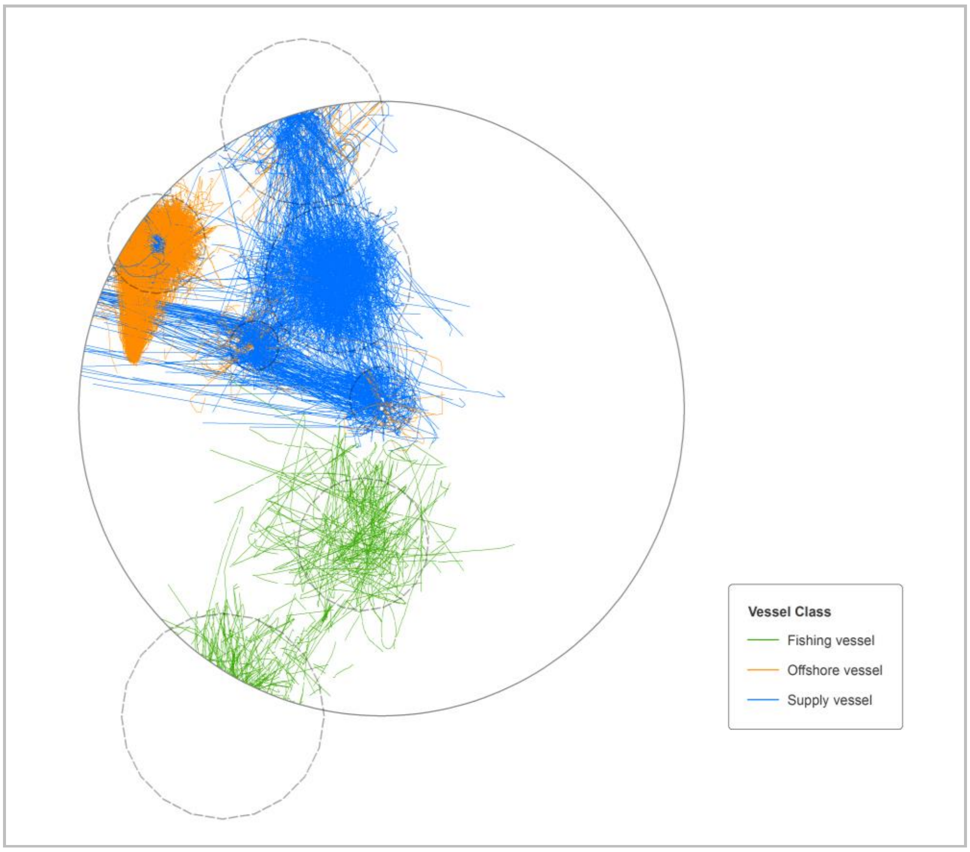
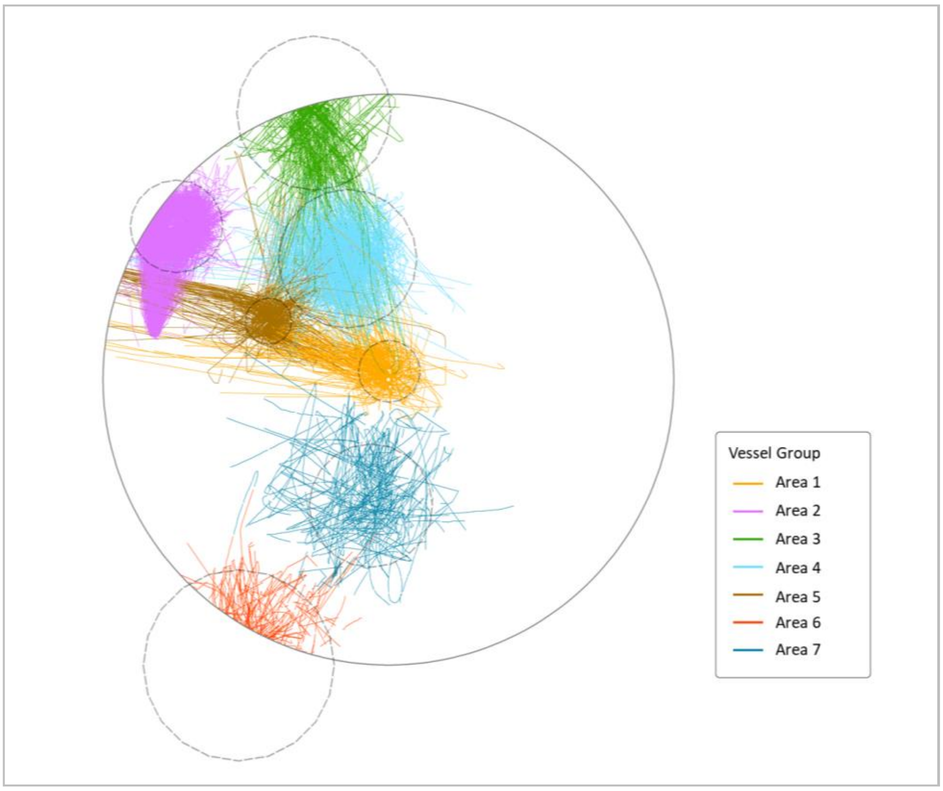


Figure 3-11 shows that the offshore and vessel supply vessels are mainly found at waterspace north east to the centre point of the Study Area and fishing vessels with a lower level of traffic density found to the south and south west of the Study Area.

3.3.2 Characteristics of Vessel's Movements

According to the AIS data analysed, the non-routine traffic can be grouped by the spatial distribution, considering various extent of "working waterspace", comprising of different vessel groups. The vessel traffics for all non-routine traffic are illustrated in Figure 3-12.

Figure 3-12 Distribution of Non-Routine Traffic by Waterspace



In general movements of fishing vessel ("Area 6" and "Area 7") are found to the south and southwest of the centre point within the Study Area.

It is identified that there were frequent movements of Construction Vessel tracks particularly in the north east of the centre point within the Study Area and the "Area 1" overlaps at the centre point.

The following tables present the annual traffic volume, average vessel length and average speed for the different vessel types (Offshore Vessel, Supply Vessel and Fishing Vessels) being reviewed.

The spatial distributions of tracks categorized by vessel length and vessel speed are presented in Appendix D.

Table 3-4 Characteristics of Offshore Vessel's Movement

Vessel Group	Ships Per Year	Average LOA (m)	Average Speed (knot)
Area 1	2	87.0	0.2
Area 2	29	57.7	1.1
Area 3	2	72.1	4.2
Area 4	1	71.4	2.1
Area 5	2	101.9	Less than 0.1
TOTAL	**36**	**78.0**	**1.5**

Table 3-4 shows that 80% of the Offshore Vessels identified within the Study Area are moving predominately in "Area 2" which is approximately 9 nm from the centre of the Project Site involving vessel in the range of 60 to 100m LOA and typical navigation in a relative slow speed under 4 knots.

Table 3-5 Characteristics of Supply Vessel's Movement

Vessel Group	Ships Per Year	Average LOA (m)	Average Speed (knot)
Area 1	22	87.0	1.5
Area 2	9	90.0	1.0
Area 3	19	73.2	3.2
Area 4	14	67.1	1.2
Area 5	18	84.6	1.1
TOTAL	**82**	**80.4**	**1.6**

In view of supply vessel's movement, it is identified that all associated activities are found to the southwest of the Project Site involving vessel of average 80m LOA and typical navigation in a relative slow speed under 3 knots.

Table 3-6 Characteristics of Fishing Vessel's Movement

Vessel Group	Ships Per Year	Average LOA (m)	Average Speed (knot)
Area 6	5	23	1
Area 7	4	19	2
TOTAL	**9**	**20.7**	**1.7**

A low level of "Non-Routine Traffic" considering fishing activities are identified to the south and south-west of the Project Site involving small fishing vessel of average 20m LOA and typical navigation in a relative slow speed under 2 knots.

4 Collision Frequency Assessment

4.1 Introduction

The risk of collision is calculated as a combination of three factors: (1) the number of vessels within the Study Area, (2) the geometric distribution of vessels and (3) causation probability for a navigation error where it fails to take the correct action to avoid a collision.

The previous section has presented the findings for item (1) about the number of vessels within the Study Area and the traffic environment has been categorised by "Main Stream Traffic" and "Non-routine Traffic". This section outlines the detailed methodology for defining item (2) and (3) and finally presents results of the risk assessment that has been conducted to estimate the probabilities of vessel collision incidents with the Talbot Project.

4.2 Collision Risk Assessments

4.2.1 Traffic Distribution – Main Traffic Streams

The annual level of traffic along each of the traffic stream has been reviewed and summarised in Table 3-2. It is identified that vessels transiting past the Project Site across the Traffic Gate are generally moving within 10 presentative traffic streams depending on their desired destination.

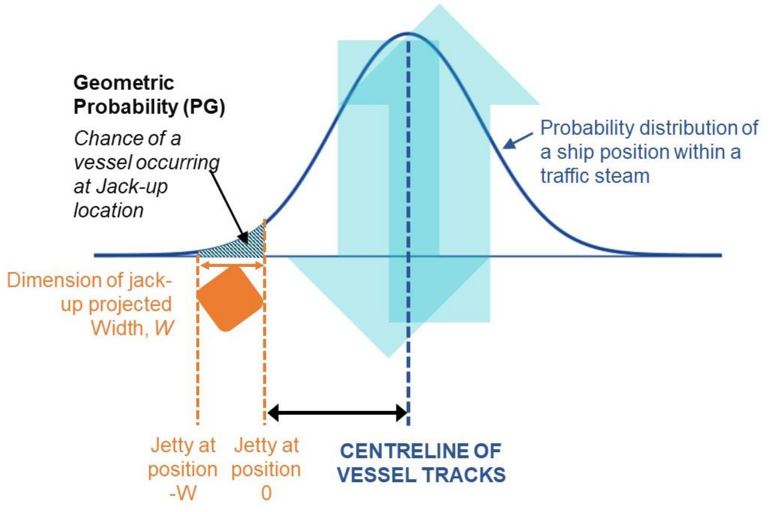
The number of vessels within each traffic steam for different length ranges is available from an analysis of AIS data and the track distributions of the relevant vessel tracks for each traffic stream were identified and presented in Appendix A.

From the track distribution, the mean and standard deviation of the relevant vessel tracks are calculated to fit a normal probability curve describing the track distributions. It is noted that the Traffic Route 3.2, 3.1, 2.2 and 5.1 can be generalized and fitted within the shape of a normal distribution of which these routes contributing to over 75% of the total annual volume.

It is assumed that the Project Site includes a jack-up rig and a footprint size of 100m x 100m is assumed. For a conservative assessment, the diagonal length measured across the square gives the longest length (141m) when projected onto the probability distribution and the chance of a vessel being on a collision course with the Project Site is therefore the probability contained in that segment of the probability distribution.

The calculation of geometric probability (PG) for each Traffic Stream is illustrated in Figure 4-1 where PG is the shadow area, which represents the vessel traffic in probability distribution on collision course with the Project.

Figure 4-1 Probability of Traffic Stream "on course" to the Project



Vessel Tracks Distribution, assumed to fit a Normal Dist. (μ, σ),

- μ = mean value of the distance of each vessel track to the Jack-up at position 0 (zero)
- σ = standard deviation of the distance of each vessel track to Jack-up at position 0 (zero)

Therefore, *Geometric Probability (PG)*
$= F(0, \mu, \sigma) - F(-W, \mu, \sigma)$

- Where F(·) is the cumulative normal distribution function
- W is the jetty structure projected width

The Mean (μ) values present the centrelines of each traffic stream and the standard deviations show how tightly grouped tracks are within each traffic steam.

4.2.2 Traffic Distribution - Non-Routine Traffic

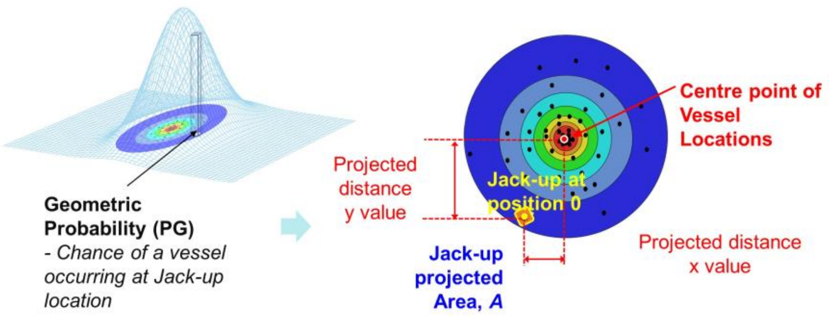
The annual level of Non-Routine Traffic positioned within various area of waterspace has been reviewed. It is identified that vessels navigating within the Study Area are generally moving within seven active areas for waterspace as illustrated in Figure 3-12.

For each identified waterspace, the mean of x and y and the covariance of each group are calculated in order to fit a bivariate normal probability curve describing the movement distributions. Corresponding to the active areas as identified, seven bivariate probability distributions of main stream traffic were developed.

It is assumed that the Project Site includes a jack-up rig and a footprint size of 100m x 100m is assumed. For a 2D assessment, a footprint area of 10,000 m^2 is adopted and the chance of a vessel being on a collision course with the Project Site is therefore the probability contained in that area of the probability distribution.

The calculation of geometric probability (PG) for each "Non-Routine Traffic" group is illustrated in Figure 4-2 where PG is the volume of cuboid, which represents the probability of a vessel being present at the Project Site

Figure 4-2 Probability of Non-Routine Traffic "on course" to the Project



Vessel Location Distribution, assumed to fit a Bivariate Normal Dist.
(μx, μy, Covariance of x and y):

- μx = mean value of the distance in x direction of each vessel location to the Jack-up at position 0 (zero)
- μy = mean value of the distance in y direction of each vessel location to the Jack-up at position 0 (zero)
- Covariance of x and y = $\begin{pmatrix} \sigma(x,x) & \sigma(x,y) \\ \sigma(y,x) & \sigma(y,y) \end{pmatrix}$

Where:

σ(x,x) = σ^2x = standard deviation of the distance in x direction of each vessel location to Jack-up at position 0 (zero)

σ(y,y) = σ^2y = standard deviation of the distance in y direction of each vessel location to Jack-up at position 0 (zero)

σ(x,y) = σ(y,x) measures how much the vessel position x and y change together.

Therefore, *Geometric Probability (PG) approximately equals to A x F(x, y,* μx, μy, Covariance of x and y)

Where: F(·) is the bivariate normal distribution function
A is the jack-up structure projected Area

The Mean (μx, μy) values present the centre of each "Non-Routine Traffic" groups and Covariance Matrix show the dispersion of the vessel position in x, y coordinates.

4.2.3 Causation Probability

The International Association of Lighthouse Authorities (IALA) Risk Management Tool, IWRAP (IALA Waterway Risk Assessment Program) identifies a range of causation factors for different navigation situations that are modelled within its "IWRAP" collision risk model.

Table 4-1 IWRAP Default Values of Causation Factors

Condition	Causation Factor
Head-on collisions	0.5 · 10-4
Overtaking collisions	1.1 · 10-4
Crossing collisions	1.3 · 10-4
Collisions in bend	1.3 · 10-4
Collisions in merging	1.3 · 10-4

Based on the pattern of AIS tracks, it is identified that the most likely geometric arrangement for a collision with the Project is a "head-on" situation. This results in a causation factor of 0.5 x 10^{-}4 which is adopted for this assessment.

In reality this causation probability in open navigation situations is conservative as it does not reflect the size and prominence of the planned Project, that once established will become a permanent navigation fixture to be specifically avoided.

4.3 Annual Collision Probability Results

The annual collision probability for the identified traffic is calculated using the following formula:

$$\textit{Annual Collision Probability} = \sum N(i) \times PG(i) \times PC(i)$$

Where:

i:	*traffic stream*
N(i):	*annual number of vessel transits on traffic stream i;*
PG:	*geometric probability of a vessel being present at the Project Site;*
PC:	*causation probability for a navigation error where a vessel on a collision course fails to take the correct action to avoid the collision.*

The results of annual collision probability for the Traffic Streams and Non-Routine Traffic are presented in the following sections.

4.3.1 Traffic Streams

Table 4-2 presents the means, standard deviations, geometric probability and annual collision risk for each of the main stream traffic.

Table 4-2 Existing Annual Collision Risk for Traffic Streams

Route No.	Ships Per Year	Normal Distribution		Geometric Probability	Annual Collision Risk
		Mean (nm)	Standard Deviation (nm)		
2.1	**19**	**4.6**	**2.5**	**4.4E-03**	**4.2E-06**
2.2	**36**	**5.1**	**1.8**	**6.8E-04**	**1.2E-06**
5.2	5	4.4	1.7	1.4E-03	3.4E-07
3.2	98	5.6	1.1	2.2E-07	1.1E-09
5.1	27	6.7	1.4	2.7E-07	3.6E-10
4.1	4	2.7	0.6	8.2E-07	1.6E-10
1.1	9	6.9	1.1	2.5E-10	1.1E-13
3.1	43	4.9	0.5	4.0E-23	8.5E-26
4.2	8	7.2	0.5	2.6E-45	1.0E-48
1.2	13	6.8	0.4	6.1E-74	4.0E-77
TOTAL	**262**				**5.8E-06**

The result identifies that the collision risk is being driven mainly by vessels along:

- Traffic Route 2.1 – with mean distance of 4.6nm from the centre point and includes an annual level of traffic of 19 movements (average daily 0.05)
- Traffic Route 2.2 – with mean distance of 5.1nm from the centre point and includes an annual level of traffic of 36 movements (average daily 0.10)

In terms of vessel size and probability distribution, the annual collision risk of the probability distributions of "Traffic Stream Traffic" for each length category are summarised in Table 4-3.

Table 4-3 Existing Annual Collision Risk for Traffic Streams (by LOA)

LOA Range (m)	Ships Per Year	Geometric Probability	Annual Collision Risk
0 - 50	30	2.5E-02	1.3E-06
50 - 100	**125**	**6.2E-02**	**3.1E-06**
100 - 150	**66**	**6.1E-03**	**3.1E-07**
>150	41	2.2E-02	1.1E-06
TOTAL	**262**		**5.8E-06**

The result identifies that the collision risk is being driven mainly by vessels in the 50 - 100m & 100 – 150m LOA category. In terms of spatial distribution, Traffic Route 2.1 and 2.2 combined comprise 26% and 14% of the vessel's LOA 50 - 100m & 100 – 150m category respectively.

4.3.2 Non-Routine Traffic

Table 4-4 presents the mean array, covariance matrix, geometric probability and annual collision risk for each of the “Non-Routine Traffic” groups.

Table 4-4 Existing Annual Collision Risk for Stationary Work Sites

Stream No.	Ships Per Year	Normal Distribution: Mean (μ_x, μ_y) (nm)	Normal Distribution: Covariance x and y (nm)	Geometric Probability	Annual Collision Risk
Area 1	24	-0.3 0.4	[1.1,-0.3 -0.3,0.4]	2.0E-01	7.0E-07
Area 2	38	-7.4 5.2	[0.3,0.1 0.1,0.5]	1.2E-87	6.5E-93
Area 3	21	-2.5 8.2	[0.7,-0.2 -0.2,2.4]	6.5E-09	2.0E-14
Area 4	15	-1.7 4.2	[0.9,-0.1 -0.1,0.9]	4.7E-06	1.0E-11
Area 5	20	-4.2 2.0	[0.3,0.0 0.0,0.2]	2.2E-16	6.4E-22
Area 6	5	-4.4 -7.9	[1.3,-0.2 -0.2,0.6]	6.5E-34	4.8E-40
Area 7	4	-1.1 -4.1	[1.7,-0.1 -0.1,2.3]	1.4E-03	6.0E-10
TOTAL	**127**				**7.0E-07**

In terms of vessel size and probability distribution, the annual collision risk of the probability distributions of “Non-Routine Traffic” for each length category are summarised in Table 4-5**.**

Table 4-5 Existing Annual Collision Risk by LOA (Non-routine Traffic)

Loa Range (m)	Ships Per Year	Geometric Probability	Annual Collision Risk
0 - 50	39	4.1E-01	5.9E-08
50 - 100	84	4.2E+00	6.1E-07
100 - 150	3	2.0E-01	2.9E-08
>150	1	1.2E-87	1.7E-94
TOTAL	**127**		**7.0E-07**

The result identifies that the collision risk is being driven mainly by the vessels navigate within waterspace of Area 1 where the focus of activities is positioned at the centre point of the Study Area. However, with the presence of the proposed jack-up rig that once established will become a permanent fixture to be specifically avoided.

For the other “Non-Routine Traffic” the effect on their navigation is considered to be negligible considering the low level of traffic and separation distance from the centre point.

5 Summary

BMT has been commissioned to conduct a Vessel Tracking Study for the Talbot Development Project in order to understand the current local marine traffic activity around the Project site within Block 30/13e and identify the probability of a vessel being on a collision course with the Project considering the installation of jack-up rig.

In order to assess these risks a review of site vessel activity was undertaken. Twelve months of vessel AIS traffic data was acquired and assessed. Although variation in the traffic volumes from month to month was identified, within 10nm radius from the propose jack-up rig installation the number of adjacent traffic activity is low considering:

- **Main Traffic Stream**: with an annual total of 262 movement or less than 1 regular movement per day focus along ten traffic routes.
- **Non-Routine Traffic**: with an annual total of 127 number or less than 1 regular movement per day focus within seven distinct extent of “navigation waterspace”

The risk of collision has been calculated as a combination of three factors:

(1) Number of vessels within passing traffic streams,

(2) Geometric distribution of vessels within traffic streams, and

(3) Causation factor for the case where a vessel fails to take the correct avoidance action

An annual ship collision frequency for Main Traffic Stream has been calculated at 5.8E-06. It has been identified the most significant contributor to collision risk is from two traffic routes considering (i) with mean distance of 4.6nm from the centre point and includes an annual level of traffic of 19 movements and (ii) with mean distance of 5.1nm from the centre point and includes an annual level of traffic of 36 movements and the routes combined comprise 26% and 14% of the vessel’s LOA 50 - 100m & 100 – 150m category respectively.

An annual ship collision frequency for Non-Routine Traffic has been calculated at 7.0E-07. It has been identified that the collision risk is being driven mainly by the vessels navigate within waterspace where the focus of activities is positioned at the centre point of the Study Area. However, with the presence of the proposed jack-up rig that once established will become a permanent fixture to be specifically avoided. Further safeguard measures may consider updates on marine chart and installation of AIS transponder and making the structure visible to others with AIS equipment.

For the other “Non-Routine Traffic” the effect on their navigation is considered to be negligible considering the low level of traffic and separation distance from the centre point.

APPENDIX A: Vessel Track Distribution by Traffic Stream

This Appendix uses histograms to present the distributions of all vessel tracks that crossed the virtual traffic gates from July 2018 to June 2019. The number of vessels is grouped by segmentations of distance from the Project Site to the boundary of Study Area (10 nm of site).

The ten main stream traffic and their track distributions were picked out by:

- Identifying major track direction;
- Drawing a virtual traffic gate from the Talbot field perpendicular to the tracks; and
- Calculating the distance between the Talbot field and the tracks that cross the virtual traffic gate.

Figure A-1 Annual Track Distribution of Vessels in Traffic Stream 1.1

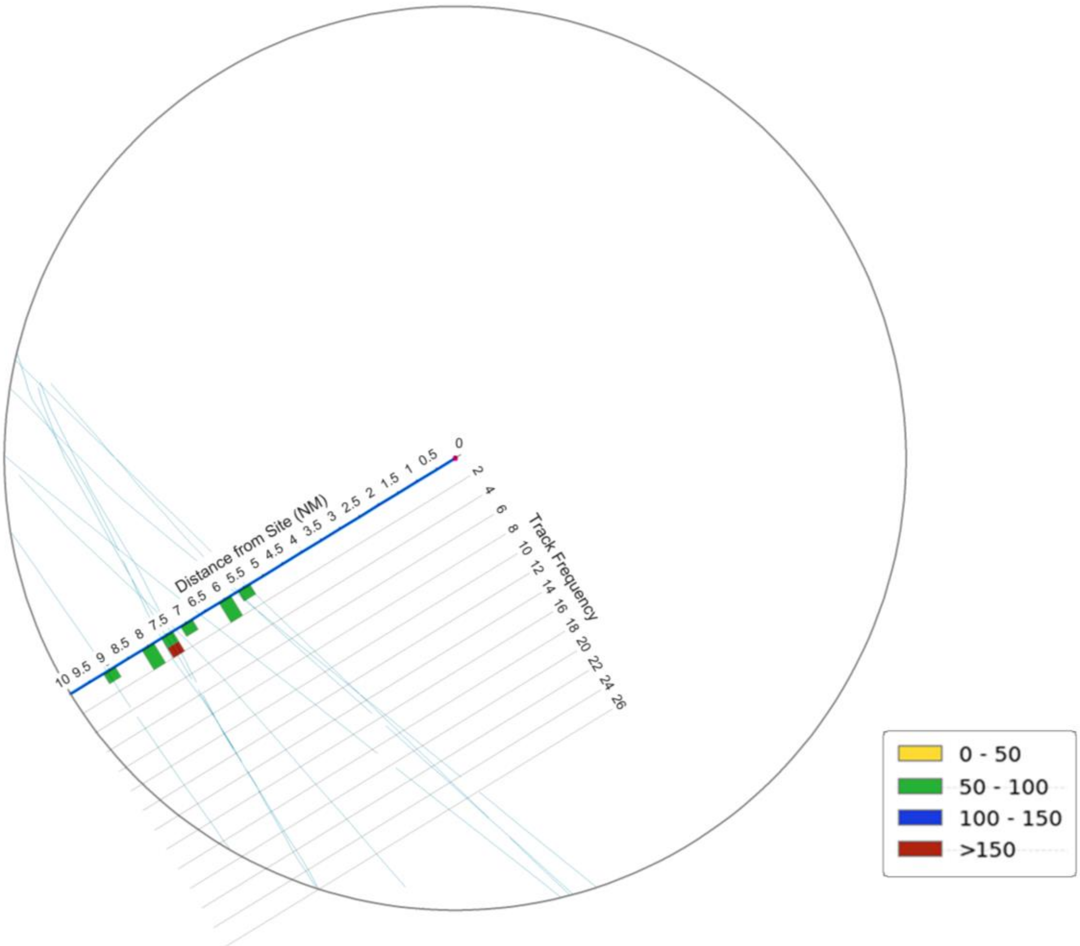


Figure A-2 Annual Track Distribution of Vessels in Traffic Stream 1.2

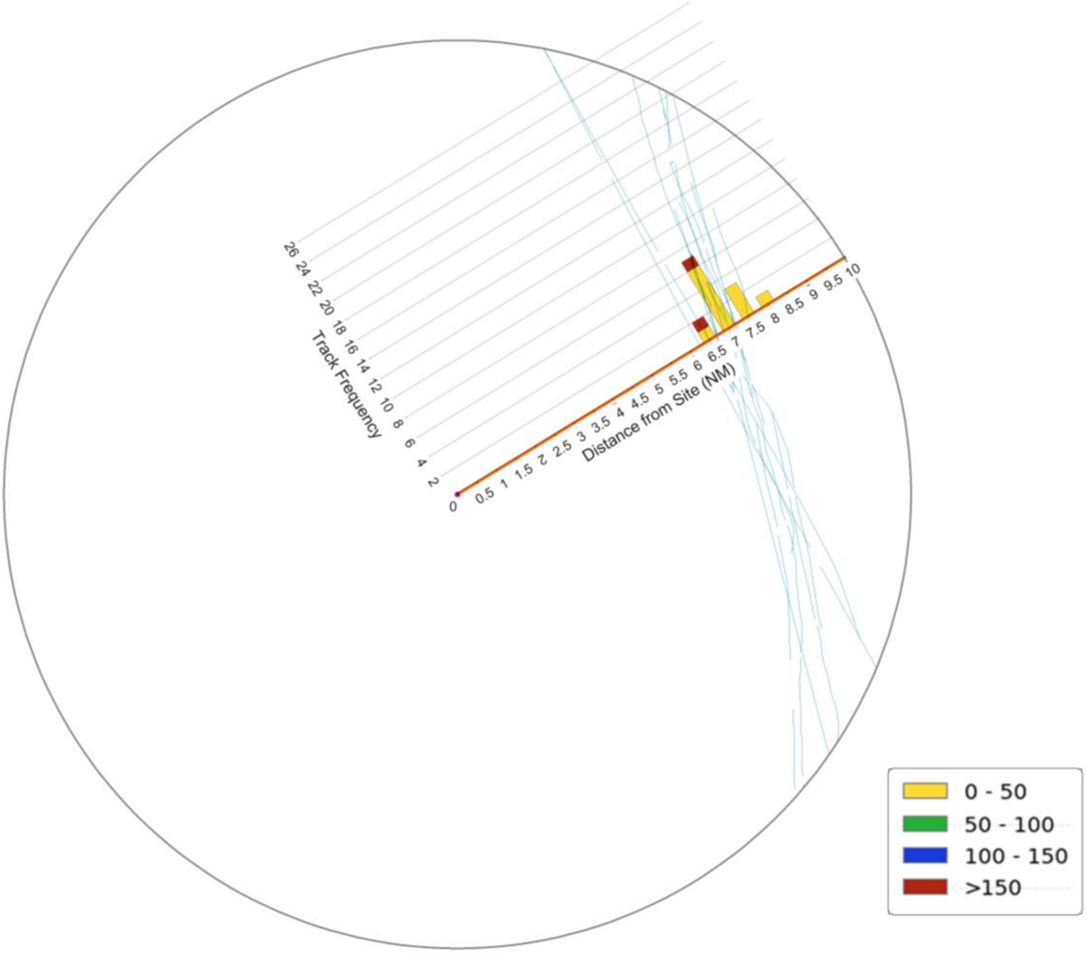


Figure A-3 Annual Track Distribution of Vessels in Traffic Stream 2.1

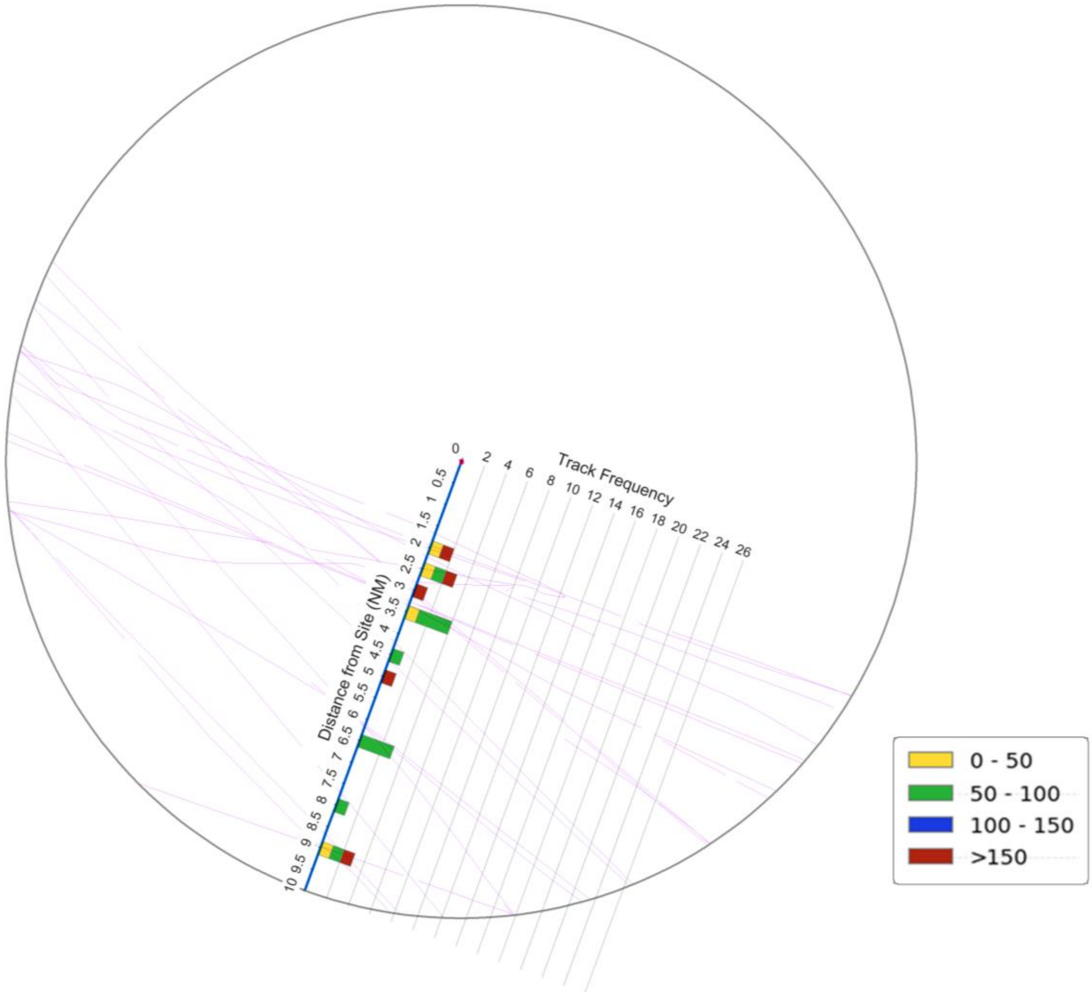


Figure A-4 Annual Track Distribution of Vessels in Traffic Stream 2.2

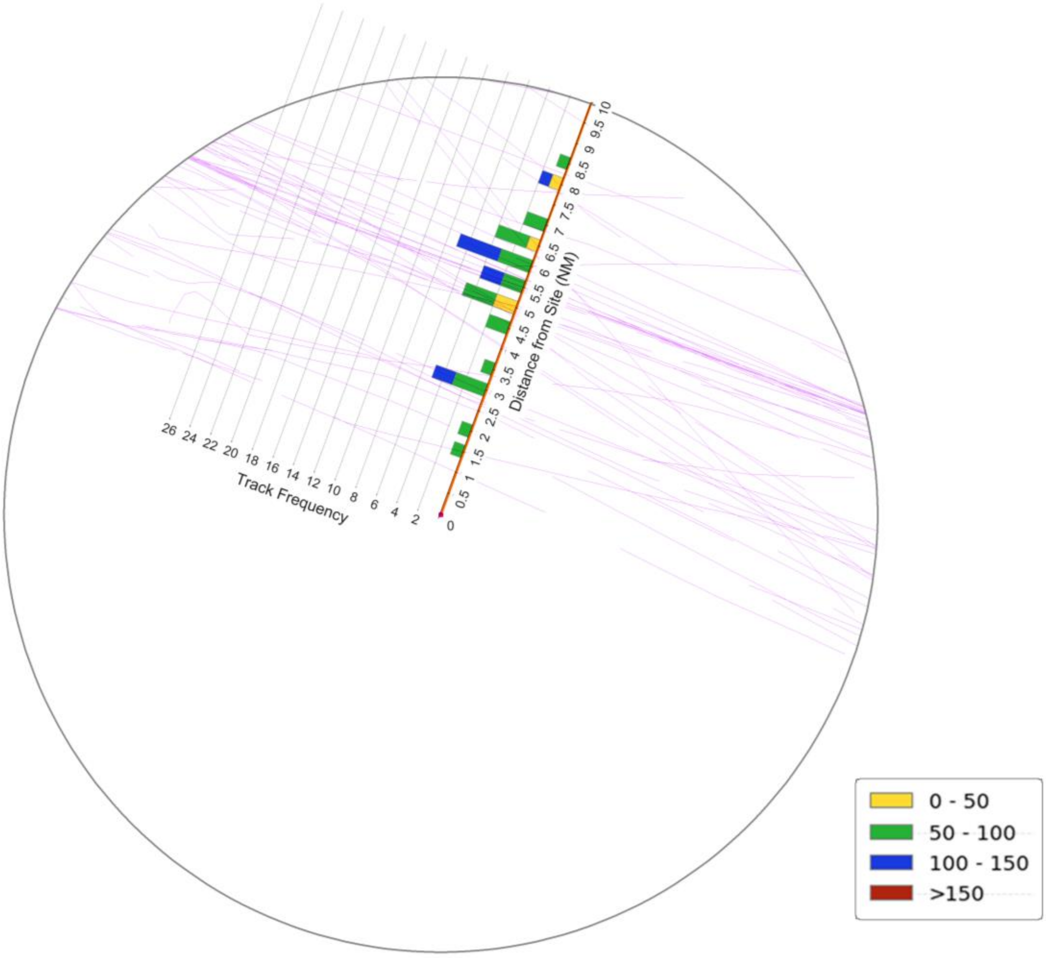


Figure A-5 Annual Track Distribution of Vessels in Traffic Stream 3.1

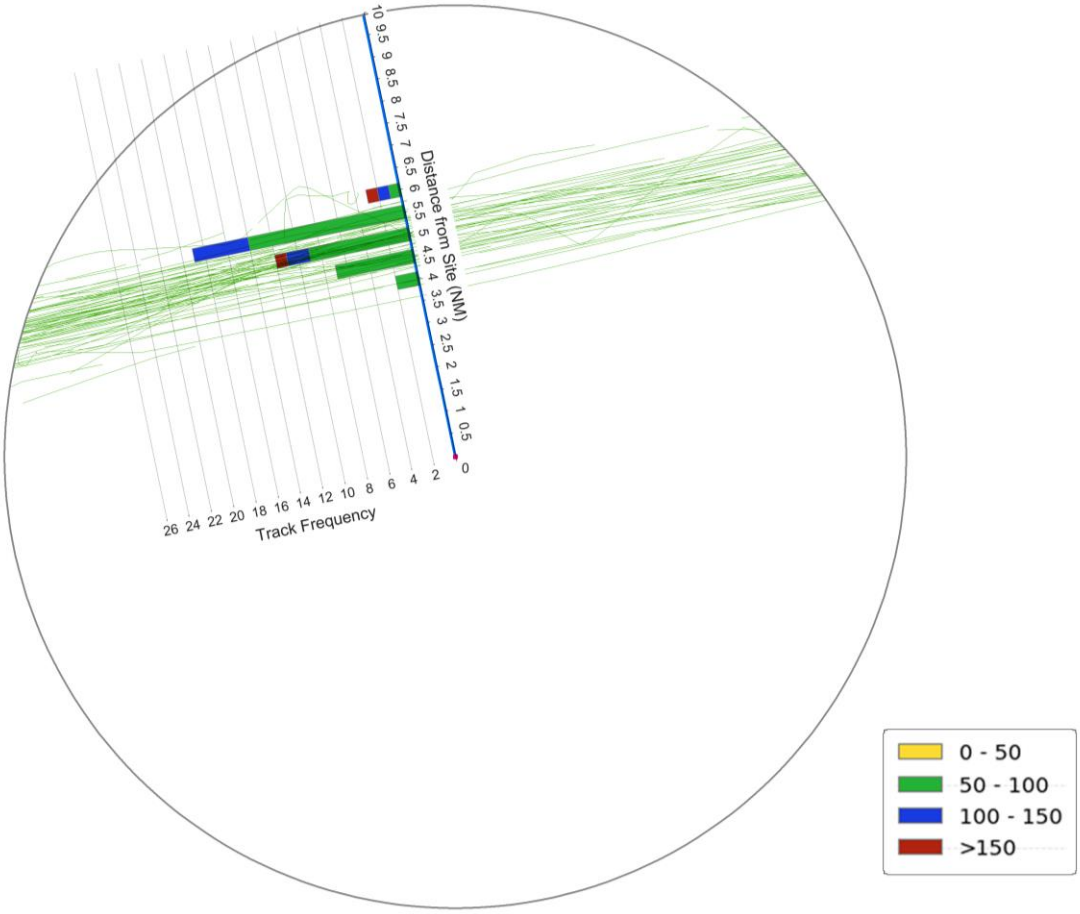


Figure A-6 Annual Track Distribution of Vessels in Traffic Stream 3.2

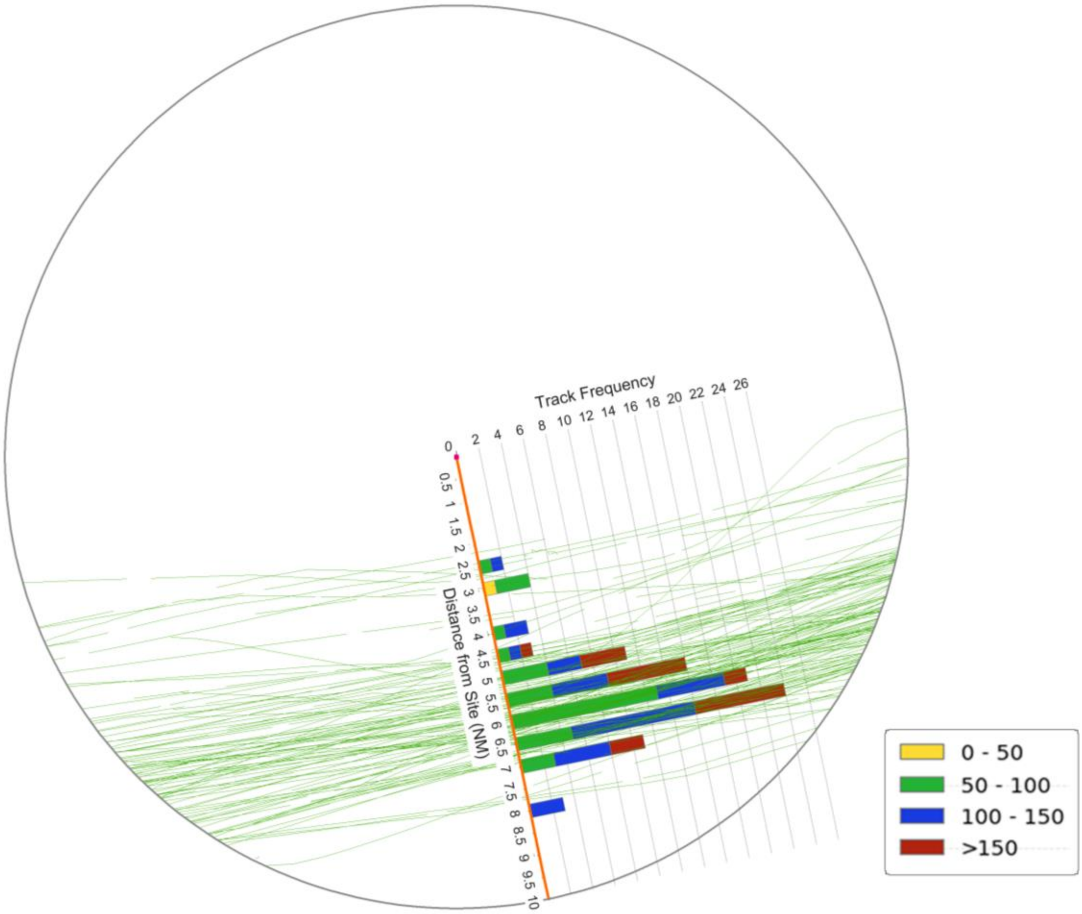


Figure A-7 Annual Track Distribution of Vessels in Traffic Stream 4.1

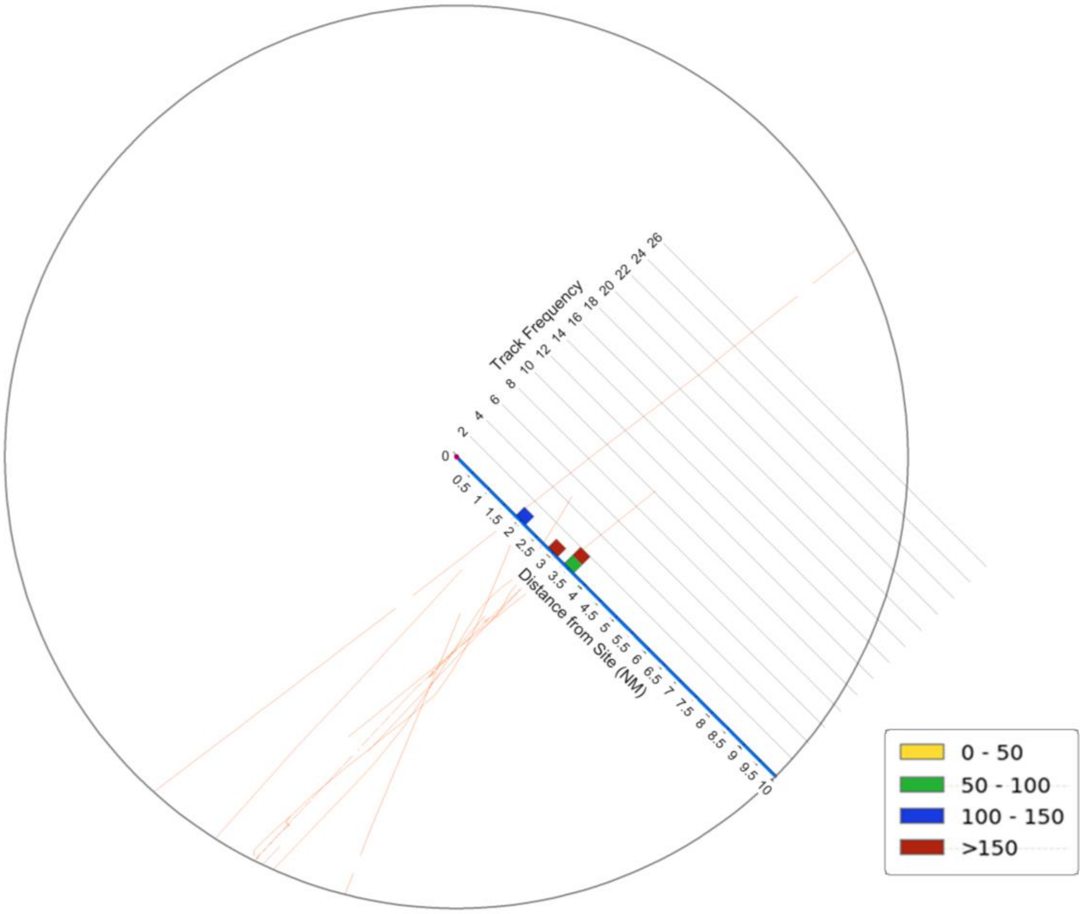


Figure A-8 Annual Track Distribution of Vessels in Traffic Stream 4.2

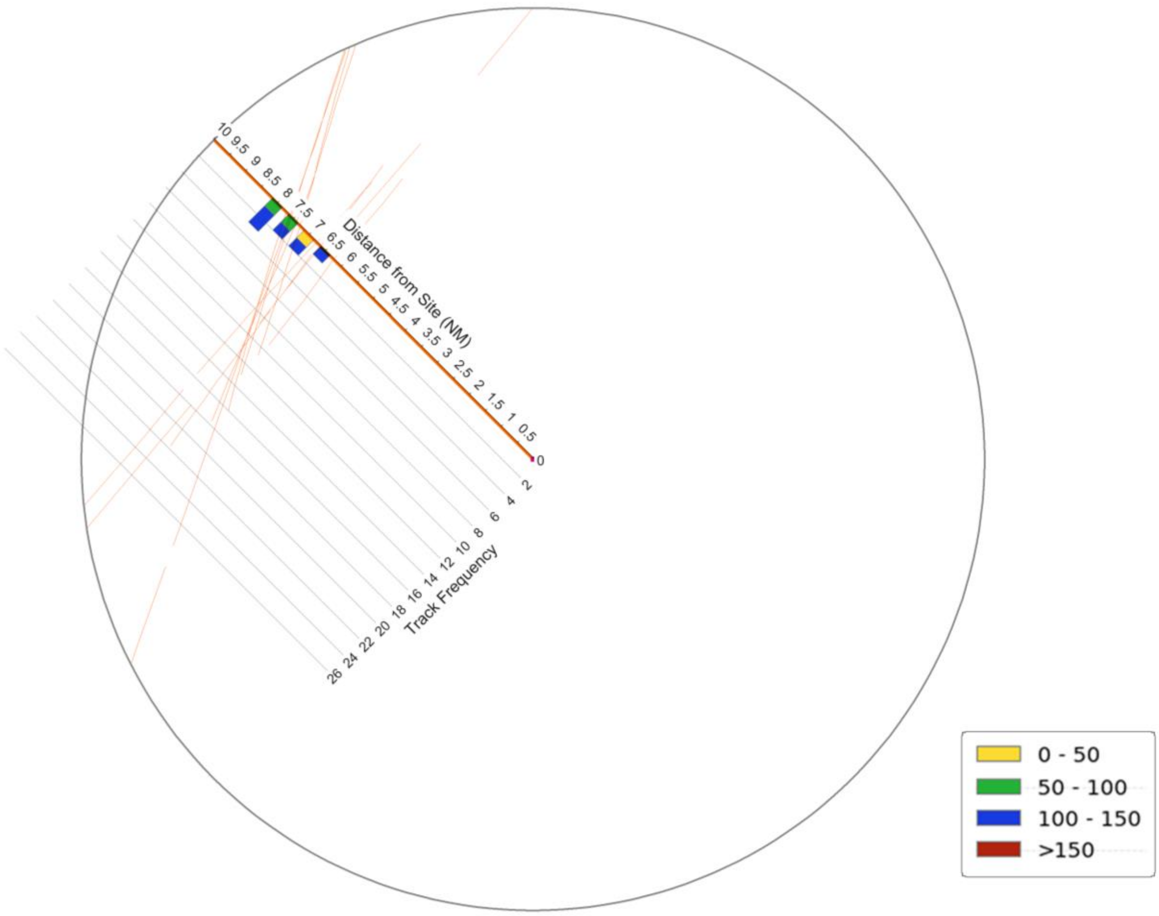


Figure A-9 Annual Track Distribution of Vessels in Traffic Stream 5.1

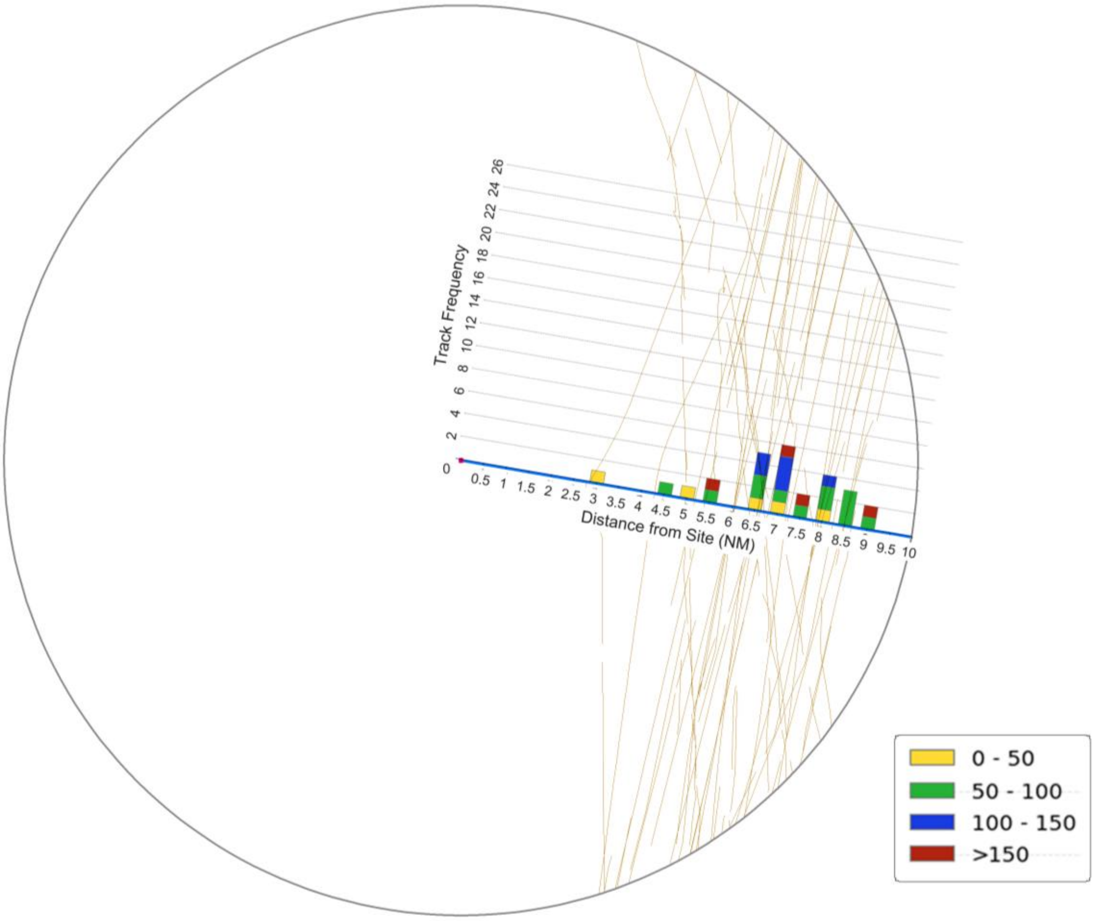
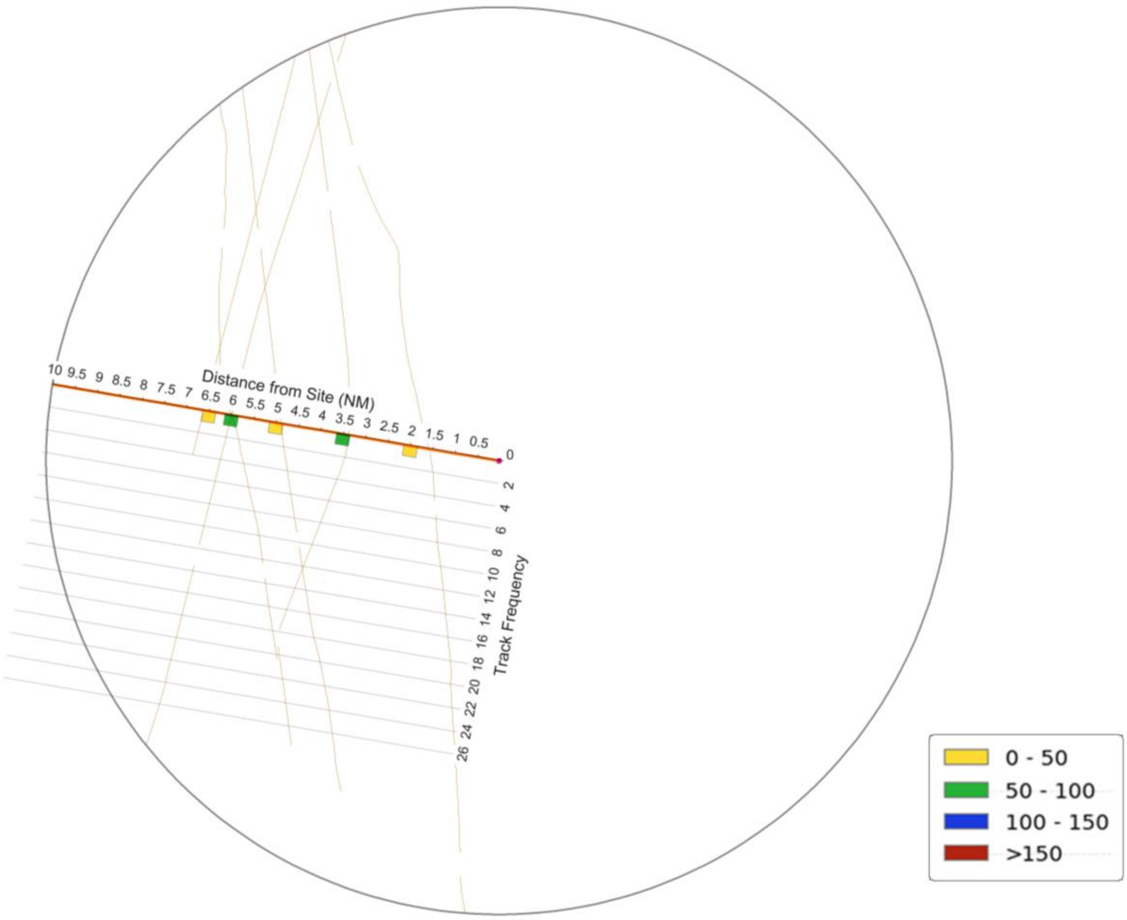


Figure A-10 Annual Track Distribution of Vessels in Traffic Stream 5.2

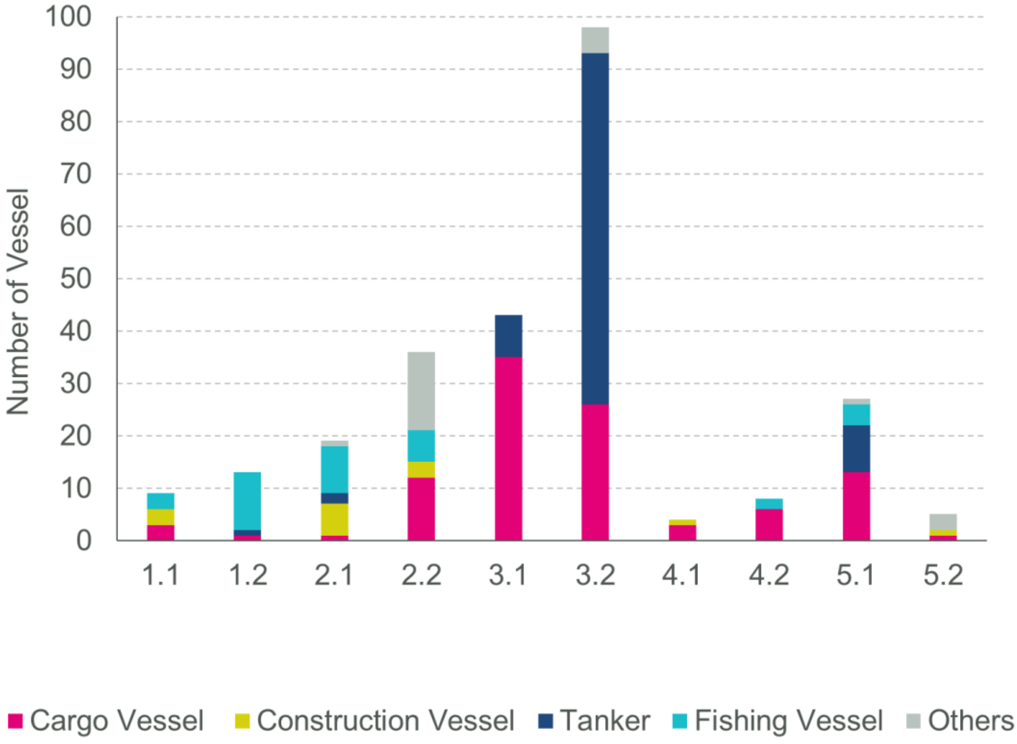


APPENDIX B: Vessel Attributes by Traffic Streams

Appendix B presents the variability of main stream traffic by different vessel attributes. **Figure B-1** to **Figure B-3** shows the annual distribution of vessel type, vessel length and vessel speed respectively. In the following figures, the unit of y-axis is the Annual Count and the x-axis lists all the main stream traffic.

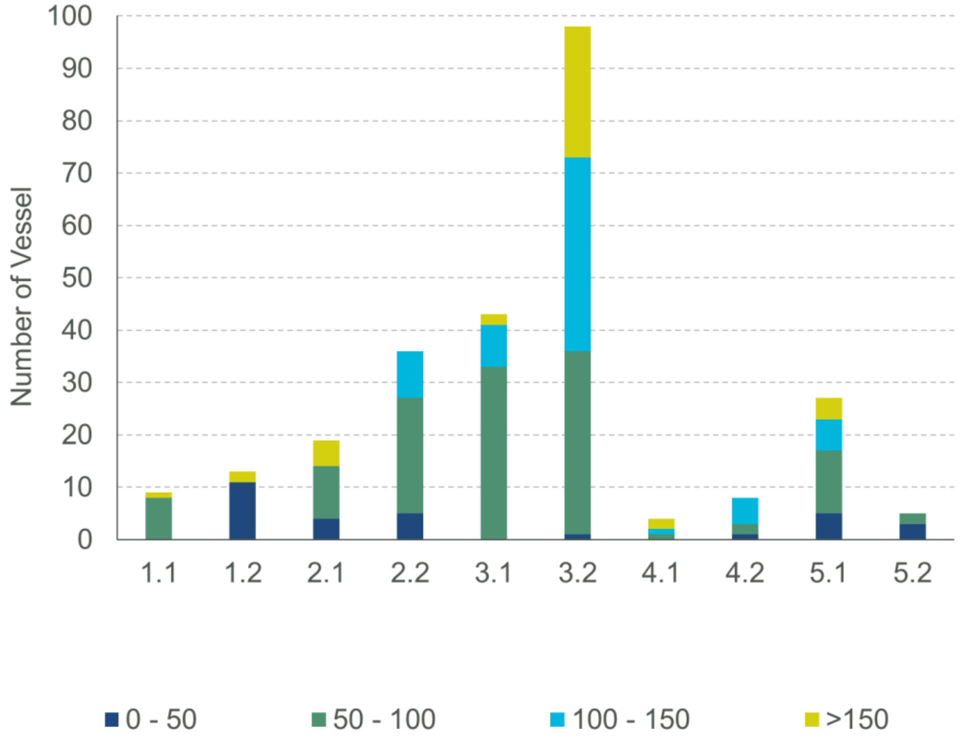
Figure B-1 presents the annual number of transits crossing each Traffic Gate categorised by vessel type. It can be seen that most of tankers transit are found in traffic stream 3.2.

Figure B-1 Annual Vessel Type Distribution within 10nm of Project Site by Traffic Streams



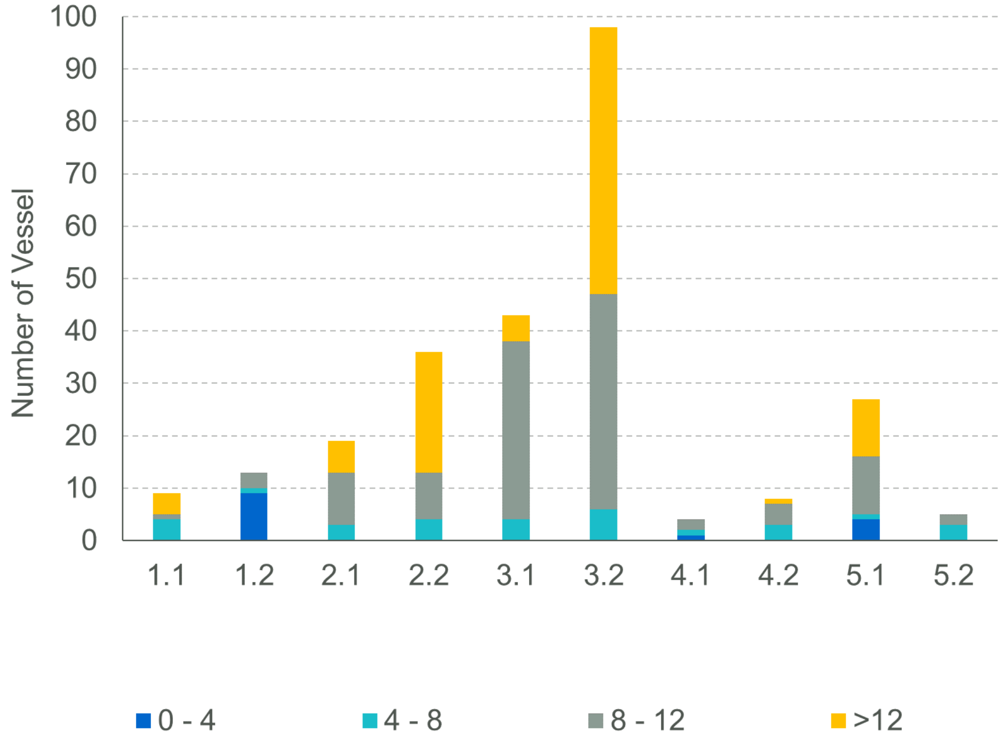
The vessel length is classified into 4 categories: 0 –50m, 50 – 100m, 100 – 150m and > 150m. **Figure B-2** shows the annual number of transits crossing each Traffic Gate classified by vessel length.

Figure B-2 Annual Vessel Length Distribution within 10nm of Project Site by Traffic Streams



The vessel speed is classified into 4 categories: 0 – 4 knot, 4- 8 knot, 8 – 12 knot, >12 knot. **Figure B-3** presents the annual number of transits across each Traffic Gate categorised by vessel length.

Figure B-3 Annual Vessel Speed Distribution within 10nm of Project Site by Traffic Streams



APPENDIX C: Spatial Distribution of Traffic Streams

This Appendix presents the spatial distribution of annual tracks by each vessel type.

Vessel Length

The vessel length is classified into 5 categories: 0 – 50m, 50 – 100m, 100 – 150m and > 150m. The following figures (**Figure C-1** to **Figure C-5**) show the spatial distributions of vessel length by vessel types. The histogram above each figure summarizes the variance in vessel lengths distribution under different vessel type. The y-axis of each histogram has unit of annual transits.

Figure C-1 Annual Spatial Distribution of Cargo Vessel Track by Vessel Length

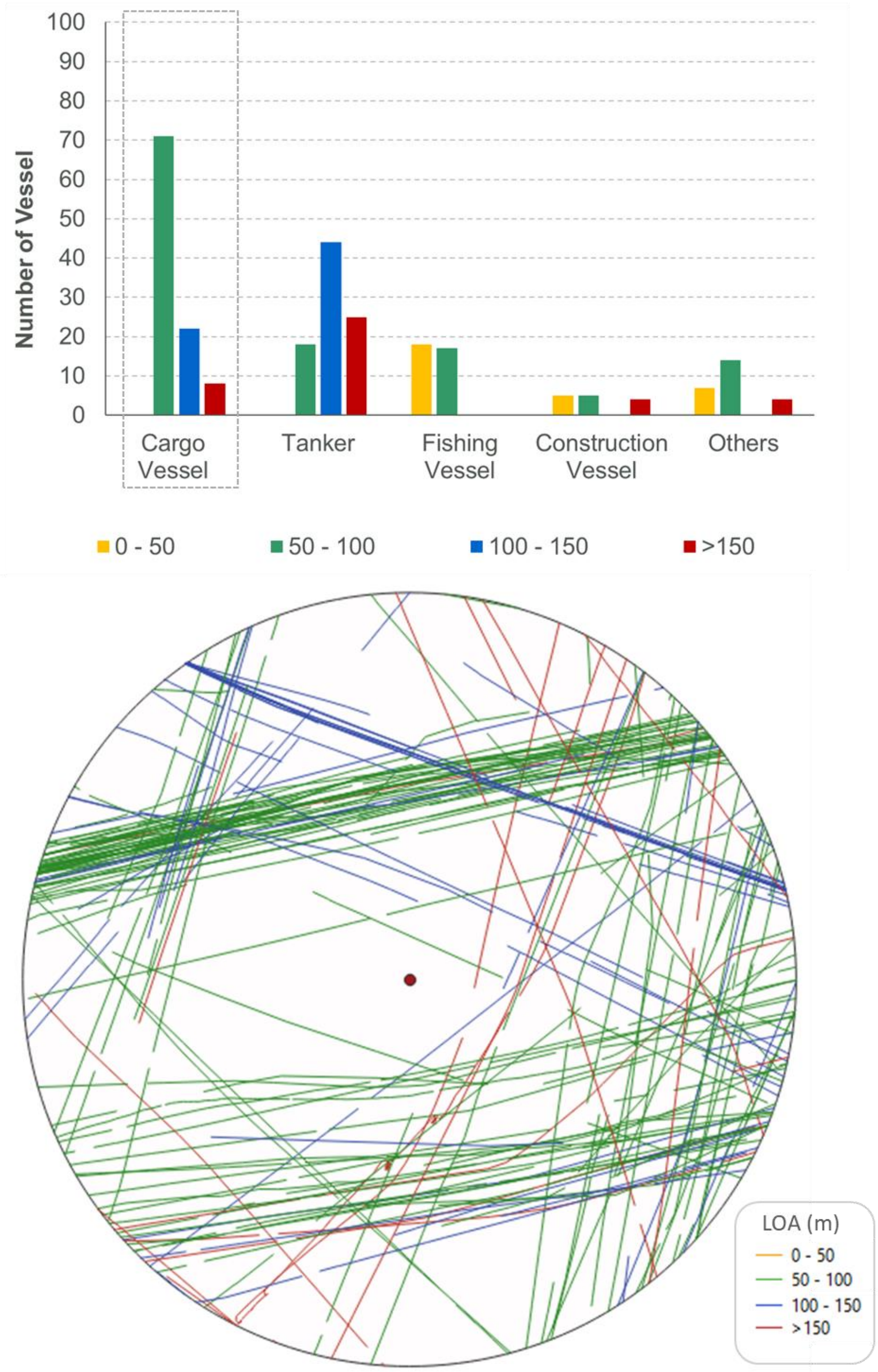


Figure C-2 Annual Spatial Distribution of Tanker Track by Vessel Length

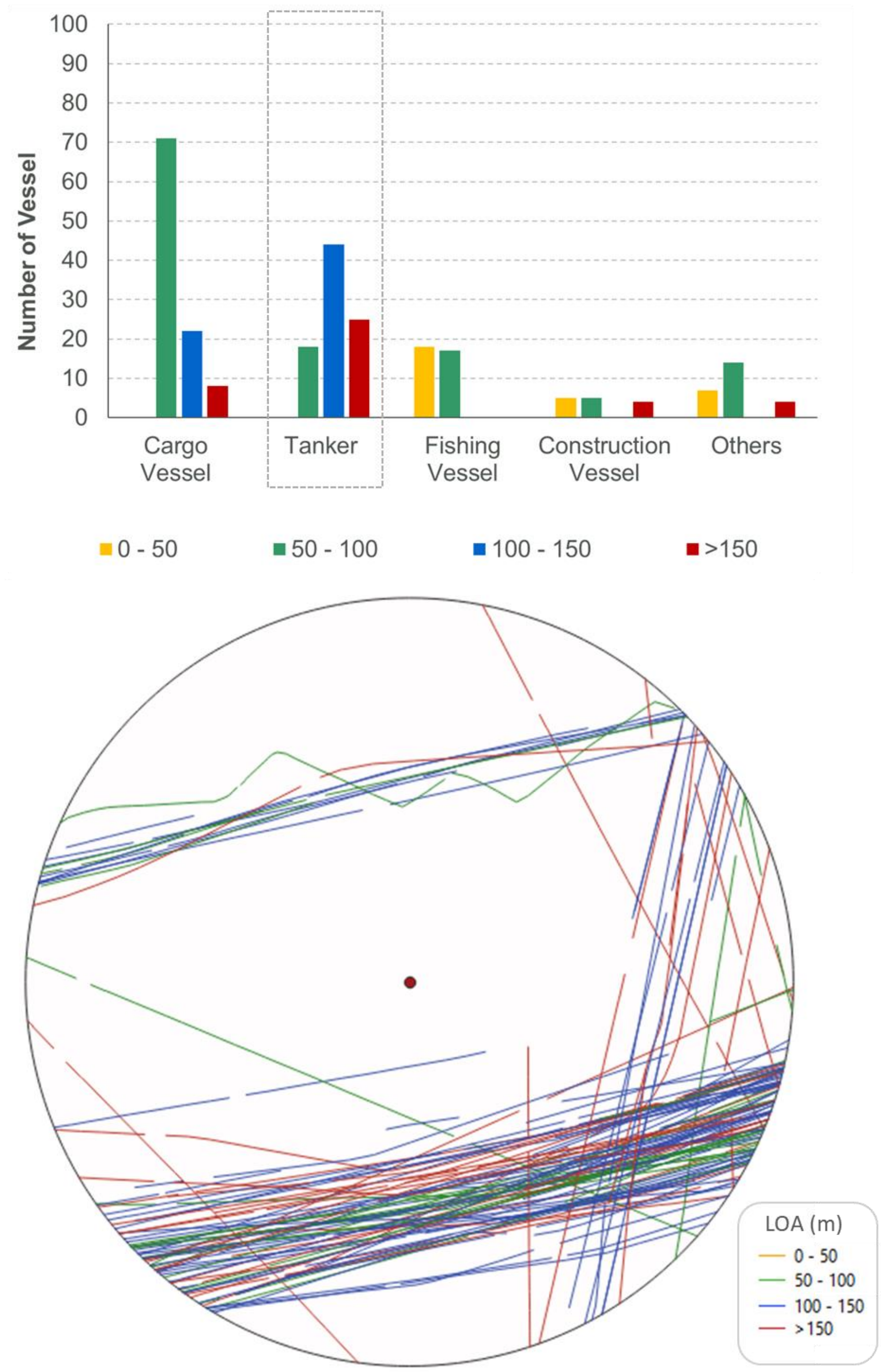
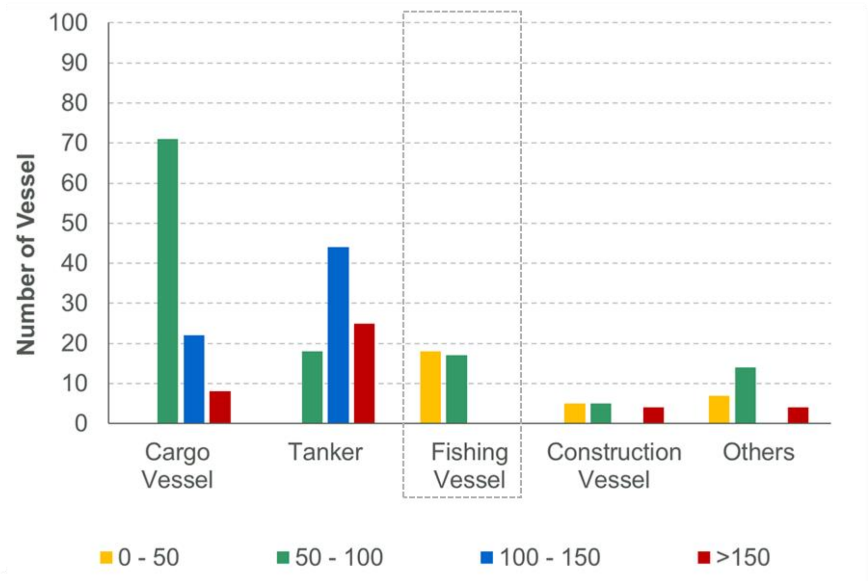


Figure C-3 Annual Spatial Distribution of Fishing Vessel Track by Vessel Length



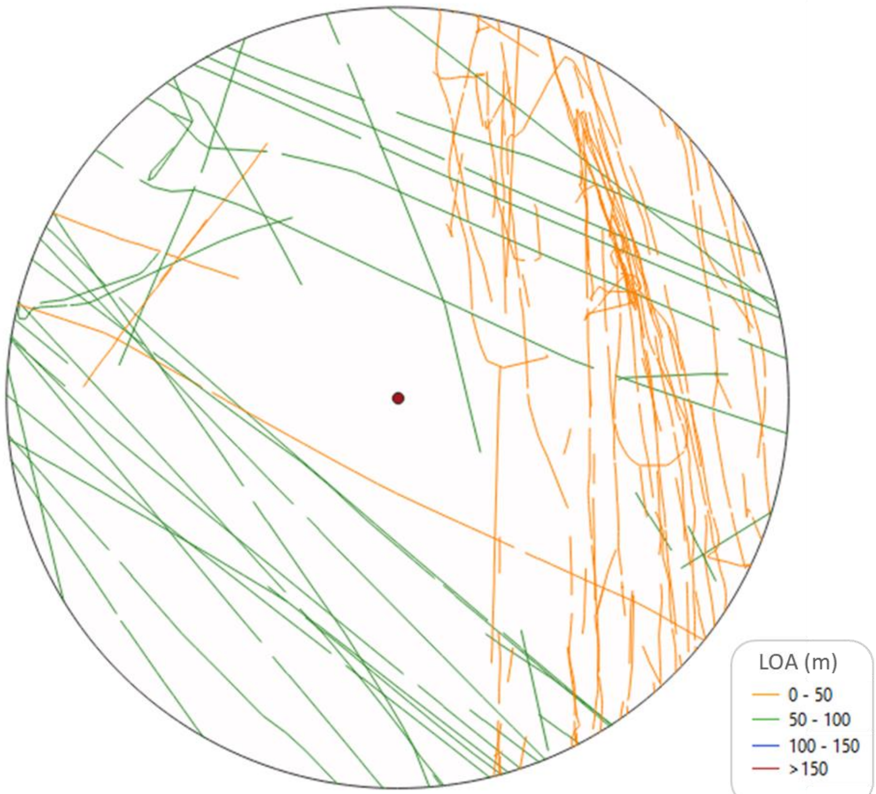


Figure C-4 Annual Spatial Distribution of Construction Vessel by Vessel Length

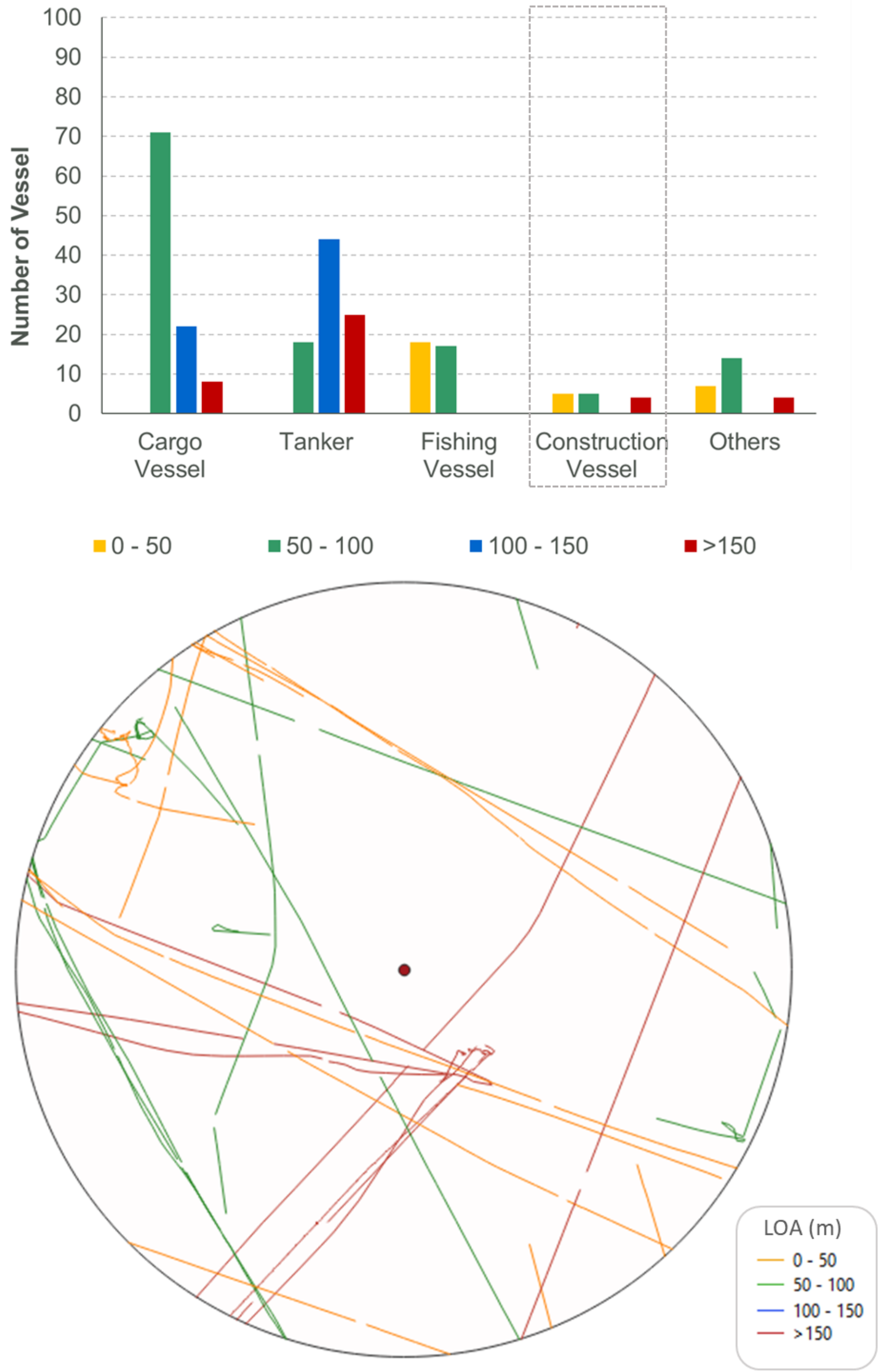
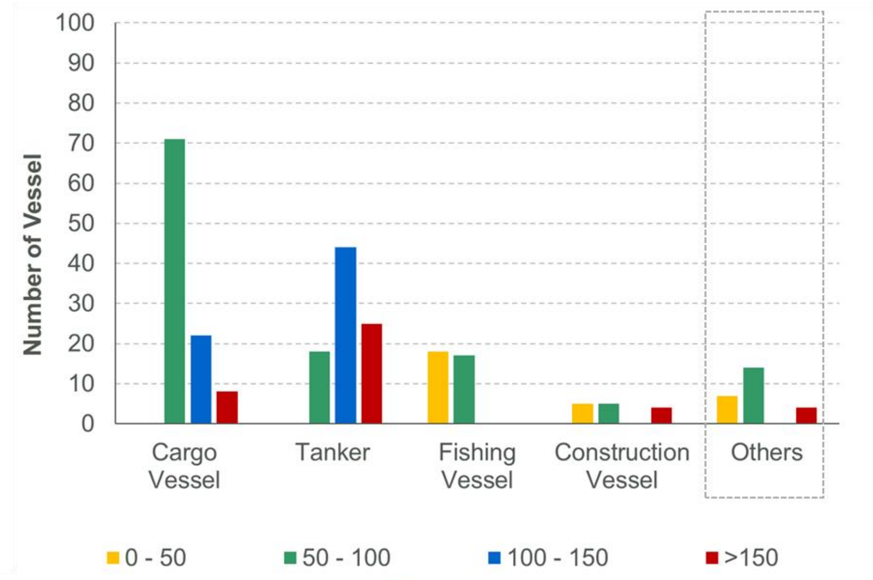
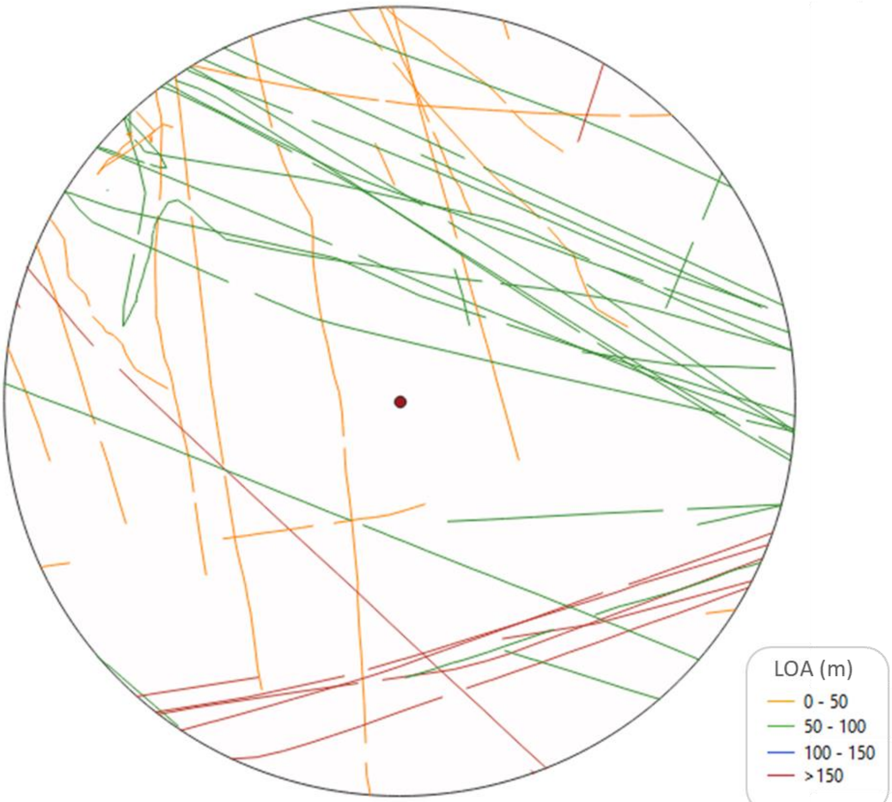


Figure C-5 Annual Spatial Distribution of Others by Vessel Length





Vessel Speed

The vessel speed is classified into 4 categories: 0 – 4 knot, 4- 8 knot, 8 – 12 knot, >12 knot. The following figures (**Figure C-6** to **Figure C-10**) show the spatial distributions of vessel speed by vessel types. The histogram above each figure summarize the variance of vessel speed distribution in different vessel type. The y-axis of each histogram has unit of annual transits.

Figure C-6 Annual Spatial Distribution of Cargo Vessel Track by Vessel Speed

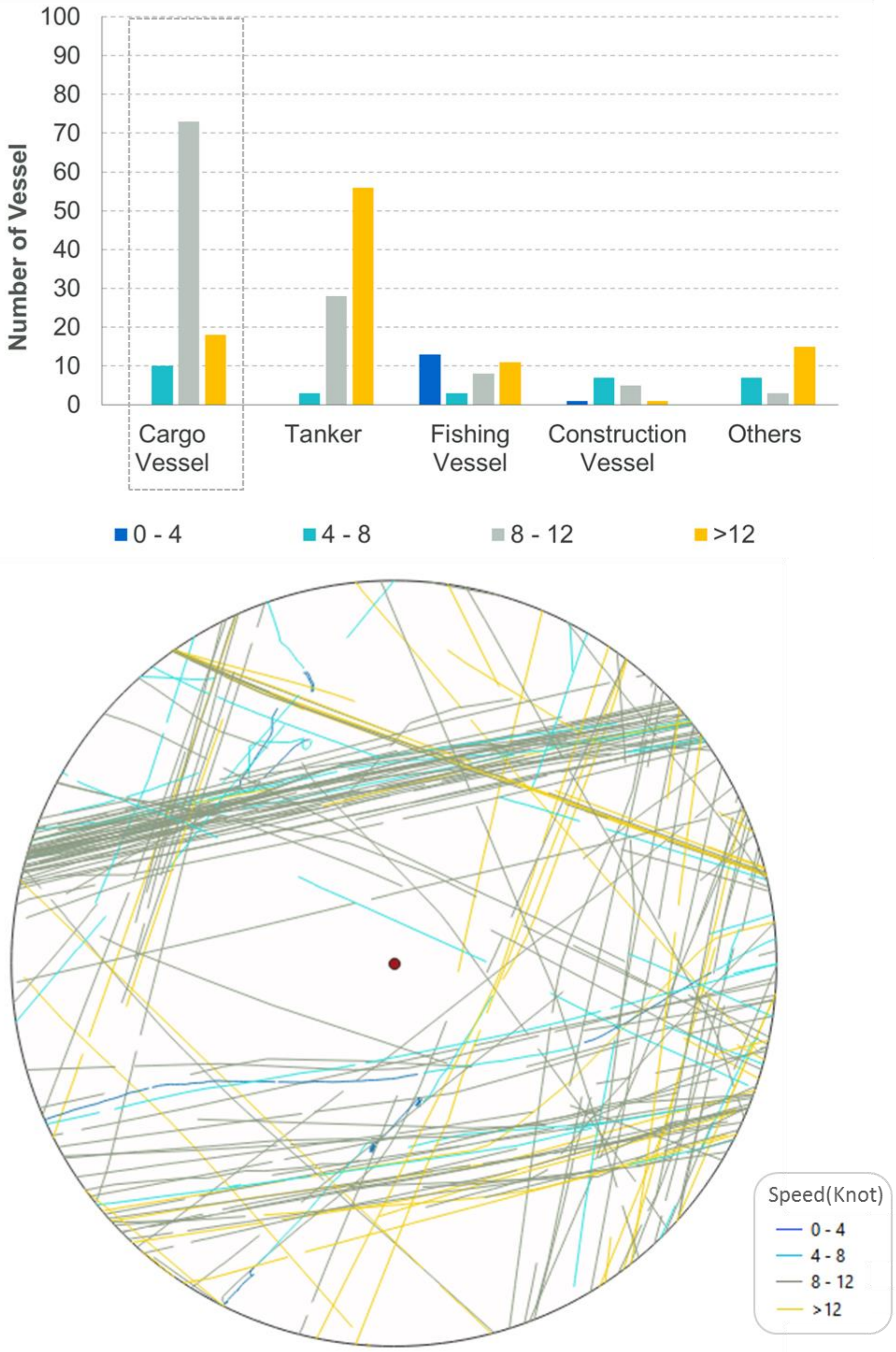
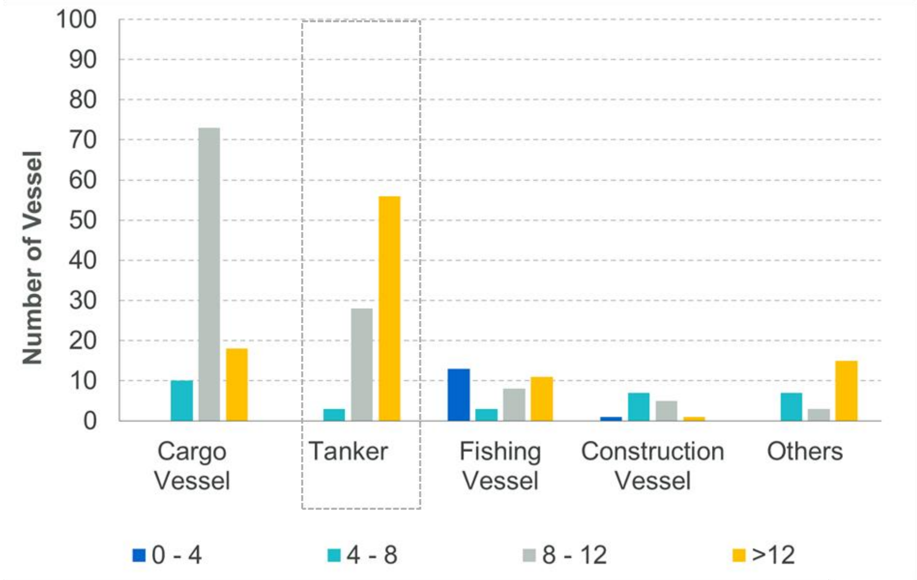


Figure C-7 Annual Spatial Distribution of Construction Vessel Track by Vessel Speed



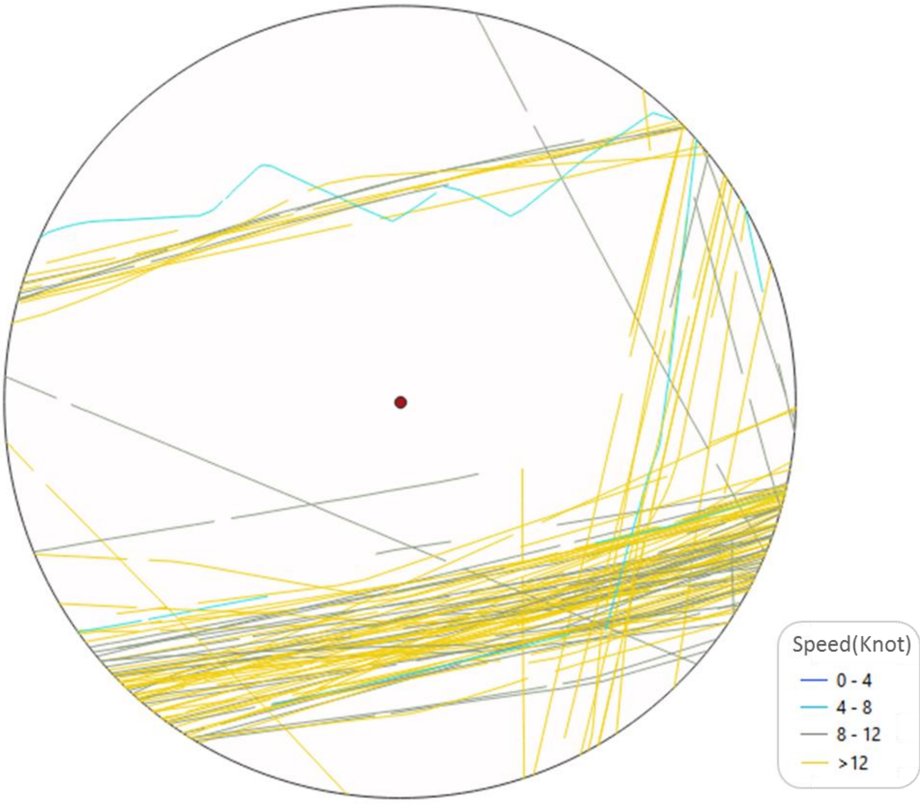


Figure C-8 Annual Spatial Distribution of Fishing Vessel Track by Vessel Speed

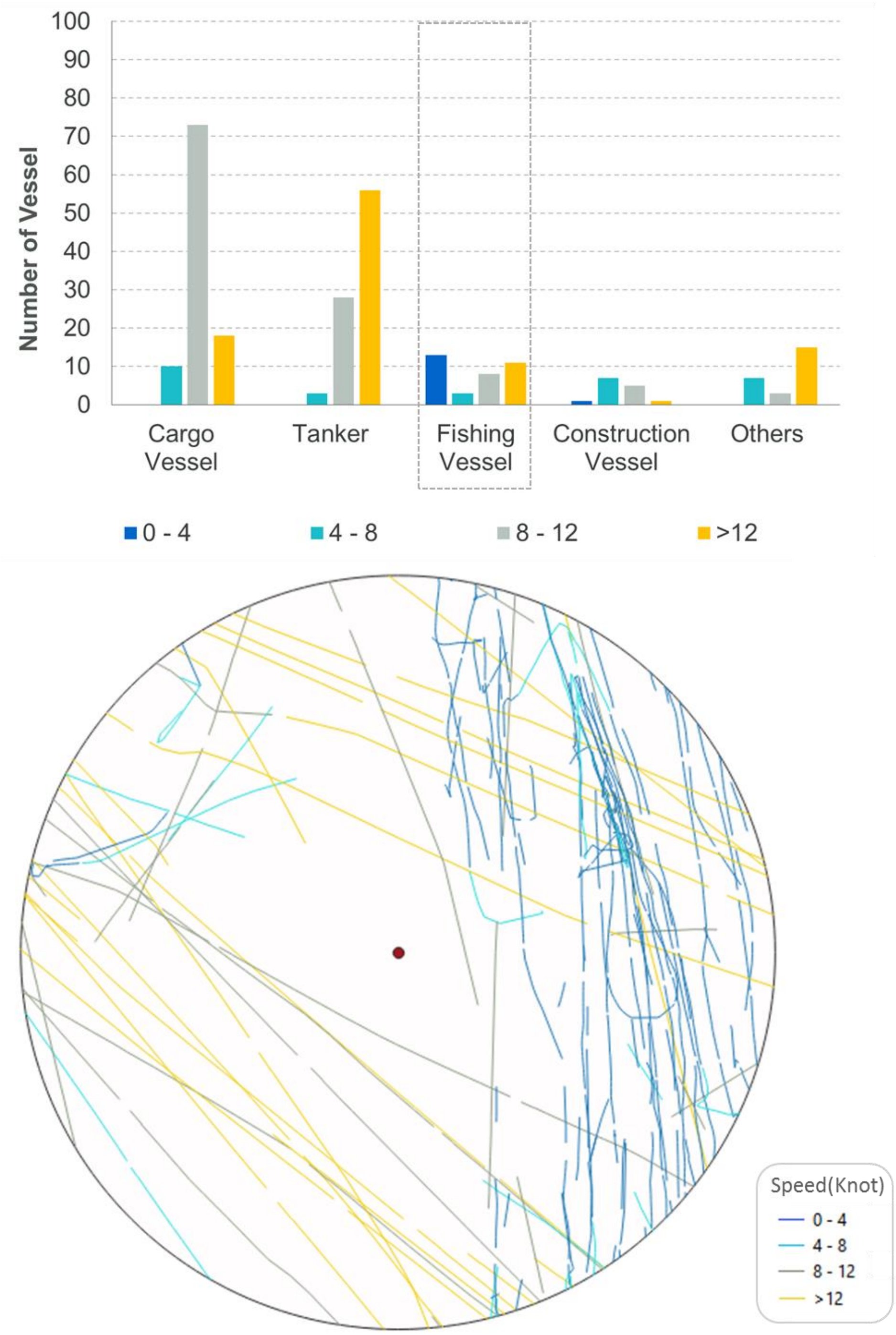
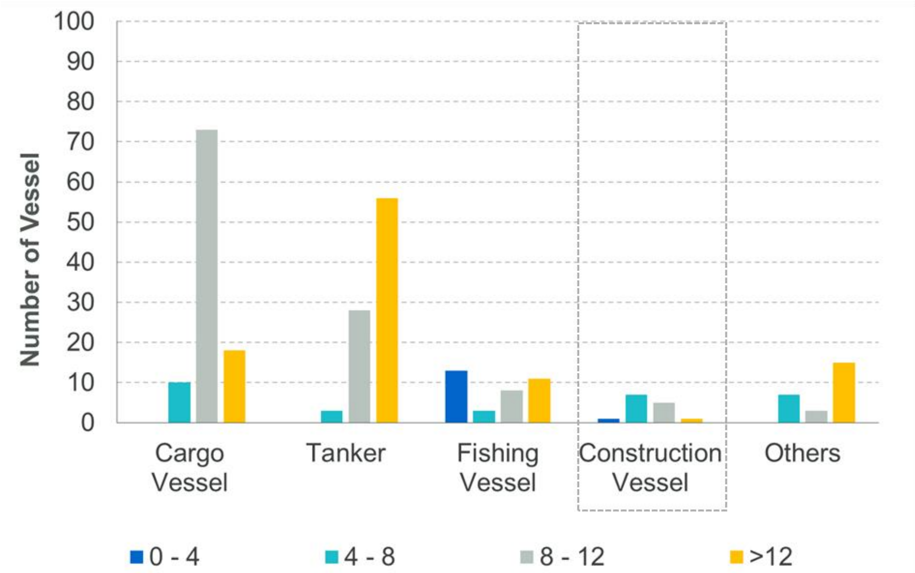


Figure C-9 Annual Spatial Distribution of Tanker by Vessel Speed



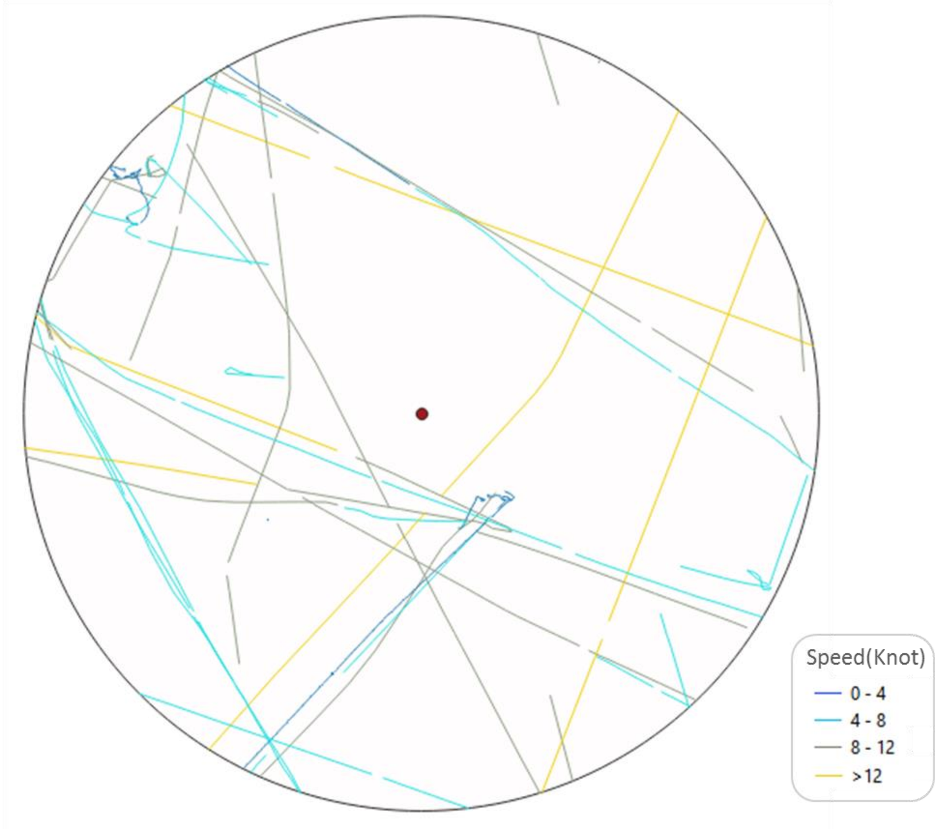
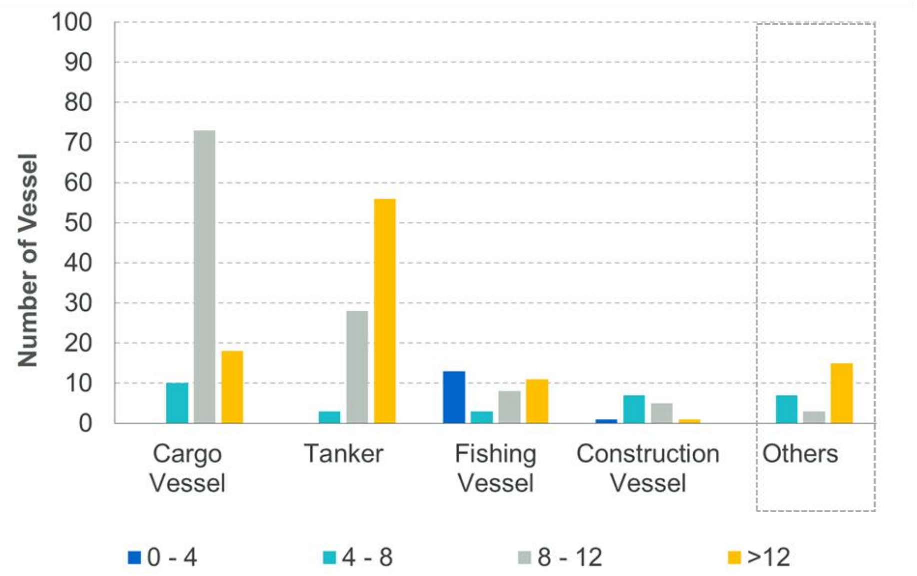
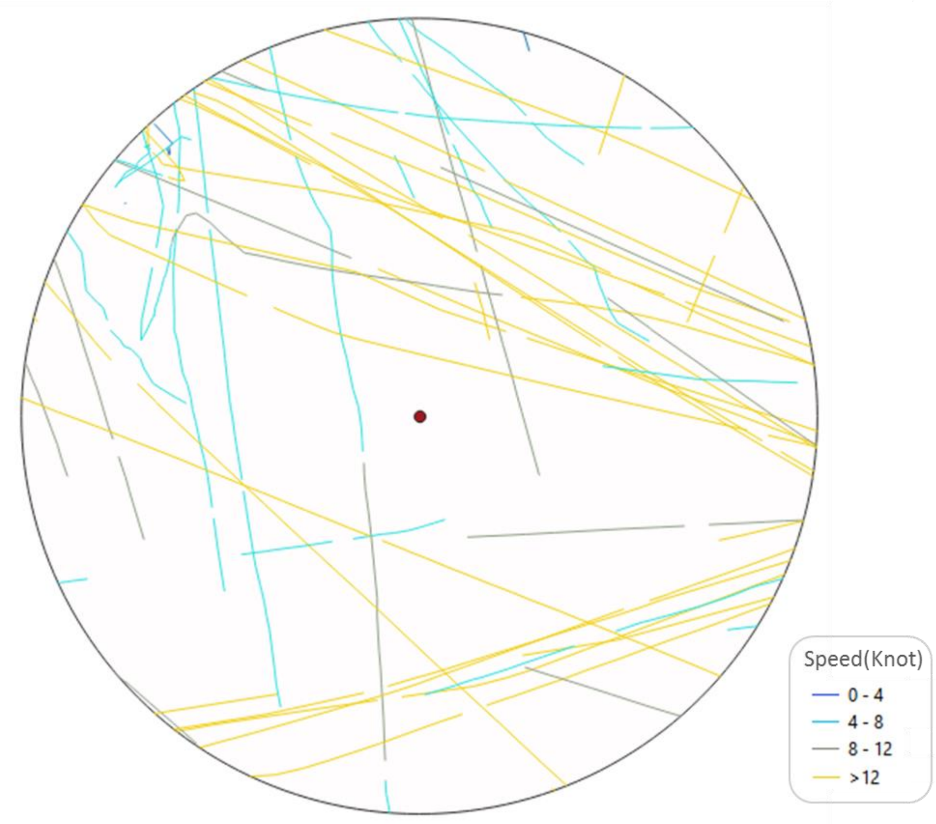


Figure C-10 Annual Spatial Distribution of Others by Vessel Speed





APPENDIX D: Spatial Distribution of Stationary Work Sites

Appendix D shows the spatial distribution of vessel type, vessel length and vessel speed by stationary work sites.

Vessel Length

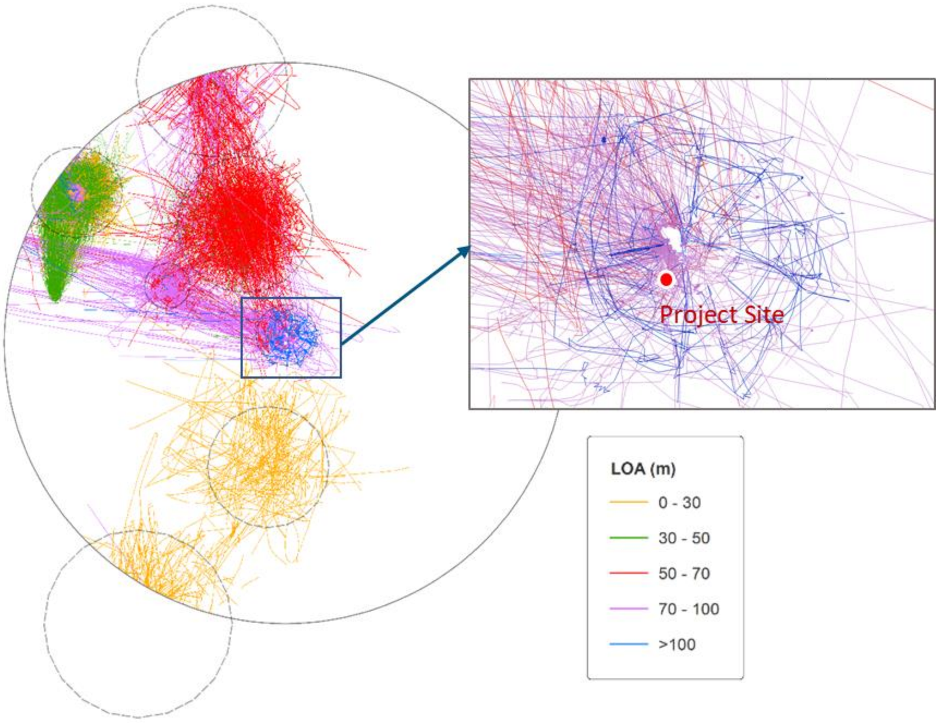
Figure D-1 presents the twelve months of AIS data categorised by vessel length

The largest vessels in the >100m category are Multi-Purpose Offshore Vessel. These vessels tend to transit around the platform which overlaps with the Project Site.

The next category in descending vessel size is 70 – 100m, which is featured by transits of Offshore Support Vessels. Again, these vessels actually came very close to the Project Site.

Most of tracks in the categories 0 - 30m and 30 - 50m are far away from the Project Site. Almost all of the vessels in fishing groups were under the 0- 30m category.

Figure D-1 Distribution of Stationary Work Sites by Vessel Length

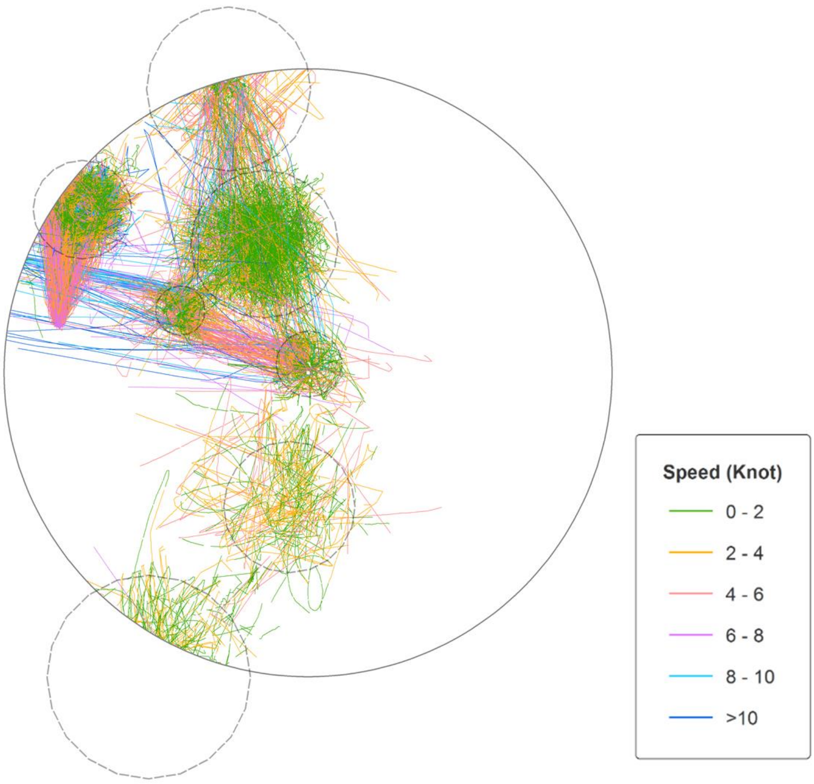


Vessel Speed

The majority of average track speeds were below 4 knots which is generally indicative of vessels involved in construction and fishing activity.

As shown in the **Figure D-2**, they typically transit at relative high speeds of above 8 knots before slowing down quickly once they reach their destination.

Figure D-2 Distribution of Stationary Work Sites by Vessel Speed



APPENDIX E: Vessel Length Frequency Distributions

In order to better understand the vessel length distribution of larger vessels (LOA under "> 150m" range), the vessel length is further divided into 5 categories: 0 – 50m, 50 – 100m, 100 – 150m, 150 – 200m and 200 – 300m. Figure E-1 shows the annual vessel length frequency distribution within 10nm of Project Site classified by vessel type.

For the vessels under 200 – 300 m category, the main sub vessel types of Cargo Vessel are Bulk Carrier and Heavy Load Carrier; 17 number of tankers under 200 – 300m category are contributed by Crude Oil Tanker and Shuttle Tanker; the large vessels in the Others type are the Passenger Ship.

Figure E-1 Annual Vessel Length Frequency Distribution by Vessel Type

Vessel Type	LOA Range (m)	Annual Count
Cargo Vessel	0 - 50	0
	50 - 100	71
	100 - 150	22
	150 - 200	5
	200 - 300	3
Tanker	0 - 50	0
	50 - 100	18
	100 - 150	44
	150 - 200	8
	200 - 300	17
Fishing Vessel	0 - 50	18
	50 - 100	17
	100 - 150	0
	150 - 200	0
	200 - 300	0
Construction Vessel	0 - 50	5
	50 - 100	5
	100 - 150	0
	150 - 200	4
	200 - 300	0
Others	0 - 50	7
	50 - 100	0
	100 - 150	14
	150 - 200	0
	200 - 300	4
TOTAL		**262**

Appendix B

Talbot ENVID Technical Note, 2022

Talbot Field Development

Chrysaor Petroleum Company U.K. Limited

ENVID Workshop Report

Revision	A1
Status	For Issue
Harbour Document Number	
Contractor Document Number	N/A
Total Number of Pages (Inc. Cover Page)	44

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Approval page

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Graham Stewart	Subsea Projects Manager	Checker		
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Revision history

Revision	Issue date	Statues	Originated by	Approval
A1		Issued for review	Chris Blackie	Craig Bell

Document revision record

Rev. No.	Revised section	Paragraph No.	Description of changes
C1	N/A	N/A	N/A
A1	Throughout report	N/A	Updated project title to *Talbot Field Development*

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Abbreviations, Acronyms and Units

Abbreviation	Definition
ALARP	As low as reasonably practicable
BAT	Best available technique
BEIS	Department for Business, Energy and Industrial Strategy
BOPD	Barrels of oil per day
DRO	Discovered Resource Opportunity
EIA	Environmental impact assessment
ENVID	Environmental Identification process
EUNIS	European Nature Information System
ES	Environmental Statement
GHG	Greenhouse gas
ICES	International Council for the Exploration of the Sea
JNCC	Joint Nature Conservation Committee
km	Kilometre

Abbreviation	Definition
m	Meter
LAT	Lowest astronomical tide
LTOBM	Low toxicity oil-based muds
MCZ	Marine Conservation Zone
MMBOE	Million barrels of oil equivalent
MMscf	Million standard cubic feet
MoD	Ministry of Defense
MPA	Marine Protected Area
NCMP	Nature Conservation Marine Protected Areas
NORM	Naturally occurring radioactive material
PMF	Priority Marine Feature
SPA	Special Protected Area
SSF	Scottish Fishermen's Federation
UK	United Kingdom
UKCS	UK Continental Shelf
WBM	Water based mud

Definitions

Host	means the existing Judy production and export platform.
Operator	means the Participant designated under P2456 Joint Operating Agreement acting in the capacity as Operator and not as the owner of a Percentage Interest.
License	means the United Kingdom Petroleum Production Licence No. P2456 dated 8 October 2018 and with a Start Date (as defined in the Licence) of 1 October 2018 issued by the Secretary as amended, supplemented or extended from time to time and shall include any other licence issued to the Participants in substitution or partial substitution for it.
Participant	means a party to the P2456 Joint Operating Agreement and its respective successors and assigns.
Project	means the Operator led project to evaluate, design, engineer, construct, install and commission the infrastructure associated with the proposed Talbot Field Development
Talbot	means the hydrocarbon accumulation (reservoir/field) designated under Licence No. P2456 under consideration for field development and proposed tophole drilling centre(s) with associated 500 m zone.
Talbot Field Development	the proposed development to extract the Talbot hydrocarbons and transport from the drilling tophole location to the Host platform.
Shall	indicates a mandatory requirement
Should	indicates a preferred course of action
May	indicates on acceptable course of action

1 Introduction

Harbour Energy Ltd (Harbour), proposes to develop the Talbot Field located in the UKCS Block 30/13e, approximately 278 km southeast of Peterhead on the Scottish east coast, 7 km west of the UK/ Norway median line, and approximately 15 km southeast of the existing Judy platform (Figure 1:1). The pipeline connecting the Talbot Field Development with the Judy platform will be located in Blocks 30/13, 30/12 and 30/7. The Talbot Field contains a light-oil and associated gas resource with an estimated accumulation of <50 million barrels of oil equivalent (MMBOE).

Harbour was awarded the licence area covering the Talbot Discovered Resource Opportunity (DRO) in 2018 and is currently undertaking front-end engineering with the intent of developing the Talbot Field. A subsea development is currently premised as the base case, tying back to an existing pipeline within the Judy 500 m zone, and is planned to consist of three to four wells at one drilling centre (Figure 1:2). The current development concept consists of one manifold, a multi-phase pipeline and an electro-hydraulic controls umbilical with chemical supply.

The reference case is for horizontal wells at a single drill centre, tied back to the Judy platform for processing. Oil and gas will be exported via pipelines to existing regional export infrastructure. The proposed drilling template and subsea manifold is provided in Figure 1:3.

Subject to regulatory approval, first oil from the offshore field development is currently planned for Q3 2024, with full production expected by Q4 2024. Harbour currently considers that production will be of the order of 25,000 barrels of oil per day (BOPD) and 40 million scfs (MMscf) of gas per day.

The ENVID considers all activities associated with drilling, installation of the pipelines and subsea structures, tie-up to Judy platform, production and operations and finally decommissioning of the Talbot Field.

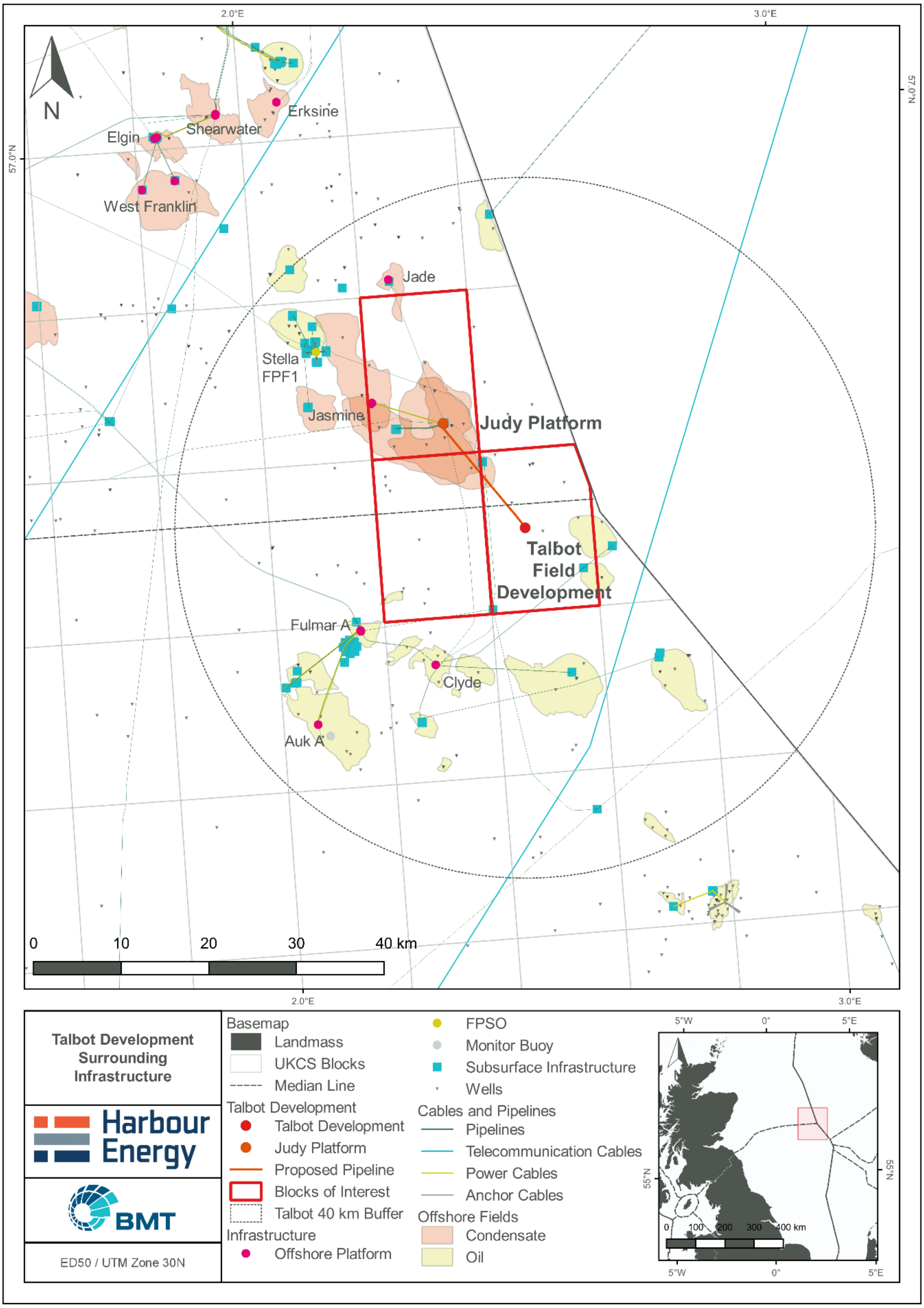

Figure 1:1 – Location of Talbot Field Development

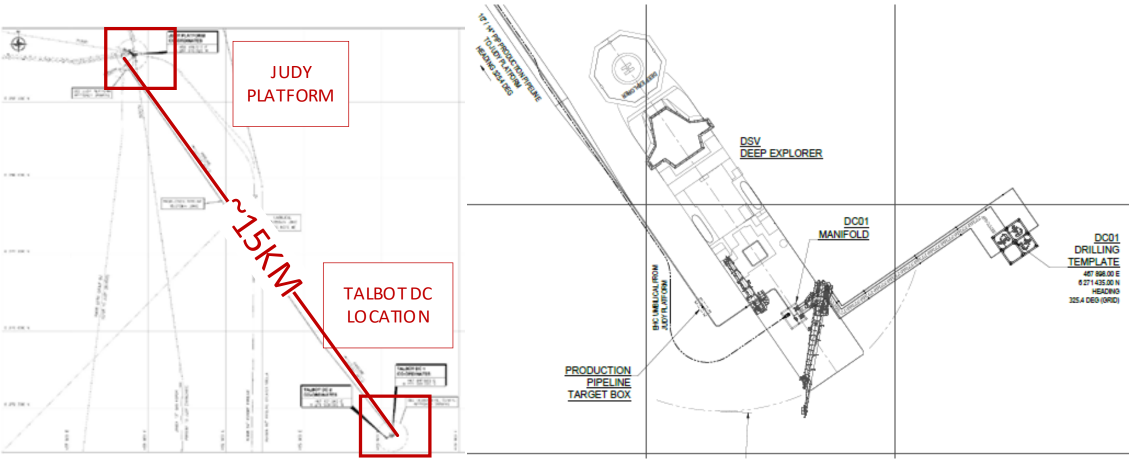

Figure 1:2 – Current Talbot Field layout plan (subject to change)

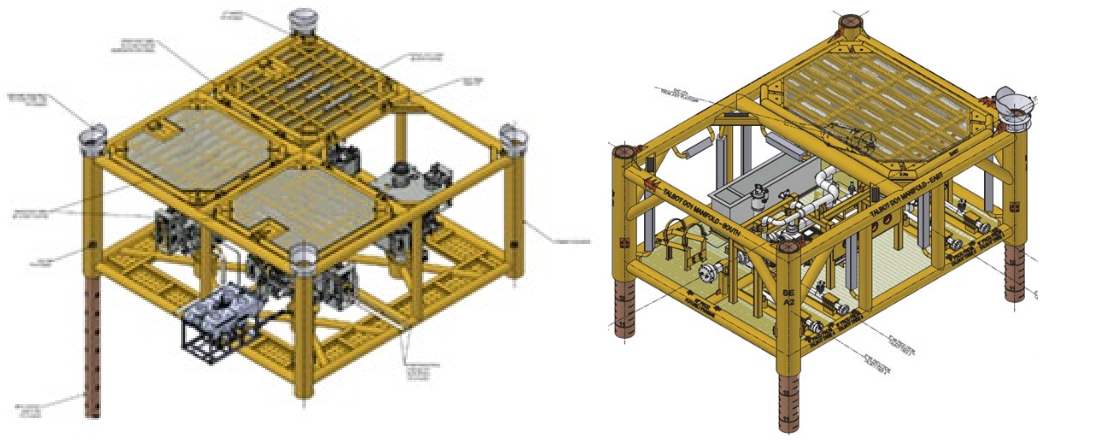

Figure 1:3 – Drilling Template (Left) & Subsea Manifold (Right) Detailed Design Views

2 Talbot Field Development Project ENVID Workshop

As part of the Talbot Field Development Project, an environmental risk identification (ENVID) workshop was held on 27th October 2021. The workshop was facilitated by representatives from BMT who have been contracted as independent consultants to conduct the environmental impact statement (EIA) and prepare the subsequent Environmental Statement (ES) for submission to Department for Business, Energy and Industrial Strategy (BEIS) to accompany the Field Development Plan. Project team representatives from Harbour and BMT attended the workshop. A list of the attendees is presented in Table 2:1.

Table 2:1 – ENVID workshop participants

Name	Company	Position or Talbot Role
Chris Blackie	Harbour	Subsea Project Lead
Tim Slaney	Harbour	HSE Lead
Simon Thomas	Harbour	Senior Environmental Scientist
Iain Sutherland	Harbour	Senior Advisor Drilling Engineer
David Vale	BMT	Facilitator
Joe Ferris	BMT	Facilitator
Cemlyn Barlow	BMT	Environmental Consultant and Scribe

2.1 Workshop Purpose and Objectives

The objectives of the Talbot Field Development Project ENVID workshop were to:

- Apply a suitable and systematic approach to the identification of environmental, social and community health risks associated with the proposed Talbot Field Development;
- Identify the risks/ effects associated with the various project activities and aspects of the field development programme, which may lead to an environmental, societal or community health impact;
- Based on the environmental sensitivities for the proposed development area Identify the receptors that may be affected by the activity;
- Identify any potential mitigation measurements or best available techniques (BAT);
- Consider what project controls are within the project design that mitigates these risks/ effects to acceptable levels;
- Score the potential risk/ effect following mitigation;
- Determine whether additional mitigation is required to reduce those risks/ effects to as low as reasonably practicable (ALARP);
- Identify any additional data requirements/ actions to be carried out and the party responsible; and
- Carry forward any environmental, social and community health risks for the development programme, which have the potential to be significant.

The environmental sensitivities of the Talbot Field Development Project area are identified in Table 2:2.

Table 2:2 – Environmental sensitivities in the proposed Talbot Field Development Project area

Aspect	Detail
Site Overview	
The Talbot Field Development will be located within Block 30/13, with the pipeline to be laid in Blocks 30/13, 30/12 and 30/7 and in Block 30/7a tied-in to Judy platform. The proposed development is also located within the International Council for the Exploration of the Sea (ICES) rectangle 42F2 and UK North Sea Quadrant 30. The proposed Talbot Field Development area is located approximately 278 km southeast of the Scottish coastline and 7 km west of the UK/ Norway median line. Average water depth across the proposed Talbot Field Development is between 71.2 and 75.4 m Lowest Astronomical Tide (LAT).	
Conservation interests within 100 km of the proposed Talbot Field Development (all distance measurements for the proposed development are provided from centre of Block 30/13e, where majority of infrastructure will be located)	
Offshore Marine Protected Areas, Species of Conservation Importance, and Annex I Habitats in the vicinity of the proposed Talbot Field Development *(Gardline, 2019; JNCC, 2021)*	
Arctica islandica (Ocean Quahog)	Ocean quahog, a species of conservation concern, is located within all three blocks of interest.
East Gannet and Montrose Fields Nature Conservation Marine Protected Area (NCMPA)	The East Gannet and Montrose Fields NCMPA is located approximately 67km northwest of the proposed Talbot Field Development. The Nature Conservation Marine Protected Area (NCMPA) is designated for protection of ocean quahog, including the supporting habitats, sand and gravel. The NCMPA also includes a band of offshore deep-sea mud which provides important habitat for many species of worms and molluscs which in turn, provide an important food source for fish. Ocean quahog and offshore deep-sea mud are listed as Priority Marine Features (PMFs).
Fulmar Marine Conservation Zone (MCZ)	The Fulmar Marine Conservation Zone (MCZ) is located within Blocks 30/12 and 30/13 and overlaps with the proposed Talbot Field Development area. The Fulmar MCZ is designated for protection of broad-scale habitats of subtidal mud, subtidal sand and subtidal mixed sediment, as well as protection of *A. islandica.* The Fulmar MCZ protects important habitats for marine animals, providing food, spawning areas and shelter. Offshore subtidal sands and gravels are listed as a PMF.
Swallow Sand MCZ	The Swallow Sand MCZ is approximately 96 km southwest of the proposed Talbot Field Development area and is designated for protection of broad-scale habitats of subtidal sand and subtidal coarse sediment, as well as the geomorphological feature, the North Sea glacial tunnel valley, known as the Swallow Hole.
Offshore and coastal Annex II species (Reid et al., 2003; NMPi, 2022)	
Harbour porpoise (*Phocoena phocoena*)	A high density of harbour porpoise is recorded in Quadrant 30 and adjacent quadrants for June, August, and November, and moderate density for September, and low density for May, July and October.

Aspect	Detail
Grey (Halichoerus grypus) and harbour (Phoca vitulina) seals	Grey seal densities range from 0 to 5 individuals per 25 km^2 and harbour seal densities range from 0 to 1 seal per 25 km^2 in the area.
Plankton (OESEA, 2016)	
Water column	The phytoplankton community of the North Sea is dominated by the dinoflagellate genus *Ceratium* (*C. fusus, C. furca, C. lineatum*), with diatoms such as *Thalassiosira* spp. and *Chaeoceros* spp. also abundant. The zooplankton community is dominated by copepods, and euphausiids, and decapod larvae are also important components of the zooplankton assemblage.
Benthic environment (NMPi, 2022; Gardline, 2019)	
Seabed sediments	Offshore subtidal sands and gravels are the PMFs identified as present at the proposed Talbot Field Development area. The EUNIS classification system identifies the area as deep circalittoral sand (A5.27) and deep circalittoral mixed sediments (A5.45).
Benthic fauna	The benthic fauna can be described as typical for offshore circalittoral sand sediments of the central North Sea, characterised by a diverse range of macrofaunal species, namely polychaetes (dominated by polychaete annelids (bristle worms)), arthropods (including crabs and shrimps), molluscs (including bivalves and snails) and echinoderms (including star fish and brittle stars).
Fish and shellfish spawning and nursery areas (Aires et al., 2014; Coull et al., 1998; Ellis et al., 2012)	
Spawning areas	There are spawning areas for cod (*Gadus morhua)*, lemon sole (*Microstomus kitt*), mackerel (*Scomber scombrus*), Norway pout (*Trisopterus esmarkii*), plaice (*Pleuronectes platessa*) and sandeel (*Ammodytes spp.*) within ICES rectangle 42F2. ICES rectangle 42F2 is considered a high concentration spawning area for mackerel and Norway pout.
Nursery areas	There are nursery areas for anglerfish/ monkfish (*Lophius piscatorius*), blue whiting (*Micromesistius poutassou*), cod, European hake (*Merluccius merluccius*), haddock (*Melanogrammus aeglefinus)*, herring (*Clupea harengus*), mackerel (*Scomber scombrus*), Norway pout, plaice, sandeel, spotted ray (*Raja montagui*), spurdog (*Squalus acanthias*), ling (*Molva molva*), and whiting (*Merlangius merlangus*) within ICES rectangle 42F2. Cod has a high nursery intensity within ICES rectangle 42F2.
Marine Mammals (Reid et al., 2003; NMPi, 2022; UKDMAP, 1998)	
Cetaceans	Harbour porpoises (*Phocoena phocoena)*, white-beaked dolphins (*Lagenorhynchus albirostris*), minke whales (*Balaenoptera acutorostrata)*, common dolphin (*Delphinus delphis*) and Atlantic white-sided dolphins (*Lagenorhynchus acutus*) have been recorded in the vicinity of proposed Talbot Field Development (Reid et al., 2003; NMPi 2022; UKDMAP, 1998).

Aspect	Detail
	These cetacean species are all listed as European Protected Species under the Habitats Directive and as Scottish PMFs. In addition, harbour porpoise is also listed as an Annex II species under the Habitats Directive. The most sensitive period for cetaceans in Quadrant 30 and adjacent Quadrants is May to November, with peak density in July.
Pinnipeds	Grey and harbour seals can both be potentially found in the Talbot Field Development area in low densities, however due to the distance from shore (approximately 278 km), their presence is unlikely.
Seabirds (Kober et al., 2010; Webb et al., 2016)	
Seabirds sensitivity	Seabird sensitivity in the region of the proposed Talbot Field Development area (Blocks 30/13, 30/12, 30/7 and surrounding blocks) varies from low to extremely high throughout the year. Seabird sensitivity peaks at extremely high in May and June in the surrounding blocks, followed by very high at Block 30/13 in May and June. In the remaining months there is low seabird sensitivity in Blocks 30/13, 30/12, 30/7 and surrounding blocks, with the exception of Block 30/12 in February which has a medium seabird sensitivity. There was no data available in October and November for all blocks within the proposed Talbot Field Development area, and data for April and December were only available for some blocks. The following species have been recorded within the proposed Talbot Field Development area: Northern Gannet (*Morus bassanus)*, Great Skua (*Stercorarius skua*), Arctic Skua (*Stercorarius parasiticus*), Great Black-backed Gull (*Larus marinus*), Herring Gull (*Larus argentatus*), Razorbill (*Alca torda)*, Little Auk (Common Guillemot (*Uria aalge*), Black-legged Kittiwake (*Rissa tridactyla*) and Atlantic Puffin (*Fratercula arctica*) The proposed Talbot Field Development is located approximately 278 km from the nearest UK coast and is therefore remote from sensitive seabird breeding areas on the coast. The nearest proposed offshore Special Protection Areas (SPAs) is located over 125 km south from Talbot Field Development.
Socioeconomic	
Fisheries	The fishing effort, value and quantity of live weight has decreased greatly from 2016 to 2020, from 49 tonnes landed in 2016 at value of £82,923 to 8 tonnes landed in 2020 at value of £18,196 (Scottish Government, 2021). Trawls were the most utilised gear type used in ICES rectangle 42F2 in each year from 2014 to 2020 (Scottish Government, 2021; MMO, 2019). No shellfish water protected areas or active aquaculture sites occur in the vicinity of the proposed Talbot Field Development. The closest active aquaculture sites are on the Aberdeen coast >250 km to the west of the proposed Talbot Field Development (NMPI, 2022).
Shipping	Blocks 30/13 and 30/12 are classified as having very low shipping density and Block 30/7 is classified as having low shipping density (Oil and Gas Authority, 2016).
Oil and gas industry	The Talbot Field Development Project is located in the central North Sea, in an area of generally extensive oil development. There are several installations within a 40 km radius of the Talbot Field Development (measured from centre of Block 30/13e):

Aspect	Detail
	Clyde 19 km south-west; Judy 20km north-west; Fulmar AD 23 km south-west; Jasmine 24km north-west; Jade 34 km north; and Auk A 37 km south-west, as well as one FPSO; Stella FPF1 31.2 km northwest.
Offshore renewables	No renewable energy developments occur within 100 km of the proposed Talbot Field Development Project. The closest offshore wind area is the Round 3 Dogger Bank zone, which is split into four projects for development, with the nearest being >150 km south of Talbot Field Development.
Military activities	According to the Ministry of Defence (MoD) there are no licence conditions applied to Blocks 30/7, 30/12 or 30/13 (Oil and Gas Authority, 2019) and there are no military training areas in the vicinity of the proposed Talbot Field Development (NMPi, 2022).
Aggregate activities	No aggregate extraction activities occur in the central North Sea (NMPi, 2022).
Wrecks	There are four wrecks within the proposed Talbot Field Development; one is the *Devotion* and the other three are designated as unknown (NMPi, 2022). There are no known wrecks of historical importance (Historic MPAs, scheduled monuments or war graces) in the vicinity of the proposed Talbot Field Development.
Telecommunication	Two telecommunication cables occur in the near vicinity of the proposed Talbot Field Development. The TAMPNET Clyde telecommunication cable is located within the proposed Talbot Field Development area and the TAMPNET Valhall telecommunication cable is located approximately 9 km southeast of the proposed Talbot Field Development area (KIS-ORCA, 2019).
Licence conditions	There is a period of concern for seismic surveys between May and August in all three blocks of interest imposed by Marine Scotland (Oil and Gas Authority, 2019). There are no licence conditions applied to Blocks 30/7, 30/12 or 30/13 on behalf of the MOD or JNCC.

2.2 Workshop Agenda

The workshop addressed the following agenda:

- Welcome and introductions.
- Overview of the development programme.
- ENVID scope and objectives.
- Environmental setting.
- ENVID methodology and completion.
- Questions and wrap-up.

Joe Ferris, an Associate of BMT, and David Vale of BMT facilitated the workshop while Cemlyn Barlow of BMT acted as the scribe and environmental consultant. David Vale opened and introduced the aims and objectives for the day. Chris Blackie of Harbour presented an overview of the field development. Joe Ferris than summarised the main environmental sensitivities in the area (Table 2:2) and outlined the objectives and methodology of the ENVID procedure.

Following the presentations (Annex A: ENVID Presentation), a facilitated discussion took place working through the assessment of the potential impacts/ risks, receptors, mitigation measures and additional data requirements and actions for each project activity. Both planned operations and unplanned or accidental events were considered. Template worksheets (Table 2:3) were used to record the project activities and outcomes of the discussion under the following headers:

- Drilling and Well Development
- Installation of Subsea Architecture & Connection to Judy platform
- Production/ Operations
- Decommissioning

This was carried out using the method described in Section 2.3 and an example of the worksheet is given in Table 2:3. The completed worksheets are provided in Annex B: ENVID Worksheets.

Table 2:3 – Talbot Field Development Project ENVID worksheet – example

Assessed in EIA Risk High Significant Medium Low Scoped IN Scoped OUT	Potential Impacts	Physical and Chemical			Biological							Socio-economic								Mitigation/ Prevention/ Control	Risk Assessment			Justification/ Comments/ Data available/ Gaps	Action and responsible party
		Sediment structure/ chemistry	Water quality	Emissions	Sediment biology (benthos)	Water column (plankton)	Finfish and shellfish	Seabirds	Sea mammals	Conservation sites	Biodiversity	Use of resources	Use of disposal facilities	Commercial fishing	Shipping	Military operations	Other users	Trans-boundary effects	Stakeholder concerns		Consequence	Likelihood	Risk		
Planned Events																									
Physical presence of drilling rig and vessels	• Obstruction to other sea users													✓	✓		✓			• Notice to Mariners and Shipping Alerts • Kingfisher charts • Standby vessel • Industry standard notifications, navigation aids and communications • Physical presence / Operations (mainly within drill centre 500 m safety zones) • Notification emails on rig moves to all stakeholders • Consent to locate • Establish 500m safety zone for template and well centre	3	3		• Shipping density in the block is low • Low fishing activity for mackerel and demersal mobile species • This will be a temporary operation within a well-defined area • Industry standard controls	• 500m safety zone for template and well centre - TS
Spudding of jack-up rig	• Disturbance to seabed and benthic communities • Scars on seabed causing obstruction to fishing gear • Wire anchor disturbance to seabed	✓			✓		✓			✓				✓						• Anchor system specified for seabed type/ loading • Controlled/ monitored deployment • Post-installation seabed survey • SFF post-installation seabed sweep • Geophysical survey and EBS will determine the extent of potential rock dump and also identify and facilitate rig placement to avoid any habitats	2	3		• Within MCZ conservation area • Deep circalittoral sand • Ocean quahog • Localised impact • Industry standard controls	• Apply for contingent rock deposition for legs stabilisation and scour mitigation (dependent on geotechnical survey) – AD • Confirm number of anchors required - AD

2.3 Risk Assessment

The potential risks associated with the proposed Talbot Field Development Project programme were assessed using Harbour's environmental risk assessment matrix, which combines the scale of environmental impact consequence/ severity with the likelihood (Table 2:4).

Table 2:4 – Risk Assessment Matrix

		Consequence/ Severity				
		Negligible (1)	Minor (2)	Moderate (3)	Significant (4)	Catastrophic (5)
Likelihood	Frequent (5)	Medium Risk (5)	Significant Risk (10)	High Risk (15)	High Risk (20)	High Risk (25)
	Probable (4)	Low Risk (4)	Medium Risk (8)	Significant Risk (12)	High Risk (16)	High Risk (20)
	Occasional (3)	Low Risk (3)	Medium Risk (6)	Medium Risk (9)	Significant Risk (12)	High Risk (15)
	Remote (2)	Low Risk (2)	Low Risk (4)	Medium Risk (6)	Medium Risk (8)	Significant Risk (10)
	Improbable (1)	Low Risk (1)	Low Risk (2)	Low Risk (3)	Low Risk (4)	Medium Risk (5)

During the ENVID, the interactions between the environmental receptors and the main activities of the Talbot Field Development Project were identified and split into individual sub-operations. For planned operations and accidental events, the potential risks to environmental receptors from all relevant project activities were scored using the risk assessment matrix, which combines likelihood of activities against their potential consequence of an environmental impact (severity) using the criteria defined below.

For each activity, a risk rating was calculated in order to determine whether the project impact was potentially significant. The risk rating was calculated as:

Risk Rating = Consequence x Likelihood

If the risk rating was determined to be Low (green), a potential risk may exist, but the associated impacts are deemed to be insignificant, and as such do not require further assessment in the ES. Any risk rating which was determined to be Medium (yellow), Significant (orange) or High (red) is regarded as potentially significant and requires further assessment and mitigation, where appropriate.

3 ENVID Workshop Findings

During the ENVID, the likelihood of the each of the project impacts was predicted Subsequently, the consequence/ severity that each impact could potentially have on the environment and/ or receptor was scored following the methodology above and noted on the ENVID worksheet. The ENVID matrices for planned operations and accidental events prepared during the workshop are presented in Annex B: ENVID Worksheets.

The proposed activities planned within the Talbot Field Development Project have been reviewed using a high-level understanding of the baseline physical, biological and socioeconomic environment. The results from the workshop also provided a means to identify the issues that are likely to be of most importance and eliminates those that pose minimal risk or concern. This scoping of the potential impacts focuses the EIA on the activities that may result in a significant effect.

A high-level summary of the environmental aspects, receptors and potential source of impacts is presented below and identifies activities that will be assessed further (Scoped In) or not (Scoped Out) in the EIA.

The activities/ risks that have been Scoped In

The following potential environmental issues were identified with potential impacts considered significant. It was therefore agreed they would be Scoped In the EIA:

Discharges to sea

- Discharge of WBM cuttings and completion chemicals from drilling operations onto the seabed and into the water column, resulting in changes in water quality, localised and temporarily increased suspended solid concentrations, and possible impacts to organisms in the water column and on the seabed; and
- Discharge of processed produced water into the water column resulting in changes in water quality and possible impacts on pelagic organisms.

Seabed disturbance

- Direct loss of benthic species;
- Direct loss of existing seabed habitat;
- Wider indirect disturbance to the benthic environment through the suspension and re-settlement of sediments;
- The installation of the subsea infrastructure and connection to Judy platform will disturb the benthic habitats and communities;
- Placement of rock and protective materials along the pipelines and over crossing will disturb seabed communities, pose obstruction to demersal trawling and lead to loss of natural habitat; and
- Spudding of the jack-up rig and the wire anchors will leave scars on the seabed and will disturb the benthic communities.

Skip and ship of low toxicity oil-based muds (LTOBM) cuttings

- Treatment of LTOBM cuttings will contribute to the deterioration of air quality; and
- Use of landfill disposal facilities.

Underwater noise

- Injury and disturbance to marine mammals and fish through noise from drilling, piling and vessels transport during the project. This also applies to helicopter transport.
- Interaction with other sea users and physical presence

- Interference with shipping and fishing activities that may occur in the area;
- Loss of access to the area for other vessels on a temporary or permanent basis; and
- Increased risk of vessel collisions through the presence of the drill rig and other vessels during the proposed activities.

Atmospheric emissions

- Climate change due to greenhouse gases (GHGs) including carbon dioxide (CO2); and
- Generation of acid rain from oxides of nitrogen (NOx) and sulphur (SOx).

Accidental events

- Possible toxicity and smothering impacts to birds, other marine species (e.g. marine mammals) and habitats through the release of hydrocarbons and chemicals from a well blowout, diesel inventory from vessels or loss of crude inventory from the pipeline.

Activities/ Issues that have been Scoped Out

The following potential environmental issues were identified but potential impacts were considered too small and likely to be insignificant. It was therefore agreed they would be Scoped Out of further assessment in the EIA:

Discharges to sea

- Routine blackwater production (sewage), grey water (from showers, laundry, hand and eye wash basins and drinking fountains), and food waste (macerated) disposal (from the platform) – these were Scoped Out due to existing, effective management controls in place for such discharges;
- Ballast water – was scoped out as no major international movement of vessels expected for this project; and
- Routine seawater usage for cooling (e.g., engine cooling) – was Scoped Out due to the highly limited temporal and spatial extent of such discharges.

Seabed disturbance from drilling activities

- Disturbance to benthic species and/ or communities – neither cuttings nor LTOBM will be discharged to seabed and therefore no additional disturbance to the seabed is expected.
- Interaction with other sea users and physical presence
- Disturbance to marine species in the project area from vessels or collision between vessels and animals – Scoped Out as the drilling campaign will a temporary short-term activity, and thus vessel use to support drilling activity will be minimal; and
- Impact on seascape – Scoped Out as there will be no change to the baseline surface infrastructure and the limited additional vessel presence will be sufficiently far offshore not to affect visual amenity.

Waste

- Routine generation and disposal of non-hazardous waste streams – Scoped Out due to existing, effective management controls in place for waste;
- Routine generation and disposal of special/ hazardous wastes, e.g. oily rags, medical waste, solvents, batteries, computers, fluorescent tubes, oil/ grease/ chemical cans/ drums/ sacks, – Scoped Out due to existing, effective management controls in place for waste; and
- Routine generation and disposal of radioactive wastes (disposal onshore) (e.g. naturally occurring radioactive material (NORM), contaminated cuttings, radiation sources in safety/ detection equipment) – Scoped Out as no radioactive waste is expected from the drilling campaign.

Accidental events

- Accidental deposit of materials on the seabed (e.g. dropped objects) – Scoped Out due to existing, effective management controls in place for dropped objects; and
- Limited unplanned operational releases, such as resulting from an overfill of the diesel tank bund – Scoped Out due to limited volumes and very low likelihood of occurrence.

Despite the low risk associated with some of the operations identified during the ENVID, several of the anticipated activities and their potential impacts have been carried forward (or Scoped In) for further assessment due to regulatory requirements and/ or stakeholder concerns. These activities are highlighted in blue (☐) in Annex B: ENVID Worksheets, while the activities that were Scoped Out are highlighted in light yellow (☐)

Out of a total 64 activities (50 planned and 14 unplanned) identified for the development of the Talbot Field Development project, 18 activities were identified as having a Low (green ☐) risk and were Scoped Out as they do not require further assessment (light yellow ☐). Ten activities were identified as having Medium (yellow ☐) risk, with one activity having Significant (orange ☐) risk, but do not require further assessment and were therefore also Scoped Out (light yellow ☐). Those activities have appropriate mitigations in place or will be part of future decommissioning.

A total of three activities associated with well blow outs and underwater noise were scored as having a potential Significant (orange ☐) risk. Twenty activities which scored as a Medium (yellow ☐) risk were identified as requiring further assessment, therefore were Scoped In (blue ☐). Eleven activities were identified as having Low (green ☐) risk but require further assessment due to the regulatory issues and/ or stakeholder concerns associated with them and were Scoped In (blue ☐). One activity associated with sand control and disposal of sand is in the worksheets but not ranked due to existing sand management procedures on Judy with negligible additional sand volumes.

For completeness the follow-up actions and responsible person that were identified during ENVID workshop are summarised in Table 3:1. Details of activities and associated actions are provided in Annex B: ENVID Worksheets.

Table 3:1 – Summary of actions identified during ENVID

Activity	Action	Responsible party initials
Activity 1 (planned events) – Physical presence of drilling rig and vessels	Confirm the 500 m safety zones around well centers will be applied for	TS
Activity 1 (planned events) – Spudding of jack-up rig	Apply for contingent rock deposition for legs stabilisation and scour mitigation (dependent on geotechnical survey)	AD
Activity 1 (planned events) – Spudding of jack-up rig	Confirm number of anchors required	AD
Activity 1 (planned events) – Permitted discharge of WBM cuttings	Confirm the need for drill cuttings dispersion modelling	AD
Activity 1 (planned events) – Permitted discharge of WBM cuttings	Confirm the cuttings disposal method	IS
Activity 1 (accidental events) – Well blow-out of oil and gas	Confirm existing oil spill modelling is sufficient	IS

Activity	Action	Responsible party initials
Activity 1 (accidental events) – Well blow-out of oil and gas	Confirm worst case discharge volumes against previously assessed	IS
Activity 1 (accidental events) – Hydrocarbon spill, e.g. from vessel collision	REWS check coverage	TS
Activity 3 (production) – Increased chemical usage	Check with chemist for quantities of chemicals	ST
Activity 4 (Pipelines, umbilicals, flowlines and power cables) – Presence of buried pipelines and umbilicals	Check SSF over-trawl no longer required in MPAs	DV

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Annex A: ENVID Presentation

(Available in the PDF version and upon request)

“Where will our knowledge take you?”

Talbot Development Project

ENVID Review

Aberdeen | 27 October 2021

Facilitated by:

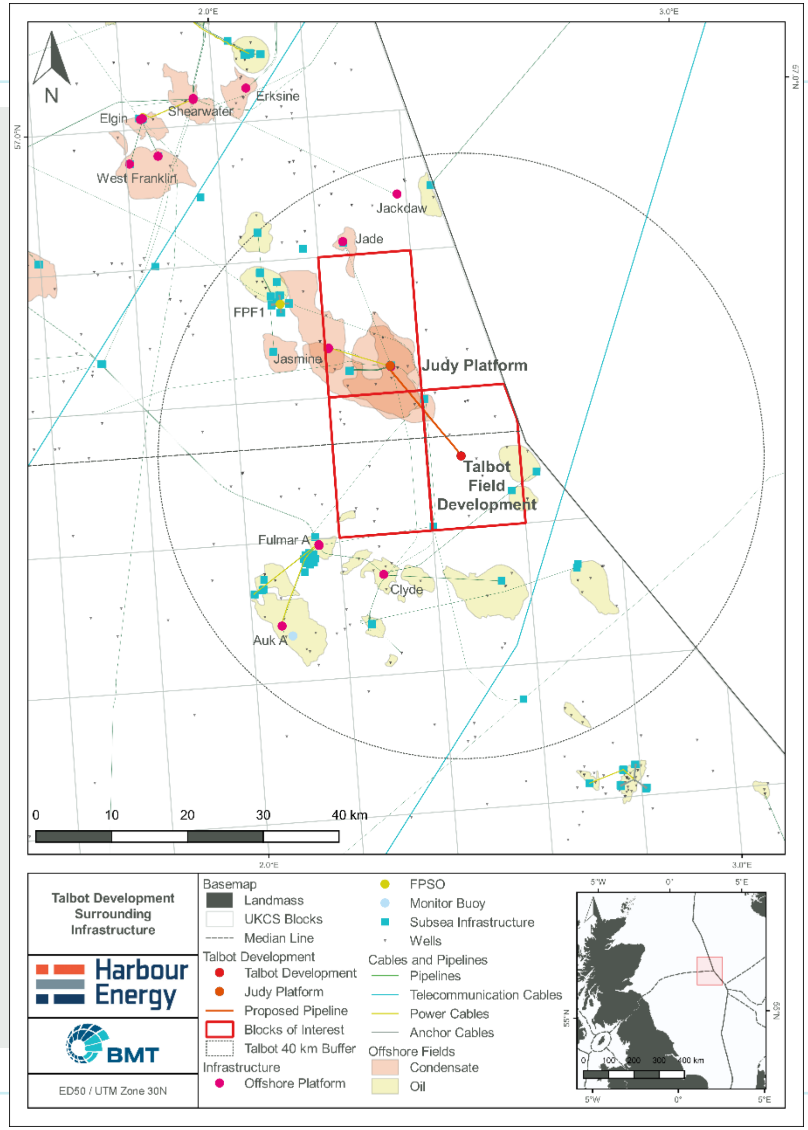
David Vale and Joe Ferris

ENVID Proposed Workshop Agenda

Time	Task
9:00 – 9:10	Welcome (Workshop Facilitator)
9:10 – 9:40	ENVID Review/ Update Introduction (Workshop Facilitator) • Objectives • Review of environmental and social setting and any changes • Regulatory changes to EIA regs & regulatory concerns
9:40 – 10:00	Overview of revised FDP and changes from previous FDP (Harbour Energy)
10:00 – 10:30	Approach to ENVID worksheets and revised risk matrix (Workshop Facilitator)
10:30 – 10:45	Break
10:45 – 12:30	Review & update of ENVID worksheets (Workshop Facilitator) • Drilling operations • Installation of subsea infrastructure, commissioning and connection to Judy Platform • Production operations • Decommissioning
12:30 – 13:00	Summary and review of findings (Workshop Facilitator)

Talbot Development

- One licence Block 30/13e with one drilling centre
- Five pipeline crossings from Block 30/13 through 30/12 to 30/7 (location of Judy platform)
- Talbot Development is located approximately 278 km southeast of Peterhead
- The proposed development is located approximately 5 km east from UK/ Norway median line
- Currently planning for 3 wells



BMT

Scope of the update to ENVID Study

Scope for the ENVID update includes environmental and societal issues for the offshore and onshore activities of the Talbot Development.

- Review changes to the conceptual design to identify actual and potential causes of environmental aspects and risks
- Review and update worksheets completed at the previous ENVID workshop to reflect the new Field Development Plan
- Identify controls to potentially minimize or eliminate impacts
- Identify actions to be carried forward into the project or incorporated in ES

As before, the ENVID scope is limited to:

- Drilling of wells;
- Installation of Subsea Infrastructure & Connection to Judy;
- Production/ Operations; and
- Projected Decommissioning at end-of-life.

Aims and Objectives

- Identification of environmental and societal risks associated with the Talbot Development Project.
- Identification of the risks/ effects associated with the various project activities.
- Identification of the receptors that may be affected by the activity.
- Identification of any potential mitigation measurements or best available techniques (BAT).
- Consideration of project controls within the project design that mitigate these risks/ effects to acceptable levels.
- Determination whether additional mitigation is required to reduce those risks/ effects to ALARP/ BAT.
- Identify any additional data requirements/ actions to be carried out.

Talbot Development Project
ENVID Environmental Settings

The following environmental details are summarised for Blocks 30/13, 30/12 and 30/7

Physical Setting

Bathymetry and seabed conditions

- Water depth approximately 80 m (LAT), gradually deepening from south to north.
- Seabed consists of a uniform sandy seabed with the sediments being mainly fine, slightly shelly, silty sand, with some areas having dispersed shelly communities.
- Seabed is considered typical of this area of the CNS

Weather and sea conditions

- Prevailing winds are from the southwest and north-northeast..
- Wave height in the Talbot area ranges from 2.11-2.40 m and the annual mean wave power is between 18.1-24.0 kW/m.

Biological Setting

Fish

- Spawning grounds for six species (various times of year):
  cod, lemon sole, mackerel (North Sea), Norway pout, plaice and sandeels.
- Nursery grounds for nine species:
  anglerfish, blue whiting, cod, haddock, ling, European hake, haddock, herring, mackerel, Norway pout, plaice, sandeel, spotted ray, spurdog and whiting.

Seabirds

- Seabird oil sensitivity index (SOSI), low sensitivity July - April
- SOSI, Medium to extremely high sensitivity in May and June

Marine mammals

- Most sensitive periods for marine mammals:
  May to November
- Six species present:
  Minke whale, common dolphin, white-beaked dolphin, white-sided dolphin, harbour porpoise and grey seal.

BMT

Offshore Socioeconomic Setting

Commercial fisheries

- Fishing value and quantity for demersal, pelagic and shellfish species are low in ICES rectangle 42F2.
- During 2020, 8 tonnes of fish were landed from ICES rectangle 42F2, with 56% of this being made up of demersal fish, and the remaining 44% from shellfish. The total value of all fish caught within ICES rectangle 42F2 for 2020 was £18,196

Commercial shipping

- Shipping traffic is low in Block 30/7 and very low in Blocks 30/12 and 30/13.

Offshore oil and gas activities

- Seven installations within 40 km radius.
- The nearest surface structures from proposed drill centres are Judy platform located in Block 30/7 and Clyde platform located in Block 30/17.
- Period of concern for seismic survey activities from May to August (Marine Scotland) in blocks of interest.

Offshore Socioeconomic Setting

Wrecks

- Three non dangerous unnamed wrecks located in the vicinity of Talbot Development, two in Block 30/7 (1.7 AND 8.5 km from Judy platform) and one in Block 30/13 (approximately 2.8 km from Talbot Development).

Telecommunications

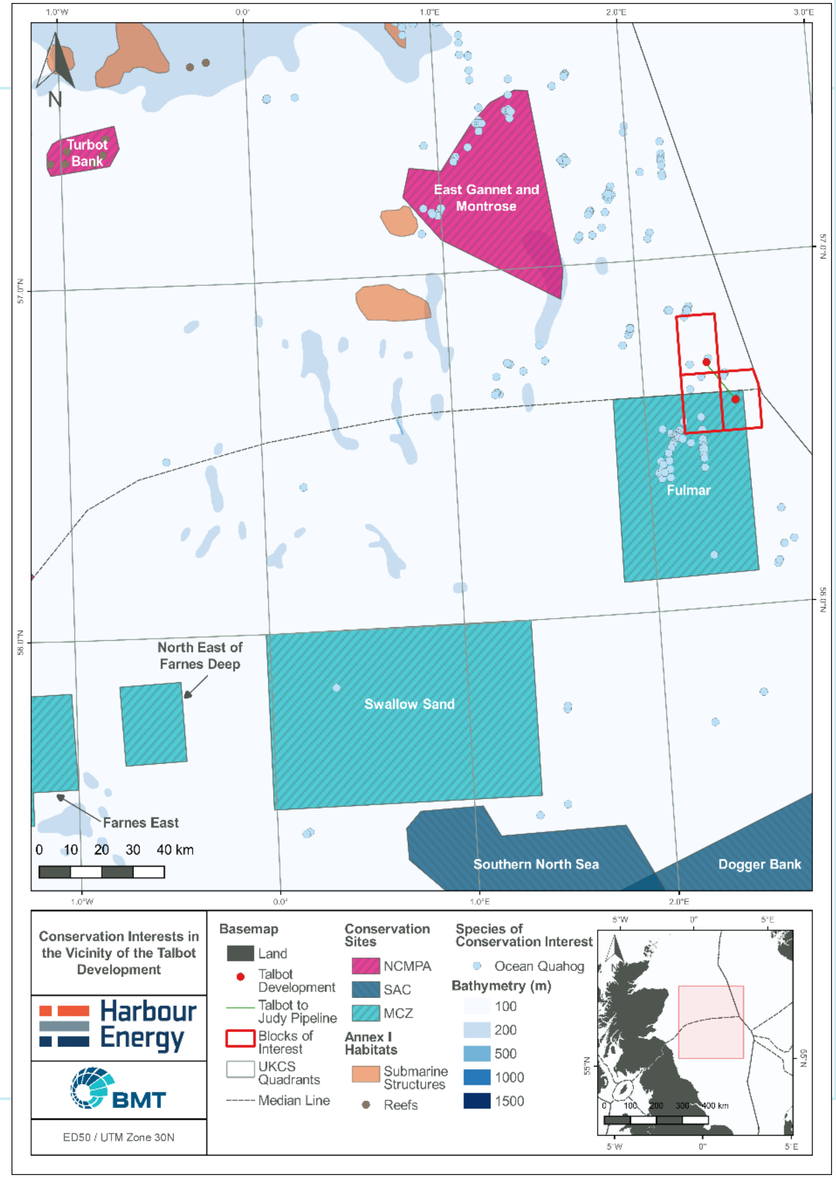
- The nearest cable are: TAMPNET (connected to Judy), ROTACS (12.5 km east), CANTAT-3 (34 km west) from the Talbot Development.

Renewables

- There is no renewable activity within 100 km.

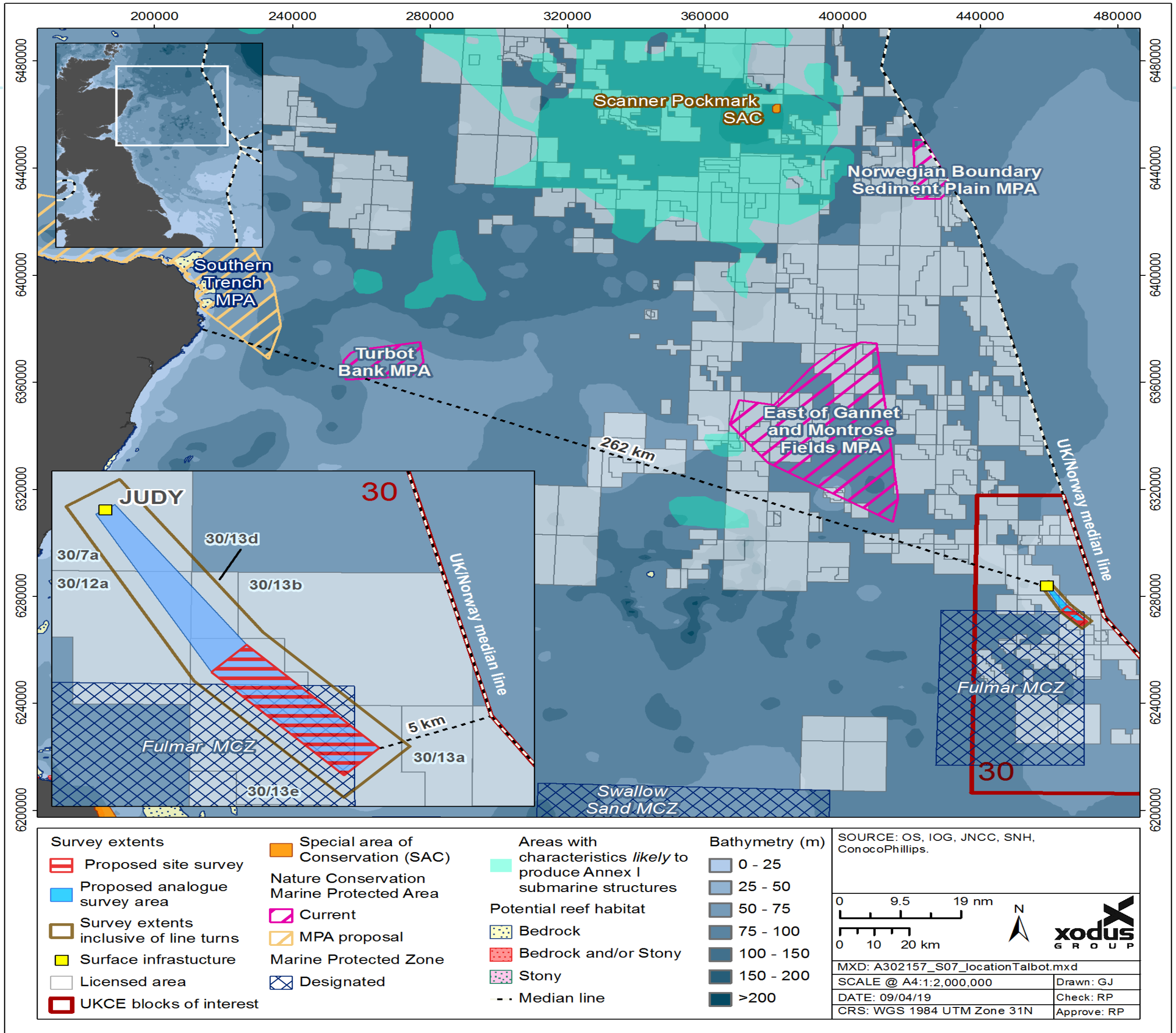
Key Conservation Interests

Designation	Name/ Comment (km distance)
National Conservation Marine Protected Area (NCMPA)	East of Gannet and Montrose Fields (67 km NW from Talbot Development and 52 km NW of Judy)
Special Areas of Conservation (SAC)	Dogger Bank (123 km S from Talbot Development and 138 km S from Judy) Southern North Sea (140 km S from Talbot Development and 149 km S from Judy)
Marine Conservation Zone (MCZ)	Fulmar (overlaps Talbot Development and 9 km S of Judy)
Potential Annex 1 habitats	Sandeel grounds (10 km S/SW from Talbot Development and 21 km S/SE of Judy)
Arctica islandica (Ocean quahog) OSPAR listed	Multiple observations, within Block 30/13 and Fulmar MCZ



BMT

Location of the Talbot environmental survey area



Ocean quahog (*Arctica islandica*)

Update to the Talbot Development

The ENVID Procedure

Using worksheets from the previous ENVID will:

- Review the actual and potential causes of environmental impact
- Check the designated impacts
- Confirm the controls
- Establish whether further actions to be taken forward or to provide information for the environmental, social and health assessment

An updated ENVID report will be prepared and issued.

BMT

Talbot Development ENVID Worksheets

Activity 1: Drilling and Well Development

Risk: High (red), Significant (orange), Medium (yellow), Low (green). Assessed in EIA: Scoped OUT (blue), Scoped IN (purple)	Potential Impacts	Physical and Chemical			Biological							Socio-economic								Mitigation/ Prevention/ Control	Risk Assessment			Justification/ Comments/ Data available/ Gaps	Action and responsible party
		Sediment structure/ chemistry	Water quality	Air quality (local)	Sediment biology (benthos)	Water column (plankton)	Finfish and shellfish	Seabirds	Sea mammals	Conservation sites	Biodiversity	Use of resources	Use of disposal facilities	Commercial fishing	Shipping	Military operations	Other users	Trans-boundary effects	Stakeholder concerns		Consequence	Likelihood	Risk		
Planned Events																									
Physical presence of drilling rig and vessels	• Obstruction to other sea users													✓	✓		✓			• Notice to Mariners and Shipping Alerts. • Kingfisher charts. • Standby vessel. • Industry standard notifications, navigation aids and communications. • Physical presence/ Operations (mainly within drill centre 500 m safety zones). • Notification emails on rig moves to all stakeholders. • Consent to locate. • 500 m safety zone around drill centres.	3	3		• Shipping density in the block is low. • Low fishing activity. • This will be a temporary operation within a well-defined area. • Industry standard controls. • Scoped out (see section 3.0).	• Confirm the 500m safety zones around well centres will be applied for - CB
Spudding of jack-up rig	• Disturbance to seabed and benthic communities • Scars on seabed causing obstruction to fishing gear • Wire anchor disturbance to seabed	✓			✓		✓			✓				✓						• Anchor system specified for seabed type/ loading. • Controlled/ monitored deployment. • Post-installation seabed survey. • SFF post-installation seabed sweep. • Geophysical survey and EBS will determine the extent of potential rock dump and also identify and facilitate rig placement to avoid any habitats.	2	3		• Within MCZ conservation area. • Deep circalittoral sand. • Ocean quahog. • Localised impact. • Industry standard controls.	• Apply for contingent rock deposition for legs stabilisation and scour mitigation (dependent on geotechnical survey) – AD • Confirm that a SFF post-installation seabed survey will be undertaken - CB

BMT

Impact Consequence/ Severity or Magnitude

Consequence / Severity					
	Negligible Impact (1)	Minor Impact (2)	Moderate Impact (3)	Significant Impact (4)	Catastrophic Impact (5)
Environmental/ Socio-economic	Intermediate or instantaneous duration, no remediation required. Small contained release that stays on facility. Very localized or reversible impact to habitats.	Minor environmental impact, but with impacts being readily remediated or addressed by natural attenuation processes. Very specific and localized permanent impact to protected habitats and species.	Environmental impacts realised greater than the surrounding area of the facility with observable off-site impacts to flora /fauna. Moderate environmental impact, most likely requires emergency response but not always.	Requires significant mitigation measures that address ecological systems or sensitive habitats. Short to medium-term (less than one season to one or two seasons) closure of tourism or fishing areas (major socio-economic impact).	Catastrophic impact such as resulting from a catastrophc release leading to enduring shoreline impact. Long-term/ permanent widespread impacts to sensitive habitats, species and multiple ecosystems. Longer term closure of tourism or fishing areas (enduring socio-economic impact).
Reputation	Social media speculation/ local comment/ internet chatter. No regulatory intervention expected.	Local media/ community interest comment in print or online. No lasting effect. Regulatory intervention expected (e.g. through multiple exceedances of a permit or regulatory limit).	National/ industry press concern with basis-in-fact and real loss of public and regular stakeholder confidence. Regulatory enforcement, improvement or prohibition notice.	International concern with media coverage and impact on shareholders confidence. Corporate criminal charges.	Longer-term international concern with prolonged media coverage and severe impact on shareholders confidence. High profile legal proceedings

BMT

Impact Likelihood/ Sensitivity for Unplanned and Planned Events

Likelihood	Definition
Frequent (5)	• More than $1x10^{-1}$ • Occurs in an asset hub more frequently than once every 10 years
Probable (4)	• $1x10^{-3}$ to $1x10^{-1}$ • Occurs a number of times in the life of all assets
Occasional (3)	• $1x10^{-4}$ to $1x10^{-3}$ • Occurs once in the asset life of all North Sea assets
Remote (2)	• $1x10^{-5}$ to $1x10^{-4}$ • Occurs a few times in the industry
Improbable (1)	• Less than $1x10^{-5}$ • Only just credible – very few examples in high-hazard industries globally

Updated Risk Rating Matrix

		Consequence/ Severity				
		Negligible (1)	Minor (2)	Moderate (3)	Significant (4)	Catastrophic (5)
Likelihood	Frequent (5)	Medium Risk (5)	Significant Risk (10)*	High Risk (15)**	High Risk (20)	High Risk (25)
	Probable (4)	Low Risk (4)	Medium Risk (8)	Significant Risk (12)	High Risk (16)**	High Risk (20)
	Occasional (3)	Low Risk (3)	Medium Risk (6)	Medium Risk (9)	Significant Risk (12)	High Risk (15)**
	Remote (2)	Low Risk (2)	Low Risk (4)	Medium Risk (6)	Medium Risk (8)	Significant Risk (10)*
	Improbable (1)	Low Risk (1)	Low Risk (2)	Low Risk (3)	Low Risk (4)	Medium Risk (5)

* Previously Medium Risk; ** Previously Significant Risk

Time to complete the worksheets…

Thank you

Annex B: ENVID Worksheets

Activity 1: Drilling and Well Development

Assessed in EIA: High; Significant; Medium; Low

Scoped IN; Scoped OUT

Assessed in EIA	Potential Impacts	Physical and Chemical: Sediment structure/ chemistry	Physical and Chemical: Water quality	Physical and Chemical: Emissions	Biological: Sediment biology (benthos)	Biological: Water column (plankton)	Biological: Finfish and shellfish	Biological: Seabirds	Biological: Sea mammals	Biological: Conservation sites	Biological: Biodiversity	Socio-economic: Use of resources	Socio-economic: Use of disposal facilities	Socio-economic: Commercial fishing	Socio-economic: Shipping	Socio-economic: Military operations	Socio-economic: Other users	Socio-economic: Trans-boundary effects	Socio-economic: Stakeholder concerns	Mitigation/ Prevention/ Control	Risk Assessment: Consequence	Risk Assessment: Likelihood	Risk Assessment: Risk	Justification/ Comments/ Data available/ Gaps	Action and responsible party
Planned Events																									
Physical presence of drilling rig and vessels	Obstruction to other sea users													✓	✓		✓			Notice to Mariners and Shipping Alerts Kingfisher charts Standby vessel Industry standard notifications, navigation aids and communications Physical presence / Operations (mainly within drill centre 500 m safety zones) Notification emails on rig moves to all stakeholders Consent to locate Establish 500m safety zone for template and well centre	3	3		Shipping density in the block is low Low fishing activity for mackerel and demersal mobile species This will be a temporary operation within a well-defined area Industry standard controls	500m safety zone for template and well centre – TS
Spudding of jack-up rig	Disturbance to seabed and benthic communities Scars on seabed causing obstruction to fishing gear Wire anchor disturbance to seabed	✓			✓		✓			✓				✓						Anchor system specified for seabed type/ loading Controlled/ monitored deployment Post-installation seabed survey SFF post-installation seabed sweep Geophysical survey and EBS will determine the extent of potential rock dump and also identify and facilitate rig placement to avoid any habitats	2	3		Within MCZ conservation area Deep circalittoral sand Ocean quahog Localised impact Industry standard controls	Apply for contingent rock deposition for legs stabilisation and scour mitigation (dependent on geotechnical survey) – AD Confirm number of anchors required - AD

Assessed in EIA
- High
- Significant
- Medium
- Low

Scoped IN
Scoped OUT

	Potential Impacts	Physical and Chemical			Biological							Socio-economic								Mitigation/ Prevention/ Control	Risk Assessment			Justification/ Comments/ Data available/ Gaps	Action and responsible party
		Sediment structure/ chemistry	Water quality	Emissions	Sediment biology (benthos)	Water column (plankton)	Finfish and shellfish	Seabirds	Sea mammals	Conservation sites	Biodiversity	Use of resources	Use of disposal facilities	Commercial fishing	Shipping	Military operations	Other users	Trans-boundary effects	Stakeholder concerns		Consequence	Likelihood	Risk		
Gaseous emissions from drilling rig and vessels	Deterioration of local air quality Contribution to GHG emissions			✓															✓	Low Sulphur Diesel. Power management system. Routine and preventive maintenance of generators/propulsion units and other equipment Route planning and management Recording vessel fuel usage/ emissions	2	4		Small-scale contributor of GHGs and other global gases Localised transient impact in the vicinity of the exhausts Emissions disperse in exposed offshore environment Industry standard controls Increased scrutiny	
Aqueous discharges from drilling rig	Drainage from low risk areas Slight deterioration in seawater quality around point of discharge Potential effects on marine fauna inhabiting the upper water column (plankton, fish and marine mammals)		✓			✓	✓	✓	✓	✓										Drainage from low risk areas. Audit of vessels Tendering specifications for vessel contractors Defined storage and handling procedures	2	3		Limited potential for adverse impact.	

Assessed in EIA
- High
- Significant
- Medium
- Low

- Scoped IN
- Scoped OUT

Aspect	Potential Impacts	Physical and Chemical			Biological						Socio-economic									Mitigation/ Prevention/ Control	Risk Assessment			Justification/ Comments/ Data available/ Gaps	Action and responsible party
		Sediment structure/ chemistry	Water quality	Emissions	Sediment biology (benthos)	Water column (plankton)	Finfish and shellfish	Seabirds	Sea mammals	Conservation sites	Biodiversity	Use of resources	Use of disposal facilities	Commercial fishing	Shipping	Military operations	Other users	Trans-boundary effects	Stakeholder concerns		Consequence	Likelihood	Risk		
Discharge of sewage and macerated waste	Localised increase in biological oxygen demand (BOD) Input of organic nutrients results in localised increase in productivity in fish, plankton and micro-organisms. Slight deterioration in seawater quality around point of discharge		✓			✓	✓	✓	✓	✓										Basic minimum requirement for screening and discharge in line with MARPOL Annex IV Treatment while in storage (hypochlorite) on most vessels. Temporary storage available on board.	1	3		Localised transient impact around discharge point Discharged material disperses degrades naturally Industry standard controls	
Ballast water	Risk of transfer of non-native species if vessel not routinely working in North Sea		✓		✓	✓	✓												✓	Segregated ballast tanks Vessels operating in North Sea/northern European waters therefore low risk of non-native introductions Vessels entering UKCS waters from overseas will abide by International Maritime Organisation (IMO) Guidance on ballasting. Marine assurance auditing by Harbour	4	1		Low risk of transfer if vessels routinely working in northern European waters and follows IMO Guidance.	

Assessed in EIA
High
Significant
Medium
Low

Scoped IN
Scoped OUT

	Potential Impacts	Physical and Chemical: Sediment structure/ chemistry	Water quality	Emissions	Biological: Sediment biology (benthos)	Water column (plankton)	Finfish and shellfish	Seabirds	Sea mammals	Conservation sites	Biodiversity	Socio-economic: Use of resources	Use of disposal facilities	Commercial fishing	Shipping	Military operations	Other users	Trans-boundary effects	Stakeholder concerns	Mitigation/ Prevention/ Control	Risk Assessment: Consequence	Likelihood	Risk	Justification/ Comments/ Data available/ Gaps	Action and responsible party
Permitted discharge of WBM cuttings	Disturbance to seabed and benthic communities	✓	✓		✓	✓	✓			✓	✓								✓	The use and discharge of the drilling chemicals will be approved under drilling application with a chemical permit. Permitted discharge is the conventional disposal method for WBM cuttings WBM formulations use mainly PLONOR chemicals.	2	3		Localised short-term impact Relatively small loss of seabed habitat that is well represented over a widespread area of the central North Sea. The cuttings pile is however likely to remain as a long-term feature on the seabed after decommissioning.	Confirm the need for drill cuttings dispersion modelling - AD
Skip and ship of LTOBM cuttings	Transportation of cuttings to shore Treatment of OBM will contribute to deterioration of air quality Use of landfill disposal facilities			✓								✓	✓				✓		✓	LTOBM recirculated within a closed system. LTOBM cuttings recovered to the rig, contained and shipped to shore for treatment (thermal desorption) and disposal.	1	2		Onshore treatment and disposal of oil contaminated cuttings	
On-site cuttings processing and disposal	Disturbance to seabed and benthic communities Impact to water column Extra use of diesel machinery	✓	✓	✓	✓	✓	✓			✓	✓								✓	Sampling of cuttings for regulatory compliance Proven technology	2	3		Reduce skip and ship quantity No requirement for onshore processing Operationally more efficient	Confirm the cuttings disposal method - IS

Assessed in EIA: High / Significant / Medium / Low; Scoped IN / Scoped OUT	Potential Impacts	Physical and Chemical: Sediment structure/ chemistry	Water quality	Emissions	Biological: Sediment biology (benthos)	Water column (plankton)	Finfish and shellfish	Seabirds	Sea mammals	Conservation sites	Biodiversity	Socio-economic: Use of resources	Use of disposal facilities	Commercial fishing	Shipping	Military operations	Other users	Trans-boundary effects	Stakeholder concerns	Mitigation/ Prevention/ Control	Risk Assessment: Consequence	Likelihood	Risk	Justification/ Comments/ Data available/ Gaps	Action and responsible party
Onshore disposal of solid waste (rig & vessels)	Potential impacts to the air quality, hydrology, flora and fauna, and socioeconomic aspects of such sites.			✓								✓	✓				✓		✓	Best practice Defined waste management procedures Licensed wastes facilities Majority recycled	1	2			
Volatile organic compounds (VOCs) from mud usage and fuel transfer	VOCs contribute to greenhouse gases thereby increasing the overall greenhouse effect			✓															✓	Closed system for bunkering; Avoid close working with muds Defined procedures and practices	2	2		Best Practice: Loading/ Unloading	
Cement discharge	Potential to cause localised alteration of the sediment structure and smothering of seabed organisms in the immediate area	✓			✓		✓			✓										Use and discharge of cementing chemicals subject to risk assessment and consent under a drilling application with a chemical permit. Cement returns monitored by ROV Excess cement (riser sections) are returned to the rig	2	2		Relatively small quantities of cement deposited on seabed Cement sets to a hard inert material	
Well bore clean up (contingency)	Some associated deterioration of water quality. Potential effect on plankton, fish, shellfish and marine mammals.		✓			✓	✓		✓	✓	✓									Chemical risk assessment. Contingency chemicals will be subject to consent under the drilling application submitted to BEIS. Used as required.	2	2			

Assessed in EIA: High / Significant / Medium / Low; Scoped IN / Scoped OUT	Potential Impacts	Physical and Chemical: Sediment structure/ chemistry	Water quality	Emissions	Biological: Sediment biology (benthos)	Water column (plankton)	Finfish and shellfish	Seabirds	Sea mammals	Conservation sites	Biodiversity	Socio-economic: Use of resources	Use of disposal facilities	Commercial fishing	Shipping	Military operations	Other users	Trans-boundary effects	Stakeholder concerns	Risk Assessment: Mitigation/ Prevention/ Control	Consequence	Likelihood	Risk	Justification/ Comments/ Data available/ Gaps	Action and responsible party
Underwater noise from drilling and vessels	Potential to affect marine mammals including cetaceans, several species of which are known to occur in the area.						✓		✓										✓	Drilling noise will be fairly continuous and prolonged	1	2		However published studies show that levels are barely distinguishable from background vessel noise	
Transport, helicopters	Deterioration of air quality around exhaust ports Contribution to GHG emissions			✓					✓			✓					✓		✓	Underwater noise modelling in the ES to predict numbers of different species of marine mammal at risk from sound pressure levels within injury or extreme disturbance thresholds. Optimise flying program	2	2		Published studies show that noise levels are barely distinguishable from background vessel noise	
Accidental/ Unplanned events																									
Well blow-out of oil and gas	An accidental hydrocarbon release could potentially result in significant impacts to marine fauna inhabiting the upper water column (plankton, fish and marine mammals) and benthic fauna. Loss of inventory.		✓	✓		✓	✓	✓	✓	✓	✓		✓	✓	✓		✓	✓	✓	Well plan. Well control. BOP. Non HPHT wells OPEP. Renewed industry-wide focus on oil spills. Incorporate industry feedback Contracts in place with OSRL and Wild Well Control Light oil Tested and approved response plans approved by SOSREP	5	2		Renewed industry-wide focus on oil spills.	Confirm oil spill modelling is sufficient - IS Confirm worst case discharge volumes against previously assessed - IS

Assessed in EIA: High / Significant / Medium / Low; Scoped IN / Scoped OUT	Potential Impacts	Physical and Chemical			Biological							Socio-economic								Mitigation/ Prevention/ Control	Risk Assessment			Justification/ Comments/ Data available/ Gaps	Action and responsible party
		Sediment structure/ chemistry	Water quality	Emissions	Sediment biology (benthos)	Water column (plankton)	Finfish and shellfish	Seabirds	Sea mammals	Conservation sites	Biodiversity	Use of resources	Use of disposal facilities	Commercial fishing	Shipping	Military operations	Other users	Trans-boundary effects	Stakeholder concerns		Consequence	Likelihood	Risk		
	Potential for transboundary effects Closure of fishing grounds																								
Hydrocarbon spill, e.g. from vessel collision	An accidental hydrocarbon release could potentially result in significant impacts to marine fauna inhabiting the upper water column (plankton, fish and marine mammals) and benthic fauna. Potential for transboundary effects Closure of fishing grounds		✓	✓		✓	✓	✓	✓	✓	✓		✓	✓	✓		✓	✓	✓	IHO database Consent to Locate ERRV monitoring of rig location and of other vessels OPEP/SOPEP Contracts in place with OSRL	3	3			REWS check coverage – TS
Spills of chemicals, muds and emergency cement discharge	Smothering of benthic (seabed) fauna and seabed spawning grounds Impact to water quality	✓	✓		✓	✓	✓	✓	✓	✓	✓			✓				✓	✓	Mud and chemicals are stored in separate containers in bunded areas. Dry break couplings in bunkering hoses Defined chemical handling procedures OPEP Chemical containing equipment managed as per maintenance plan Spill kits	2	4		Chemicals typically disperse quickly so unlikely to reach median line	

Assessed in EIA: High / Significant / Medium / Low; Scoped IN / Scoped OUT	Potential Impacts	Physical and Chemical			Biological							Socio-economic								Mitigation/ Prevention/ Control	Risk Assessment			Justification/ Comments/ Data available/ Gaps	Action and responsible party
		Sediment structure/ chemistry	Water quality	Emissions	Sediment biology (benthos)	Water column (plankton)	Finfish and shellfish	Seabirds	Sea mammals	Conservation sites	Biodiversity	Use of resources	Use of disposal facilities	Commercial fishing	Shipping	Military operations	Other users	Trans-boundary effects	Stakeholder concerns		Consequence	Likelihood	Risk		
																				Contingency emergency discharge will be permitted					
Objects dropped into the sea	Disturbance to the seabed and benthos. Potential obstruction to commercial fishing and other commercial users of the sea.	✓			✓		✓							✓	✓		✓		✓	Lifting zones on rig and platform. Pre- and post-installation debris survey. Measures put in place as required. Certified equipment Compliance to lifting procedures and standards	2	3			

Activity 2: Installation of subsea architecture & connection to Judy platform

Assessed in EIA	Potential Impacts	Physical and Chemical			Biological							Socio-economic								Mitigation/ Prevention/ Control	Risk Assessment			Justification/ Comments/ Data available/ Gaps	Action and responsible party
Risk: High / Significant / Medium / Low; Scoped IN / Scoped OUT		Sediment structure/ chemistry	Water quality	Emissions	Sediment biology (benthos)	Water column (plankton)	Finfish and shellfish	Seabirds	Sea mammals	Conservation sites	Biodiversity	Use of resources	Use of disposal facilities	Commercial fishing	Shipping	Military operations	Other users	Trans-boundary effects	Stakeholder concerns		Consequence	Likelihood/ Sensitivity	Risk		
Planned events																									
Vessels																									
Physical presence of vessels	Obstruction to other sea users													✓	✓		✓			Notice to Mariners and Shipping Alerts Kingfisher charts Standby vessel Industry standard notifications, navigation aids and communications Physical presence / Operations (mainly within drill centre 500 m safety zones) Notification emails on rig moves to all stakeholders Consent to locate Establish 500m safety zone for template and well centre	3	3		Shipping density in the block is low Low fishing activity for mackerel and demersal mobile species This will be a temporary operation within a well-defined area Industry standard controls	500m safety zone for template and well centre - TS
Gaseous emissions from vessels	Deterioration of local air quality Contribution to GHG emissions			✓															✓	Low Sulphur Diesel. Power management system. Routine and preventive maintenance of generators/propulsion units and other equipment Route planning and management Recording vessel fuel usage/ emissions	2	4		Small-scale contributor of GHGs and other global gases Localised transient impact in the vicinity of the exhausts Emissions disperse in exposed offshore environment Industry standard controls Increased scrutiny	
Discharge of sewage and macerated waste	Localised increase in biological oxygen demand (BOD) Input of organic nutrients results in localised increase in productivity in fish, plankton and micro-organisms.		✓			✓	✓	✓	✓	✓										Basic minimum requirement for screening and discharge in line with MARPOL Annex IV Treatment while in storage (hypochlorite) on most vessels. Temporary storage available on board.	1	3		Localised transient impact around discharge point Discharged material disperses degrades naturally Industry standard controls	

Assessed in EIA Risk High Significant Medium Low Scoped IN Scoped OUT	Potential Impacts	Physical and Chemical			Biological							Socio-economic								Mitigation/ Prevention/ Control	Risk Assessment			Justification/ Comments/ Data available/ Gaps	Action and responsible party
		Sediment structure/ chemistry	Water quality	Emissions	Sediment biology (benthos)	Water column (plankton)	Finfish and shellfish	Seabirds	Sea mammals	Conservation sites	Biodiversity	Use of resources	Use of disposal facilities	Commercial fishing	Shipping	Military operations	Other users	Trans-boundary effects	Stakeholder concerns		Consequence	Likelihood/ Sensitivity	Risk		
	Slight deterioration in seawater quality around point of discharge																								
Underwater noise from pipelaying and support vessels	Potential to affect marine mammals including cetaceans, several species of which are known to occur in the area.						✓	✓	✓										✓	Underwater noise modelling in the ES to predict numbers of different species of marine mammal at risk from sound pressure levels within injury or extreme disturbance thresholds.	2	2		Noise will be fairly continuous but limited duration (approx. 8 weeks) However published studies show that levels are barely distinguishable from background vessel noise	
Pipeline, umbilical, flowlines and power cables																									
Pipeline and umbilical lay operations	Disturbance to seabed communities Obstruction to demersal trawling	✓	✓	✓	✓		✓			✓	✓	✓		✓					✓	Pipeline route survey, EBS, engineering studies and planning to optimise the pipeline configurations, designs, routes and installation methods. Operational controls during lay, including accurate positioning and in situ monitoring by ROV. Guard vessel in place.	2	2		Short term obstruction to fisheries (during ops – pipeline will be trenched).	
Trenching and backfill	Disturbance to seabed communities Obstruction to demersal trawling	✓	✓	✓	✓		✓			✓	✓			✓					✓	Operational controls during trenching and burial, including accurate positioning and in situ monitoring by ROV. Pre- and post-lay surveys.	3	2		Localised turbidity and displacement of natural (uncontaminated) seabed sediments during trenching and backfilling. Disruption to a seabed habitat on either side of the pipeline routes that is well represented over a widespread area of the northern North Sea. Re-establishment of the natural benthic fauna (within 2 – 10 years; OSPAR, 2009).	

Assessed in EIA Risk: High / Significant / Medium / Low Scoped IN Scoped OUT	Potential Impacts	Physical and Chemical			Biological							Socio-economic								Mitigation/ Prevention/ Control	Risk Assessment			Justification/ Comments/ Data available/ Gaps	Action and responsible party
		Sediment structure/ chemistry	Water quality	Emissions	Sediment biology (benthos)	Water column (plankton)	Finfish and shellfish	Seabirds	Sea mammals	Conservation sites	Biodiversity	Use of resources	Use of disposal facilities	Commercial fishing	Shipping	Military operations	Other users	Trans-boundary effects	Stakeholder concerns		Consequence	Likelihood/ Sensitivity	Risk		
Rock placement along pipelines	Disturbance to seabed communities Obstruction to demersal trawling Loss of natural habitats	✓		✓	✓		✓			✓	✓			✓					✓	ROV monitoring of rock dump placement. Rock berm profile overtrawlable and rock size graded. The quantity of rock dump will be minimised. Placed by fall-pipe. Deployed accurately.	3	3		Small area impacted	
Testing and commissioning of pipelines	Discharges of chemicals	✓	✓		✓	✓	✓	✓	✓	✓									✓	Permitted and controlled activity. Risk assessment. Primarily low toxicity chemicals	1	3		Permitting process. Rapid dispersion.	
Crossings, installation of rock, concrete mattresses and plinths	Disturbance to seabed communities Loss of seabed habitat Obstruction to demersal trawling	✓		✓	✓		✓			✓	✓	✓		✓			✓		✓	Minimise use or rock and footprint wherever possible ROV monitoring of rock dump placement. Rock berm profile overtrawlable and rock size graded. The quantity of rock dump will be minimised. Placed by fall-pipe. Deployed accurately.	3	3		Permitting process – Direction to deposit	
Installation of protective materials, concrete mattresses and grout bags within 500m zone	Disturbance to seabed communities Obstruction to demersal trawling Loss of natural habitats	✓		✓	✓		✓			✓	✓	✓		✓					✓	ROV monitoring of mattresses placement. The quantity of mattresses will be minimised. Deployed accurately. As left survey	2	2		Permitting process – Marine Deposits Licence from MS.	
Manifolds and skids																									
Installation on the seabed	Disturbance to seabed communities Obstruction to demersal trawling	✓		✓	✓		✓			✓	✓			✓			✓		✓	Fishing friendly structures Consent to locate Standard notification to stakeholder bodies	2	2			

Assessed in EIA		Physical and Chemical			Biological							Socio-economic									Risk Assessment				
Risk: High / Significant / Medium / Low; Scoped IN / Scoped OUT	Potential Impacts	Sediment structure/ chemistry	Water quality	Emissions	Sediment biology (benthos)	Water column (plankton)	Finfish and shellfish	Seabirds	Sea mammals	Conservation sites	Biodiversity	Use of resources	Use of disposal facilities	Commercial fishing	Shipping	Military operations	Other users	Trans-boundary effects	Stakeholder concerns	Mitigation/ Prevention/ Control	Consequence	Likelihood/ Sensitivity	Risk	Justification/ Comments/ Data available/ Gaps	Action and responsible party
Underwater noise from piling operations	Potential to affect marine mammals including EPS (European Protected Species), several species of which are known to occur in the area.			✓			✓	✓	✓			✓							✓	Underwater noise modelling in the ES to predict numbers of different species of marine mammal at risk from sound pressure levels within injury or extreme disturbance thresholds. Having a marine mammal observer on board / as per JNCC requirements Soft start for piling Limited duration	3	4		Take note of seasonal sensitivity	
Accidental/ Unplanned events																									
Pipeline leak or rupture (third party) during pipelay and trenching operations	Localised impact on seabed, benthic and pelagic fauna. Large hydrocarbon spill (oil)	✓	✓		✓	✓	✓	✓	✓	✓	✓			✓			✓	✓	✓	OPEP. Defined procedures Mechanical separation Minimised lifting over live pipelines	4	2			
Spill of fuel from vessel collision	An accidental hydrocarbon release could potentially result in significant impacts to marine fauna inhabiting the upper water column (plankton, fish and marine mammals) and benthic fauna. Potential for transboundary effects Closure of fishing grounds		✓	✓		✓	✓	✓	✓	✓	✓		✓	✓	✓		✓	✓	✓	IHO database Consent to Locate ERRV monitoring of rig location and of other vessels OPEP/SOPEP Contracts in place with OSRL	3	3			REWS check coverage - TS
Spills of fuel and chemicals	Smothering of benthic (seabed)	✓	✓		✓	✓	✓	✓	✓	✓	✓			✓				✓	✓	Chemicals are stored in separate containers in bunded areas.	2	4		Chemicals typically disperse quickly so unlikely to reach median line	

Assessed in EIA Risk High Significant Medium Low Scoped IN Scoped OUT		Physical and Chemical			Biological							Socio-economic									Risk Assessment				
	Potential Impacts	Sediment structure/ chemistry	Water quality	Emissions	Sediment biology (benthos)	Water column (plankton)	Finfish and shellfish	Seabirds	Sea mammals	Conservation sites	Biodiversity	Use of resources	Use of disposal facilities	Commercial fishing	Shipping	Military operations	Other users	Trans-boundary effects	Stakeholder concerns	Mitigation/ Prevention/ Control	Consequence	Likelihood/ Sensitivity	Risk	Justification/ Comments/ Data available/ Gaps	Action and responsible party
	fauna and seabed spawning grounds Impact to water quality																			Dry break couplings in bunkering hoses Defined chemical handling procedures OPEP Chemical containing equipment managed as per maintenance plan Spill kits Contingency emergency discharge will be permitted					

Activity 3: Production/ Operations

Risk: High (red); Significant (orange); Medium (yellow); Low (green)

Scoped IN (blue); Scoped OUT (pale yellow)

Assessed in EIA	Potential Impacts	Physical and Chemical: Sediment structure/ chemistry	Physical and Chemical: Water quality	Physical and Chemical: Emissions	Biological: Sediment biology (benthos)	Biological: Water column (plankton)	Biological: Finfish and shellfish	Biological: Seabirds	Biological: Sea mammals	Biological: Conservation sites	Biological: Biodiversity	Socio-economic: Use of resources	Socio-economic: Use of disposal facilities	Socio-economic: Commercial fishing	Socio-economic: Shipping	Socio-economic: Military operations	Socio-economic: Other users	Socio-economic: Trans-boundary effects	Socio-economic: Stakeholder concerns	Mitigation/ Prevention/ Control	Risk assessment: Consequence	Risk assessment: Likelihood/ Sensitivity	Risk assessment: Risk	Justification/ Comments/ Data available/ Gaps	Action and responsible party
Planned events																									
Wells and pipelines																									
Physical presence of trees and manifolds (Scoped IN)	Disturbance to seabed habitats Obstruction to demersal trawling	✓			✓		✓							✓						Kingfisher charts/ hydrographic office charts Industry standard notifications and communications 500 m safety zones Consent to locate Protective structures in place	2	2	Low	Low toxicity fluids.	
Discharge of hydraulic fluid in operations (Scoped OUT)	Deterioration of water quality		✓			✓			✓											Water based hydraulic fluid. Minimal quantities. Permitted yearly quantities	1	3	Low	Low toxicity fluids.	
Production																									
Power generation (Scoped IN)	Deterioration of air quality around exhaust ports Contribution to GHG emissions			✓														✓	✓	Routine and preventive maintenance of generators/propulsion units and other equipment No increase in total emissions of the existing platform	2	3	Medium	No additional power generation required initially Bringing Talbot on will maintain Judy production operations	
Gaseous emissions from platform (incl. flaring and venting) (Scoped IN)	Deterioration of air quality around exhaust ports Contribution to GHG emissions UK ETS			✓														✓	✓	Minimal flaring – only as required during start up and depressurisation	2	4	Medium		
Increased chemical usage (Scoped OUT)	Potential pollution of water column		✓			✓	✓	✓	✓	✓	✓			✓					✓	Permitted and controlled activity. Chemical risk assessment Used as required. Minimise chemical discharge. Chemicals selected as per existing J-Block chemicals	2	4	Medium		Check with chemist for quantities of chemicals – ST Check with Andrew Davies – ST
Sand control and disposal of sand	Smothering of benthic organisms	✓			✓		✓			✓	✓									Sand screens in well completion Existing Judy sand management procedures				Not assessed due to existing sand management procedures on Judy with negligible additional sand volumes	

Assessed in EIA

Risk
- High
- Significant
- Medium
- Low

Scoped IN

Scoped OUT

	Potential Impacts	Physical and Chemical: Sediment structure/ chemistry	Physical and Chemical: Water quality	Physical and Chemical: Emissions	Biological: Sediment biology (benthos)	Biological: Water column (plankton)	Biological: Finfish and shellfish	Biological: Seabirds	Biological: Sea mammals	Biological: Conservation sites	Biological: Biodiversity	Socio-economic: Use of resources	Socio-economic: Use of disposal facilities	Socio-economic: Commercial fishing	Socio-economic: Shipping	Socio-economic: Military operations	Socio-economic: Other users	Socio-economic: Trans-boundary effects	Socio-economic: Stakeholder concerns	Mitigation/ Prevention/ Control	Risk assessment: Consequence	Risk assessment: Likelihood/ Sensitivity	Risk assessment: Risk	Justification/ Comments/ Data available/ Gaps	Action and responsible party
Produced water management	Oil/ water emulsions can impact water quality and marine fauna/ flora		✓			✓	✓		✓	✓	✓								✓	Appropriate engineering and modification (if required) to produced water system ensuring discharge specification is met Priority for PLONOR chemicals and chemicals with a low HQ or RQ. Ensure that discharge is below permit requirements.	1	3		Minor and manageable increase of existing water volumes leading to negligible oil/water quality decrease	
Wastes and disposal	Management of operational wastes Onshore disposal		✓			✓	✓		✓				✓						✓	Best practice. Waste management plan.	1	3		No initial increase in waste and disposal	
Hazardous drain system on platform	Deterioration in seawater quality around discharge site		✓			✓	✓		✓										✓	Closed systems in hazardous areas. Treatment as per MARPOL requirements.	1	2		No material impact on existing system	
Non-hazardous drain system on platform	Deterioration in seawater quality around discharge site		✓			✓	✓		✓										✓	Open systems in non-hazardous areas. Treatment as per MARPOL requirements.	1	2		No material impact on existing system	
Accidental/ Unplanned events																									
Uncontrolled loss of well integrity	An accidental hydrocarbon release could potentially result in significant impacts to marine fauna inhabiting the upper water column (plankton, fish and marine mammals) and benthic fauna. Loss of inventory. Potential for transboundary effects Closure of fishing grounds		✓	✓		✓	✓	✓	✓	✓	✓		✓	✓	✓		✓	✓	✓	Well plan. Well control. BOP. Non HPHT wells OPEP. Renewed industry-wide focus on oil spills. Incorporate industry feedback Contracts in place with OSRL and Wild Well Control Light oil Tested and approved response plans approved by SOSREP	5	2		Renewed industry-wide focus on oil spills.	Confirm oil spill modelling is sufficient - IS Confirm worst case discharge volumes against previously assessed - IS
Process control failure/ process upset resulting in discharge to sea	Potential pollution of water column		✓			✓	✓	✓	✓	✓	✓			✓				✓	✓	Regular review and update of OPEP	2	2			

Harbour Energy

Assessed in EIA

Risk
- High
- Significant
- Medium
- Low

- Scoped IN
- Scoped OUT

Assessed in EIA	Potential Impacts	Physical and Chemical: Sediment structure/ chemistry	Physical and Chemical: Water quality	Physical and Chemical: Emissions	Biological: Sediment biology (benthos)	Biological: Water column (plankton)	Biological: Finfish and shellfish	Biological: Seabirds	Biological: Sea mammals	Biological: Conservation sites	Biological: Biodiversity	Socio-economic: Use of resources	Socio-economic: Use of disposal facilities	Socio-economic: Commercial fishing	Socio-economic: Shipping	Socio-economic: Military operations	Socio-economic: Other users	Socio-economic: Trans-boundary effects	Socio-economic: Stakeholder concerns	Mitigation/ Prevention/ Control	Risk assessment: Consequence	Risk assessment: Likelihood/ Sensitivity	Risk assessment: Risk	Justification/ Comments/ Data available/ Gaps	Action and responsible party
	Oil/ water emulsions can impact water quality and marine fauna/ flora																			Adherence to strict maintenance regimes for all equipment					
Pipeline leak/ rupture leading to a hydrocarbon spill	An accidental hydrocarbon release could potentially result in significant impacts to marine fauna inhabiting the upper water column (plankton, fish and marine mammals) and benthic fauna. Loss of Inventory Potential for transboundary effects Closure of fishing grounds	✓	✓		✓	✓	✓	✓	✓	✓	✓			✓			✓	✓	✓	Well barriers tested in accordance to well integrity performance standard. OPEP Non HPHT wells Contracts in place with OSRL Light oil Tested and approved response plans approved by SOSREP 500m safety zone around drill centres Fishing friendly structures Pipeline above seabed will be protected by rock or other method. Pipelines will be buried to a suitable depth. Scheduled pipeline route inspection to identify any free spans or/and snagging hazards Pipeline route displayed on marine charts and Fishsafe Low pressure alarms on platform to indicate potential loss	4	2		Oil spill potential below that modelled already for Judy	
Chemical spill (rupture of umbilical)	Release of chemicals to marine environment	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			✓				✓	✓	Umbilical managed under PWA Integrity IRM surveys (Inspection repair and maintenance) Umbilical above seabed will be protected by rock or other method. Umbilical will be buried to a suitable depth.	2	3		Small quantities of chemicals	

Assessed in EIA		Physical and Chemical			Biological							Socio-economic								Risk assessment					
Risk: High / Significant / Medium / Low; Scoped IN; Scoped OUT	Potential Impacts	Sediment structure/ chemistry	Water quality	Emissions	Sediment biology (benthos)	Water column (plankton)	Finfish and shellfish	Seabirds	Sea mammals	Conservation sites	Biodiversity	Use of resources	Use of disposal facilities	Commercial fishing	Shipping	Military operations	Other users	Trans-boundary effects	Stakeholder concerns	Mitigation/ Prevention/ Control	Consequence	Likelihood/ Sensitivity	Risk	Justification/ Comments/ Data available/ Gaps	Action and responsible party
																				Scheduled umbilical route inspection to identify any free spans or/and snagging hazards Umbilical route displayed on marine charts and Fishsafe Low pressure alarms on platform to indicate potential loss					

Activity 4: Decommissioning

Risk: High (red), Significant (orange), Medium (yellow), Low (green)

Assessed in EIA: Scoped IN (blue), Scoped OUT (pale yellow)

	Potential Impacts	Physical and Chemical: Sediment structure/ chemistry	Water quality	Emissions	Biological: Sediment biology (benthos)	Water column (plankton)	Finfish and shellfish	Seabirds	Sea mammals	Conservation sites	Biodiversity	Socio-economic: Use of resources	Use of disposal facilities	Commercial fishing	Shipping	Military operations	Other users	Trans-boundary effects	Stakeholder concerns	Mitigation/ Prevention/ Control	Risk Assessment: Consequence	Likelihood/ Sensitivity	Risk	Justification/ Comments/ Data available/ Gaps	Action and responsible party
Planned events																									
Vessel operations																									
Physical presence of vessels	Obstruction to other sea users													✓	✓		✓			Notice to Mariners and Shipping Alerts Kingfisher charts Standby vessel Industry standard notifications, navigation aids and communications Physical presence / Operations (mainly within drill centre 500 m safety zones) Notification emails on rig moves to all stakeholders Consent to locate Establish 500m safety zone for template and well centre	3	3	Medium	Shipping density in the block is low Low fishing activity for mackerel and demersal mobile species This will be a temporary operation within a well-defined area Industry standard controls	500m safety zone for template and well centre – TS
Gaseous emissions from vessels	Deterioration of air quality around exhaust ports Contribution to GHG emissions			✓															✓	Low Sulphur Diesel Power management system Routine and preventive maintenance of generators/propulsion units and other equipment Route planning and management	2	4	Medium	Small-scale contributor of GHGs and other global gases Localised transient impact in the vicinity of the exhausts Emissions disperse in exposed offshore environment Industry standard controls	
Underwater noise from vessels	Potential to affect marine mammals including cetaceans, several species of which are known to occur in the area.						✓		✓										✓	Drilling noise will be fairly continuous and prolonged	1	2	Low	However published studies show that levels are barely distinguishable from background vessel noise	
Transport, helicopters	Deterioration of air quality around exhaust ports Contribution to GHG emissions			✓					✓			✓					✓		✓	Underwater noise modelling in the ES to predict numbers of different species of marine mammal at risk from sound pressure levels	2	2	Low	Published studies show that noise levels are barely distinguishable from background vessel noise	

Risk: High / Significant / Medium / Low

Assessed in EIA: Scoped IN / Scoped OUT

	Potential Impacts	Physical and Chemical: Sediment structure/ chemistry	Water quality	Emissions	Biological: Sediment biology (benthos)	Water column (plankton)	Finfish and shellfish	Seabirds	Sea mammals	Conservation sites	Biodiversity	Socio-economic: Use of resources	Use of disposal facilities	Commercial fishing	Shipping	Military operations	Other users	Trans-boundary effects	Stakeholder concerns	Mitigation/ Prevention/ Control	Risk Assessment: Consequence	Likelihood/ Sensitivity	Risk	Justification/ Comments/ Data available/ Gaps	Action and responsible party
																				within injury or extreme disturbance thresholds. Optimise flying program					
Discharge of sewage and macerated waste	Localised increase in biological oxygen demand (BOD) Input of organic nutrients results in localised increase in productivity in fish, plankton and micro-organisms. Slight deterioration in seawater quality around point of discharge		✓			✓	✓	✓	✓	✓										Basic minimum requirement for screening and discharge in line with MARPOL Annex IV Treatment while in storage (hypochlorite) on most vessels. Temporary storage available on board.	1	3		Localised transient impact around discharge point Discharged material disperses degrades naturally Industry standard controls	
Wells																									
Plug and abandonment	Localised short term turbidity and displacement of (contaminated) seabed sediments	✓	✓		✓	✓	✓			✓									✓	The wells will be plugged and abandoned, after removing wellheads, following the Oil & Gas UK Guidelines for well abandonment.	2	3		Industry best practice/ best available technique utilised. Assumed abandonment undertaken by drilling rig.	
Mechanical cutting of casing	Solid deposition onto seabed Underwater noise	✓			✓				✓	✓									✓	Where possible, casing cuttings to be recovered via riser to drill rig or deposited down the well	1	2		No additional seabed impact. Less emissions than during installation and production.	
Retrieve and disposal of wellheads, manifolds and casing	Underwater noise, Gaseous emissions, Landfill space Aqueous discharge Disturbance to seabed Potential for NORM contamination		✓	✓	✓	✓			✓			✓	✓				✓		✓	Removed items will be returned ashore for reuse, recycling or disposal. Contaminated items to be treated appropriately at dedicated vendor and recycled	2	3		Localised impact including excavation. Temporary impact.	
Presence of cuttings piles	Long term disturbance of the local benthic habitat	✓			✓		✓			✓	✓			✓					✓	Minimise dredging activities.	2	2		WBM – no toxicity issues. Primary issue is temporary disturbance to seabed and benthos.	
Pipelines, umbilicals, flowlines and power cables																									
Diamond wire cutting of piles and pipelines, and vessel activity	Underwater noise Emissions of GHG			✓			✓		✓										✓	Pipelines flushed and cleaned Minimise excavation around piles	2	2			

Harbour Energy

Risk: High / Significant / Medium / Low; Assessed in EIA: Scoped IN / Scoped OUT	Potential Impacts	Physical and Chemical			Biological							Socio-economic								Mitigation/ Prevention/ Control	Risk Assessment			Justification/ Comments/ Data available/ Gaps	Action and responsible party
		Sediment structure/ chemistry	Water quality	Emissions	Sediment biology (benthos)	Water column (plankton)	Finfish and shellfish	Seabirds	Sea mammals	Conservation sites	Biodiversity	Use of resources	Use of disposal facilities	Commercial fishing	Shipping	Military operations	Other users	Trans-boundary effects	Stakeholder concerns		Consequence	Likelihood/ Sensitivity	Risk		
																				Internal cutting where possible					
Removal/ disturbance of rock placement and mattresses	Temporary disturbance of seabed and benthos	✓			✓		✓			✓	✓			✓					✓	Volume of rock displaced will be minimised Mattresses will be polypropene linked which will aid the recovery	2	2			
Presence of buried pipeline and umbilicals	No additional disturbance and minimal risk of interaction Contamination from long term degradation of pipeline	✓			✓					✓				✓					✓	Post-decommissioning monitoring surveys Subsea pipeline flushing programme with seawater flushes and pigs. Depth of burial to be greater than 0.6m	2	3			Check SSF over trawl no longer in SNS – DV
Recycling and/ or disposal of materials onshore	Gaseous emissions during cutting and recycling. Where materials are disposed of, use of landfill space and loss of resources. Potentially NORM contamination			✓								✓	✓				✓		✓	Materials would be re-used or recycled where possible, thereby minimising landfill requirements. Compliance with UK waste legislation and Duty of Care. Use of designated licensed sites only. Established routes for recycling of materials. Contaminated items to be treated appropriately at dedicated vendor and recycled	2	3			
Accidental/ Unplanned events																									
Hydrocarbon spill from vessels and rigs	An accidental hydrocarbon release could potentially result in significant impacts to marine fauna inhabiting the upper water column (plankton, fish and marine mammals) and benthic fauna. Potential for transboundary effects		✓	✓		✓	✓	✓	✓	✓	✓		✓	✓	✓		✓	✓	✓	IHO database Consent to Locate ERRV monitoring of rig location and of other vessels OPEP/SOPEP Contracts in place with OSRL	3	3			REWS check coverage - TS

Risk
- High
- Significant
- Medium
- Low

Assessed in EIA
- Scoped IN
- Scoped OUT

		Physical and Chemical			Biological							Socio-economic									Risk Assessment				
	Potential Impacts	Sediment structure/ chemistry	Water quality	Emissions	Sediment biology (benthos)	Water column (plankton)	Finfish and shellfish	Seabirds	Sea mammals	Conservation sites	Biodiversity	Use of resources	Use of disposal facilities	Commercial fishing	Shipping	Military operations	Other users	Trans-boundary effects	Stakeholder concerns	Mitigation/ Prevention/ Control	Consequence	Likelihood/ Sensitivity	Risk	Justification/ Comments/ Data available/ Gaps	Action and responsible party
	Closure of fishing grounds																								
Objects dropped into the sea	Disturbance to the seabed and benthos. Potential obstruction to commercial fishing and other commercial users of the sea.	✓			✓		✓							✓	✓		✓		✓	Lifting zones on rig and platform. Pre- and post-installation debris survey. Measures put in place as required. Certified equipment Compliance to lifting procedures and standards	2	3			
Well blow-out of oil and gas	An accidental hydrocarbon release could potentially result in significant impacts to marine fauna inhabiting the upper water column (plankton, fish and marine mammals) and benthic fauna. Loss of inventory. Potential for transboundary effects Closure of fishing grounds		✓	✓		✓	✓	✓	✓	✓	✓		✓	✓	✓		✓	✓	✓	Well plan. Well control. BOP. Non HPHT wells OPEP. Renewed industry-wide focus on oil spills. Incorporate industry feedback Contracts in place with OSRL and Wild Well Control Light oil Tested and approved response plans approved by SOSREP	5	2		Renewed industry-wide focus on oil spills.	Confirm oil spill modelling is sufficient - IS Confirm worst case discharge volumes against previously assessed - IS

Appendix C

Talbot Underwater Noise Assessment, 2022

Underwater Noise Assessment

Technical Note

Customer	
Project	600870
Deliverable	Draft
Version	0.1
	22 March 2022

Document Control

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Abbreviations and Glossary

Audiogram	A curve of hearing threshold (SPL) as a function of frequency that describes the hearing sensitivity over tis normal hearing range
BEIS	The Department for Business, Energy & Industrial Strategy
˚C	Degrees Celsius
Category I	Fish with no swim bladder or other gas volume (particle motion detectors)
Category II	Fish with a swim bladder or other gas volume, and therefore susceptible to barotrauma, but where the organ is not involved in hearing (particle motion detectors)
Category III	Fish with a swim bladder or other gas volume, and therefore susceptible to barotrauma, where the organ is also involved in hearing (sound pressure and particle motion detectors)
dB	Decibel – the logarithmic measure of sound intensity/ pressure
dB re 1 μPa m (peak)	Units of the zero-to-peak decibel ratio of sound pressure to a reference pressure of 1 microPascal at 1 metre (re 1 μPa m) in underwater acoustics
DP	Dynamic Positioning
EDGAR	Explosives use in Decommissioning - Guide to Assessment of Risk
EMODNet	European Marine Observation and Data Network
EMS	Environmental Management System
EPS	European Protected Species
Hz	Hertz
ICES	International Council for the Exploration of the Sea
JNCC	Joint Nature Conservation Committee
kHz	kiloHertz
km	kilometre
km^2	kilometre squared
m	metre
MCZ	Marine Conservation Zone
MMO	Marine Mammal Observer
MMOA	Marine Mammal Observer Association
MSFD	Marine Strategy Framework Directive
NA	Not Applicable
NITS	Noise-Induced Threshold Shift
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration

NSTA	North Sea Transition Authority
PAM	Passive Acoustic Monitoring
PIGAR	Piling Impact - Guide to Assessment of Risk
PTS	Permanent Threshold Shift – A permanent elevation of the hearing threshold resulting from physical damage to the sensory hair cells of the ear
rms	Root Mean Squared
s	second
SCANS	Small Cetaceans in the European Atlantic and North Sea
SEL	Sound Exposure Level in dB re 1 µPa^2 s
SL	Source level - the SPL that would be measured at 1 m from a point-like source radiating an equivalent amount of sound power as an actual source (dB re 1 µPa m)
SMRU	Sea Mammal Research Unit
SPL	Sound Pressure Level – the decibel ratio of sound pressure to some reference pressure in dB re 1 µPa in underwater acoustics (zero-to-peak or peak)
TOL	Third octave level – interval of 1/3 of an octave. Three adjacent 1/3 octave bands span one octave
TTS	Temporary Threshold Shift – Temporal and reversible elevation of the auditory threshold which is the minimum sound level that can be perceived by an animal in the absence of background noise
UK	United Kingdom
UKCS	United Kingdom Continental Shelf
WFA	Weighting Factor Adjustment

1 Introduction

1.1 Project overview

Harbour Energy PLC (hereafter referred to as Harbour) is proposing to carry out installation activities using piling on the United Kingdom Continental Shelf (UKCS) at the Talbot Development Project located in Block 30/13e in the central North Sea (CNS), approximately 278 km southeast of the nearest landfall at Peterhead and 7 km west of the UK/ Norway median line. The water depth in this area is approximately 78 m (European Marine Observation and Data Network, 2022).

Four Piles (24” x 30 m) will be used to secure each of one drilling template and one manifold. The operations are expected to take 7 hours (h) for the templates, and 4 to 7 h for the remaining manifolds. The piling operations are expected to take 6 h per pile and piling operations will be sequential.

A maximum of six vessels is likely to be on site at the same time, one each of Construction Support Vessel (CSV), Diving Support Vessel (DSV), Trenching Support Vessel (TSV), Survey Vessel (SUV), Pipelay Vessel (PLV) and Guard Vessel (GUV). No vessels will be anchored and all vessels aside from the guard vessel will be premised to be using dynamic positioning (DP). This underwater noise impact assessment report has been based on the worst-case scenario from those vessels.

During piling the predicted zero-to-peak (referred to as ‘peak’ hereafter) worst case sound source levels (SL) are 208 decibels (dB) re 1 microPascal at 1 metre (µPa m) for the 24” (0.610 m) diameter piles.

The exact dates of the proposed installation operations are not defined yet, but it is envisioned that the work will be undertaken during Q2 2022. This will be confirmed to the Department of Business, Energy & Industrial Strategy (BEIS) in due course. For the purposes of modelling, the metocean data have been averaged over the summer, April to September inclusive.

2 Underwater Sound

Sound is important to many marine organisms, marine mammals, fish and certain species of invertebrates have a range of complex mechanisms for both the emission and detection of sound (Richardson et al., 1995). Underwater noise may cause animals to become displaced from activities potentially interrupting feeding, mating, socialising, resting and migration. Subsequently, this may impact body condition and the reproductive success of individuals or populations (Southall et al., 2007; Richardson et al., 1995). Feeding may also be affected if noise disturbs prey species (Southall et al., 2007; Richardson et al., 1995).

As sound spreads underwater, it decreases in strength with distance from the source. This transmission loss is the sum of spreading loss and attenuation loss. Attenuation losses are the physical processes and conditions in the sea that weaken the sound signal. These factors include sound absorption or scattering by organisms in the water column, reflection or scattering at the seabed and sea surface, and the effects of temperature, pressure, stratification and salinity. Variations in temperature and salinity with depth cause sound waves to be refracted downwards or upwards causing increases or decreases in sound attenuation and absorption. This leads to actual sound transmission having considerable temporal and spatial variability that is difficult to quantify.

Sound can be categorised as continuous noise where there are no sudden rises or falls in pressure, (e.g. from vessels), or impulsive noise (e.g. from piling and seismic activities).

2.1 Regulatory context

In the UK, The Offshore Petroleum Activities (Conservation of Habitats) Regulations 2001 (as amended) set down the obligations for the assessment of the impact of offshore oil and gas activities on habitats and species protected under The Conservation of Offshore Marine Habitats and Species Regulations 2017. This aims to halt any decline, but also to ensure that the qualifying species and habitats recover sufficiently to enable them to flourish over the long-term. Part 5 provides powers to issue licences for specific activities that could result in the injury or disturbance of "European Protected Species (EPS)[1]" under Schedule 1. Under regulation 45 it is an offence inter alia "to deliberately capture, injure or kill any wild animal of such an EPS, or to deliberately disturb, or damage or destroy a breeding site or resting place of such an animal[2]".

In a marine setting, EPS include all species of cetaceans (whales, dolphins, and porpoises). As underwater noise has potential to cause injury and disturbance to cetaceans, an assessment of underwater noise generated by subsea decommissioning operations is required in line with guidance provided by the JNCC (JNCC, 2010).

2.2 Acoustic source levels

In order to model the worst-case scenario, it has been assumed that all sources will operate at all times during each activity. In reality, this will not happen, and the source level is likely to be lower than that predicted within this assessment.

Noise sources resulting from the Talbot Development installation operations are detailed in the following sub-sections.

Vessels

Most forms of oil and gas installation activities are typically dominated by vessel noise which is continuous. Broadband source levels for these activities rarely exceed about 190 dB re 1 µPa m and

[1] https://www.legislation.gov.uk/uksi/2017/1013/schedule/1/made
[2] https://www.legislation.gov.uk/uksi/2017/1013/regulation/45/made

are typically much lower (Erbe et al., 2012). The level and frequency of sound produced by vessels is related to vessel size and speed, with larger vessels typically producing lower frequency sounds (Richardson et al., 1995). Noise levels depend on the operating status of the vessel and can therefore vary considerably with time. In general, vessels produce noise within the range 100 Hz to 10 kHz, with strongest energy within the range 200 Hz to 2 kHz.

Whilst continuous noise can mask biologically relevant signals such as echolocation clicks, the subsea noise levels generated by surface vessels used during the installation activities are unlikely to result in physiological damage to marine mammals. Depending on ambient noise levels, sensitive marine mammals may be locally disturbed by noise from a vessel in its immediate vicinity, however, the impact is not expected to be significant.

Various combinations of vessels will be on site during the installation operations and for the purposes of modelling it has been assumed that a maximum of six will be operating in the area at any one time. Source levels resulting from a study giving the average of ten merchant ships (lengths 89 to 320 m, average 194 m) during entry or exit to port were used as a basis for this assessment. This data is more conservative than many of the published examples for specific construction and support vessels.

For continuous sound such as shipping noise, it is usual to use a measure of the total root mean squared (rms) sound intensity of a signal. However, the larger zero-to-peak values have been used in the modelling to illustrate the worst-case scenario.

Modelling considerations

Hallett (2004) investigated the underwater radiated noise measurements of ten merchant ships (lengths 89 to 320 m, average 194 m) during port entry or exit. The results of the study suggested that acoustic source level is not dependent on ship speed or displacement and an average spectrum level was calculated that can be taken to be representative of a wide variety of merchant ships during port entry/ exit, i.e. under non-transit conditions. It is thought that the results of this study provide a more conservative measure of vessel noise than many of the published examples for specific construction and support vessels.

Piling operations

Some high intensity sources of underwater sound, such as pile drivers and seismic airguns can be detected over distances of several thousand kilometres (Popper and Hawkins, 2019). Impact piling involves repeated impact of the pile using a hammer to drive the pile to a desired depth in the seabed.

Piles emit sound directly into the air and the water and excite elastic waves in the seafloor which can have an important contribution to the sound field formed in the water column. The strike of an impact hammer creates a compressive wave that travels through the pile producing sound by at least three transmission paths (Duncan et al., 2010):

- Direct acoustic radiation from the submerged pile
- Vibration and sudden displacement of the embedded portion of the pile
- Surface waves propagating along the water-sediment interface.

The generation of underwater noise during pile driving is largely due to a radial expansion wave that propagates along the pile after impact. This structural wave produces a pressure field in the form of a Mach cone in both the water and the sediment media as it moves down the pile at supersonic speed relative to the speed of sound in water (Reinhall and Dahl, 2011).

Sound levels received in the water column at some distance from the pile depend on many operational and environmental factors, including:

- Pile size (diameter, wall thickness), shape (closed end, open end), and material
- Hammer type and energy
- Sediment type and thickness
- Bedrock type and depth
- Bathymetry
- Salinity and temperature
- Sea surface conditions.

Analyses of noise measurements made during the installation of offshore wind turbine foundations in the North Sea (U.K.) indicate that pile diameter itself is not likely to substantially influence the sound radiation, but the hammer energy positively correlates with sound energy in the water with all other influencing factors remaining constant (Parnum et al., 2018). However, source levels are likely to vary from site to site due to factors such as variation in the seabed and so comparisons are not straightforward (Parnum et al., 2018).

A higher blow or strike energy in an impact hammer tends to produce higher sound levels. Robinson et al. (2007) found a roughly linear relationship between hammer energy and acoustic pulse energy. The increase in sound level caused by an increase in blow energy can be approximated by $10\ log_{10}(E_2/E_1)$, with $E_1$and E_2 the initial and final blow energies. A steeper increase in sound level is expected in the main frequency range of impact pile driving (100-1000 Hz) (Thomsen et al., 2006), where $13\ log_{10}(E_2/E_1)$ is a more realistic approximation (Nehls et al., 2007). Numerical studies suggest that ~0.5 % of the hammer energy goes into acoustic energy that ultimately gets into the water column (Dahl, 2014; Robinson et al., 2007).

It has been assumed that the 1/3-octave band source level spectrum based on hammer strike energy quoted for the Block Island Wind Farm modelling (Tetra Tech, 2012) is representative of the 90 kJ pile-hammer in this study after suitable adjustment (Figure 2.1).

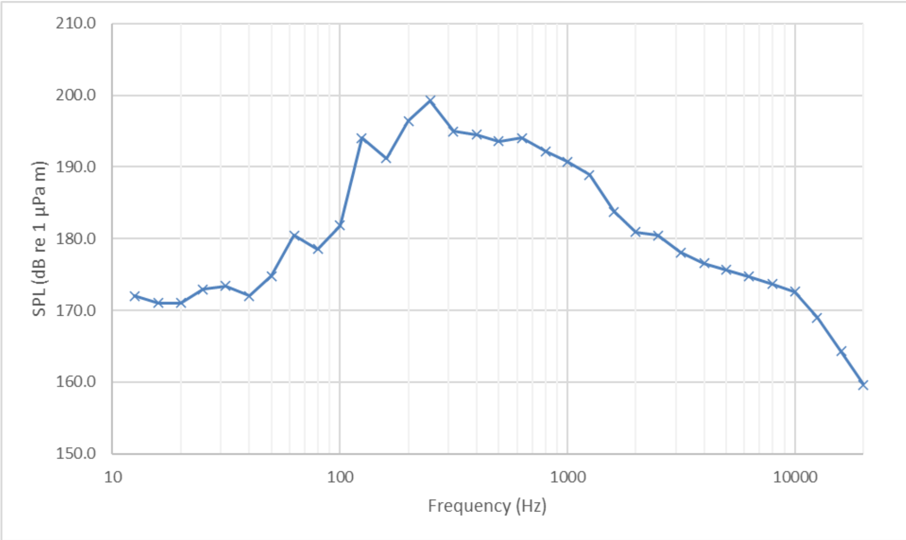

Figure 2.1 Estimated 1/3-octave band source levels for impact driven steel piles scaled for hammer strike energy of 90 kJ (After Tetra Tech, 2012)

The proposed pin pile diameters are 0.610 m (24") piles for the drilling template and manifold. The predicted source sound level generated during piling is 218 dB re 1 µPa m.

The subsea noise levels generated by surface vessels used during the piling phase would be insignificant when compared to the noise levels generated during marine impact piling. Depending on ambient noise levels, sensitive marine mammals may be temporarily displaced by noise from a vessel in their immediate vicinity, however, the impact is not expected to be significant relative to noise from piling.

Ambient noise

Ambient or background noise in the ocean results from sounds generated by physical factors such as wind and waves; by marine mammal vocalisations; and by other shipping.

2.3 Underwater Sound Metrics

In this section, several important measures of sound will be discussed. The maximum absolute pressure within a particular time interval is known as the peak level. The source level is the strength of an acoustic source. The higher the source level the louder the sound that the source produces. However, the larger the distance from the source, the lower the level that is experienced. This location-specific measure for received sound, the sound pressure level is indicative for an average level of sound that is present at that location. The total cumulative amount of sound that is received in a period of time is the sound exposure level.

Source level determination

The value of the source level can be considered to be the sound pressure that would exist at a nominal range of 1 m from the acoustic centre of an equivalent monopole source (Robinson et al., 2014). For piling and other impulsive sources, the metric used is L_{pk}, which represents the peak decibel ratio of sound pressure to a reference pressure of 1 µPa at 1 m (re 1 µPa m) in underwater acoustics.

Assuming that the underwater acoustic energy is directly proportional to the hammer energy for a pile driving hammer (MacGillivray et al., 2011), the source level (L_{pk} , zero-to-peak (peak) in dB re 1 µPa m) is given by

$$L_{pk} = L_{ref} + 13\ log_{10}(E/\mathrm{E}_{ref})$$

Equation 1

where L_{ref} is the reference broadband level in dB re 1 µPa m, and E and E_{ref} (kJ) are the strike energies of the study hammer and the reference hammer, respectively. In this study the reference values used were: $L_{ref} = 223$ dB re 1 µPa m and $E_{ref} = 200$ kJ.

Sound pressure level

The root-mean-square (rms) Sound Pressure Level (SPL, L_p), (dB re 1 µPa) indicative for the average amount of sound at one location, is defined as:

$$L_p = 20log_{10}\left(\frac{p_{rms}}{p_{ref}}\right)$$

Equation 2

where p_{ref} is the reference pressure in water of 1 µPa, and p_{rms} the rms pressure (Pa) is:

$$p_{rms} = \sqrt{\frac{1}{T}\int_0^T p^2(\mathrm{t})\ dt}$$

Equation 3

where T is the integration time (s), and $p(\mathrm{t})$ is the sound pressure at that location as a function of time t (Pa). L_p is a measure of continuous underwater noise.

Sound exposure Level

Exposure to brief, high-pressure, transient sounds (impulsive sounds, such as explosions, airgun shots or pile strikes) can be more damaging to marine life than exposure to continuous sound at lower pressures (Hastie et al., 2019). The hearing threshold rises faster when exposed to impulsive sound than to non-impulsive sound (such as from drilling and shipping). Consequently, the sound energy required to induce TTS or PTS is lower (Hastie et al., 2019).

Unlike SPL, the SEL_{24h} is generally applied as a dosage metric, meaning that its value increases with the number of exposure events (MacGillivray et al., 2011).

An "equal energy" approach is adopted where the cumulative daily Sound Exposure Level (SEL), SEL_{24h}, is used as a simplifying assumption to accommodate sounds of various SPLs, durations, and duty cycles (National Marine Fisheries Service, 2018). SEL_{24h} is related to the energy of the sound and this approach assumes exposures with equal SEL_{24h} result in equal effects, regardless of the duration or duty cycle of the sound.

The SEL, L_E, is defined as the level of continuous sound with 1 s duration and the same sound energy as the impulse.

$$L_E = 10\ \log_{10}\left(\int_0^T \frac{p^2(t)}{{p_{ref}}^2(t)}dt\right)$$

Equation 4

where T is the time window of integration which represents the exposure duration (s) and $p(t)$ is the sound pressure (Pa), referenced to 1 μPa^2, ${p_{ref}}^2(t)$.

The SEL for a single strike, $L_{E,ss}$ (dB re 1 μPa^2 s), indicative for the amount of sound (SPL) received at one location, over the duration of a single pulse, T_p (s), is defined as:

$$L_{E,ss} = L_p + 10log_{10}(T_p)$$

Equation 5

The SEL_{24h} metric considers both the received level and the duration of exposure, as both factors contribute to noise induced hearing loss, and

$$L_{E,24h} = L_{E,ss} + 10\ log_{10}(N)$$

Equation 6

where N is the number of strikes or shots in a 24 h period.

NOAA recommend that the weighted $L_{E,24h}$ metric should only be applied to predict impacts for a single source/activity in a discrete spatiotemporal scale (National Marine Fisheries Service, 2018).

Marine mammal auditory weighting functions

Auditory weighting functions best reflect an animal's ability to hear a sound (and do not necessarily reflect how an animal will perceive and behaviourally react to that sound). To reflect higher hearing sensitivity at particular frequencies, sounds are often weighted.

Frequency-dependent auditory weighting functions have been proposed for marine mammals, specifically associated with PTS onset thresholds expressed in the weighted SEL_{24h} metric (National Marine Fisheries Service, 2018), which consider what is known about marine mammal hearing (Erbe et al., 2016; Finneran et al., 2016; Southall et al., 2007). Separate functions were derived for each marine mammal hearing group.

The auditory weighting function amplitude, $W_{aud}(f)$ (dB) at a particular frequency, f (kHz) is given by:

$$W_{aud}(f) = C + 10log_{10}\left\{\frac{(f/f_1)^{2a}}{[1+(f/f_1)^2]^a[1+(f/f_2)^2]^b}\right\}$$

Equation 7

The function shape is determined by the following auditory weighting function parameters, where the low-frequency cut-off (f_1) is directly dependent on the value of the low-frequency exponent (a); the high-frequency cutoff (f_2) is directly dependent on the value of the high-frequency exponent (b); and C is the weighting function gain. The influence of each parameter value on the shape of the auditory weighting function is detailed in the NOAA guidelines (National Marine Fisheries Service, 2018).

The default weighting adjustment factor (WFA) for piling is 2 kHz (National Marine Fisheries Service, 2018). Table 2.1 gives the auditory weighting function parameters for marine mammal hearing groups for use with pile driving sound sources.

Table 2.1 Auditory weighting function parameters for cetacean and pinniped hearing groups for use in steady state exposures to piling (* assumes a weighting factor adjustment frequency of 2 kHz).

Auditory Weighting Function Parameters	Low-Frequency Cetaceans	Mid-Frequency Cetaceans	High-Frequency Cetaceans	Phocid Pinnipeds
a	1	1.6	1.8	1
b	2	2	2	2
f_1 (kHz)	0.2	8.8	12	1.9
f_2 (kHz)	19	110	140	30
C (dB)	0.13	1.2	1.36	0.75
Adjustment (dB) *	**−0.01**	**−19.74**	**−26.87**	**−2.08**

Source: (National Marine Fisheries Service, 2018). Note: Southall et al. (2019) have since reclassified mid- and high-frequency cetaceans as high- and very high-frequency cetaceans, respectively.

Determination of Impact Radii

Combining $L_{E,24h}$ and the auditory weighting function amplitude $W_{aud}(f)$ gives the cumulative weighted SEL, $L_{E,24h,wt}$, as follows:

$$L_{E,24h,wt} = L_{E,24h} + W_{aud}(f)$$

Equation 8

To determine impact radii using the NOAA thresholds (National Marine Fisheries Service, 2018), and assuming a propagation loss of $20\ log_{10}(R)$, this leads to:

$$r = 10^{(L_{E,24h,wt} - L_{E,th})/20}$$

Equation 9

where $L_{E,th}$ is the appropriate threshold level for impulsive sound for mortality and potential mortal injury, recoverable injury, and TTS onset for fish and behaviour, TTS, and PTS onset for marine mammals (National Marine Fisheries Service, 2018).

The radii of impact for each of the threshold levels can be used along with marine mammal densities to estimate organism abundance.

2.4 Underwater Noise Model

The underwater noise model used is Piling Impact – Guide to Assessment and Risk (PIGAR). This model brings together the underwater sound metrics detailed in Section 2.3 with the marine mammal risk assessment modules of the Explosives use in Decommissioning – Guide to Assessment of Risk (EDGAR) model (Brand, 2021a, 2021b). The EDGAR modules are based on the existing NOAA frequency-weighted SEL thresholds and Marine Scotland and SMRU marine mammal data.

Oceanographical and Physical Assumptions

The model assumes both a consistent uniform seabed geology and sea state, and in deeper water there is less sound and energy propagation interference associated with the seabed and water surface.

Several of these factors depend on the acoustic frequency, and a complex model will include frequency dependence explicitly within the model parameters. However, many of the above factors are highly context dependent and as such many preclude a model from being used over a wide spatial extent.

Biological Assumptions

Potential impacts are determined by considering the sound received by an organism. Receivers are assumed to be stationary within the water column for the entire duration of the activity and not avoid the sound. Additionally, animals on the edge of the isopleth (in order to exceed a threshold) will remain there. In reality, most receivers will minimise their time at close range to a sound source/activity (Gedamke et al., 2011).

Accumulation over a 24 h period, which is dependent on how many strikes or shots occur, could lead to unrealistically large isopleths associated with PTS onset.

An “equal energy” approach is adopted where SEL_{24h} is used as a simplifying assumption to accommodate the sounds of various SPLs, durations, and duty cycles. SEL is related to the energy of the sound, and this approach assumes exposures with equal SEL result in equal effects, regardless of the duration or duty cycle of the sound. The equal energy rule overestimates the effects of intermittent noise, as the pauses between noise exposures will promote some hearing recovery. Exposure to continuous noise with the same total SEL (Hastie et al., 2019), but different durations, will tend to produce more TTS with increased duration (i.e., if the weighted $SEL_{24h,wt}$ of two sources are similar, a short duration/high source level noise may have similar risks to long duration/low source level sound) (Hastie et al., 2019).

The potential for recovery from hearing loss exists between successive sound exposures or after sound exposure ceases, with TTS resulting in complete recovery and PTS resulting in incomplete recovery. Predicting recovery from sound exposure is not straightforward.

3 Receivers Potentially at Risk from Underwater Piling Noise

Underwater noise can affect the behaviour of or may cause physical injury or physiological changes such as increased stress to, several different marine taxa, in particular to marine invertebrates, fish, and marine mammals such as pinnipeds and cetaceans.

The noise level perceived by an organism (the “received noise level”) depends on the hearing sensitivity of the organism or receptor, and the level and frequency of the sound received at the organism’s location (Southall et al., 2019, 2007; Spiga et al., 2012; Richardson et al., 1995). If a high source level sound is in the immediate vicinity of a receptor, a permanent threshold shift (PTS) in hearing can occur, leading to hearing loss and with rising exposure to potentially fatal physical injuries (Southall et al., 2019, 2007; Spiga et al., 2012; Richardson et al., 1995). However, the noise decreases with increasing distance from a source, reducing the potential to cause the onset of a temporary shift in hearing thresholds (Temporary Threshold Shift (TTS)) (Southall et al., 2019, 2007; Spiga et al., 2012; Richardson et al., 1995).

Behavioural responses include any change in behaviour from small and short-duration movements to changes in migration routes and leaving a feeding or breeding site. Such responses vary between species and can depend on factors such as an organism’s age or level of motivation, or the time of day or season. Some changes in behaviour, such as startle reactions, may only be transient and have little consequence for the animal or population (Popper and Hawkins, 2019).

The ability of marine mammals and fish to detect and respond to biologically relevant sounds is critical and anthropogenic sound can hinder, or mask this (Popper et al., 2014). Masking effectively raises the temporary or permanent hearing threshold of an organism, and the degree of masking is dependent on the received level and frequency content of the masking noise. Popper et al. (2014) defined masking as impairment of hearing sensitivity by over 6 dB, and TTS as any persistent change in hearing of 6 dB or more.

Even if a sound is detected (for example, a very low-frequency sound), an organism may show little or no behavioural response, possibly due to habituation. However, there is no guarantee that physical injury or physiological changes have not occurred (Popper and Hawkins, 2019).

3.1 Marine Invertebrates

There have been few studies of the effects of underwater noise on marine invertebrates (Hawkins and Popper, 2017; Edmonds et al., 2016; Hawkins et al., 2014; Morley et al., 2014; Cheesman, et al., 2012).

Impulsive noise, which involves sudden high pressure and particle motion changes, may cause behavioural disruption, physical injury, mortality, sensory damage, and physiological changes in invertebrates (Fitzgibbon et al., 2017; McCauley et al., 2017). Zooplankton underpin the health and productivity of global marine ecosystems. McCauley et al. (2017) suggested that seismic surveys cause significant mortality to zooplankton populations.

Impact pile driving generates water-borne pressure and particle motions, which propagate through the water column and the seabed. Spiga et al. (2016) investigated the influence of impact pile driving on the clearance rate of the blue mussel (*Mytilus edulis*). Mussels had significantly higher clearance rates when feeding upon microalgae during exposure to pile driving compared with individuals tested in ambient conditions. This suggested that mussels under pile driving conditions moved from a physiologically maintenance state to active metabolism to compensate for the stress caused by pile driving.

Exposure to sources of sound can result in behavioural responses that alter how species mediate ecosystem processes known to be key determinants of functioning for invertebrate species that do not rely on acoustics for communication (Solan et al., 2016). In the case of *Nephrops norvegicus*, the addition of either continuous or impulsive broadband noise repressed burying and bio-irrigation behaviour and considerably reduced locomotion activity (Solan et al., 2016). For the clam *Ruditapes philippinarum*, the introduction of an anthropogenic sound source elicited a typical stress response where individuals reduce surface relocation activity, move to a position above the sediment-water interface, and close their valves (Solan et al., 2016). These responses reduce the capacity of the organism to mix the upper sediment profile and prevent suspension feeding from taking place. Studies on cephalopods have reported behavioural and physiological responses to waterborne sound stimuli at low frequencies (Mooney et al., 2010; Kaifu et al., 2007).

Although many anthropogenic sound-producing activities are in direct contact with the seabed and many marine invertebrates are benthic dwellers, little is known about the potential effects of vibration within the seabed (Roberts and Elliott, 2017). Substrate-borne vibrational waves may also propagate through the seabed, particularly when a source is in direct contact with the sediment (Roberts and Elliott, 2017). Roberts et al. (2016a, 2016b) found that anthropogenic substrate-borne vibrations resulting from noise pollution have a clear effect on the behaviour of the hermit crab (*Pagurus bernhardus*) and the blue mussel. At high enough acoustic energy, oysters (*Crassostrea gigas*) were observed to transiently close their valves in response to frequencies in the range of 10 to < 1000 Hz (Charifi et al., 2017).

Chemical cues and signals enable animals to sense their surroundings over vast distances and find key resources, like food and shelter. However, the use of chemosensory information may be impaired in aquatic habitats by anthropogenic activities, which generate impulsive noise. (Roberts and Laidre, 2019) reported that fewer marine hermit crabs were attracted to a chemical cue indicative of a newly available shell home after noise exposure in field experiments.

Although marine invertebrates may be affected by piling activities, there is insufficient knowledge currently available to be able to make an assessment.

3.2 Fish

Fish use a variety of sensory systems to learn about their environments and to communicate. Hearing is understood to be present among virtually all fish (National Research Council, 2003) and supplies information in 3D, often from great distances. Fish use sound for communication, orientation and migration, to detect prey and predators, to determine habitat suitability, and during mating behaviour. The sensory systems used by fish to detect sounds are very similar to those of marine (and terrestrial) mammals and hence sounds that damage or in other ways affect marine mammals could have similar consequences for fish (Popper et al., 2014). Thus, the survival and fitness of individuals and populations can be impacted if the ability of a fish to detect and respond to biologically relevant sounds is impaired (Popper and Hawkins, 2019).

Fish species vary in many ways, anatomically, physiologically, ecologically and behaviourally, in their response to sound, such that a guideline for a behavioural response can never fit all fish (Popper et al., 2014). Many finfish species to display an alarm “startle” response of tightening schools, increased speed and movement towards the seabed (Roberts et al., 2016b; Fewtrell and McCauley, 2012; McCauley et al., 2003; National Research Council, 2003). The abilities of individual fish to coordinate their movements with one another in a group were disrupted when pile-driving sound was played back, compared to when ambient-sound was played back (Herbert-Read et al., 2017). Such responses last less than a second and do not necessarily result in significant changes in subsequent behaviour.

Fish eggs and larvae also may be killed or damaged (Bolle et al., 2016; Wright, 1982).

Hearing Loss

At high sound levels, there may be temporary or partial loss of hearing, particularly in fish where the swim bladder enhances sound pressure detection. The time interval between pulses may be important when considering effects upon hearing, as there may be sufficient time for hearing to recover. Rogers and Zeddies (2008) speculated that the density of swim bladder gas will rise with increasing depth. This could lead to a decrease in pressure-aided hearing sensitivity as the swim bladder would stiffen.

Particle Motion

Fish initially detect pressure signals via an air bubble in the body, for example by the gas-filled swim bladder. Vibration of the air bubble acts as a small sound source which reradiates the signal as a near-field particle motion directly to the inner ear. Acoustic particle motion-induced tissue oscillation occurs in fish as their average density and elasticity is very similar to that of water (Popper and Hawkins, 2018). Particle motion is an extremely important signal to fish as they use this component of a sound field to determine about sound source direction (US Department of the Navy, 2011). This is because particle motion is highly directional. Conversely, pressure does not appear to come from any direction (Continental Shelf Associates, Inc., 2004).

Both particle motion and pressure are always present in the signal as it propagates from the source. As attenuation of the signal from particle motion is much greater over distance than that for pressure, a fish that is only able to detect particle motion will be most sensitive to sounds in the near field (Wright, 1982). Consequently, fish that detect both particle motion and pressure are more sensitive to sound.

Most fish respond to the particle motion component of sound waves, particularly at frequencies below several hundred Hz, whereas marine mammals do not (Popper and Hawkins, 2019, 2018). Animals near the seabed may not only detect water-borne sounds, but also sound that propagates through the substrate and re-enters the water column (Hawkins et al., 2021; Popper et al., 2014).

3.3 Marine Mammals

Behavioural changes will vary from a minor change in direction to confusion and altered diving behaviours, which may have varied medium- and long-term effects on the individual.

Whilst TTS itself is not evidence of injury (Richardson et al., 1995), it may result from injury and increase the risk that an organism may not survive. The ability of an animal to communicate, respond to predators, and search for prey may be compromised.

Finneran (2015) suggested that marine mammals exposed to sufficiently intense sound may exhibit an increased hearing threshold, called a noise-induced threshold shift (NITS). For plane progressive waves, sound exposure is proportional to sound energy flux density, so the use of SEL is often described as an “equal-energy” rule, where exposures of equal energy are assumed to produce equal amounts of NITS, regardless of how the energy is distributed over time. Since SEL changes by 3 dB for each doubling or halving of exposure duration, the use of SEL or an equal energy rule can also be described as a “3-dB exchange rate” for acoustic damage risk criteria. This means that the permissible noise exposure SPL will change by 3 dB with each doubling or halving of exposure time; e.g., an equal energy rule means that if the permissible exposure limit is 150 dB re 1 μPa for an 8 h exposure, the limit for a 4 h exposure would be 153 dB re 1 μPa.

Pinnipeds

Pinnipeds (seals, sea lions, and walruses) also produce a diversity of sounds, although generally over a low, restricted bandwidth (generally from 100 Hz to several tens of kHz). Their sounds are used primarily in critical social and reproductive interactions (Southall et al., 2007). Available data suggest that most pinniped species have peak sensitivities between 1 and 20 kHz (National Research Council, 2003). However, the data available on the effects of anthropogenic noise on pinniped behaviour are limited.

Grey seals (*Halichoerus grypus*) and harbour or common seals (*Phoca vitulina*) are resident in UK waters and occur regularly over large parts of the North Sea (SMRU, 2001). Both species are found predominantly along the UK coastline but there are few data available on the distribution and abundance of seals when offshore. Tracking of seals suggests they make feeding trips lasting two to three days, normally travelling less than 40 km from their haul-out sites, and with the animal ultimately returning to the same haul-out site from which it departed (SMRU, 2001). Grey seals may spend more time further offshore than common seals.

It is considered unlikely that seals will be encountered near the installation activities given the distance of the Talbot Field from the coast (278 km). Seal numbers recorded by telemetry in the survey area are 0-1 per 25 km^2 for both harbour and grey seals (Sea Mammal Research Unit (SMRU) and Marine Scotland, 2017).

Cetaceans

Cetaceans use sound for navigation, communication and prey detection. Anthropogenic underwater noise has the potential to impact on marine mammals (JNCC, 2010; Southall et al., 2007; Richardson et al., 1995).

Several species of cetacean have been recorded in the Talbot Development area. In particular, minke whale (*Balaenoptera physalus*), bottlenose dolphin (*Tursiops truncatus*), common dolphin (*Delphinus delphis*), white-beaked dolphin (*Lagenorhynchus albirostris*), Atlantic white-sided dolphin (*Lagenorhynchus acutus*) and harbour porpoise (*Phocoena phocoena*) have been recorded as present in the area (Hammond et al., 2017; Reid et al., 2003).

3.4 Summary of Environmental Sensitivities

The main environmental sensitivities in the Talbot Development area are summarised in Table 3.1.

Table 3.1 Environmental sensitivities in the Talbot Development area

Environmental Receptor	Main Features
Conservation interests	The Talbot Field lies within the Fulmar Marine Conservation Zone (MCZ), which has been designated for the ocean quahog (*Arctica islandica*). **Annex II species:** The Annex II species bottlenose dolphin (*Tursiops truncatus*), harbour porpoise (*Phocoena phocoena*), grey (*Halichoerus grypus*) and harbour (common) (*Phoca vitulina*) seals have been recorded within the Talbot Development area. **Annex IV species:** The Annex IV species, minke whale (*Balaenoptera physalus*), bottlenose dolphin (*Tursiops truncatus*), common dolphin (*Delphinus delphis*), white-beaked dolphin (*Lagenorhynchus albirostris*), Atlantic white-sided (*Lagenorhynchus acutus*) and harbour porpoise have been recorded within the Talbot Development area. High to very high sightings of at least one Annex IV species occur from May to November, with low densities of white-beaked dolphin occurring in January and April (UKDMAP, 1998) **Annex V species:** The Annex V species, grey and harbour (common) seals have been recorded within the Talbot Development area, with very low densities of harbour and grey seals (0 to 1 seal per 25 km^2) occurring in the area (Sea Mammal Research Unit (SMRU) and Marine Scotland, 2017)
Fisheries	**Fish spawning areas** The Talbot Development coincides with spawning areas for cod (*Gadus morhua*), lemon sole (*Microstomus kitt*), mackerel (*Scomber scombrus*), Norway pout (*Trisopterus esmarkii*), plaice (*Pleuronectes platessa*) and sandeel (*Ammodytidae marinus*). The spawning intensity for mackerel and plaice has been recorded as high in this area (Ellis et al., 2010; Coull et al., 1998). **Fish nursery areas** Nursery areas for anglerfish (*Lophius piscatorius*), blue whiting (*Micromesistius poutassou*), cod, European hake (*Merluccius merluccius*), haddock (*Melanogrammus aeglefinus*), herring (*Clupea harengus*), ling (*Molva molva*), mackerel, Norway pout, plaice, sandeel, spotted ray (*Raja montagui*), spurdog (*Squalus acanthias*) and whiting (*Merlangius merlangus*) occur in the Talbot Development area (Aires et al., 2014; Ellis et al., 2010; Coull et al., 1998). The nursery area for cod is considered high intensity (Ellis et al., 2010) **Commercial Fisheries** From 2014 to 2017, annual landings of fish from the Talbot Development area (International Council for the Exploration of the Sea (ICES) rectangle 42F2) ranged from 13 tonnes in 2017 to 273 tonnes in 2014. Fishing effort in ICES rectangle 42F2 ranged from 16 to 87 days, with effort mainly occurring from April to August (Scottish Government, 2019). Fishing effort was dominated by trawling gears. Demersal and shellfish species dominated the landings from 2014 to 2017, accounting for 1 tonne of *Nephrops*, 2 tonnes of lemon sole, 4 tonnes of haddock and 5 tonnes of plaice in 2017. The relative value of catches landed in the UK from ICES rectangle 42F2 during 2017, were £18,785 for demersal species, £75 for pelagic species and £3,249 for shellfish (Scottish Government, 2019). Note: Fisheries data was disclosive for 2018.
Marine Mammals	Minke whale, bottlenose dolphin, common dolphin, white-beaked dolphin, Atlantic white-sided and harbour porpoise, and grey and harbour seals have been observed within the Talbot Development area, (Hammond et al., 2017; Sea Mammal Research Unit (SMRU) and Marine Scotland, 2017; Reid et al., 2003; UKDMAP, 1998). The main species of conservation interest have been discussed in detail above in the earlier section.

4 Characterisation of Hearing Sensitivities

Criteria for predicting the onset of injury and behavioural response in marine mammals were defined by Southall et al. (2007) after reviewing the impacts of underwater noise on marine mammals. These criteria depend on frequency-based hearing characteristics and pulse-based noise exposures (Tables 4.1-4.2).

Table 4.1 Functional cetacean and pinniped hearing groups including examples of species found on the UK Continental Shelf. Species in bold have been sighted in the Talbot field area.

Functional Hearing Group	Estimated Auditory Bandwidth	Species
Low-frequency cetaceans	7 Hz–25 kHz	**Minke whale (*Balaenoptera acutorostrata*)** Long-finned pilot whale (*Globicephala melas*) Fin whale (*Balaenoptera physalus*) Sperm whale (*Physeter macrocephalus*) Cuvier's beaked whale (*Ziphius cavirostris*), Gervais' beaked whale (*Mesoplodon europaeus*), Sowerby's beaked whale (*Mesoplodon bidens*), Northern Bottlenose whale (*Hyperoodon ampullatus*)
Mid-frequency cetaceans	150 Hz–160 kHz	**White-beaked dolphin (*Lagenorhynchus albirostris*)** **Atlantic white-sided dolphin (*Lagenorhynchus acutus*)** **Bottlenose dolphin (*Tursiops truncates*)** **Common dolphin (*Delphinus delphis*)** Risso's dolphin (*Grampus griseus*) Striped dolphin (*Stenella coeruleoalba*)
High-frequency cetaceans	200 Hz–180 kHz	**Harbour porpoise (*Phocoena phocoena*)**
Pinnipeds in water	75 Hz–100 kHz	**Grey seal (*Halichoerus grypus*)** **Common seal (*Phoca vitulina*)**

Sources: (National Marine Fisheries Service, 2018; Sea Mammal Research Unit (SMRU) and Marine Scotland, 2017; Southall et al., 2019, 2007; Reid et al., 2003). Note that Southall et al. (2019) reclassified mid- and high-frequency cetaceans as high- and very high-frequency cetaceans, respectively.

Table 4.2 Noise types and activities associated with the Talbot Development Project (NA is not applicable). Adapted from Southall et al. (2007)

Noise Type	Acoustic Characteristics	Piling Activities
Single pulse	Brief, broadband, atonal, transient, single discrete noise event; characterised by rapid rise to peak pressure (> 3 dB difference between received level using impulsive vs. equivalent continuous time constant)	NA
Multiple pulse	Multiple discrete acoustic events within 24 h; (> 3 dB difference between received level using impulsive vs. equivalent continuous time constant)	Multiple pile strikes

Non-pulse	Intermittent or continuous, single or multiple discrete acoustic events within 24 h; tonal or atonal and without rapid rise to peak pressure	Vessel activity

Currently available data (via direct behavioural and electrophysiological measurements) and predictions (based on inner ear morphology, modelling, behaviour, vocalisations, or taxonomy) indicate that not all marine mammal species have equal hearing capabilities, in terms of absolute hearing sensitivity and the frequency band of hearing (National Marine Fisheries Service, 2018) and, consequently, vulnerability to impact from underwater noise differs between species. The US National Marine Fisheries Service (NMFS) (2018) recently revised the “hearing types” classifications of different marine mammal species (Table 4.1).

4.2 Sound Exposure Guidelines for Fish and Marine Mammals

The noise level perceived by an animal (the “received noise level”) depends on the level and frequency of the sound when it reaches the animal and the hearing sensitivity of the animal. In the immediate vicinity of a high sound level source, noise can have a severe effect causing a permanent threshold shift (PTS) in hearing, leading to hearing loss and ultimately with increasing exposure, to physical injuries which may be fatal. However, at greater distance from a source the noise decreases, and the potential effects are diminished (Nedwell et al., 2005; Nedwell and Edwards, 2004), possibly causing the onset of only a temporary shift in hearing thresholds (Temporary Threshold Shift (TTS)-onset). As noted above hearing sensitivity, in terms of the range of frequencies and sound levels that can be perceived, varies with species; and the minimum level of sound that a species is able to detect (the hearing threshold) varies with frequency.

It has been suggested that TTS itself is not evidence of injury (Richardson et al., 1995), although it may result from injury. During a period of TTS, the survival of the animal may be at risk. Its ability to communicate may be impaired, it may be unable to respond to predators, and its ability to seek out prey may be compromised.

Fish

Fish may be grouped into different functional categories, depending on their structure and degree of hearing specialisation (Table 4.3) (Hawkins et al., 2020; Popper et al., 2020, 2014; Popper and Hawkins, 2019; Spiga et al., 2012).

Table 4.3 Mortality and potential mortal injury, recoverable injury and Temporary Threshold Shift (TTS) for fish and onset dual metric threshold levels for impulsive sound. Peak sound pressure levels (SPL_{pk}) dB re 1 μPa; cumulative sound exposure levels (SEL_{cum}) dB re 1 μPa^2 s. All criteria are presented as sound pressure even for fish without swim bladders since no data for particle motion exist. After guidelines for piling (Popper et al., 2014).

Type of Fish	Mortality and Potential Mortal Injury	Recoverable Injury	TTS
Category 1 Fish: no swim bladder (particle motion detection)	> 219 dB SEL_{cum} or > 213 dB SPL_{pk}	> 216 dB SEL_{cum} or > 213 dB SPL_{pk}	>> 186 dB SEL_{cum}
Category 2 Fish: swim bladder is not involved in hearing (particle motion detection)	210 dB SEL_{cum} or > 207 dB SPL_{pk}	203 dB SEL_{cum} or > 207 dB SPL_{pk}	>> 186 dB SEL_{cum}

Category 3 Fish: swim bladder is involved in hearing (primarily pressure detection)	207 dB SEL_{cum} or > 207 dB SPL_{pk}	203 dB SEL_{cum} or > 207 dB SPL_{pk}	186 dB SEL_{cum}
Eggs and larvae	> 210 dB SEL_{cum} or > 207 dB SPL_{pk}		

Reviews on the effects of anthropogenic sound on fishes concluded that there are substantial gaps in the knowledge that need to be filled before meaningful noise exposure criteria can be developed, especially for explosives (Hawkins et al., 2020; Popper et al., 2020, 2014; Popper and Hastings, 2009).

Marine Mammals

The 2007 Southall study has been updated, and revised noise exposure criteria to predict the onset of auditory effects in marine mammals have been published (Table 4.4) (Southall et al., 2019). The study includes estimated audiograms and hearing-weighted functions which are in line with the details documented in the NOAA 2018 Guidelines (National Marine Fisheries Service, 2018). The only exception is the reclassification in Southall et al. (2019) of the mid- and high-frequency hearing groups to high- and very high-frequency groups, respectively. The current study uses the NOAA 2018 terminology (National Marine Fisheries Service, 2018).

Table 4.4 Behaviour, TTS and PTS onset dual metric threshold levels for piling and other impulsive sound sources.

Group	Behaviour $SEL_{weighted}$ (dB re 1 μPa^2 s)	TTS-Onset: $SEL_{weighted}$ (dB re 1 μPa^2 s)	TTS-Onset: SPL_{pk} (dB re 1 μPa)	PTS-Onset: $SEL_{weighted}$ (dB re 1 μPa^2 s)	PTS-Onset: SPL_{pk} (dB re 1 μPa)
Low-Frequency Cetaceans	163	168	213	183	219
Mid-Frequency Cetaceans	165	170	224	185	230
High-Frequency Cetaceans	135	140	196	155	202
Phocid Pinnipeds	165	170	212	185	218

Source: National Marine Fisheries Service (2018). Note that Southall et al. (2019) reclassified mid- and high-frequency cetaceans as high- and very high-frequency cetaceans, respectively.

For impulsive sound, it is also important to consider the peak sound pressure levels (National Marine Fisheries Service, 2018), SPL_{pk}, which can induce TTS or PTS regardless of its energy and frequency content. Hence, for impulsive noise, un-weighted SPL_{pk} thresholds also need to be considered in parallel with the frequency-weighted SEL thresholds (National Marine Fisheries Service, 2018). Consequently, the threshold resulting in the largest impact radius/isopleth for the calculation of PTS onset should be adopted.

Generally, animals do not hear equally well at all frequencies within their hearing range. Even if an animal cannot hear a noise well, a noise with a high pressure level can still lead to disturbance or physical injury (Popper and Hastings, 2009). NOAA (National Marine Fisheries Service, 2018) developed frequency weighting criteria to make allowances for differential frequency responses of sensory systems.

5 Results

Results are presented for the impact of underwater noise generated by the piling and other installation activities (vessels-only) on marine biota. Impact radii for injury and significant behavioural disturbance have been determined for the marine mammals and fish. Estimates of the potential number of marine mammals affected are also recorded.

5.1 Subsea Installation Activities involving Piling

The planned installation operations involving piling will generate a maximum estimated SL of 218.5 dB re 1 µPa m (expected frequency range 100 Hz to 10 kHz[3], with near peak energy at frequencies of 100 Hz to 1 kHz before attenuation). Vessel-only piling operations will generate a maximum estimated source level, SL of 196 dB re 1 µPa m (expected frequency range 10 Hz to 10 kHz). However, the contribution of any vessels to the cumulative noise levels of the piling operations is negligible in comparison to the sound levels generated from the pile-driving.

For this study, sound propagation from the source was determined using the Marsh-Schulkin model (Schulkin and Mercer, 1985).This model applies to acoustic transmission in shallow water (up to approximately 185 m) and represents sound propagation loss in terms of sea state, substrate type, water depth, frequency and the depth of the mixed layer. A worst-case scenario was used for the underwater noise modelling. A description of the noise quantification, the Marsh-Schulkin model and the parameters used in the model are given in Annex A.1 and full modelling results are presented in Annex A.2.

5.2 Impact on Fish

Based on the injury thresholds proposed for fish (Popper et al., 2014; Section 4.2), it is anticipated that no fish (Category I fish (no swim bladder) or Categories II and III fish (with swim bladder)) will be injured within a designated 500 m mitigation zone for either metric (Table A.2.).

5.3 Impact on Marine Mammals

Noise generated will be detectable by all species present. Injury or behavioural changes varying from a minor change in direction, to confusion and altered diving behaviours may occur. These changes may have medium or long-term effects on an individual.

The contribution of the vessels to the cumulative noise levels of the piling operations dominates the 1/3-octave level (TOL) spectrum at low frequencies up to about 100 Hz but is negligible at higher frequencies (Figure A.1.). At low frequencies where the only noise source is from vessels, the cumulative noise level is outside of the hearing range of most species except low-frequency marine mammals such as minke whales. Sound at frequencies between 100-630 Hz will cause the greatest impact as it is both at its loudest and it is within the most susceptible range for low-frequency marine mammals.

Comparison with the frequency-weighted SEL thresholds suggest worst case impact radii of 1.1 km for PTS onset, 5.9 km for TTS-onset and 10.5 km for behaviour disturbance, all of which relate to high-frequency cetaceans (Table A.2.). This is for a worst-case scenario of 2,400 strikes per pile for the drilling template and completion of its installation (4 piles) within 24 h. To reduce the impact radii using this metric to approximately within the confines of the 500 m exclusion zone (526 m) would require that only one pile be driven per 24 h period.

[3] For reporting purposes for inclusion in the underwater noise register under the Marine Strategy Framework Directive (MSFD) Descriptor 11, Indicator 11.1.1 on low- and mid- frequency impulsive sounds: a hammer strike energy of 90 kJ will fall within the ‘very low’ category for impact pile drivers, (Dekeling et al., 2016).

The worst-case scenario of 2,040 strikes per pile for the manifold and completion of its installation (4 piles) within 24 h leads to predicted worst case impact radii of 970 m for PTS onset, 5.5 km for TTS-onset and 9.7 km for behaviour disturbance (high-frequency cetaceans) (Table A.3.). To reduce the impact radii using this metric to within the confines of the 500 m exclusion zone (485 m) would require that only one pile be installed per 24 h period.

Using the un-weighted SPL_{pk} thresholds suggests that the onset of injury PTS may occur within 15 m of the sound source (drilling template piling) as a worst-case for high-frequency cetaceans (Table A.2.). Severe behavioural changes (avoidance) or TTS thresholds may be exceeded within 30 m for high-frequency cetaceans (Table A.2.). Marine mammals from other functional hearing groups (Table 4.1) are unlikely to be adversely affected by any of the installation operations using the PK metrics.

Note that whilst SEL_{24h} is relatively high, it has been estimated that it should take ~41 min and ~48 min to drive each pile to the target depth for the manifold and drilling template piles, respectively. This equates to no more than 4 hours of piling noise in a 24 h period.

Injury and Behavioural Displacement of Marine Mammals

JNCC (JNCC, 2010) suggest that ‘significant displacement’ relates to a change in the natural distribution of a sufficient proportion of individuals, both temporally and spatially, such that there is an adverse effect to a local population. Significant behavioural displacement can lead to abandonment of an area or habitat and results in changes in dispersion patterns.

Marine Mammal Density Estimates

The UK Continental Shelf (UKCS) is divided into numbered rectangular Quadrants, each one degree of latitude by one degree of longitude. Maps compiled In EDGAR (Brand, 2021b) were used in PIGAR to enable ease of marine mammal risk assessment (Figure 5.1). An North Sea Transition Authority (NSTA) UKCS Quadrants (North Sea Transition Authority, 2022) layer has been laid over each of the Small Cetaceans in the European Atlantic and North Sea (SCANS) III survey areas (Thomas et al., 2010), the Harbour Seal Total Mean Usage Maps, and the Grey Seal Total Mean Usage Maps (Sea Mammal Research Unit (SMRU) and Marine Scotland, 2017) (Figure 5.1).

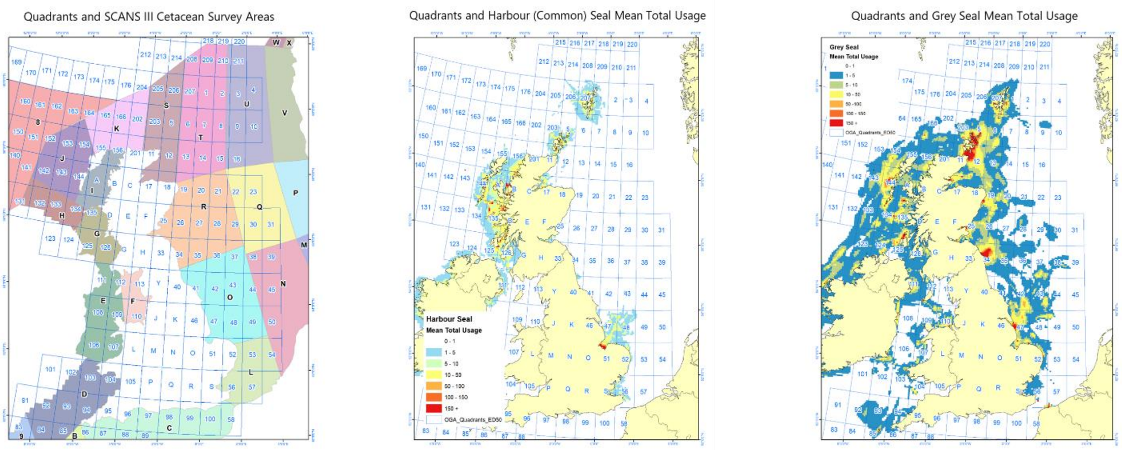

Figure 5.1 EDGAR Marine mammal risk assessment maps. (Adapted from North Sea Transition Authority, 2022; Sea Mammal Research Unit (SMRU) and Marine Scotland, 2017; Thomas et al., 2010)

Approximate densities of marine mammals in the area, based on the SCANS III (July 2016) survey and modelling (Hammond et al., 2017), and the mean Grey and Harbour Seal Usage Maps (Sea Mammal

Research Unit (SMRU) and Marine Scotland, 2017) have been used to estimate the number of animals of each species present in a quadrant and potentially experiencing PTS, TTS, or behavioural displacement from piling.

Marine mammal management units (MUs) for the seven most common cetacean species in UK waters have been agreed by the UK country nature conservation bodies (IAMMWG, 2021; Thompson et al., 2019; Duck and Thompson, 2007). These provide an indication of the spatial scales at which impacts of plans and projects need to be assessed.

Approximate densities of marine mammals in the Talbot Development area have been used to estimate the number of animals of each species potentially experiencing injury, TTS-onset or behavioural displacement from subsea installation activities (Table 5.1). In addition, MUs have been used to determination the percentage of reference population potentially affected (Table 5.1).

Table 5.1 Estimated number of marine mammals potentially experiencing injury, TTS-onset or behavioural displacement for worst-case scenario of complete installation of manifold in 24 h (4 piles) and percentage of reference population potentially affected

Species	Density estimate per km^2	Estimated number of animals that may experience[3]			Abundance of animals in UK portion of Management Unit[4]	Percentage of reference population potentially affected[5] (%)
		Behavioural displacement	TTS-onset	PTS-onset (injury)		
Minke whale[1]	0.007	2	1	0	10,288	0.018
Common dolphin[1]	0	-	-	-	57,417	NA
White-beaked dolphin	0	-	-	-	34,025	NA
Atlantic white-sided dolphin[1]	0	-	-	-	12,293	NA
Harbour porpoise[1]	0.333	116	37	2	159,632	0.073
Common seal[2]	0.04	5	2	0	31,282	0.013
Grey seal[2]	0.04	5	2	0	39,436	0.011

[1] Note that bottlenose dolphin, common dolphin, white-beaked and Atlantic white-sided dolphin were not observed in the Talbot Development area during the SCANS III survey (Hammond et al., 2017)

[2] Source: seals - (Sea Mammal Research Unit (SMRU) and Marine Scotland, 2017)

[3] Calculation method: density x behavioural change area determined from impact radii with abundance given to the nearest whole animal

[4] Sources: cetaceans (IAMMWG, 2021); pinnipeds (Thompson et al., 2019; Duck and Thompson, 2007) – note that the seal MU only relates to the North Sea area of the UK.

[5] Worst-case - based on behavioural displacement thresholds.

As a general rule, animals do not hear equally well at all frequencies within their hearing range. Whilst noises are less likely to disturb animals if they are at frequencies that the animal cannot hear well; out of band frequencies can still cause physical injury if pressure levels are very high (Matthews et al., 2010).

There is little empirical information on the impact of pile driving on cetacean individuals or populations and currently no direct evidence for a causal link between pile driving sound and physical injury exists (JNCC, 2010). However, auditory sensitivity data do suggest that, without mitigation, pile driving is likely to produce sound levels capable of causing injury or displacement to cetaceans (JNCC, 2010). Several studies have addressed the impact of pile driving during wind farm construction on harbour porpoises (Brandt et al., 2011; Tougaard et al., 2009; Carstensen et al., 2006). Tougaard et al. (2009) found that acoustic activity from harbour porpoises decreased at the onset of piling but returned to normal several hours after cessation of piling. The area of impact extended to 21 km from the piling site for 4 m diameter steel monopiles. Porpoise displacement was observed at up to 12 km from pile-driving activities and up to 4 km from construction vessels during windfarm construction in the Moray Firth (Benhemma-Le Gall et al., 2021).

Within the vicinity (up to about 2 km) of the construction site, porpoise detections declined several hours before the start of piling and were reduced for about 1−2 d after piling, while at the maximum effect distance, avoidance was only found during the hours of piling (Brandt et al., 2018). Brandt et al. (2011) found that the time taken for harbour porpoise acoustic communication to return to baseline decreased with increasing distance from the construction site; at 2.6 km, recovery took one to three days. Exposure to pile driving where most sound energy is in the low frequencies was found to cause reduced hearing (TTS) at higher frequencies in harbour porpoises, however, recovery occurred within 48 min following noise cessation (Kastelein et al., 2015).

Bottlenose dolphins spent a reduced period of time in the vicinity of construction works during both impact and vibration piling (Graham et al., 2017).

Russell et al. (2016) reported that there was no overall significant displacement of harbour seals during construction of a windfarm. During piling, seal abundance was significantly reduced up to 25 km from the piling activity. However, displacement was limited to piling activity; within 2 h of cessation of pile driving, seals were distributed as per the non-piling scenario.

It should be noted that the predicted number of animals either injured or temporarily displaced may be an overestimate. There is no clear relationship between received SPL and likely behavioural response, and so this analysis conservatively uses the lowest reported SPL causing injury or severe behavioural response. Additionally, in practice marine mammals are likely to be sparsely located, whether as individuals or groups of individuals, and move over large areas. There may be no individuals within the estimated zones of injury or displacement at the time of the installation operations.

Scientifically, risk assessment based on noise levels is problematic, since received noise level is a poor predictor of marine mammal behavioural responses (Gomez et al., 2016; Brandt et al., 2012) and fish displacement (Handegard et al., 2013). Merchant et al. (2018) have proposed indicators based on overall exposure to the noise and the distribution of exposure. For example, a small percentage of the population may be exposed for a large percentage of time (chronic exposure), or vice versa (prevalent exposure). Overall exposure was observed to increase by season, over the year, whilst exposure prevalence was markedly lower in spring, yet chronic exposure was higher (Merchant et al., 2018).

6 Transboundary and Cumulative Impacts

The proposed development is located approximately 7 km from the UK/ Norway median line. At this distance, noise levels from pile-driving, the greatest source of sound associated with the Talbot Development Project, would attenuate to a level lower than that likely to cause injury or temporary displacement to any cetacean species. Therefore, there is unlikely to be a transboundary impact from the noise generated by the installation activities.

7 Impacts Mitigation and Monitoring

Mitigation measures, in accordance with JNCC guidelines (JNCC, 2010) where available, will be implemented during the proposed subsea installation operations as appropriate (Table 7.1). Two Marine Mammal Observers (MMOs) will be present on the vessel.

Table 7.1 Mitigation Measures

Underwater noise from piling	• Using MMO commence pre-piling searches for marine mammals 30 minutes prior to activity. This search will be undertaken within a mitigation zone of at least 500 m radius around the operations, leading to a delay in piling operations if marine mammals are detected. • Delay the commencement of piling activities should any marine mammals be detected during this pre-piling search within a radius of 500 m (the mitigation zone). • Soft start of pile driver (20 minutes minimum), whereby the piling power is increased slowly over a set time period. This is believed to allow any marine mammals to move away from the noise source, reducing the likelihood of exposing animals to sounds, which may cause injury. In general, shorter piling times and reduced hammer energy will reduce the overall exposure levels and therefore the likelihood of injury. If it is assumed that the animal swims away at the onset of piling, then it is the initial hammer strikes which are the most critical as the SEL dose is greatest at shorter ranges and rapidly reduces with distance. • Use Passive Acoustic Monitoring (PAM) hydrophones[1] deployed in the water column to detect vocalising marine mammals after dark and during periods of poor visibility, also leading to a delay in piing if marine mammals are detected within the mitigation zone. • Continue pre-piling search and soft start to cover any breaks in piling. • Report piling activity and any marine mammal detections via the MMO report submitted upon completion to JNCC. • Consideration of the use of Acoustic Deterrent Devices which have the potential to exclude animals form the piling area.
Underwater noise from construction activities	• Machinery and equipment will be in good working order and well-maintained. • Helicopter maintenance will be undertaken by contractors in line with manufacturers and regulatory requirements. • The number of vessels utilising DP will be minimised and restricted to supply and anchor handling vessels.

Notes: [1] PAM equipment can be used with reasonable effectiveness during mitigation for some cetacean species. The harbour porpoise and other small odontocetes (e.g. porpoise species and *Cephalorhynchus dolphins*) are known to emit regular high-frequency echolocation clicks. If these clicks are detected, then animals are generally within a few hundred metres of the PAM system. However, research has shown that aside from these species, the use of PAM equipment for mitigation purposes for other cetaceans should not be considered to represent a reliable sole method but rather supplementary to the use of MMOs (MMOA, 2012)

Drilling, rock-placement, vessel activity and trenching are in general not considered by (JNCC, 2010) to pose a high risk of injury or non-trivial disturbance. The noise impact assessment undertaken supports this view, showing that there is unlikely to be any significant impact on any marine species. It is therefore considered unlikely that further mitigation measures will be required.

8 Conclusions

Sound levels associated with the Talbot Development Project attenuate to ambient levels within a few kilometres of the sound source. As such it is unlikely that sound produced by the Talbot Development installation activities or the production operations would have any effect on fish behaviour that would be noticeable at a population level when considering the limited spatial extent of the sound generated and the generally fluid, mobile nature of fish populations.

The proposed Talbot Development is over 273 km southwest of the nearest UK coastline (Peterhead) so it is unlikely that grey and common seals would be regularly found in the vicinity of the proposed development.

Records indicate previous sightings of up to six cetacean and two pinniped species within the study area during the year. These species are all subject to regulatory protection from injury and disturbance.

The predicted cumulative source sound level during the piling operations is 218 dB re 1 µPa m, only when a pile is being driven into the seabed. Comparison with the frequency-weighted SEL thresholds suggest worst case impact radii of 1.1 km for PTS onset, 5.9 km for TTS-onset and 10.5 km for behaviour disturbance, all of which relate to high-frequency cetaceans. This is for a worst-case scenario of 2,400 strikes per pile for the drilling template and completion of its installation (4 piles) within 24 h. To reduce the impact radii using this metric to approximately within the confines of the 500 m exclusion zone (526 m) would require that only one pile be driven per 24 h period. This represents < 0.1 % of the reference population of any one of the marine mammal species in the UK being impacted, assuming that the individuals were to remain stationary during the whole piling activity.

The contribution of surface vessels to the cumulative noise levels of the piling operations dominates the 1/3-octave level (TOL) spectrum at low frequencies up to about 100 Hz but is negligible at higher frequencies. At low frequencies where the only noise source is from vessels, the cumulative noise level is outwith the hearing range of most species except low-frequency marine mammals such as minke whales. Sound at frequencies between 100-630 Hz will cause the greatest impact as it is both at its loudest and it is within the most susceptible range for low-frequency marine mammals. Depending on ambient noise levels, sensitive marine mammals may be locally displaced by noise from a vessel in its immediate vicinity, or by any other continuous noise source during the offshore construction activities at the Talbot Development, however, the impact is not expected to be significant.

Harbour has an Environmental Management System (EMS) that applies to all oil and gas activities. The proposed activities described in this report will be carried out in accordance with this management system and with Harbour's policy and procedures.

Harbour will re-assess the piling noise levels and the possible impact on protected species closer to the start of the activities and discuss the results with JNCC. Agreements will then be made to put in place appropriate mitigation measures.

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ANNEX

A.1 Underwater Noise Model

A.1.1 Noise Quantification

Sound propagation from the source was determined using the Marsh-Schulkin model (Schulkin and Mercer, 1985). This model applies to acoustic transmission in shallow water (up to 100 fathoms or about 185 m) and represents sound propagation loss (transmission loss, TL) in terms of sea state (wave height), substrate type (bottom loss), water depth, frequency and the depth of the mixed layer.

Received sound pressure levels, L_r, can be determined from the source level, L_s, and the transmission loss, TL (all in dB *re* 1 µPa m):

$$L_r = L_s - TL$$

Equation 10

A reference parameter, the refractive cycle or skip distance is included, which is a function of the water depth, D and L, the depth of the mixed layer.

The skip distance (H in km) is defined as

$$H = \left(\frac{D + L}{3}\right)^{\frac{1}{2}}$$

Equation 11

Consideration is given to the deflection of energy into the seabed at high angles by scattering from the sea surface and the model also uses a simplified Rayleigh two-fluid model of the seabed for sand or mud sediments.

The model allows for the gradual transition from spherical spreading in the near-field to cylindrical spreading in the far-field. The near-field model is used when the range (R in km) between the source and the receiver is less than or equal to H.

$$L_r = L_s - (20\log_{10}(R) + \alpha R - k_L + 60)$$

Equation 12

For intermediate ranges with $H < R \leq 8H$

$$L_r = L_s - \left(5\log_{10}(H) + 15\log_{10}(R) + \alpha R + a_t\left(\frac{R}{H} - 1\right) - k_L + 60\right)$$

Equation 13

For the far-field, where $R > 8H$

$$L_r = L_s - \left(10\log_{10}(H) + 10\log_{10}(R) + \alpha R + a_t\left(\frac{R}{H} - 1\right) - k_L + 64.5\right)$$

Equation 14

where α is the absorption coefficient in seawater (dB/km) which varies frequency, temperature, salinity and pH, as sourced from the National Physical Laboratories on-line calculator[4], k_L (dB) is the near-field anomaly, and a_t (dB) is the attenuation factor.

A summary of the model input parameters is given in Table A.1.

Table A.1. Summary of model input parameters

Parameter	Value
Water depth	Approximately 75 m.
Layer depth	Approximately 0 m
Pile diameter	0.610 m outer diameter: manifold and drilling template
Hammer blow rate, strikes per minute	Specification of the Hydraulic Hammer states 50 blows/min at a max blow energy on the pile of 90 kJ.
Piling operations per 24 h period	Manifold: 22 m piles with a target penetration depth of 17 m below the seabed. Assuming 30 blows/0.25 m would result in 2040 blows per pile. Given a rate of 50 blows/minute, should take ~41 minutes to drive each pile to the target depth. Total blows for Manifold = 8160 blows. Drilling Template: 28 m piles with a target penetration depth of 20 m below the seabed. Assuming 30 blows/0.25m would result in 2400 blows per pile. Given a rate of 50 blows/minute, should take ~48 minutes to drive each pile to the target depth. Total blows for Drilling Template = 9600 blows
Near-field anomaly	Worst-case 7 dB at sea state 0[1].
Seabed substrate	Sand
Frequency range	Pile driving: 0.031 - 20 kHz; highest noise levels from 0.1 to 1 kHz Vessels: 0.005 to 16 kHz; highest noise levels from 0.125 to 1.25 kHz[2]
Source level (varies with frequency)	Pile driving: maximum ~218 dB re 1 µPa m (zero-to-peak) at 1 kHz Vessel: maximum ~196 dB re 1 µPa m (zero-to-peak) at 0.08 kHz[2]

Sources: [1]Urick (1983); [2]Hallett (2004)

Received sound levels have been modelled for sea state 0 as this gives the most conservative comparisons to the hearing thresholds of marine mammals.

Threshold levels for PTS/ injury and TTS in marine mammals and fish were substituted for the received sound levels, L_r.

A.1.2 Scattering and Reflection

Scattering of sound from the surface and bottom boundaries and from other objects is difficult to quantify and is site specific but is extremely important in characterising and understanding the received sound field. Reflection, refraction and diffraction from gas bubbles and other inhomogeneities in the propagating medium serve to scatter sound and will affect TL. Since the inhomogeneities in water are very small compared to the wavelength of the signal, this attenuation-effect will mostly contribute when the signals encounter changes in bathymetries and propagate through the sea floor and the subsurface.

[4] http://resource.npl.co.uk/acoustics/techguides/seaabsorption/

For complex bathymetries, the calculation complexity increases, as individual portions of the signal are scattered differently. However, if the acoustic wavelength is much greater than the scale of the seabed non-uniformities, as is most often the case for low-frequency sounds, then the effect of scattering on propagation loss is negligible. Scattering loss occurring at the surface will also increase with sea state.

The bottom type in the project area is predominantly sand and is expected to result in comparatively higher attenuation rates with increased distance from the source. The near field anomaly (k_L) which describes attenuation in the acoustic nearfield is dependent on sea state and bottom conditions. The anomaly term is related to the reverberant sound field developed near the source by surface and bottom reflected sound energy resulting in an apparent increase in received sound levels in proximity to a source.

Values for the attenuation factor and the near-field anomaly parameters used in the Marsh-Schulkin model were only available for frequencies of 0.1 to 10 kHz (Urick, 1983) p178, Table 6.2).

A.1.3 Cut-off Frequency

The cut-off frequency, below which no sound propagation is possible, is determined based on the type of bottom material and water column depth. This limiting frequency (f_c) can also be calculated if the speed of sound in the sediment (c_s) is known (Urick, 1983) and the speed of sound of the seawater (c_w) are known using the following equation:

$$f_c = \frac{c_w}{4h}\left(\frac{1}{\sqrt{1 - {c_w}^2/{c_s}^2}}\right)$$

Equation 15

where f_c is critical frequency, h is water depth in the direction of sound propagation, and c_w and c_s are the speed of sound in water and in sediment, respectively.

In the Project Area, the speed of sound in the sediment is larger than in water, where it is approximated at 1,500 m s^{-1}. Values for speed of sound in sediment will range from 1,650 m s^{-1} in muddy sand to 1,800 m s^{-1} in predominantly sandy areas (Sutton et al., 2013). For example, at a 75 m water depth, the cut-off frequency f_c is approximately 10 Hz. This means that for underwater noise generated during construction activities, no sound can propagate below this cut-off frequency and therefore cannot be detected except at very close ranges.

A.1.4 Cumulative Sound Levels During Piling Operations

Source levels resulting from a study giving the average of ten merchant ships during entry or exit to port were used as a basis for this assessment (Hallett, 2004; note that the standard deviation was given as 5 to 10 dB).

The contribution of the vessels to the cumulative noise levels of the piling operations dominates the 1/3-octave level (TOL) spectrum at low frequencies up to about 100 Hz but is negligible at higher frequencies (Figure A.1.). At low frequencies where the only noise source is from vessels, the cumulative noise level is outside of the hearing range of most species except low-frequency marine mammals such as minke whales. Sound at frequencies between 100-630 Hz will cause the greatest impact as it is both at its loudest and it is within the most susceptible range for low-frequency marine mammals.

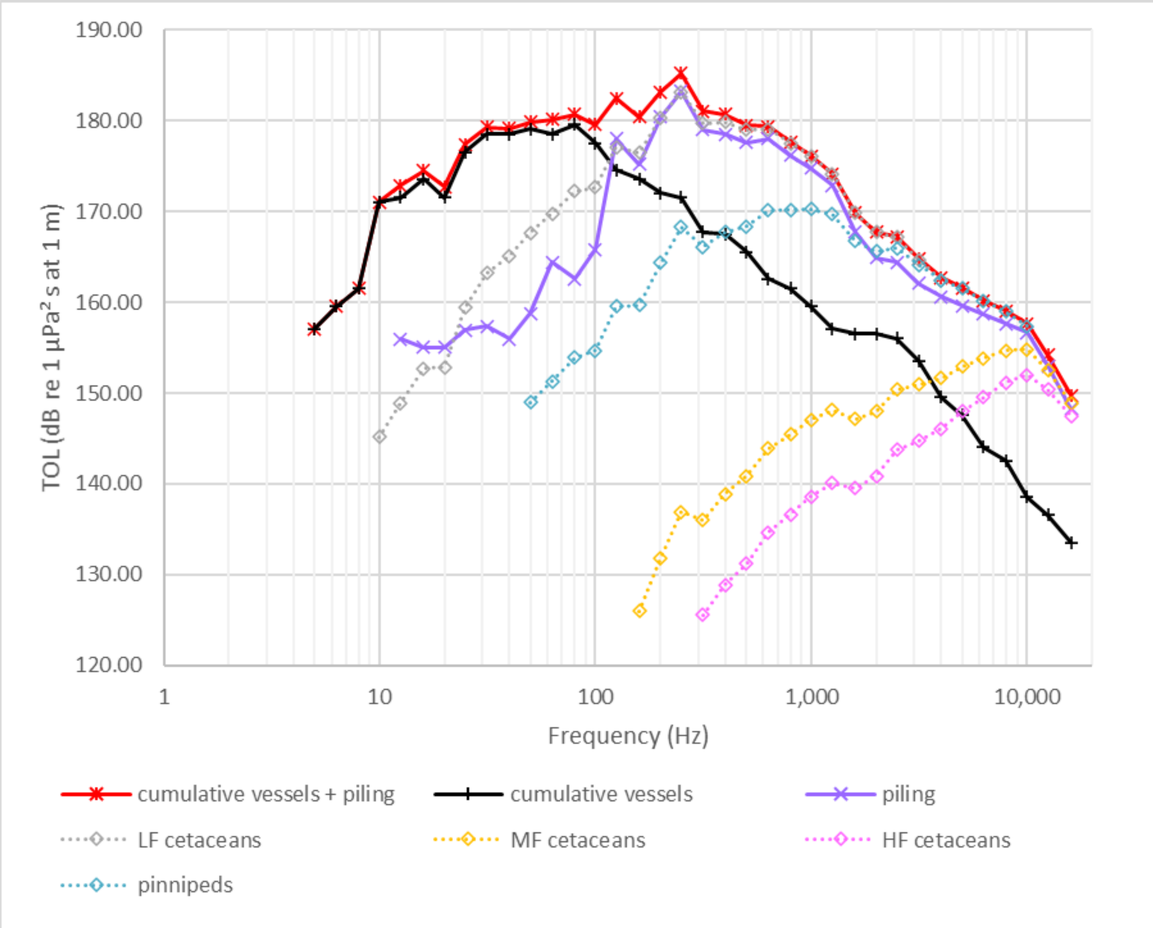

Figure A.1 Cumulative noise source levels (SL) during piling operations. Note that the vessels' SL (after Hallett, 2004) is the cumulative total for all six vessels that may to be on site during the piling operations. Also shown is the unweighted single strike sound exposure level (SEL_{ss}) for piling (after Tetra Tech, 2012) and the weighted $SEL_{ss,}$ using the auditory weighting functions for each marine mammal hearing group (National Marine Fisheries Service, 2018)

A.2 Underwater Noise Modelling Results

Sound propagation from the source was determined using the Marsh-Schulkin model for SPLs. The estimated radii of displacement for this study all lie within the near-field.

A.2.1 Piling of the Drilling template

Table A.2. summarises the received sound level thresholds and consequent impact radii for each marine mammal and fish category according to the impact thresholds of NOAA (National Marine Fisheries Service, 2018), Southall et al. (Southall et al., 2019, 2007) and Popper et al. (Popper et al., 2014) for the drilling template installation.

A.2.2 Piling of the manifold

Table A.3. summarises the received sound level thresholds and consequent impact radii for each marine mammal and fish category according to the impact thresholds of NOAA (National Marine Fisheries Service, 2018), Southall et al. (Southall et al., 2019, 2007) and Popper et al. (Popper et al., 2014) for the manifold installation.

Table A.2. Summary of impact thresholds and radii for marine mammal and fish categories for the worst case piling of the drilling template.

Receptor	Behaviour		TTS				PTS			
	SEL_{24h} Threshold (dB re 1μPa^2 s)	Isopleth to threshold (m)	SEL_{24h} Threshold (dB re 1μPa^2 s)	Isopleth to threshold (m)	L_{pk} Threshold (dB re 1μPa m)	Isopleth to threshold (m)	SEL_{24h} Threshold (dB re 1μPa^2 s)	Isopleth to threshold (m)	L_{pk} Threshold (dB re 1μPa m)	Isopleth to threshold (m)
Pinnipeds	165	5,776	170	3,248	212	4.7	185	578	218	2.4
High-frequency cetaceans	135	10,526	140	5,919	196	29.8	155	1,053	202	14.9
Mid-frequency cetaceans	165	756	170	425	224	NA	185	76	230	NA
Low-frequency cetaceans	163	9,232	168	5,191	213	4.2	183	923	219	NA
	TTS		Recoverable injury				Mortality and potential mortal injury			
Fish (swim bladder involved in hearing)	186	654	203	92	207	8.4	207	58	207	8.4
Fish (swim bladder not involved in hearing)	186	654	203	92	207	8.4	210	41	207	8.4
Fish (no swim bladder)	186	654	216	21	213	4.2	219	15	213	4.2

Greatest Impact Range (m)	Behaviour	10,526	TTS	5,919	PTS	1,053

Table A.3. Summary of impact thresholds and radii for marine mammal and fish categories for the worst case piling of the manifold.

Receptor	Behaviour		TTS				PTS			
	SEL_{24h} Threshold (dB re 1µPa^2 s)	Isopleth to threshold (m)	SEL_{24h} Threshold (dB re 1µPa^2 s)	Isopleth to threshold (m)	L_{pk} Threshold (dB re 1µPa m)	Isopleth to threshold (m)	SEL_{24h} Threshold (dB re 1µPa^2 s)	Isopleth to threshold (m)	L_{pk} Threshold (dB re 1µPa m)	Isopleth to threshold (m)
Pinnipeds	165	5,325	170	2,995	212	4.7	185	533	218	2.4
High-frequency cetaceans	135	9,704	140	5,457	196	29.8	155	970	202	14.9
Mid-frequency cetaceans	165	697	170	392	224	NA	185	70	230	NA
Low-frequency cetaceans	163	8,511	168	4,786	213	4.2	183	851	219	NA

	TTS		Recoverable injury				Mortality and potential mortal injury			
Fish (swim bladder involved in hearing)	186	603	203	85	207	8.4	207	54	207	8.4
Fish (swim bladder not involved in hearing)	186	603	203	85	207	8.4	210	38	207	8.4
Fish (no swim bladder)	186	603	216	19	213	4.2	219	14	213	4.2

Greatest Impact Range (m)	Behaviour	9,704	TTS	5,457	PTS	970

Appendix D

Talbot Oil Spill Modelling Technical Note, 2019

Talbot Development Project – Oil spill modelling assessment Technical Note

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Contents

1.0 INTRODUCTION

BMT has been commissioned by ConocoPhillips (U.K.) Limited (ConocoPhillips, hereafter) to undertake an oil spill modelling assessment in support of drilling applications in the North Sea associated with the proposed Talbot Development.

The proposed Talbot Development is located in the United Kingdom Continental Shelf (UKCS) Block 30/13, in the central North Sea (CNS). The majority of proposed Talbot Development infrastructure is located in Block 30/13e, approximately 278 km southeast of Peterhead on the Scotland's east coast, 7 km west of the UK/ Norway median line, and approximately 20 km south-east of the existing Judy platform to which the Talbot Development will connect. The pipeline connecting the Talbot Development with the Judy platform is likely to be located in Blocks 30/13, 30/12 and 30/7.

In general, use of oil spill modelling outputs provides a conservative assessment of potential impacts but allows for an estimation of the probability and mass of oil beaching and the potential time for any spilt hydrocarbons to reach land from a defined offshore event; for example, a hypothetical long-term loss of control of a wellhead (well blowout) that would be described as the worst-case scenario.

In this study, oil spill modelling was conducted using SINTEF's Oil Spill Contingency and Response (OSCAR) v11.0 (latest version) software.

An essential aspect of any oil spill model is the ability to represent accurately the environment into which oil may be released. The geography, topography and bathymetry, oceanography and meteorology are all important factors influencing the transport and fate of oil released to the marine environment. OSCAR is an oil spill model supporting several model modalities, generally characterised as either deterministic or stochastic:

- Deterministic modelling simulates a spill scenario under a specific single set of metocean conditions. The model provides output on a map indicating the trajectory of the oil, the area of the slick, presence of oil in the water column and sediments, and beaching locations of the spill after a specified period.
- Stochastic modelling allows the simulation of a spill scenario under several different probable metocean conditions, i.e. a variety of wind and ocean current speed and direction. This modality provides likelihood outputs, as contour plots showing the probability of surface, water column and shoreline oiling, as well as the probability of oil beaching at potential locations.

The OSCAR model simulates the trajectory, fate, weathering and dispersion of oil in three dimensions by combining:

- Three-dimensional transport processes acting on the oil due to the currents, wind, waves, dispersion in the marine environment along with advection from local plume dynamics (buoyancy, momentum, turbulence and thermal processes); and
- Weathering processes to determine changes in oil physical properties as it weathers; including algorithms for spreading, evaporation, dissolution, emulsification, entrainment in sediments and natural degradation of hydrocarbons.

This study assessed one hypothetical spill scenario, as defined by ConocoPhillips. The scenario consisted of a well blowout representing the worst-case outcome for the several wells planned from Drill Centres 1 and 2. The two centres are expected to be within a few hundred metres of each other. The requirement of two drill centres is not primarily driven by subsea target facilitation but to allow the rig to cantilever and drill without having to undertake additional rig moves which are expensive and can be technically challenging with overlapping spudcan locations from a stability point of view. The Talbot reservoir target is the same regardless of the drill centres the wells are drilled from and the reservoir hydrocarbon will have the same properties with no more variation than would be normally be expected from a reservoir location. It is believed that the wells are sufficiently close in the scale of oil release to make selection of modelling on well or top-hole location immaterial, in terms of being closer to protected sites, transboundary lines or coastline. The worst case well selected for modelling was that with the highest flow potential.

Moreover, since a jack up rig with a BOP on the rig floor will be used for the drilling operations, a surface spill was modelled (as opposed to a seabed released when the BOP is on the sea floor). In addition, it was assumed within the modelling that no oil spill response would be undertaken, which is not expected to be the case in a real incident.

2.0 MODEL CONFIGURATION

This section provides an overview of the parameters and forcing datasets applied within the model to define the environmental and oil characteristics.

2.1 Metocean Data

Metocean data used in this project was supplied by Oil & Gas UK. Although the dataset of currents does not reflect diurnal tidal variations and the wind grid is relatively coarse, it is considered an acceptable dataset for long range oil spill modelling in environments far from the shore as here.

2.2 Oil Type Properties

To consider weathering of oil within its model, OSCAR contains a database of physical and chemical information for over 100 oil types. A matching of the oil characteristics of the expected specified crude (specific gravity, API gravity, viscosity, pour point, wax and asphaltene contents) was carried out with the oils from the OSCAR oil database.

Because Talbot Oil has a pour point which is high (9°C) and the average ambient temperature in the North Sea is very close to that number (around 10°C on an annual average), it was decided to conduct a sensitivity analysis. The choice of the oil analogue is one of the most important parameter for this modelling. Four scenarios were considered for which all the parameters were unchanged except for the oil analogue and/or the ambient temperature. Simulations were run in deterministic mode and for each scenario, the output were analysed. The mass balance and the fate of submerged contaminants were not significantly affected by these two different oil analogues and/or the changes in temperatures. Therefore, it was decided to run the stochastic simulations for each season with the oil analogue YME (IKU - the Norwegian Department of Continental Shelf Research) because it has composition and properties matching that of Talbot oil. It also has the highest Pour Point of the two analogues, which is expected to result in a closer weathering behaviour to that of Talbot oil. It is believed that the 'YME (IKU)' oil got its name from the 'Yme' oil field in the Central part of the North Sea.

The model parameters can be seen in (Table 2.1).

It was also decided to apply to the stochastic simulations different average temperatures for each season as follows:

- Winter: Air 4°C and Water (upper column) 7.4°C;
- Spring: Air 8.7°C and Water (upper column) 9.4°C;
- Summer: Air 12.5°C and Water (upper column) 13°C; and
- Autumn: Air 6.3°C and Water (upper column) 10.7°C.

These averages were taken from the websites:

- Sea temperatures: https://www.seatemperature.org/europe/united-kingdom/orkney-february.htm
- Air temperatures: https://www.metoffice.gov.uk/research/climate/maps-and-data/uk-climate-averages/

2.3 Modelling configuration

The key inputs and modelling parameters for the proposed scenario are summarised in Table 2.1. Gridding and further detail on the modelling configuration are summarised in Table 2.2.

Table 2.1: Inputs and parameters used in the stochastic modelling of a worst-case well blowout

Modelled oil release for Well Blowout						
Oil name		Talbot Oil		Assay available	No	
Analogue oil modelled		YME (IKU)		Analogue oil source	OSCAR database	
Oil Matching Comparison						
Name	ITOPF Group	SG/ API	Viscosity (cP)	Pour Point (°C)	Wax Content (%)	Asphaltene Content (%)
Talbot Oil	2	0.82/ 41.0	0.157	9.0	6.6	0.5
YME (IKU)	2	0.833/ 38.4	4.0	6.0	5.9	0.3
Inventory Loss Parameters						
Release source		Well blowout	Unconstrained flow rate		Not given	
Worst case volume		1,000,000 bbl	Justification		Release rate over 90 days	
Anticipated well self-kill (days)			Unlikely to self-kill within relief well drill timings			
Depth			78 m (see comment after this table)			
Metocean Parameters						
Air temperature (°C)		4–13*	Sea surface temperature (°C)		7–13*	
Wind data (years covered)		2009–2014	Wind data reference		European Centre for Medium-Range	

Modelled oil release for Well Blowout			
			Weather Forecasts (ECMWF)
Current data (years covered)	2009–2014	Current data reference	Hybrid Coordinate Ocean Model (HYCOM)
Modelled Release Parameters			
Latitude (WGS 84)	56˚ 35' 7.73087"N	Longitude (WGS 84)	2˚ 28' 30.00622"E
UKCS Block	30/13e	Type of release	Well blowout
Release volume	1,000,000 bbl	Release duration assumed to be arrested after 90 days, as indicted by worst case relief well drilling estimated timings.	
Release duration	90 days		
Total simulation time	120 days		
Release period	Multi-year statistic		
Number of simulations for each season	25 per year	Total number of simulations for each season	100
Oil Spill Modelling Software Used		OSCAR (Marine Environmental Modelling Workbench v11)	

Note: * The temperatures presented represent the range of conditions. The stochastic analysis uses a North Sea regional dataset of surface and seabed water temperatures that varies according to the simulated release period.

A jack up drilling rig with a BOP on the rig floor will likely be used for this project, so it was decided to apply a release depth of 0.05 m under the mean sea surface. The total simulation time included a run-on period of 30 days more than the total release time to allow the model to simulate the dispersion of the oil.

Table 2.2: Gridding and time-step configuration for modelling the well blowout

Parameter	Well blowout
Approximate grid cell size	1,000 × 1,000 m^2
Number of particles	Liquid/ solid: 10,000
	Dissolved: 3,000
	Gas: 1,000
Model time step	1 h
Output time step	3 h

3.0 RESULTS

The key results and figures for both stochastic and deterministic modelling are presented in this section.

3.1 Stochastic Modelling Outputs

A summary of the stochastic modelling results is presented in Table 3.1. Table 3.2 demonstrates the potential arrival time of surface oil following a well blowout. Table 3.3 presents the shortest predicted time and probability for shoreline oiling along the shorelines throughout the North Sea.

Table 3.1: Stochastic modelling results summary for the well blowout scenario by season

Scenario description	Months	P50 Mass of oil on shore (tonnes)	P50 shoreline arrival time (days)	Probability of shoreline oiling (%)	Maximum mass accumulating on shore in a simulation (tonnes)	Minimum time of arrival (days)
Winter	December–February	0.5	63.5	83	11.7	25.3
Spring	March–May	7.6	74.1	91.0	89.7	31.8
Summer	June–August	16.6	47.9	95.0	63.7	24.0
Autumn	September–November	0.5	51.8	85.0	12.8	24.5

Figure 3.1 shows the probability of surface oiling by season, Figure 3.2 shows shortest time of arrival of oil by season and Figure 3.3 shows the probability of water column contamination by season.

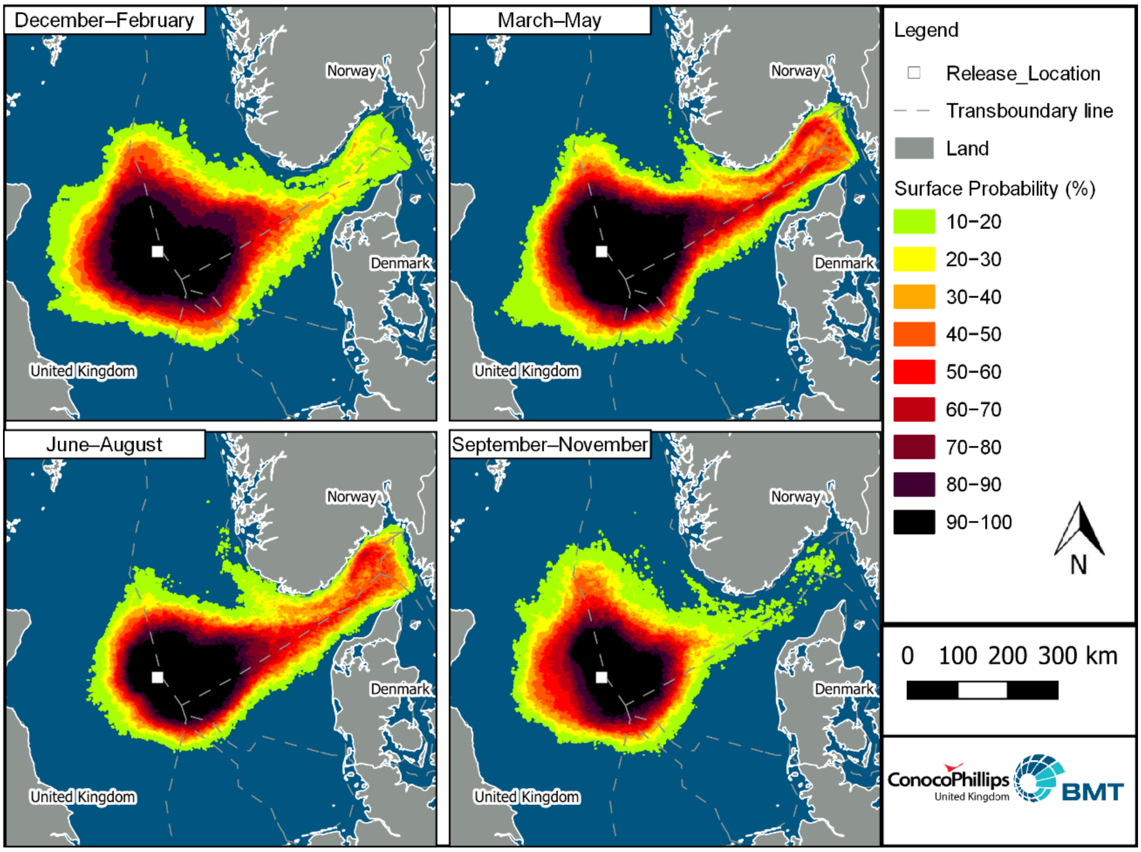

Figure 3.1: Predicted probability of surface oiling for the well blowout scenario by season

It should also be noted that when comparing the output results the probabilities for surface and shoreline oilings are calculated and stored independently from each other.

The threshold applied to surface oiling is 0.3 microns and will have no effect on the shoreline oiling probability outputs. The minimum volume threshold applied to shoreline oiling is 1 kg. Table 3.3 summarises the probability and arrival time for shoreline oiling in this well blowout scenario. The highest probability in the UK is 2% affecting the Grampian coast and Yorkshire and the Humber in the autumn season. In the member states, the highest probability is 35% affecting Western Norway in the summer season.

Table 3.2: Shortest time (days) of surface oil to shoreline, and probability of crossing, the median line in the well blowout scenario, per season

Member States	Dec–Feb	Mar–May	Jun–Aug	Sep–Nov
Norwegian Waters	90–100%	90–100%	90–100%	90–100%
	1–2 days	1–2 days	1–2 days	1–2 days
Danish Waters	90–100%	90–100%	90–100%	90–100%
	4–7 days	4–7 days	4–7 days	4–7 days
Swedish Waters	20–30%	50–60%	50–60%	10–20%
	>30 days	20–25 days	20–25 days	25–30 days
German Waters	90–100%	90–100%	90–100%	70–80%
	7–10 days	7–10 days	7–10 days	10–14 days
Dutch Waters	90–100%	90–100%	60–70%	50–60%
	7–10 days	7–10 days	7–10 days	10–14 days
Faroese Waters	<10%	<10%	<10%	<10%
	NA	NA	NA	NA

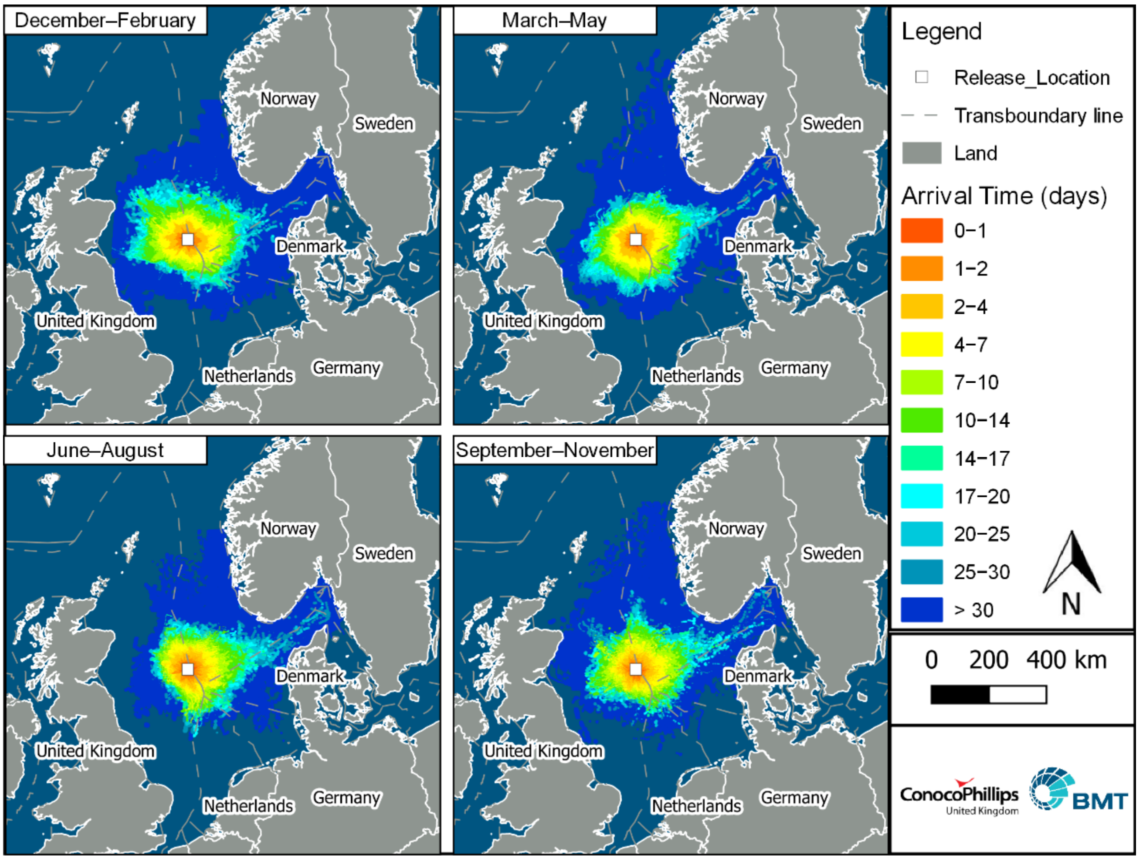

Figure 3.2: Predicted shortest time of arrival of oil for the well blowout scenario by season

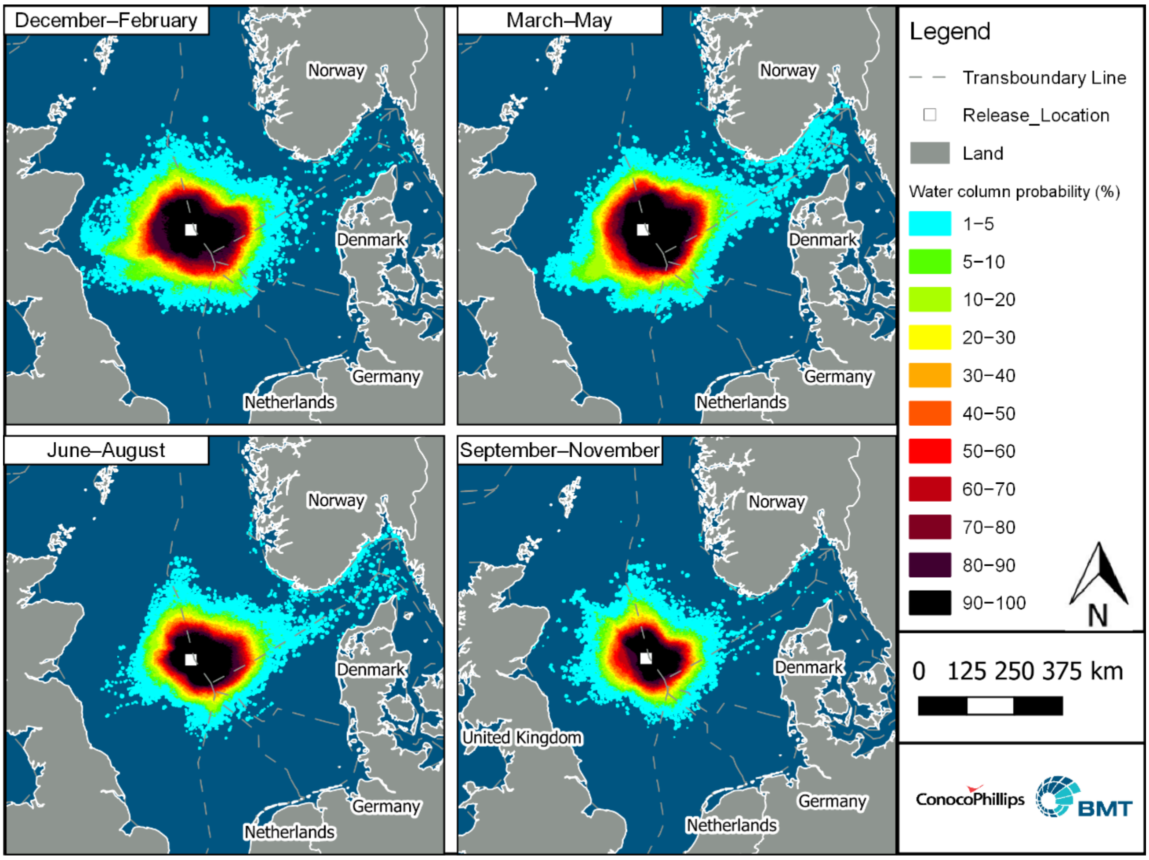

Figure 3.3 Predicted probability of water column contamination for the well blowout scenario by season

Table 3.3: Probability (%) and arrival time (days) for shoreline oiling in the well blowout scenario

Shoreline	Dec–Feb	Mar–May	Jun–Aug	Sep–Nov
United Kingdom				
Scotland				
Shetland	<1%	<1%	<1%	<1%
	NA	NA	NA	NA
Orkney	<1%	<1%	<1%	<1%
	NA	NA	NA	NA
Highlands	<1%	<1%	<1%	<1%
	NA	NA	NA	NA
Grampian	<1%	<1%	<1%	2%
	NA	NA	NA	>30 days
Tayside to Lothian	1	1%	<1%	<1%
	NA	>30 days	NA	NA
Borders	<1%	<1%	<1%	<1%
	NA	NA	NA	NA
England				
North East	1%	<1%	<1%	<1%
	>30 days	NA	NA	NA
Yorkshire and The Humber	1%	<1%	<1%	2%
	>30 days	>30 days	NA	>30 days
Member States				
Western Norway	9%	32%	35%	8%
	> 30 days	> 30 days	27.5	24
Western Denmark	8%	13%	17%	6%
	>30 days	>30 days	>30 days	>30 days
Western Sweden	3%	8%	23%	2%
	>30 days	>30 days	>30 days	>30 days
Western Germany	1%	<1%	1%	<1%
	>30 days	NA	>30 days	NA
Northern Netherlands	<1%	<1%	<1%	<1%
	NA	NA	NA	NA
Maximum volume * accumulated onshore in any one simulation (m^3)	14	108	76	15

Note: * Maximum volumes ashore were calculated using the density of the analogue oil (0.833 $kg.m^{-3}$)

3.2 Deterministic Modelling Outputs

Two deterministic simulations were carried out to evaluate the full mass balance using the worst-case output from the stochastic modelling assessment; these were the simulations:

- With the shortest time of arrival (worst-case A) across simulations carried out in all seasons in this scenario (Figure 3.3).
- With the highest mass ashore (worst-case B) across simulations carried out in all seasons in this scenario (Figure 3.4).

Results for worst-case A: with the shortest time of arrival

The results in Figure 3.3 show that 35% of the oil mass evaporated after 1 day and over time, a significant fraction is dissolved or decayed in the water column. By the end of the simulation (120 days), 7% of the oil mass was decayed and 48% of the oil mass evaporated to the atmosphere. This leaves no significant proportion of the oil on the water surface and 45% settled on the seabed. Maximum volumes ashore have been calculated using the density of the analogue oil (0.833 kg.m^{-3}) in the deterministic simulation after 120 days.

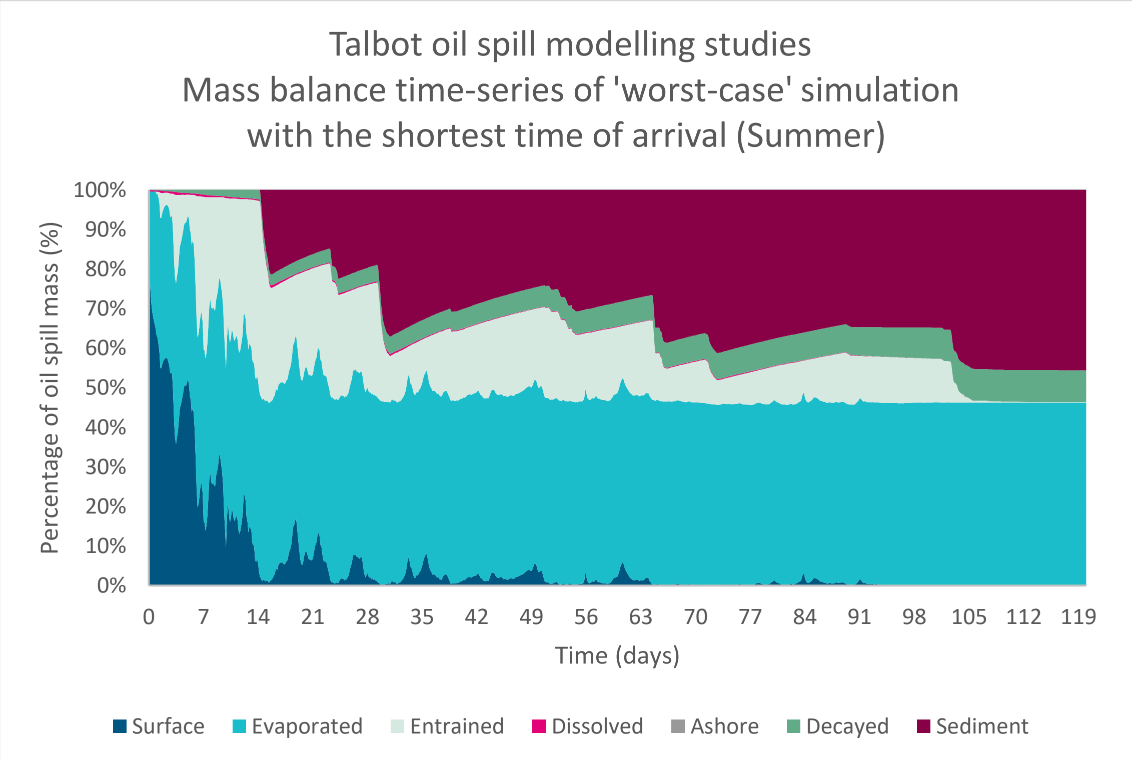

Figure 3.3: Mass balance of the simulation with the shortest time of arrival for this well blowout scenario. Weathering fates are presented by colour.

Results for worst-case B: with the highest mass ashore

The results in Figure 3.4 show that 32% of the oil mass evaporated after 1 day and a significant fraction is dissolved or decayed in the water column over time. By the end of the simulation (120 days), 10% of the oil mass was decayed and 50% of the oil mass evaporated to the atmosphere. This leaves no significant proportion of the oil on the water surface, 35% settled on the seabed and 5% entrained. Maximum volumes ashore have been calculated using the density of the analogue oil (0.833 kg.m^{-3}) in the deterministic simulation after 120 days.

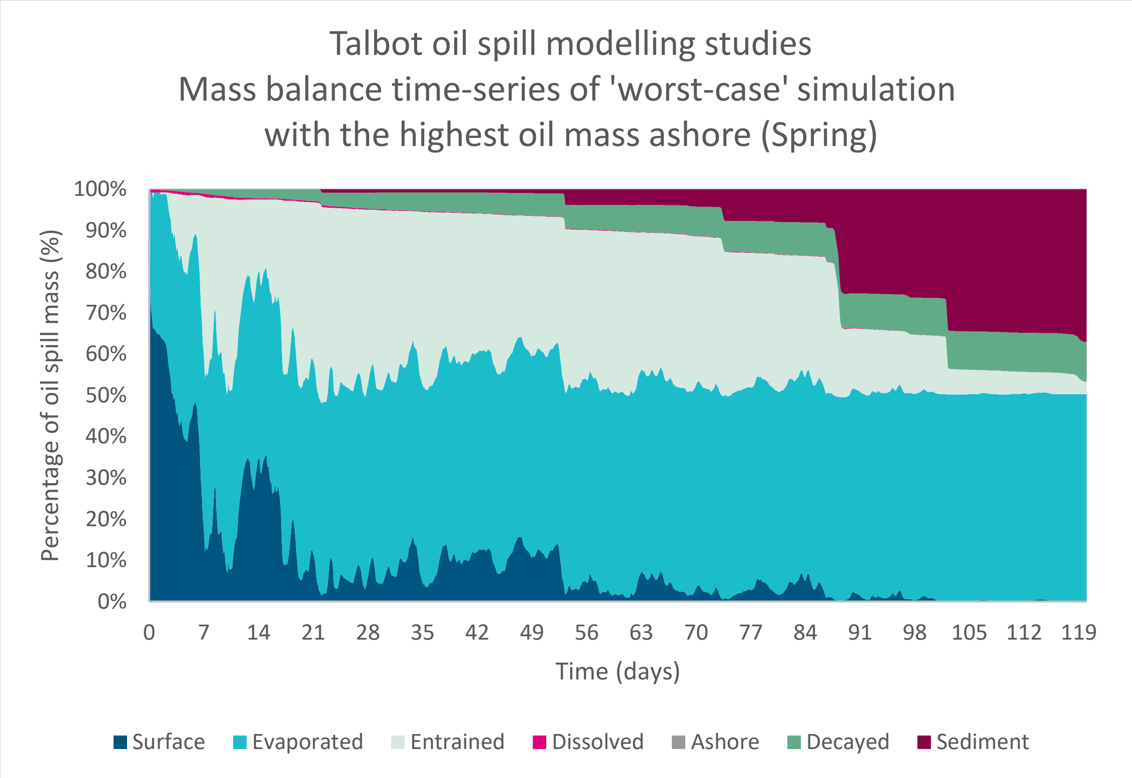

Figure 3.4: Mass balance of the simulation with the highest mass ashore for this well blowout scenario. Weathering fates are presented by colour.

4.0 POTENTIAL IMPACTS SUMMARY

The potential impacts of the proposed scenarios are outlined in Table 4.1.

Table 4.1: Potential impacts summary for the proposed hydrocarbon spill scenarios

Environmental receptor	Impact description
Plankton	Oil is toxic to a wide range of planktonic organisms. Those living near the sea surface are particularly at risk, as water-soluble components leach from floating oil. Although oil spills may kill individuals, the effects on whole plankton communities appear to be short-term according to some studies; however, more data are required to make a robust assessment of the effects of oil pollution on phytoplankton. Following an oil spill incident such as a well blowout from a Talbot Development well, plankton biomass may fall dramatically, due either to animal deaths or avoidance of the area.

Environmental receptor	Impact description
Benthos	The seabed in the local area is mainly characterised by sandy sediments. Suspension feeders gather nutrients directly from seawater and would, therefore, take in any oil present within the surrounding water as would be the case in a well blowout. This leaves these organisms more vulnerable to the toxic effects of oil dispersed in the water column. Deposit feeders such as tubeworms are supported by the fine organic matter trapped between the fine sediments and, therefore, these animals would only be affected if the oil settles or is entrained into sediments.
Fish and shellfish	Fish eggs and larvae are more vulnerable to oil pollution than adult fish. In many fish species, these stages float to the surface where contact with spilt oil is more likely. Near the proposed Talbot Development, there are spawning areas for cod (*Gadus morhua)*, lemon sole (*Microstomus kitt*), mackerel (*Scomber scombrus*), Norway pout (*Trisopterus esmarkii*), plaice (*Pleuronectes platessa*) and sandeel (*Ammodytes marinus*). Mackerel and Norway pout have high concentration spawning within ICES rectangle 42F2. There are also nursery areas for anglerfish (*Lophius piscatorius*), blue whiting (*Micromesistius poutassou*), cod, European hake (*Merluccius merluccius*), haddock (*Melanogrammus aeglefinus)*, herring (*Clupea harengus*), mackerel , Norway pout, plaice, sandeel, spotted ray (*Aetobatus narinari*), spur dog (*Squalus acanthias*), ling (*Molva molva*), and whiting (*Merlangius merlangus*) within ICES rectangle 42F2 where cod has a high nursery intensity. Certain fish stocks may be more affected than others, particularly if the spill is very large, coincides with spawning periods or enters the grounds of species with restricted spawning areas.
Marine mammals	Harbour porpoises (*Phocoena phocoena)*, white-beaked dolphins (*Lagenorhynchus albirostris*), minke whales (*Balaenoptera acutorostrata)*, common dolphin (*Delphinus delphis*) and Atlantic white-sided dolphins (*Lagenorhynchus acutus*) have been recorded in the vicinity of the proposed Talbot Development. The most sensitive period for cetaceans in Quadrant 30 and adjacent Quadrants is May to November, with peak density in July. Cetaceans and seals are generally accepted to be able to avoid hydrocarbon spills. However, should contact occur, effects include irritation and respiratory problems. Hypothermia effects are generally avoided due to the thick layer of blubber that both cetaceans and pinnipeds possess.
Seabirds	The vulnerability of seabirds to oil pollution in the Talbot Development area varies from low to high throughout the year, with increased vulnerability corresponding to the periods, when coastal bird colonies feed offshore. Physical fouling of feathers and toxic effects of ingesting hydrocarbons can result in fatalities in seabirds. Effects will depend on species present, their abundance and time of year. Seabird sensitivity in the region of the proposed Talbot Development area (Blocks 30/13, 30/12, 30/7 and surrounding blocks) varies from low to extremely high throughout the year. Seabird sensitivity peaks at extremely high in May and June in the surrounding blocks, followed by very high at Block 30/13 in May and June. In the remaining months there is low seabird sensitivity in Blocks 30/13, 30/12, 30/7 and surrounding blocks, with the exception of Block 30/12 in February which has a medium seabird sensitivity. There was no data available in October and November for all blocks within the proposed Talbot Development area, and data for April and December were available for some blocks. Seabirds found within this area of the northern North Sea, including the well location, are most likely migrating on-route to wintering or breeding grounds (season dependent). Consequently, any effects

Environmental receptor	Impact description
	resulting from an accidental hydrocarbon release offshore could be prolonged, of high magnitude and spatial extent.
Rocky shores	Rocky shores are found along the western coast of Norway, which may be significantly affected by an oil spill such as that modelled in this well blowout scenario. They can be very varied in structure, ranging from exposed vertical walls to flat bedrock, or stable boulder fields to aggregations of cobbles. Rocky shores are generally high energy beaches, and while oil may have an impact on the animals and plants which live on them, stranded oil is often quickly removed by wave action and water movement. The vulnerability of rocky shore habitats to oiling is dependent on the type of rocky shore and its exposure. The action of the waves may start to remove the oil from an exposed vertical wall almost immediately, but the oil may remain for longer in more sheltered, kelp dominated areas.
Sedimentary shores	Sedimentary sandy shores are commonly found throughout eastern Scotland and may be affected by the hydrocarbon release scenarios considered here. The fate of oil stranded on sediment shores depends on the nature of the substratum. Due to the increased sediment movement and relatively large gaps between the particles, beached oil can penetrate further into the more mobile shingle or coarse sand shores. These coarse sediment shores tend to be less productive than sheltered mudflats, as the movement of the loose sediment is very abrasive, meaning few animals can survive in it.
Commercial fisheries	If fishing in the area of an oil spill, gear and catch may become fouled with floating oil. Trawling is a key fishing method in the Talbot Development area and therefore, tainting of gear and catch by spilled oil is a risk. This not only causes damage to the nets themselves but contact with fouled fishing gear may also contaminate subsequent catches. The whitefish gear fishery takes the greatest proportion of fish landed from the area around the proposed field development. This trawl fishery operates year-round and therefore, in the unlikely event of an oil spill occurring, nets may be at risk from tainting. Major spills may also result in loss of fishing opportunities with boats unable or unwilling to fish due to the risk of fouling, causing a temporary financial loss to commercial fishermen. Spilled oil reaching the shorelines of Orkney and the Shetland Islands may affect local aquaculture sites as fish are in enclosed areas and cannot avoid incoming hydrocarbon pollution. In addition, tainting of aquaculture fish may damage local economic activity. The hydrocarbon spill scenarios considered here showed high probabilities of reaching the Shetland Islands, therefore impacts on aquaculture in the event of an oil spill from the Talbot Development are possible.
Protected habitats and species	There is the potential for some conservation sites to be impacted by a well blowout (here listed for surface probability presence of >50% in any season). The Fulmar Marine Conservation Zone (MCZ) and the East Gannet and Montrose Fields Nature Conservation Marine Protected Area (NCMPA) may be affected by surface oiling. Figure 4.1 shows the potential oil spill coverage resulting from the Talbot Development activities in relation to designated sites.

Figure 4.1 shows the potential oil spill coverage if a blowout would happen in the area of the Talbot Development. This map displays the total surface contamination layers for all four seasons combined with a probability higher than 50%. It is a useful tool to visualise the proximity of the designated conservation sites to the potential oil spill.

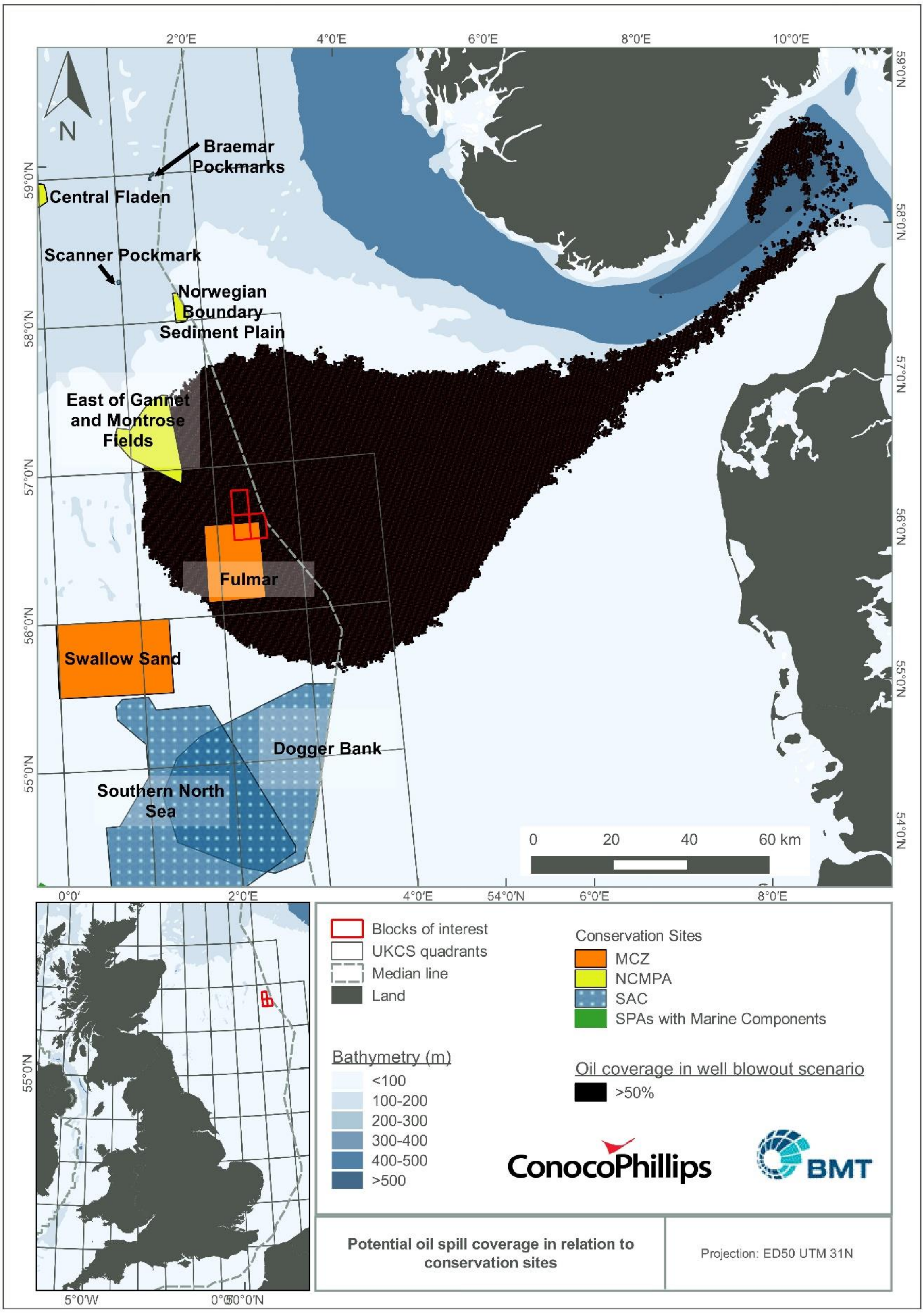

Figure 4.1: Potential oil spill coverage resulting from the Talbot Development activities in relation to designated conservation sites

5.0 CONCLUSIONS

During the Talbot Development Project, there is a number of activities which may result in the accidental release of hydrocarbons. ConocoPhillips recognise the severe impact that such an event may result in, and as such will put in place stringent control procedures and measures.

The assessment undertaken within this technical note has intentionally investigated the worst-case release scenarios (without response measures), using numerical modelling techniques and information contained within the evidence base. The OSCAR (v11) software has been used to assess the behaviour and consequences of a hypothetical accidental hydrocarbon release for a well blowout scenario.

A riser failure or pipeline release were not considered as the well blowout was deemed the worst-case hydrocarbon release. Stochastic modelling assessment was completed for each season using timeseries wind and current data for a representative 5-year period. In addition, the simulation with the shortest arrival time and the highest mass ashore were modelled as two deterministic worst-case outcome.

The modelling results concluded that:

- This well blowout scenario resulted in a potential environmental impact in terms of surface, water column and shoreline oilings;
- The coasts of western Norway and Sweden are predicted to be impacted with the overall shortest arrival time of 24 days for Norway;
- The probability of shoreline oiling is the highest on the western coast of Norway with a probability of 35%; and
- The maximum amount of oil that came ashore in any one simulation is, approximately, 108 m^3 (or 89.7 tonnes), for a simulation starting during spring months.