4.0 CHAPTER D – EVALUATION OF ENVIRONMENTAL IMPACTS EXPECTED TO DEVELOP DUE TO PERFORMANCE OF THE APPLICATION AND MEASURES TO BE TAKEN TO PREVENT/ MINIMISE SUCH

Impact Assessment Methodology

In order to determine the potential impacts associated with the proposed Leviathan Field Development Project, this EIA has been conducted, following a structured methodology for the identification and assessment of environmental impacts. The approach is generally qualitative, although where it has been possible, estimates of some quantitative data such as atmospheric emissions and the area of disturbed seabed/ associated footprint are also provided (refer to Section 3.1and 3.2 respectively).

The EIA has been conducted to ensure inclusion of all those requirements stipulated in the Ministry of Environment Protection Guidelines, 2016 (hereafter referred to as the MoEP Guidelines). Reference is made throughout this Section to the corresponding requirement section presented in these MoEP Guidelines.

For the purpose of this EIA, the following definitions, according to ISO 14001 (Environmental Management Systems), have been employed:

- **Aspect -** elements of an organization's activities or products or services that can interact with the environment.
- **Impact -** any change to the environment, whether adverse or beneficial, wholly or partially resulting from an organization's environmental aspects.

The aspects associated with the full lifecycle of the Leviathan Field Development Project from construction through to decommissioning have the potential to affect the environment in a number of different ways. Project aspects can be categorised into a sequence of planned events that must occur for the project to be successfully completed and during the course of any project there is a risk that, if such activities do not occur as planned, an accidental event may occur. Both planned and accidental events have the potential to give rise to environmental impacts.

The structured methodology that has been systematically applied to this Leviathan Production EIA is as follows:

1. Identify all Leviathan Field Development Project Aspects;
2. Identify and assess the environmental resources likely to be impacted by an Aspect;
3. Assess the likelihood that the environmental aspect(s) will occur;
4. Assess the magnitude/severity of the environmental impact(s) caused by the aspect;
5. Assess the significance of the impact based on the magnitude/severity of the risk and the likelihood of the event occurring; and

6. Report the mitigation measures used to reduce the identified impact(s).

Leviathan Field Development Aspects

The potential environmental impacts assessed in these sections are considered according to the following aspects (project phases and activities):

- Construction and Installation;
- Pre-Commissioning and Commissioning;
- Normal Operations;
- Non-Routine or Accidental Events;
- Decommissioning; and,
- Cumulative and Transboundary Impacts.

Sensitive Receptors

Sensitive receptors were identified by systematically stepping through the different phases of the known (and likely) project aspects which could potentially present an impact. The receptors considered to be relevant to aspects of the Leviathan Field Development Project include:

- Seabed sediment;
- Benthic environment (animals living on or in the seabed);
- Plankton (plant or animals which live in the water column and drift with the ocean currents);
- Fish;
- Seabirds;
- Marine mammals;
- Sea turtles
- Cumulative impacts, including air quality;
- Culture and heritage;
- Waste including hazardous;
- Geological risks;
- Fishing and marine farming;
- Infrastructure safety; and
- Resource monitoring.

Likelihood

The likelihood of an aspect is determined by considering whether the aspect is likely to occur when all management and mitigation measures that have been identified are in place. The likelihood of occurrence of each potential aspect was given a score between one (1) and five (5). A low score [one (1)] indicates that the likelihood of an aspect occurring is low.

Consequence

The magnitude of each potential impact was also rated on a scale of one (1) to five (5); five (5) being the most severe, as shown in Figure 4-1. Where magnitude appeared to fall within two categories, the higher category was selected to provide a worst-case scenario for the purposes of this assessment.

Combining Likelihood and Consequence to Establish Risk

The overall risk posed by each aspect has been assessed using a combination of magnitude and likelihood scores in the Noble Energy Risk Matrix (below) in order to determine what level of risk the proposed activity could pose to receptors in the physical and biological receiving media.

Assessment of Potential Impacts

To support this EIA, an Environmental Identification (ENVID) style process was used to systematically capture activities that may impact on the environment. Environmental impacts are risk ranked and those impacts classified as moderate or high are carried forward for further assessment. The EIA therefore focuses its resources and efforts on the key project concerns. For issues of concern, practicable mitigation measures were agreed through modelling, analysis and the application of Best Available Technique (BAT) assessments, to minimise harm to project affected environments.

Safety and Environmental Management System

Assessment of potential impacts allows for the adoption of means and methods for reduction and prevention of the hazards for those actions that give rise to environmental impacts that are considered to be undesirable. Any impacts that are identified as unacceptable during the impact assessment process will be prevented permanently or reduced to acceptable levels.

Following this impacts assessment process, mitigation measures surrounding the environmental aspects are used to inform the Safety and Environmental Management System (SEMS) as described in Chapter E.

Figure 4-1: Noble Energy Risk Assessment Matrix

Description: Noble Energy, Inc. Global Risk Matrix
Doucment Date: July 1st 2012
Doucment Number:

								INCREASING LIKELIHOOD				
		CONSEQUENCES						1	2	3	4	5
							Historical Occurrence	Never occurred or prevented with standard practices, procedures and safeguards.	Possible to occur but unlikely if standard practices, procedures and safeguards are used.	Likely to occur even if standard practices, procedures and safeguards are used. Additional safeguards are required.	Has occurred in the industry. Additional safeguards are required.	Has occurred in Noble. Additional safeguards are required.
Severity		Health Safety	Environment	Reputation	Financial	Legal	After Controls/Mitigation (Residual)	Controls have historically been highly effective.	Controls have generally been effective previously.	Controls are unproven but are expected to be effective.	Controls have been ineffective previously.	Controls are likely to fail or be ineffective.
5	Very High	One or more fatalities on workforce or fatalities to public. Serious illness or chronic exposure resulting in significant life shortening effects/death to public.	Adverse permanent impacts on key ecosystem functions and services in larger natural habitats (e.g. restitution time > 5 years).	Extensive negative national and some international news coverage. Extensive negative exposure from elected officials, regulators and NGOs.	> $1 Billion US (Example: Substantial damage to facility or major asset resulting in expenses or loss of production)	Criminal prosecution with potential material sanctions against employees/company. Major/multiple civil litigation (e.g. shareholder or class action) with potential material adverse judgment(s) against company.	HEAT MAP	5	10	15	20	25
4	High	Serious illness or chronic exposure resulting in significant life shortening effects to workforce.	Adverse impact on ecologically valuable natural habitats (e.g. restitution time 2-5 years).	Negative national news coverage. Negative exposure from elected officials, regulators, NGOs.	$100 Million - $1 Billion US (Example: Significant damage to facility or major asset resulting in expenses or loss of production)	Criminal prosecution with potential sanctions against company. Civil litigation with potential material adverse judgment(s) against company.		4	8	12	16	20
3	Medium	Serious injury or illness with possible permanent effects.	Adverse impacts on a significant part of habitats (e.g. restitution time 1-2 years).	Short-lived national negative exposure. Limited negative exposure from national authorities/regulators.	$10 Million - $100 Million US (Example: Major damage to facility or major asset resulting in expenses or loss of production)	Civil enforcement proceeding with potential material administrative penalty. Civil litigation with potential adverse judgment against company.		3	6	9	12	15
2	Low	Medical treatment injury or occupational illness.	Adverse short term impact on natural habitats.	Local/regional negative exposure in media and/ or from local authorities and customers.	$1 Million - $10 Million US (Example: Minor damage to facility or major asset resulting in expenses or loss of production)	Civil enforcement proceeding with potential non-material administrative penalty. Civil litigation with potential non-material adverse judgment against company.		2	4	6	8	10
1	Insignificant	First aid injury or occupational illness/effect with minor impact on health and ability to function.	No or very limited impact on natural habitats. No impact on population level, only on individual organism level.	Short-lived negative exposure with limited importance.	$0 - $1 Million US (Example: Slight damage to facility or major asset resulting in expenses or loss of production)	Non-material issue requiring legal analysis and appropriate action.		1	2	3	4	5
							ERM 24-Month Outlook	< = 10%	10 - 35%	35 - 65%	65 - 90%	> = 90%

4.1 Assessment of Potential Impact on Marine Environment

This section assesses the potential marine impacts from the project using the risk assessment methodology presented in Section 4.0 and discusses the management and mitigation measures employed in order to adhere to legislation and to minimize environmental impact. All phases of submarine production infrastructure and transmission / supply pipeline will be considered (within Section 4.1.1) from temporary construction, installation and commissioning activities and the permanent placement of facilities on the seabed.

4.1.1 Submarine Production Infrastructure and Transmission / Supply Pipeline

This Section addresses the potential impact on the marine environment due to the submarine production infrastructure and transmission/ supply pipelines. The assessment that follows will consider:

- Assessment of impact of the pipeline on the seafloor;
- Potential risks with extreme conditions; and
- Measures considered to mitigate adverse impacts.

The Leviathan Field Development subsea infrastructure and pipeline(s) (refer to Section 3.2) will include the following:

- Infield production flowlines;
- Primary and infield umbilicals;
- Rigid steel production pipelines and SSIVs;
- Rigid steel MEG supply lines (to be either stand-alone or piggybacked onto production pipelines);
- Pipeline End Terminals (PLETs);
- Tie-in spools;
- Gathering manifold and associated suction pile;
- Subsea Distribution Unit (SDU); and,
- Umbilical Termination Assemblies (UTAs).

4.1.1.1 Submarine infrastructure and pipeline(s) impacts

The Project intends to utilize DP on all construction vessels, resulting in no anchor requirement and thus reducing any impact on the benthic environment. It is possible, however, that dredging activities will be required in order to mitigate any adverse geo-hazard conditions prior to the installation of the flowlines on the seafloor.

In order to determine the sensitivity of the benthic environment, a Background Monitoring Survey was conducted along the proposed pipeline route and in the Leviathan Field (the area that is proposed to be occupied by the subsea infrastructure described above). The findings of the baseline survey are presented in Chapter A of this document and have been used to inform this impact assessment.

The benthic environment in the vicinity of the Leviathan Field Development is considered to be homogenous consisting of very soft clays and silt (GEMS, 2014) and does not alter significantly along the pipeline route to the Leviathan Field Subsea facilities (refer to CSA Ocean Sciences Inc. 2016a&b). The general taxonomic assemblage found consistently, across all survey locations in the Leviathan Field during the site specific environmental baseline survey, found that the dominant phyla were Annelida and Arthropoda, which composed 73.78% and 17.63% of the total infauna, respectively. The phyla Mollusca, Sipuncula, and Platyhelminthes contributed 3.88%, 2.75%, and 1.28%, respectively. Similarly, along pipeline sections one (1), two (2) and three (3), annelid polychaetes were the dominant phyla representing 71.1%, 61.5% and 61.2% respectively. Such species are low sensitivity, high fecundity species and therefore activities are likely to have no measurable effects on local benthic productivity.

Temporary disturbance will occur to benthic fauna during construction, installation and commissioning activities along the proposed pipeline route and in the vicinity of the Leviathan Field where the subsea facilities will be located. Sessile and sedentary fauna will be most susceptible due to their limited ability to move away from affected areas, particularly immotile species. Motile species such as crustacea will likely move away from the area of activity, however immotile species will be directly impacted due to placement of the infrastructure. The majority of the species inhabiting the benthic environment along the proposed pipeline route and in the Leviathan Field are mobile and are likely to demonstrate quick recovery as a result of disturbance. Temporary direct effects will be limited to the direct area of the footprint of the activity which is of a negligible spatial scale in comparison to the Levantine Basin and no sensitive or protected benthic species have been identified in the vicinity of the Leviathan Field Development Project.

As discussed, in Section 3.2, pre-commissioning and commissioning activities will also involve hydrotesting of the pipeline/flowline systems in order to ensure integrity. This will involve the discharging of the hydrotest fluid into the surrounding marine environment, the fluid will comprise of hydrotest chemicals and associated scale and debris material. In order to minimize the potential impact on the surrounding benthic environment, the discharge ports located on the PLETs will be designed to direct discharges vertically upwards to prevent seabed disturbance or potential for scouring. All hydrotest activities will be subject to the acquisition and implementation of a hydrotest discharge permit.

Section 3.2 also describes the hydraulic fluid actuation system and details that hydraulic fluid will be discharged to the surrounding marine environment. DREAM modeling has been performed in order to assess the impacts of the release of hydraulic fluid into the marine environment. The results of this are presented in Section 4.4.

Hydraulic fluid is denser than seawater, therefore will initially sink to the seabed which may have some impacts on benthic communities and sediment quality. DREAM modeling has indicated that due to the water depth at the infield location the seabed currents are low and as a result any discharge plumes will not traverse the seabed at a significant rate, thus giving mobile species significant time to relocate away from the advancing plume. Although, immotile species will not be able to move away from the plume, the hydraulic fluid is water based and of low toxicity (refer to Section 3.2) and therefore will not pose a significant impact on a population level. Further analysis using DREAM shows that, due to the significant depths at which this fluid is released and the very small quantities that will be released it poses a low risk to the surrounding marine environment (refer to Section 4.4).

A permanent net reduction in the total area of original benthic habitat will occur as a result of the placement of subsea infrastructure on the seabed and the removal of sediment should dredging activities be conducted. Should dredging activities be required, the removed sediment will also be directly displaced to another area of the seabed.

The total footprint of the Leviathan Production Development subsea installation results from the infield flowlines and PLETs (associated flowline end terminals) which is 8, 991 m^2; and the production pipeline and PLET (associated with the production pipeline) which is 167, 462 m^2 or 207, 007 m^2 if standalone MEG supply lines are used. All of the transmission pipelines and associated umbilicals will be laid into a single transmission corridor from the LPP to the Leviathan Field. This corridor will be up to 600 m wide.

The physical presence of the infrastructure will result in the reduction of seabed habitats and will be a long term impact, lasting for the duration of the development. However, as discussed, no sensitive species or habitats have been identified in the vicinity of the Leviathan Field Development activities and the area that will be directly impacted is small in comparison to the spatial scale of the Levantine Basin. Therefore the impact significance is considered to be low.

Although, the option to piggyback the MEG supply lines onto the production pipelines is the preferred option since there is a lower associated footprint, the incremental increase in seabed take as a result of the MEG supply lines being laid separately would not represent any additional impacts of significance.

The presence on the seabed of pipelines and associated subsea infrastructure may also affect local currents to the extent that scouring or deposition may occur around this infrastructure. However, no sand waves were observed during the benthic habitat assessment which indicates low current speeds near the seafloor (refer to CSA Ocean Sciences Inc. 2016a). This is further supported in the MetOcean study that was conducted for the deepwater development concept which found that under normal conditions, >75% of currents are less than 1 m/ s at 1500 m (Noble Energy Mediterranean, 2012). Therefore, these impacts are considered to be localized and insignificant.

The presence of newly introduced hard substrates provided by pipelines and subsea production systems on a seafloor composed of fine salts and mud can also create potential habitats for new colonizing species. However, the majority of the facilities to be installed for the Leviathan development project will be installed at depths corresponding to low densities of marine organisms, thus precluding significant changes to existing habitats. No consolidated substrates (hard bottom features) were observed during the benthic baseline habitat assessment.

4.1.1.2 Submarine infrastructure and pipelines stability

The pipelines are under combined loads such as bending, axial force and external pressure during installation due to the dynamic vessel motion. At the touch down point (TDP), seabed disturbance will occur by the dynamic pipe-soil interaction leading to pipeline penetration effects. The environmental loads on the embedded pipelines will be addressed in the pipeline design so as to withstand external pressures. Once in place on the seabed, soil behavior against hydrodynamic load of wave and currents may lead to pipeline instability concerns and free spanning of subsea pipelines.

Free spanning is usually caused by a combination of seabed movement, wave action and current effects. In traditional offshore pipeline design, the on-bottom stability of submarine pipelines is governed by the Morrison's equations (ref. Van den Abeele *et al*, 2011). According to this set of equations, offshore pipelines are designed to satisfy two stability conditions: the submerged weight of the pipe has to be greater than the lift force and the horizontal frictional force should exceed the combined drag and inertia forces.

Analyses will be conducted to ensure that the Leviathan pipelines will not move from their as-installed position when subjected to extreme storm conditions. These analyses will consider detailed, site-specific geotechnical and metocean environmental data. The geotechnical data is based on the findings of multiple survey campaigns conducted from 2013 to 2016 which utilized a mix of cores, borings, cone penetration or cone penetrometer test (CPT) and sub-bottom profiles along the pipeline routes. Both field and laboratory tests were used to characterize the soil properties. The metocean data is based on a combination of local historical data, operational hindcasts and field measurements. These sources will be used to determine design values for wind, wave and current characteristics.

4.1.1.3 Prevention of damage

The majority of the pipeline and infield facilities associated with the Leviathan Development is located in deep water of greater than 250 m. By virtue of its deep water location the risk of damage resulting from anchor drop as the Leviathan pipelines cross shipping lanes is extremely low as most ship's anchors will not extend beyond 250 m. The LPP and associated facilities within Territorial Waters by virtue of the TAMA a 500 m exclusion zone around the LPP, substructures and pipelines is allowed which protect from trawler fishing in the shallow waters (less than 120 m water depth). Between the shipping lane and the LPP exclusion zone there is roughly 3.65 km of pipeline (from the edge of the shipping lane to the platform) that is potentially "trawlable" and outside the TAMA jurisdiction. This section of the 32" pipeline is currently unburied. Within the vicinity of the 32" line the gathering lines.

The risk of damage to the pipelines due to factors such as landslides, anchors in shipping lanes and trawler fishing will be assessed at all relevant locations along the route will also be considered in the safety risk assessment. Where significant risk is identified, preventative measures will be taken such as burying the pipeline or providing external shielding such as concrete coating, Uraduct® coating or concrete mattresses. The risk due to earthquakes will be assessed through seismic hazard assessment and seismic engineering.

Submarine Production Infrastructure and Transmission/ Supply Pipeline Mitigation and Control Measures

A Background Monitoring Survey was conducted along the proposed pipeline route and the area to be occupied by subsea facilities to ensure that there are no sensitive species or habitats present (refer to Chapter A).

Additional geo-hazard survey work is planned for summer 2016.

DP construction, pipe lay and support vessels will be used for infrastructure installation activities. This removes the requirement for vessel anchoring and the associated impact to the seabed and benthic communities.

Currently, there is no requirement for trenching and backfill of the infield flowlines and the transmission facilities which reduces the area of seabed impact.

The footprint associated with subsea facilities will be minimized where practicable. For example the use of a single six (6) m suction pile to secure the gathering manifold reduces the land take compared to either a multiple pile solution or a mudmat solution.

It is confirmed that at least three (3) sets of engineered crossings will be required in areas where active drainage channels are present. Further engineered crossings may be required for additional drainage channels or where there is seabed faulting. Crossing of these seabed features may require seabed dredging, however a number of alternative options have been identified (refer to Section 3.2.2.1). Where practicable flowlines and transmission facilities will be routed to avoid crossing faults and channels, where this is not possible, alternatives to seabed dredging will be used if practicable. Thereby reducing the direct seabed impact associated with the project.

Hydrotest discharge ports located on the PLETs will be designed to direct discharges vertically upwards to prevent seabed disturbance or scouring.

Hydraulic fluid will be water based and DREAM modelling has been conducted to confirm that it poses little or no threat to the marine environment.

Submarine Production Infrastructure and Transmission/ Supply Pipeline Impact Significance

The overall environmental impact associated with seabed disturbance as a result of the installation of subsea infrastructure is considered to be low. This is primarily due to the fact that direct seabed disturbance will be limited to a relatively small area (in comparison to the wider Levantine basin) and any environmentally sensitive locations will be avoided where practicable.

The residual risk is therefore assessed as Low.

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Table 4-1: Summary of Impacts, Mitigation & Controls and Residual Risk of Submarine Production Infrastructure and Transmission/ Supply Pipeline

Activity	Aspect	Potential Impact	Mitigation & Control	Likelihood	Severity	Residual Risk
Installation of flowlines, transmission pipelines and associated subsea infrastructure	Temporary water quality impact & direct losses to infaunal benthic community	Losses or changes to benthic habitats	Optimization of the size of foundations and removal of any non-permanent construction aids Minimize trenching and backfilling Use of DP vessels precludes anchor damage	2	2	4
Preparation for installation of Transmission Pipelines	Engineer seabed drainage channels by dredging seabed sediments	Seabed disturbance and changes to benthic community Impact to filter feeding organisms due to temporary suspension of sediments in the water column	Localized impact at limited locations along the 117 km route No sensitive protected habitat recorded in Application Area or near pipeline route corridor	3	1	3
Presence of subsea production systems and pipelines	Physical presence & sediment deposition	Reduction of available benthic habitats and changes to benthic community	Seabed survey Minimal footprint associated transmission pipelines Seafloor currents are very low - not expected to be an environmental issue.	2	1	2
Pre-commissioning and commissioning (cleaning, gauging, hydrotesting, dewatering and drying) infield flowlines and transmission pipelines	Discharge of inhibited hydrotest water and particulate residues such as ferrous oxides within hydrotest water	Impacts to benthic marine fauna and flora and sediment quality	Usage of Inhibitors will be minimized as practicable Selection of chemicals which are classified as 'PLONOR' – Pose Little Or No Risk where practicable Proposed chemicals are 'Gold' rated under the OCNS and thus present a low environmental hazard Permits to be obtained for discharge of hydrotest water	2	2	4

Activity	Aspect	Potential Impact	Mitigation & Control	Likelihood	Severity	Residual Risk
Subsea control valve operation	Hydraulic fluid discharges when valves are activated	Impacts to benthic marine fauna and flora and sediment quality	Water based hydraulic fluid Discharge volumes estimated to be low Approved low toxicity fluids preferred DREAM modeling conducted	2	2	4
Subsea pipeline design	Pipeline Stability	Impacts to benthic marine fauna and flora and sediment quality	Control in design through application of industry standard procedures Areas of instability will be engineered and designed to withstand spanning strain on pipeline Areas of instability will be monitored post installation	2	2	4

4.2 Environmental Impacts of a Sea Pollution Event by Oil Based Extreme Scenarios

Releases of hydrocarbons (oil or gas) into the marine environment have the potential to impact marine organisms through the following mechanisms:

- Dissolution of toxic components into the water column leading to poisoning or irritation of marine organisms;
- Indirect asphyxiation due to microbial consumption of released hydrocarbons, resulting in decreased dissolved oxygen in the affected area, potentially leading to a “marine dead zone”;
- Direct asphyxiation of marine mammals and other marine dwelling air breathing species who rely on access to the sea surface to breath, formation of an oil slick can prevent these creatures from accessing the surface, or where they do, may result in irritation or poisoning as a result of contact with toxic components.

In addition to impacting marine life forms, a release of oil into the marine environment may impact birds (through coating of feathers), shore based terrestrial species, where oil grounding occurs and industries reliant on the marine environment (e.g. fishing and tourism).

Accidental releases may arise from either a loss of containment from a hydrocarbon production system or as a result of a vessel based spill.

Accidental hydrocarbon releases arising during the operational phase of the Leviathan development project have been assessed through employing the Spill Contingency And Response (OSCAR) model. An explanation of the model, its development, historical use and how it may be applied in the Eastern Mediterranean, has previously been submitted to MoEP within an OSCAR Approval Note (Genesis, 2016a). A summary of the modelling developed for this assessment is provided in the following sections.

Worst case vessel based spills have previously been assessed in the Leviathan Drilling EIA (Noble Energy Mediterranean Ltd., 2016a) and are not further modelled in this assessment as the construction and operations phases are not considered to present a more environmentally damaging vessel release scenario than that already modelled (instantaneous release of 53,000 bbl of drill rig fuel). For comparison, the approximate fuel oil cargo capacity of a typical offshore supply vessel being considered for the Leviathan Field development project (e.g. M.V Highland Rover) is 4,800 bbl.

Oil spill modelling has been performed specific to this assessment to investigate the impact of a subsea release from the Leviathan production system. Oil spill modelling has previously been performed for scenarios relating to production drilling activities which are not within the scope of this assessment in the Leviathan Drilling EIA (Noble Energy Mediterranean Ltd., 2016a).

For modelling proposes it was assumed that no company intervention will take place, in order to investigate a worst case scenario event. In case of hydrocarbon release the company will implement the OSCP and will apply all relevant resources to reduce potential impact.

Operational Release Causes

The subsea production system will be designed such that it is not possible for operator error on the LPP to lead directly to a hydrocarbon discharge into the marine environment. This will be by way of control system interlocks, ROV actuated valves and blind flanges on unconnected tie-in points. As a result, accidental release due to operator error is not a credible scenario.

On the basis that operator error (leading to a subsea release) is not considered credible; the remaining scenario for a release is a subsea loss of containment from the production system.

Typically, the following may be considered as possible causes for a subsea loss of containment:

1. Line pipe defect as a result of manufacturing or installation failings;
2. Internal corrosion due to substandard or mishandled corrosion coatings; and
3. Loss of integrity due to external forces, e.g.:
    a. Seismic activity;
    b. Vessel interaction; or
    c. Dropped Object impact.

Cause 1 is discredited for the Leviathan development due to the quality assurance process and NDT procedures to be implemented during and immediately following pipeline installation (e.g. non-destructive weld testing and hydrotesting). Further, cause 2 is not considered credible for the Leviathan production system as the Leviathan fluids are not expected to show significant levels of either CO_2 or H_2S (acid gases) based on the reservoir fluid composition conducted during open-hole sampling of Leviathan wells (Noble, 2016b). This testing showed a low fraction of CO_2 and no detected H_2S in samples. For this reason, the production system will not utilise any corrosion resistant cladding or exotic construction materials. Continuous monitoring of the fluid composition will be in place to alert the asset to any increase in corrosive species and corrective actions will then be taken as appropriate. Continuous monitoring of the fluid composition will alert the asset to any increase in corrosive species and corrective actions will then be taken as appropriate.

As the production pipeline and subsea systems will be designed to international codes and standards, utilising specialist manufacturing/installation suppliers, a loss of containment resulting from defects and unmitigated corrosion is not considered credible. This leaves only external forces as a potential cause of a pipeline loss of containment. Of these, the impact of seismic activity on the system is to be mitigated throughout the design process so that the production system can adequately withstand the most severe seismic activity reasonably foreseeable in the region, without becoming subject to a loss of containment. Further, due to the water depth along the transmission corridor, the potential for vessel interactions (e.g. anchor drag or bottom trawling) will generally be limited to areas within Territorial Waters. The potential for a dropped object to impact on the pipeline will be greatest within the immediate vicinity of the LPP where regular supply and loading operations will be performed.

Based on the above, a deepwater loss of containment (outside Territorial Waters) is not considered credible due to the water depth (750 m – 1,710 m) which precludes any vessel anchoring or fishing operations. Dropped object impacts in the deepwater region are not considered credible as there are no identifiable areas where equipment or load transfers between vessels will be occurring. Further the transmission corridor occupies a very small fraction of the sea bed in the deepwater region so the likelihood of a dropped object actually falling within it is considered negligible. Finally, any dropped object would have to be of sufficient mass and density to result in damage to the thick-walled production pipelines.

Within Territorial Waters, three scenarios have been identified which show varying potential for either vessel interaction or dropped object impact on the production pipelines upstream of the LPP. These scenarios are detailed below (note that export pipelines from the LPP are excluded from the scope of this assessment):

- **Mid-water Release (within Shipping Channel) due to impact –** The north/south Hadera to Haifa shipping channel lies within Territorial Waters and has an eastern boundary approximately 13.5 km from the shore where it passes over the proposed transmission corridor (see Section 1.3). This corresponds to a minimum water depth of approximately 250 m. At this depth fishing interactions or vessel anchoring is considered extremely unlikely for all but the largest/most specialist vessels. Further, there is no foreseeable scenario where equipment/loads will be being transferred between vessels in this area.
- **Shallow-water Release (East of Shipping Channel) due to impact –** There exists approximately 2-3 km of open sea between the eastern limit of the shipping channel and the LPP. In this area water depth decreases from approximately 250 m in the east, to 86 m directly adjacent to the LPP. Similarly to the other loss of integrity scenarios considered, vessel anchoring is unlikely for all but the very largest vessels at the water depths in this area. Noble Energy will have a Field Boat available in the vicinity of the LPP to intervene upon the identification of a risk to the integrity of the production system.
- **Shallow-water Release (Within LPP Exclusion Zone) –** The LPP will be surrounded by a 1,500 m (radius) marine exclusion zone for which permission to enter must be obtained prior to vessel approach.. Frequent entrance into the

exclusion zone will primarily be limited to the offshore supply vessel which will perform regular supply sorties from the onshore supply base, this vessel will feature dynamic positioning and as such anchoring within the exclusion zone will not be a regular occurrence. Where anchoring is required this will be subject to a dedicated review process to ensure the potential for impacting the production pipelines is minimized. During supply operations equipment and supply loads will be lifted from the supply vessel onto the LPP by platform mounted cranes. During these lifts it is possible that a load may be lost into the marine environment whereby it would likely sink to the seabed with the potential to impact on the production pipelines within the immediate vicinity of the LPP (downstream of the SSIVs). Such an impact may result in sufficient damage to the impacted pipeline to lead to a subsea loss of containment.

A further consideration when assessing the credibility of a subsea loss of containment as a result of vessel interactions is that, based on data available from the UK Health and Safety Executive (UK HSE, 2009), the largest diameter rigid pipeline on the UK continental shelf to have been subject to a loss of containment as a result of an anchor impact is 16” NB. The Leviathan production pipelines will be of either 18” or 20” NB with wall thicknesses in the region of an inch, as such these pipelines would be expected to resist moderate impacts arising from vessel interactions without any loss of containment.

In light of the information presented above, the most credible scenario for an oil spill from the Leviathan production system is a loss of containment from a single production pipeline within close proximity to the LPP as a result of an impact from a dropped object. As this scenario is reliant on proximity to the LPP, the loss of containment shall be considered to occur downstream of the production SSIVs, which will act to isolate the effected section of pipe by closing upon positive detection of a loss of containment. This will limit the total release volume. The worst case scenario is considered to be a dropped object impact on the 20” REM production pipeline resulting in a 100 mm diameter hole as defined by the Centre for Marine and Petroleum Technology as a large release (CMPT, 1999).

Details specific to the selected oil spill scenario are provided in Section entitled “Model Details – Dropped Object Impact Downstream of SSIV”.

As the design of the LPP and production system is further developed during FEED and detailed design, the LPP will be subject to a dropped object study. Based on crane lifting requirements, the dropped object study will determine what levels of protection should be implemented around the LPP to minimize the potential for a dropped object to lead to a subsea loss of containment.

Model Details – Dropped Object Impact Downstream of SSIV

Based on the justification given earlier in the Section entitled “Operational Release Causes”, the scenario modelled in OSCAR is a subsea release from within 100 m of the LPP as a result of a dropped object impacting on one of the large diameter production pipelines. A release from the 20” REM production pipeline is selected for this assessment as this pipeline presents the largest total gas inventory.

Following a positive detection of a pipeline loss of containment (irrespective of location or cause) the platform safety and controls system will act to isolate the affected pipeline by shutting in the pipeline at the following locations:

- Infield Gathering Manifold;
- Relevant SubSea Isolation Valve (SSIV); and,
- Topsides SDV at the riser tie-in point.

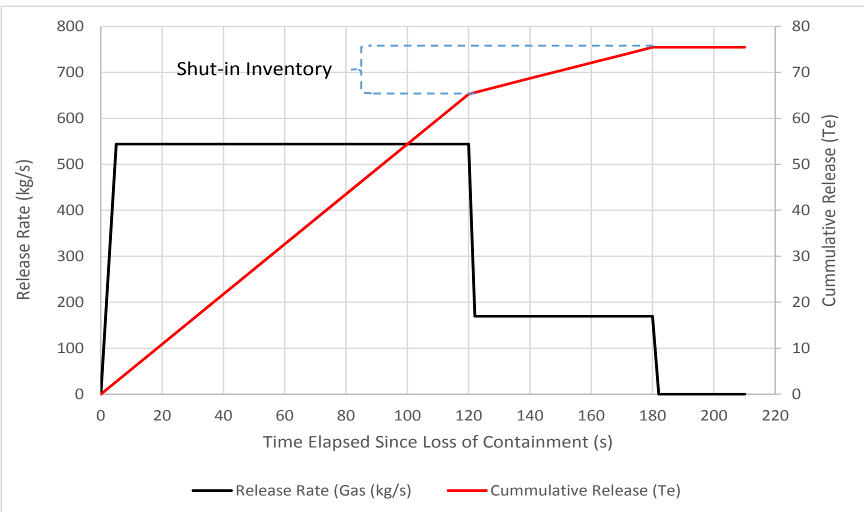
Specific to the dropped object scenario, the loss of containment scenario is viewed as occurring as follows:

1. Object dropped during platform supply operation with ensuing impact on, and resultant loss of containment from the 20" REM production pipeline downstream of the SSIV;
2. Production management system/control system positively identifies loss of containment and initiates pipeline shutdown by closing the subsea valves at the Infield Gathering Manifold, and relevant SSIV, as well as the relevant topside SDV at the riser tie-in;
3. Pipeline isolation to take up to two (2) minutes from initiation to completion, during this time the pipeline shall be assumed to be flowing at full flow to the LPP; and
4. Following isolation the impacted section of pipeline (SSIV to LPP) will continue to depressurise through the subsea hole until all gas/hydrocarbon inventory has been released and the pipeline is water filled.

Based on the definition previously provided a "large release" from a 100 mm hole is considered to provide a conservative basis. A full bore rupture is not considered credible due to the likely nature of equipment being lifted and the thick walled nature of the production pipelines. This is an industry standard approach for hydrocarbon release modelling.

The gas release profile (in kg/s) is provided in Figure 4-2 for the release scenario described above. The depressurisation period of release is simplified to assume a continuous release rate for one (1) minute following isolation, the rate modelled during this time is such that the total mass of gas released over this time is equal to that of the inventory of the isolated section of pipe during normal (high pressure) operation.

Figure 4-2: Gas Release Profile for Oil Spill Modelling



Based on a typical density for natural gas of 0.84 kg/m^3 (at standard temperature and pressure) the gas release is equivalent to approximately 3.17 MMscf. Considering a worst case (maximum) Condensate Gas Ratio (CGR) of 5 bbl/ MMscf the total condensate release associated with the identified scenario is 15.9 bbl (2.51 m^3). Providing the actual temperature and pressure at the release depth or the volume at that point is not useful since the gas will immediately rise through the water column and thus the volume will change. As the gas will eventually leave the water column and enter the atmosphere, stating volume at STP will be more useful. Stating the volume at STP means that the volume can be converted later to any temperature and/or pressure that might be required. Providing an equivalent gas volume at STP is fairly common as well. Additionally the CGR is based on gas at STP, so the volume of released gas needs to be at STP in order for the assumed CGR to be meaningful.

All released oil/condensate is modelled as per the “Kristin 2006 13°C” assay available in OSCAR. This assay is selected due to the similarities in properties (especially specific gravity and pour point) between this assay and the oil/condensate expected from the Leviathan field.

4.2.1 Modelling Domain

The Eastern Mediterranean was used as the modelling domain to model the credible scenario described above (loss of containment near the LPP due to a dropped object). Wind and current data fed into the model covered a portion of the modelling domain large enough to monitor the movement of released oil on the sea surface and submerged in the water column until it had fully dispersed in the environment. This stretched from approximately 32 degrees latitude along the coastline of Israel Northward to the Southern part of Lebanon. The geographic extent of these two data sets is provided in Table 4-2 below.

Table 4-2: Model Domain Wind and Current Coordinates

	Wind Grid	Current Grid
Northeast corner	35° 10’ 31” E	35° 09’ 31” E
	33° 08’ 31” N	33° 08’ 31” N
Southwest corner	34° 38’ 31” E	34° 37’ 31” E
	32° 18’ 31” N	32° 18’ 31” N

4.2.2 Modelling Domain Coastal Features

A variety of coastal features and natural and anthropogenic in origin, were identified during the maritime environment baseline surveys conducted by CSA, Inc. Key species identified during the survey work, which overlap with the modelling domain, include:

- Marine mammals (multiple species);
- Turtles nesting grounds (multiple species);
- Numerous species of birds (including breeding grounds); and
- Fish.

In addition to fauna present in the modelling domain, a number of coastal features present include:

- Commercial fishing ports (areas around Akko, Haifa and Dor);
- National parks and nature reserves (Achziv, Alexander Stream, Beit Yanai, Poleg Stream, Apollonia);
- Archaeological sites;
- Beaches, bathing and recreation areas;
- Marine aquaculture facilities (near Haifa); and
- Industrial facilities (Haifa gas power plant, Orot Rabin coal power plant; desalination plants at Shomrat, Haifa Bay and Hadera).

For a full description of the baseline maritime environment in the modelling domain, refer to CSA Ocean Sciences Inc. 2016a&b.

4.2.3 Modelling Periods

The time periods used to model the credible oil release scenarios were in-line with the four most common sea states on Israeli beaches. The oil spill model was run using three different start dates, each for a duration of ten days, to represent the full 30 day period. This was done similarly for each of the four sea states.

Splitting the sea states into 10 day increments was done to show illustrate small variations in oil plume behavior related to start date and because the oil plume being modelled in the credible scenario dispersed completely after only a short time. The specific start and end dates for all of the models is provided in the following Section 4.2.4.

4.2.4 Modelled Sea States

The following models have been developed for this assessment based on four predominant sea states in the Eastern Mediterranean. These are all based on the scenario described in Section entitled “Model Details – Dropped Object Impact Downstream of SSIV”. The duration of each run was 30 days apply three (3) different start dates (as per Israeli EIA Instructions) and includes:

4.2.4.1 Extreme Winter Wave Storm (EWWS) period: 09/12/10 – 08/01/11:

- Model EWWS1: Spill commencing at 0:00 on 09/12/10;
- Model EWWS2: Spill commencing at 0:00 on 19/12/10; and,
- Model EWWS3: Spill commencing at 0:00 on 29/12/10.

4.2.4.2 Winter Wave Storm (WWS) period: 26/01/08 – 14/02/08:

- Model WWS1: Spill commencing at 12:00 on 26/01/08;
- Model WWS2: Spill commencing at 12:00 on 05/02/08; and,
- Model WWS3: Spill commencing at 12:00 on 15/02/08.

4.2.4.3 Summer Swell (SS) period: 17/07/08 – 16/08/08:

- Model SS1: Spill commencing at 12:00 on 17/07/08;
- Model SS2: Spill commencing at 12:00 on 27/07/08; and,
- Model SS3: Spill commencing at 12:00 on 06/08/08.

4.2.4.4 Strong North-Easterly Wind (SNEW) period: 25/09/07 – 25/10/07:

- Model SNEW1: Spill commencing at 12:00 on 25/09/07;
- Model SNEW2: Spill commencing at 12:00 on 05/10/07; and,
- Model SNEW3: Spill commencing at 12:00 on 15/10/07.

4.2.5 Oil Spill Modelling Results

Table 4-3 summarises the modelling results for each of the models listed above. Due to the nature of the release being mostly gas with a small volume of condensate, a large proportion evaporates within the first 24 hours. The total volume of condensate released is approximately 15.9 bbls, equivalent to 2.12 te.

In the majority of the models none of the released hydrocarbons reach the shoreline, while in the few instances where stranding on the shoreline is seen, the total amount is insignificant (i.e. < 0.1% of the total release) and a result of dispersed oil being washed onto the shore, as opposed to mass beaching of an oil slick. In all instances of beaching the geographic extent is minor. In instances where hydrocarbons reach the shoreline, this takes between two (2) and seven (7) days depending on the specific METOcean conditions.

Table 4-3: Plume Behavior and Fate Model Results for Dropped Object Release Scenario

Scenario	Percent Evaporation	Percent Dispersed	Percent Degraded	Hours to Coastal Stranding	Percent Stranded	Plume Behavior
EWWS1	60.4	34.5	4.8	n/a	n/a	No beaching witnessed, compact plume travels NE parallel to coastline, surface slick disappears within 18 hours of discharge
EWWS2	63.1	24.1	3.7	n/a	n/a	No beaching witnessed, compact plume travels SE parallel to coastline, surface slick disappears within 18 hours of discharge
EWWS3	49.9	36.2	13.8	n/a	n/a	No beaching witnessed, drawn out plume travels SW parallel to coastline, surface slick disappears within 12 hours of discharge

Scenario	Percent Evaporation	Percent Dispersed	Percent Degraded	Hours to Coastal Stranding	Percent Stranded	Plume Behavior
WWS1	63.0	26.4	3.6	n/a	n/a	No beaching witnessed, compact plume remains near platform while dispersing, surface slick disappears within 18 hours of discharge
WWS2	56.5	34.8	8.7	n/a	n/a	No beaching witnessed, drawn out plume travels SSE and S continuing to dissipate, surface slick disappears within 12 hours of discharge
WWS3	60.2	8.8	9.3	128	<0.1	Negligible beached condensate at Haifa and Dor, plume disperses NE and SW from platform parallel to coastline, surface slick disappears within 12 hours of discharge
SS1	58.1	33.2	8.2	91	<0.1	Negligible beached condensate near Israel – Lebanon border and Haifa, Broken plume travels NE parallel to coastline, surface slick disappears within 12 hour of discharge
SS2	56.1	35.8	8.2	n/a	n/a	No beaching witnessed, compact plume travels NE parallel to coastline until dissipated, surface slick disappears within 12 hours of discharge
SS3	58.1	32.7	8.6	107	<0.1	Negligible beached condensate near Israel – Lebanon border, drawn out plume travels NE parallel to coastline, surface slick disappears within 14 hours of discharge
SNEW1	60.5	32.5	6.9	174	<0.1	Negligible beached condensate near Israel – Lebanon border, plume travels NE parallel to coastline slowly dispersing, surface slick disappears within 12 hours of discharge

Scenario	Percent Evaporation	Percent Dispersed	Percent Degraded	Hours to Coastal Stranding	Percent Stranded	Plume Behavior
SNEW2	57.6	24.9	10.5	50	0.1	Negligible beached condensate at Haifa and small patches near Israel – Lebanon border, compact plume travels NE parallel to coastline dissipating, surface slick disappears within 12 hours of discharge
SNEW3	56.5	34.1	9.4	n/a	n/a	No beaching witnessed, plume travels NNE parallel to coastline then NW slowly dissipating, surface slick disappears within 12 hours of discharge

All formulas and calculations conducted for modelling with and without 30 day control have been discussed and presented in Appendix D.1 which details the oil spill model methodology (refer to Section 4.2.7).

Modelling has been performed based on international knowledge and experience from past oil pollution events as discussed in Section 4.2.

Table 4-3, above, describes how the plume behaved following the release from the subsea production pipeline for each of the twelve different variations of the model (i.e. different start dates and different sea states).

A large proportion of the release evaporated quickly due to it being primarily gas with a small amount of condensate. This large proportion of gas also helped to increase mixing of the condensate, thus increasing dispersion and aiding in evaporation of the light ends of the condensate once the release reached the sea surface.

In all cases, within 18 hours of release, all visible evidence of an oil slick on the sea surface had disappeared. This means that the oil slick had thinned sufficiently to no longer be visible to the naked eye of an observer (i.e. there is no remaining visual impact).

Due to the nature of the release from the subsea production pipeline (i.e. mostly gas with a very small quantity of condensate) no significant beaching of hydrocarbons was seen in any of the modelling. In the majority of cases there was no beaching of hydrocarbons on the coastline. Those cases where beaching was seen are described in Table 4-4 below. Beaching was more likely to happen during the calmer sea states (Summer Swell and Strong NE Wind) where the reduced wave action resulted in less dispersion and degradation of the hydrocarbons.

What each of these cases have in common is a:

- Very insignificant quantities of hydrocarbons stranded on the coastline (0.1% or less of the original released mass equating to a few kilograms of beached hydrocarbon in total);

- Small fraction of heavier ends from the released condensate will become well-weathered into small globs of oil-water emulsion or more solid chunks (tarballs) that will reach the coastline; and
- Number of days spent at sea (> 2 days) prior to any hydrocarbons reaching the coastline, which will give Noble time to respond to the release thereby likely avoiding any beaching.

Table 4-4: Hydrocarbon Beaching Model Results for Dropped Object Release Scenario

Scenario	Hours to Coastal Stranding	Beaching Location	Extent of Beaching
WWS3	128	Areas near Haifa and Dor	Broken up small patches 100 – 200 m in size surrounding Haifa and a few 100 m size patches near Dor
SS1	91	Israel – Lebanon border; Haifa	8 km broken up small patches 100 – 300 m in size on both sides of the border; single 100 m patch at Haifa
SS3	107	Israel – Lebanon border	4 km broken up small patches 100 m in size just on Lebanese side of the border
SNEW1	174	Israel – Lebanon border	Two patchy spots each 100 m in size just on Lebanese side of the border
SNEW2	50	Area around Haifa; Near Israel – Lebanon border	3.5 km of patchy beaching with other disconnected small patches about 100 m in size

It is Noble's intention, that should a hydrocarbon release occur, such as that described by the credible scenario that has been modelled, a response team will be able to deploy to the area within four (4) to six (6) hours of the incident being identified.

Based on analysis of the results of each of the models described in Table 4-3 above, the behavior of the released hydrocarbons appears to be in agreement with the typically expected behavior for a large quantity of gas with a small quantity of condensate being released from a subsea pipeline based on international experience of similar activities.

The environmental significance of the thickness and expected spread of the spill is discussed in Section 4.2.6.

4.2.6 Oil Spill Analysis

A set of representative results for the EWWS models (specifically EWWS2) are shown in Figures 4-3 to Figure 4-26. The two time shots demonstrate the general behavior of the plume in each of the three models during this sea state and show the concentration of hydrocarbons within the water column. Any oil sheen visible on the surface of the water dissipates to the point where it was no longer visible to the naked eye within 18 hours. While there was some variability in the direction that the plume travelled depending on the model start-date, in all cases the plume fully dispersed at sea to a concentration of less than one (1) ppb and no beaching of hydrocarbons was seen in any of the three models within the EWWS sea state. The oil budget for the EWWS2 model is provided within Figure 4-3 and shows the ultimate fate of the hydrocarbons in the marine environment over the ten day model period.

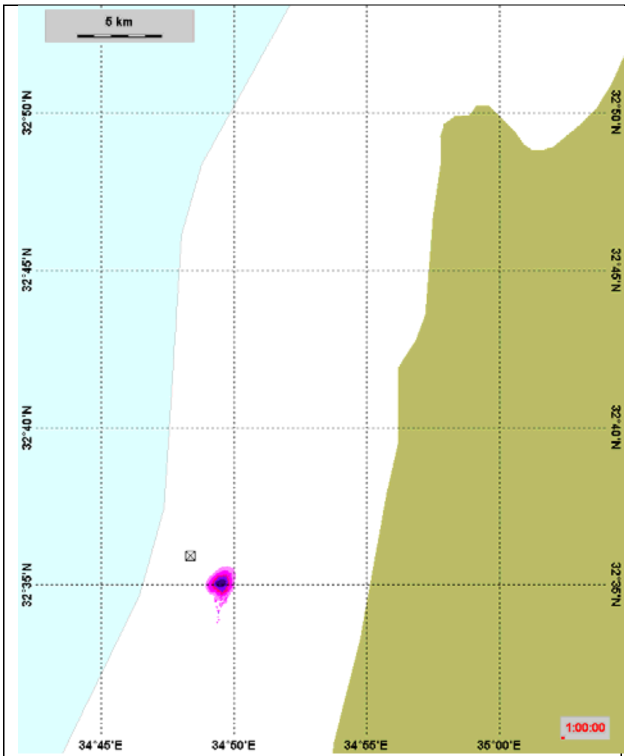
Representative results for the Winter Wave Storm models (specifically WWS3) are shown in Figure 4-4. The two time shots demonstrate the general behavior of the plume in each of the three (3) models within this sea state and indicate typical concentrations of hydrocarbons within the water column as a result of the spill scenario. Any oil sheen visible on the surface of the water dissipates to the point where it was no longer visible to the naked eye within 18 hours of the spill. Movement of the plume in all models within the WWS sea state was limited, with the spill predominantly dispersing in the vicinity of the platform to a concentration of less than one (1) ppb. Stranding of hydrocarbons was seen in one of the models in the WWS sea state but this was at a level considered insignificant (less than 0.1% of the entire spill). Stranding occurred 128 hours after release, first at Haifa and later in the vicinity of Dor. The oil budget for the WWS3 model is provided within Figure 4.4 and shows the ultimate fate of the spilled hydrocarbons within the marine environment over the ten day model period.

Representative results for the Summer Swell models (specifically SS1) are shown in Figure 4-5. The two time shots demonstrate the general behavior of the plume in each of the three models within this sea state and show the concentration of hydrocarbons within the water column. Any oil sheen visible on the surface of the water dissipates to the point where it was no longer visible to the naked eye within 14 hours or less. Minor variations were seen in the dispersion of the plume, but movement in all of the models within the SS sea state was to the NE parallel to the shoreline with the plume dispersing to a concentration of less than one (1) ppb as it moved. In two of the models stranding of hydrocarbons was seen around the Israel – Lebanon border but this was at levels of less than 0.1% of the total spill. Beaching occurred at 91 and 107 hours after release in models SS1 and SS3 respectively. The oil budget for SS1 is included within Figure 4-5 and shows the ultimate fate of the spilled hydrocarbons. It should be noted that, although approximately 0.7 Te of the spill end up outside of the model grid, this is made up entirely of dispersed oil in water at concentrations of less than 25 ppb.

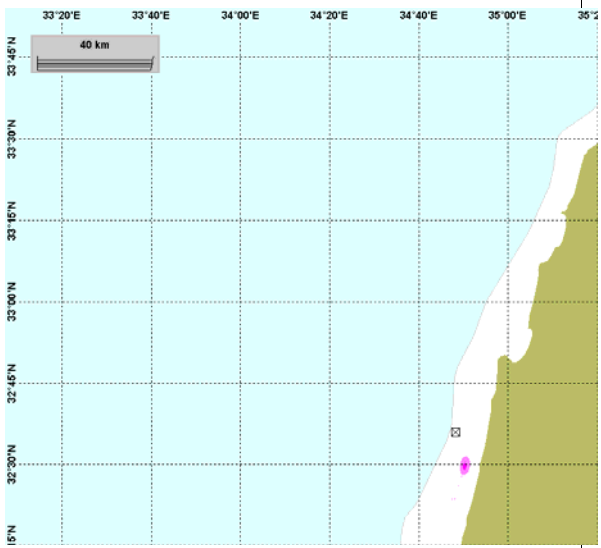
Representative results for the Strong NE Wind sea state (specifically SNEW2) are shown in Figure 4-6. The two (2) time shots show that the general behavior of the plume is to rapidly dilute to water in oil concentrations of less than 25 ppb (24 hours after the release) and drift to the NE of the LPP approximately parallel to the shore. Any oil sheen visible on the surface of the water dissipates to the point where it was no longer visible to the naked eye within 12 hours of the initial spill. Beaching of hydrocarbons is seen in two (2) of the cases (SNEW1 and SNEW2); the smaller instance of beaching occurs in the SNEW1 model approximately 174 hours after release near the Israel – Lebanon, however this is equivalent to less than 0.1% of the total spill and is considered insignificant. The larger, but still extremely small, instance of beaching is associated with the SNEW2 model which sees beaching 50 hours after release at Haifa, the total beached oil is equivalent to approximately 0.1% (2.1 kg) of the total spill. The oil budget for the SNEW2 model is displayed within Figure 4-6 and shows that the total mass of oil beached is insignificant when compared to that either evaporated or dispersed within the water column. As noted for the SS sea state although a significant mass of oil ends up outside of the model grid, this is in the form of extremely dilute dispersed oil in water (less than 5 ppb).

A general point to note when viewing Figure 4-3 through to Figure 4-6, is that hydrocarbons stranded on the shoreline are shown in the oil budget graphs as “stranded”, while the “sediment” fraction refers to any oil which sinks to the seafloor and becomes trapped in the marine sediments. As stated previously oil in the “outside grid” fraction consists solely of dispersed oil at low concentrations that has drifted beyond the modelling area. No instances of observable oil slicks traversing maritime boundaries have been observed during the OSCAR modelling.

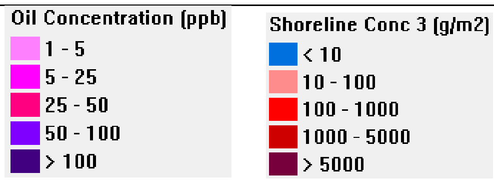
Figure 4-3: Extreme Winter Wave Storm Water Column Concentrations and Oil Budget

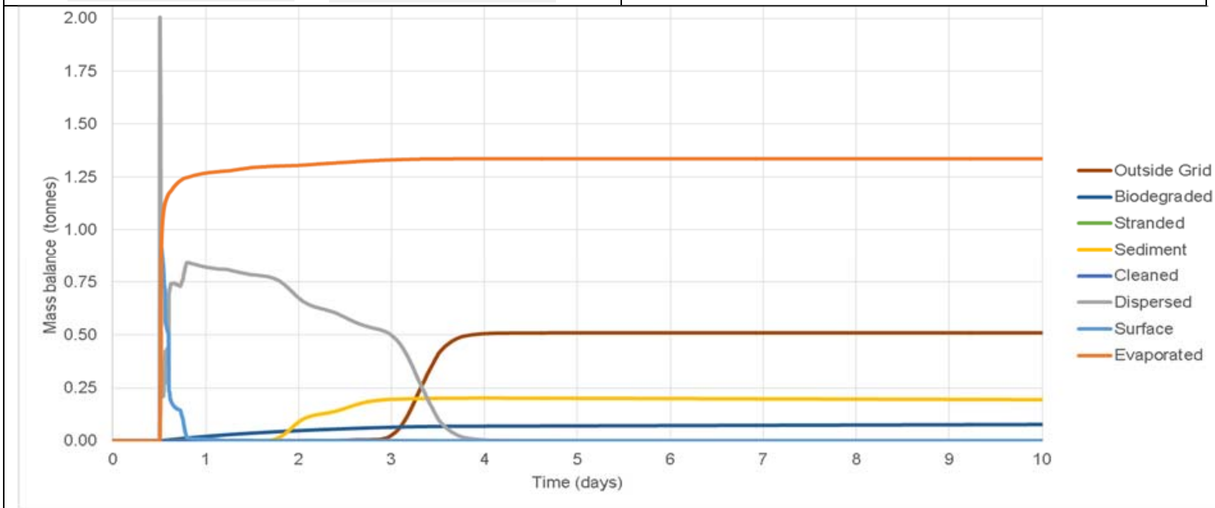


Extreme Winter Wave Storm 2 at 12 hrs



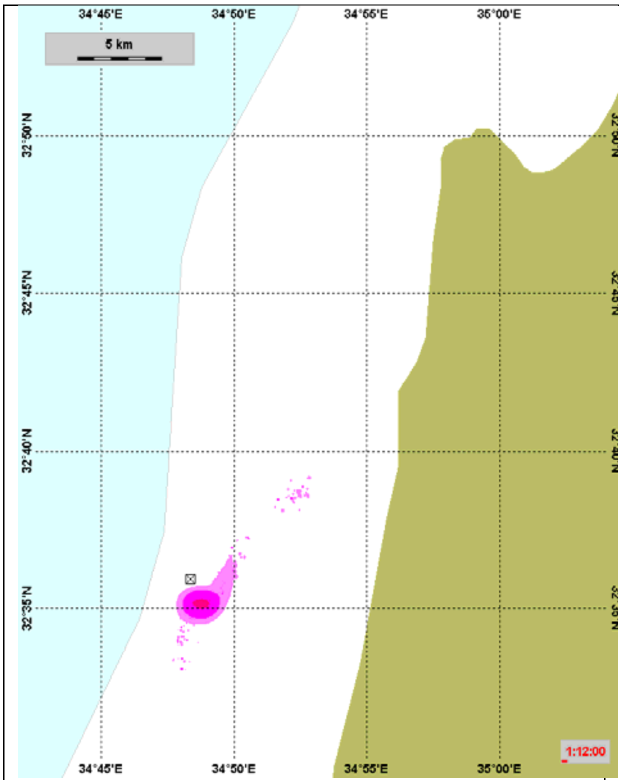
Extreme Winter Wave Storm 2 at 48 hrs



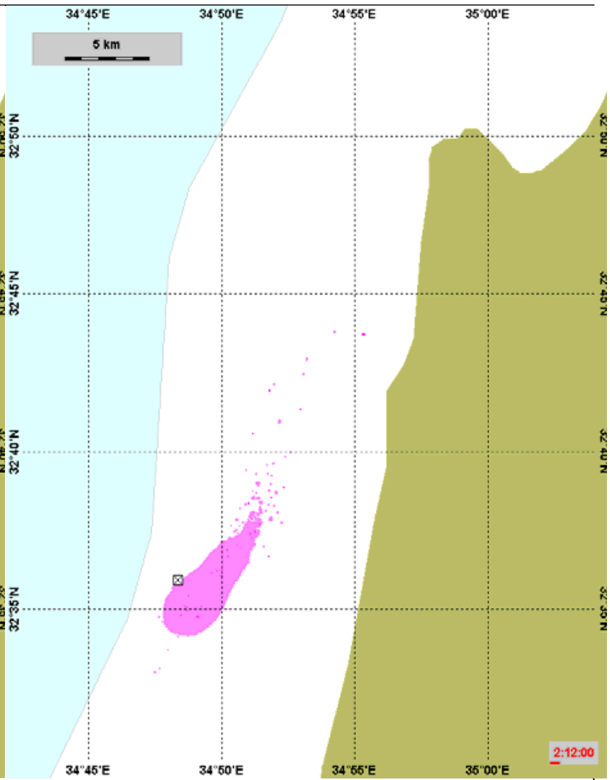


Extreme Winter Wave Storm 2 Oil Budget

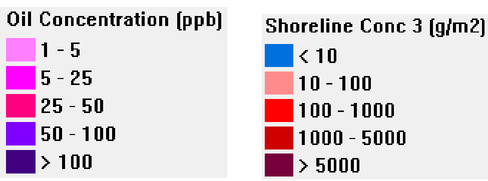
Figure 4-4: Winter Wave Storm Water Column Concentrations and Oil Budget Results

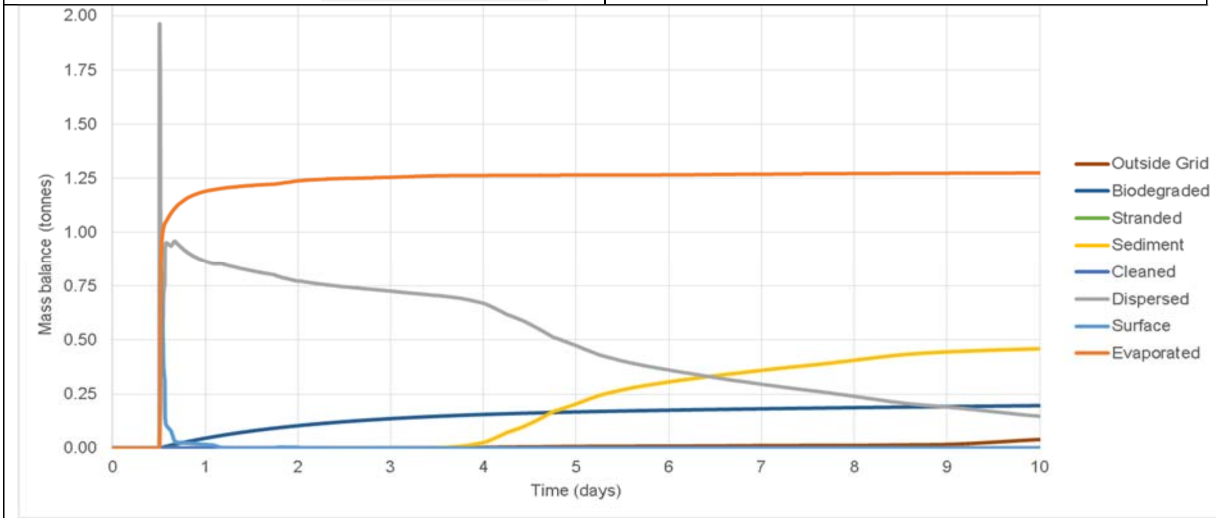


Winter Wave Storm 3 at 24 hrs



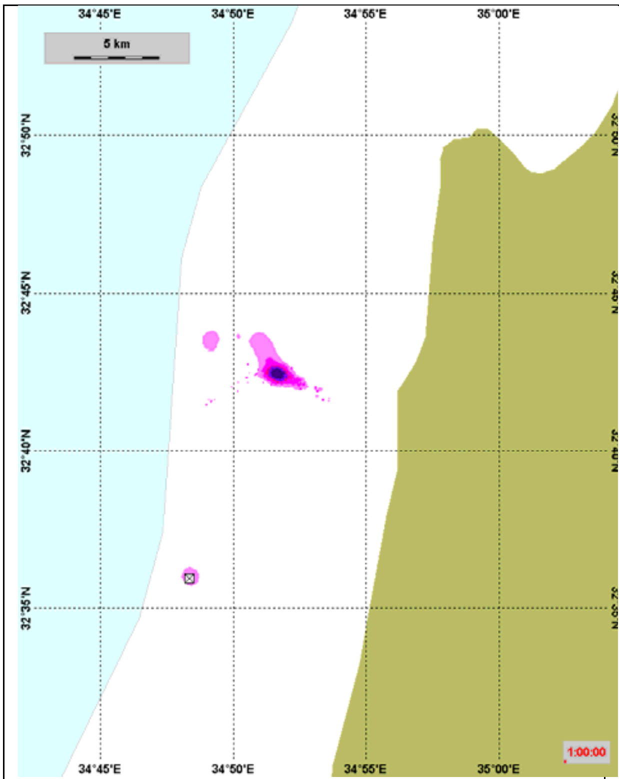
Winter Wave Storm 3 at 48 hrs



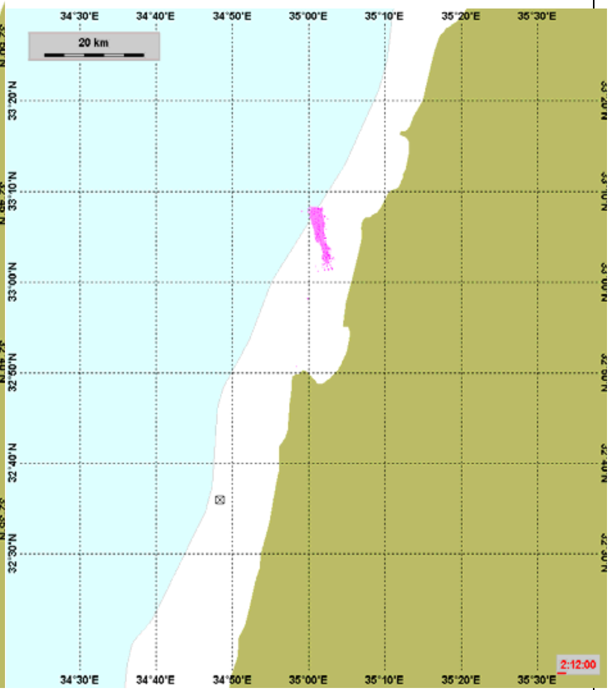


Winter Wave Storm 3 Oil Budget

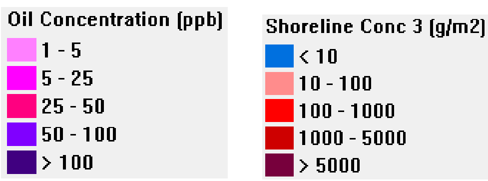
Figure 4-5: Summer Swell Water Column Concentrations and Oil Budget Results

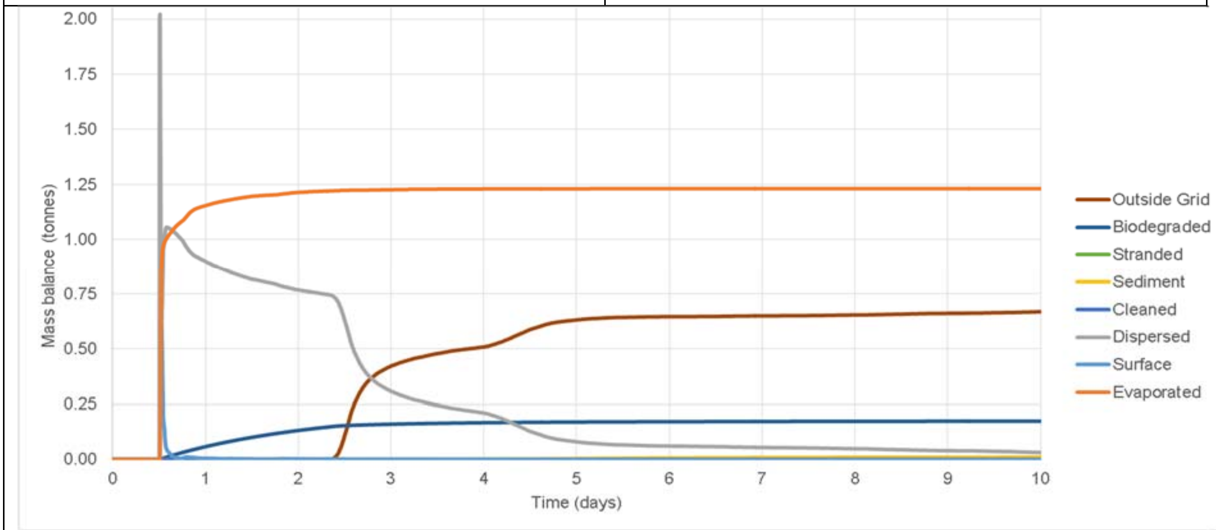


Summer Swell 1 at 12 hrs



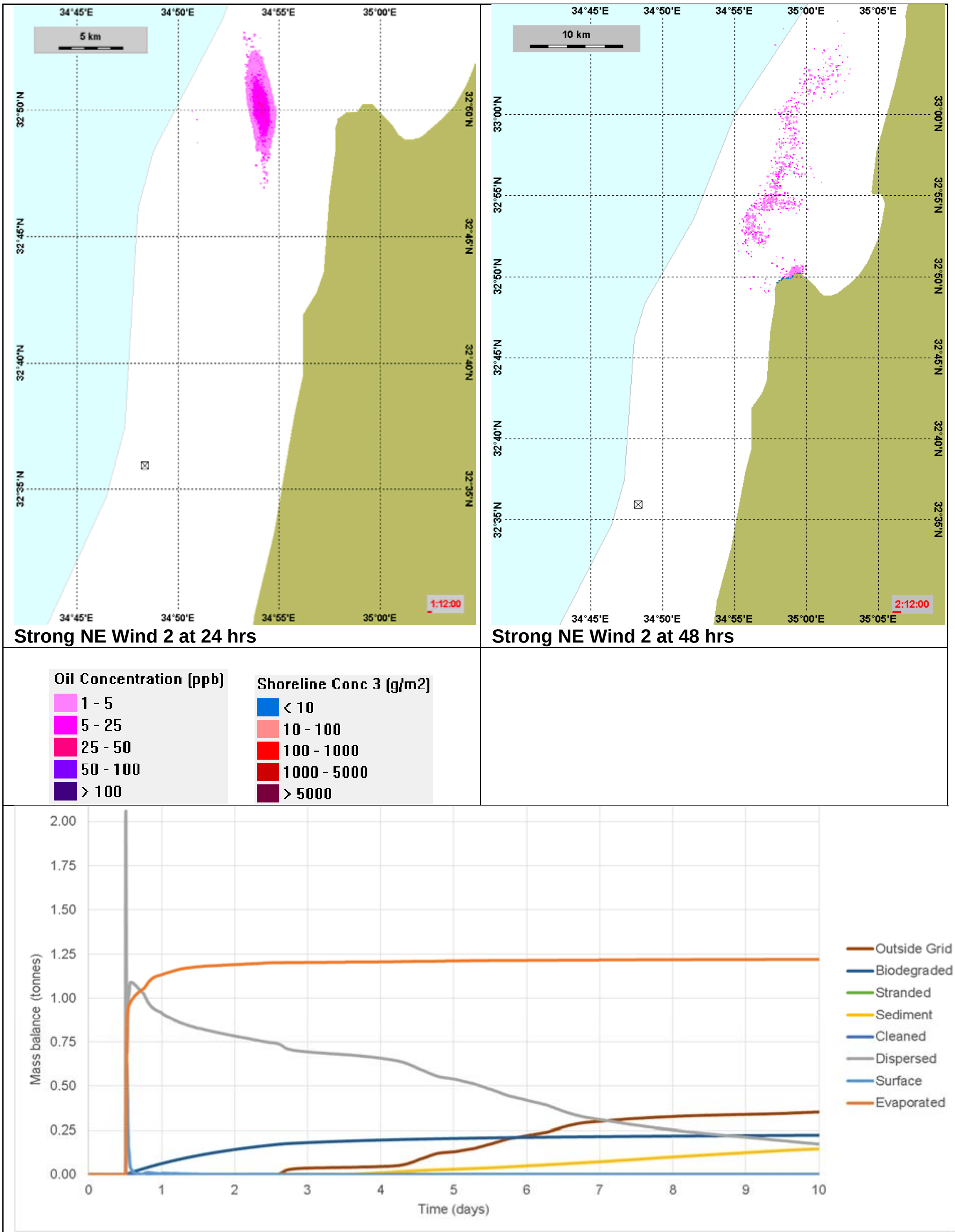
Summer Swell 1 at 36 hrs





Summer Swell 1 Oil Budget

Figure 4-6: Strong NE Wind Water Column Concentrations and Oil Budget Results



Strong NE Wind 2 at 24 hrs

Strong NE Wind 2 at 48 hrs

Strong NE Wind 2 Oil Budget

A detailed explanation of the environmental and other implications that might arise from an oil spill incident at sea under the various scenarios and the various environments is presented in the sections to follow. Environmental significance is presented following the detailed impact assessment of the ecosystem in general and various species is presented in Section 4.2.6.1. The impact assessment pertaining to the various environments that the Application Area gives rise to is presented in Section 4.2.6.3. Although currently not within the scope of this EIA, in the interests of completeness, the impact assessment below also makes reference to sensitive areas in the coastal environment that may be affected by a pollution incident as described above. A map of the sensitivity of beaches to sea pollution by oil has been used to inform this aspect of the impact assessment as provided by the Israel Ministry of Environmental Protection, Marine and Coastal Division, Atlas of Israel coastal sensitivity to oil pollution in the Mediterranean. Jerusalem, 2006.

4.2.6.1 Oil Spill Impact on Ecosystem

Water Quality Impacts

The dissolved hydrocarbon components and small oil droplets released into the water column as a result of loss of containment from the pipeline can affect water quality by releasing hydrocarbon concentrations in the water column. The small amount of oil released into the water column, begins to weather and its physical and chemical characteristics change over time. As soon as the oil is released, due to its density, the majority will migrate upwards in the water column and spread over the sea surface. The speed at which it spreads is dependent to a great extent on the viscosity of the oil and the volume spilled. The more volatile components of oil will evaporate to the atmosphere. Warm temperatures and high wind speeds also increase evaporation. Waves and turbulence at the sea surface can break-up a slick into oil droplets which become mixed in the upper layers of the water column. Smaller droplets remain in suspension while larger droplets rise and coalesce with other droplets at the surface. The dispersed oil mixes with ever greater volumes of sea water resulting in the rapid and very substantial reduction of the oil concentration that will likely disperse completely within a few days if the oil remains fluid and unhindered. Modelling determined that in the instances where a surface slick occurred, it disappeared within hours, primarily as a result of evaporation.

Sediment Quality and Benthic Organisms Impacts

A loss of inventory will increase hydrocarbon concentrations in the sediments and may impact benthic communities by smothering and or coating organisms. Shallow coastal areas are often laden with suspended solids that can bind with dispersed oil droplets. Oil can also be ingested by planktonic organisms and incorporated into faecal pellets which drop to the seabed. However, due to the size of the release expected, and the rapid dilution seen in the OSCAR modelling it is expected that if toxic hydrocarbons come into contact with sediment, they will likely be below thresholds that could create sediment toxicity.

Marine Mammals Impacts

A hydrocarbon spill could potentially affect marine mammals if they were to come into contact with a surface oil slick. Inhalation of volatile components, ingestion (directly or indirectly through the consumption of fouled prey species), skin irritation and inflammation are just some of the symptoms that have been recorded (Geraci and St. Aubin, 1990 and Marine Mammal Commission, 2012).

Following the Macondo spill in the Gulf of Mexico, physiological impacts on dolphins were detected in shallow, enclosed embayments with limited circulation where the animals were exposed to persistent contamination (Schwacke *et al.,* 2014). The impacts included adrenal toxicity and lung disease. Similar habitats do not exist along the Israeli shoreline and it is unlikely that dolphins would be exposed to persistent hydrocarbon contamination from the credible spill scenarios assessed within this Production Development EIA.

However, as discussed previously, in scenarios where a slick is present, it is very rapidly evaporated and is not considered to result in a significant impact, particularly due to the low density of marine mammals in the Application Area (refer to CSA Ocean Sciences Inc. 2016a&b).

Sea Turtle Impacts

According to the Sensitivity Analysis of Israelis Coastlines to Oil Pollution (Pareto, 2006), marine pollution effects to sea turtles is considered to be irreversible. Sea turtles are afforded the highest level of priority in the event of a spill, in addition to official nature preserves (see below) according to ecological parameters. Sea turtles are also a protected species that is in danger of extinction and Israel has undertaken to protect them under the Barcelona Convention (refer to Section 4.2.6.3).

A hydrocarbon oil spill could potentially affect sea turtles if they were to come into contact with a surface oil slick. Several aspects of sea turtle biology and behavior place them at risk, including lack of avoidance behavior and inhalation of large volumes of air before dives. Similarly to marine mammals, direct exposure may produce irritation and inflammation and hydrocarbons can adhere to turtle skin or shells. In the open ocean, a sea turtles could come into contact with a spill, but impacts to sea turtles population in the Application Area, is extremely unlikely due to their low density, the spill plume (production fluid release) being predominantly gas rises to the surface rapidly and there is a short duration of a potential spill event.

Sea turtle nesting sites have been identified all along the Israeli shoreline. Modelling shows that the earliest incident in which beaching would occur would be 50 hours (refer to Table 4-4) following the event of credible spill scenarios within the scope of this EIA as described in the section above. Upon realisation of a spill event, Noble Energy will adopt a similar strategy to the Leviathan Development as they apply to their existing operations in Israel. This oil spill response strategy will able deployment of a response within a timeframe of four (4) to six (6) hours of identification of the spill. The tactic deployed will be based on the Leviathan-specific risk assessment that is currently underway.

Nesting starts at the end of May for loggerhead turtles and in mid-June for green turtles, continuing until about the end of July and mid-August, respectively. Specific locations for sea turtle nesting are noted in Israel Ministry of Environmental Protection, Marine and Coastal Division, Atlas of Israel coastal sensitivity to oil pollution in the Mediterranean. Jerusalem, 2006. As the spill modelling indicated beaching from an oil spill event would arrive to shore after a period of 50 hours and therefore in the unlikely event of hydrocarbons reached these sensitive sites, the hydrocarbon will be highly weathered (tar-balls) and hydrocarbon recovery and remediation response (currently under development for the Leviathan Development Project) would be actioned as a high priority given the likely impact on these sensitive receptors.

Seabirds and Migratory Bird Impacts

Direct exposure of marine birds to hydrocarbons may result in fouling and matting of plumage which can impact their ability to fly as well as their insulating and water repelling properties and buoyancy. Exposure may also produce irritation and inflammation of skin or sensitive tissues. If oil is ingested it can have serious effects, such as congested lungs, intestinal or lung issues and other internal damage. However, although individual marine birds may come into contact with a spill, population level impacts are unlikely due to the relatively small area that would be impacted, the brief duration of a spill event and the density of marine birds in the Application Area.

It is worth noting the presence of two (2) designated coastal International Bird Areas (IBAs) in Israel (refer to Section below entitled 'Protected Habitats and Species'. Of the 15 IBAs designated in Israel, two include coastal habitats (Bird Life International, 2014c):

- Zevulun Valley IBA
- Carmel coast IBA

These are both described in detail below.

Fish

In the open ocean, individual fish species (as well as eggs and larvae) may come into contact with a spill, but population level impacts are extremely unlikely due to the brief duration of a spill event and the relatively small area that would be impacted. Despite the susceptibility of juvenile stages of fish to relatively low concentrations of oil in the water column, adult fish are far more resilient and effects on wild stock levels have seldom been detected. Free swimming fish are thought to actively avoid oil (ITOPF, 2004).

Fishing

Aquaculture is usually undertaken onshore using traditional earthen ponds, such activities onshore will not be impacted by any spill incidents described above. Mariculture is generally focused in the nearshore environment therefore are unlikely to be affected in the event of a spill since there are only negligible instances of oil reaching the coastline the spill scenarios modelled. Further, the aerial extent of any slicks or areas of increased oil in water concentrations have shown to be minor when simulated in OSCAR, as such the overall fraction of Israeli fishing ground impacted by a spill would be minor.

Offshore marine fishing within the scope of this EIA is relatively sparse as a result of water depths and the oligotrophic nature of the environment (UNFAO, 2007).

Archaeological and Cultural Heritage

A hydrocarbon spill is not expected to impact archaeological sites on the sea floor due to the tendency of condensate to rapidly migrate to the sea surface and for dispersed oil to readily become diluted below observable levels.

Impacts on Marine Transport and Infrastructure

The release of gas inventory due to a pipeline loss of containment could potentially impact shipping activities. Shipping lanes are present, with the nearest approaching the port of Haifa and numerous others crossing Israel's Territorial Waters. However, the identified spill scenario is specific to within the 1,500 m exclusion zone around the LPP where marine traffic will be controlled. Further, the nearest boundary of the north/south shipping lane is approximately 2-3 km from the release site which allows for substantial dilution of any flammable gas cloud prior to it impacting on shipping activities within the shipping corridor.

4.2.6.2 Habitats and Impacts to Secondary Users

The Open Sea Environment

The open sea environment, also termed the pelagic environment, is the body of water that extends from the sea surface and almost to the seabed. The pelagic environment is occupied by pelagic species including marine mammals, sea turtles and fish. The impacts associated with these species is discussed in Section 4.2.6.1 above.

While most of the impacts from a loss of containment from the subsea production pipeline is present on the sea surface, some dissolved hydrocarbons and small hydrocarbon droplets will be dispersed through the water column. This occurs as the released gas and condensate rise quickly though the water column.

From the moment of release it takes between five (5) and 10 minutes for the leading edge of the release to reach the sea surface. During this short duration a small insignificant portion of gas will dissolve into the water column as it rises, although the majority of the gas will continue to the atmosphere thus leaving the marine environment. Most of the condensate fluid will rise with the gas, and upon reaching the sea surface will drift, where some will evaporate and some will continue to dissolve into the water column. The heaviest fractions remain within half a kilometre of the release point and slowly disperse into the water column.

Hydrocarbons dispersed in the water column represent a potential acute toxic risk to marine biota, generally when above 50 ppb, as the plume of hydrocarbons drifts through the marine environment. In this release scenario, however, only small isolated areas within the plume were seen to exceed that concentration while most of the plume was less concentrated.

The distinction between deepwater and the critical transition zone is made using benthic community assemblages that occupy the seabed. According to the benthic habitat as described in CSA Ocean Sciences Inc. 2016a&b, this significant change in assemblage occurs at a depth of 60 m where species composition changes from being dominated by Mollusca and Echinodermata to primarily Annelida *sp.* at a depth of 60 m onwards.

The Seabed

The seabed environment, also termed the benthic environment, includes both the sediments that comprise the seabed and the benthic species which live on or in the seabed. Impacts to sediment quality and benthic organisms is discussed in Section 4.2.6.1 above.

The Coastline

Israel's coastline stretches approximately 195 km along the Mediterranean Sea, from the cliffs of Rosh Hanikra in the north to the Gaza Strip in the south. About 32 tiny islands spread along the coast provide a refuge for sea birds, birds and a variety of animals.

As presented in Table 4-4, modelling demonstrated that in the instance of a spill scenario as detailed above, beaching would occur at five (5) different locations depending on weather conditions. These impacts are described below.

Beaches used for Swimming and Leisure

There are many bathing beaches along the coast of Israel and coastal locations which give rise to leisure activities such as swimming and fishing and also exhibit points of interest such as archaeological sites.

As presented in Table 4-4, modelling demonstrated that in the instance of a spill scenario as detailed above, beaching would occur at five (5) different locations depending on weather conditions. These impacts are described below.

Rocky Beaches and/ or Sandy Beaches

All beaches along the Israeli coastline are comprised of varying rocky or sandy habitat. According to Israel's Sensitivity Index, Haifa has the highest remediation priory, therefore in the instance of spill during a SS1 or SNEW2 weather condition (refer to Table 4-4), Noble would execute its response strategy as a matter of high urgency.

As described in Table 4-4, in the instances where the oil will beach, it does so only in small, broken up patches of highly weathered hydrocarbon material. Noble Energy employ an oil spills response strategy with allows deployment of necessary response within a timeframe of four (4) to six (6) hours upon becoming aware of a spills incident and therefore the likelihood of hydrocarbon beaching is low. Hence, the significance of the impact to rocky or sandy beaches is considered to be Low (as a result of time to beach is much great than expected time to respond to such a spill).

There is a coral reef habitat present at Achziv, however modelling shows that the spill will not make contact with this location.

Marinas, Moorings, Marine Anchorages and Ports

Most of the goods in Israel (imports/ exports) pass through its seaports. According to Israel's Sensitivity Index the economic damage to Israel can be substantial. At the same time, since the damage is localized, it can be quickly remediated.

A marina does not necessarily stop functioning due to an oil spill, the damage is localized and remediation can be quick. The only instance where a spill may come into contact with a port is would be at Haifa, however it is not anticipated that a spill scenario as described in the sections above will have a significant impact since the slick, as it reaches the coastline will disappear within hours of discharge (refer to Table 4-3).

Industrial Facilities

According to Israel's Sensitivity Index, power stations are afforded the highest level of priority, however according to modelling results, power stations will not be impacted in a spill event.

Fish Farm Cages

According to modelling results, marine farming locations will not be significantly impacted by a spill event.

Protected Habitats and Species

The European Union (EU) adopted the Council Directive 92/43/EEC in 1992 on the conservation of natural habitats and of wild fauna and flora aims to promote the maintenance of biodiversity, taking account of economic, social, cultural and regional requirements. It forms the cornerstone of Europe's nature conservation policy with the Birds Directive, 2009/147/EEC and establishes the EU wide Natura 2000 ecological network of protected areas, safeguarded against potentially damaging developments. Although Israel is not a member state, care should be taken during all Leviathan Field Development Activities so as not to compromise the interests of the legislation which specifies that the following is prohibited:

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

Additionally, the International Union for the Conservation of Nature (IUCN) is the global authority on the status of the natural world and affords each species an IUCN status which indicates the numbers remaining for the population globally.

Species which have been afforded an IUCN and/ or EU Directive status and whose presence has been recorded regularly in Israeli waters are presented in the table below.

Table 4-5 Sensitive/ Vulnerable Species Regularly Present in Israeli Waters

Common Name	Scientific Name	IUCN Status	EU Habitats/ Birds Directive Listed
Marine Mammal			
Shortbeaked common dolphin	*Delphinus delphis*	EN[1]	II and IV
Striped dolphin	*Stenella coeruleoalba*	VU[2]	-
Common bottlenose dolphin	*Tursiops truncatus*	EN[1]	IV
Mediterranean monk seal*	*Monachus*	EN[1]	II and IV
Sea Turtle			
Loggerhead turtle	*Caretta*	VU[2]	II and IV
Green turtle	*Chelonia mydas*	EN[1]	IV
Leatherback turtle	*Dermochelys coriacea*	VU[2]	IV
Seabirds			
Dalmatian Pelican	*Pelecanus crispus*	VU[2]	I
Yelkouan Shearwater	*Puffinus yelkouan*	VU[2]	I
White-Eyed Gull	*Larus leucophthalmus*	NT	-
Cory's Shearwater	*Calonectris diomedea*	LC	I
Black Tern	*Chlidonias niger*	LC	I
Slender-Billed Gull	*Larus genei*	LC	I
Mediterranean Gull	*Larus melanocephalus*	LC	I

Common Name	Scientific Name	IUCN Status	EU Habitats/ Birds Directive Listed
Great White Pelican	*Pelecanus onocrotalus*	LC	I
Pygmy Cormorant	*Phalacrocorax pygmeus*	LC	I
Little Tern	*Sterna albifrons*	LC	I
Leach's Storm-Petrel	*Oceanodroma leucorhoa*	LC	I
Lesser Crested Tern	*Sterna bengalensis*	LC	-
Caspian Tern	*Sterna caspia*	LC	I
Gull-Billed Tern	*Sterna nilotica*	LC	I
Sandwich Tern	*Sterna sandvicensis*	LC	I
Red-Necked Phalarope	*Phalaropus lobatus*	LC	I
Fish			
Blue Shark	*Prionace glauca*	NT	-
Atlantic Bluefin tuna	*Thunnus thynnus*	EN	-

** The monk seal is listed here as its presence is confirmed in Israeli waters however it is considered to be extremely rare (refer to CSA Ocean Sciences Inc. 2016, 2016b).*

Israel is a signatory to the Barcelona Convention for the Protection of the Marine Environment and the Coastal Region of the Mediterranean (adopted in 1995) which aims to:

- Assess and control marine pollution
- Ensure sustainable management of natural marine and coastal resources;
- Integrate the environment in social and economic development;
- Protect the marine environment and coastal zones through prevention and reduction of pollution, and as far as possible, elimination of pollution, whether land or sea-based;
- Protect the natural and cultural heritage;
- Strengthen solidarity among Mediterranean coastal States; and
- Contribute to improvement of the quality of life.

There are no protected habitats in the Leviathan Application Area within the scope of this Production EIA. The Background Monitoring Survey identified the presence of pockmarks which could be representative of the EU Habitats Directive Annex I habitat for 'Submarine Structures made by Leaking Gases' (EUR28, 2013). However, pockmarks that do not exhibit carbonate structures are not included in this habitat designation and since no consolidated substrates (hard bottom features) were identified during the baseline survey (refer to CSA Ocean Sciences Inc. 2016a&b) it is unlikely that these are representative of an Annex I habitat.

Although there are no offshore protected habitats, it is worth noting however, that there are protected environments along the coastline, that according to modelling results have the potential to receive some contact from a spill event:

- DorHabonim Marine Protected Area (MPA); and
- DorHabonim National Park.

There are also 15 designated IBAs in Israel, two (2) of which have coastal components as follows:

- Zevulun Valley IBA – an area of the coastal plain north of Haifa, largely developed or agricultural, with fish ponds and some other small wetlands including the marsh at Ein Afeq (a nature reserve and Ramsar wetlands site), approximately eight (8) km south of Akko.
- Carmel coast IBA – a 20-km-strip along the Mediterranean coast, from Atlit south to the Taninim River Nature Reserve. The site includes the Atlit saltpans (eight (8) km south of Haifa) and a large complex of fish ponds at Ma'agan Mikhael and Ma'ayan Zvi, 25 km north of Netanya, as well as some small islands off Ma'agan Mikhael.

According to Israel's Sensitivity Atlas, an official nature preserve is highly sensitive to marine pollution. The damage to the flora and fauna can be great and the recovery process can be long, up to several years. Nature preserves are afforded the highest level of priority, along with sea turtles (see Section above), in the instance of a spill, a speedy response is essential. National parks are third on the list of priorities according to ecological parameters.

For detailed information pertaining to potential impacts on protected/ sensitive coastal habitats refer to the EIA document that was prepared and approved as part of the TAMA 37H process, which addresses the permitting and approvals of Oil and Gas Projects in Israel up to the limit of Israel Territorial Waters (i.e., 12 nautical miles from shore).

Oil Spill Beaching Incidents

As presented in Table 4-4, modelling demonstrated that in the instance of a spill scenario as detailed above, beaching would occur at five (5) different locations depending on weather conditions. Details pertaining to the amount of time it would take for the spill to beach show that the most rapid beaching incident would occur within 50 hours. Upon realisation of a spill event, Noble Energy will adopt a similar strategy that they apply to their existing operations in Israel. This oil spill response strategy will able deployment of a response within a timeframe of four (4) to six (6) hours of identification of the spill. The tactic deployed will be based on the Leviathan-specific risk assessment that is currently underway. Therefore, it is considered unlikely that the spill would make contact with the Israel coast.

In the unlikely instance that this would occur however, it is important that Noble tailors its response strategy according to the priority of the coastal stranding location. The priority of each location as presented in Table 4-4 is discussed below.

Areas near Haifa and Dor

Beaching of the spill at this location would occur during WWS3 weather conditions and would take approximately 128 hours to make contact with this point of the coast.

According to Israel's Sensitivity Analysis, Haifa is afforded the highest level of priority for remediation and protection. This is primarily due to the fact that it gives rise to the following:

- Power Station – this receives the highest level of priority for response and remediation; and
- Nature Preserves and Sea Turtles – There are four (4) Nature Preserves within the vicinity of Haifa and sea turtle presence and/ or nesting is noted at two (2) locations. Nature Preserves and sea turtles are afforded the second highest level of protection.

Other features include 27 beaches, five (5) aquaculture sites, a harbor, six (6) marine centers, five (5) archaeological sites and four (4) stream mouths.

Therefore, a beaching incident at this location would be given highest priority for Nobles remediation response.

Israel – Lebanon Border and Haifa

Beaching of a spill at this location would occur during SS1 weather conditions and would take approximately 91 hours to make contact with this point of the coast.

For the reasons discussed above, with regards to the sensitivity of Haifa, this area would be given highest priority for Nobles remediation response.

Israel – Lebanon Border

Beaching of a spill at this location would occur during SS3 and SNEW1 weather conditions and would take approximately 107 and 174 hours respectively, to make contact with this point of the coast.

Modeling demonstrated that 100m patches would occur on the Lebanon side of the border. Since the beaching incident would be in Lebanon, the sensitivity of the location cannot be assessed according to the Israel Sensitivity Analysis however, there is the presence of Tyre Coast Nature Reserve approximately 20 km north of the coastal beaching location at Lebanon.

Noble would ensure that response was provided, as stated above within four (4) to Six (6) hours and that the appropriate authorities are immediately informed as part of the ERP.

It should be noted, that it is estimated to take approximately 107 or 174 hours for the spill to make contact with this location therefore, in the instance of a spill, Noble would respond and have implemented its remediation strategy prior to the occurrence of a beaching event.

Area around Haifa, near Israel Lebanon- Border

Beaching of a spill at this location would occur during SNEW2 weather conditions and would take approximately 50 hours to make contact with this point of the coast.

For the reasons discussed above, with regards to the sensitivity of Haifa, this area would be given highest priority for Nobles remediation response.

Transboundary Spill Impacts

Hydrocarbons released to the environment will also be mobile without respect for human maritime boundaries. Without intervention, there exists a small possibility that hydrocarbons could be swept across maritime boundaries and result in beaching of hydrocarbons on the coastlines of countries neighbouring Israel. Modelling work showed a tendency for hydrocarbons to travel north and northeast from the release site.

Modelling of a loss of containment from the subsea production pipeline showed that in some instances hydrocarbons did indeed travel northward on a trajectory towards Lebanon, and in a few of those cases extremely limited quantities of hydrocarbons beached on the far southern coastline of Lebanon. The transboundary impacts were limited however. Any surface sheen thinned to a degree where it was no longer visible to unaided human eye well in advance of leaving Israeli maritime territory. Water column concentrations diluted to below the 50 ppb threshold, below which acute toxic effects on marine biota are not expected, at this point. Any hydrocarbons that beached on the southern tip of Lebanon were present in extremely small quantities and were well weathered.

Impact Significance

Given the controls in place, within the Application Area, the anticipated impact significance is considered to be low.

Table 4-6: Impact Ranking – Sea Pollution Event by Oil Based Scenario

Activity	Aspect	Potential Impact	Mitigation & Control	Likelihood	Severity	Residual Risk
Pipeline gas and hydrocarbon inventory	Loss of containment	Impacts to sediment and water quality and marine flora and fauna	OSRP Pipeline designed to industry standards PMS and controls system programmed to minimize potential release inventory Marine exclusion zone around the LPP	2	2	4
Pipeline gas and hydrocarbon inventory	Loss of containment	Interference with fishing and shipping industry	OSRP Pipeline designed to industry standards PMS and controls system programmed to minimize potential release inventory Marine exclusion zone around the LPP Notification to marine users in the instance of a spill	1	1	2
Pipeline gas and hydrocarbon inventory	Loss of containment	Beach landing (rocky beaches and/or sandy beaches that are rich in biota)	OSRP Pipeline designed to industry standards PMS and controls system programmed to minimize potential release inventory Marine exclusion zone around the LPP Notification to marine users in the instance of a spill	1	1	1
Pipeline gas and hydrocarbon inventory	Loss of containment	Impact to leisure and tourism, marinas etc)	OSRP Pipeline designed to industry standards PMS and controls system programmed to minimize potential release inventory Marine exclusion zone around the LPP Notification to marine users in the instance of a spill	1	1	1
Pipeline gas and hydrocarbon inventory	Loss of containment	Industrial Secondary Users	OSRP Pipeline designed to industry standards PMS and controls system programmed to minimize potential release inventory Marine exclusion zone around the LPP Notification to marine users in the instance of a spill	1	1	1

4.2.7 Hydrodynamic Oil Spill Modelling Tool

In line with the MOEP Guidelines, Genesis prepared a technical note for Regulatory approval of OSCAR prior to running the model. The technical note was prepared as outlines in sections 4.2.7.1 to 4.2.7.5 of the MOEP Guidelines and can be found in Section G entitled Appendices, Appendix D.1.

4.3 Noise

Potential noise impacts from the Leviathan Field Development Project are principally associated with the construction, installation and commissioning of the infield flowlines, gathering lines and associated subsea infrastructure.

Relative sound intensities given in decibels (dB) in water are not directly comparable to relative sound intensities given in dB in air. Sound propagates over longer distances in water than in air. The intensity of a sound wave with a pressure of one (1) microPascal (μPa) is used as the reference intensity for underwater sound and in air, a sound wave with the higher pressure of 20 μPa is used as the reference intensity. The intensity of a sound wave depends not only on the pressure of the wave, but also on the density and sound speed of the medium through which the sound travels. The density of water is much greater than the density of air and the speed of sound in water is much greater than the speed of sound in air.

Noise Sources

Pipelay Activities

The frequency spectrum from pipelay vessels is predominantly low (10-1000 Hz) with peak levels typically below 500 Hz. Noise levels from pipelaying are likely to be generally comparable to noise levels from dredging activities, which are typically of low frequency below one (1) kHz and the sound source levels typically range from 168-186 dB (rms) re one (1) μPa-m. Parvin *et al*. (2008) measured the source levels of a trailing suction hopper dredger operating on the Hastings shingle and calculated the broadband source level to be 186 dB re 1μPa-m; it was estimated that the dredging noise would not be audible beyond a range of six (6) km.

Installation vessels fixed by anchors generate lower sound levels than those which use thrusters and engines for propulsion. The pipelay vessel will utilise DP (refer to Section 3.2), which will result in sound generation along the length of the pipelines. DP involves the use of a number of thrusters and is therefore likely to result in increased noise levels when compared with an anchored vessel. It is important to discuss the impacts of this sound, due to the long distances over which sound propagates through water and the sensitivity of receptors in the marine environment.

Support Vessels

Underwater sound during Leviathan subsea facility installation will primarily result from the operation of vessels. The primary sources of noise from vessels are from propellers, propulsion and other machinery (Richardson *et al*., 1995). In general, vessel noise is continuous, from narrowband tonal sounds at specific frequencies and broadband sounds. Acoustic broadband source levels typically increase with increasing vessel size, with smaller vessels (< 50 m) having source levels 160-175 dB [re one (1) μPa], medium size vessels (50-100 m) 165-180 dB [re one (1) μPa] and large vessels (> 100 m) 180-190 dB [re one (1) μPa] (OSPAR, 2009; Richardson *et al,* 1995). However, noise levels depend on the operating status of the vessel and can vary considerably in time. Acoustic energy is strongest at frequencies below one (1) kHz.

Helicopters

Few measurements have been made of the underwater noise generated by helicopters during approach and take-off from platforms and vessels. Helicopters generate a pulsating noise referred to as 'blade slap'. There may be occasional helicopter flights to and from some of the larger construction/ installation vessels for the transportation of personnel and equipment, but all flights will be scheduled during day-time hours and the duration of such activities is regarded as being relatively short. Helicopter noise impact is therefore deemed insignificant and poses little or no risk to marine life in the area and is not discussed further in the section to follow.

Pile Driving

The Infield Gathering Manifold will require a piled foundation that will be in the form of a single suction pile. Suction piling uses tubular piles that are driven into the seabed, or dropped a few meters into a soft seabed, after which air and water are sucked out the top of the tubular pile thereby sinking the pile into the ground. The outer diameter of the pile will be approximately six (6) m. Although noise levels have not been reported, they are expected to be low as the only source of noise is the pump. Since the Project intends to employ the suction pile method rather than hammer driven piling, the impact significance is considered to be very low and is not discussed further in the section to follow.

Impacts

Marine fauna use sound for navigation, communication and prey detection (e.g. reviews in Southall *et al*., 2007; Richardson, *et al*., 1995). Therefore, the introduction of any anthropogenic underwater noise has the potential to impact on marine animals if it interferes with the animal's ability to use and receive sound (e.g. OSPAR, 2009). The impact of sound on an animal depends on many factors including the level and characteristics of the sound, hearing sensitivity of the species and behavior of the species.

It is generally accepted that exposure to anthropogenic sound can induce a range of adverse effects on marine life (e.g. OSPAR, 2009). These can vary from insignificant impacts such as temporary avoidance or changes in diving behavior to significant behavioral changes and also include non-injurious effects such as masking of biologically relevant sound signals (Richardson *et al*., 1995). Activities that generate very high sound levels can cause auditory and other physical injuries and in some circumstances, lead to mortality (Southall *et al.* 2007; Richardson *et al.* 1995). Auditory effects include temporary or permanent reduction in hearing sensitivity. Non-auditory impacts may include damage to body tissues, especially air-filled cavities including swim bladder and muscle tissues (review by Richardson, *et al*. 1995).

Underwater Noise Modelling

To assess the impact of sound from the Leviathan Field Development Project on marine receptors, the propagation of sound into the surrounding environment was modeled. The sound sources have been modeled using representative spectra from published noise measurements. The propagation of this sound into the environment has been calculated using the Genesis noise model, which incorporates depth-dependent geometrical spreading and empirical functions for frequency attenuation (Jensen *et al*., 2011; Richardson *et al*., 1995; Marsh & Schulkin, 1962).

Modelling of the sound generated specifically during pipelay has been carried out using a measured source spectrum for a pipelay vessel (Hannay *et al*., 2004) and a modelled spectrum for a vessel of a similar size to a guard boat (Breeding *et al*., 1996). As the pipelines are approximately 117.5 km in length and pass from a water depth of approximately 1,700 m to 86 m, two scenarios have been modelled:

1. A deep water scenario at the Leviathan field; and,
2. A shallow water scenario at the LPP.

A grid size of 50 km by 50 km has been used with a spatial resolution of 50 m. This provides predictions of the received noise level by an animal in the area. The modelled sound levels from pipelay vessel activities are shown in Figure 4-7 and Figure 4-8.

Figure 4-7: Modelled Propagation of Underwater Sound during Pipelay (deep water)

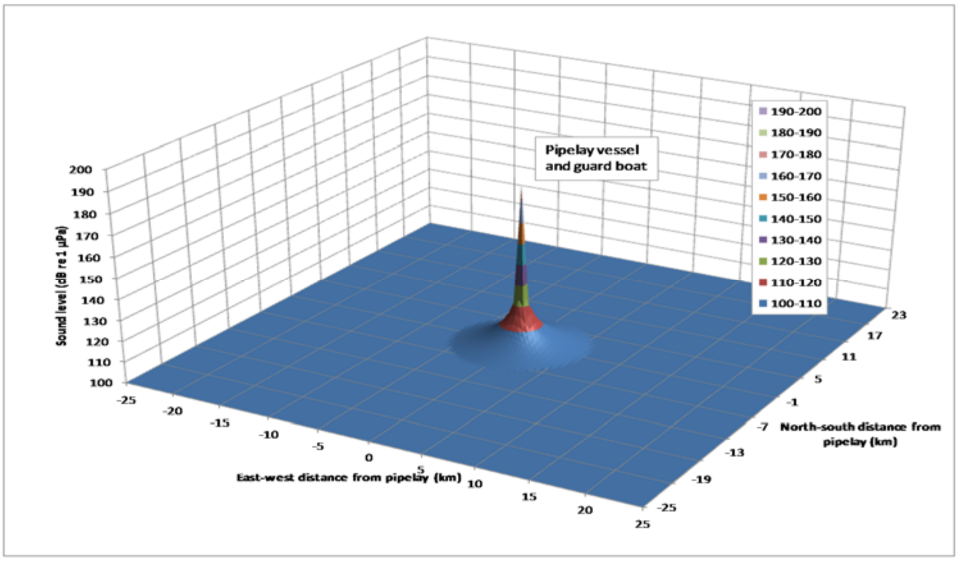
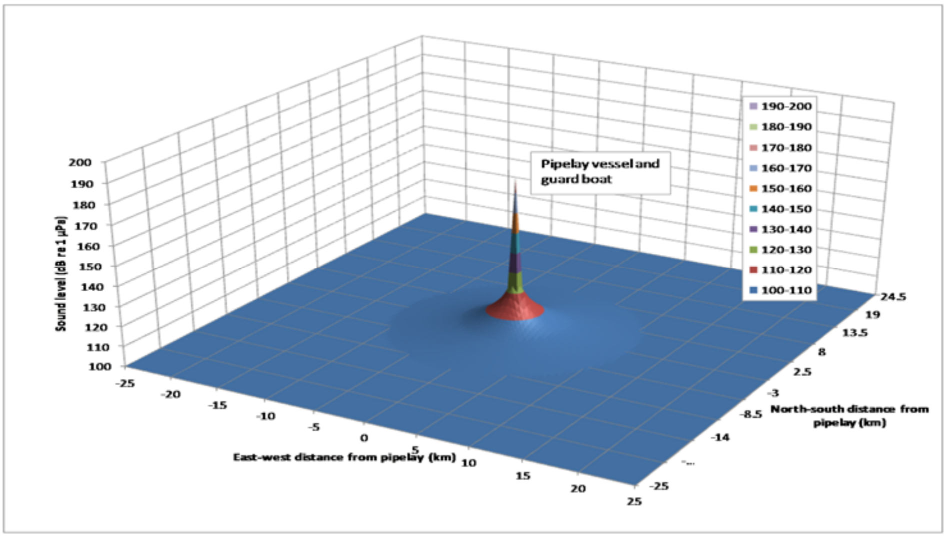


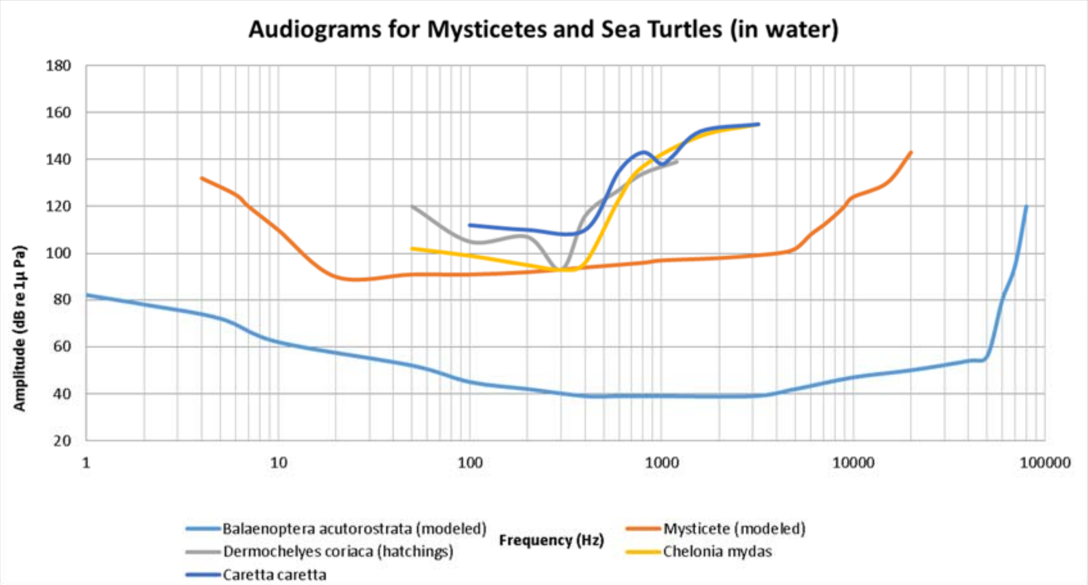
Figure 4-8: Modelled Propagation of Underwater Sound during Pipelay (shallow water)



The predicted sound level for both scenarios is 178 dB re one (1) µPa.

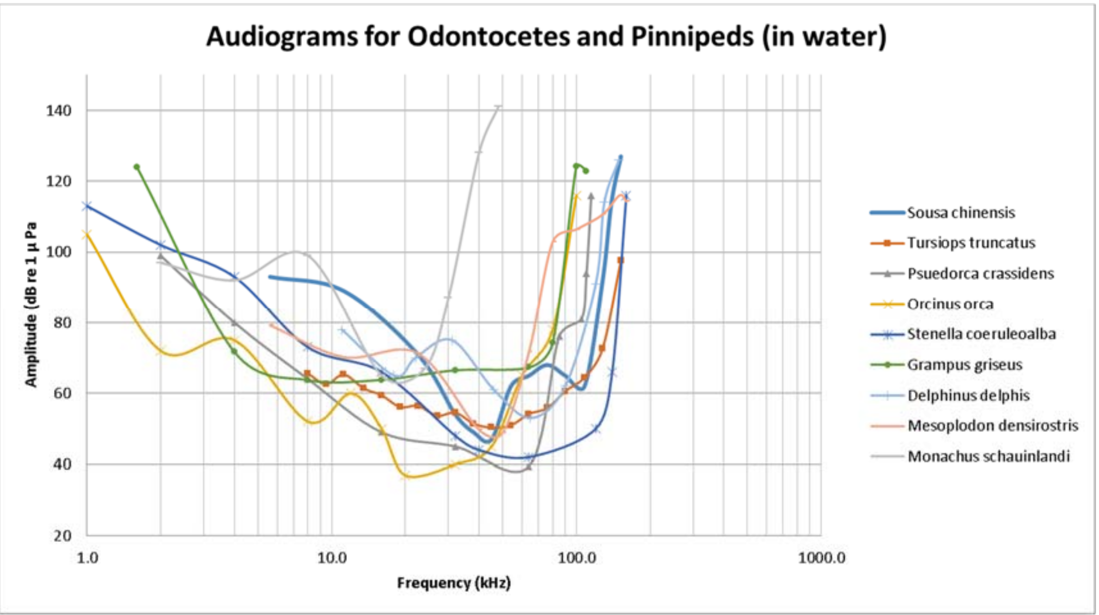
To model the generation of underwater sound anticipated to be produced by support vessels, third octave frequency band spectra were taken from the literature for similar vessel types and are presented in Figure 3-13.

Figure 4-9 Baleen Whale (Mysticete) and Sea Turtle Audiogram



Sources: Ketten & Mountain, 2001; Pinial *et al.* 2012; Martin *et al.* 2012; Piniak, 2012; Erbe, 2002.

Figure 4-10 Toothed Whate (Odontocetes) and Pinnipeds Audiogram



Sources: Wang *et al,* 2012; Houser, *et al.* 2008; Thomas, *et al.* 1988; Syzmanski, *et al.* 1999; Kastelein *et al*, 2003; Nachtigall, *et al*. 2005; Popov and Klishin, 1998; Pacini, *et al*. 2011; Thomas, *et al.* 1990.

Marine Mammals

Marine mammal species that are likely to be present in the Application Area are detailed in CSA Ocean Sciences Inc. 2016a and discussed further in Section 4.4. For the purpose of this assessment it should be noted that both toothed whales and dolphins and baleen whales are present in the Levantine Basin. The Mediterranean Monk Seal's presence is recorded as being extremely rare in Israeli waters and is unlikely to be found offshore within the scope of this EIA so this section will focus only on the impacts to cetaceans (dolphins and whales).

The range at which marine mammals may be able to detect sound arising from offshore activities depends on the hearing ability of the species and the frequency of the sound. Odontocete (toothed) whales are most sensitive to underwater sound at high frequencies between approximately 10 kHz and 50 kHz (refer to Table 4-7). In many species, this is related to their use of high frequency sound for echolocation. Data indicate that sensitivity is poor below one (1) kHz (Richardson *et al*., 1995). Mysticete (baleen) whales' hearing has not been studied directly. Indirect evidence suggests they are most sensitive to "low to moderate" frequencies between 20 Hz and 2 kHz (Erbe, 2002) (refer to Table 4-7).

To determine the consequences of the received levels on an animal it is necessary to relate the levels to known or estimated impact thresholds. The predicted sound levels have been compared with the hearing sensitivities of those marine mammal species whose presence has been recorded in the Application Area (refer to CSA Ocean Sciences Inc. 2016a). Comparison has been made using the following references as guidance for internationally recognized thresholds:

- Southall *et al*., (2007) presents thresholds for injury to marine mammals which are based on a comprehensive review of evidence for impacts of underwater noise on marine mammals. Criteria were proposed for peak Sound Pressure Levels (SPL) and Sound Exposure Levels (SEL) for different types of noise that are likely to lead to injury to marine mammals with different hearing characteristics. Injury is defined as the onset of permanent hearing damage. Thresholds are summarized in Table 4-6. These criteria are now widely recognized within the scientific community as the appropriate precautionary criteria for assessing the impact of underwater noise on marine mammals (JNCC, 2010a&b).
- Nedwell *et al*., (2007) presents an audiogram method which proposes that injury and disturbance to a marine animal is likely to occur at 140 dB and 90 dB respectively above the animals hearing threshold. This metric is written as dBht (species), i.e. dB above the hearing threshold for a particular species. These criteria can be used to assess the impact on noise on any species for which hearing sensitivity data are available.

Table 4-7 Estimated Auditory Bandwidth and Marine Mammal Injury Criteria - Southall *et al.,* (2007)

Marine Mammal Group	Examples of Species Potentially Occurring in Leviathan Area	Estimated Auditory Bandwidth	Sound Metric	Sound Type		
				Single Pulse	Multiple Pulse	Non-Pulse
				e.g. blast, airgun shot, pile strike	e.g. seismic survey, piling operation	e.g. vessels, helicopters, drilling
Low-frequency cetacean	Fin whale, minke whale, sperm whale	7 Hz – 22 kHz	Peak SPL (dB re 1 µPa)	230	230	230
			M-weighted SEL (dB re 1 $\mu Pa^2 s$)	198	198	215
Mid-frequency cetacean	Risso's dolphin, striped dolphin, false killer whale	150 Hz to 160 kHz	Peak SPL (dB re 1 µPa)	230	230	230
			M-weighted SEL (dB re 1 $\mu Pa^2 s$)	198	198	215
High-frequency cetacean	N/a	200 Hz to 180 kHz	Peak SPL (dB re 1 µPa)	230	230	230
			M-weighted SEL (dB re 1 $\mu Pa^2 s$)	198	198	215
Pinniped (in water)	Mediterranean monk seal	75 Hz to 75 kHz	Peak SPL (dB re 1 µPa)	218	218	218
			M-weighted SEL (dB re 1 $\mu Pa^2 s$)	186	186	203

For pipelay activities, the predicted sound level for both the deep (Figure 4-7) and shallow water (Figure 4-8) operations is 178 dB re one (1) µPa. This is below the Southall *et al.*, (2007) thresholds for injury and disturbance to marine mammals as demonstrated in Table 4-2.

Figures 4-9 and 4-10 and Figure 3-11 indicate that sound from the support vessels will be audible to marine mammals. In particular, the low frequency sound produced by vessels coincides with the most sensitive hearing range of baleen whales, of which the minke whale and fin whale have the potential to be in the development area (refer to CSA Ocean Sciences Inc. 2016a). However, for these species the source level is predicted to drop below the 90 dBht (species) threshold for disturbance within the first few meters of the source. For all other species that are considered to be regular visitors in Israeli waters, the sound levels are predicted to be below the dBht threshold for disturbance. The predicted sound levels are below the Southall *et al.* (2007) thresholds for distance and injury to cetaceans even for anticipated noise levels produced from the largest vessels as described above.

Despite DP not being a new system, there is relatively little information on the emitted noise levels and frequencies from thrusters. Of the research that has been undertaken, thruster noise measurements are in the region of anywhere between 121 – 197 dB re1 µPa @ 1 m (reported in AT&T 2008). Low frequencies of thruster noise have been measured between 50 – 3,200 Hz. As these noise sources have their peak levels in the low-frequency end of the spectrum, it is suggested that the primary sensitive receptor for underwater noise from DP systems will be the baleen whales, specifically fin and minke whales.

The potential impact would be for the thruster noise to mask the hearing of baleen whales. The potential for masking at higher frequencies [one (1) to 25 kHz] exists when the vessel is in close proximity to the particular animal. In these close proximity circumstances other marine mammals may also experience masking from vessel noise (for example, toothed cetaceans (Lusseau *et al*., 2009). There is very little known about the potential of DP thrusters to cause auditory impairment in or physical damage to cetaceans. Moderate levels of underwater noise can induce short-term reductions in hearing sensitivity in marine mammals, termed Temporary Threshold Shifts (TTS) (Southall *et al*., 2007), whilst it is possible that higher levels may result in more permanent damage (Finneran *et al*., 2005).

The DP vessels will be operating in an open offshore area and as such there is no potential for marine mammals to become trapped in a high-noise environment. Additionally, the DP pipelay vessel will be travelling at a relatively slow speed allowing time for any marine mammals in the vicinity to become accustomed to the vessel (or move away from it) as it approaches thus avoiding any startle responses. Continuous or prolonged sounds are less problematic for animals than loud, intermittent noises as individuals will have the opportunity for avoidance. Since the DP vessel will be employed along the entire pipeline route, the sound of the DP activity will be relatively continuous during construction and installation activities and allow for marine mammals to avoid the area if necessary.

Sea Turtles

Sea turtle species that are known to be present in the Application Area include the loggerhead turtle, green turtle and leatherback turtle (refer to CSA Ocean Sciences Inc. 2016a). Sea turtles have the greatest hearing sensitivity at low frequencies that coincide with those produced by typical vessels (refer to Figure 4-9 and Figure 3-11 – vessel noise characteristics) and are therefore potentially at risk from the installation operations (Martin *et al.* 2012; Ketten, 2005).

Historically sound exposure criteria for marine mammals have been applied to sea turtles. If the marine mammal criteria discussed in the preceding section are applicable to sea turtles, the levels of sound produced are sufficient to be audible to sea turtles and to produce behavioral responses. However, there is no direct evidence of mortality or potential mortal injury to sea turtles from ship noise (Popper *et al*., 2014).

Popper *et al*. (2014) recently proposed preliminary sound exposure guidelines for sea turtles. However, no quantitative criteria were proposed for shipping and other continuous sources. Instead the risk of impacts was qualitatively characterised as low, moderate or high based on proximity to the source, as summarised in Table 4-8.

Table 4-8: Relative Risk of Auditory Impacts on Sea Turtles Exposed to Shipping Noise and Other Continuous Sound Sources (Popper *et al*., 2014)

Type of Impact	Proximity to Source		
	Near (tens of metres)	Intermediate (hundreds of metres)	Far (thousands of metres)
Mortality and potential mortal injury	Low	Low	Low
Recoverable injury	Low	Low	Low
TTS	Moderate	Low	Low
Masking	High	High	Moderate
Behavioral response	High	Moderate	Low

Based on the information presented in Table 4-8, sea turtles that are located more than a few hundred metres from supply vessels are probably at low risk of any impacts other than auditory masking. The importance of auditory masking is difficult to assess for sea turtles, as they are not known to use sound to the same extent as marine mammals. However, sea turtles may use sound for navigation, locating prey, avoiding predators and environmental awareness (Dow Piniak *et al*., 2012).

Sea turtles near the vessels may be exposed to sound levels sufficient to elicit behavioral responses and potentially may create auditory interference by masking. However, the most likely impacts would be short-term behavioral changes such as diving and evasive swimming since they would not be trapped in an excessive/ high noise environment, avoidance strategy would most likely be implemented.

Fish Impacts

Fish species that are known to be present in the Application Area are described in CSA Ocean Sciences Inc. 2016a. Sensitive species include the blue shark and the Bluefin tuna which are listed as Near Threatened and Endangered on the IUCN Red List (refer to sections to follow).

Sound plays a major role in the lives of fish (Zelick *et al*., 1999; Fay and Popper, 2000). In addition to listening to the overall environment and being able to detect sounds of biological relevance, many species of bony fish communicate with sounds for a wide range of behaviors including but not limited to mating and territorial interactions (Zelick *et al*., 1999). Most fish cannot hear sounds above approximately three (3) – four (4) kHz and the majority of species are only able to detect frequencies of one (1) kHz or below. Broad discussions of interactions of anthropogenic sounds and fish can be found in Popper and Hastings (2009) and Popper and Hawkins (2012).

Fish species differ in their hearing capabilities depending on whether they possess a swimbladder, which acts as a pressure receiver and whether the swimbladder is connected to the otolith hearing system, which is sensitive only to particle motion (McCauley, 1994; Slabbekoorn, *et al*., 2010). Most fish can hear in the range 100 to 1000 Hz, with some able to detect lower frequencies. Within this range, the hearing threshold varies from around 50 dB [re one (1) µPa] for hearing specialists species to 110 dB [re one (1) µPa] for non-specialists. Fish with a connection between the swimbladder and otolith system have better hearing and may detect sound frequencies up to three (3) kHz. Based on this, it is likely fish species will be able to detect sound from the construction and installation work and levels may be 70 to 130 dBht depending on the hearing sensitivity of the species. Therefore, injury is unlikely to occur but disturbance may result for the most sensitive species. The effects of "excessive" noise on fish include avoidance reactions and changes in shoaling behavior (Slabbekoorn *et al*., 2010). Noise levels are predicted to drop below 90 dBht for even the most sensitive species within 500 m of the operations. Therefore, the impact on fish is unlikely to be significant.

Popper *et al*. (2014) recently proposed preliminary sound exposure guidelines for fish exposed to shipping and continuous noise sources. There is no direct evidence of mortality or potential mortal injury to fish from ship noise, but there is some evidence for reversible auditory tissue effects and TTS caused by continuous sound. Quantitative thresholds were proposed for recoverable injury and TTS for fish that have a swim bladder used in hearing. Also, the risk of impacts was qualitatively characterised as low, moderate or high based on proximity to the source, as summarised in Table 4-9.

Table 4-9: Relative Risk of Auditory Impacts on Fish Exposed to Shipping Noise and Other Continuous Sound Sources (Popper *et al*., 2014)

Type of Impact	Proximity to Source			Threshold
	Near (tens of metres)	Intermediate (hundreds of metres)	Far (thousands of metres)	
Mortality and potential mortal injury	Low	Low	Low	None specified (no evidence of this impact)
Recoverable injury	Low	Low	Low	170 dB_{rms} for 48 hours (fish with a swim bladder involved in hearing)
TTS	Moderate	Low	Low	158 dB_{rms} for 12 hours (fish with a swim bladder involved in hearing)
Masking	High	High	Moderate-High	None specified
Behavioral response	Moderate-High	Moderate	Low	None specified

Fish near the vessels may be exposed to sound levels sufficient to; elicit behavioral responses, create potential auditory interference by masking and cause recoverable auditory impacts (TTS). However, due to the limited extent and recoverable nature of impacts, these are unlikely to be significant on population levels.

Noise Mitigation and Control Measures

DP thrusters cannot be disengaged in the presence of sensitive species as they control the positioning of the vessel; disabling this control would introduce unacceptable safety risk as the vessel would no longer be navigable and as a result, the risk of collision and spills would be elevated. However, the DP vessel will be travelling at a relatively slow speed allowing animals time to become accustomed to the vessel (or to move away from it) as it approaches, thereby avoiding any startle responses. DP thrusters are regularly utilised by sea-going vessels and there is likely to be only a very small area of disturbance surrounding the DP source. In addition, continuous sounds and sounds where levels are raised over a period of time are less problematic for animals than loud, intermittent sounds as individuals will have an opportunity not to approach a sound that is already occurring. It is therefore likely that any effects of the increased vessel activity will be minor.

No critical habitats for marine mammals, sea turtles or fish and no seasonal periods of peak abundance or activity have been identified in the Application Area. Sea turtle nesting season starts at the end of May for loggerhead turtles and in mid-June for green turtles and continue on until near the end of July and mid-August respectively (refer to CSA Ocean Sciences Inc. 2016a). During these periods, should construction and installation activities be implemented, vessel speed should be lowered upon approach to the coastal environment.

Noise Impact Significance

The small, incremental increase in noise as a result of the additional vessels that will be on site during the development and the deep water in which the vessels will operate, mean that the potential for significant negative impacts of noise resulting from the increase in vessel numbers and movements is low.

Sound levels produced are predicted to be too low to cause significant disturbance or injury and impacts are likely to be limited to temporary avoidance of the area of operation with low potential for population-level impacts.

Table 4-10: Summary of Impacts, Mitigation & Controls and Residual Risk for Noise

Activity	Aspect	Potential Impact	Mitigation & Control	Likelihood	Severity	Residual Risk
Infield Gathering Manifold	Piling to secure to seafloor	Noise and vibration disturbance to marine fauna	Suction piling	2	1	2
Construction/ Installation and support vessels	Use of DP thrusters for positioning	Noise disturbance to marine fauna	None specific Pipelay vessel utilizing DP will be travelling at a slow speed Reduce vessel speeds upon coastal approach, particularly if activities are conducted during sea turtle nesting seasons	2	2	4
Installation logistical support: Helicopters	Noise & vibration from 'blade slap'	Noise and vibration disturbance to marine fauna	Standard aviation procedures and regulations	2	1	2

4.4 Nature and Ecology

4.4.1 Impacts Associated with Laying of Pipelines

The impacts considered in this Section relate Project activities including:

- Pre-commissioning and commissioning (cleaning, gauging and hydrotesting) infield flowlines and transmission pipelines activities;
- Presence of construction/ installation and support vessels/ helicopters;
- Construction/ installation and support vessel discharges; and
- Ballast discharges.

Pre-Commissioning and Commissioning Activities

Cleaning and gauging pigs will be used for initial clean-up to clear construction debris and loose mill scale from the flowline/ pipeline interiors. This material will be returned to the surface within pig receivers and transported to shore for appropriate disposal (see Section 3.2.2.2). During cleaning and gauging, chemically treated water from the initial system flooding will be displaced from the system and discharged to the marine environment, this will be similar in nature to the treated water used for hydrotesting purposes (see below).

Following cleaning and gauging the flowlines/ pipelines will then be hydrostatically tested and as part of the commissioning process, dewatered and dried (and made free of oxygen) with nitrogen gas in preparation for first gas. Hydrostatic testing will be used to verify pipeline integrity following installation and will be completed prior to commissioning. Gas pipelines are normally hydro-tested by filling the test section of pipe with water (often treated with biocides and oxygen scavengers, for details refer to Section 3.2.2.2) and pumping the pressure up to a prescribed value that is higher than the maximum allowable operating pressure and holding the pressure for a period of four (4) to eight (8) hours. After the test period is completed the pressure is let down and the hydrotest water is often displaced from the system with an inert gas. For details of the quantities of hydrotest fluid expected to be discharged into the marine environment and associated chemical concentrations refer to Table 3-10.

MEG will be used to flush subsea connectors and tie-in spools following installation. During this operation some MEG will be released into the surrounding marine environment.

In addition to chemicals, when discharged the hydrotest fluid will also contain any particulate residues from reactions occurring within the pipe. Solid residues are mainly a result of scale breakdown (e.g. iron oxides and traces of manganese and copper) or reaction products from the additive chemicals products (e.g. inorganic salts such as ammonium bisulphite). Previous studies have shown that constituent levels in the used hydrotest water are generally not toxic, but can compromise bottom water quality and temporarily increase turbidity.

Pre-Commissioning and Commissioning Impacts

The impacts of initial flood and hydrotest water discharge to the marine environment are primarily associated with the following:

- Temporary increased water toxicity due to chemical discharge (specifically biocides);
- Temporary decline in water quality due to the presence of oxygen depleted water; and,
- Temporary increase in turbidity due to discharge of residual entrained solids.

The effects of water treatment chemicals discharged into the marine environment are dependent on the toxicity of the chemical, the quantities discharged and resulting concentrations in the water column, the duration that the biota are exposed to that concentration and the sensitivity of organisms to those particular chemicals.

Potential impacts associated with treated water discharges will be limited to within the mixing zone of the effluent plume at the point of discharge. This discharge is temporary and will occur twice during the pre-commissioning/ commissioning phase (once during cleaning/gauging and once following hydrotesting). Therefore impacts upon water quality and marine organisms will be short lived and limited to a localized area. The discharge will occur at the seafloor and will be directed upwards to ensure the plume does not come into contact with the seafloor, thus minimizing the impact on the benthic community. Where avoidance by fish is not possible, the sensitivity to turbidity varies greatly between species and their life stage (Newcombe, C.P. & Jensen, J.O.T, 1996). Fish gills, the major organ for respiration and osmoregulation, are directly exposed to and can be blocked by suspended solids in the water, which can lead to oxygen deprivation. Juvenile fish are most vulnerable to this, as they have smaller, more easily clogged gills, and a higher oxygen demand (FeBEC, 2013).

Ecotoxicity tests have demonstrated that phytoplankton are the most susceptible organisms to biocides. However, such tests also demonstrated that healthy phytoplankton populations were recorded within one week following hydrotest discharge activities (Boulton, B. and Roddie, B.D., 2008), showing the capacity of ecosystems to rapidly recover from temporary impacts associated with subsea chemical discharges. The majority of hydrotest discharges will occur in the deepwater infield area which precludes the presence of phytoplankton, as such the impact of these discharges is expected to be less than an equivalent shallow water discharge due to decreased susceptibility of species at this depth.

Pre-Commissioning and Commissioning Mitigation and Control Measures

For the Leviathan development water used for flooding and hydrotesting is expected to comprise of seawater, treated with scale and corrosion inhibitors, oxygen scavengers and biocide. These additives will be selected in accordance with their toxicity rating, using a globally accepted hazard assessment tool and where practicable, the lowest toxicity rated product will be selected. The proposed chemicals are “Gold” rated under the Offshore Chemical Notification Scheme (OCNS) and will therefore present a low hazard to the environment (refer to Section 3.2.2.2.2).

Chemicals will be carefully selected according to OCNS guidance and it is expected that hydrotest waters will disperse and biodegrade rapidly in the deep offshore environment. If necessary the rate of water discharges can be reduced so as to reduce peak concentrations and accumulation of chemicals in the water column. This will in turn reduce the level of environmental risk.

MEG, which will be discharged during tie-in spool installation, has a low risk of ecotoxic effect as it has a low toxicity, biodegrades readily in the marine environment and has low potential for bioaccumulation.

Hydrotest fluids and MEG discharges will be directed upwards in order for it to be more readily assimilated into the water column.

A Hydrotest Water Disposal Plan will be developed by Noble Energy that will include the regulatory expectations and will describe the mitigation measures to be adopted to ensure environmental risks from hydrotest water disposal are minimized. This may include a quantitative modelling assessment if appropriate.

All hydrotest discharges will be subject to discharge permit approval.

Pre-Commissioning and Commissioning Impact Significance

Potential impacts associated with flooding and hydrotest water discharges will be limited to within the mixing zone of the effluent plume at the point of discharge. This discharge is temporary and will occur only twice during the pre-commissioning/ commissioning phase, once during clean and gauge and once during dewatering. Therefore impacts on water quality and marine organisms will be short lived and limited to a localised area. The majority of hydrotest water will be discharged at the seafloor, at depths of approximately 1,700 m, where there is expected to be less of an impact as this is below the productive zone for species such as phytoplankton. The discharge at seafloor will be directed upward to ensure the plume contact with the seafloor and benthic communities is minimized. The residual risk associated with hydrotest discharges is therefore assessed as Low.

Table 4-11: Summary of Impacts, Mitigation & Control and Residual Risk for Pre-Commissioning and Commissioning Activities

Activity	Aspect	Potential Impact	Mitigation & Control	Likelihood	Severity	Residual Risk
Pre-commissioning and commissioning (cleaning, gauging and hydrotesting) infield flowlines and transmission pipelines	Discharge of construction debris and loose mill scale to the marine environment	Sea water quality and marine organism impacts	This material will be returned to the surface within pig receivers and disposed of appropriately onshore	1	1	1
	Discharge of inhibited hydrotest water	Sea water quality and marine organism impacts	Usage of Inhibitors will be minimized as practicable Selection of chemicals which are PLONOR where practicable Proposed chemicals are 'Gold' rated under the OCNS, and thus present a low environmental hazard	2	2	4
	Discharge of particulate residues such as ferrous oxides within hydrotest water	Temporary water quality impact caused by increased turbidity	Permits for discharge of hydrotest water Pre-cleaning of pipe prior to discharge	2	1	2

Construction, Installation and Support Vessel/ Helicopter Presence

The total number of vessels required to support the installation, construction and pre-commissioning activities are detailed in Table 3-14.

Construction, Installation and Support Vessel/ Helicopter Presence Impacts

There is no site-specific marine mammal data available for the Application Area and so regional sightings and stranding data for marine mammals in the Mediterranean Sea has been reviewed and summarized for the purpose of this assessment (refer to CSA Ocean Sciences Inc. 2016a). In the Levantine Basin, only five (5) marine mammal species are considered to be regularly present, the short-beaked common dolphin (*Delphinus delphis),* risso's dolphin *(Grampus griseus),* the striped dolphin *(Stenella coeruleoalba), rough toothed dolphin (Steno bredanensis)* and the common bottlenose dolphin *(Tursiops truncates).* Other species that are considered to be visitor or vagrant species are detailed in CSA Ocean Sciences Inc. 2016a.

Similarly, there is no site-specific sea turtle data however, tracking studies have indicated that sea turtles could occur in the Application Area (Seaturtle.org, 2008). Three sea turtle species are known to occur in the Levantine Basin, the green turtle (*Chelonia mydas*), leatherback turtle (*Dermochelys coriacea*) and loggerhead turtle (*Caretta caretta*) (refer to CSA Ocean Sciences Inc. 2016a).

The Mediterranean monk seal (*Monachus monachus*) is the only pinniped found in the Mediterranean region however it is considered very unlikely that monk seals will be present in the Application Area because they are extremely rare within waters offshore Israel (refer to CSA Ocean Sciences Inc. 2016a).

All marine mammal and sea turtle species have the potential to be impacted by vessel movement and presence as they spend time at the surface in order to breathe. The time spent at the surface and the mobile agility of the species denotes the degree of sensitivity to this aspect.

Most dolphin species are agile swimmers and are unlikely to collide with vessels. Of the 11 marine mammal species known to have been hit by vessels in the eastern Mediterranean Sea, fin whales and sperm whales, which are both considered visitor species in Israel waters (refer to CSA Ocean Sciences Inc. 2016a), are among the species that are struck most frequently (Laist *et al*., 2001). Although all sizes and types of vessels can collide with whales, the most lethal or severe injuries are caused by ships 80 m or longer and traveling 14 knots or faster (Laist *et al*., 2001). During pipelay and flexible lay operations, the installation vessels will be travelling well below this threshold (0.2 knots for umbilical lay and 0.06 knots for pipelay).

Vessel strikes represent a recognized threat to the population status of sperm whales (National Marine Fisheries Service, 1991; 2010). Sperm whales are vulnerable to ship strikes because they typically spend up to 10 minutes “rafting” at the surface between deep dives (Jacquet *et al*., 1998). There have been many reports of sperm whales of different age classes being struck by vessels, including passenger ships and tug boats. There were also instances in which sperm whales approached vessels too closely and were injured by propellers (National Ocean Service, 2015).

There is a remote possibility of vessels striking a sea turtle during routine operations. Leatherback turtles are the most pelagic of all marine turtles, spending a large amount of time in the open ocean (Bjorndal in Lutz and Musick, 1997). Vessel strikes are among the threats affecting the endangered population status of several sea turtle species (National Research Council, 1990). The risk of striking a sea turtle is low due to the slow vessel speeds during pipelay and subsea facility installation. Studies indicate that sea turtles are at the surface approximately 10% of the time and readily sound (dive) to avoid approaching vessels (Byles, 1989; Lohoefener *et al*., 1990; Keinath and Musick, 1993; Keinath *et al*., 1996).

Due to the speed at which the support vessels will be traveling and the relatively low levels of both vessels and marine mammals present in the application, the impact significance is considered to be low.

Helicopter traffic also has the potential to disturb marine mammals (Richardson *et al*., 1995). Reported behavioral responses of marine mammals are highly variable, ranging from no observable reaction to diving or rapid changes in swimming speed or direction (Efroymson *et al*., 2000; Smultea *et al*., 2008). Similarly, sea turtles may experience behavioral disturbance from helicopter noise. Sea turtles will hear the sound source prior to any exposure to these source levels; they may respond by changing course or diving to avoid further exposure. Smultea *et al*., (2008) concluded that behavioral responses to brief overflights by aircrafts are short-term and probably of no long-term biological significance.

The impact significance of helicopter traffic presence on marine mammals and turtles is negligible.

No site-specific bird data is available for the Application Area, however, records for the wider Mediterranean demonstrate that it is home to several hundred bird species, many of which could occur in the area (refer to Section 1.6.2.3). At least 38 seabird species are native to Israeli waters (BirdLife International 2014a; International Union for Conservation of Nature, 2014; Palomares and Pauly, 2014). Israel is also well known as one of two major migratory pathways in the Mediterranean region, with the other being Gibraltar. Research over the past decade has shown that approximately 500 million migrating birds fly over Israel's narrow airspace (Leshem and Atrash, 1998). Sensitive species/ species of importance are detailed in Section 4.2.6.3.

Helicopter and vessel traffic could sporadically disturb feeding, resting or nesting behaviors of birds or, if severe and ongoing, cause them to abandon their preferred habitat altogether.

The effects of low flying aircraft within the vicinity of aggregations of birds on the ground or on the water typically results in mass disturbance and abandonment of the immediate area. Flight paths should be coordinated and planned to avoid population centers and wildlife areas including bird colonies and set minimum cruise altitudes when traversing the coast in order to minimize physical presence impacts. It is expected, however, that some trips will occur at lower altitudes due to bad weather conditions but these incidents are expected to be very short-term in duration and sporadic in frequency. Birds in flight over water are expected to avoid helicopters; giving rise only to temporary disruption of feeding or flight paths when encountering low flying helicopters.

Marine vessels on transit between port facilities and offshore installation areas will follow vessel speed restrictions as appropriate and it is expected that they will seldom disturb populations of coastal and marine birds. Recreational vessel traffic is a much greater source of impact to birds in coastal habitats and they often flush coastal and marine birds from feeding, resting and nesting areas. As such the incremental impact from vessels associated with the Leviathan development are expected to be negligible.

Artificial light (i.e. light emitted from an artificial source such as construction, installation, commissioning and support vessels) which is visible in the open environment, can alter the behavior or disorientate marine organisms and seabirds that use light for natural responses. Excess light from artificial sources can therefore be considered as light pollution and since open seas have less artificial light sources compared to terrestrial environments, the effect and range of artificial lighting can be greater.

Artificial lighting on the construction, installation and commissioning vessels has the potential to alter the behavior or disorientate marine organisms that use light for natural responses. Artificial light has several effects on female turtles searching for locations for nests and on hatchlings finding the sea. The female turtles avoid illuminated beaches for their nests with the effect that the nests are concentrated in the less illuminated and shaded areas (Salmon M, 2003; Deda, 2007). Given the duration of construction, installation and commissioning activities and the distance between these activities and coastal nesting sites in the eastern Mediterranean, any light sources are unlikely to have a significant impact upon those species most vulnerable to changes in natural light patterns. Activities associated with the Leviathan

Field Development that are within the scope of this EIA will occur at the point of the LPP and continue offshore to the Leviathan Field site. The LPP is located approximately 10 km offshore. Impacts associated with development and production activities on sea turtles from the LPP location and along the pipeline route to shore will be addressed in the EMMP.

Marine mammals are less likely to be sensitive to light emissions as they do not rely on light for natural responses. Indirect effects on marine mammals may occur as a result of changes in behavior of their prey, such as temporary aggregations of fish in the vicinity of the construction activities due to light.

The resulting impact of artificial light on construction, installation, commissioning and support vessels on marine mammals and sea turtles is considered to be negligible.

Birds are also attracted to sources of light, particularly those on migratory paths during the hours of darkness. Birds tend to circle around light sources reducing their energy reserves and making them unable to reach the next shore or decreasing their ability to survive the winter or reproduce effectively (Deda *et al.,* 2007). However, due to the limited duration of construction, installation and commissioning activities and the low abundance of seabirds present in the Application Area, the impacts of artificial light on seabirds are considered to be low.

As is typically observed across the offshore oil and gas industry, certain fish species will be attracted towards vessels due to artificial light sources projected onto the sea surface. Other fish species will exhibit avoidance behavior from artificial light sources. The effects of this change in behavior of affected fish species is typically localized and minor.

Construction, Installation and Support Vessel/ Helicopter Presence

Mitigation and Control Measures

No specific regulations apply to protect marine mammals and sea turtles from potential collision with vessels in the Application Area. However, the low speeds at which the majority of vessels will be working during pipelay pose little to no risk to species that may be spotted in the vicinity of operations. Additional measures may be adopted if practicable, such as vessel masters avoiding approach or a sudden change of course when within 100 m of a cetacean or sea turtle and speed restrictions for vessels on transit when a whale, cetacean or sea turtle is sighted within 300 m of the vessel.

To the extent practicable without compromising safety or work performance, lighting in open deck areas shall be oriented downward to minimize excess lighting of the sea surface. This is subject to the minimum lighting requirements for navigational and safety performance.

Navigational lighting onboard all vessels associated with the Leviathan development will meet SOLAS requirements as per IMO Resolution MSC.253 (83), or equivalent requirements.
Where present, helicopter flight decks shall use perimeter lighting in accordance with international standards.

To the extent practicable without compromising safety or work performance, lighting in open deck areas shall be oriented downward to maximize work areas and minimize excess lighting of the sea surface. This is subject to minimum lighting requirements to ensure vessel navigation and safety is not compromised.

Navigational lighting onboard all vessels to be used during the Leviathan development construction and operations phases will meet Safety of Life at Sea (SOLAS) requirements as per IMO Resolution MSC.253 (83), or equivalent requirements.

Helicopter flight decks shall be equipped with perimeter lighting in accordance with international standards.

Flight paths should be coordinated and planned to avoid population centers and wildlife areas including bird colonies and set minimum cruise altitudes when traversing the coast in order to minimize physical presence impacts.

To the extent practicable without compromising safety or work performance, lighting in open deck areas shall be oriented downward to maximize work areas and minimize excess lighting of the sea surface, when feasible and when vessel navigational safety is not compromised.

Navigational lighting onboard all vessels associated with the Leviathan development will meet SOLAS requirements as per IMO Resolution MSC.253 (83), or equivalent requirements.

Where present, helicopter flight decks shall use perimeter lighting in accordance with international standards.

Construction, Installation and Support Vessel/ Helicopter Presence Impact Significance

The impacts of vessel presence on water quality, plankton, fish and fishery resources, marine mammals and seabirds is considered to be negligible.

There is the potential for disturbance of marine mammals and sea turtles during transit of installation, supply and support vessels. However, disturbance impacts will be similar or less than those associated with existing vessel traffic in the region due to the low speeds expected during the majority of operations associated with the Leviathan development.

Due to the relatively low levels of vessel support traffic, the low abundance of marine mammals in the Application Area and the implementation of mitigation and control measures such as speed restrictions and avoidance of marine mammals and sea turtles when sighted, the likelihood of vessels significantly disturbing marine mammals is considered to be low.

Table 4-12 Summary of Impacts, Mitigation & Control and Residual Risk Associated with Construction, Installation and Support Vessel/ Helicopter Presence

Activity	Aspect	Potential Impact	Mitigation & Control	Likelihood	Severity	Residual Risk
Vessel presence	Artificial light employed on vessels	Disturbance to fish and fishery resources	Minimize excess lighting and orient downward SOLAS	1	1	1

Activity	Aspect	Potential Impact	Mitigation & Control	Likelihood	Severity	Residual Risk
Construction/ installation, commissioning and support vessels and helicopters	Movement of vessels during transit and whilst working and helicopter flights	Disturbance/ vessel strike to marine mammals and sea turtles	Installation vessels will generally operate at very slow speeds Communication between vessel masters upon sighting of a marine mammal Vessel speed and distance restrictions upon sightings	2	1	2
Vessel presence	Artificial light employed on vessels	Disturbance to marine mammals and sea turtles	Minimise lighting requirements as far as practicable. All lighting to be SOLAS compliant	2	1	2
Construction/ installation, commissioning and support vessels and helicopters	Movement of vessels during transit and whilst working and helicopter flights	Disturbance to seabirds	Helicopter altitude requirements Installation vessels will typically be operating at very slow speeds Communication between vessel masters upon sighting of a marine and coastal birds Vessel speed restrictions	3	1	3
Vessel presence	Artificial light employed on vessels	Disturbance to seabirds	Minimise lighting requirements as far as practicable. All lighting to be SOLAS compliant	3	1	3

Construction, Installation and Support Vessel Discharge

Effluents that are expected to be routinely discharged into the marine environment during Leviathan Field Development pipelaying activities that are within the scope of this Production Development EIA) include:

- Sewage;
- Domestic waste; and,
- Drainage.

Construction, Installation and Support Vessel Discharge Impacts

Routine discharges from installation and support vessels are unlikely to affect most marine mammals, sea turtles and birds since the concentrations discharged are considered to be non-lethal and if the environment is non- favorable, such organisms are likely to adopt avoidance behavior. Plankton and fish species present in the installation areas however, may be impacted.

In the upper portion of the water column, the turbidity plume caused by routine discharges will reduce light penetration for a short period of time in close proximity to the discharge, with limited impacts on phytoplankton. Whilst increased turbidity is not expected to physically affect fish (interference with gill function), turbidity increases may alter the foraging success of some fish when they are present within a plume (De Robertis *et al*., 2003). Given that the total area affected by these discharges is very small, foraging fish are expected to either avoid or move out of the discharge plume and overall, turbidity effects will be localized.

Construction, Installation and Support Vessel Discharges Mitigation and Control Measures

The International Convention for the Prevention of Pollution from Ships 1973/1978 (MARPOL 73/78) contains a series of annexes that introduce regulations addressing specific areas for the prevention and control of pollution, including:

- Annex I (Oil) of MARPOL 73/78;
- Annex V (Garbage) of MARPOL 73/78 which implements the changes made to Annex V (Garbage) of MARPOL 73/78 by the IMO, since 1998 up to the 2008 Regulations being signed; and,
- Annex IV (Sewage) of the International Maritime Organization's (IMO) International Convention for the Prevention of Pollution from Ships. This is the Annex IV adopted by the Marine Environment Protection Committee of the IMO on 1 April 2004, plus further amendments adopted up to the 2008 Regulations being signed.

MARPOL defines the Mediterranean Sea as a "Special Area" under Annex V (pollution by garbage). This imposes additional restrictions on the disposal of garbage from vessels operating in the region. Specifically, discharge of uncomminuted food waste is prohibited, while discharge of comminuted food waste, cargo residue and cleaning agents is only permissible at distances of greater than 12 nm from the nearest shorelines. Further, the discharge of uncomminuted domestic waste (sewage) is restricted by MARPOL Annex IV to areas that are greater than 12 nm from shore. As such all of the above discharges will only occur in areas outside of Israeli Territorial Waters. Further, it is likely that sewage will be treated onboard and macerated prior to discharge.

Deck drainage from machinery space bilges will pass through an oil-water separator prior to discharge, or in some circumstances, oil and oily mixtures may be retained onboard for discharge to port reception facilities (See MARPOL Annex I, Regulation 14).

It is expected that the aforementioned discharges will have a negligible impact on water quality and that any discharges will dilute rapidly in the offshore marine environment and would not be detectable beyond the immediate vicinity of the vessel(s). The impacts on identified sensitive receptors including plankton, fish and fishery resources is considered to be negligible.

Construction, Installation and Support Vessel Discharge Impact Significance

Due to the nature of routine discharges and their dilution into the receiving environment, impacts to plankton, fish and fishery resources are expected to be low.

Table 4-13: Summary of Impact, Mitigation & Control and Residual Risk for Construction, Installation and Support Vessel Discharges

Activity	Aspect	Potential Impact	Mitigation & Control	Likelihood	Severity	Residual Risk
Construction/ installation and support vessel discharges	Discharge of vessel sewage, drains and food waste	Impacts to water quality and marine fauna and flora	MARPOL 73/78	3	1	3

Ballast Water Discharge

For Leviathan subsea installation activities, ballast water may be discharged from construction and installation vessels, support vessels and decommissioning vessels during the lifetime of the project.

Ballast water is water used to maintain the stability of vessels during operations. Ballast water is typically seawater or freshwater that can be added or removed from defined ballast compartments in order to maintain the draft of a vessel within the proper limits. The water is drawn up by pumps either near shore or mid-ocean into ballast tanks and can be discharged to counteract additional cargo loads or changing offshore conditions.

Ballast Water Discharge Impacts

Since a vessel takes up ballast at its point of origin, the water may contain plants and animals that are not present in the environment where the ballast is discharged. Species that survive the transit and are able to become established in the new environment are termed non-native (or alien) invasive aquatic species and are typically defined as species which are agents of change and which may threaten native biological diversity (IUCN, 2002). In general non-native invasive species pose a threat to biodiversity by impacting on native (or endemic) species directly (e.g. predation) or indirectly by causing changes to ecosystem structure and function. There are also potential impacts to fisheries associated with the introduction of non-native invasive species through the reduction of yields in fisheries and aquaculture either directly (e.g. pests or predation of species lower in the food chain) or indirectly (e.g. clogging of nets).

Some 925 non-native species have been recorded in the Mediterranean. Mollusks' constitute the largest taxonomic group (216 species), followed by fish (127 species), plants (124 species) and crustaceans (106 species). It should be noted that there have been some benefits from the introduction of exotic species into the eastern Mediterranean. For example in the Levantine basin, three exotic species (the rabbitfish *Siganus rivulatus*, the lizardfish *Saurida undosquamis* and the Goldband goatfish *Upeneus moluccencis* are now exploited commercially (UNEP, 2011).

Non-native invasive species are typically introduced to a new area via uptake and discharge of ballasting water from vessels which transit from one geographically distinct location to another. These species may also be introduced via bio-fouling on vessel surfaces and within ship systems. In the case of Leviathan, various support vessels may be used to facilitate transfer of infrastructure from international waters into the eastern Mediterranean and therefore present a risk of introducing non-native invasive species.

The establishment of any non-native invasive species is contingent on its survival during transit and the ability of the introduced species to adapt to the prevailing environmental conditions (e.g. temperature/ salinity etc.) in their surroundings in order to survive, grow and reproduce in a new habitat.

Ballast Water Discharge Mitigation and Control Measures

Noble Energy will implement management measures to minimize the risk of invasive marine species introduction through ballast water in accordance with the International Maritime Organization (IMO) International Convention for the Control and Management of Ships' Ballast Water and Sediments (BWM). Vessels will treat ballast prior to being discharges to ensure the specification presented in Table 4-14 are met. Ballast Water Management requirements and IMO ballast discharge stipulations are also presented in the Oil and Gas Producers Guidance Document OGP Report Number 436, OGP/IPIECA 2010. All ballast water treatment and discharge activities will be conducted in line with this document as is an MEWR requirement.

Table 4-14: Ballast Water Convention Treatment Standards according IMO BWM

Organism Category	Regulation
Plankton, >50 µm minimum dimension	< 10 cells / m^3
Plankton, 10-50 µm	< 10 cells / ml
Toxicogenic *Vibrio* cholera (O1 and O139)	< 1 cfu* / 100 ml
Escherichia coli	< 250 cfu* / 100 ml
Intestinal *Enterococci*	< 100 cfu* / 100 ml

Ballast Water Discharge Impact Significance

Ballast water contains a variety of organisms including bacteria, viruses and the adult and larval stages of many marine and coastal species. While the vast majority of such organisms will not survive to the point when the ballast is discharged, some may survive and thrive in their new environment. These 'non-native species', if they become established, they can have a serious ecological, economic and public health impact on the receiving environment (Lloyds Register, 2010).

The de-ballasting of installation and support vessels present a moderate level of risk given that the vessels will have ballast water treatment available onboard prior to discharge.

Table 4-15: Summary of Impacts, Mitigation & Control and Residual Risk for Ballast Water Discharge

Activity	Aspect	Potential Impact	Mitigation & Control	Likelihood	Severity	Residual Risk
Presence of construction/ installation and support vessels	De-ballasting of vessels (potentially international)	Introduction of non-native invasive species	Controlled discharge under permit Maintenance and classification of vessels Adherence to IMO and MARPOL 73/78 standards	5	1	5

4.4.2 Impacts Associated with Production including Physical and Cumulative Impacts

The impacts considered in this Section relate to the Leviathan Development Project operational activities including:

- Subsea control valve operations;
- Vessel presence during operations; and
- Bio-fouling of pipeline.

Subsea Control Valve Operations

The subsea controls system will be an open loop system which will necessitate periodic discharge of hydraulic fluid to the marine environment via vent lines located locally to the actuated valves.

Subsea Control Valve Operations Impacts

During operations, there will be occasions that necessitate actuation of subsea valves in order to maintain safe operations and test their functionality. During actuation, small quantity of hydraulic fluid will be released into the marine environment.

All hydraulic fluid discharge will be minimized as far as practicable, and where possible the environmental impact will be minimized by selecting low toxicity alternatives that are Gold rated under the OCNS. The majority of discharges associated with the aforementioned activities will occur in the deepwater environment where the risk of significant environmental impact is considered to be decreased.

Subsea Control Valve Operations Mitigation and Control Measures

All hydraulic fluid discharge will be minimized as far as practicable, and where possible the environmental impact will be minimized by selecting low toxicity alternatives that are Gold rated under the OCNS.

Subsea Control Valve Operations Impact Significance

Computer modelling of hydraulic fluid discharges has been performed using the Dose-related Risk and Effect Assessment Model (DREAM) which forms part of the SINTEF developed Marine Environment Modelling Workbench (MEMW) simulation suite. The modelled scenario focusses on valve discharges at the Infield Gathering Manifold as this location will see the largest discharge of all infield sites in the event of simultaneous closure of all subsea actuated valves. Total discharge in the event of all Infield Gathering Manifold valves being simultaneously closed is 117 litres.

Results of the DREAM model show that the hydraulic fluid will initially sink towards the seabed following release (due to its density) and the resultant plume will drift in accordance to the prevailing current conditions. Due to the water depth at the infield location the seabed currents are low and as a result the plumes will not traverse the seabed at a significant rate, thus giving mobile species significant time to relocate away from the advancing plume. Immotile species, however, will be directly impacted due to the permanent placement of the infrastructure. The majority of the species inhabiting the benthic environment along the proposed pipeline route and in the Leviathan Field are mobile and are likely to demonstrate quick recovery as a result of disturbance (refer to Section 4.1).

Further analysis shows that the discharged fluid is rapidly diluted in the water column with peak concentrations decreasing from 390 ppm two (2) minutes after the release, to 330 ppm eight (8) minutes later, and further decreasing to 200 ppm 20 minutes after the discharge. The concentration is predicted to decrease, 40 minutes after the release, to a peak of 41 ppm. Concentration contours for the modelled scenario at the aforementioned time intervals are provided in Figure 4-10.

It takes approximately 2.75 hours for the residual concentration in the water column to fall below one (1) ppm (based on a sample volume of 300 m^3). The peak seabed area impacted by chemical concentrations above one (1) ppm is approximately 8,700 m^2 (equivalent to a circular area of 100 m diameter) as shown in Figure 4-11.

Figure 4-11: Hydraulic Fluid Concentration Contours

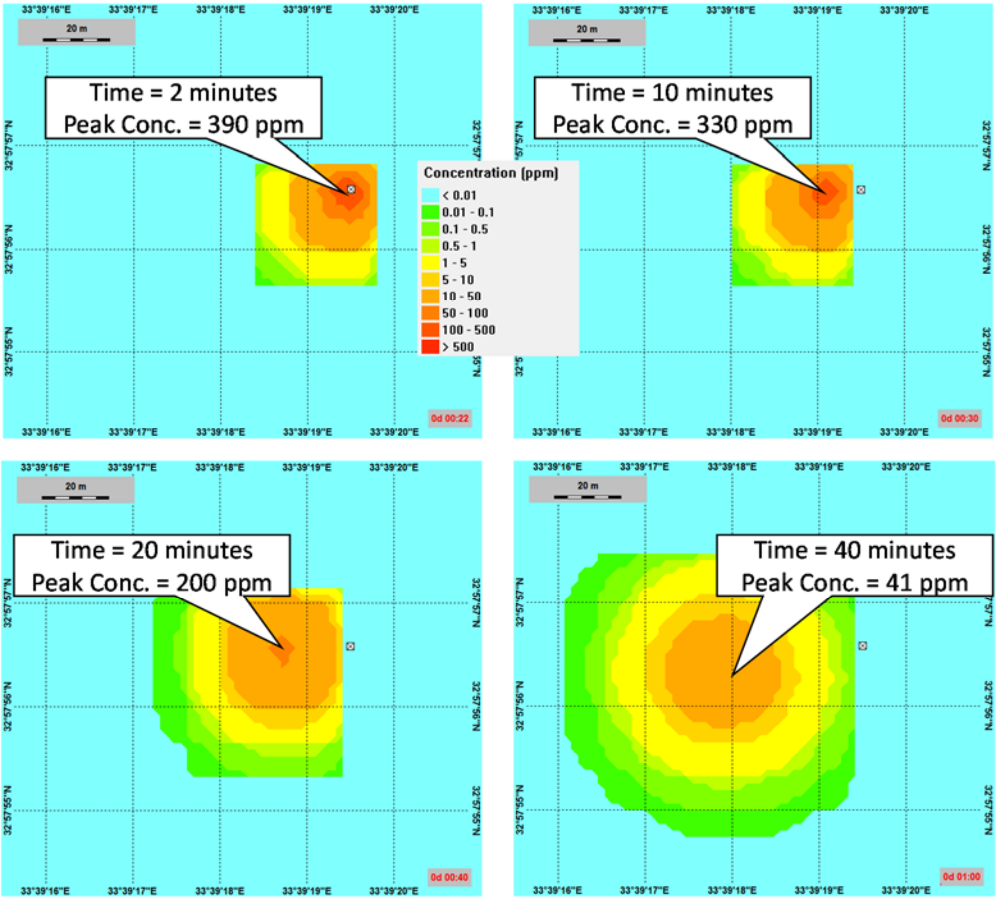
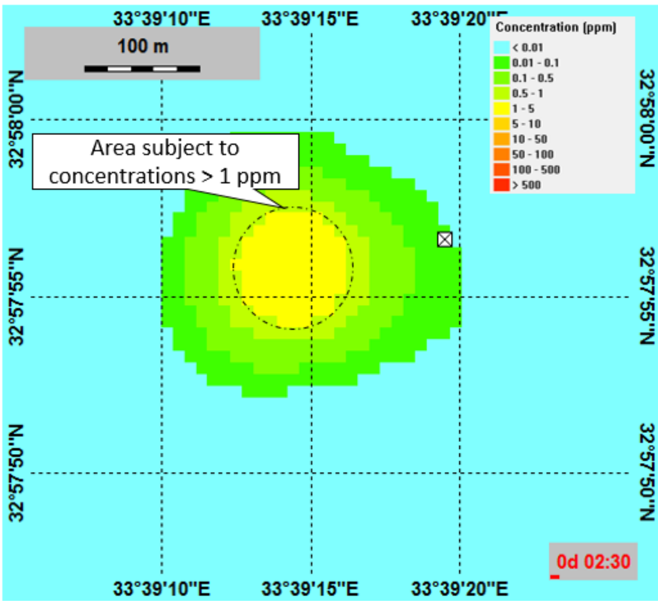


Figure 4-12: Hydraulic Fluid Concentration – Area subject to > 1 ppm



As a result of observations made from modelling a 117 litr discharge of hydraulic fluid at the Infield Gathering Manifold Location the overall impact of the discharge is not expected to be significant.

Impacts from subsea control fluids are therefore considered to present a low risk to the biota and any effects will be on a minor scale and highly localized at the discharge locations in the deep-water infield area.

Due to the remoteness of the subsea infrastructure from other discharge sources there is not considered to be a cumulative impact arising from the combination of control fluid discharges and other sources of discharge to sea.

Table 4-16: Summary of Impacts, Mitigation & Control and Residual Risk for Subsea Control Valve Operations

Activity	Aspect	Potential Impact	Mitigation & Control	Likelihood	Severity	Residual Risk
Subsea control valve operation	Hydraulic fluid discharges when valves are activated	Impacts to water quality and marine fauna and flora	Water based hydraulic fluid Discharge volumes estimated to be low Approved low toxicity fluids preferred	2	1	2

Support Vessel Presence

Vessel activity in the Application Area will be intermittent and it is not expected that any helicopters will be required during operations of the subsea infrastructure.

The impact assessment, associated impact significance and mitigation measures for vessel presence is discussed in Section 4.4.1 for Construction, Installation and Support Vessel/ Helicopter Presence. The requirement during operations will be lower than that of the construction, installation and support vessel therefore no further assessment and mitigation is required. Those mitigation measures that have been identified in Section 4.4.1 shall also be applied during operational activities.

Bio-fouling of Pipeline

Organisms with relatively immobile life stages, including marine invertebrates, colonize and grow upon such infrastructure and as a result will represent biomass production. Macroalgae and nearly all major invertebrate taxa, including corals, anemones, hydroids, sponges, sessile bivalves, mollusks and polychaetes have been observed on oil and gas infrastructure (Reed *et al,* 2004; Bulleri *et al,* 2005; Chapman, 2006; Page *et al,* 2008).

It is not considered likely that biofouling of the pipeline will result in any significant impacts, either to the surrounding environment or to the integrity of the pipelines. The Background Monitoring Survey conducted and described in Chapter A did not identify any hard structures during the survey therefore potential settlement from such organisms is not likely to be at a significant scale.

There will likely be an increased abundance in invertebrate species in proximity to the subsea infrastructure which may result in an increased level of predator abundance in the vicinity of

Application Area. Due to the depths at which the majority of the subsea infrastructure is located however, it is not considered likely that this will result in a significant change on a population level.

Bio-fouling of Pipeline Impact Significance

The impact significance of biofouling is considered to be negligible therefore no further mitigation and control measures are required.

Table 4-17 Summary of Impacts, Mitigation & Control and Residual Risk for Bio-fouling

Activity	Aspect	Potential Impact	Mitigation & Control	Likelihood	Severity	Residual Risk
Pipeline infrastructure	Biofouling of pipeline	Changes ecosystem	None required	2	2	4

Cumulative Impacts

Cumulative effects can result from a situation where two or more vessels are operational at the same time; for example pipelay and supply vessels will both generate noise from their DP thrusters, emit pollutants to atmosphere from vessel engines working concurrently, or discharge domestic waste and machinery space drains to sea.

Cumulative impacts may occur as a result of separate activities associated with the Leviathan development as described above, or by interactions with other oil and gas activities in the vicinity of the Leviathan Field Development Project which can result in a larger environmental impact in terms of extent or duration.

There may be cumulative effects if other similar work is taking place within the region. Noble Energy, however, is not aware of any other work programmes that will run concurrently.

Currently, the only other identified submarine production infrastructure in the vicinity of the Leviathan Field Development infrastructure are the existing submarine facilities associated with the Tamar Project. These facilities are presented in Figure 3-12. Due to the homogenous benthic environment and the fact that there were no sensitive species identified during the Background Monitoring Survey, the cumulative impact resulting from the presence of these facilities is not considered to be significant. Similarly, both facilities will be discharging very low levels of hydraulic fluids which, as described above, will dissipate and become assimilated into the surrounding environment very rapidly and so the cumulative impact significance is considered to be negligible.

Discussions surrounding the impacts from invasive species are presented in Section 4.4.1. The potential for invasive species will arise due to the discharge of ballast water associated with construction, installation and support vessels. As mentioned, there are no other offshore oil and gas construction activities planned to coincide with those conducted for the Leviathan Field Development Project therefore cumulative impacts are considered to be low.

There may also be inputs from other anthropogenic sources that are unrelated to the oil and gas industry including shipping, fishing vessels, helicopter flights and military exercises. The Leviathan Field Development Project will add additional sound to background noise levels, but the nature of the anticipated noise sources, the distance location from shore and the fact that the area is not busy in terms of shipping and fishing suggest that significant cumulative noise effects are unlikely.

Emissions from vessel activities, also have the potential to contribute to a variety of cumulative environmental effects, including local air pollution, acidification (acid rain) and on a wider scale will contribute to global warming (greenhouse gases). Vessel activities within the scope of this EIA include installation, supply and support vessels during the construction phase, and those vessels required to perform intermittent maintenance operations. The LPP and vessels associated with supporting the installation are specifically excluded from this assessment.

Localised impacts may include elevated levels of atmospheric emissions in the immediate area. However, it is considered that these elevated concentrations will be short lived and it is unlikely to be detectable within a short distance of the vessels due to the dispersive nature of the offshore environment and the fact that vessels are mobile thus preventing emissions being concentrated at a single location.

The table below (Table 4-18) shows the forecast Leviathan vessel emissions as a % of the total emissions associated with the shipping industry in the Mediterranean.

Table 4-18: Leviathan Installation, Hook-up, Commissioning and Maintenance Vessel Emissions as a % of Total Mediterranean Shipping Industry[1]

Total Emissions	Annual Greenhouse Gas Emissions (Te)		
	CO_2	NOx	SO_x
Mediterranean Shipping Industry	48,344,100	1,228,600	594,800
Leviathan Vessel Emissions	174, 251	3, 233	218
Leviathan as % of Mediterranean Shipping industry	0.36	0.26	0.04

[1] Emissions and shipping statistics in the SafeSeaNet area in 2011 (A comprehensive inventory of ship traffic exhaust emissions in the European sea areas in 2011)

Atmospheric emissions of vessels associated with Leviathan Field Development activities within the scope of this EIA contribute approximately 0.36 % of typical CO_2 annual emissions from shipping in the Mediterranean Sea.

Mitigation and Control Measures

All vessels will be required to adhere to maintenance programs pursuant to their classification and in accordance with MARPOL 73 / 78 standards which sets limits on sulphur oxide and nitrogen oxide emissions from ship exhausts and prohibits deliberate emissions of ozone depleting substances.

All vessels will implement an IMO BWM in order to reduce the potential for invasive species.

Impact Significance

The cumulative impact significance for all aspects assessed in this Cumulative Impact section are considered to be low and/ or negligible.

Table 4-19 Summary of Cumulative Impacts, Mitigation & Control and Residual Risk

Activity	Aspect	Potential Impact	Mitigation & Control	Likelihood	Severity	Residual Risk
Presence of construction/ installation and support vessels	Emissions production	Reduced air quality and contribution to climate change	MARPOL 73 / 78	2	2	4
Presence of construction/ installation and support vessels	De-ballasting of vessels (potentially international)	Introduction of non-native invasive species	Controlled discharge under permit Maintenance and classification of vessels Adherence to IMO and MARPOL 73 / 78 standards	5	1	5

Transboundary Impacts

Transboundary impacts are impacts that occur outside the jurisdictional borders of a project's host country. The Leviathan Field is located in the Eastern Mediterranean region approximately 140 km offshore of Israel with Lebanese exclusive economic waters to the north-east (circa. 70 km). Cypriot exclusive economic waters to the north-west (circa. 30 km) and Egyptian exclusive economic waters to the south-west (circa 50 km). The nearest foreign land mass is the southern coast of Lebanon which is approximately 135 km to the east, north-east.

The potential for the Leviathan Field Development Project to result in transboundary impacts is extremely small. Impacts from activities associated with the Leviathan Field Development are localised and transient for short-term activities.

Potential transboundary impacts arising from oil spill events are discussed in Section 4.2 of this document,

4.5 Cultural and Heritage Site Impacts

As the cradle of civilization, it is little surprise that the Fertile Crescent (the Levant and Mesopotamia) contains some of the oldest evidence of seafaring in the world. The shipwrecks and submerged cultural heritage that lie on the seafloor of the eastern Mediterranean Sea often include intact ship remains and cargo. The maritime trade routes of ancient seafaring cultures such as the Greeks, Phoenicians and Romans indicate heavy traffic in the region. The hull remains and artifacts from wreck sites represent an enormous wealth of knowledge on ancient seafaring history, culture, and technology.

Cultural and Heritage Site Mitigation and Control Measures

A 305 m archaeological zone is recommended upon the identification of possible wreck sites and a 31 m avoidance zone is recommended for other contacts. No seafloor disturbing activities will be conducted within these avoidance zones should such sites be identified.

Because DP installation and support vessels will be used there will be no anchoring associated with the installation, commissioning or pre-commissioning of the Leviathan infrastructure upstream of the LPP. This will thereby minimise seafloor impacts, damage and disturbance to potential sites of archaeological interest during pipelay the aforementioned activities.

Cultural and Heritage Site Impact Significance

The results of surveys will be used to ensure potential archaeological resources are not impacted. The overall impact significance is considered to be low.

Table 4-20: Summary of Impacts, Mitigation & Control and Residual Risk on Cultural and Heritage Sites

Activity	Aspect	Potential Impact	Mitigation & Control	Likelihood	Severity	Residual Risk
Subsea installation	Disturbance to seafloor during pipelay	Damage/ destruction to important archaeological sites	305 m avoidance zone for potential wreck sites and 31 m avoidance zone for other sonar contacts	2	2	4

4.6 Hazardous Materials

Pollution of the marine ecosystem with anthropogenic debris is currently acknowledged as a significant global issue since it can be ingested by marine organisms both directly or indirectly through the consumption of debris contaminated prey.

4.6.1 Risks Associated with Hazardous Materials

This section discusses the types of waste likely to be generated as a result of the proposed Leviathan Production Development and the waste management procedures that will be implemented to minimise and monitor the volumes produced and disposed to landfill. Waste will be generated during all phases of the project.

Noble Energy is committed to reducing waste production and to managing all produced waste by applying approved and practical methods. Waste should only be disposed of if it cannot be prevented, reclaimed or recovered. A Waste Management Plan (WMP) will be developed for the Project and will identify (1) the types of waste generated and (2) management procedures for each waste stream. The Plan will detail appropriate waste contractors to be used to ensure the waste is correctly documented, transported, processed and disposed of in accordance with applicable legislation.

Integrated waste management is an important component of Israel's environmental policy. To address the challenges of both solid and hazardous waste, the MoEP has formulated policies founded on reduction at source, reuse and recycling, with disposal as the last priority.

Appropriate safety and control procedures for handling and treating hazardous substances and their wastes from "cradle to grave" are integral elements in Israel's environmental management program. By means of the Hazardous Substances Law, Israel has instituted administrative and legislative measures to control hazardous substances at every stage of production, storage, transfer, maintenance, use, and disposal. The Hazardous Substances Law obligates any person dealing with a hazardous substance to apply for a Hazardous Materials Permit. The applicant must provide details on the types and quantities of hazardous materials handled and the types and quantities of hazardous waste produced.

Israel's policy on hazardous waste is based on minimization, reuse, recycling, neutralization and safe disposal of hazardous wastes, according to the following priorities:

- Recovery of the hazardous waste through recycling or reuse.
- Reuse of the waste as an energy source through incineration in a facility which recovers the energy.
- Disposal of hazardous waste, including landfilling, above-ground collection and incineration without energy recovery.

Waste from Vessels

Waste will be generated from the AHVs, survey, supply, pipelay, standby and dive support vessels associated with the proposed development. This waste will be taken onshore for disposal with resultant landfill issues and the potential for contribution to contamination of land and atmospheric emissions.

It is likely that small amounts of general waste and special waste that can be recycled will be generated.

Noble Energy will look to contract vessel operators which aim to minimise all wastes during the project in accordance with MARPOL requirements via the project's Waste Management Plan. Vessel operators will be required to maintain a Waste Record Book and submit monthly reports of waste sent to shore. Controlled Waste Transfer Notes will be completed and Waste Management Duty of Care audits will also be carried out. Given the likelihood of the production of some special waste the impact of waste from vessels was considered moderate.

Waste during the Installation and Commissioning Phase

Installation activities will routinely generate a number of wastes including scrap metal, wooden crates etc. All wastes will be properly segregated for recycling/disposal/treatment in accordance with the Noble Energy's Waste Management Plan and Controlled Waste Transfer Notes will be completed. Asset targets and KPIs will be set to encourage waste minimisation.

This phase is anticipated to result in a small contribution to general waste volumes, with no special waste generation, and is therefore anticipated to have a minor impact.

Waste during the Production Phase

For the Leviathan Production Scope, it is unlikely that any solid waste will be generated for disposal expect from overboard losses associated with survey and petrol vessels.

Water and Sediment Quality and Benthic Organism Impacts

Debris lost overboard from installation vessels and/or survey vessels could potentially impact water and sediment quality and benthic communities (National Research Council, 2008; U.S. Bureau of Ocean Energy Management, 2012). Heavy items such as welding rods, buckets, pieces of pipe, etc. may have a minor impact on sediment quality by creating small areas of hard substrate on the soft bottom seafloor. The size of the area affected would be negligible. Lighter pieces of debris may float on the sea surface and adversely affect water quality and marine biota (National Research Council, 2008; National Oceanic and Atmospheric Administration, National Ocean Service, 2013). Invertebrates not only ingest microscopic plastic debris, they also facilitate debris degradation which can accelerate fragmentation and produces enormous amounts of microplastic debris (NOAA, 2014).

Marine Mammal and Sea Turtle Impacts

Materials accidentally lost overboard from survey vessels and / or vessels associated with the Leviathan Field Development Project installation could entangle marine fauna or result in injury through the ingestion of debris. Many marine mammals are subject to entanglement due to marine debris and post-mortem examinations of beached marine mammal carcasses show that various items of debris have been ingested. Ingestion is generally thought to occur because the marine debris is mistaken for prey. Most of that which has been erroneously ingested is plastic (NOAA, 2014. Baleen whales may be particularly susceptible to large items of debris that can become entangled in their baleen (feeding structure) since they filter extremely large volumes of water while feeding. Plasticizer chemicals have been measured in both fin whales and their planktonic prey in the Mediterranean and there is the potential that such plasticizers may be associated with microplastics from the same area (NOAA, 2014).

Reports of sea turtles ingesting marine debris are numerous and consumed debris has been implicated in nutrient deficiency (NOAA, 2014). Marine debris is among the threats affecting the endangered population status of several sea turtle species (National Research Council, 1990). Leatherback turtles are especially attracted to floating debris, particularly plastic bags because they resemble jellyfish which is their preferred food. Ingestion or entanglement of plastic and Styrofoam can result in drowning, lacerations, digestive disorders or blockage and reduced mobility.

Marine Bird Impacts

Marine trash and debris from installation and survey vessels could kill or injure birds that ingest it or become entangled in it. The ingestion of plastic by marine and coastal birds can cause obstruction of the gastrointestinal tract, which can result in mortality (Laist, 1996). The yelkouan shearwater for example (refer to CSA Ocean Sciences Inc. 2016a) may be particularly susceptible to physical health effects, as debris most often gets stuck in the gizzard and cannot easily pass through the digestive system (NOAA, 2014).

Waste Impacts Mitigation and Control Measures

The general approach to managing solid waste will be described in an Integrated Waste Management Plan (WMP). This will provide guidance on:

- Waste minimisation and prevention;
- Identification and segregation of waste materials at source;
- Recycling and reuse of suitable materials, and,
- Treatment and disposal of specific waste streams.

The Integrated WMP will refer to vessel-specific WMPs which will include provisions for segregating waste on-board, having secure areas for storage of hazardous waste and recycling / reuse where practicable.

Offshore waste during both construction and operation will be managed in accordance with the requirements of MARPOL 73 / 78. Project vessels will carry a WMP, specific to the Leviathan Field Development Project which will include written procedures for collection, storage, processing and disposal of waste, including the use of any relevant equipment fitted on-board. The WMP will also designate the persons responsible for carrying out the Plan.

For the purposes of complying with MARPOL 73 / 78, construction waste arising on-board the vessels will be managed as MARPOL Annex V waste, with discharge at sea strictly prohibited. All waste (predominantly welding and packaging waste) will be retained on-board, source separated where practicable and collected by the port authorities or their nominated contractors using the existing port waste reception facilities. Any hazardous waste generated during offshore construction (other than MARPOL Annex I Oily Waste, described separately below) will be stored, collected and managed separately in accordance with Israeli regulations.

Where waste is to be transported to shore for disposal the general approach will be to use licensed facilities which comply with national regulations enforced by MoEP. Prior to the start of construction and installation, contracts will be arranged with licensed organisations for the transport, reuse, recycling, treatment and final disposal of waste. However, it should be noted that no decision has been made as to which waste facilities in Israel will be used. This will be subject to further investigation during the detailed design phase.

Consignment notes detailing the quantity and type of waste transferred between ships will be kept.

The majority of solid wastes produced will be transferred to vessel waste reception facilities for disposal at a suitable waste facility. Where appropriate equipment is available on board the vessel, selected wastes may be incinerated on-board in accordance with the IMO "Standard Specification for Shipboard Incinerators". These operations will be performed such that they comply with the requirements of Regulation 16 of MARPOL Annex VI and the Standard Specification for On-board Ship Incinerators, adopted by the Marine Environment Protection Committee (MEPC) and detailed in MEPC-244-66 Regulations.

Loss of containment of hazardous chemicals is not expected during construction unless it results from an unplanned and then considered unlikely. The inventories of such chemicals carried on-board vessels are sufficient for consumption during one day. As such chemicals will be placed in bunded areas upon the vessels, trips and spills will be small, resulting in a low significance impact.

During commissioning water will be used for either flooding or hydrotesting of pipelines will be filtered and chemically treated prior to use to protect the pipeline materials in the event of a commissioning delay. Indicative chemicals to be used for this purpose are:

- Roemex RX5227: Combined oxygen scavenger, corrosion inhibitor and biocide – typically dosed at 1,000 ppm; and
- Roemex RX9025: Leak tracer dye – typically dosed at 50 ppm.

Both of these chemicals are classified as Gold chemicals under the OCNS which indicates that they present a relatively low hazard to the environment.

Waste Impact Significance

Table 4-21: Summary of Impacts, Mitigation & Control and Residual Risk for Waste

Activity	Aspect	Potential Impact	Mitigation & Control	Likelihood	Severity	Residual Risk
Waste Management	Generation of domestic waste and general non-hazardous waste including scrap metal etc.	Waste transfer to shore	Waste handling, treatment and disposal will be in accordance with the WMP	2	2	4
	Hazardous waste generation including solid spent chemicals, filter elements and waste MEG etc.	Waste transfer to shore	Waste handling, treatment and disposal will be in accordance with the WMP	2	2	4
	Hydrotest water discharge at LPP	Water quality Impact on marine biota	Gold chemicals under the OCNS Optimize and manage discharge rate at LPP to mitigate adverse impact on marine environment. Optimal rate can be determined through modelling	2	2	4

4.6.2 Leviathan Production Fluids

Aside from hydrocarbons, hazardous materials that may be produced from oil and gas reservoirs include corrosive or toxic compounds [carbon dioxide (CO_2), or hydrogen sulphide (H_2S)], oil contaminated sand or produced water, Naturally Occurring Radioactive Matter (NORM) and heavy metals.

Based on the findings of exploration and appraisal drilling the Leviathan field is expected to produce “sweet” gas with minimal corrosive species or impurities. All hazardous materials produced from the Leviathan reservoir will be routed to the LPP with no discharge of production fluids from the subsea production system during normal operation.

As a result of the Leviathan fluids being classed as “sweet” gas the majority of the subsea production system will be constructed from carbon steel, with corrosion inhibitor injection used for managing trace levels of CO_2 or H_2S. Should the Leviathan reservoir (or a specific well) be found to produce unexpectedly high levels of corrosive impurities then this will be managed as follows:

As far as possible any increase in corrosive species will be managed through the application of additional corrosion inhibitor or hydrogen sulphide scavenger injection;

If an increase beyond that which can be safely manged through chemical injection is observed then the affected well(s) will be shut-in and the field produced in a manner which mitigates the impact on field deliverability of this action.

In addition to the above any unexpected findings arising during the development drilling campaign (e.g. impurities associated with a particular well) will be considered during the initial start-up and operation of the Leviathan field.

4.6.3 Treatment in Emergencies

As stated previously all fluids produced from the Leviathan reservoir will be routed to the LPP for processing and treatment as appropriate. The LPP shall be designed such that it has appropriate facilities to treat, store and dispose of all hazardous materials that are expected to occur and at the levels that they are expected to occur, in an acceptable manner. Should hazardous materials be produced at a rate that is above that which can be appropriately handled at the LPP, then production will be managed such that the production rate of relevant material is reduced to an appropriate level. This may be through choking back or shutting in a particular well, or if necessary reduction in the overall field production.

The specifics of processing and disposal of hazardous materials on the LPP is out with the scope of this assessment.

4.7 Measures for Reduction of Geological and Seismic Risks

Noble Energy has considered seismic risk (including potential earthquakes) when developing the proposed pipelay and subsea infrastructure program. The design and engineering of the pipelines and associated subsea infrastructure takes into account identified seismic risk as well as seafloor and shallow geo-hazards.

There has been one recorded earthquake (magnitude 4.0) within approximately 40 km of the Leviathan Field since 1979. There have been no strong (magnitude 5.6 or greater) regional earthquakes recorded since 1983 within 200 km of the proposed drill sites.

4.7.1 Early Warning

In Israel, early warning of earthquakes or tsunamis is under the responsibility of the Geophysical Institute of Israel (GII). When the GII receives an alert (for earthquake or tsunami) they immediately contact the INP (Israeli National Police) and the HFC (IDF Home Front Command). The INP and HFC notify the Noble Energy Operations Support Centre (OSC). The Noble Energy OSC is manned 24 hours per day and seven (7) days per week with and will notify all Noble Energy locations of the situation and appropriate response taken as outline in the Noble Energy's Emergency Response Plan which will be extended to include the Leviathan Development Project facilities.

4.7.2 Prevention of Damage

Seismic engineering will be performed to evaluate the structural integrity of the pipeline system and its components in accordance with DNV OS F101 and supplemented with PRCI and MCEER industry guidelines. First steps will be taken in the pipeline routing studies to avoid slopes with instability potential, liquefiable soils and routed in a manner which places the pipeline in tension where possible. Detailed engineering studies will include determining the maximum strain levels due to wave propagation to ensure pressure containment of the pipelines during seismic events. Pipeline models will be developed at critical fault crossings and unstable slope runouts to evaluate the pipe-soil interaction and potential for local buckling or tensile rupture of the pipelines. Mitigation efforts that will be considered if needed are increased wall thickness, increase tension, re-routing of pipeline, buoyancy or sleeper structures.

4.7.3 Emergency Procedures

Noble Energy's Emergency Response Plan will deal specifically with the actions to be taken in the event of emergencies including earthquakes. Noble Energy will also require the vessel contractor(s) to have an Emergency Response Plan to deal specifically with the actions to be taken in the event of emergencies. The facilities and procedures will provide for emergency response and, where appropriate, evacuation, escape and rescue requirements. Emergency response capabilities of equipment and personnel will be tested through regular drills and exercises.

Mitigation and Control Measures

Noble Energy's Emergency Response Plan will deal specifically with the actions to be taken in the event of emergencies including earthquakes and tsunamis. Noble Energy will also require the vessel contractor(s) to have an Emergency Response Plan to deal specifically with the actions to be taken in the event of emergencies. The facilities and procedures will provide for emergency response and, where appropriate, evacuation, escape and rescue requirements. Emergency response capabilities of equipment and personnel will be tested through regular drills and exercises.

Impact Significance

No environmental impacts from earthquakes are expected during the Leviathan Field pipelay program. The response to any spills resulting from an earthquake or other emergency would be in accordance with Noble Energy's OSCP. For details pertaining to accidental spill events refer to Section 4.3.

4.8 Fishing and Marine Farming

4.8.1 Impact to Fisheries

Impacts to the fishing industry may occur through interference with fishing activities during installation, particularly pipelaying activities and the presence of exclusion zone during these activities will lead to a removal of available fishing grounds.

Impacts to the fishing industry may occur through interference with fishing activities during installation, particularly pipelaying activities and the presence of exclusion zone during these activities will lead to a removal of available fishing grounds.

Fish farming (aquaculture and mariculture) is the main producer of fish in Israel, accounting for 84 percent of domestic fish production in 2005 (UNFAO, 2007). Aquaculture is usually undertaken onshore using traditional earthen ponds, such activities onshore will not be impacted by development operations offshore. Mariculture is generally focused in the nearshore environment therefore the physical presence of vessels will not impact the nearshore environment within the scope of this EIA.

Offshore marine fishing within the scope of this EIA is relatively sparse as a result of water depths and the oligotrophic nature of the environment (UNFAO, 2007). In total, marine fishing only contributed 10 % towards the total domestic fish production in Israel in 2005 (UNFAO, 2007). Fishing is concentrated along the narrow continental shelf, which, though 50 km wide in the south (along Gaza) narrows to only 10 km in the north (Haifa–Carmel Mountains).

Due to the distance from shore, recreational fishing is not expected in the Application Area (refer to CSA Ocean Sciences Inc. 2016a).

Fisheries Mitigation and Control Measures

Where construction activities will be occurring within in areas subject to fishing activities, planned construction activities will be published via the port authority channels and a 500 m exclusion zone enforced around all installation vessels. On start-up and production, the 1,500m exclusion zone will be maintained around the LPP and all submarine infrastructure within the TAMA jurisdiction.

During installation activities, Noble Energy will provide necessary notice via the port authority channels to fishing community and stakeholders ahead of installation commencement to inform of exclusion zones and extent of disruption. Vessel patrols to ensure fishing boats maintain their distance will also be engaged to mitigate collision risks out at sea.

Fisheries Impact Significance

Table 4-22: Summary of Impacts, Mitigation & Control and Residual Risk for Fisheries

Activity	Aspect	Potential Impact	Mitigation & Control	Likelihood	Severity	Residual Risk
Construction, installation and support vessels	Vessel presence	Impact to fisheries	500 m exclusion zone Communication with Port Authorities	2	2	4

4.8.2 Impact to Fish Populations due to Overfishing

Oil and Gas infrastructure (pipelines and platforms) in other global locations have been observed to attract significant levels of marine species (including fish) to their vicinity. This is primarily a result of two key features:

- Pipelines and platforms provide a hard substrate within the seabed environment for settlement of organisms such as hard corals and bivalves (refer to Section 4.4.2 for discussion on bio-fouling);

- Production fluids are generally produced at temperatures above ambient seabed temperature as a result of the elevated temperatures found in subsurface reservoirs. As heat is conducted across pipeline walls this has a warming effect on the surrounding environment which is known to attract fish species and infaunal communities.

The impacts associated with fish populations being attracted to such facilities however is difficult to assess, if fish populations are limited by the amount of available habitat, then the addition of suitable artificial habitat increases the environmental carrying capacity, resulting in a sustained increase in population biomass. This phenomenon is known as the 'production hypothesis' (Bohnsack, 1989). However, fish observed on artificial reefs may simply have been attracted to those locations from surrounding habitats, this is termed the 'attraction hypothesis' (Bohnsack, 1989). Initial attraction, however, does not preclude the possibility of later production which may occur over several decades (Macreadie, *et al.* 2011).

The 'attraction' hypothesis can be considered detrimental to fish populations as otherwise sparsely distributed resources can be concentrated making them easier to exploit (Bohnsack, 1989). However, the depths at which the majority of the subsea infrastructure within the scope of this Production EIA precludes it being located in areas where the seabed may be considered a fishery. Within Territorial Waters water depth decreases such that fishing activity may occur (< 500 m) at the seabed, however, fish abundance is generally low due to the oligotrophic nature of the Eastern Mediterranean Basin. As a result, the fishing effort is generally lower.

Since the Leviathan Field Development is reliant on continuous thermal hydrate inhibitor injection the subsea production system will not be thermally insulated. As such the production pipelines will be at approximately ambient temperature in the midwater / shallow water areas (> 105 km from the wellheads). Therefore the pipelines would not be expected to result in significant colonisation (by fish) of the waters immediately surrounding them.

Overfishing Impact Significance

Table 4-23: Summary of Impacts, Mitigation & Control and Residual Risk for Overfishing

Activity	Aspect	Potential Impact	Mitigation & Control	Likelihood	Severity	Residual Risk
Subsea infrastructure	Subsea infrastructure presence	Impact to fish populations due to overfishing	None required	1	1	1

Overfishing Mitigation and Control

Since the impact assessment process found that the presence of the subsea infrastructure is unlikely to cause any increased fishing effort and therefore there is no significant impact envisaged from overfishing activities, no further mitigation is considered necessary for the scope of this Production EIA.

4.9 Safety and Protection

Consistent with international industry practice, Noble Energy will establish a 500 m radius safety exclusion zone around the pipelay vessel and the OCV while it is operating, this will be patrolled by the standby vessel and kept clear of all unauthorized vessels. A standby vessel (capable of housing the entire workforce of the largest vessel) will be dedicated to supporting the pipelay and OCV vessels in order to both enforce the exclusion zone and provide rapid response in the event of an emergency situation occur.

Numerous shipping lanes cross Israel's Territorial Waters, although the Leviathan Field, pipeline route and the proposed platform location are not located within any shipping lanes (refer to Figure 2-3). However, shipping lanes do extend westward from Haifa in the direction of the Leviathan Field. Therefore, it is possible that shipping traffic may pass through the area en-route to or from various Mediterranean ports.

Safety and Protection Mitigation and Control Measures

In order to avoid any unwanted interactions between project vessels and the wider marine traffic of the Eastern Mediterranean, Noble Energy will consult (prior to commencing pipelay activities) with Haifa port authorities and provide notice to mariners to inform the authorities and public of planned vessel movements.

The authorities and public will also be notified of the implementation of the 500 m radius marine/safety exclusion zones around the pipelay vessel and OCV. All vessel operators must follow applicable maritime navigation rules.

Safety and Protection Impact Significance

Impacts on marine transportation and infrastructure due to the physical presence of the pipelay vessel and support/supply vessels are considered unlikely.

Table 4-24: Summary of Impacts, Mitigation & Control and Residual Risk for Safety and Protection

Activity	Aspect	Potential Impact	Mitigation & Control	Likelihood	Severity	Residual Risk
Construction, installation and support vessels	Vessel presence	Impact to other marine users	Communication with Port Authorities Notification to authorities and public of a 500-m radius safety exclusion zone around the pipelay vessel and the OCV while it is operating	2	2	4

4.10 Monitoring and Control Programme

Monitoring procedures are an integral element of Noble Energy's operations and help to ensure that the mitigation measures identified for the project are implemented. Some monitoring is prescribed in the various regulations and plans; other monitoring is directed by Noble Energy's EHS procedures. The following discussion is divided into the following categories: environmental monitoring, collecting samples, calibration methods and background monitoring plan.

4.10.1 Environmental Monitoring

Noble Energy conducted a Background Monitoring Survey of the marine environment as required by the Ministry of Environmental Protection and the Ministry of National Infrastructures, Energy and Water Resources which is required in order to characterize the environment encompassing the development areas before any Field Development.

These survey reports are entitled Leviathan Field Development Background Monitoring Survey: Drilling Component, March 201 and Leviathan Field Development Background Monitoring Survey: Pipeline Component, March 2016.

4.10.2 Collecting Samples

Sampling and monitoring of the effluent discharge of the LPP will be implemented as follows:

- Samples for toxicity sampling and oil and grease, if required, will be taken during operation.
- The first sample from the batch should be shipped to the designated laboratory for analysis.
- The remaining samples should be dated, labeled and stored in a designated cool place.
- If the sample results exceed effluent limitations for a particular month, then a sample from the batch of samples shall be sent to the laboratory for analysis.
- Additional samples should be analyzed if necessary to get a realistic monthly (quarterly or annual) average.
- If the sample results are within the specified limits, the remaining sample(s) in the batch should be discarded.
- If the sample results exceed the effluent limitation, then it must be reported according to specifications provided with the Leviathan Field Development Environmental Monitoring Plan and samples shall be collected as instructed by the appropriate laboratory.

4.10.3 Environmental Calibration Methods

Calibration and maintenance procedures shall be performed on all monitoring and analytical instruments at intervals frequent enough to insure accuracy of measurements and appropriate records of such activities maintained.

Appropriate flow measurement devices and methods consistent with accepted scientific practices shall be selected and used to ensure the accuracy and reliability of measurements of the volume of monitored discharges. The devices shall be installed, calibrated, and maintained to insure that the accuracy of the measurements is consistent with the accepted capability of that type of device. Devices selected shall be capable of measuring flows with a maximum deviation of less than 10% from true discharge rates throughout the range of expected discharge volumes.

All facilities and systems of treatment and control (and related appurtenances) shall be properly operated and maintained in a manner which will minimize upsets and discharges of excessive pollutants and will achieve compliance with the conditions of this Plan.

4.11 Abandonment and Dismantling of the Infrastructure

Given the water depths at the proposed infield flowline locations (>1,500 meters) and for a large proportion of the transmission pipelines locations, removal would be difficult and costly. Currently it is anticipated that these will be left in situ following flushing/cleaning operations to ensure the pipelines are in an environmentally acceptable condition prior to abandonment.

Removal of infrastructure at the end of field life would disturb the seabed sediments and cause an increase in local turbidity which could lead to smothering of benthic communities. The effects of smothering would be greater in deeper waters which are subjected less to seabed disturbances caused by oceanographic or meteorological processes. Often, any positive environmental impact of removing deep-water pipelines is considered to be outweighed by the negative increases in turbidity and seabed disturbance associated with the removal operation. Additionally, deepwater pipelines often offer an alternative hard substrate habitat which may act to increase biodiversity in the region, subsequent removal of this habitat may result in the loss of any increased biodiversity that has developed over the project life cycle.

Abandonment and Dismantling Mitigation and Control Measures

Prior to decommissioning a detailed impact assessment will be undertaken to review and assess decommissioning options. The comparative assessment will be based on technical feasibility, complexity and risk, safety, environmental impacts, effects on other sea users and cost. The aspects that will be covered in detail in the plan will include:

- Plans to plug and abandon/ suspend the wells;
- Methods to clean and/ or remove subsea trees/ manifold;
- De-oiling of pipeline, flowlines and risers; and
- Any pipeline/ flowline removal or burial.

Decommissioning will be conducted according to national regulations and guidelines including MEWR Guidance for Decommissioning Activities.

Abandonment and Dismantling Impact Significance

Although it is too early at this stage to assess the significance of the impacts expected to arise as a result of decommissioning activities, a dedicated Decommissioning EIA shall be prepared to ensure that residual impact significance is considered to be low prior to conducting any decommissioning activities.

Summary of Impacts, Mitigation & Control and Residual Risk for the Leviathan Field Development

Activity	Aspect	Potential Impact	Mitigation & Control	Likelihood	Severity	Residual Risk
Submarine Production Infrastructure and Transmission/ Supply Pipeline						
Installation of flowlines, transmission pipelines and associated subsea infrastructure	Temporary water quality impact & direct losses to benthic infaunal community	Losses or changes to benthic habitats	Optimization of the size of foundations and removal of any non-permanent construction aids. Minimize trenching and backfilling. Use of DP vessels precludes anchor damage	2	2	4
Preparation for installation of Transmission Pipelines	Engineer seabed drainage channels by dredging seabed sediments	Seabed disturbance and changes to benthic community Impact to filter feeding organisms due to temporary suspension of sediments in the water column	Localized impact at limited locations along the 117 km route. No sensitive protected habitat recorded in Application Area or near pipeline route corridor.	3	1	3
Presence of subsea production systems and pipelines	Physical presence & sediment deposition	Reduction of available benthic habitats and changes to benthic community	Seabed survey Minimal footprint associated transmission pipelines. Seafloor currents are very low - not expected to be an environmental issue.	2	1	2
Pre-commissioning and commissioning (cleaning, gauging, hydrotesting, dewatering and drying) infield flowlines and transmission pipelines	Discharge of inhibited hydrotest water and particulate residues such as ferrous oxides within hydrotest water	Impacts to benthic marine fauna and flora and sediment quality	Usage of Inhibitors will be minimized as practicable Selection of chemicals which are classified as 'PLONOR' – Pose Little Or No Risk where practicable Proposed chemicals are 'Gold' rated under the OCNS and thus present a low environmental hazard Permits to be obtained for discharge of hydrotest water	2	2	4

Activity	Aspect	Potential Impact	Mitigation & Control	Likelihood	Severity	Residual Risk
Subsea control valve operation	Hydraulic fluid discharges when valves are activated	Impacts to benthic marine fauna and flora and sediment quality	Water based hydraulic fluid. Discharge volumes estimated to be low. Approved low toxicity fluids preferred DREAM modeling conducted	2	2	4
Subsea pipeline design	Pipeline Stability	Impacts to benthic marine fauna and flora and sediment quality	Control in design through application of industry standard procedures Areas of instability will be engineered and designed to withstand spanning strain on pipeline Areas of instability will be monitored post installation	2	2	4
Sea Pollution Event by Oil Based on Extreme Scenarios						
Pipeline gas and hydrocarbon inventory	Loss of containment	Impacts to sediment and water quality and marine flora and fauna	OSRP Pipeline designed to industry standards PMS and controls system programmed to minimize potential release inventory Marine exclusion zone around the LPP	2	2	4
Pipeline gas and hydrocarbon inventory	Loss of containment	Interference with fishing and shipping industry	OSRP Pipeline designed to industry standards PMS and controls system programmed to minimize potential release inventory Marine exclusion zone around the LPP Notification to marine users in the instance of a spill	1	1	2
Pipeline gas and hydrocarbon inventory	Loss of containment	Beach landing (rocky beaches and/or sandy beaches that are rich in biota)	OSRP. Pipeline designed to industry standards. PMS and controls system programmed to minimize potential release inventory. Marine exclusion zone around the LPP. Notification to marine users in the instance of a spill.	1	1	1

Activity	Aspect	Potential Impact	Mitigation & Control	Likelihood	Severity	Residual Risk
Pipeline gas and hydrocarbon inventory	Loss of containment	Impact to leisure and tourism, marinas etc.	OSRP Pipeline designed to industry standards. PMS and controls system programmed to minimize potential release inventory. Marine exclusion zone around the LPP. Notification to marine users in the instance of a spill.	1	1	1
Pipeline gas and hydrocarbon inventory	Loss of containment	Industrial Secondary Users	OSRP Pipeline designed to industry standards. PMS and controls system programmed to minimize potential release inventory Marine exclusion zone around the LPP. Notification to marine users in the instance of a spill.	1	1	1
Noise						
Infield Gathering Manifold	Piling to secure to seafloor	Noise and vibration disturbance to marine fauna	Suction piling	2	1	2
Construction/ Installation and support vessels	Use of DP thrusters for positioning	Noise disturbance to marine fauna	None specific Pipelay vessel utilizing DP will be travelling at a slow speed Reduce vessel speeds upon coastal approach, particularly if activities are conducted during sea turtle nesting seasons	2	2	4
Installation logistical support: Helicopters	Noise & vibration from 'blade slap'	Noise and vibration disturbance to marine fauna	Standard aviation procedures and regulations	2	1	2
Nature and Ecology: Pre- Commissioning and Commissioning Activities						
Pre-commissioning and commissioning (cleaning, gauging and hydrotesting)	Discharge of construction debris and loose mill scale to the marine environment	Sea water quality and marine organism impacts	This material will be returned to the surface within pig receivers and disposed of appropriately onshore	1	1	1

Activity	Aspect	Potential Impact	Mitigation & Control	Likelihood	Severity	Residual Risk
infield flowlines and transmission pipelines	Discharge of inhibited hydrotest water	Sea water quality and marine organism impacts	Usage of Inhibitors will be minimized as practicable. Selection of chemicals which are PLONOR where practicable. Proposed chemicals are 'Gold' rated under the OCNS, and thus present a low environmental hazard	2	2	4
	Discharge of particulate residues such as ferrous oxides within hydrotest water	Temporary water quality impact caused by increased turbidity	Permits for discharge of hydrotest water. Pre-cleaning of pipe prior to discharge.	2	1	2
Nature and Ecology: Construction, Installation and Support Vessel/ Helicopter Presence						
Vessel presence	Artificial light employed on vessels	Disturbance to fish and fishery resources	Minimize excess lighting and orient downward SOLAS	1	1	1
Construction/ installation, commissioning and support vessels and helicopters	Movement of vessels during transit and whilst working and helicopter flights	Disturbance/ vessel strike to marine mammals and sea turtles	Installation vessels will generally operate at very slow speeds Communication between vessel masters upon sighting of a marine mammal Vessel speed and distance restrictions upon sightings	2	1	2
Vessel presence	Artificial light employed on vessels	Disturbance to marine mammals and sea turtles	Minimise lighting requirements as far as practicable. All lighting to be SOLAS compliant	2	1	2
Construction/ installation, commissioning and support vessels and helicopters	Movement of vessels during transit and whilst working and helicopter flights	Disturbance to seabirds	Helicopter altitude requirements Installation vessels will typically be operating at very slow speeds Communication between vessel masters upon sighting of a marine and coastal birds Vessel speed restrictions	3	1	3
Vessel presence	Artificial light employed on vessels	Disturbance to seabirds	Minimize lighting requirements as far as practicable. All lighting to be SOLAS compliant	3	1	3
Nature and Ecology: Construction, Installation and Support Vessel Discharges						
Construction/ installation and support vessel discharges	Discharge of vessel sewage, drains and food waste	Impacts to water quality and marine fauna and flora	MARPOL 73/78	3	1	3

Activity	Aspect	Potential Impact	Mitigation & Control	Likelihood	Severity	Residual Risk
Nature and Ecology: Ballast Water Discharge						
Presence of construction/ installation and support vessels	De-ballasting of vessels (potentially international)	Introduction of non-native invasive species	Controlled discharge under permit Maintenance and classification of vessels Adherence to IMO and MARPOL 73/78 standards	5	1	5
Nature and Ecology: Subsea Control Valve Operations						
Subsea control valve operation	Hydraulic fluid discharges when valves are activated	Impacts to water quality and marine fauna and flora	Water based hydraulic fluid. Discharge volumes estimated to be low. Approved low toxicity fluids preferred.	2	1	2
Nature and Ecology: Bio-fouling						
Pipeline infrastructure	Biofouling of pipeline	Changes ecosystem	None required	2	2	4
Nature and Ecology: Cumulative Impacts						
Presence of construction/ installation and support vessels	Emissions production	Reduced air quality and contribution to climate change	MARPOL 73 / 78	2	2	4
Presence of construction/ installation and support vessels	De-ballasting of vessels (potentially international)	Introduction of non-native invasive species	Controlled discharge under permit. Maintenance and classification of vessels. Adherence to IMO and MARPOL 73 / 78 standards.	5	1	5
Cultural and Heritage Sites						
Subsea installation	Disturbance to seafloor during pipelay	Damage/ destruction to important archaeological sites	305 m avoidance zone for potential wreck sites and 31 m avoidance zone for other sonar contacts.	2	2	4
Hazardous Materials						
Waste Management	Generation of domestic waste and general non-hazardous waste including scrap metal etc.	Waste transfer to shore	Waste handling, treatment and disposal will be in accordance with the WMP	2	2	4
	Hazardous waste generation including solid spent chemicals, filter elements and waste MEG etc.	Waste transfer to shore	Waste handling, treatment and disposal will be in accordance with the WMP	2	2	4

Activity	Aspect	Potential Impact	Mitigation & Control	Likelihood	Severity	Residual Risk
	Hydrotest water discharge at LPP	Water quality Impact on marine biota	Gold chemicals under the OCNS Optimize and manage discharge rate at LPP to mitigate adverse impact on marine environment. Optimal rate can be determined through modelling	2	2	4
Fisheries						
Construction, installation and support vessels	Vessel presence	Impact to fisheries	500 m exclusion zone Communication with Port Authorities	2	2	4
Overfishing						
Subsea infrastructure	Subsea infrastructure presence	Impact to fish populations due to overfishing	None required	1	1	1
Safety and Protection						
Construction, installation and support vessels	Vessel presence	Impact to other marine users	Communication with Port Authorities Notification to authorities and public of a 500-m radius safety exclusion zone around the pipelay vessel and the OCV while it is operating	2	2	4